Proceedings of the
NATIONAL SEMINAR
on

Creeks, Estuaries and Mangroves Pollution and Conservation

28th to 30th November, 2002, Thane

Edited by
Dr. Goldin Quadros



Organised by
Zoology Department
Vidya Prasarak Mandal's
B. N. Bandodkar College of Science
"Jnanadweepa", Chendani, Bunder Road, Thane (W) 400 601. Maharashtra



Mangrove Thicket



Sea Gulls - Ulhas River Estuary



Flamingoes - Thane Creek



Sample Collection An Adventure



Microphotograph of Phytoplankton



Microphotograph of Zooplankton



Microphotograph of Polychaete



Caterpillar on *A. officinalis*



Polychaete mat in Thane Creek



Mugil catch in Ulhas River Estuary

Proceedings of the
NATIONAL SEMINAR
on
Creeks, Estuaries and Mangroves Pollution and Conservation

28th to 30th November, 2002, Thane

Edited by
Dr. Goldin Quadros

Editorial Comittee
Dr. R. P. Athalye
Dr. (Mrs.) M. K. Pejaver
Dr. (Mrs.) N. N. Patil
Prof. (Mrs.) M. U. Borkar
Mrs. Vaishali U. Somani
Dr. (Mrs.) P. N. Kurve

Organised by
Zoology Department
Vidya Prasarak Mandal's
B. N. Bandodkar College of Science
"Jnanadweepa", Chendani, Bunder Road, Thane (W) 400 601. Maharashtra

Advisory Committee

Dr. Arvind G. Untawale
Executive Secretary, Mangrove Society of India

Dr. V.V. Bedekar
Chairman, Vidya Prasarak Mandal

Mr. G. S. Pantabalekundri
Secretary MMR-EIS

Mr. Shyam Ghate
President, HOPE – Thane.

Dr. Sanjay Deshmukh
Scientist, Rambhau Mhalgi Prabodhini

Mr. Vivek Kulkarni
Mangrove Project Incharge, Godrej group

Prof. D.K. Nayak
Vice Principal, V.P.M.s' Polytechnic

Chief Co-ordinator

Prin. C.G. Patil

Convenors

Vice-Principal, Dr. (Mrs.) M.K. Pejaver

Dr. R.P. Athalye

Organising Secretary

Dr. Goldin Quadros

Organising Committee

Prof. M.H. Dixit

Dr. (Mrs.) N.N. Patil

Dr. (Mrs.) S.V. Mahajan

Prof. S.D. Rathod

Dr. (Mrs.) V.D. Manjramkar

Dr. (Mrs.) P.N. Kurve

Prof. K.M. Pariya

Dr.(Mrs.) S.P. Bendigeri

Prof. (Mrs.) M.U. Borkar

Dr. Sanjay Joshi

Prof. H.V. Nanivadekar

Prof. (Mrs.) Sandhya Pawale

Prof. (Mrs.) Priti Jambhulkar

Mrs. Vaishali U. Somani

Mr. Hemant V. Karkhanis

Mr. Amol Patwardhan

Ms. Sujata Parab

Mrs. Nayana S. Raut

Mr. Prakash Virkar

Please Note :

The authors of the papers are alone responsible for technical content of the papers and references cited therein.

Price Rs. 500/-

Published by

Zoology Department,
V.P.M.'s B.N.Bandodkar College of Science,
Jnanadweepa, Chendni, Bunder Road,
Thane (W) 400 601.
Nov. 2002; 341pp.

Printed by : Mr. Vilas Sangurdekar
at
Perfect Prints,
22, Jyoti Indl. Estate, Nooribaba Darga Road,
Thane - 400 601.
Tel. : 2534 1291 / 2541 3546
E-mail : perfectprints@vsnl.net

CHAIRMAN'S NOTE

I have great pleasure in presenting the proceedings of the National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation held under the auspices of Vidya Prasarak Mandal's Department of Zoology of B. N. Bandodkar College at Thane during 28, 29 and 30 Nov. 2002

Vidya Prasarak Mandal (VPM) is committed to quality education. Since 1996 we have conducted about seven workshops on various subjects ranging from Interaction Between Industry and Education (1996), Relevance of ISO-9000 to Education (1997), Internet Awareness (1997), Information Technology (IT) and Library Automation (1998), IT and Accounting Profession (1998), Standardization and Validation of Ayurvedc Formulation (2000), and Intellectual Property Rights (IPR) (2002). This activity helps students and teachers go beyond syllabus and interact with scholars of repute from Industry and other Academic Institutions.

Pollution and the speed with which we are damaging our Ecosystem is a matter of great concern. We have adequate knowledge of the polluting sources but do not have the Social and Political will to take corrective measures. I am sure the proceedings of this Seminar, apart from giving us academic figures and information about the damage we have caused to our Creeks and Rivers, would help Policy-makers and Regulating Authorities understand damage caused by their inactivity, corruption in the system and ignorance.

We are anxious to hear your comments and suggestions.

Vijay Bedekar

Chairman
Vidya Prasarak Mandal, Thane

Dr. R. P. Athalye

FOREWORD

We the staff of Zoology department, Vidya Prasarak Mandal's B.N. Bandodkar College of Science, Thane are very happy to publish the proceedings of the National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation which include 65 research papers and 14 invited talks by scientists and environmentalists.

While working on the Thane creek, Ulhas river estuary and the mangroves along their banks for past 20 years, we could clearly notice the infinite scope of the subject and our limitations in knowing it fully. The subject has multiple facets and to understand them we must work in co-operation with each other, so as to learn through the perception of those working with devotion and dedication. Hence, a gathering of scientists and environmentalists was proposed in form of the National Seminar. It was well responded and we received over 75 presentations that are published herewith. I take this opportunity to thank all the contributors.

There were two options before us i) strict scrutiny of the articles and then publish them duly after the seminar ii) optimum screening and publication at the time of the seminar. We have chosen the second option. Though we tried our level best, owing to time constraints, compromise was inevitable. I hope the readers will look at theme of the presentations and their positive aspects.

To complete the task in a short span of less than 3 months would not have been possible without the promising support by Dr. V. V. Bedekar, Chairman, Vidya Prasarak Mandal's, Thane. The Principal Prof. C. G. Patil, my department and college colleagues and friends from different V.P.M. institutions as well as other organisations. Sincere thanks to all who have worked for the seminar and the proceedings.

Dr. R. P. Athalye

Covenor, Organising Committee

CONTENTS

Sr. No.	Title	Page nos.
	Chairman's Note	iii
	Foreword	iv
1	Organisers view *R.P. Athalye*	1
2	Degradation of Marine Habitats and Coastal management framework *M.D. Zingde*	3
3	Saving the Seas: an Indian Experience *Sanjay V. Deshmukh*	8
4	Status of Oil pollution along the Indian coast *A.N. Kadam and M.K. Chouksey*	12
5	Insect fauna of mangrove ecosystem *P.V. Joshi and R.N. Sharma*	17
6	Impact of wastewater on phytoplankton *M Jiyalal Ram Jaiswar*	19
7	Zoolplakton - Study Methods, Importance and Significant observations *S. N. Gajbhiye*	21
8	Marine Benthos - A future perspective *K. Govindan*	28
9	Microfossils and their importance in paleo-environmental analysis *K.P.N. Kumaran*	31
10	Mangrove Afforestation - A point of view *Arvind G Raddi*	34
11	Indian Mangroves : Conservation Aspect *Vivek Kulkarni*	37
12	Protecting India's Coastline – the Coastal Regulation Zone Notification *Debi Goenka*	41
13	Solid waste management in India *K.S.Gokhale*	44
14	Sea-level rise and Sundarban Mangrove *Pranabes Sanyal*	47
15	Assessment of water quality and aspect of Pollution in a stretch of Patalganga creek and Arabian Sea of Raigad District, Maharashtra *Patil S. M. and Hande R. S*	51
16	Physico chemical characterisation of waste water stream and its Significance with Creek Pollution due to industrial effluents *C. N. Sathe, Deepali Pimple and R. S. Lokhande*	54

Sr. No.	Title	Page nos.
17	Present status of water quality of Thane creek and Ulhas river estuary *Goldin Quadros, R. P Athalye, Vaishali U. Somani, Mangal U. Borkar and N.N. Patil*	58
18	Nature and properties of mangrove soils of Sundarbans, India *Dolanchampa Ghosh (Sarkar), Kumudranjan Naskar and G.N. Chattopadhyay*	63
19	Studies on the intertidal sediments of Thane creek and Ulhas River estuary *R.P.Athalye and Goldin Quadros*	66
20	Biodiversity, Ecology and Conservation of Mangroves in Devbagh Creek of Kali estuary near Karwar, Karnataka, India *V. S. Achari, L. V. Andrade and V. N. Nayak*	72
21	Biodiversity and Ecology of the Gulf of Kachchh mangroves, Gujarat *Oswin D. Stanley*	78
22	Seasonal variation of Phytoplankton in Uran estuary *K. N. Babu, S. G. Yeragi and S. S. Yeragi*	84
23	Phytoplankton of Ulhas river estuary and Thane creek *Mangal U. Borkar, Goldin Quadros and R.P. Athalye*	86
24	Estimation of gross primary production of Uran Creek *S. G. Yeragi, K. N. Babu and S. S. Yeragi*	93
25	Plankton Biodiversity of Dharamtar Creek Adjoining Mumbai Harbour *L.R.Tiwari and Vijayalakshmi R.Nair*	96
26	Study of Rotifers in Thane Creek and Ulhas river estuary *Vaishali U. Somani, N.N. Patil, Goldin Quadros and R.P. Athalye*	103
27	Living Dinoflagellate Cysts of *Gymnodinium catenatum* and *Alexandrium catenella* from the recent sediments of Bhatye estuary, Ratnagiri, Maharashtra *Sameer Terdalkar, S.N.Kumbhar and A.S.Kulkarni*	106
28	Study of Zooplankton distribution from Ulhas river estuary and Thane Creek *N.N. Patil, Goldin Quadros, V.U. Somani, P.N. Kurve and R.P. Athalye*	109
29	Food and Feeding habits of *Matapenaeus monoceros* found in Thane Creek *Pejaver M. K. and K. S. Gokhale*	116
30	Survey of Mangrove Clam *(Gelonia proxima)* Fishery in Ratnagiri District *R.B.Kale and B.K.Pawar*	120
31	On presenting a suitable method of combined culture comprising *Artemia salina* (SFB strain) and *Indomysis annandalei* W.M.Tattersall under laboratoryconditions *S.V. Deshmukh*	125
32	Parasitic copepods in *Saccostrea cucullata* (Born, 1778), a mangrove associated oyster at Pitchavaram backwaters, Southeast coast of India *B. A. Venmathi Maran* and K. Ayyakkannu*	132

Sr. No.	Title	Page nos.
33	Qualitative Study of Fin fish and Shell fish Fauna of Thane Creek and Ulhas River Estuary *Sudesh D. Rathod, N. N. Patil, Goldin Quadros and R. P. Athalye*	135
34	Food and feeding of *Metapenaeus monoceros* (Fabricius) *Prasad Karnik and V. D. Deshmukh*	142
35	*In Vitro* _Effects of Cadmium Chloride on Brain and Muscle Acetylcholinesterase of Mus-Skipper *Boleopthalmus* *Ritu Sharma, Jyoti Nair, Anuja Pai and Sharma B.B.*	145
36	Histopathological alterations induced by pesticides on gill and liver of the mudskipper, *Boleophthalmus dussumieri* *A. M. Rana and S. G. Yeragi*	152
37	Metabolism in Estuarine Clam - *Katelysia Opima* upon heavy metal stress *S.N.Kumbhar, D.V.Muley, Sameer Terdalkar and A.S.Kulkarni*	156
38	Alterations in the Na^+, K^+ contents of the tissues of the marine edible clam, *Marcia hiantina* (Lamarck) exposed to Fenthion *Sathe M.C.* and Shrotri R.V.*	159
39	Physiological studies on an Intertidal Blood Clam *Cardita antiquata* (LAM) of Mumbai Coast *Meenakshi Narayankar Choudhary, B.G.Kulkarni and Ashok Jaiswar*	162
40	Cadmium level in coastal areas of Mumbai and its Toxicity to Intertidal Clams *B.G.Kullarni, Shriprasad Kerkar, Delphine Pereira*	167
41	Toxic effects of heavy metals (Lead, Copper) on Acid Phosphatase and Alkaline Phosphatase in the Intertidal Crab *Scylla serrata* *K. M. Pariya and B.B. Sharma*	170
42	Effect of naphthalene on lactate and succinate dehydrogenase of male esturine crab, *Scylla serrata* *K.Durgabhavani, K.Vijayavel and M.P.Balasubramanian*	175
43	Electrophoretic studies of Phosphatases and Non-Specific Esterases in the estuarine edible crab *Scylla serrata* with reference to Naphthalene stress *K.Vijayavel, K.Durgabhavani and M.P.Balasubramanian*	177
44	Effects of the Pesticide Malathion on Acid Phosphatase Enzymes in certain tissues of the Marine Crab *Uca marionis* (Des) of Mithbav Creek *V. A. Koli, S. G. Yeragi and S. S. Yeragi*	180
45	Changes in Digestive Diverticula of *Gafrarium divaricatum* after exposure to water soluble fractions of a Crude Oil. *Donde Snehal S., Nayak R. R. and Sawant K. B.*	182
46	Benthic Macrofauna of Thane creek: Seasonal Variations. *Smita Venkatachalam and P.G. Kale*	186

Sr. No.	Title	Page nos.
47	Study of the Dominant Fauna of Mangroves at Seven Bungalows Beach,Versova, Mumbai – A preliminary study *Contzen Pereira, C. V. Rao and S. Krishnan*	196
48	Study of Copper in Polychaeta *Lycastis merukensis* from Thane Creek *Mukherji M.N. and Gokhale K. S.*	201
48	Temporal and spatial variations in sedentary marine macrofouling organisms *B.S. Swami, M. Udhayakumar and S. N. Gaonkar*	203
50	Increased Macrobenthic density and diversity: Indicator of recovery of Chilika Lake from environmental degradation *Baban Ingole*	213
51	Intertidal macrobenthos from Ulhas river estuary and Thane Creek *Goldin Quadros and R.P. Athalye*	216
52	Restoration of Mangroves at Jamnagar *Dhiren M Pania*	223
53	Mangrove Diversity and its Role for Sustaining Productivity of the N.W. Coast of India. *M.J. Kothari*	226
54	Mangrove Plantation at the Rituchakra by HOPE *Amol Patwardhan and Madhuri Pejaver*	234
55	Germination and growth performance of *Xylocarpus granatum* (Koen) *M. V. Gokhale and N. S. Chavan (Mulik)*	237
56	Composition and present status of Mangroves at Achara Creek *Aarati. S. Yeragi, Rajendra Nayak & S. G. Yeragi*	240
57	Studies on the associated Flora in the Mangrove Environment of Mithbav Creek *S. S. Yeragi and S. G. Yeragi*	243
58	Studies on composition of Starch and Amylase activity in three *Sonneratia Species* *A. B. Telave and N. S. Chavan*	247
59	Arid zone mangroves of Kachchh, Gujarat: Vegetation structure and environmental characteristics *G.A. Thivakaran, A. Saravanakumar, Sesh Serebiah and Justus Joshua*	249
60	Nutrient Enrichment by waste water discharge -Mangroves of Pondicherry, South India *Saravanan, K.R. and Anisa B.Khan*	256
61	Mangroves of Ulhas river estuary and Thane creek *Mangal U. Borkar, Goldin Quadros and R.P.Athalye*	260
62	Avian diversity in and around mangroves of Mahul Creek, Mumbai, India *Ashok Verma, Naresh Chaturvedi, S. Balachandran and Isaac Kehimkar*	266
63	Species Diversity Of Avifauna At Thane Creek Near Rutuchakkra Nature Park *Shriharsha R. Nitsure and Madhuri Pejaver*	276

Sr. No.	Title	Page nos.
64	Behavioural Ecology and Physico-Chemical Analysis of Nest of Crematogaster Ants from Mangrove Forest *Randive Jayant, Bhalerao A. M. and Modak Manisha*	283
65	Some observations on Teak Defoliator *Hyblaea puera* (Lepidoptera: Hyblaeidae) on secondary host plant *Avicennia marina* *Naresh Chaturvedi*	289
66	Occurrance of Scale Insect *Icerya* spp. on Mangroves of Thane Creek and Ulhas river estuary, Maharashtra, India *Hemant V. Karkhanis and R.P.Athalye*	290
67	Studies on Wood Borers from the Mangroves of Mithbav Creek *S. G. Yeragi & S. S. Yeragi*	293
68	Biotechnological studies on Mangrove Ecosystems ***Plenary lecture :*** *A. D. Agate*	296
69	Quantification of halophilic phosphobacteria from Pitchavaram mangroves and their potential application to crop culture *S. Ravikumar, G. Ramanathan , M. Babuselvam and S. Prakash*	301
70	Chitin : The best from the waste *Varad Ravindra Pradhan and Atul N. Bedekar*	304
71	Eco-tourism potential of mangrove swamps of Goa: An appraisal *Manoj R. Borkar, Neelam K. Komarpant, Padma Kamat and Nirmal Kulkarni*	310
72	Nadi to Nallah a story of a river that was at Dahisar *Indira Bhende*	317
73	Need of Public Participation in Plantation, Conservation and Protection of Mangroves in Thane District *Mahesh M Lahigude*	320
74	Sustainability equation and an individual's role *Jyoti Marwah and Manjushri Ganguly*	323
75	Dynamics of Coastal Regimes *Sudha Srivastava*	325
76	Degradation of Creeks and Mangroves and its impact on Urban Environment ---- A case study of Mumbai *Dipti Mukherji*	331
77	Quantifying Mangrove cover change in and around Mumbai using Satellite data *Hrishikesh P. Samant*	334
78	Present estuarine and Coastal Fisheries in India ***Plenary lecture :*** *V.S.Somvanshi and A.K.Bhargava*	338

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 1-2

ORGANISERS VIEW

R.P. Athalye
Zoology Department,
B.N. Bandodkar College of Science, Thane 400 601.

The creeks and estuaries are coastal bodies in which marine water enters during high tide and recedes during the low tide. In estuaries, and also in the creeks which have a fresh water connection, the tidal incursion produces brackish water conditions due to mixing of fresh and saline waters. This produces gradient of salinity with high salinity towards the sea and low salinity towards the riverine end. The organisms and plants which can tolerate and adapt to these varying salinity stresses settle in the niche suitable to them. They face some hardships, stress due to fluctuating conditions but are rewarded by gaining shelter from the crowded and harsh conditions in the sea.

As the sea water penetrates deeper in the creeks and estuaries, the wave force weakens to make the environment calm as compared to the sea. This facilitates settling of silt, clay particles and the nutrient rich humus brought by the rivers, leading to formation of mudflats. The soft sediment mudflats favour establishment and growth of specially adapted mangrove trees whose intricate network of roots further enhances mudflat formation process. Gradually dense mangrove forest is established. The ecosystem is further enriched by mangrove litter and hence supports diverse and rich plant and animal life.

Many marine fishery types visit creeks and estuaries for laying their eggs. The young ones grow in these sheltered breeding grounds and then migrate to the sea. There are others which sence the richness of these ecosystems and visit with the tide to exploit them as feeding grounds. Thus estuaries, creeks and mangrove swamps being the feeding and breeding grounds of many marine and riverine organisms, play an important role in supporting the fishery.

Thane-Mumbai complex is an island surrounded by Thane creek on its east, Ulhas river estuary on the north and the Arabian sea on its west. The uniqueness of Thane creek is its minor connection with Ulhas river estuary giving it a fresh water source. A few decades back this region had luxuriant vegetation including the mangroves and a variety of sea food wealth. Different types of prawns, crabs, shells and fishes flourished even in the inner upstream stretches of Thane creek and Ulhas river estuary. However in the past 20 years the status of these rich environments has deteriorated. We blame it on the heavy industrialization and urbanization in the region; however the main causes are our own negligence, disconcern and lack of will to implement the right things.

V.P.M.s' B.N.Bandodkar College is located on the bank of Thane creek and in proximity with Ulhas river estuary. Hence we felt it our duty to study the environmental parameters of these ecosystems to assess their pollution status. The work at the zoology department was initiated in 1980 by our guiding teacher Dr. (Mrs.) Kusum S. Gokhale. Since then we have completed 3 projects (2 major and 1 minor.) on the ecosystems and yet many things remain unexplored. Presently we are assessing the 40 km. stretch of Ulhas river estuary and 26 km. stretch of Thane creek for different parameters, in a project sanctioned by Mumbai Metropolitan Region – Environment Improvement Society, C/O MMRDA, Mumbai. These ecosystems are very well studied by prominent national institutions like NIO, BARC, CMFRI, NEERI, MPCB, etc. However, because we have been studying these ecosystems consistently, though not continuously, we are witnessing their deteriorating status. It is indeed a matter of concern for all of us. We have realized that we all are responsible for this situation.

The creeks and estuaries infact have a good flushing ability because of the diurnal tidal cycles. The sewage and effluents released in them get flushed with the tide to the ocean and are diluted. However, due to their this quality, we are over exploiting them by allowing excessive industrialization and urbanization in their viscinity. This tremendously increases the effluent load on creeks and estuaries leading to their pollution. The same has happened with Thane creek and Ulhas river estuary. The number of industries and human population density in this region is so high that the quantity of pollutants released are now beyond their carrying capacity. We are not only releasing the effluents in them but are also dumping solid wastes and reclaming mangrove forests along their banks. It has been observed that while constructing the bridges across the creek or estuary proper precautions to maintain tidal flow are not taken. These activities cause hinderance in tidal flushing leading to accumulation of pollutants, sewage sludge and silt causing a bottle neck.

Following changes have been noticed by us especially in Thane creek and also in Ulhas river estuary

during the past decade.

1. The average dissolved oxygen in water has become less than 2.5 mg/l which indicates hypoxic condition.

2. Nutrients have significantly increased in the water and sediment leading to eutrophication and excessive growth of opportunistic species.

3. Suspended solids in the water have increased from the earlier few hundred milligrams per litre (mg/l) to the present grams per litre (gm/l).

4. Mangrove mudflats which are breeding grounds of prawns and fishes are either reclaimed by solid waste dumping or the trees are cut for fuel or clearing the land.

5. Clay component in the sediment has decreased and silt is increasing. Which has made the mudflats soft and sinking.

These changes have adversely affected the fishery of creek eliminating prawns, crabs, mudskippers etc.

Previously ample fishes of different varieties were available near Thane city. Now the fisher men have to go 10 to 15 km downstream in the creek so as to get better catch or change their traditional profession. We have damaged the breeding places of the aquatic life which has led to drastic reduction in the fishery yield in open sea. Ulhas river estuary is also facing these atrocities, especially in the Riverine zone, but is other wise better, as the larger water volume dilutes the pollutants.

We all, in which I include every individual in Thane –Mumbai Complex, the corporations (TMC, BMC, KDMC), the industries and the government are responsible for the deterioration of Thane creek and Ulhas river estuary

As our Hounarable President Dr. A.P.J. Abdul Kalam states 'Each one of us should work in self disciplined manner guided by strict rules and regulations.' (Presently we are enjoying so much liberty that we have become extremely indiciplined) By sincere efforts only, we will be able to revive these dying ecosystems. This can be achieved by implementing the following.

A) As an individual we should

1. Mimnmise the solid waste by bio-decomposing the degradable matter at source i.e. at home. This will give biofertilizer as well as reduce the solid waste load by at least 40 – 50 %.

2. Educate others regarding importance and conservation of creeks, estuaries, mangroves and our environment.

B) At Community level we can do the followings

1. We can recycle water used for bathing by storing it in a separate tank, repumping it and utilizing for flushing the toilets. This will save precious fresh water.

2. Restart the septic tank method in which excreta is collected in the tanks, allowed to decompose to produce nutrient rich fertile water. This will significantly reduce the sewage load.

3. Sort the non-degradable solid wastes and recycle them in small scale industries set within the corporation limits.

4. Treatment of industrial effluents and sewage before releasing them in creek / estuary.

5. To remove accumulated debris from the creek / estuary so as to clear hindrance in tidal flow.

6. Plantation of mangroves can be done along the banks of the creeks and estuaries and harvest them alternately. This will conserve them as well as benefit us.

As an individual and as a community we must do this. We must leave our lethargic nature, wake up and work hard to achieve the goal.

These are various aspects of pollution and conservation of the creeks, estuaries and mangroves. They are not confined to Thane creek and Ulhas River estuary. Many of you might have witnessed such environmental degradation, studied the causes, effects; thought about them and discussed on these issues. Some of you might have also found some remedial measures. Hence, to have exchange of views, suggestions and discussions on these issues; to give our message to all the concerned authorities and with a plan to educate and motivate the masses, this seminar has been arranged. Its success lies in our sincere approach and genuine willingness. Let us join hands and work to minimize the pollution and implement conservation.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 3-7

DEGRADATION OF MARINE HABITATS AND COASTAL MANAGEMENT FRAMEWORK

M. D. Zingde
Regional Center, National Institute of Oceanography, Mumbai - 400 054.

INTRODUCTION

India has a long coastline of over 8000 km with associated continental shelf of 0.5 million km^2 and an Exclusive Economic Zone of 2.02 million km^2. The coastal zone of the country with its wetlands, lagoons, mangroves, sea-grass beds, coral reefs and shallow bays, creeks and estuaries is rich in natural resources including fisheries, coastal forestry products and minerals, and offers tremendous potential for recreation, aquaculture, extraction of freshwater and harnessing of tidal and wave energies. Unfortunately, much of this wealth is often exploited in an indiscriminate or ill planned manner resulting in rapid resource depletion and irreversible environmental degradation. Major driving forces for coastal degradation include (a) high rate of growth in population leading to reclamation of coastal areas and release of wastes, (b) over-fishing due to lack of alternative livelihoods, (c) large commercial enterprises aiming at quick profit at the cost of sustainability and their insensitivity to the interests of local inhabitants, (d) ignorance about management of resource sustainability among stake holders and policy makers, (e) lack of understanding of environmental significance and importance of coastal habitats, and (f) inadequate enforcement of environmental rules and regulations.

The present paper examines the trends that have emerged concerning the status of the nearshore ecology of India in the context of development activities and the Government policies aimed at minimizing the impacts of anthropogenic interventions on the marine environment.

SOURCES OF POLLUTION

Among number of concerns regarding the coastal zone, degradation caused by disposal of domestic and industrial wastes is one of the major issues. Indiscriminate releases of untreated or partially treated wastes without considering the assimilative capacity of the waste receiving water body have resulted in pockets of polluted environs with depleted coastal resources, public health risks and loss of biodiversity. The population of India which was 345 million people at the time of independence (1947) has crossed 1 billion by the middle of 1999. over 300 million people living in the coastal zone of India are considered to generate 1.11 x 10^{10} m^3 of sewage annually, a considerable fraction; particularly from coastal cities and towns where sewage collection network exists, enters the marine waters. (Zingde, 1999a).

There is a high concentration of large and medium industries within the narrow coastal belt of 25 km width than the rest of the country. These industries are estimated to generate 1.35 million m^3/d of liquid effluent and about 34,500 t/d of solid waste. The West coast of India is more industrialized than the East coast with Maharashtra and Gujarat having largest concentration of industries. A 1994-95 survey (CPCB 1996) revealed that out of 308 large and medium industries in the country, 233 were located along the West Coast. The industries established within the 25 km belt along the West coast generate 0.85 million m^3/d of liquid effluents and 14,600 t/d of solid waste. A major fraction of the liquid effluents is released to marine areas, presumably treated, to meet specifications of the respective state pollution control board. In addition, aquaculture farms, largely concentrated in Andhra Pradesh and Tamil Nadu, generate 2.37 million m^3/d of effluent.

Much of the development along South Gujarat and Maharashtra has taken place several kilometers inland from the coastline. Primary considerations for such developments in the past had been the availability of water, electricity and transport, while, environment received the lowest priority. Evidently, many industries are located near national highways and railway stations and release their effluents in nearby rivers, estuaries or creeks. Nearly 8% of industries in the country are located around Mumbai in four lrge industrial clusters namely, Trans Thane – Belapur belt, Kalyan-Ulhasnagar-Ambarnath belt, western bank of Thane Creek and around Patalganga and Amba Rivers. Evidently, Ulhas, Patalganga and Amba rivers as well as Thane Creek are the recipients of a variety of wastes (Zingde, 1999a).

Recent major industrial development in Gujarat is along the southern Gulf of Kachchh, at Dahej and at Hazira on the northern bank of the Tapi estuary. The industrialization along the Gulf of Kachchh is of considerable concern because of high ecological sensitivity of the region, and hence needs special attention. Availability of relatively deep waters near the southern shore and protection from the monsoon waves has made the Gulf attractive for the import of crude oil

through Very Large Crude Carriers (VLCCs) and systems to shore-based tank farms. Four SPMs with a potential to handle about 50 million t/y of crude oil are already operational and a few more are being considered. The traffic of crude oil is projected to increase from the present 40 million t/y to over 70 million t/y by 2007. With this, the traffic of VLCCs is expected to go up to roughly 500 per annum by 2007 apart from the traffic of the tankers carrying petroleum products. This multifold increase in traffic of crude oil and its products enhances the risk of oil spills due to tanker accidents, hose ruptures, sub-sea pipeline leakage, operational discharges etc. If a large spill occurs, the Gulf ecology particulary of the intertidal and subtidal nearshore habitats will be under high risk (Zingde, 1999b). As a matter of fact the waters around the entire coast of India have become vulnerable to oil pollution due to increasing transport of crude oil and its products as well as enhanced oil exploration and production activities on the shelf.

The rivers along the coast of India discharge about 1.56×10^{12} m^3 of runoff annually to the seas transporting a wide range of pollutants of terrestrial origin. The transport of fertilizers through land runoff is expected to have increased substantially with the enhancement in its consumption. The progress made in the agricultural sector in India in the last four decades has been one of the biggest success stories. The agricultural production increased from 50.82 million t in 1950 – 51 to 208.07 million t in 1999 – 2000 with the sown area increasing from 97.32 to 123.06 million ha over the same period. The use of fertilizers and pesticides played an important role in this success. The total fertilizers and pesticides played an important role in this success. The total fertilizer consumption in India that was less than 0.1 million t/y in 1950s, increased dramatically in 70s and thereafter, with the consumption in 1999 – 2000 estimated at 18.37 million t. The use of nutrients, particularly nitrogen, per unit of gross cropped area increased from 0.55 kg/ha in 1950s to more than 90 kg/ha in 1998 – 99 (Zingde, 2001). It is well established that a considerable fraction of nutrients applied on land, particularly nitrate, is washed to the sea through river runoff thereby increasing the productivity potential of the marine area that, in the long run, can considerably modify the marine ecosystem (GESAMP 2001).

The consumption of pesticides (insecticides, herbicides, fungicides, bactericides, and rodenticides) also increased phenomenally – from 5000 t in 1950 to over 84,000 t in 1998 – 99. Today India is the largest manufacturer of basic pesticide chemicals among the South Asian and African countries next only to Japan and along with China accounts for more than 10% of the total world production. Of the persistent chlorinated pesticides, DDT and BHC have been widely used in the country till recently. Their indigenous production began in 1954 though they were used since 1948 for malaria (DDT) and Locust (BHC) controls. The use of BHC that formed 20-30% of the total production of pesticides in the country during 1995 – 97 was banned in 1997 and the use of DDT has been restricted largely to malaria control. Evidently, the production of DDT declined form 6000 t in 1995 – 96 to 3400 t in 1999 – 2000. It is feared that indiscriminate use of DDT and BHC in agriculture/ malaria control has caused dangerously high levels of pesticides in the food chain (Zingde, 2001). As in the case of fertilizers, a fraction of pesticides applied on land is transplanted to coastal waters through runoff (GESAMP 2001).

Another source of nuisance particularly on the beaches near cities and towns in India is the discarded plastic materials. The consumption of plastic, which was negligible in 1950s, has gone up exponentially to 2.2 million t in 1997 – 98 (Zingde, 2001).

STATUS OF COASTAL ENVIRONMENTAL QUALITY

A fairly comprehensive database has been generated for the coastal water quality through the national program 'Coastal Ocean Monitoring and Prediction Systems' under which openshore waters up to a distance of 25 km from the shoreline are monitored at pre-decided transects. Independent site specific investigations at a number of locations have also been carried out along the coast by several other agencies. An assessment of the available results indicates that the openshore waters, about 1 km away from the shore, are clean and healthy except in some isolated pockets around coastal cities where degradation has spread a few kilometers further. Several inshore regions such as estuaries, creeks and bays however, have been degraded to a varying degree depending on the fluxes of pollutants they receive and their flushing characteristics. Domestic wastewater is the major source of pollution though industrial emissions also contribute locally in some instances (Zingde 1999a).

Inshore waters of Mumbai and region around, particularly Versova Creek, Mahim Creek, Ulhas estuary, Thane Creek and Patalganga estuary, are the examples of highly degraded environment because of anthropogenic perturbations. Several other inshore waters also reveal varying degrees of ecological deterioration. These include Veraval, Porbandar and Visakhapatnam harbours, Mahi, Mindhola, Purna, Par, Ambika, Auranga, Kolak, Damanganga, Ulhas, Savitri, Kundalika, Vashishti, Ashatmudi and Ennore estuaries, interior Kochi Backwaters and coastal waters of Chennai. Excess organic loading, often associated with the release of untreated or partially treated domestic wastewater, is largely responsible for this degradation. These waters are characterized by abnormally high and tide dependant levels of PO_4^{3-}-P, NO_3^--N and NH_4^+-N, Variable DO falling to zero at low tides in some instances and abnormally high and tide dependant populations of pathogens (Zingde 1999a).

Marine sediments of the Indian coast are by an large free from gross contamination by heavy meatls such as Co, Ni, Cu, Zn, Pb, Cd and Hg (NIO 1997) though a few localized areas have been reported to have accumulated trace metals. Some examples are: Cr and Hg in Par estuary, Hg in Mindhola estuary, Cr, Cu, Zn, Pb, Cd, and Hg in Ulhas estuary (Sahu and Bhosale, 1991) and Ni, Cu and Zn in Visakhapatnam harbour (Satynarayana *et. al*., 1994). Mercury levels of 60 ppm. have been found (Ram, 1999) in the surficial sediment of the interior Ulhas estuary which progressively decrease in the seaward direction with the sediment of the mid-estuarine segment sustaining the concentrations of about 0.6 ppm and the baseline (0.1 ppm) is attained several kilometers off in the sea from the mouth of the estuary. Caustic soda industry is considered to be the major source of Hg to the marine environment.

Except in a few cases of elevated concentrations of some toxic metals in marine organisms localized to a few wastes receiving sites, the commercial fish and shellfish is free from heavy metal contamination. Uptake of DDT and Aldrin by marine organisms to levels to cause concern is also not indicated though the results are not exhaustive (Zingde, 2001). The levels of petroleum hydrocarbons in water (<20µg/l) as well as sediment (<10 ppm) in some port areas though show a marked enhancement as compared to those at the openshore regions, they do not reveal serious accumulation (Chokshi, 2002).

Although long-term data on nutrient levels in coastal waters is not available, the concentration of NO_3^- N is considered to be increasing at least along the north west coast of India due to the load transported by rivers which drain agricultural areas in the hinterland (Zingde, 1999a).

STATUS OF MANGROVES

The mangroves are wide spread along the Indian coast. Gangetic Sundarbans occupying an area of 2067 km^2 is the largest single block formation of mangroves in the world annually yielding 30,000 t of fish, crab and prawn. It is estimated that over three-fourths of India's commercial fishing in the Ganga-Brahmaputra estuary is dependent upon the health of mangroves. Mangroves of the A&N Islands are the second largest in India. The other prominent mangrove formations are in the deltaic areas of Mahanadi, Godavari, Krishna and Pichavaram and Puthupet on the East coast. Mangroves, though to a lesser extent, also occur along the West coast in the states of Gujarat, Maharashtra, Goa, Karnataka and Kerala. The total area under mangroves along the Indian coast is estimated at 4460 km^2 (Nayak, 1998).

Overexploitation and unsustainable demand has resulted in considerable degradation of mangrove areas though exact estimates are not available. Mangrove formations along the Gujarat coast have declined from 165.2 km^2 in 1992 to 128.9 km^2 in 1998 when mangroves of the Kachchh District are excluded. Significant improvement from 601.8 km^2 to 938 km^2 over the same period has been reported in the mangrove formations of the Kachchh District probably because these areas are remote and not easily accessible (Bahuguna *et. al*., 1998). It is feared that the area under mangroves around Mumbai areas has dwindled by 35% in the last 25 y and only about 20 km^2 of mangroves exist today.

STATUS OF CORALS

The major coral formations are around the Lakshadweep (816 km^2) and A&N Islands (960 km^2) as well as in the Gulf of Mannar (94 km^2) and the Gulf of Kachchh (460km^2). Many of these areas are under anthropogenic pressure due to mining, dredging, fishing, coral collection and recreational activities. The coral reefs of the Gulf of Kachchh have been degraded to a considerable extent with the deposition of mud over reef. Localised reef areas of the A&N Islands also have mud deposits. These deposits of mud on reefs are as a result of mangrove deforestation. A study conducted in the Lakshadweep and Andaman Islands as well as the Gulf of Kachchh indicates that disease, predation and stress are the major factors of coral mortality (Ravindra *et. al*., 1999).

STATUS OF MARINE FISHERY

The progress and the problems of marine fishery of India have been reviewed by Devraj and Vivekanandan (1999). The marine fish production in India is exclusively from the capture fisheries, barring an annual production of about 0.7 million t of brakishwater prawns through aquaculture. However, the production from inshore waters (<50 m depth) has reached the catchable potential (2.2 million t/y) and scope for further increase in production from nearshore waters is limited. Inappropriate exploitation patterns of concentrating 80% of the total fishery effort in the nearshore areas and over-dependence on trawlers is feared to have become counter productive. The catch rate of fishing vessels in several fishing centres is on the decline leading to an increase in competition and, often, conflicts between different fishing fleets.

Among other factors, the trawlers are also responsible for declining population of the Olive Ridley sea turtles, an endangered species, which nest along the east coast of India, due to incidental capture of adults in fishing nets (Pandav *et. al*., 1998). The rookery at Gahirmatha in Orissa has been the largest in the world with annual nesting of 0.1 to 0.5 million turtles. Intense patrolling along the coast to prevent unregulated trawling in order to provide the turtles safe passage in recent years has shown signs of recovery.

With active encouragement by the government, shrimp culture boom was witnessed during early 1990s. Unfortunately, the developments were unplanned and basic norms with regards to water treatment, use of antibiotics, seed quality, pond fertilization, effluent disposal practices etc. were flouted. The cumulative effect of this negligence was the severe outbreak of white spot disease in 1995 that wiped out the crop in majority of aquaculture farms. Since then though the virulence of the virus seems to have declined, sporadic mass mortalities occur locally. To add to the woes of the farmers there were allegations of contamination of drinking water and salinization of agriculture areas resulting in major legal problems which effectively crippled the industry (BOBP, 1998).

COASTAL ZONE MANAGEMENT FRAMEWORK

From the foregoing discussion it is evident that the coastal zone of India is under considerable pressure an it is inevitable that these pressures will continue to increase, intensifying the conflicts among different sectors, with passage of time. Hence, for proper appraisal of projects planned in the coastal zone, the government has issued several directives aimed at planned management of the marine coastal areas, though approach towards ICZM is yet to crystallize clearly.

The most important of the regulatory framework is the Coastal Regulatory Zone Notification promulgated in February 1991 with modifications from time to time. Under this notification, the coastal stretches of seas, bays, estuaries, creeks, rivers and backwaters which are influenced by tidal action (in the landward side) up to 500 m from the High Tide Line (HTL) and the land between the Low Tide Line (LTL) and the HTL are declared as CRZ. In case of rivers, creeks and backwaters, the distance should not be less than 100 m or the width of the water bodies whichever is less. Development activities within 100-500 m from the HTL (as applicable) are classified into 4 CRZ regions as follows : CRZ (I) (i): Areas that are ecologically sensitive and important, such as national parks, marine parks, sanctuaries, reserve forests, wild life habitats, mangroves and coral reefs; areas close to breeding and spawning grounds of fishes and other marine life; areas of outstanding natural beauty; historical heritage areas; regions rich in genetic diversity etc. CRZ (I) (ii): Areas between the LTL and the HTL. CRZ II: The areas that have already been developed up to or close to the shoreline. CRZ III: Areas that are relatively undisturbed an those which do not belong to CRZ I and CRZ II. CRZ (IV): Insular stretches of Andaman & Nicobar and Lakshadweep Islands and other Islands. Norms for development or construction activities in different catergories of CRZ are specified in the notification. The activities declared as prohibited within the CRZ include (1) setting up of new industries and expansion of existing industries, except those directly related to water front or directly needing foreshore facilities : (2) manufacture or handling or storage or disposal of hazardous substances except in certain port areas; (3) setting up and expansion of fish processing units; (4) setting up and expansion of units/mechanism for disposal of wastes, except facilities required for discharging treated effluents into the water course; (5) discharge of untreated wastes; (6) dumping of city or town waste; (7) dumping of ash or any other wastes from thermal power stations; (8) land reclamation, bunding or disturbing the natural course of sea water except in certain cases; (9) mining of sand, rock and other materials; (10) harvesting or drawl of ground water; (11) any construction activity between the LTL and HTL, except facilities for carrying treated effluents and wastewater discharges into the sea and facilities for carrying seawater for cooling purposes, oil gas and similar pipelines, and (12) dressing or altering of sand dunes, hills and natural features. The notification also lists the activities which are permissible but regulated. The government has set-up a National Coastal Management Authority and State Coastal Management Authorities; one in each state for ensuring effective implementation of the notification.

Guidelines for water quality for nearshore areas have been evolved for five designated best uses as follows:

Class SW-I : Salt pans, Shell fishing, mariculture and ecologically sensitive areas.

Class SW-II : Bathing, contact water sports and commercial fishing.

Class SW-III : Industrial cooling (non-contact) and aesthetics.

Class SW-IV : Harbour.

Class SW-V : Navigational and controlled waste disposal.

Setting up of an Aquaculture Authority (AA) in 1997 is another important decision of the Government with powers to protect the ecologically fragile coastal areas and deal with the situation created by the shrimp culture industry in coastal states. The AA has finalized its rules and procedures for applications for new shrimp farms and has delegated tasks to coastal states to process such applications and make their recommendations to the Authority. The AA has also laid down guidelines for the adoption of improved technology by shrimp farmers, especially on design aspects, stocking density, pelleted feed etc. The guidelines also specify permissible activities on the part of shrimp farmers, and suggest measures the farmers should take to protect the ecosystem.

National Oil Spill Disaster Contingency Plan (NOS-DCP) has been in operation since 1996 and stipulates the organizational and operational details to effectively combat a national oil spill contingency. The

plan covers such aspects as reporting, communication, alerting, assessment, operations, administration, finances, public relations and other arrangements with contiguous states. The plan also assigns the responsibility to various tasks to be taken by the relevant Government departments and agencies and identifies trained personnel, equipment and resources. Indian Coast Guard is the central coordinating authority and has the overall responsibility to ensure that appropriate response is made to an accident in the seas around India. The ports however are responsible for the response to accidents within the port limits but can request any additional assistance from the Indian Coast Guard. Likewise, oil and petroleum exploration and production agencies are fully responsible for instituting preventive, precautionary and other measures for monitoring, controlling and combating an oil spill in their area of operations. The entire maritime zone around the Indian Coastline is divided into three Coast Guard regions viz. West, East and A&N with Headquarters at Mumbai, Madras and Port Blair respectively (NOS-DCP 1999).

Another important directive is the Environmental impact Assessment Notification, 1994. This notification makes environmental clearance mandatory for certain projects on environmental impact assessment report and environment management plan. The Environment (Protection) Rules of 1986 have also further amended and called Environment (Protection) (Amendment) Rules 1996. The amended rules include a large number of industries whose effluent should meet the prescribed standards defined for each group of industries, before release to aquatic environment.

At least 15 ecologically sensitive marine areas have been declared as marine protected zones. These include segments of the Gulf of Kachchh, the Gulf of Mannar and the Lakshadweep and A&N Islands.

To protect the interest of artisanal fishermen many maritime State Governments have banned the mechanized vessels from operating up to a specific distance (5-10 km) from the shoreline. However, there is no proper surveillance mechanism to prevent encroachment by mechanized vessels in areas reserved fo artisanal crafts. Most fish groups undergo peak spawning during monsoon and to spare the spawning populations, several States along the West Coast ban operations of mechanized vessels for 30 to 145 d a year, though there are no such restrictions along the east coast (Devraj and Vivekanandan, 1999).

REFERENCES

Bahuguna, A., H. B. Chauhan and S. Nayak 1998. Coastal vegetation of Gujarat, Space Application Centre, Ahmedabad.

BOBP 1998. Bay of Bengal News, Bay of Bengal Programme, 11, 1 – 24.

Chouksey, M.K. 2002. Migration and Fate of Selected Contaminants from Anthropogenic Discharges in Coastal Marine Enviroment, (Ph. D. Thesis, submitted to the University of Mumbai), 241 pp.

CPCB 1996. Pollution potential of industries in coastal areas of India, Coastal Pollution Control Series : COPOCS/9/1995-96, Central Pollution Control Board, New Delhi, 1 – 83.

Devraj M and E. Vivekanandan 1999. Marine capture fisheries of India : Challenges and opportunities, Current Science, 76, 314 – 332.

GESAMP 2001. GESAMP(IMO/FAO/UNESCO-WMO/WHO/IAEA/UN/UNEP Joint Group of Experts on the Scientific Aspects of Marine Enviromental Protection). Protecting the oceans form land-based activities – Land-based sources and activities affecting the quality and uses of the marine, coastal and associated freshwater environment. Rep. Stud. GESAMP No. 71, 162 pp.

Nayak S.1998. Information Needs of Integrated Coastal Zone: Role of Remote Sensing and Geographic Information System, Space Application Centre, Ahmedabad.

NIO 1997. Marine environmental studies : Environmental quality along the North-West coast of India. National Institute of Oceanography, Mumbai.

NOS-DCP 1999. National Oil Spill Disaster Contingency Plan, Coast Guard Headquarters, New Delhi.

Pandav B., B.C. Chaudhury and K. Shankar 1998. The Olive Ridley sea turtle (*Lepidochelys olivacea*) in Orissa: An urgent call for an intensive and integrated conservation programme, Current Science, 75, 1323 – 1327.

Ram A 1999. Unpublished results.

Ravindran J., C. Raghukumar and S. Raghukumar 1999. Disease and stress induced mortality of corals in Indian reefs and observations on bleaching of corals in the Andamans, Current Science, 76: 233 – 237.

Sahu K.C. and U. Bhosale. 1991 Heavy metal pollution around the island city of Bombay, India. Part I : Quantification of heavy metal pollution of aquatic sediments and recogonition of environmental discriminants. Chemical Geology, 91 : 263 – 283.

Satyanarayana D., P.K. Panigrahy and S.D. Sahu 1994. Metal pollution in harbour and Coastal sediments of Visakhapatnam, east coast of India. Indian Journal of Marine Sciences., 23 : 52 – 54.

Zingde, M.D. 1999a Marine Polution – what are we heading for ? In : Ocean Science Trends and Future Directions (ed Somayajulu B L K), Indian National Science Academy, New Delhi, 229 – 246.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 8-11

SAVING THE SEAS: AN INDIAN EXPERIENCE

Sanjay V. Deshmukh
Director (Research), Rambhau Mhalgi Prabodhini
Keshav Srushti, Uttan, Bhayander (W), Thane 401106, Maharashtra.
Tel.: + 91-22-28450101/ 28450102/ 28450103; Fax: + 91-22-28450106
E-mail: drsanjaydeshmukh@vsnl.com, docsvd@yahoo.com
Website: www.rmponweb.org

INTRODUCTION

2002 marks the 10th anniversary of the United Nation's Conference on Environment and Development, which was held at Rio De Janeiro in 1992. While providing the operational content to the concept of sustainable development, it has been observed that "The state of the global environment has continued to deteriorate, and therefore, reversing the trend is more urgent than ever".

A majority of the developing countries are in the tropical zone, each with a rapidly expanding population. Demands for plant products as the sources of food, fuel, fibre, medicine, and construction materials are continuously increasing, thereby making increasingly difficult for the ever-increasing population, meet its demand. Human activities are leading to considerable disturbances in the normal processes of climate, as well as radiation regulation. Computer simulation as well as actual measurements indicates, that alterations in the mean temperatures, precipitation patterns as well as ocean levels and increased evidences of ultraviolet radiation are now, a distinct possibility. This is evident from the continuation of patterns of fossil-fuel energy consumption, deforestation, and unsustainable lifestyles of human beings.

Almost two thirds of the human population live in the 60-kilometre belt of land, adjacent to coasts. Currently, almost 33 per cent of the global population lives in cities. New York, Tokyo, London, Shaghai, Buenos Aires, Osaka, Los Angeles and Mumbai are the 8 out of 10 largest metropolitan areas, which border estuarine regions, and also account for some 65 million people. In several cases, these conurbations have all, but obliterated the original coastal wetlands that were in their pristine state, biologically productive areas, and hence were also important between land and sea.

The Oceans have given rise to all manners of unhappy conflicts, from disputes over resources, to depletion of marine species, whether seen as competition or as prey. Each individual or nation has viewed the ocean resources, as free for the taking; each has sought to out-do the rest. This self-defeating process is compounded, as the competition for a diminishing resource grows more severe, until all too often, the exploiters drive the resource to extinction.

MARINE ECOSYSTEMS

Marine ecosystems consist of Oceans and seas. Oceans cover 71% of the earth's surface and also provide 300 times the habitable space provided by land and fresh water bodies.

Oceans are just as diverse as the land. Even though they are inter-woven with human history, we tend to see them as barriers, as alien spaces. In reality however, Ocean ecosystems are continuous or rather, a world with landmasses as the true barriers. The uniqueness of Oceans is that the gradients of temperature and salinity separate them into a multiple series of discrete regions.

Despite having the abundant natural resources for sustenance, through ignorance and misunderstanding, man is placing Ocean's wealth in jeopardy. This has caused gross impoverishment of many fisheries, near-extinction for most large whales, widespread pollution of fish-rich waters, and degradation and disruption of many coastal habitats.

All these natural resources of the Oceans contribute to sustenance of human population, and its economic development. Over 80 per cent of the World's economy depends directly on trade that is conducted by transportation of cargo through waterways.

THE BALLAST WATER

The World would be a very different and much poorer place if there were no ships to carry huge amounts of cargo. Unfortunately, that is not all they carry. They also carry what is called as Ballast water in addition to it. Ballast is a mass of solid or liquid which is used for balancing the huge ships while on passage. It is necessary not only for the safe operations of ships, but is also used for their stability, trim, and list control.

Ships take-on Ballast water while on voyage, and in most cases, they discharge it somewhere else. Along with that vast quantity of water, go thousands of species of marine plants and animals, together with pathogens such as bacteria and viruses, which may carry diseases like typhoid and cholera.

Ships ballast to immerse their propellers, and achieve better propulsive power. They also ballast to control their draft for entering or departing port without grounding. Merchant ships and to some extent, naval ships also Ballast to compensate for, off-loading the material, or for the use of fuel and other consumables. In exceptional cases, such as collisions or some damage while running aground, ballasting is done.

Water is used as Ballast in the ships to ensure that, the propeller and bow are submerged to an acceptable depth. Large ships, particularly the bulk carriers, tend to spend 40 to 50 per cent of their sea-time in Ballast. Total water Ballast tonnage of various such ships can range from a few hundred, up to about 80,000 tonnes.

1. The Ballast Process

The Ballast process can be described in two ways. In a process called "Ballast operation", commercial ships load Ballast while off-loading cargo. Likewise, the same ships off-load their Ballast, when cargo, fuel or ore is taken aboard. This process is referred to as "De-ballasting". When ships do not have cargo aboard, they are "In-ballast ", that is, their Ballast tanks are generally full. In other words, quantities of Ballast are determined for maintenance of stability of the Ships with or without Cargo.

Ballasting is generally done with a Ballast pump while de-ballasting by gravity, so as to save the costs of operations. This process continues, until the tank level reaches the level of the sea. To prevent fouling, sea chests for Ballast pump suction, are generally located near the ship's keel. Commercial ships are equipped, with two Ballast pumps. The capacity of these pumps can be as high as 16,000 tonnes per hour. Full Ballasting of some ships can take, as long as 3 to 4 days.

It is estimated, that the amount of Ballast water transported by Ships is about ten billion tonnes every year, worldwide. Apart from the combination of sheer volume of water carried, the increasing frequency of voyages and speed of ships, due to opening up of new trade routes and Ports, the global shipping industry will be facing one of the greatest environmental challenges, this Century.

2. The Ballast Water Movement

On a global scale, the movement of Ballast water by ships appears to be the single largest vector, for marine non-indigenous species today. For example, a single ship can carry more than a hundred and fifty thousand metric tonnes of Ballast water, and a single port system, can receive thousands of ships per year, with foreign Ballast.

Most of the times, when water is ballasted from bays and estuaries, a diverse assemblage of organisms are carried with, and are often released, at the ports of call. In such situations, invasion by non-indigenous species in new regions is a common phenomenon.

INVASIVE SPECIES

Translocation of organisms through shipping is going on for ages. With the advent of faster shipping, changes in biodiversity as a kind of threat on environment is increasingly felt. Many organisms such as plants, animals and pathogens, which are transported to different environments through ballast water, do not always survive, because conditions of the place of transfer are very different. But when, those that do survive, and find themselves with no natural predators, their population can grow explosively, with devastating consequences, not least, for human beings and our economies.

For marine communities in which, non-indigenous species have been surveyed, the known number of such species, range from tens to hundreds of species, and includes all major taxonomic groups. There are some spectacular examples of the damage, which these unseen passengers can cause:

1. The zebra mussel, attaches itself in millions, to any flat surfaces such as jetties, and block water intakes to power stations. Over 5 billion dollars have been spent to eliminate this species, which invaded Canadian fresh waters from Europe through ballast water.

2. Annual anchovy catch in the Black Sea was reduced from 650 thousand tonnes to 15 thousand tonnes in less than a decade, by a species of jellyfish. This almost destroyed the local fishing community thereby, creating severe unemployment.

3. Toxic dinoflagellates, a microscopic form of algae, create red tides, when grow in large numbers. They cause paralytic shellfish poisoning and even death in humans, to the tune of about 50,000 every year thorough out the World.

It is estimated that in US alone, more that 300 species are known to have invaded its continental marine habitats. This could well be an underestimated figure, because many species may have simply not been examined in the inventories, and second, of those examined, the status of many species is difficult to resolve.

BALLAST WATER IN INDIAN CONTEXT

With over 7500 km long coastline, India has substantial volumes of shipping activities, through its 12 major ports. It is estimated, that in the Mumbai Port alone, an average of 5000 ships call each year, and receive approximately 2 million tones of Ballast water. Going by these estimates, there exists a possibility, of Indian coastlines falling prey, to the harmful marine bio-invasion, through ballast water.

Apart from the destructive effects of Ballast water on coastal ecosystems, it ultimately impacts the society, economy and human health, causing irrecoverable damages. Unfortunately, even the basic awareness about ballast water Hazard and its ill effects are poor or non-existent in India.

Despite this situation, during the last two decades, India has made a significant contribution, by playing an important role for the developing World, in moving the world environmental agenda forward, and linking it to the issues of hunger, poverty and population that are central to the global concerns.

It's high time that we all know about this harmful problem, spread awareness amongst every community, and take essential preventive and safety measures, to tackle the issue effectively.

In view of the global threat to Oceans by Ballast water, the International Maritime Organisation, i.e., IMO of London, is implementing in six countries, a scientific Project called Global Ballast water Management Programme. India is one of the six countries along with Brazil, China, Iran, South Africa and Ukraine, participating in the Globallast Programme. The United Nations Development Programme and Global Environment Facility financially support this unique Project.

The IMO has a Global Project Task Force, which is the highest Advisory Body of the Project. This comprises representatives of GEF, UNDP, IMO and the six participating countries. The IMO-based Project Coordination Unit (PCU) ensures effective Programme Co-ordination and Support such as, information communications, expert assistance, programme implementation, capacity building, as well as project evaluation and assessment.

1. GloBallast (India) Programme

Government of India has identified the Directorate General of Shipping as its Lead Agency for Globallast (India) Programme. Country Focal Point of the Project represents Lead Agency, and heads Country-level Project Task Force. The CPTF is represented by three National Level research Organisations, which are National Institute of Oceanography, Fisheries Survey of India and Rambhau Mhalgi Prabodhini.

Besides these, representatives of the Mumbai Port Trust, Jawaharlal Nehru Port Trust, Shipping Corporation of India, Maritime Training Institute and the Lalbahadur Shastri Institute of Advance Maritime Studies and Research, are also members of the CPTF. They provide technical guidance to the Project.

1.1. The Work

The pilot sites chosen for research in India are the Port of Mumbai and Jawaharlal Nehru Port, both located in the vicinity of the City of Mumbai. Selection of sites in India was based on the assumption that since these Ports are handling larger cargo as compared to other Ports in India, with large ships departing and arriving, the biological profile of Ballast water would be better known.

National Institute of Oceanography (NIO) and Fisheries Survey of India (FSI) have been conducting Port Baseline Surveys at both the demonstration sites. This survey is fundamental to the Programme, and also vital for assessing existing natural conditions of the sites. Based on the available biological resources of the sites, it would be possible to find out introduced species in the region of study. A standard Port Survey Protocol provided by the IMO has been followed for this work.

A team of physical, chemical and biological oceanographers from NIO is working on the Port Baseline Survey of the Mumbai region. Besides this work, NIO is also involved in using test locations as models for studying Ballast Water impact. A software-based programme is used to study the dispersion of, and the trajectory of the particles coming from the Ballast Water. Dynamic conditions of Oceans are simulated within a small area and a possible impact of dispersal with respect to its spread as well as washing off from the estuarine region can be understood.

The primary responsibility of Fisheries Survey of India in the Globallast Programme is to conduct exploratory surveys on inshore coastal waters and to some extent, those of offshore sea around Mumbai region. Rambhau Mhalgi Prabodhini has prepared detailed maps (1:50,000 scale) based on the Satellite imageries. The maps highlight various land use patterns of the Mumbai Port as well as Jawaharlal Nehru Port and their surrounding waters and inland regions. The data generated would be useful for development of risk assessment protocol for the region.

Since there is hardly any historical record of the fish fauna of Mumbai Port region, the role of FSI in documenting the fish and other macro-faunal elements in the region of study, becomes all the more relevant.

Rambhau Mhalgi Prabodhini, in co-ordination with the Country Focal Point, has initiated a Nation-wide campaign, to generate greater awareness on the subject. This involves:

- Media based awareness campaigns, through preparation of films, documentaries, presentation material, and fillers for television and theatres.

- Grass roots level activities to reach coastal villages, particularly the schools, are also initiated. Marine Eco-clubs are established in 60 schools of Maharashtra and Goa. By doing this, Prabodhini has ensured a direct involvement of over 3000 school children in spreading the

message of environmental conservation, particularly the implication of ballast water on coastal environment.

- Prabodhini has also conducted training-cum-orientation programmes for School Teachers, Peoples' representatives, Port authorities, and Professionals from Shipping Industry, so far. They have received tremendous response. It is hoped that such activities would provide to the general public, a better understanding of the subject.

The Ministry of Shipping of the Government of India is also committed to the successful execution of the Globallast Programme in India. There has been a frequent exchange of technical data as well as project related information within the Country Focal Point and the Members of CPTF. The Union Minister of Shipping is one of the active participants of this Programme. Important findings of the Project are communicated to Media from time to time, through appropriate authorities.

FUTURE RESEARCH QUESTIONS

The research on Ballast Water in India has highlighted a few key areas for which international standards could be developed. They are as follows:

- **While standardising the sampling methods** for water, benthic community and sediment, the means to calculate the ballast will have to be standardised too.

- **Improved understanding of the complexities involved in sampling design** is another key area. Diversity of ship designs, variety of ballast tanks and their configuration as well as types of ballast discharge patterns can lead to misinterpretation of sampling data. Hence, verification of discharge activity is necessary, immediately after collection of water and sediment samples.

- **Research on Ballast water biology** and the diversity of ballast environment is also an important issue. Transportation of organisms over different spatial and temporal conditions of diverse aquatic environment will be useful. Similarly, a part of "larger tool-kit", research could be directed towards providing long-term control and management options, rather than looking at developing short-term control technologies.

- **Quantitative Risk Assessment** can help in identification of ballast and invasion processes, as well as the risk associated with it. This technique is being applied on a pilot scale in India and other participating countries.

- **It is necessary to develop a global expertise** through networking systematic botanists, ecologists, molecular biologists and taxonomists. Such inter-disciplinary Team of Experts can meaningfully contribute to understanding generic, species and intra-specific variation among various organisms, that are either indigenous or are carried away through Ballast water, and are eventually named as invasive species.

- **Compliance Monitoring and Enforcement (CME)** is one of the key components of the Globallast Programme. The adoption of international Convention will be done in late 2003. Based on the existing ballast water guidelines developed by IMO, India is developing a set of measures for assembly in a CME System. This will help to determine the extent of compliance with both the forthcoming Convention and Country-specific Ballast Water Management requirements.

- **Model systems such as education programmes** could be incorporated into broader public and industry, which could provide a better understanding of issues and challenges of Ballast water.

- **Development of an international cooperation** on the subject is extremely important. Formulation of joint strategies by bringing together, working groups of various intergovernmental agencies and discuss mutual interests in the subject of Ballast water is need of the hour.

WHERE DO WE GO FROM HERE?

The Ocean crisis includes serious industrial and oil pollution, the dumping of nuclear and toxic wastes, the seabed disturbance caused by deep-sea mining, and the destruction of rich coastal ecosystems – from salt marsh to mangroves and coral reef. Eventually, with new national and international laws, many such activities will be branded as ecological crimes, but the legislative machinery often grinds exceedingly slowly. Sometimes, non-violent direct action by concerned groups is the only way to focus public attention on an issue such as this, and thereby accelerate the political process.

Our efforts through Ballast Water Management through actions, unfortunately, often speak louder than words. But the issues and warning systems that are highlighted here, explain why our attention to such global questions is so urgent. We can no longer use the World Ocean as a dustbin. We must view it as a living ecosystem, a vital and integral part of our planet's workings.

2002 marks the 10th anniversary of the United Nation's Conference on Environment and Development, which was held at Rio De Janeiro in 1992. While providing the operational content to the concept of sustainable development, it has been observed that "The state of the global environment has continued to deteriorate, and therefore, reversing the trend is more urgent than ever".

It is hoped that the International Maritime Organisation's Globallast Programme being implemented in India by National Institute of Oceanography, Fisheries Survey of India and Rambhau Mhalgi Prabodhini would prove a critical testing ground for our emerging planet management skills.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 12-16

STATUS OF OIL POLLUTION ALONG THE INDIAN COAST

A. N. Kadam[1] and M. K. Chouksey[2]
[1]Regional Center, National Institute of Oceanography Mumbai. 400 053.
[2]Central Institute of Fisheries Education (Deemed University)
Versova, Mumbai. 400 061.

The Arabian Sea and the Bay of Bengal have been estimated to annually receive around $5x10^6$ and $4x\ 10^5$ t/y petroleum respectively from routine discharges from oil tankers and other ships plying the shipping lanes originating from the Middle East (Hinrichsen, 1990). This estimate appears to be exaggerated and needs re-examination since, the total input of oil to the World oceans is considered to be $2.145x10^6$ t/y (Clark, 1992). Consequently, tar balls and oily residue are a common sight on many beaches of countries including India, bordering the Indian Ocean. Further, damage to coral reefs of Andaman and Nicobar Island due to coating with oil residues has been reported (Sengupta *et. al.*, 1995). With the consumption of petroleum products in India increasing from $5.5x10^7$ t during 1990-91 to $8.8x10^7$ t during 1997-98 and domestic production remaining nearly stagnant at around $3.3x10^7$ t/y, it has become inevitable to increasingly import crude oil and its products thereby exposing the coastal segments to oil pollution (Zingde, 1999). Moreover, accelerated efforts in offshore oil prospecting in several areas of the continental shelf of India further enhance the vulnerability of the coastal zone to oil induced degradation.

Although tanker accidents and other accidental as well as intentional discharges of oil at sea are highly visible, the municipal and industrial wastewaters are considered as prominent local sources of hydrocarbons contributing to the contamination of the sea (NRC, 1985). Their entry to the sea is much less conspicuous because they are released in small concentrations though more or less continuously. In contrast with dramatic short-term effects of episodic large-scale releases, the impact of such continuous contamination of oil on biota is chronic.

CONCENTRATIONS IN WATER

Several investigations have been conducted in the seas around India to evaluate the levels of petroleum hydrocarbons (PHc) in water. The available information is summarized in Table 1:

Table 1

Location	PHc (µg/l)	Standard	Reference
West coast of India	120 – 2440 0.6 – 41.6	Heavy furnace oil Arabian crude	Sengupta *et. al*., 1978 Fondekar and Alagarsamy, 1984
Central West coast of India	16.8 - 42.8	Saudi Arabian Crude	Fondekar *et. al*., 1980
Northern Indian Ocean	0.6 – 26.5	Saudi Arabian Crude	Sengupta *et. al*., 1980
Bay of Bengal	0.8 – 5.2	Saudi Arabian Crude	Sengupta *et. al*., 1980
Andaman Sea	28 – 83	Arabian crude	Topgi *et. al*., 1981
Bay of Bengal	1.1 – 67.7	Arabian crude	Topgi *et. al*., 1982
Bombay High, Mumbai	0.01 (av)	Chrysene	Ram and Kadam, 1991a
Ports along the West Coast of India	7.5 – 87.7	Saudi Arabian Mix crude	Kadam and Bhangale, 1992
Arabian Sea along the Indian Coast	1.8 – 8.7	Saudi Arabian Crude	Sengupta *et. al*., 1993
Mumbai coast, intertidal	0 – 93.5	Saudi Arabian Mix crude	Ingole *et. al*., 1995
Great Channel, Andaman	0.32 – 1.85	Saudi Arabian Crude	Sengupta *et. al*., 1995
Kakinada Bay	1.6 – 14.8	-	Sharma *et. al*., 1996
Visakhapatnam Harbour	11.5 – 123.8	-	
Visakhapatnam Harbour	108 (av)	-	Mohan and Prakash, 1998
Harbour area of Chennai	11 – 139	Arabian crude	Selvaraj *et. al*., 1999
South Maharashtra coast	1.7 – 3.7	Saudi Arabian Mix crude	Chouksey 2002
Around Mumbai	3.9 – 39.2	Saudi Arabian Mix crude	Chouksey 2002

Sengupta *et. al*., (1978) reported very high and variable values of PHc along the oil tanker route and the Bombay High region.. Exceptionally high levels of oil and grease (3.8 – 20.0 µg/l) have been recorded in the Dock waters of Mumbai Port (NEERI, 1985), while, Kadam and Bhangale (1992) found much lower levels of PHc (7.5 – 87.7 µg/l) in selected ports including the Mumbai Port, along the West coast of India. The high PHc concentration of 3348 µg/l was recorded in the coastal waters of Murud, near Mumbai, after a major oil spill in the Bombay High area that, under the prevailing tidal currents and winds, preferentially drifted towards the Murud coast (NIO, 1993). Sengupta *et. al.,* (1995) reported levels of 0.32 – 1.85 µg/l in the surface water of the Great Channel (Andaman Sea), 15 d after the disaster of the Danish Tanker VLCC Maersk Navigator.

ACCUMULATION IN SEDIMENT

The table 2 complies the levels of PHc in marine sediments at some locations along the Indian coast

The above table indicates wide variations in the PHc levels in the sediment of the marine area of India with high level of contamination in the Cochin estuary (Nair *et. al*., 1995) perhaps due to large-scale port activities. High PHc content of the Elliot Beach was due to an oil spill that affected the area on 12 November 1995 (Selvaraj *et. al*., 1999). Rokade *et. al*., (1989) reported PHc level as un-saponifiable residue of 76 – 336 and 41 – 301 µg/g (wet wt) in Thane Creek and Bombay Harbour respectively.

BIOACCUMULATION

Except for a few reports given in the table 3, not much information is available on the levels of PHc in marine organisms along the Indian coast :

Table 2

Location	PHc (mg/g)	Standard	Reference
Central West coast of India	4.8 – 9.4 (dry wt)	Saudi Arabian Crude	Fondekar *et. al*., 1980
Arabian Sea	4.4 – 12.4	-	Fondekar 1987
along the Indian coast	6 – 5.8 (dry wt)	Saudi Arabian Crude	Sengupta *et. al*., 1993
Off West Coast of India	0.4 – 0.2	Chrysene	Ram and Kadam (1991a and b)
Mumbai High	0.01– 0.09 (wet wt)	Chrysene	Ram and Kadam (1991a and b)
Mumbai beaches	2.9 – 10.3 (wet wt)	Saudi Arabian Mix crude	Ingole *et al*., 1995
Cochin estuary	249 – 570 (dry wt)	Bombay High crude	Nair *et. al*., 1995
Elliot Beach, Chennai	4 – 11,059	Saudi Arabian Mix crude	Selvaraj *et. al*., 1999
Off Bassein	2.2 (av; wet wt)	Saudi Arabian Mix crude	NIO 1999
Off Mumbai	1.2 (av; wet wt)	Saudi Arabian Mix crude	NIO 1999
Gujarat Coast	< 0.5 (av; wet wt)	Saudi Arabian Mix crude	NIO 1999
Gujarat Coast	ND – 20.7 (dry wt)	Saudi Arabian Mix crude	Chouksey 2002
Maharashtra coast	0.9 – 42.8 (dry wt)	Saudi Arabian Mix crude	Chouksey 2002

Table 3

Location	Species	PHc (mg/g)	Standard	Reference
Central-west coast of India	Plankton	19.5 – 83.3 (dry wt)	Saudi Arabian oil	Fondekar *et. al*., 1980
Arabian Sea along Indian coast	Zooplankton	10.0 – 107.5 4.5 – 144.7 (dry wt)	- -	Fondekar 1987 Sengupta *et. al*., 1993
Mumbai beaches	Mollusks	2.7 – 406 (dry wt)	Chrysene	Fernandes 1991
Northwest coast of India	Johnius glaucus	0.8 – 6.1 (wet wt)		
	Coilia dussumieri	1.0 – 9.6	Chrysene Chrysene	Mehta *et. al.* 1994 Mehta *et. al.* 1994
Visakhapatnam	Bivalve	186	- 1998	Mohan and Prakash
Around Mumbai Mix crude	Shellfish	1.8 – 10.8 (wet wt)	Saudi Arabian	Chouksey 2002

These results indicate that the levels vary considerably and no trends are discernible.

DISTRIBUTION OF TAR BALLS

Oil residue in the form of tar balls is commonly observed along the Indian beaches. These were first reported by Nair *et. al*., (1972). Since then many studies have been conducted on deposits of oil residues on the beaches around India (Dwivedi and Parulekar, 1974; Dhargalkar *et. al*., 1977; Oostdam, 1984; Kadam, 1988; Ramamurthy, 1991; Sengupta *et. al*., 1995; Kadam and Rokade, 1996). A total of 1000 and 750 t of tar ball deposition was estimated on the West coast of India during 1975 and 1976 respectively (Dhargalkar *et. al*., 1977; GESAMP, 1993; Glasby and Roonwal, 1995). Ramamurthy (1991) suggested that about 6,000 to 7,000 t of tar residues were generated annually along the West coast of India. The available information on tar deposition along coasts of India is compiled in table 4:

Dwivedi and Parulekar (1974) observed that the tar deposition on beaches varied considerably with highest deposition of 4,480g/m^2 on the beach at Sinquerim, Goa in pre-monsoon season. Density of deposition of 247.1 and 28.5 g/m^2 on High Tide Line (HTL) and Mid Tide Line (MTL) respectively has been reported along the Ratnagiri coast while, the density was high (759 g/m^2) at HTL at Deogarh beach during July 1972. Tar deposition was higher along the west coast than the east coast and the tar deposits were more during monsoon and pre-monsoon seasons. However, Dhargalkar *et. al*., (1977) failed to notice any deposition along the Ratnagiri beach during 1975 and 1976. Reddy and Singbal (1973) collected some tar like materials from selected beaches along the East and the West coasts of India and analysed them for water, sand, oil, total S, asphaltene, waxes, V and Ni. Based on the results these workers inferred that the source material of tar they sampled was Aghajari crude oil. Kadam (1988) investigated tar pellets from the Veraval beach (Gujarat) during 1984 to identify suspected source on the basis of IR spectra, GLC fingerprint patterns and wax and asphaltene contents.

Sengupta *et. al*., (1995) assessed the fate and immediate as well as long term impacts of oil spilled after an accident of Maersk Navigator (January 1993), on marine environment in the Great Channel (South Andaman Sea). Kadam and Rokade (1996) collected tar residue from Mumbai beach after collision of a cargo vessel “Puppy-P” in July 1989 and based on the ratios of UV absorbances and IR transmittances as well as their GLC fingerprint patterns concluded that the spill from the vessel was the probable source of the beach residue.

REFERENCES

Chouksey, M. K. 2002. Migration and Fate of Selected Contaminants from Anthropogenic Discharges in Coastal Marine Environment. Ph. D. Thesis. University of Mumbai, Mumbai.

Clark, R. B. 1992. Marine Pollution (3rd ed.), Clarendon Press Oxford. 215 pp.

Dhargalkar, V. K., T. W. Kureishy and M. V. Bhandare, 1977. Deposition of Tar Balls (Oil Residue) on Beaches Along the West Coast of India. Mahasagar, Bull. Natn. Inst. Oceanogr., 10, 103 – 108.

Dwivedi, S. N. and A. H. Parulekar 1974. Oil Pollution Along the Indian Coastline. Spec. Publ. U. S. Natl. Bur. Stand., 409, 101 – 105.

Dwivedi, S. N., B. N. Desai, A. H. Parulekar, V. Josanto. and M.D. George, 1974. Oil Pollution along Gujarat Coast and its Possible Source, Mahasagar Bull. Natn. Inst. Oceanogr., 7, 91 – 94.

Table 4

Location	PHc (g/m^2)	Reference
Goa beaches	3.2 – 375.0	Nair *et. al*., 1972
East coast of India	5.9 – 138.7	Dwivedi and Parulekar 1974
West coast of India	1.9 – 4480.0	Dwivedi and Parulekar 1974
West coast of India	0.5 – 32.8	Oostdam 1984
West coast of India	0.03 – 3.5 (pelagic tar)	Sengupta 1991
Gujarat coast	0.7 – 2375.0	Dwivedi *et. al*., 1974
Arabian sea along the Indian coast	0 – 0.005 (floating tar)	Sengupta *et. al*., 1993
Andaman Sea	Nil	Sengupta *et. al*., 1995
Central West coast of India	0.01 – 3.5	NIO 1996
Mandwa beach, near Mumbai	1.2 – 2230	Chouksey 2002
Uran beach, near Mumbai	22.5 – 1187.5	Chouksey 2002

Fernandes, L. J. L., 1991. Impact of Marine Pollution on Selected Intertidal Gastropods of Bombay. Ph. D. Thesis, University of Mumbai, Mumbai.

Fondekar, S. P. and R. Alagarsamy 1984. Petroleum Hydrocarbon Contamination Along Oil Tanker Routes in the Arabian Sea. Indian J. Mar. Sci., 13, 181 – 183.

Fondekar, S. P., 1987. Studies o Petroleum Hydrocarbons in the Marine Environment Around India. Ph. D. Thesis, University of Mumbai, Mumbai.

Fondekar, S. P., R S. Topgi. and R.J. Noronha 1980. Distribution of petroleum Hydrocarbons in Goa Coastal Waters. Indian J. Mar. Sci., 9, 286 – 288.

GESAMP, 1993. Impact of oil and related Chemicals and wastes on the Marine Environment, Rep. Stud. GESAMP, 50, 180 pp.

Glasby, G. P. and G.S. Roonwal 1995. Marine Pollution in India; An Emerging Problem. Curr. Sci. 68, 495 – 497.

Hinrichsen, D., 1990. Our Common Seas. Coasts in Crisis. Earthscan Publications London, 184 pp.

Ingole, S., A,N. Kadam, M.S. Mayadeo. and P.M. Dhadke 1995. Petroleum Hydrocarbons in Intertidal Ecosystem Along the Bombay Coast. Indian J. Mar. Sci., 24, 116 – 118.

Kadam, A. N. and V.P. Bhangale 1992. Petroleum of the 2nd International Conference on Environmental Planning and Management (ICOEM 92). Pp 43 – 47.

Kadam ,A. N. and M.A. Rokade 1996. Source Identification of a Tar Residue from Mumbai Beach. Indian. J. Mar. Sci., 25, 379 – 380.

Kadam, A. N., 1988. Some Studies on Tar Pellets at Veraval Coast (Gujarat). Mahasagar, Bull. Natn. Inst. Oceanogr., 21, 173 – 175.

Mehta, P., A.N. Kadam, S.N. Gajbhiye and B.N. Desai 1994. Petroleum Hydrocarbon Concentration in Selected Species of Fish and Prawn from North West Coast of India. Indian J. Mar. Sci., 23, 123 – 125.

Mohan, P. C. and R.R. Prakash. 1998. Concentration of Petroleum Hydrocarbons in Bivalve Mytilopsis sallei and in the Harbour Waters of Visakhapatnam, East Coast of India. Indian J. Mar. Sci., 27, 496 – 498.

Nair, S. A., V.P. Devassy, S.N. Dwivedi. and R.A. Selvakumar. 1972. Preliminary Observations on Tar like Material Observed on Some Beaches. Curr. Sci., 41, 766 – 767.

Nair, T. V., J. Chaclo and K.N. Chandramohan, 1995. Distribution of Petroleum Hydrocarbons in Sediments of the Cochin Estuary South West Coast of India. Indian J. Mar. Sci., 24, 240 – 242.

NEERI, 1985. Environmental Impact Study for Bombay Port Trust. National Environmental Engineering Research Institute, Bombay.

NIO, 1993. A Report on Assessment of Oil Spill of 17th May 1993 on Coastal Environment of Murud. National Institute of Oceanography, Mumbai.

NIO, 1996. Marine Environmental Impact Assessement of Coastal Waters off Thal in Relation to Release of Waste Water from RCF. National Institute of Oceanography, Mumbai.

NIO, 1999. Marine Environmental Studies: Environmental Quality Along the North-West Coast of India. (COMPS). National Institute of Oceanography, Mumbai.

NRC, 1985. Oil in the Sea : Inputs, Fates and Effects. National Research Council. Natl. Academy Press, Washington, DC. 601 pp.

Oostdam, B. L., 1984. Tar pollution of Beaches in the Indian Ocean, the South China Sea and the South Pacific Ocean. Mar. Pollut. Bull., 15, 267 – 270.

Ram, A. and A.N. Kadam, 1991a. Petroleum Hydrocarbon Concentration in Surface Sediments in Continental Shelf Region Along the Central West Coast of India. Asian Environ., 13, 3 – 7.

Ram, A. and A.N. Kadam, 1991b. Petroleum Hydrocarbon Concentration in Surface Sediments Along the North West Coast of India. Indian J. Mar. Sci., 20, 223 – 225.

Ramamurthy, V. D., 1991. Effects of Oil Pollution on Bio Ecology and Fisheries on Certain Enclosed Coastal Regions of Arabian Sea. Mar. Pollut. Bull., 23, 239 – 245.

Reddy. C. V. C. and S.V.S. Singbal, 1973. Chemical Characteristics of Tar-like Materials found on the Beaches Along the East and West Coasts of India in Relation to Their source of Origin. Curr. Sci., 42, 709 – 711.

Rokade, M. A., N.B. Bhosale and A.N. Kadam 1989. Extractable Organics in surface Sediments from Thane Creek and Bombay Harbour. Indian J. Mar. Sci., 18, 131 – 133.

Selvaraj, K., M.P. Jonathan, V.R. Mohan, G.S. Thangaraj, M. Pugalendhi and B. Jayaraman, 1999. Observations of Petroleum Hydrocarbons and some water quality parameters during oil spill, Near Madras Harbour. Indian J. Mar. Sci., 28, 245 – 248.

Sengupta, R. 1991. Gulf Oil Spill and India. Mar. Pollut. Bull., 9, 423 – 424.

Sengupta, R., S.P. Fondekar and R. Alagsamy R., 1993. State of Pollution in the Northern Arabian Sea After the 1991 Gulf Oil Spill. Mar. Pollut. Bull., 27, 85 – 91.

Sengupta, R., S.P. Fondekar and R.S. Topgi, 1978. A Survey of Petroleum Hydrocarbons Concentrations in the Shelf Regions and Adjacent Waters of the West Coast of India. Indian. J. Mar. Sci., 7, 12 – 14.

Sengupta, R., S.P. Fondekar, M.S. Shailaja. and V.N. Sankaranarayanan. 1995. Maersk Navigator Oil Spill in the Great Channel (Andaman Sea) in January 1993 and its Environmental Impact. Spill. Sci. Technol. Bull., 2, 113 – 119.

Sengupta, R., S.Z. Qasim, S.P. Fondekar. and R.S. Topgi. 1980. Dissolved Petroleum Hydrocarbons in Some Regions of the Northern Indian Ocean. Mar. Pollut. Bull., 11, 65 – 68.

Sharma, V. V., S.J.D. Varaprasad, G.V.M. Gupta. and U. Sudhakar, 1996. Petroleum Hydrocarbons and Trace Metals in Visakhapatnam Harbour ad Kakinada Bay, East Coast of India, Indian J. Mar. Sci., 25, 148 – 150.

Topgi, R. S., R.J. Noronha, and S.P. Fondekar, 1981. Dissolved Petroleum Hydrocarbons in the Andaman Sea. Indian J. Mar. Sci., 10, 241 – 242.

Topgi, R. S., R.J. Noronha, S.P. Fondekar and R. Sengupta, 1982. Dissolved Petroleum Hydrocarbons Along the Oil Tanker Route in the Southern Bay of Bengal. Indian J. Mar. Sci., 11, 175 – 179.

Zingde, M. D., 1999. Health of the Coastal Marine Environment and Fisheries Development in India. In : S. A. H. Abidi, N. K. Thakur, R. S. Biradar and L. Shenoy (eds), Proceedings of the National Seminar on Vision India Fisheries of 21st Century. Central Institute of Fisheries Education, Mumbai, pp 276 – 287.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 17-18

INSECT FAUNA OF MANGROVE ECOSYSTEM – PLANT GALLS FORMED BY INSECTS

P.V. Joshi and R.N. Sharma *
Prof. In Zoology (Retd.) Pune Univ. Pune.
* Scientist, Zoological Survey of India, Pune.

Primary qualitative survey of insects associated with mangrove was done in Vikhroli, Mankhurd, Kanjurmarg, Vitava, Goregaon area.

Attempt was also done to collect plant galls on mangroves.

In general insect from ten orders were collected

Sr. No.	Order	Insects
1.	Odonata	Dragonflies
2.	Orthoptera	Grass hoppers, Locusta, Mole crickets
3.	Dictyoptera	Cockroaches
4.	Mantoidea	Mantis
5.	Homoptera	Frog hoppers, Cicada, Coccids, Pseudococcids
6.	Heteroptera	Bugs
7.	Neuroptera	Lace wing fly
8.	Coleoptera	Beetles (7 families, few of them were stem borers)
9.	Lepidoptera	15 species of Butterflies
10.	Hymoptera	Ants and wasps, (species of *Ropalidia* and *Crematogaster*)

In general the habitat is rich for insect fauna.

Plant Galls

These are abnormal structures like tumors. They are induced by plant itself or animal parasites. The ones induced by plant parasites are called as `Phytocecidia', whereas animal induced galls are known as `Zoocecidia'. The animals that induce galls are called 'Cecidozoa'.

As said galls are structural abnormalities caused by hypertrophy (overgrowth) and hyperplasy (excessive cell division) of tissues in response to the feeding activity of a parasite, cecidozoan can be considered as best plant taxonomists. They show high degree of specificity to host plant.

Approximately 15000 gall inducing insects have been recorded from the world. Following orders of insects are known to be involved in induction of gall formation: Thysanoptera (Thrips), Homoptera (Psyllids, aphids and coccids), Coleoptera (Curculionids), Hymenoptera (Cynipids, chalcids), Lepidoptera (moths) and Diptera (Cecidomyiids-gall midges), Tephritids (fruitflies) and Agromyizids (leaf miner flies)

Plant galls are comparatively rare in mangroves. However, *Avicennia marina* is found to be highly susceptible to gall formation.

During the survey conducted during 1999 – 2000 at Vikhroli region, it was observed that *Avicennia marina* is the dominant mangrove species while *Salvadora persica* is the dominant mangrove associate of the region. Both plants are subjected to gall formation. Besides, *Sonneratia apetala* was also found to be infested with gall forming Microlepidoptera (moth). It was observed that the shape and size of the gall varies. The detailed description is as follows:

Galls observed on *Avicennia marina*: Caused by unknown *Cecidomyiid* (Diptera)



Disc shaped, glabrous, smooth, 2–10 galls occur per leaf Size of the gall varied from 4-5 mm in diameter galls on the petiole were also recorded.

Stem galls : caused by unknown Hymenoptera



Irregularly globose or subglobose, verrucose Gall cavity multichambered Single larva inside each chamber 1-3 galls appear per tender branch Size of the gall varies from 10-20 mm

Galls observed on *Sonneratia apetala* : Caused by unidentified Microlepidoptera (moth)



Leaf fold galls: Mainly hypophylous, rarely epiphyllous. Occur along the leaf Margins. Apical portion of leaf margin gets folded downward. Galls solitary, simple, solid, glabrous (smooth), indehiscent and persistent. Gall cavity is unilocular Single gall per leaf

Deserted galls were found to be occupied by other insects (successor) like small beetles or ants.

Gall size varies

Leaf roll on *Sonneratia apetala* seems to be unrecorded.

Galls observed on *Salvadora persica* Linn.





A) Galls caused by a mite *Aceria* sp. (Acarina: Eriophyidae): Eepi-phyllus, globose, subglobose or sometimes irregular

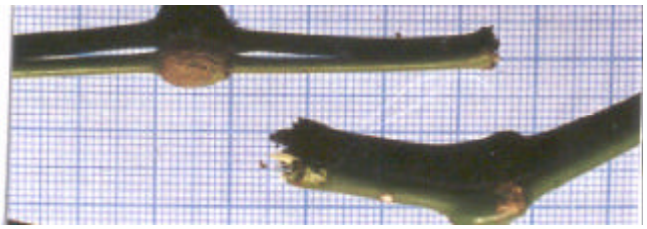
B) Caused by unknown insect: Leaf gall mostly epi-phyllous sometimes epi-hypophyllous, globose pouch gall.

C) Gall caused by a gall midge *Thomasiniana salvadorae* Rao. A single gall on the midrib is observed.

Stem galls – subglobose, ovoid or fusiform, some times cylindrical and moniliform

Causes swelling to the tender branches

Single branch may harbor 5-7 separate galls.



ACKNOWLEDGEMENT

The authors wish to thank Mr. V.M. Crishna, Dr. Tetali and Soonabai Godrej Foundation – Mumbai.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 19-20

IMPACT OF WASTEWATER ON PHYTOPLANKTON

M. Jiyalal Ram Jaiswar
National Institute of Oceanography,
Regional Centre, Mumbai-400 053

Phytoplankton : All the drifting organisms which cannot swim against the winds and currents are called plankton. The plant components of plankton are known as phytoplankton. In other words the suspended particulate matter in the sea consists of living organisms called plankton and dead particles commonly referred to as detritus.

Importance : Phytoplankton being autotrophs fix solar energy by photosynthesis using carbon dioxide, nutrients and trace metals. They are the basic component of food chain. They also play a major role in generation of petroleum hydrocarbons. Most phytoplankton have density greater than that of water. The higher density is in part caused by skeletons which consist of silica, calcium, carbonate and cellulose. Phytoplankters are of great ecological significance because they comprise the major portion of primary producers. Phytoplankton may be used to identify "natural regions" of the oceans. These regions can be characterized by typical species. Phytoplankters are good indicator of water pollution. Thus they play a major role in pollution monitoring studies. Phytoplankters are the basic aspects for environmental impact assessment studies.

Methods of Analyses : The estimation of primary productivity, phytoplankton pigments and phytoplankton population were carried out as follows:

a) Primary productivity : A known amount of radioactivity ($^{14}CO_3^{2-}$) was injected to the seawater sample in light and dark bottle. The sample was filtered through a 0.45 µ Millipore membrane filter paper after incubation. The radioactivity of the phytoplankton cells retained on the filter paper was assayed using a LKB1214 Rack beta Liquid Scintillation Counter by following the methods of Vollen Weider (1969).

b) Phytoplankton Pigment : A known volume of water filtered through 0.45µ Millipore membrane filter paper and the pigments retained on the filter paper were extracted in 10ml of 90% acetone. The absorbance (OD) was measured at 750 and 665 nm before and after treatment with 0.1N HCl. The further estimation of chlorophyll *a* and phaeophytin was carried out by following the Standard Methods (APHA, 1992).

c) Phytoplankton population : A known volume of water sample was preserved in Lugol's solution for the quantitative and qualitative estimation of phytoplankton. Enumeration and identification of phytoplankton were done using a compound microscope and Sedgwick – Rafter slide as per the Standard Methods (APHA, 1992).

Studies : A number of studies on phytoplankton were conducted by NIO at Thane Creek, Ulhas River estuary, Versova Creek and Mahim Creek under Coastal Ocean Monitoring and Prediction System (COMAPS) programme during the period from 1990 to 2000. The present information is in general and reveals the impact of wastewater on phytoplankton.

Observation : The polluted locations were characterized by significantly enhanced phytoplankton population and poor algal species diversity. At these locations the ratios of chlorophyll *a* / phaeophytin were markedly low indicating an unhealthy conditions of phytoplankton cells. Primary productivity followed the same trend of distribution as phytoplankton population under the normal weather condition. Similar results were recorded at Thane Creek, Ulhas River estuary and Mahim Creek.

The values of phytoplankton population, pigments and primary productivity were significantly higher at these polluted locations than those of offshore waters which were associated with markedly depleted dissolved oxygen and enhanced nutrient level observed particularly during low tide. However declined phytoplankton population were observed at highly polluted location like Versova Creek.

Skeletonema costatum, Nitzschia closterium, Oscillatoria chlorina, Spirulina major, Thalassiosira subtilis, Chaetoceros decipiens, Melosira sulcata, Asterionella japonica were the dominant species in polluted estuarine system where as offshore water sustained *Thalassiothrix longissima, T. fraunfieldii, Coscinodiscus excentricus, C. marginatus, C. lineatus, C. nitidus, Chaetoceros simplex, C. socialis, Biddulphia sinensis, B. mobilensis, Pleurosigma directum, P. elongatum, P. normanii, Surirella fastuosa, Gyrosigma balticum, Gyrosigma sp, Trichodesmium thiebauti, Rhizosolenia hebetata, R . robusta, R . fragilissima, R. stolterfolthii, R. delicatula, Corethron coriophylum, Guinardia flaccida, Ceratium hirrundinella, Peridinium sp* as the major species.

Results : A few examples of the overall average values of different parameters are presented below

Location	Parameters				
	Primary productivity (mg C/m^3/h)	Phytopigments		Phytopopulation	Species Diversity
		Chlorophyll a (mg/m^3)	Phaeophytin (mg/m^3)	Cell Count (no. x 10^3 / l)	
Creek waters	3.3	13.45	3.6	1398.1	0.002
Offshore waters	0.9	2.0	1.4	80.0	0.704

The prominent features observed on the basis of results are summarized below.

Sr no.	Location	Phytoplankton Status
1	Polluted enriched water	Enhanced phytopopulation & pigment. Poor ratios of chlo **a** / phaeo. Poor species diversity
1a	Nearshore waters	Enhanced phytopopulation & pigment. Poor ratios of chlo **a** / phaeo. Comparatively lower species diversity
1b	Creek systems	Enhanced phytopopulation & pigments. Poor ratios of chlo **a** / phaeo. Poor species diversity
1c	Estuarine systems	Enhanced phytopopulation & pigments. Poor ratios of chlo **a** / phaeo. Comparatively lower species diversity
2	Offshore waters	Comparatively lower phytopopulation and pigments but sufficient food for the organisms of secondary and tertiary trophic level. Healthy ratio of Chlo **a** / phaeo. Enhanced species diversity
3	Highly polluted waters	Poor phytopopulation and pigments. Poor ratios of chlo **a** / phaeo. Poor species diversity.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 21-27

ZOOPLANKTON – STUDY METHODS, IMPORTANCE AND SIGNIFICANT OBSERVATIONS

S. N. Gajbhiye
National Institute of Oceanography
Regional Centre, Lokhandwala Road,
Four Bungalow, Andheri (w), Mumbai – 400 053

INTRODUCTION

The intent of this section is to review briefly current knowledge of the structure and dynamics of the zooplankton and its ecology. Zooplankton are mysids of animal organisms that drift with currents. In an aquatic ecosystem zooplankton form an important link in the food chain from primary to tertiary level leading to the production of fishery. It has been well established that potentials of pelagic fishes viz. finfishes, crustaceans, mollusks and marine mammals either directly or indirectly depend on zooplankton. By virtue of sheer abundance and intermediatary role between phytoplankton and fish, they are considered as the chief index of utilization of aquatic biotope at the secondary trophic level. The herbivorous zooplankton are efficient grazers of the phytoplankton and have been referred to as living machines transforming plant material into animal tissue. Hence they play an important role as the intermediaries for nutrients/energy transfer between primary and tertiary trophic levels. Due to their large density, shorter life span, drifting nature, high group/species diversity and different tolerance to the stress, they are being used as the indicator organisms for the physical, chemical and biological processes in the aquatic ecosystem. In the deeper water they occur at different depths and constitute a complicated ecological system worthy of specia attention.

DEFINITION OF PLANKTON

It is the plankton with which we are concerned here. This word originates from the Greek meaning "Wandering". Plankton as a term was first used by Victor Hensen (1887) for the aquatic communities of floating and drifting organisms which are carried primarily by movement of water current rather by their own swimming ability. While this is so, it must be remembered that, considering their small size, many plankton animals are strong swimmers and are capable of moving through relatively long distances over a period of time, particularly in a vertical direction. Plankton includes organisms of both plant and animal origin. The plant component of the plankton is called phytoplankton and the animal component is called as zooplankton. There is a third group which can absorb dissolved organic matter called as saproplankton. The majority of phytoplankton belong to Chlorophyceae, Cyanophyceae and Bacillariophyceae. Their unique ability to fix inorganic carbon to build up organic matter through primary production makes them very important in food web.

Zooplankton consists mostly of invertebrates and larvae, immature stages of both invertebrates and vertebrates. Most of the zooplankton in freshwater are members of three main taxonomic groups i.e. protozoa, rotifera and crustacea. The marine environment differs mainly in having few rotifers or cladocera, more extensive representation of protozoa groups and widespread occurrence of planktonic larvae of sedentary forms ranging from mollusks and malacostracan to chordata. During the decades following Hensen's early investigations, advances in techniques of taxonomy, ecological sampling and chemical analysis provided more detailed information an the ecology of zooplankton.

CLASSIFICATION

1 Based on size

Irrespective of the fact, whether plankton belongs to plant or animal origin, it is divided into two groups.

(i) Euplankton - All true plankton.

(ii) Pseudoplankton – Dead plankton and non-living debris.

Zooplankton are characterized by their faunal diversity compared to phytoplankton and include arrays of animal organisms, varying in size from the microscopic protozoans of a few microns to some jelly fish with tentacles of several metres. No single system of classification has been adopted universally. They have been classified into several groups by size (Cushing *et al.,* 1958).

(i)	Ultraplankton	:	< 5 µm
(ii)	Nanoplankton	:	5-60 µm
(iii)	Microplankton	:	1-500 µm
(iv)	Mesoplankton	:	0.5-1.0 mm
(v)	Macroplankton	:	1-10 mm
(vi)	Megaplankton	:	10 mm

The larger planktonic organisms (20-100 mm) are called micronekton. Depending upon the size (Raymont, 1983), the zooplankton are divided into megaloplankton, macroplankton, mesoplankton, microplankton and nanoplankton.

2 Ecological classification

A. Marine plankton (haliplankton)

(i) Neritic plankton : Those inhabiting waters overlying continental shelves.

(ii) Oceanic plankton : Those inhabiting waters beyond continental shelves.

(iii) Brackishwater plankton : Those inhabiting in brackishwater, also known on hypalmyroplankton.

B. Freshwater plankton : Those inhabiting in freshwater, also designated as limnoplankton (lake plankton), heloplankton (pond plankton) and rheoplankton or potamoplankton (running or lotic water plankton).

3 Based as per depth distribution

(i) Pleuston : Those living at the surface of the sea, part of whose bodies project in to the air. Example – Physalia and velella.

(ii) Neuston : Living in the uppermost part (few to 10 mm) of the surface layer.

(iii) Epipelagic : Living between 0-200 m.

(iv) Mesopelagic : Living between about 200 and 1000 m in daytime.

(v) Bathypelagic : Living below 1000 m.

4 By length of planktonic life

(i) Holoplankton (Permanent plankton) : Those living as plankton during their entire life. Example – Chaetognaths, copepods

(ii) Meroplankton (Temporary plankton) : Those living as plankton during only a part of their life. Example – Eggs and larval stages of fishes

5 By food habit

(i) Herbivores : Those zooplankton feeds on phytoplankton are called as herbivores. Example – Copepods, shrimps

(ii) Carnivores : Those zooplankton feeds on other small zooplanktons are called as carnivores. Example - Chaetognaths, ctenophores, etc.

(iii) Omnivores : Those zooplankton feeds both on phytoplankton and zooplankton are called omnivores.

STUDIES ON ZOOPLANKTON

Studies on secondary production are limited because at present there is no simple *in situ* method for its measurement comparable to the techniques used for measuring primary productivity. The zooplankton patchiness generally renders the extrapolation of the data from a sample to a larger volume of water rather inconsistent not withstanding this constraints. Secondary production has been measured from the zooplankton biomass values which represent the zooplankton standing stock.

1 Sampling

The sampling design is as important as the analysis and techniques used in the laboratory because field sampling provides the most valuable information for investigating the ecology of plankton in nature.

1.1 Choice of methods

Zooplankton is distributed in the seas as well as in ponds, swamps and rivers. It is almost impossible to sample the entire zooplankton assemblage of particular interest by using a single method. Many factors like sampling gear, frequency of sampling, horizontal and vertical migration of species, influence the distribution of zooplankton. Uniformity in sampling methods is necessary for comparison of data over a wide geographical areas. The zooplankton studies involve collection of samples, fixation and preservation, analysis and computation of data.

1.2 Sample collection

Plankton sampling can be divided into three types :

(i) By bottle, (ii) With a pump and (iii) With a net

Bottle samples are used for the very small organisms. A water-sampling bottle is lowered into the water, and when it reached the required depth a messenger is sent. However, since only a small volume of water is sampled it is not very useful. Sampling with a pump also is not very useful due to disadvantages and limitations.

Methods of plankton sampling in which nets are common. The basic shape of plankton net is a cone. Various types of nets are used to collect plankton. They are :

(i) Bongo net, (ii) WP2 net, (iii) Indian Ocean Standard Net (IOSN) and (iv)H.T.net

Most of the sampling methods depend upon the catching power of netting material. The mesh size of the net, towing speed, clogging, patchiness, avoidance etc. will determine the quality and quantity of zooplankton.

In my center and most of the laboratories in India are using Heron Tranter Net for horizontal or oblique hauls

and IOSN nets for vertical haul.

1.3 Flowmeter

It measures the volume of water which passes through a plankton net. The water which is passed over the rotor vanes causes the whole rotor to rotate. The rotor is connected to a gear train so that a given number of rotations is equal to one unit on the dial. Before first use, the flowmeter is calibrated so that one unit of this dial is related to a certain volume of water.

2 Fixation and preservation of sample

Proper fixation and preservation of zooplankton is very important. The sample should be fixed immediately to prevent decay of organisms. The poorly fixed organisms would make their subsequent identification and analysis difficult. Analytical grade buffered formation (4-5%) is commonly used as fixative. Various type of preservatives are available. The choice is made according to taxonomic group of zooplankton and type of studies to be undertaken. The wide-mouthed polythelene containers with screw lid are recommended for storing the samples. The samples are to be kept in a dark room for subsequent analysis.

3 Analysis

The basic analysis of zooplankton measurement of biomass, enumeration of common groups, percentage composition and species identification. The methods of analysis selected will depend on the objective.

3.1 Biomass

This can be given as one of the following measures.

(i) Wet weight, (ii) Dry weight and (iii) Volume

Before determining biomass, large organisms such as large medusae, big fish larvae etc. should be removed and recorded separately.

3.2 Population count

This is the most time consuming part of zooplankton analysis. Information on the faunal composition and abundance of different zooplankton can be obtained by counting the organisms present in the sample.

3.3 Volume of water filtered

During the time of collection note the revolution given by the flow meter. Calculate the volume of water filtered (V) using the following equation :

$$V = \frac{A \times R}{K}$$

where

A = Mouth area of the net

R = Revolutions of the flow meter

K = Constant (Calibration value of the flow meter)

The biomass or population have to expressed in terms of cubic meter.

COMPOSITION / COMMUNITY STRUCTURE

The number of species/group or the presence/ absence of the species/group in a station in the study area may be due to two factors viz. evolutionary history of the geographic region and the interactions of the species/groups and their relationships to the physical environment (Cliford and Stephenson, 1975). But these factors are not mutually exclusive. Evolution affects the pattern of interactions in a community and the pattern of interactions in a community determine to a great extent the course of evolution.

Two of the special features of the plankton community are the relatively high numbers of omnivorous animals and the filter-feeders. Carnivores are numerous forming about 5 percent of numbers of the zooplankton and volume-wise they are dominant. Planktonic carnivores are usually noticeably larger than the herbivores on which they pray. Protozoans represent by foraminerans and radiolaria, while medusae, siphonophores and ctenophores contribute as coelenterates. Polyclads form a group of flatworms and they are never common in plankton samples. There are some polychaetes worms which are part of the permanent plankton. Crustaceans forms the major group, normally easily out numbers the remainder of the plankton. Most of the groups of crustacea are reasonably distinctive. Major groups of crustacea are cladocera, ostracods, copepods, mysids, amphipods, cumaceans, various stages of decapods, euphausiids, *Acetes, Lucifor* sp., caridean larvae, macruran adults, crabs larvae, stomatopod larvae and other so many larval stages. Gastropod larvae, bivalvae larvae, heteropods, pteropods and cephalopods are the major groups of mollusks. The other groups echinoderms and chordates are represent as cyphonautes larvae, phoronis larvae, sipunculids, brachiopod larvae, chaetognaths, echinoderm larvae, tornaria larvae, larvaceans, thaliaceans, amphioxus larvae, fish eggs and fish larvae. Among all this, copepods generally are regarded as the most important group of planktonic animals and constitute major part of the zooplankton at coastal marine ecosystem. They are so numerous that they have been called the insects of the sea. It has also been said that there are more copepods in the sea than all the rest of the multi-cellular animals put together. Most of the copepods are herbivores. Some species of copepods are carnivores as well as omnivores, but the prevalence of such species in general is very low.

FOOD CHAINS AND ENERGY TRANSFER

The ultimate source of energy for most of life on the earth planet is the Sun. Photosynthetic organisms, such as plants and some bacteria, transform radiant energy into chemical energy for their existence. Some fraction of this energy is passed along food chains in a stepwise fashions to higher trophic levels where secondary food production occurs. A simplified marine food chain consists of

Phytoplankton → Zooplankton → Nekton

As we proceed up the chain, the organisms become larger and less abundant, the bulk of the biomass is concentrated at the base of the chain. The smaller organisms at the base of the food chain comprise a much larger biomass than the larger animals at the top of the food chain. The growth rate of population is also correlated to body size and to trophic level. The smaller organisms are able to double their biomass at much faster rates than the larger animals. Relationships among primary producers and consumers are usually complex. In a food chain, organisms at each level are eaten only by organisms of the next higher trophic level. One example is a grazing food chain, consisting of the following :

Primary producers → herbivores → carnivores

This classic trophic relationship is known on the grazing food chain. As the “term” grazing indicates, this food chain is supported by photosynthesizing plants. More recently another types of trophic interaction, the detritus food chain, has been identified. In this case “detritus” forms a crucial link in the food chain. Essentially all the energy stored in organic matter is consumed by organisms and only a small amount falls to the bottom which is finally buried in sediment for organisms to use it. A small amount of the organic matter in sediment deposits is converted into oil and gas. The main point is that energy is not recycled. It is a one way flow, unlike the recycling of chemical constituents in water.

At each step in a food chain, energy is transferred from one trophic level to the next. Energy is lost at each transfer because organisms use much of the energy they take in for maintenance. Only about 10% of the food intake is available for growth at each trophic level. Thus, 1000 grams of plants support 100 grams of herbivores and 10 grams of carnivores.

So far, we have considered only food chains. Most organisms eat more than one type of food. In turn, each organism is eaten by many predators. The result is more complicated feeding relationships which is called food webs.

To quantify the amount of organic material in an ecosystem we use the concept of biomass, where biomass is the amount of plant or animal material, expressed on the weight of organic carbon, per volume of water or area of bottom. It is similar to the expression used for production. Production expresses how much is being produced, while biomass indicates how much is available to other organisms to eat. Another way of expressing this relationship is the standing crop, which is the difference between the amount produced and the amount consumed.

FOOD AND SURVIVAL STRATEGY

Primary productivity is dependent on light, CO_2, temperature and nutrient elements. The nature and quantity of available fertilizers affect the species composition of primary producers and the rate of primary production. Phosphorous and nitrogen are considered to be the most important fertilizers for increasing density of phytoplankton. At lower concentrations, diatoms are common, but with increase in phosphate concentration, green algae become more frequent, eventually giving way to blue-green algae at the higher concentration.

Zooplankton for their survival do not depend directly upon nutrients, except for microflagellates. The majority of them are affected indirectly by nutrient control of the quality and quantity of their algal, bacterial or detrital food. The predominant feeding method in plankton is the filtering of wide range of living and detrital organic particles, with larger species feeding upon large algae or other zooplankton. To a certain extent, all are size selective feeders, depending upon the dimensions of their food gathering apparatus.

Feeding strategies used by marine organisms vary with depth in the ocean. This is because of the abundance of different kinds of food are greatly different at the various depths. Herbivores dominate near surface waters where phytoplankton are abundant. They decreased markedly in abundance below thy pycnocline. Carnivores are most dominant in the middepths, where they can feed on herbivores in the surface zone. Many of the vertically migrating organisms are carnivores. Omnivores occur throughout the ocean, but they are especially common in deeper waters. Many planktonic organisms are suspension feeders, that is, they feed by removing particles suspended in the water.

There are perhaps more than two lakh species of animals and plants living in the sea. The species evince different survival strategies such as body size, food and feeding habits, response to stress and reproduction rates. For prolonged passive suspension in the water column, small body size is preferred. The sinking rates are also reduced by extending appendages provided with setae and fine hairs. The presence of air-filled floats in siphonophores, velilla, porpita and spines in decapods

assist floatation. The oil droplets serve a duel function as food reserve and a buoyancy device. As mentioned earlier zooplankton organisms employ various methods to capture food, but the most common is filter feeding. The herbivores filter the planktonic algae from the water currents generated by tides and waves or by animal itself.

The different filters used by zooplanktonic organisms include mucus nets (salps), meshwork secretions (copelates) and basket work of setae (crustacea). The planktonic crustaceans even use specialized limbs, fringed with setae for filter feeding. In contrast with the relative stability of the sea, the estuaries are dynamic environments, often showing sudden and extensive changes in salinity. The rate and magnitude would depend on the geological, metrological and hydrographic conditions. The species have to be highly adaptive and are reported to show mechanism to detect changes in salinity and oxygen. Many produce resting eggs to tide over unfavourable conditions. The reproduction rates counter mortality. Several zooplankton species show quick maturation, reproduce early, with shorter generation time and low species diversity.

Zooplankton have different reproductive strategies which influences rate of population increase and hence availability of food. Two different reproductive strategies are used by organisms. One is suited for sparsely inhabited but resource-rich environments, where rapid population growth is advantageous the other appropriate for resource-poor environments already saturated by organisms, where slow population growth is more desirable. The first strategy is used by opportunistic organisms that develop rapidly to take advantage of hazardous environments or variable resource which other organisms can not exploit. Many fishes and invertebrates follows this strategy.

DISTRIBUTION

Planktonic organisms are not distributed uniformly in space. The variability of an ecosystem in space and time is one of its most important features. The physico-chemical boundaries play an important role as there are usually strong gradients in terms of light, temperature and salinity from surface to the bottom layers. The zooplankton exhibit uneven distribution both along the horizontal and vertical planes. It is well known that the zooplankton are abundant at depth during day and their abundance shifts to surface at night. This has been explained on the basis of vertical migratory behaviour. It could be ontogenetic, seasonal and diel migrations. Besides light, food availability, inter and in a specific competition, predation pressure, niche selection, energy conservation and physiological state of zooplankton are other factors responsible for this phenomenon. The diel migration is most common but some planktonic forms don't show migration and occur in discrete depth zones or in the surface layers.

In the deeper marine environment, the zooplankton usually congregate above the thermocline or discontinuity layer which acts as an ecological barrier and results in stratification in distribution. The vertical zooplankton abundance has also been associated with chlorophyll concentration and primary productivity. In addition to vertical gradient, there are also patches in horizontal distribution. The zooplankton patchiness or spatial heterogeneity becomes a dominant character of distribution of some taxa during certain period of the year. The patchiness extends on scales of several meters to hundred or thousands of kilometers. The zooplankton are dispersed according to the scales of ocean turbulence. Since the latter range from small scale eddies to very large gyre, the scales of zooplankton patchiness will be correspondingly varied (Parsons, 1980). The intensify of zooplankton aggregation will depend on their ability to counter dispersion, phytoplankton growth, grazing rates, predator prey relationship and reproduction strategies of zooplankton. The zooplankton patchiness is utilized by higher trophic levels particularly by pelagic fish species and their larvae.

AS INDICATOR ORGANISMS

It is fundamental of ecology that an living organism cannot survive indefinitely in an environment that does not provide its physical, chemical and nutritional requirements. Hence, the presence of a particular species, if it is reasonably abundant, indicates that its environment requirements are being met. Within certain limitations the presence, absence or relative abundance of species may be used as indicators of environmental quality.

The environment of the plankton consists of many factors, each exerting its influence on the organism. Also the zooplankton being passive drifters, they are used as indicators of water masses and their movements, circulation, coastal upwelling, productivity of waters, neritic or oceanic conditions and so on. It is well known that several zooplankton organisms and their species have their main centers of distribution within a specific water mass. Their geographical range would depend on the temperature and salinity tolerance limits. The indicator species could be selected on the basis of adults carried by currents into regions where no recruitment occurs; planktonic larvae carried into regions where the adults do not occur and the species that have their greatest abundance in mixing zones with little recruitment from the outside source. The zooplankton species also serve as indicator of coastal upwelling. The copepod species of family calanidae dominate zooplankton population during upwelling events. The upwelling results in high primary productivity over an appreciable area with high production of herbivorous zooplankton. The zooplankton production and fauna are also indicators of neritic or oceanic conditions. The neritic and inshore waters are

most productive with typical seasonal fluctuations influenced by monsoons and upwelling.

ZOOPLANKTON AND POLLUTION

1 Ecological aspects

We know pollution and its disasterous impacts. However, the open sea is still relatively clean. The margins of the seas and most of riverine systems are affected by man, almost everywhere, and encroachment on coastal areas continues worldwise. Habitats are being lost irretrievably to the construction of harbours and industrial installations. Although difficult to quantify, destruction of beaches, coral reefs and wetlands, mangrove forests and increasing shore erosion are evident all over the world. If unchecked, this trend will lead to global deterioration.

Toxic and microbial agents have not so far affected exploitable living resources on a wide scale, although some stocks especially of shellfish in limited areas, have been declared unfit for human consumption. Coastal grounds and shallow waters are being increasingly degraded, and marine resources both wild and farmed, could eventually be damaged on a global scale.

Different pollutants have different effects on living aquatic organisms and on fisheries. Some stimulate the growth of plants and could have beneficial effects if properly controlled. Some are toxic and can kill aquatic organisms or make them unfits for human consumption. Others are innocuous and have little or no effect on the aquatic ecosystem. Most effluents are complex mixtures of a large number of different harmful agents. These include toxic substances of many kinds, extreme levels of suspended solids and dissolved and particulate organic matter. Most effluents also vary in their strength and composition, on a seasonal, diurnal or even hourly basis. There are about four million different chemical substances in existence, a number which increases by about 3,00,000 every year. In order to survive, a living organisms must spend its life in an environment which meets its needs, a suitable physical habitat which provides space, shelter and a sufficient supply of food, oxygen and other metabolic requirements. Any of living organism's many individual requirements may be a limiting factor.

Pollution may directly influence one or more components of the dynamic equilibrium of physical, chemical and biological phenomena which give an ecological community its characteristics. Wherever and whenever the input of organic material exceeds the capacity of the system to assimilate it, a number of changes take place. Occurrence of these responses or changes will depends upon the nature and severity of the pollution, and upon the relative susceptibility of the species within the community to specific kinds of environmental alteration. Living organisms like zooplankton can provide useful indication of these changes and environmental quality of water. There are furthermore, very few organisms whose presence specifically indicates that the water is polluted.

In a severely polluted area the invertebrate fauna including zooplankton is affected by the elimination or numerical reduction of certain species. If the input of pollution ceases, the fauna gradually recovers with the passage of time. A similar process of recovery can be observed with increasing distance from a source of pollution on the concentration of pollutants decreases. The nature of the recovery is a gradual increase in the numbers of species and in the numbers of individuals. However, it is well known that even in the unpolluted environments, the biological community and its physical environment are not well understood and it is therefore extremely difficult to distinguish the consequences of pollution from the response of the community to natural variations in its physical environment.

Effects of pollution on the aquatic ecosystem are the most difficult to establish and evaluate. As mentioned earlier each environment is somewhat different. The species inhabiting any given environment have evolved over long periods of time and each individual species in a community plays its own role. There are many ways in which pollutant might affect a given population without being lethal to the adult organism. The affect may be in form of migration, behaviour, incidence of disease, life cycle, physiological processes, nutrition and food chains, genetic effects and ecological effects.

Zooplankton are used in the pollution assessment and monitoring studies in various ways which include changes in community structure, species diversity, species preference and bioaccumulation of toxicants. Grazing zooplankton accumulate higher concentrations of DDT than is found in the phytoplankton they eat. The top levels carnivores accumulate the greatest amount of DDT. Study of the uptake, metabolism and excretion of pollutants and of their distribution in the various body organs and tissues, makes an important contribution to understanding their mechanisms of action. Levels of pollutants in the tissues of living organisms are widely used to indicate the degree of contamination of the watermass in which they live. Pollutants may, over long time periods, accumulate in tissues to levels which may be harmful to the organisms. Since many aquatic species are utilized for human consumption, the public health significance of toxic substances accumulated in their tissue is obvious.

2 Biological monitoring

Any surveillance and monitoring system should be established with clearly defined objectives. The

following are the minimum objectives suggested for monitoring.

(i) Establish present – day base lines

(ii) Detect and evaluate trends of changes

(iii) Give advance warning

(iv) Detect accidental critical events

(v) Information, storage and retrieval

Monitoring of the biological characteristics of watermass might indicate the occurrence of ecologically significant environmental changes – including the incidence of pollution, which may otherwise be undetected.

In the monitoring programme, sampling stations are surveyed at intervals of between one and six months. Information is gathered on the presence and relative abundance of species and may be used to derive numerical values like species diversity biotic index, to facilitate spatial or temporal comparisons. Significant alterations from previously – established conditions may indicates the need for further investigation and lead to action designed to preserve or improve the existing water quality. Biological monitoring data also can be used to formulate water management strategies notably through the identification of technically and economically feasible water quality objectives.

FUTURE PROSPECTS

Many commercially important pelagic fishes feeds on zooplankton, hence, the study on prevalence and distribution is necessary in assessing the production potential of a given ecosystem. Investigations on zooplankton have been confined mainly to taxonomy, zoogeography, distribution pattern, community structure and trophic relationships. However, efforts are underway to integrate studies of biological and physical phenomena in the ocean. New techniques either already available or in processes of development are being used for synoptic sampling (acoustics, optical imaging, bioluminescence) and biochemical indicators (digestive enzymes, lipids, genetic markers).

The use of new sampling and analysis technologies in zooplankton research would greatly facilitate rapid data acquisition for evaluation of biological resources and understanding of processes in the ocean.

REFERENCES

Cliffered and Stephenson (1975). An introduction to numerical classification. Academic Press, New York : 225 pp.

Cushing, D. H., G. F. Humphrey, K. Banse and T. Laevastu (1958). Report of the committee on terms and equivalents. Rapp. P. V. Reun. *Cons. Perm. Int. Explor. Mer.,* 144 : 15,16.

Hensen, V. (1887). Uber die Bestimmung des Planktons order des im mere treibenden materials an Pfanyen and Tieren Funften Bericht der Komn. 2 Wissensch unter such Deufschen Meere in Kiel 12-16, 107 pp.

Parsons, T. R. (1980). Fundamentals of aquatic ecosystems, Barnes & Mann (ed), Blackwell Scientific Publications Oxford, 229 pp.

Raymont, E. G. John (1983). Plankton and productivity in the Ocean, Vol.2, Zooplankton, Pergamon Press.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 28-30

MARINE BENTHOS – A FUTURE PERSPECTIVE

K Govindan
National Institute of Oceanography
Regional Centre, Mumbai.

INTRODUCTION

The term benthos is widely referred to flora and fauna which are intimately associated with sediments in an aquatic environment. They support a rich variety of floral and faunal assemblage of marine bottom communities, viz., bacteria to vertebrates. Their distribution in the marine environment starts from intertidal zone to deep sea. Depending on the ecological niche they are classified as interstitial, eulittoral, sublittoral and abyssal benthic communities. Their distribution is inversely proportional to depth on the horizontal and vertical realm. The littoral zone supports rich benthic communities than deep sea. Development of morphological adaptations such as calcerous shells, elongated, stalked and branched body, appendages with cilia and bristles and strong body musculature are characteristics of benthos.

Benthic organisms are reported from different kinds of substrate like hard bottom, soft bottom, coarse bottom and also from organic matter and other macrodebris. Benthos are, in general, sessile and slow moving in nature. 75% of benthic animals live on firm substrates (rocks, corals etc), 20% on sandy/muddy bottoms and only 5% of the total are planktonic. Many benthic animals within the sediment perform periodic vertical migration. Benthos are mostly either filter feeder or browsers or deposit feeders. Their feeding depends on particle size, quantity abundance and choice preference. Their species diversity and abundance vary widely with geographical area, climate, spatial and temporal difference, physico-chemical factors and other biological interactions.

The size of benthos varied from microscopic to several orders of magnitude. Benthos are classified on the basis of their size and their position in the sediment. The organisms that live within the sediment are called as 'in fauna' and they move within the interstitial spaces or they build burrows or tubes. 'Epifauna' which are either attached or move at or on the surface sediment. Organisms that like amphipods, shrimps and scallops make extensive movements by swimming at the bottom. Based on the size, benthos are classified into three categories viz., microfauna which vary from 1 to 50 µm (bacteria, protozoans, protophytes etc) meiofauna which vary from 50 to 500 µm (foraminiferans, copepods, nematodes, turbellarians, several larval forms etc) and macrofauna which are more than 500 µm in size (all macroinvertebrates, macrophytes and selected vertebrates like fishes).

The community structure of benthos is mainly decided by the following environmental factors:

(i) Physico-chemical factors such as region, climate, temperature, salinity, water currents and circulation, tidal exposure, depth, substratum, sediment grain size, oxidation- reduction state, dissolved oxygen, organic content, nutrients and light.

(ii) Biological factors like (a) food availability and feeding activities, (b) prey-predator relationship and species removal, (c) reproductive effects on breeding, spawning dispersal and settlement, (d) behavioural effects which induce movement and aggregation and (e) growth and mortality.

TYPES OF BENTHOS

Benthic flora

The benthic flora widely represents from phytobenthos to macrophytes. In general, the flora is highly diversified and heterogenous in size with dominance in selected habitats like creeks, estuaries, intertidal salt marshes, rock pools, shallow lagoons and coral reefs etc. Major components of phytobenthos are (a) cyanophyceans, (b) cryptomonads, (c) euglenoids, (d) dinoflagellates, (e) diatoms, (f) fungi and (g) photosynthetic bacteria. While major components of macrophytes are seaweeds and grasses, mangroves, and salt marsh vegetations.

Macro and microalgae and photosynthetic bacteria sustain extensive populations in and on the sediments and solid substrates depending on the availability of light and oxidation – reduction condition. High algal production is observed in salt marshes, intertidal sediments (80-200 g C $m^{-2}y^{-1}$) and in the eulittoral areas upto 20 to 30 m (<80 g C $m^{-2}y^{-1}$) depth depending on the light penetration. In sediment, photosynthetic activity is restricted to the upper 6-8 mm from the surface depending on the type of sediment and the wave length of light. Chlorophyll *a* of the order of 100 mg/m^2 is common in intertidal sediments. In most of the cases about 2 to 4 mm from the surface sediment accounts for the compensation depth.

MICRO-BENTHOS

Microfauna is mainly consisted of bacteria, ciliates and micro-flagellates. Bacteria are the most numerous and ubiquitous organisms present in sediments and their metabolic activities largely control the chemical nature of sedimentary environment. Bacteria in sediments are generally similar to those in water in reference to antibiotic sensitivity, degradative, and fermentative capability and cation requirements. Common aquatic bacteria like *Flavo bacterium* and *Achromobacter* are often present in sediments. Both gram+ve and gramve cell types are present with larger cell size than bacteria isolated from water. Aerobic heterotrophs which oxidize organic compounds usually occur in surface sediments to depth determined by the penetration of dissolved oxygen. In anoxic conditions at deeper layer anaerobic bacteria use various organic and reduced inorganic compounds as hydrogen acceptors. Bacteria capable of anaerobic respiration (fermentation) and chemosynthesis characterize these sediment layers. The bacterial biomass in the top 10 cm sediment vary from 5.5 gm^2 – 26.5 gm^2 depending on the sediment particle size. Bacteria accounts for more than 50% of the metabolism of benthic communities. In general, micro organisms are responsible for over 95% of community respiration.

MEIO-BENTHOS

Meiofauna includes a wide assortment of metazoans with small elongate bodies adapted to an interstitial mode of life. They include ciliates, tardigrades, turbellarians, gastrotrichs, oligochaetes, archiannelids, harpacticoids, ostracods, nematodes, foraminiferans, rotifers, and gnathostomulids. The meiofaunal community shows complex ecological properties, with predictable patterns of species composition and abundance in time and space and with recognizable patterns of resource partitioning. Micro flora and fauna form major source of food for the meiofaunal communities although they use selectively the dissolve organic compounds to synthesize carbon. About 16-20% of the meiofaunal production (av 20 g C $m^{-2}y^{-1}$) is utilized by macrofauna, while the rest is available for the mobile carnivores like fishes, birds and crabs, as well as used for within meiofaunal communities.

MACRO-BENTHOS

The larger metazoans over 500 µm in size representing all the phyla form this group. Macrofauna mainly constitute three mode of feeding such as filter feeders (bivalves, sponges, ascidians, worms, barnacles etc), browsers (amphipods, isopods, gastropods etc) and deposit feeders (annelids, bivalves, gastropods, holothurians, crustaceans etc). The preference of macrofauna to hard bottom and silty sand rather than muddy bottom is well recognized. Enumeration of population and community structure, biomass, and species diversity of macrobenthos is much easier as compared to meiofauna and microfauna. Macrofauna serve as a major source of food for the demersal fishes. It is possible that the macrobenthos get about half of the sedimented carbon and that many species are able to transform it to macrobenthos production with an efficiency around 40%. In that case an overall benthic transformation efficiency of 20% may be realizable and yield to demersal fish of 5 g C $m^{-2}y^{-1}$ be well within the capacity of most benthic communities.

ROLE OF BENTHOS

Benthos play a vital role in the marine food chain and in the recycling of essential life sustaining elements like, C, N and P in the marine ecosystem. The sedimented organic matter from the water column is effectively consumed and converted into invertebrate benthic biomass, dissolved organic matter and inorganic nutrients by benthic organisms. The nutrients released from the sediments due to bacterial degradation of organic matter, diffuse and disperse fairly rapidly into the overlying water and influence the primary production which in turn triggers the zooplankton production in the marine environment. There is certain amount of evidence that significant amounts of nitrogen and phosphorus are released from sediments in organic form which is directly utilized by selected microfauna and meiofauna for the organic synthesis.

Bacteria play a vital role in the process of decomposition of organic matter, nutrient recycling, in the energy cycle of benthic ecosystem and as a source of food for benthic animals. Bacteria are responsible for more than 50% of the metabolism of benthic communities. In short, they are responsible for an healthy marine food chain.

Bacteria are major source of food for meiobenthos and meiobenthos are food for macrobenthos which in turn serve as an important source of food for demersal fishes. Since, the demersal fishery contributes about 30 to 50% of the total fishery potential of an area, the benthic production plays a major role in deciding the demersal fishery potential.

Macrobenthos create bioturbation during their movements and feeding activities which conditions the sediments for meiofauna and microfauna and as a stimulant of nutrient regeneration. Many deposit feeders ingest anaerobic sediments and transfer them to surface layer where they become oxidized. This also helps transfer of bacteria and organic matter from deeper reduced layer to surface oxidized zone. Simultaneously, this also aids the transport of well oxygenated water from the surface to deeper zones.

Benthos due to their differential tolerance have been considered as the best indicator organism of environmental stress or aquatic pollution. Benthic macroinvertebrates are widely used in 'biomonitoring' programmes both as surveillance and compliance in order to assess the health of the environment.

In the aquaculture industries, benthos play a significant role in the assessment and monitoring of culture ponds. If the benthic ecosystem of the culture pond is properly maintained, the benthos form an additional source of natural food for the culture species like shrimps which invariably feed on benthic organisms.

The benthic ecosystem of coral reef, mangroves and intertidal beach and mudflats serves as a good feeding, breeding, spawning and nursery grounds for many marine organisms of economical importance, variety of migratory and resident birds, fishes, sea mammals and reptiles.

FUTURE RESEARCH

- Integrated approach on benthic ecology viz. studies on micro, meio and macrobenthos with required physico-chemical parameters will enable better understanding of benthic marine environment and its role on the overall marine food chain.
- Biodiversity of the benthic ecosystem is essentially to be established for formulating adequate marine conservation and protection measures.
- The role of mangroves, salt marshes and coral reefs on the fertility of the nearshore coastal ecosystem is to be understood in detail. Public awareness on this subject is to be created.
- The importance of bioturbation on the benthic ecology is to be investigated.
- Clear understanding of the energy flux within the benthic ecosystem as well as between the overlying water column and benthic ecosystem is needed for developing reliable predictive ecosystem models.
- Benthos in environmental monitoring studies should be persuaded in depth.
- More information on deep sea benthos needs to be established for a better understanding of deep sea benthic ecosystem.
- The relationship between demersal fishery potential and benthos is to be understood in detail.
- Study to understand relationship between benthos and fossil fuel is needed.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 31-33

MICROFOSSILS AND THEIR IMPORTANCE IN PALEO-ENVIRONMENTAL ANALYSIS

K.P.N. Kumaran
Geology and Paleontology Group
Agharkar Research Institute
G.G. Agarkar Road, Pune 411 004
E-mail : kpnkumaran@hotmail.com

ABSTRACT : Microfossils are discrete remains of ancient life whose study requires the microscope throughout. There are broadly three categories of microfossils, viz., mineral walled forms such as foraminifers, ostracods, diatoms, silicoflagellates, cocolithos and radiolarians, organic walled forms such as pollen grains, spores, and microplanktons and nannofossils, which are too small prevailingly less than 5 µm. The study of all these forms of microfossils is called micropaleontology, while palynology is restricted only to study of all types of organic walled forms and share identical aim to unravel the past history. Since many microfossil groups have occupied a place at or near the base of the food web, our understanding of the development and stability of the present ecosystem has much to learn from microfossil record. A glimpse of different types of microfossils associated with the mangroves and coastal ecosystems, methods of separation from the rock matrix and their utility in palaeoecology and paleoenvironment are being focused in the present lecture.

INTRODUCTION

The world of microfossils is unique as it has got its own fascinating story to reveal. Most of the mineral-walled microfossils are derived from marine and fresh water aquatic realm while the organic-walled forms belong to both aquatic and terrestrial ecosystems. As the mangrove and coastal ecosystems are influenced by both marine and terrestrial environments, the coastal deposits have preserved a good record of past life. Accordingly, the study of coastal sediments has significance with regard to sea level fluctuations and accompanying change of environmental conditions. The types and importance of microfossils preserved in coastal sediments and their implications in paleoecology and palaeoenvironment form the subject matter of this communication.

As the theme of the seminar is restricted to mangrove environment, the scope of my presentation is focused upon mainly the coastal deposits and their associated microfossils. What are the main types of microfossils associated with the coastal sediments, how they are separated from the rock/mineral matrix and how do we proceed while studying them through the microscope are some of the queries that are being addressed to while presenting my data. Besides, most of my exposure and experience in microfossil study particularly on Kerala-Konkan basin, Saurashtra coast and Niger Delta of West Africa are also being shared while talking to you.

The study of microfossils is properly called **micropaleontology** and at the same time, **palynology** is being used for study of organic-walled microfossils. The former includes mineral-walled forms, such as foraminifers, ostracods, diatoms, silicoflagellates, coccoliths and radiolarians while the latter comprises mainly the organic-walled spores, pollen and dinoflagellates. However, there are some other very small microfossils, less than 5 µm from the nannoplankton group proved to be extremely useful for biostratigraphy of marine sediments and paleoenvironmental analysis.

METHODS OF STUDY

The technique of isolating microfossils varies and it all depends upon the type of rock samples and the desired objectives of the study. However, there are many simple, safe and inexpensive methods that can be used for more routine investigations. First of all, the sample must be disaggregated into smaller fragments for quicker and faster action on the sediments to release the microfossils and this can be achieved with the help of a pestle and mortar. For larger and harder samples a rock splitter or a rock crusher is required. The partially broken rock pieces and sediments can be disaggregated by keeping them in solvents like hydrogen peroxide (H_2O_2), washing soda (Na_2Co_3), ordinary domestic bleach (NaClo), sodium hypochloride and formic acid to release the desired type of microfossils especially for mineral walled microfossils. This process is called Demineralization. The extraction follows washing and wet sieving and this is done by washing over a 325, 230 or 200 mesh sieve. However, in the case of separation of organic-walled microfossils, hydrofluoric acid (HF) is being used as it dissolves the siliceous particles faster. Care is to be taken to avoid the loss of

smallest types of microfossils by using the finest sieve size. Sorting and concentration of microfossils can be achieved by a variety of methods such as decanting, dry sieving and also with the help of heavy liquid separation. Carbon tetrachloride (Ccl_4. SG 1.58), Tetrabromomethane and zinc chloride are being used to concentrate calcareous and siliceous microfossils as heavy fraction and the lighter fraction respectively. The next step is maceration and it involves oxidation and removal of oxidation products. Organic materials can be separated and concentrated by "swirling method" with the help of watchglass or by mechanically using centrifuges. Depending upon the type of fossils, slides can be prepared either by picking them under a binocular stereomicroscope as in the case of foraminifera and ostracodes or by making smear slides of others like diatoms, nannofossils and spores and pollen grains. The dried smear cover slips can be mounted on to a microglass slide with the help of Canda balsam or DPX mountant. For high resolution surface details, selected forms are picked out of the maceration with a very small camel hair brush or a capillary tube and mounted on S.E.M. stubs. Picking and mounting of selected forms are usually done with a stereoscope microscope.

ORGANIC-WALLED MICROFOSSILS

Most of the organic-walled microfossils that have definite morphological identity are referred to as palynomorphs. Palynomorphs include pollen, spores of many sorts, acritarchs, dinoflagellate thecae and cysts, certain colonial algae, scolecodonts, chitinizoans and other acid-insoluble microfossils. The walls of these fossils are made up of a resistance organic substance (usually sporopollen, chitin, or pseudochitin). In fact, it is this substance which gives the palynomorph its extreme durability during geologic time. The sporopollen has a high molecular weight polymer of C-H-O, perhaps similar to carotenoid-like substance. As the spores and pollen are mostly derived from the terrestrial environment, they can be easily transported to marine ecosystem and thereby they score over the mineral-walled microfossils for paleoecological consideration. Pollen grains derived from the mangroves are usually found in the coastal deposits and as such they are reliable markers of paleo-mangroves or near-shore deposits indicating the paleostrandlines along the coast. The location of paleostrandlines and near-shore deposits are very useful for location of probable hydrocarbon accumulation. The use of mangrove pollen as a biostratigraphic and paleobiogeographic marker is evident in the deltaic sediments of Niger Delta and Indonesia while correlating the subsurface samples during the hydrocarbon exploration programme.

The other important organic-walled microfossils are acritarchs, scolecodonts, dinoflagellates, and foraminiferal linings. Acritarches include algal bodies mostly marine but there are very brackish water or fresh water forms probably of green algal akinetes. Leiospheres, tasmanitids and aconthomorphs are same of the common acritarchs in recent and modern sediments. Scolecodonts are frequently encountered in palynological preparations of coastal deposits that are especially derived from marine environment. These are acid resistant chitinous mouthparts (jaw apparatus) of marine annelid worms (polychaetes). Their occurrence in good frequency in sediments is a very useful indication of the site of deposition being very near shelf or beach environment. However, this group of fossils and the aquatic chirinomids have not been studied in detail and need attention for their proper application in palaeoecology.

Dinoflagellate cysts and foraminiferal linings (= microforaminifera) frequently occur in palynological preparations of marine sediments and coastal deposits. Dinoflagellates are unicellular algae and most of them form an important constituent of the marine phytoplanktons and are autotrophic. The foraminiferal linings represent the chitinous inner tests of foraminifera. Their presence in the sediments is certainly indication of brackish to marine conditions. Their relative abundance along with adequate pollen representation in a given sample/profile would be interesting to ascertain the sea-level fluctuation of the coastline.

MINERAL-WALLED MICROFOSSILS

The mineral-walled microfossils that are frequently encountered in palynological slides of coastal deposits are diatoms, acid insoluble tests of foraminifera, ostracods, spongespicules and icthyoliths. However, calcareous nannofossils like coccoliths, radiolarians and silicoflagellates are mostly derived from deep marine sediments and as such seldom encounter in the coastal deposits.

Diatoms are unicellular golden brown algae which thrive virtually in all aqueous and semi-aqueous environment. They have an external, box-like skeleton or frustule which consists of two overlapping opaline silica valves and which forms the basis for diatom taxonomy. Based on bilateral or radial symmetry diatoms are divided into the Pennales and the Centrales respectively. Fossil diatoms are known from two main regions – fresh water deposits of Kashmir and marine deposits of the Andaman and Nicobar Group of Islands and as such there is tremendous scope to study from other parts of India. The diatom data from the Indian subcontinent are scanty and exploitation of this group would certainly address problems related to paleolimnological aspects of the coastal wetlands including the lagoons, estuaries and backwaters.

Foraminifera and smaller foraminiferal tests are other significant microfossils associated with the marine

and near-shore deposits. In most places, a tablespoonful of marine sediments yields hundreds of foraminiferal tests. The majority of species are benthic, but some are planktic. When foraminifera die, their tests accumulate in sediments. Because of their great abundance, worldwide distribution, and long fossil record, they are ideal for paleoecologic, paleobiogeographic and biostratigraphic studies. Due to their small size, they are readily recoverable by subsurface drilling and have been the major group of fossils used by oil industry for dating rocks.

Ostracodes are tiny bivalve crustaceans and occur in wide variety of aquatic environments including fresh water. They are extensively used for dating, correlation and interpretation of paleoenvironments systematically for the last seven decades. Like diatoms, the study of freshwater ostracode is still limited to Siwaliks and Karewas only. The study of Recent ostracodes of India has not got much attention so far. Studies in Israel showed population density and diversity of ostracodes are affected to sewage effluent. Accordingly, there is good scope to study them particularly in relation to water pollution investigation. Therefore, there is good scope to study these microinvertebrates.

Itchyolithes are microscopic fish skeletal debris frequently associated with marine and coastal deposits. In fact, they form an important component of pelagic sediments especially prominent in clays lacking siliceous and calcareous microfossils. Though they have been widely used for the past 15 years or so, for biostratigraphic and paleoenvironmental studies, in India attempts have been made only very recently by the NIO scientists. Strewn slides are the most efficient method for keeping and viewing large numbers of skeletal fragments.

Invertebrate skeletal remains belonging to sponge-spicules are very common in the marine and coastal sediments. The mudflats and clays are very rich in such forms. The skeletal remains are formed of either crystalline to microgranular calcium carbonate, silica in an opaline form, secreted by the sclerocytes or spongin fibers secreted by spongocytes. The other recognizable microfossils of marine sediments are coccoliths, silicoflagellates and radiolarians. Coccoliths are the minute calcite plates produced by unicellular marine algae, the coccolithopheres. The fossil coccoliths, together with small calcite bodies of organic called nannoliths by some constitue the calcareous nannofossils. Their small size allows for age determination of even very small samples such as ditch cuttings, side wall cores etc. They are good indicators of shallow depth, calm water, restricted environment and marginal seas-open ocean conditions. Silicoflagellates represent a group of silica secreting marine flagellates. The microfossils consist of siliceous tests which are tubular, latticed, subspherical, stellates or ring shaped. They vary in size from 5-20 µm and are likely to be confused with radiolarians. Radiolarians are single celled pelagic organisms and inhabit open seas and are grouped under protozoa. They are spherical to bell shaped with a siliceous skeleton secreted by the protoplasm. Radiolarians are used extensively for correlating oceanic sediments, particularly where calcareous tests have been removed through dissolution.

UTILITY OF MICROFOSSIL STUDY

In order to make use of various microfossil groups for their application in paleoecological and palaeoenvironmental studies, it is very essential to have a taxonomic approach initially. The identifiable types are compared with those of known geologic ages and also with their associated flora and fauna. For a proper and better assessment of the results one must consider the diverse types of microfossils recovered regarding aspects like the ecologic conditions in which they commonly occur, the quantity in which they are produced and dispersed, the distance of their habitat from the site of deposition, the effectiveness of the transporting agency, the biotic, the chemical and sedimentary environment in which the organic matter buried at the time of deposition etc.

With the help of identifiable palynomorphs (organic-walled fossils) it is possible to define the various floral ecological complexes of given coastal deposits that were formed under the influence of marine-mangrove and terrestrial influences. At least ten such floral complexes, viz., marine-microplanktons, mangrove, low-salinity water, palms (sandy beach), fungal complex, ferns; fresh water (Aquatic), other plants, inland and montane plant complex. Further, the detailed quantitative analysis of these microfossils can be used to infer the conditions such as shallow-marine, near-shore, brackish-water, coastal, littoral, sandy-beach and montane environments. Similarly, mineral-walled forms which are mostly associated with marine deposits are useful for paleobathymetry and paleoecological conditions.

Considering the state of art of microfossil study in India, there is tremendous scope further to investigate the polychaete remains, ostracodes, Icthyoliths and diatoms that are associated with the coastal deposits of India. In fact, data of sub-recent and modern microflora and microfauna are the need of the hour for our reference and environmental studies. Creation of data basis of the fossil and subfossil microscopic world is of paramount importance for environmental and climatic studies as they are intimately associated with the Biosphere and Geosphere.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 34-36

MANGROVE AFFORESTATION - A POINT OF VIEW

Arvind G Raddi
Jt. Director, Social Forestry (Retd.)

Distinguished Participants,

When Dr.Athalye requested me to inaugurate one of the sessions of the present seminar, and talk to the participants my initial reaction was one of hesitancy. After all I had retired from the Forest service since 1995 and though Mangroves has been a subject of my interest I was not in touch with the newer developments. Moreover over the years so many seminars, workshops, consultations, discussions, committees , Task forces and action plans had already given extensive attention to this subject, in India. What more could I possibaly add to this already existing bulky body of knowledge? I was therefore more inclined to decline the invitation with thanks. It was however obvious that not with standing all this attention Mangroves in the country as a whole continue to be in difficulty and are loosing ground.The November 4th, 2002 issue of " India Today " brings this out starkly in respect of Mangroves of Sunderbans as well as Orissa .Under these circumstances I felt that may be some of my Forest Department experiences from those early pioneering days of Mangrove plantations in 1985 could be of some interest and relevance , particularly to the younger participants interested in extending Mangrove coverage.And that is why I am standing here before you to share my perceptions .

It is recognised that atleast in Maharashtra, the subject of Mangroves was in a state of benign neglect till 1985.Perhaps in the country as a whole the situation was no different. The problem was that most of the Mangrove areas were categorised as Revenue wastelands and were in charge of the Revenue Department whose priorities , through force of circumstances were different.These waste lands were relevant to them only when they were conventionally developed through construction of buildings , roads etc.Forest Department had at that point of time , nothing to do with the protection or management of these mangrove areas since they were not in their charge..The ecological significance of the Mangroves and its contribution to the sustenance of coastal fisheries etc was then hardly known and certainly not high lighted. It was the Maharashtra Social Forestry project ,1982 funded by the US AID that was responsible for Forest Authorities getting interested in Mangroves. One of the conditions of the project was that social forestry demonstration plantations were to be taken on village common lands ie Panchayat lands. I had just then taken over as Joint Director of Social Forestry in 1985 and was in charge of six districts including Sindhudurg and Ratnagiri. Curiously the coastal regions of these two districts had hardly any community lands ,and the option with us then was either to delete this zone from social forestry project or to think up of some innovative new approach. It was then that the degraded intertidal mud flats which had scrubby, scattered mangrove growth attracted our attention. This was government waste land and in the context of my background in Marine sciences ,I felt that with revenue department permission , such areas could be rehabilitated through social forestry plantations of Mangrove species like *Avicennia officinalis* and *Rhizophora mucronata.*These plantations I felt while serving interests of coastal fisheries could later in course of time be also attached formally to the adjoining coastal village as community reserves of fuel and fodder for use in an emergency.

None of us , Maharashtra Foresters at that time knew the methodology of Mangrove planting. (We also realised that none of the other foresters in the coastal states in the country were any wiser than us.In Sunderban area the forest authorities then depended on natural regeneration to recoup worked or degraded areas). A few of the coastal zone academic institutions did have some exposure to mangroves but this was limited to its physiological aspects .They had no knowledge of its plantation methodology and management. It was then in a way a case of the blind leading the deaf. Fortunately my background in Botany and Marine zoology came in handy and in consultation with Dr.Vannucci of UNESCO, and Dr.Untwale then with the NIO I was able to work out some planting approaches, which were later tested in field on pilot scale basis, and eventually adopted in Maharashtra. The Mangrove plantation work was different in many ways from regular forestry plantations. The terrain was slushy, muddy and subject to tidal influences.Our field staff was not used to working in such terrain.Since all able bodied men from coastal villages were usually working in cities, obtaining labour was a problem. Barring some mud flats , the planting was restricted to estuarine fringes.This increased linear distances and created logistical and protection problems. However unlike other forestry plantations which were restricted to rainy seasons, Mangrove planting could be carried out in principle on a year round basis provided it was effectively supported by a network of intertidal Mangrove nurseries supplying

plants of different heights to cater to varying water depths. Factors like damage from buffaloes grazing in the mangrove plantations exposed at low tide,and from fishing activity of local fishermen at high tides, when the early stages of mangrove plantations were submerged were also presennt. So also Barnacle encrustations on young Mangrove plants or smothering of young mangrove saplings by growth of algal forms like *Enteromorpha* were also observed. But many of these were locality specific phenomena and on the whole the Mangrove planting programme was successful. This opened up a new dimension in coastal social forestry in Maharashtra , a fact which was appreciated. Based on this and further experience Mangrove planting has now been integrated in the state's planting activity for rehabilitating coastal waste land. The fact that rehabilitation of Mangroves is not succeeding effectively as one would have liked is now obvious.Media reports and public testimony have brought this out. The question is Why is this so inspite of all the effort? Why are things not quite working out as hoped? In this context I have some views to offer.

COASTAL VILLAGES ECODEVELOPMENT PROJECT.

Considering the magnitude of the problem , the mangrove restoration efforts appear to be falling short. Though well meaning they have been scattered and sporadic.The plantations though highly successful during their early stages eventually have often fallen victim to the local biotic and other attritionary pressures and interests.Unless the root causes of these biotic attritionary pressures are tackled realistically and effectively ,the planting effort however well meaning can not achieve its full success.The ground reality makes it obvious that our restoration problems are not technological but social.

A way out of this depressing ground reality is offered by the village Ecodevelopment approach, which is a holistic effort aimed at restoring the village ecosystem and ensuring its sustainability for the future.It aims at making the village which is a physical as well as a social unit self sustaining for its requirements of fuel, fodder, small timber . This can be acieved through planting effort on village wastelands, farm boundries without affecting in any way the agricultural production. These areas have enormous capacity for generating additional produce, a fact which has been grossly understimated in our planning. Induction of realistic and complementary of measures like biogas, stall feeding of cattle, solar cookers and solar water heaters ,(at domestic as well as at community levels) can make a world of difference to the eventual success of the planting effort. As a special activity within this village ecodevelopment effort one could also usefully think of a green belt all along the coastal fringe as a social need.Irrespective of their legal ownership of the land, this belt could cover the supratidal zone as well as the intertidal zone .For example the supratidal component could be planted up with tree genera like *Casuarina equisetifolia , Calophyllum inophyllum, Terminalia catappa,* and the mangrove mudflats could be planted up with Avicennia officinalis and Rhizophora mucronata. There is no need to clutter the effort with large number of species.Rather one should concentrate on plant genera that are most likely to succeed and are relevant to the people. The tree growth on the government owned land could be attached to the Panchayat for nmanagement as a community asset This could function as community fuel wood and fodder asset which can be availed of in case of an emergency and not otherwise. On privately owned land the such tree growth could be treated as a private asset, to be maintained by the owner. This will bring into existance a greenbelt consisting of supratidal species as well as mangroves which would collectively have economic as well as environmental benefits to the village community. Experience in Orissa has reiterated that where there had been good coastal Mangrove growth the storm damage in the hinterland was much reduced. Mangroves also act as nurseries for the annual recruitment to our coastal fisheries. The ecodevelopment approach will involve the people themselves and when the benefits become tangible and real , their support for the protection and maintainance of these assets would be voluntarily forth coming. Such a comprehensive coastal village ecodevelopment could cover all the villages on the coast of say Maharashtra in a finite period of 5 years, and give it total coverage, leaving the subsequent years only for maintainance and selective harvesting activities. In view of its obvious utility and ecological benefits to the coastal communities ,there is good chance that funding for it could come from bilateral or multilateral donor agencies. I strongly feel that only such a comprehensive and focussed approach would be a reasonable way out of our present morass. In its absence there is every likelihood of the mangrove and related ecological development on the coast going four steps forward and three steps backwards.Considering the limitations of the time frame within which the ecosystem needs to be rehabilitated this is no way to wards progress.

Two other points also need to be attended to in the above context. First relates to construction of Kharland bandharas.These are constructed traditionally to keep the influx of salt water out so that rice cultivation can take place in the hinterland of the Bandharas. However in the process Mangroves located behind such Bandharas get killed of due to the blockage of the tidal inflows. It is now understood that agricultural research scientists have over the years evolved new salt tolerant varieties of rice.This sort off knocks out the rationale for construction of the Kharland Bandharas. Adopting such salt tolerant rice varieties in our coastal belt may not only save mangroves but also the expenditure on construction of the Bandharas. This matter needs to be

thoroughly investigated as a masters or doctoral level study and factual position brought out for the information of the people.

It would also be very helpful if studies are carried out to establish the viability period of the Mangrove propagules in their free floating condition. (*Avicennia* and *Rhizophora*) If this is long then a large quantity of propagules can be collected in the rainy season and maintained in free floating condition in Net enclosures located strategically in our coastal creeks at a nominal cost.It will greatly facilitate mangrove planting activity, through year round direct sowing of the propagules in suitable spots on our coastal belt. It is also now known that aerial seeding of Bamboo in the western ghat tracts, even on as is where is basis gives reasonably good numbers of established Bamboo clumps. Perhaps large coastal mudflats could be seeded aerially with mangrove propagules and thus covered effectively in very short time.

These are some points for consideration.In the final analysis it is felt that unless we adopt bold and focussed coastal village ecodevelopment approach in the coastal belt and integrate new innovative methods in it's working, mangrove rehabilitation success on a wide scale will continue to elude us. Thus there is urgent need to pause and do some serious introspection on the rehabilitation strategies adopted so far for the mangroves, and the ground realities and carry out appropriate mid course corrections.

BACK GROUND INFORMATION RELATING TO DR.A.G.RADDI

Retired in 1995 from the Indian Forest Service as Principal Chief Conservator of Forests, Maharashtra ie head of the Forest department in Maharashtra state. Prior to that held different posts eg Chief conservator of Forests, coordinating the 431 crore World bank aided Maharashtra Foresty sector Project. Has also functioned in Govt of India Department of Tourism at the level of Deputy Director General in charge of wild life Tourism development in the country.As Joint Director Social Forestry was instrumental in initiating Mangrove afforestation in the coastal Districts of Ratnagiri and Sindhudurg.

On retirement functioned for few years as consultant on UNDP, World Bank projects as well as advising private Industry on conservation related matters.

Has B.sc. in Botany ,Zoology and Geology from Univ of Pune., Msc in Marine zoology from Univ of Bombay, Holds Ph.D in zoology (wild life) from University of British Columbia , Canada. Has Associate ship of the Indian Forest College, Dehradoon. Has been elected fellow of the Maharashtra Academy of Sciences.

Considers himself as a Naturalist Forester. Presently leading a quiet retired life in Pune, doing reading, writing, some lecturing on topics of interest. Associated in an advisory capacity with social organisations dealing with Social Forestry, nature conservation , and Ecodevelopment. Has travelled extensively in country as well as abroad.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 37-40

INDIAN MANGROVES : CONSERVATION ASPECT

Vivek Kulkarni
Mangrove Project
Godrej & Boyce Mfg. Co. Ltd.

WHAT IS MANGROVE

Mangroves are tropical and subtropical littoral plants growing at the interface between the land and the sea. They grow on clayee soil which is flat and sloping gently (mud-flats) and in the region where tidal action brings in water regularly. Mangroves are found extensively in the **estuarine regions** where mud-flats are wide and gently sloping. Besides estuaries, they also inhabit the intertidal regions of shallow bays and creeks where the environment is conducive for the growth of mangroves.

In different parts of the world, Mangroves are called as 'mangals', 'coastal woodlands', 'tidal forests' etc. and are littoral plant formations. The Shorter Oxford Dictionary describes the word "mangrove" as obscurely connected with the Portuguese word "mangue" and the Spanish word "mangle" and the English word "grove" and it dates its origin as 1613. This explaination of the origin of the word has been largely accepted throughout the world. However, Martha Vannucci in her book "The Mangrove and Us" claims that the word "mangue" derives from the national language of Senegal. She comments that it was probably adopted by the Portuguese, and later modified by the Spanish.

Mangroves are very special plant community with highly evolved morphological and physiological adaptations to extreme conditions. Because of their environment, mangroves are highly tolerant of salinity and have mechanisms to take up water despite strong osmotic potentials. Some also show excretion of salts through specialized glands in the leaves. Others transfer salts in leaves or store them in the bark or the wood. Some mangroves maintain body salts through intake of excessive water. Morphological adaptations include profuse lateral roots that anchor the trees in the loose sediments, exposed aerial roots for gas exchange and viviparous water-dispersed propagules.

Through the specialised root systems and other morphological adaptations, mangroves form dense forests on the shore lines, creating a secured habitat for a variety of fauna. Since mangals are transition ecosystems, they give refuge to terrestrial, marine/ brackish water as well as purely intertidal organisms, making itself a richly diversed ecosystem. The muddy or sandy sediments of the mangal are home to a variety of epibenthic, infaunal, and meiofaunal invertebrates. Channels within the mangal support communities of phytoplankton, zooplankton, and fish. The mangal may play a special role as nursery habitat for juveniles of fish whose adults occupy other habitats (e.g., coral reefs and seagrass beds) Because they are surrounded by loose sediments, the submerged mangroves roots, trunks, and branches provide niche for epifaunal communities including bacteria, fungi, macroalgae, and invertebrates. The aerial roots, trunks, leaves and branches host other groups of organisms. A number of crab species live among the roots, on the trunks or even forage in the canopy. Insects, reptiles, amphibians, birds and mammals thrive in the habitat and contribute to its unique character.

As a transition habitat between the land and the sea mangroves are well adapted to deal with natural stressess like temperature, salinity, lack of oxygen, wave action, wind currents, etc. However, as these mangroves live close to their tolerance limits, they are particularly sensitive to any other disturbances like those created by human activities. Especially, in the past few decades, human activities in the shore regions have increased with many folds having tremendous impact on the coastal communities like mangroves.

Habitat destruction through human encroachment has been the primary cause of mangrove loss. Diversion of freshwater for irrigation, hydro-electricity, drinking purpose and land reclamation in both rural and urban areas has destroyed extensive mangrove forests. Nearly 80% of the coastal wetlands have been destroyed since the pre-agriculture time and most of it in the time since the industrial revolution.

Measurements reveal alarming levels of mangrove destruction. Some estimates put global loss rates at one million ha per year, with mangroves in some regions in danger of complete collapse. Heavy historical exploitation of mangroves has left many remaining habitats severely damaged.

These impacts are likely to continue, and worsen, as human populations expand

further into the coastal areas. Comparatively, minimal conservation efforts are attempted in India.

Mangroves are ecological heritage. They are sole protectors of the coastlines. They enrich coastal waters and soils, yield commercial forest products and support coastal fisheries. Mangrove forests are among the world's most productive ecosystems, producing organic carbon well in excess of the ecosystem requirements and contributing significantly to the global carbon cycle. Extracts from mangroves and mangrove-dependent species have proven activity against human, animal and plant pathogens. Mangroves may be further developed as sources of high-value commercial products and fishery resources and as potentialsites for ecotourism.

TYPES OF MANGROVE FORESTS

Mangrove forests are best developed on tropical shorelines where there are large areas available between high and low (mid) tide points. Large mangrove formations are typically found in sheltered muddy shorelines that are often associated with the formation of deltas at the mouth of a river system. Mangroves are also found growing on sandy and rocky shores, coral reefs and oceanic islands. There are instances where islands can be completely covered by mangroves. It is difficult to describe a typical mangrove forest, as the variation in height and girth, even for the same species, is immense, depending on the many factors that control growth. However, for simplicity, there are some functional types of mangrove forests found by the scientists. The various functional types of mangrove forest can be briefly described as:

Over wash mangrove forests: These are small islands covered with mangroves that are frequently washed by the tides. The dominant species is *Rhizophora* or the red mangrove.

Fringing mangrove forests: These strips of mangroves are found along waterways and are covered by daily tides. The dominant species is red mangrove.

Riverine mangrove forests: These are luxuriant stands of mangroves along tidal rivers and creek with a good input of fresh water. Often composed of red mangrove, grey mangrove, mangrove apple, etc.

Basin mangrove forests: These are stunted mangroves located in places such as the interior of swamps. Often dominated by *Avicennia* or the Grey mangrove.

Hammock mangrove forests: Similar to basin mangrove forests but are found in more elevated sites.

Scrub mangrove forest: A dwarfed stand of mangroves found on flat coastal fringes.

THE WORLD DISTRIBUTION

Mangroves dominate approximately 75% of the world's tropical coastline between 25^0 N and 25^0 S latitude. There are two centres of mangrove diversity. These are: Eastern Hemisphere, i.e., East Africa, India, Southeast Asia, Australia and the Western Pacific and Western hemisphere, i.e., West Africa, South and North America and the Carribean countries. These areas include around 30 countries spread in Africa, North and South America and Asia.

Region	Mangrove area (ha)	Percentage to global area
South and Southeast Asia	7517300	41.
Australasia	1878900	10.4
The Americas	4909600	27.1
West Africa	2799500	15.5
East Africa and the Middle East	1002400	5.5
Total	18107700	100

Source: Spalding *et al* (1997)

From the table, it is clear that the most extensive mangrove vegetation is observed in South and Southeast Asia.

DISTRIBUTION OF MANGROVES IN INDIA

In India, mangrove vegetation is observed all along its 5700 km coastline. India's coastline can be divided in to two parts, viz. Western coast on the Arabian Sea and the Eastern coast on the Bay of Bengal. Western coastline includes five States, viz. Gujarat, Goa, Maharashtra, Karnataka and Kerala. The eastern coastline consists of states of West Bengal, Orissa, Andhra Pradesh, Tamilnadu and Andaman & Nicobar Islands. However, the distribution, extension and number of species in these areas differ according to the physiographic formation of the coast. The west coast is more or less steeply shelved, lacks major deltas and river estuaries and is dominated by sandy or rocky substratum. On the other hand, the east coast is shallow, largely influenced by major deltas and river estuaries and mostly dominated by the deltaic alluvium. Hence, East Coast is considered as better place for the development of mangroves.

In India, as well as across the globe, there has been different estimates of mangroves. Just a glance at the following table can give brief idea of the totally unrelated figures. Therefore, it is very difficult to give exact estimates of the mangrove distribution, which is a major hinderence in deciding management strategy for the mangroves in India.

Total areas in the world	1,71091 Sq. km.
(source : Wacharakitty, 1993) In the world	1,810700 Sq. km.
(Source: Spalding, et. al. 1997)	
Total areas in India (non IRS)	6756 Sq. km.
Total areas (IRS) India	4844 Sq. km.

COMMERCIAL VALUES

The economic value of mangroves has been known only to the coastal communities due to their peculiar position. Also, mangroves have been largely remained unexploited due to their inaccessibility. Nevertheless, the recent research and traditional records have shown a lot of economic uses of the mangroves. As anthropogenic pressures are mounting on the mangroves, economic perspective might help in preserving them. Some of the commercial values of mangroves have been listed below:

Firewood and Charcoal

Adhesive

Timber for house and ship building

Fish food and fish float Fishes

Shrimps and prawns

Perfume

Crabs, shelfish amd crustaceans

Soft wood industries

Oils

Tannin

Alcohol used as transport fuel

Rayon

Ply wood

Fibre

Paper pulp

Fodder

Condiments

Honey and wax

Sweet meat

Medicine

Cigarette wrappers

ENVIRONMENTAL VALUES

Compared to the economic values of the mangroves, the environmental values are extremely high and crusial. The list given below, highlights some of the environmental values attached to the mangroves.

Protection from wind, storm, cyclone and hurricanes.

Shore line stabilization.

Reduction in coastal erosion.

Natural land reclamation from sea.

Protection to coastal agriculture.

Shoreline nourishment.

Transportation of coastal pollutants to the deep sea.

Oxygen generation and carbon fixation.

Preservation of gene pool.

Protection to inland flora and fauna from the effect of sea level rise

Breeding and Nursery grounds for fish and and other marine vertebrates/invertebrates.

Reduction in coastal pollution.

Habitat for a variety of mammals, birds, reptiles and amphibians.

Eco-tourism

Education and Scientific studies

PROBLEMS

Mangrove ecosystems are receiving increasing attention, but we still lack much basic information about their structure and function. There are still fundamental gaps in our knowledge of the reproductive biology of mangroves, and mangrove evolution is poorly understood. We are still far from understanding energy flow and food web dynamics in mangrove environments and how the mangroves connect with other ecosystems. There is a great need to better understand the effects of environmental change and pollution on mangrove flora and fauna. Animals that are highly dependent on mangroves need additional study, particularly with respect to larval supply and recruitment. Such ecobiological research can be linked to management of mangroves and associated fishery resources (e.g., Bacon and Alleng, 1992; Hudson and Lester, 1994; Fouda and Al- Muharrami, 1995).

Mangrove ecosystems are seriously threatened, mainly by human activities that impact the habitat (Pons and Fiselier, 1991; Fouda and Al-Muharrami, 1995; Farnsworth and Ellison, 1997a; Figure 20). The value of mangroves has gone unrecognized for many years (Farnsworth, 1998a) and the forests are disappearing in many parts of the world. The full extent of the damage is not yet fully known, but technological advances (e.g., airborne multispectral sensors and satellite imagery) are allowing researchers to map and monitor mangrove habitats (Ibrahim and Hashim; 1990; Gang and Agatsiva, 1992; Lin *et al.*, 1994; Aschbacker *et al.*, 1995; Wei *et*

al., 1995; Long and Skewes, 1996; Green *et al.*, 1997, 1998; N.F.Y. Tam *et al.*, 1997; Blasco *et al.*, 1998; De Jesus and Bina,1998). The results of such studies are not encouraging; mangrove habitats continue to shrink around the world.

In India alone, the maximum threat to Mangroves comes from land reclamation for various reasons. Reclamation for agriculture is the major culprit. Various States have policies to reclaim mangrove habitats for agricultural production. For example, the Maharashtra State has a body of irrigation engineers called as Kharland Development Circle. Under the pretext of development of these areas, over 80,000 ha area has been destroyed. These activities has not only developed large tracts of saline blanks but destroyed equal area of agricultural fields. Large areas have also been destroyed for aquaculture, especially on the East Coast. On the West Coast, new aquaculture projects are fast emerging and may compete with the east coast in the near future.

It has long been known that mangroves protect and stabilize coastlines. They are more effective than concrete barriers in reducing erosion, trapping sediments, stabilizing shorelines, and dissipating the energy of breaking waves (Pearce, 1996). However, in the highly priced urban areas like Mumbai, Chennai, Kolkata and some other coastal cities, reclamation of land and construction of retaining walls with tetrapods are still preferred by the engineers.

Cutting of mangroves for fuelwood and for charcoal is another major reason for the loss of mangrove cover. The fuelwood problem in most of the coastal regions has been badly managed by the authorities including the Forest and Social Forestry Departments. This has led to scarsity of fuel wood which is replaced

There are a number of other reasons for the destruction of the mangroves. The main reason for this destruction is lack of awareness, increasing land prices for coastal areas and general apathy.

STRATEGIES

As discussed earlier, there is urgent need for evolving a strategy to save mangroves and other coastal communities. The strategy should involve Policy, legislation, and effective implementaion. As seen everywhere, our policies generally lack clear vision. The legislation has plenty of loopholes and implementation is week. One of the major reason for such failures is legal and institutional issues have received little attention by the decision makers in the country. There are several underlying reasons for this lack of effort by the concerned Government agencies. The factors for this oversight range from the lack of resources and ulterior political interest amongst the concerned agencies to the vast number of multiple users and economic interests attached to the coastal wetlands. The lack of accurate scientific information on wetlands particularly with the vast body of decision makers is another key factor responsible for the neglect of the review of laws and institutions governing wetlands. This is further aggravated by the number of laws and institutions applicable to wetlands.

The existing body of laws (within the federal structure of the Government of India) applicable to wetlands can be classified into four categories: central laws, state laws, municipal laws as well as customary laws (sanctioning wise use or management of wetlands). Significantly, at the central level, wetlands do not have a separate legal definition or legal entity under the existing environmental laws. In other words, the corpus of environmental laws do not extend exclusive protection to wetlands as distinct ecosystems.

⇒ There is a need for a systematic study of the legal system and the institutions that would be involved in wetland management in the country. This study would need to reflect a holistic perspective of mangrove management in the country and therefore would need to go beyond action taken by Government's agencies and departments and look at local and customary practices of wise use and reviving and supporting local institutions that regulate these practices.

⇒ A National Mangrove Policy for India would need to suggest broad guidelines for affirmative action for mangrove conservation.

⇒ The Environment(Protection) Act, 1986 can be effectively used to phase out certain unsound practices and ensure safeguards for threatened wetlands. For example, Acts like Kharland Act in Maharashtra needs to be abolished to stregthen CRZ Notification.

Lastly, It is imperative for instituions at all levels to come on a common platform to save Mangroves in India.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 41-43

PROTECTING INDIA'S COASTLINE – THE COASTAL REGULATION ZONE NOTIFICATION

Debi Goenka
Bombay Environmental Action Group
Environmental Education Office
Kalbadevi Municipal School, 54, 2nd floor, Mumbai 400002

India is blessed with a bountiful variety of habitats – from the coast to the Himalayas, the diversity of India's natural habitats is virtually unmatched. What is sadly lacking is the will of the people to protect this rich diversity, and unfortunately, even the decision makers of today have failed to realise the importance of protecting our natural assets. The link between forests and water conservation are still a mystery to our political leaders and even our bureaucrats, despite year after year of droughts, invariably followed by floods. Similarly, the role of wetlands and the fact that wetlands are some of the most productive eco-sytems in the world has still to be recognised in practice. And the fact that our coastal zones are some of the richest and biologically most productive areas is still to be recognised.

Basically, the coast is the interface between the land and the sea. The beaches and the inter-tidal zones are literally the area where the transition from land to sea, or sea to land, takes place. Considering the fact that the first life forms evolved from the sea, and gradually migrated to the land via the inter tidal zones is a fact that very few people still remember. And the fact that several tens of millions of people depend on the coastal bounty for their survival, and not on the non-existent rations in the non-existent PDS, is also a factor that does not seem to affect decision making.

India is probably the only country in the world that has legislation in place for protecting the entire coastline of the country - and it is not only the actual coastline that is protected but also the land between the High Tide Line(HTL) and the Low Tide Line (LTL) as well as the land extending to 500 metres from the highest HTL. Indeed, February 19, 1991 will go down as one of the greatest and most glorious days for the protection of the country's coastal environment, for it is on this day that the Coastal Regulation Zone (CRZ) Notification was issued by the Government of India, Ministry of Environment & Forests (MEF).

The Coastal Regulation Zone Notification, or CRZ notification as it is universally known, is perhaps one of the most forward looking pieces of legislation in India. Not surprisingly, it is also one of the most controversial of the environmental laws of our country today.

The genesis of the CRZ notification lies in a simple letter that the then Prime Minister of India, Mrs. Indira Gandhi, wrote to the Chief Ministers of all the coastal states on 27th November 1981, directing them to ensure that the entire coast line of India should be protected from environmental degradation. In her letter, Mrs Gandhi also stated that the 500 metre strip of coastline should be kept free of all unnecessary development. The Chief Ministers were also asked to get a Coastal Zone Plan prepared for their entire state and get the same approved by the Central Government.

It was perhaps not surprising that almost every Chief Minister immediately wrote back to her stating that this "directive" would be enforced. In one case, one of the Chief Ministers even suggested that the 500 metre strip would be inadequate and it would be necessary to protect an area of 1000 metres.

Unfortunately, since the Prime Minister's directive had no legal statutory basis, it was never really seriously enforced anywhere in the country. As long as Mrs. Indira Gandhi remained in power, some kind of semblance of enforcement was observed. As we all know, the moment she was out of power, all intentions to comply with this directive also disappeared. The directive itself was conveniently forgotten by the State Governments. For every State Government - it was back to business as usual. Every State Government resumed the indiscriminate setting up of industries, residential building, commercial buildings, etc. wherever permissions were sought. In the State of Maharashtra, the "Kharlands Board" continued to reclaim coastal wetlands for the cultivation of salt resistant varieties of paddy—in the process, thousands of acres of mangrove ecosystems were destroyed.

Needless to say, not one State Government even attempted to prepare the Coastal Zone Plan – in the case of Goa, which was then a Union Territory, an attempt was made by the UT administration to prepare a plan, but this document also never really saw the light of day.

(i) Areas that are ecologically sensitive and important, such as national parks/marine parks, sanctuaries, reserve forests, wildlife habitats, mangroves, corals/coral reefs, areas close to breeding and spawning grounds of fish and other marine life, areas of outstanding natural

beauty/historical/heritage areas, areas rich in genetic-diversity, areas likely to be inundated due to rise in sea level consequent upon global warming and such other areas as may be declared -by the Central Government or the concerned authorities at the State/Union Territory level from time to time.

(ii) Area between the Low Tide Line and the High Tide Line. No construction or any activity is permitted within 500 metres of such areas. However, in case of the the land between HTL and LTL which is also classified as CRZ I. However, in such cases, certain activities (such as laying of pipelines) are permissible.

CRZ II is defined as areas that are within the limits of legally designated urban areas, are substantially built up and which are provided with infrastructural facilities such as drainage and approach roads, water and sewage mains, etc.

CRZ III is defined as those that are neither within I & II.

CRZ IV category is applicable to islands.

The CRZ Notification stipulates the types of prohibited and permissible activities - it also stipulates that a Coastal Zone Management Plan (CZMP) should be prepared and submitted to the MEF for approval within one year of the date of the Notification i.e. by February 19, 1992. Until such time as the CZMP is approved, the State Governments are directed to strictly implement the provisions of this Notification.

What is interesting is the fact that the CRZ notification was not supported in 1991 by even one State Government. In fact, the draft notification was objected to by almost every State Government. The MoEF itself was under terrific pressure, and totally unable to withstand this. In fact, the officer who conducted the hearings and drafted the final notification can be thanked for the horrendous ambiguity and lack of cohesion that emerged from the battering the draft notification got from the State Governments. However, looking back, it now seems incredible that a notification like this, though castrated in many ways, got gazetted at all.

The ambiguities and inconsistencies in the notification, and there are several, have been capitalised upon by builders, industrialists, hoteliers, State Governments, port authorities, highway authorities, and all the other vested interest lobbies whose only interest is to put up their projects along the coast line. However, to my mind, these inconsistencies and ambiguities can still be easily resolved if one accepts the fact that the notification was brought in to protect the coastal environment. I have been saying it at meeting after meeting, and at every conference when we meet with lawyers to discuss and draft legal challenges to CRZ violations. And certainly, when viewed in this perspective, things certainly become much clearer.

Since the notification has been enacted, I think the Bombay Environmental Action Group and the Goa Foundation have been the two NGOs that have been actively fighting for the implementation of the CRZ notification at the grass roots level. Amongst the two groups, perhaps more than 50 cases have been filed in the Bombay High Court only on CRZ. And I still remember with agony attempt after attempt that has been made to destroy the CRZ notification in our Courts. Fortunately for us, the boost from the Supreme Court in upholding the CRZ notification in 1996 has made a tremendous difference, but I still remember one memorable day in the Bombay High Court when, despite the Supreme Court Order, every line of the CRZ notification was dissected with the objective of establishing the fact that this notification could be applied only to industries!

NON IMPLEMENTATION OF THE NOTIFICATION

What is shocking is the fact that not one State Government had prepared a CZMP even by mid 1993. This provoked a Writ Petition being filed in the Supreme Court of India by the Indian Council for Enviro-Legal Action. It was only following a series of orders from the Supreme Court of India that the MEF and the State Governments woke up from their slumber. Finally, on September 27, 1996, the CZMPs were conditionally approved by the MEF.

The State Governments were asked to collect various types of information, from sources specified by the MEF, and superimpose these on the maps approved by the MEF. Thus, for example, information regarding the breeding grounds for turtles was to be collected from the Wildlife Institute, Dehra Dun; information about mangroves, mud flats, coral reefs was to be obtained from the Space Application Centre, Ahmedabad; etc. A two month period was provided for this purpose.

It is not surprising that not one State Government has submitted the final CZMP to the MEF.

In the interim, what is happening? One has to only look at different parts of the coastline to realise that very little has changed. The Municipal Corporation of Greater Mumbai has destroyed two extensive patches of mangroves for the purpose of setting up sewage treatment plants and aeration lagoons. The Mumbai Metropolitan Regional Development Authority is still busily reclaiming land in the Bandra-Kurla Complex in total defiance of the CRZ Notification and the Orders of the Supreme Court. So is the case in New Mumbai. Reclamation is still going on in Versova and in Malad. The BSES power project in Dahanu continues to discharge fly ash and bottom ash within the inter-tidal zone, and the Dabhol Power Company has merrily dumped thousands of tons of soil into the creek and reclaimed land for their power project jetty. Hundreds of illegal buildings have been constructed within the CRZ areas after 1991. In Mahim Bay, when the MoEF gave

environmental clearance to the Bandra Worli "sealink" project, the project proponents were permitted to reclaim not more than 4.7 hectares of land for the toll centre. And guess what has actually happened? About 30 hectares of land has been brazenly reclaimed in total defiance to the law, and orders of the Supreme Court to strictly implement the CRZ notification have been conveniently and completely forgotten.

Another major threat the coast line has been the aquaculture projects. Supposedly meant to increase the marine exports, these projects have been environmental disasters. Most of the aquaculture projects have come up in areas that were rich in mangroves. So the first step has been to invariably build embankments with the intention of blocking the flow of tidal water and thus killing the mangroves. Secondly, to maintain the salinity of the sea water at the desired levels, the ground water is ruthlessly exploited to compensate for evaporation losses, thus depriving the local communities of their drinking water sources. This form of over-exploitation also results in salinity ingress. And finally, since the modern high tech aquaculture centres rely on high dosages of nutrient feeds laced with antibiotics to maintain the high growth rates, the impact of the wastes that are pumped out into the natural ecosystem are catastrophic. Not only are the local fish populations decimated, but the spread of bacteria and infections ultimately results in even the aquaculture ponds from being wiped out. And yet, hundreds and thousands of new aquaculture projects were coming up, particularly along the east coast, until the Supreme Court stepped in and put a stop to it. And what is the Government's response – a new Aquaculture Bill that will circumvent the Supreme Court judgment and allow the destruction of our coastline to continue.

WHAT IS THE SOLUTION?

However, what is reassuring is that despite efforts at the highest levels, the CRZ Notification still remains in force. Secondly, citizen groups and environmental groups all over the country are getting organised and are taking legal action against specific violations. Some State Governments have also finally realised that the protection of the environment should also be given priority.

The role of the mangroves in mitigating the impact of the recent cyclone in Orissa has fortunately been realised. Preliminary surveys carried out a few days after the "super cyclone" devastated the coastal areas of Orissa in 1999 indicated that areas that had good mangrove cover suffered minimal damage as compared to those areas that had destroyed their mangroves.

Rather than opposing the CRZ notification and asking that it should be further relaxed or scrapped, it would be desirable if the State Governments appreciate the importance of protecting the coastline.

The basic approach should be to restrict new development within the CRZ to the bare minimum and allow only those activities that are essential.

CRZ I areas should be scrupulously identified and protected.

It is imperative that any fresh investments along the coastline should be critically examined keeping in mind the fact that vast stretches of our coastline would probably be submerged within the next 30-50 years as a consequence of Global Warming. Storm/cyclone damage is also likely to escalate over the years.

NIO should be asked to do a report on the impact of Global Warming on coastal areas. This information is already required to be collected by the State Governments as stipulated in the conditional approval of the CZMPs by the MoEF vide its letter of September 27, 1996. However, there seems no harm if the MoEF independently commissions NIO to do this study for the entire country.

A Study needs to be done urgently to establish the mitigative impact of mangroves in minimising the cyclone damage in Orissa.

The need to permit only genuine local inhabitants to continue to expand their dwelling units to cater to natural growth – outsiders should not be allowed to masquerade as locals.

The notification needs to be redrafted only to remove the legal loopholes/ambiguities. However, if it is accepted by all that the basic intent of the notification is to protect the environment and the coastal areas from the impact of unwanted activities, there is actually very little ambiguity.

Coastal zone management plans require to prepared on a scientific basis by an institution that enjoys high credibility within and outside the Government.

There is also a need to establish the links between reclamation and erosion. The need of the hour is that any reclamation, if allowed at all, should be kept to the bare minimum and allowed only where it is absolutely unavoidable.

People must also be made aware of the fact that Global Warming is now a reality. The effect of Climate Change as a result of Global Warming will result in the rise of sea levels. At a national level, such changes could lead to the submergence of vast areas of Bangladesh, leading to a massive influx of ecological refugees into India. Cities like Mumbai, which in any case get submerged with 15 centimetres of rainfall will also be affected. As I never fail to mention, automobile pollution would not be a problem in Mumbai 50 years down the line – not because automobiles would be non-polluting – but because we would all be commuting by boats!

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 44-46

SOLID WASTE MANAGEMENT IN INDIA

K.S.Gokhale

Estuaries and creeks are the victims of rapid industrialization and urbanization due to their easy access. The classic example is of Thane creek which receives 1000-million liters/ day of industrial effluent and domestic sewage and approximately 3000 metric tonnes of solid waste per day from 300 authorized and unauthorized dumping grounds situated in the vicinity of Thane creek. Often the solid waste is directly dumped in the creek due to various reasons. This initiates the encroachment and subsequent reclamation resulting in indiscriminate destruction of mangrove mudflats, hindering the tidal flow leading to siltation and pollution. It also disturbs the breeding and feeding habitats of organisms like fishes, crabs and prawns. Nowadays the solid waste management is attracting greater attention particularly during outbreaks of epidemics like plague, dengue and leptospirosis. Otherwise it remains neglected as it is considered an inferior function by the authorities concerned.

Unfortunately the literature on this subject is scanty which concentrates mainly on technologically advanced treatments, which are more suited to laboratory research. Solid waste management is neither just technology nor mere the organization of a workforce. It encompasses many disciplines like sociology, management science, town planning, mechanical engineering, financial management, geology, environmental engineering, environmental science, chemistry and even public relations. That makes it all the more difficult to make it successful. Merely collection of garbage and dumping it near the creek is only a superficial treatment and not the real solution to the problem. The solution lies in reducing the garbage by segregation of wet and dry garbage at the source itself and banning the main culprit- plastic.

PRESENT STATUS OF SOLID WASTE:

According to NEERI (1996), the waste generation rate depends on the population (Table 1).

The urbanization in India is rising rapidly with 25.72% of total population living in cities according 1991 census. This percentage is expected to increase to 30.5% in 2001. Further the number of urban areas is also rising with 65.2% of urban population concentrated mainly in larger urban agglomerations. This clearly indicates the problem of solid waste management (SWM) is going to be a challenge to the urban local bodies.

Table 1 Waste generation per capita.

Population range in lakhs	Average per capita waste generation Gms/capita/day
1 to 5	210
5 to 10	250
10 to 20	270
20 to 50	350
50 lakhs above	500

Table 2 Physical characteristics of Solid waste

Population Range In Lakhs	Paper %	Rubber, Glass %	Total Compostable %	Inert Material %
1 to 5	2.91	1.67	44.57	43.59
5 to 10	2.95	1.51	40.04	48.38
10 to 20	4.71	1.66	38.94	44.73
20 to 50	3.18	1.55	56.67	40.07
50 lakhs above	6.43	2.02	30.84	53.90

NEERI 1995

This shows larger cities have more non-biodegradable matter and less compostable material.

Table 3 Chemical Analysis of Solid Waste

	Before Composting	After Composting or Decomposer
Total N	0.56-0.71 %	0.9-1.3%
Total P- P2O5	0.52-0.82%	0.9-1.5%
Total K- K2O	0.52- 0.83 %	0.08-0.5%
C/N Ratio	21.13-30.94%	–
Caloric Value in Kcal/Kg	800.70-1009.89	–

(NEERI (1995) & Fertiplant Engineering Co.Pvt.Ltd.., Mumbai at pH 7 to8. ,moisture-10 to 12% &org.C 15 to 17%.) High contamination of heavy metals in solid waste has been reported with Cu-200ppm, Zn-900ppm, Fe-900ppm, Mn-250ppm & Boron-120ppm.

The prevalent practices show that all the solid waste is mixed indiscriminately. The waste consists of

a) Domestic waste collected in domestic bins or municipal bins or thrown on the streets.

b) Construction waste lies along the road obstructing the traffic.

c) Biomedical waste or infectious hospital waste which has to be incinerated.

d) Industrial waste- No suitable licensed sites, inadequate treatment facilities singly or collectively.

Hence these wastes have to be segregated at the source so that the recyclable material can be saved with out being soiled or deteriorated.

Solid waste management is an essential service of local bodies like municipalities or corporations. It is obligatory to arrange for street cleaning, transport, processing & disposal in an environmentally acceptable manner. They almost spend 70 to 80% of their resources (excluding expenses of establishment) on this essential service. Despite this SWM shows poor level of management (50%) on account of apathy shown by the authorities.

I) PRIMARY COLLECTION

• This activity is carried in the most primitive and inefficient way. The segregation of bio degradable and non-biodegradable waste has to be done at the household level. The recyclable material has to be given to the rag pickers at the source so that the quality of this material does not deteriorate. Further the rag pickers are interested only in the recyclable waste which can be sold saving the national resources. Many industries are based on this recyclable raw material (from 30 –100 %.) Non-recyclable and non-biodegradable waste like plastic of less than 20 micron is not collected by the rag pickers hence it lies littered on the road. They must be motivated to collect it, paying them extra if necessary as they spend time and energy in doing this work. The best solution for this problem is total ban on the plastic. Biodegradable matter can be converted in to the compost.

Community dustbins must be at the appropriate short distance (varies from 100m to 1000m). Smaller bin sizes must be suitably designed and kept on smooth approachable pavement so that they can be emptied easily. A favorable ratio between the number of household and community dustbins (varies from 130 to 2389). Must be standarised as suggested by the expert committee a pointed by the Supreme court.

• Street sweeping: This activity has to be done twice a day by standardizing the road length to be swept (varies from 100m to 5 km) depending upon the roughness of the road, households in the area and the quality of the tools like broom, metal plates and wheel barrows for collection. No protective equipment is provided to them to handle the health hazardous waste. Double handling of garbage is unnecessary. The main deficiency in the SWM is the lack of supervision, motivation and neglect of slums. Furthermore organized labour unions and huge rate of absenteeism are the hindrances in the activity, as a consequence large backlog is created and efficiency is reduced to 50 %.

II) TRANSPORTATION

Various types of vehicles ranging from bullock carts, tricycles, autorickshaws, truck trailers are used. They carry solid waste from the source to the dumping ground (not landfill site). The sanitary landfill site must be certified by testing the porosity of the soil to prevent potential subsoil contamination. The need of the land can be calculated on the basis of 1 cubic meter of land for 0.75 ton of waste. It must be usable for at least 20-25 years. . Instead, any low lying area especially near the creeks or estuaries are used as dumping site causing foul smell & breeding flies. The vehicles are not covered & are in bad condition, which require constant repairs. The dumping ground should lie away from the human habitation to reduce the nuisance value. (e.g. Parsik 5 acres- 10km away, Kausa 18 acres- 22 km at Thane). As no segregation is done at the source they become filled within a year. Often the solid waste is dumped in the waterways to avoid transportation due to absence of proper monitoring of those vehicles and lack of accountability.

III) COMPOSTING

Composting improves the condition of the soil, retention and utilization of natural resources, reduces erosion, improves water retention and root aeration.

There are two types of composting aerobic and anaerobic. Aerobic composting is more suited to the Indian conditions as the solid waste contains 30-50 % organic waste having favorable 10-12 % moisture and C/N ratio. It requires no skills, small land requirement, less time (40 days) and less foul smell and has market potential. It can be decomposed either by microbial culture or vermiculture.

Anaerobic composting requires 180 days causes nuisance & does not kill the pathogens.

IV) ROLE OF NGO'S

It is the lack of community involvement which causes the failure of SWM. NGO's can play a greater role in creating awareness acting as a catalyst between community and local bodies and working as pressure groups. The problem of SWM is so large that all available help is needed and hence however small the role of NGO's, it should not be despised or ridiculed. NGO's do make impact in many ways by initiating socially oriented pilot projects. Their attitudes are also flexible and have inherent potential to improve. The authorities should encourage them even though their impact may be localized. They are not politically active and they do not work for the local bodies but work with them. Translating an idea into the reality requires experimentation and constant modification which can be done by only NGO's. Besides NGO's have dedicated and committed workers and can supervise the work, improve the recycling and provide backup support.

The other alternatives for the disposal of waste are incineration, which requires high capital operation and maintenance cost with high technical skill. The waste contains 3- 7 % plastic which has to be carefully separated. Besides, it cannot burn without any external fuel as the caloric value (800-1000 Kcal/Kg) is low, producing high amount of ash. Many have recommended it for power generation, fuel pellet and bio-methanation which have yet to get installed successfully in India. Adequate experimentation and better technology backup is required for this purpose which is badly lacking.

It is widely felt that the most expensive solution is always the best. Nowadays privatization has been treated as pill to cure all ills which has many deficiencies. The private operators are not interested without income, unwilling to buy appropriate equipment and exploit workforce to the maximum. Further they create opportunity for corruption.

The central & state government refused to share the functional burden as the local bodies are supposed to be autonomous. Local bodies are reluctant to mobilize the funds. If proper incentives and satisfactory services are given, the residents/societies may be ready to share the financial burden if they are allowed to supervise and actively participate in the process.

India is a huge country with immense variety, energy and talent. It can innovate new schemes with available technology and modify them according Indian condition. Besides these schemes must be affordable, reliable and sustainable. What required is the political will and public awareness. Lack of these makes SWM a herculean task.

The rivers, creeks, estuaries, mangroves and coastal marshy lands suffer the maximum due to solid waste dumping. Hence, in this context, the need for proper solid waste management is emphasized.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 47-50

SEA-LEVEL RISE AND SUNDARBAN MANGROVE

Pranabes Sanyal
Additional principal chief conservator of forests.
Directorate of forests, Government of West Bengal, Calcutta, 700098.
pranabes@hotmail.com

ABSTRACT : Sundarban is the largest continuous mangrove patch of the planet (8500Km^2). During cretaceous period, a creek development in continental shelf of Bengal basin along which the basin is gradually tilting eastwards. As a result there is a continuous subsidence in Sundarban which causes a sea level rise of much greater intensity than eustatic rate of 2.2 mm/year. The base of the hinge is located at Sagar island and the semicircular crack extends to Maymansingh and syllet to meet the Halflong thrust. Thus away from Sagar eastwards the radius of tilt increases, which leads to more subsidence. Resultant rate of sea level rise is 3.1 mm /year at sagar and 10 mm/year at Bangladesh.

This creates a shallow marine condition at Southern boundary of Sunderban and the mangroves are getting a natural pressure to shift northwards where 2/3rd of erstwhile mangroves have been reclaimed to make room for human settlement. The same type of shift occurred 6500 years before at the time of Flandrian transgression when mangove shift was 120 Kms.North. As a result the subclimax species like *Heritiera fomes, Xylocarpus granatum* are tip dying in Bangladesh. Remedial action is to plant up the two species along numerous fresh water canals of reclaimed Sunderban. The experiment in Indian Sunderban has already succeeded.

Key words *:* Sunderban, Sea level rise, mangrove replantation.

INTRODUCTION

The history of formation of Bengal basin starts way back from 126 million years (MY) initiated with Alpine Himalayan Orogeny. The basin was formed initially bounded by Mikir hill and Meghalaya hills on the north, Assam-Nagaland on north-east, Kachar-Surma valley on the east down to 6^0 latitude below sea and peninsular Indian shield on the west. The Bengal geo-province is the western most portion of this entire basin which also comprises of the western part of Bangladesh. The initial delta building continued up to 49.5 million years B.P. During Oligocene period the initial 'proto delta' experienced a strong regression of sea and the coast line shifted south wards taking almost the present configuration. During later part of tertiary between 49.5 to 10.5 million years B.P. this 'transitional delta' received rapid deposition and led to the formation of 'modern delta', (10.5-4.5 million year B.P.).

The late Pleistocene mangrove strand was situated also on the west of river Ganges. In fact, the present tidal excursion in Rupnarayan river also extends up-stream upto the point called Bandar. This strand line is apparent from the lineament called *Bandar - Kalindi* lineament, evident from Land-sat imagery (Map 1). Between 8 to 10,000 years B.P. the shallow marine condition extended only upto north of Barrackpore spreading east wards and north of which the mangroves existed (Banerjee 1996). Such situation was succeeded by Flandrian transgression when tidal mangroves appear in the excavation of Kolaghat to Dumdum line (Hait, 1996). This strand line more or less coincide with the *Jalbandh-Kishorgunge* lineament identified in the landsat imagery (Map-1). During 4000 years B.P. mangrove line came down to Kakdwip-Namkhana area and the line more or less coincide with *Kakdwip-Basirhat-Dhaka* lineament (which is more or less the well known Dampier-Hodges line that marks the northern boundary of the present Sunderbans Biosphere Reserve). The present age of Sunderban mangals can be dated as late as 3000 year B.P.

The general depositional pattern as identified from core samples indicated that enhanced subsidence, which created accommodation space along a NE-SW trend had to accommodate 50m of sediment during past 7500 YBP. A deep lying NE-SW hinge zone, defined on tectonic and stratigraphic criteria, extends from bay of Bengal to delta proper.

Threat of Sea-Level Rise

During the 16th - 18th century Bengal basin suffered a neo-tectonic movement when there was an easterly tilt along a hinge zone (Map 2), starting from Sagar going north of Malda and then curving towards Dhaka. A third observation pertains to trend of surface elevation contours ENE-WSW. As a result the present course of Ganges started flowing along the river Padma within Bangladesh leaving Hoogly the erstwhile course as a mere tidal channel. The tidal excursion of Hoogly used to reach 281 Km. upstream upto Nabadwip, till early eighties. During this period (16th to 18th century) innumerable back water channels of Indian Sunderbans were formed.

John Milliman (1989) from his core sample studies established a threat of global sea-level rise along Bangladesh Sundarban. He identified the following threats :

- Bangladesh coast is subsiding @ 10 mm / y which accelerates the minimum estimate of Global Sea-Level Rise @ 2.20 mm / y.
- There is a tendency of northerly shift of present mangrove vegetation due to rapid development of shallow marine conditions created due this accelerated rise of Sea-level.
- Delta progradation in Bangladesh side stopped during last 200 years.
- Salinity increased in creek waters.
- Salt water intrusion is taking place within coastal ground water aquifer which has been augmented due to a five fold increase in bore wells.
- The dense habitation of reclaimed Sundarban may be more vulnerable to inundation.

Recently McDowell (1995) estimated the sediment load of Ganga-Brahmaputra river system to be 1670 million tones per year which is only 2nd to Yellow river of China. But Milliman estimated seaward directed suspended sediment load of $1060x10^6$ t/year (Stanley J, 1999). Spatial and temporal configuration of Holocene deltaic sediment thickness, mud and sand layers, peats interstratified in Holocene sequences and modern mangrove forests attribute to NE-SW and to lesser extent NW-SE, neotectonic trends. Question arises, where this sediment load goes. As already mentioned Milliman in 1989 determined subsidence rate of Bangladesh Sunderbans to be 10 mm/ year from buried wood radio-metric age determination. Such rate was found to be 25 mm/Year from the single well study in Bangladesh, by Alam. Such subsidence rate from 10 to 25 mm/Year due to slow tilting of Bengal basin can accommodate this huge silt load or else, a good portion is fanned into Bay of Bengal through a submarine Canyon called 'Swatch of no ground'. This crack in continental shelf extends down to 6° latitude marking southern boundary of Bengal geo-province.

Taking cue from Milliman's findings the Indian Sundarban gemorphology was studied in details.The rate of deposition found out from thickness of peat layers by Banerjee (1996) stands as below:

Year BP		Rate of deposition
7000 to 6650	:	0.01 mm/y
6650 to 210	:	10.0 mm/y
2740 to present	:	0.82 mm/y

Further, a study was conducted on all the forested islands of Indian Sunderbans being least affected by anthropogenic interventions over a period of 13 years interval by the Forest Survey of India (Table 1) during pre Farakka periods. The aerial photos of 1968 were compared with the aerial photos supported by Working plan maps and ground verification in 1981. Rate of resultant island building was found to be less than the rate of subsidence/sea-level rise. Rate of loss was found to be 2.8 km² per year. This agrees with the findings of Chakrabarty (1995) and Bandopadhya (1998) from the Sagar islands, that during last about 200 years delta progradation of the island is negative. Bandopadhya calculated the rate of retrogression of Sagar Island during last 144 years to be as high as 45.3 h / y.

Table 1 : Area change of forest blocks between 1968 & 1981(FSI, 1989)

Block	Area eroded (km²)	Area deposited (km²)
1. Saptamukhi	3.23	14.19
2. Thakuran	6.45	-----
3. Chulkati	2.58	1.29
4. Dhulibhasani	6.45	5.16
5. Ajmalmari	2.00	4.54
6. Herobhanga	0.65	0.65
7. Pirkhali	0.65	----
8. Panchamukhani	0.13	----
9. Netidhopani	0.65	----
10. Chamta	No Change	
11. Matla	0.65	----
12. Goasaba	----	1.00
13. Chotahardi	1.30	1.29
14. Mayadwip	38.70	----
15. Gona	1.29	0.29
16. Baghmara	No aerial photograph	
17. Chandkhali	No Change	
18. Harinbhanga	2.10	0.65
19. Khatuajhuri	No aerial photo	
20. Jhilla	1.30	1.30
21. Arbesi	0.65	0.65
TOTAL:	71.26 (-)	34.01 = 37.25

In recent times during the post Farakka period a comparative study was carried out while preparing the Coastal Zone Management Plan for West Bengal. The

SPOT imageries of 1989 were compared with that of 1995 taken at the same lunar time (4 days after highest spring tide) 1995. Sagar tide level was 2.27m on 27.01.89 (9=30hr) and 3.27m, on 5.1.95 (10=25hr). This was done in collaboration with the School of Oceanographic Studies, Jadavpur University. The results show a progradation of delta at the rate of 112 h per year (Sanyal, 1998), which clearly counteracts the findings of continuous engulfing of sea, theory of Bengal coast at the rate of 10 mm/y as propounded by John Milliman (1989). Further, the mean sea-level rise was calculated at the starting point of the 'Hing line' at Sagar tide gauge from their last five years data. It was found to be 3.10 mm / y which is only 0.9 mm (3.1-2.2) more than global minimum estimate and this accounts for the rate of subsidence at Sagar point. Thus, it becomes apparent from the findings of Milliman , Alam and this present study that the rate of subsidence in Bengal basin increases eastwards away from the 'Hinge' point (Sagar). This fact reduces the threat of rising sea-level in Indian Sundarban. We have only to monitor periodically the state of delta progradation effected by Farakka discharge.

While the Bengal basin is gradually tilting eastwards (Morgan and McIntire, 1959), the delta is characterised by significant subsidence (Milliman, 1989). Faulting and sediment compaction allow thick deltaic sequence (Morgan, 1970). Evolution of new islands, however, indicates greater rate of sediment accretion than sediment subsidence (Banerjee and Sen, 1984) in Indian Sundarban.

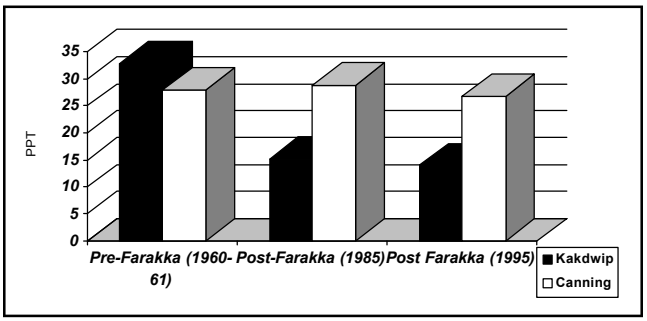
Mangrove zonation in Indian Sunderbans often shows topsy terby lay out due to lack of upstream fresh water flow and sea-level rise. Migration of species association takes place. Typical outer estuarine mangals settle in the inner or mid estuary and vice versa (Sanyal, 1984). This dancing state of existence leads to abnormal adaptations of plants and animals (Sanyal, 1986). Heavy monsoon freshets accumulate at the outer estuary and thus lowers the salinity for a prolonged period. The undeterred rush of surf also causes accelerated geomorphic activity. Thus, about 13 to 15 years geomorphic cycle was noticed for undergoing a change from pioneer vegetation to mature vegetation followed by a vertical collapse. After collapse pioneer vegetation restarts. So *Heretiera* ***fomes*** the subclimax species does not get sufficient time for diameter growth, inspite of frequent natural regeneration. *Avicennia* plants normally do not bear stilt roots. When these typical outer estuarine *Avicennia* plants grow in midestuary creek network the high velocity of creek waters gives rise to stilt roots. Similarly, *Excoecaria agallocha* the inner estuarine plant having no pneumatophore when grows foreshore and remain submerged in outer estuary, the perforated burr formation takes place to augment breathing. These abnormal adaptations of mangrove were first reported by the author (Sanyal and Ball, 1986).

The change of salinity regime in Sundarban delta due to effect of sea level rise could not be more profound than the effect of release of fresh water from Farakka barrage which will be evident from the following chart.

Table 6: River Salinity (ppt)
(After Nath and De, 1996)

Place of Measurement	Pre Farakka (1960-61)	Post Farakka (1985)	Post Farakka (1995)
Kakdwip	32.80	15.10	13.93
Canning	28.00	28.90	26.70

In Hoogly estuary the lower most zone exhibited maximum salinity (5.361-28.65 ppt) throughout the year (CICFRI, 1989-90). Soil salinity often reaches 30 ppt. Older the sediment, higher is the salinity in Sunderbans.



Graph 1: River salinity (Av) in Sunderbans
(AR of CICFI, 1997)

In fact the increased release of Farakka water has started assisting regeneration of Sundari trees on Western Sundarban. During early to middle Holocene period due to rapid subsidence and sea level rise the mangrove forest developed far from the present location (80-120 kms North) on a more stable sector. But present effect of global climate change is not showing such profound tendency of **northerly shift** in Indian Sundarban but in Bangladesh, that is away from 'Hing' line such 'shift effect' is possibly top dying the sub-climax species the Sundari (*Heritiera fomes*) trees and delta progradation has stopped during last 200 years (Milliman, 1989). Such a shift took place during Flandrian transgression when the mangrove line shifted 120 kms north-wards some 6500 year BP (Stanley and Hait,1999)

Remedy : As a remedial measure in Indian Sundarban plantations of *Heritiera fomes, Xylocarpus mecongensis, X. granatum* and *Nypa fruiticans* has been planted in the year 2001 along the fresh water canals of reclaimed Sundarban on the northern side. The results had been most encouraging for *Heritiera* and *Xylocarpus*. This is an aided northward movement of mangrove on one hand to combat the shallow marine condition generated by sea-level rise on one hand and restocking of reclaimed

Sundarban on the other.

CONCLUSIONS

From the above analysis following facts become apparent on the possibilities of threat to Bengal coast due to global warming:

1. The control of sea- level rise along Bengal coast is dependent not only on global temperature rise , but also on neo-tectonic phenomenon along the hinge line, subsidence and rate of fresh water flow (sediment carrying capacity) of river Hoogly (for Indian portion).

2. The high rate of sedimentation (1670 million tons/year, McDowell, 1995) has outwitted rate of subsidence and sea level rise. Thus Indian Sundarban furnish oscillatory delta building activity even during last 50 years where even various delta lobes behave differently. The overall situation on the face of Global climate change is not alarming from delta building point of view. The delta is prograding at a rate of at least 212 h per year in the Indian part during last decade. As a result the mangrove patch of Indian Sundarban is not being pushed northwards like the Bangladesh Sudarban situated at a longer tilt radius with respect to arc of 'Hing'line. Possibly the 'Sundari' tip drying problem of Bangladesh is due to this northerly push of the mangroves caused by augmented sea level rise.

3. The easterly tilt of Bengal basin due to neo-tectonic movement changed the main flow of Ganges through the river Padma of Bangladesh (Morgan & Mc Intire, 1959). Owing to lack of upstream fresh water flow the monsoon freshets accumulate at the estuary mouth over salt wedge. The **rise in sea level** is causing extension of salt wage which during driest period extends upto Diamond-harbour. Coupled with this an accelerated geomorphic action by the surge of surf goes undeterred. These two factors resulted in the migration (dancing state of existence) of plant communities in the inner, outer and mid-estuaries of Indian Sundarban. The typical outer estuarine communities feature at inner estuary or mid estuary and vice-versa. Thus when *Avicennia marina* has to appear at the narrow creeks of mid-estuary, it shows abnormal adaptations throwing stilt roots to protect against high current velocity. Similarly *Excoecaria* plants on the foreshore have to develop perforated burrs to augment their breathing being a plant without pneumatophore. Abnormal mangal adaptations have thus resulted basically from Neo-tectonic movement and Global warming (Sanyal and Ball, 1986).

4. Remedial measure will be a prophylactic action of planting the subclimax species of Sundarban along the freshwater canals of reclaimed Sundarban.

REFERENCES

Bandopadhya, S. (1998) Coastal Erosion and its Managament in Sagar Island, South 24 Parganas, West Bengal. Indian journal of Earth Science, Vol. 24, Nos. 3-4 : 51-69.

Banerjee, M, Sen P K (1984). On the depositional condition of the holocene sediments of Bengal basin with remarks on environmental conditions of the soft grey clay deposition in Calcutta. *Ind Geotech Conf* I/12 : 63-69.

Banerjee, M.S.,(1996). Biological remains in tracing coastal evolution with particular reference to West Bengal geo-province of Bengal basin, India. Manual of Integrated Coastal Zone Management. Pub. Department of Environment, Govt. of W.Bengal, India. Ed. Sanyal P.,Ghosh A.K.p 229-237.

Chakrabarty, Parthasarathi (1991). Morphostratigraphy of coastal quarterneries of West Bengal and Subarnarekha Delta, Orissa. Ind. Jour. of Earth Sciences, 18/3-4 :219-225.

Hait, A K, Das H K, Roy A K, Chanda S (1996). Environmental variations in the quarternery sequence of Kolahghat, W. Bengal, India. *Current Science*, 70/12: 1089-1092.

McDowell, M.C. (1995), The Development of the river Hooghly for navigation. Commemoration volume of Port of Calcutta, 125 years, p 69.

Milliman, John, Broadus D J M, Gable Frank (1989).Environmental and Economic Implications of rising sea level and subsiding deltas. The Nile and Bengal examples. *Ambio*.18/6 : 340-345.

Morgan, T P, McIntire W G (1959) Quarternery Geology of the Bengal basin, East Pakistan and India. *Bull Geol Soc Amer* 70 :319-342.

Sanyal, P. and Ball A.K.(1986).Some observations on abnormal adaptations of mangrove in Indian Sunderbans.*J. Ind. Soc. Coastal Agric. Res*. 4(1):9-15.

Sanyal, P., Banerjee L.K.,Choudhuri M.K.,(1984),Dancing Mangals of Indian Sunderbans.*J, Ind.Soc.Coastal Agric. Res*.,2(1):10-16.

Stanley, D.J. and Hait A.K. (1999). Holocene dopositional Patterns, Neotectonics and Sundarban Mangroves in the Western ganges –Bramhaputra Delta. Journal of Coastal Research, 16(1), 26-39. Royal Palm Beach (Florida) : 26-39.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 51-53

ASSESSMENT OF WATER QUALITY AND ASPECTS OF POLLUTION IN A STRETCH OF PATALGANGA CREEK AND ARABIAN SEA OF RAIGAD DISTRICT, MAHARASHTRA.

Patil S. M. & Hande R. S.*
*Dept. of Zoology,KET's V. G. Vaze College,Mulund, Mumbai – 400 081.
Dept. of Zoology,SVKM's Mithibai College,Vile Parle (W),Mumbai – 400 056.

ABSTRACT : Most developing countries have embarked in recent years on numerous large scale water resources development programme for industrial and agricultural development but without due attention to the waste water disposal, thus causing severe contamination of the water resources. Man has committed himself to a world of increasing technology and is responsible for drastically upsetting the spatial balance of ecosystem.

This study deals with physico-chemical characters (hydrography) and water quality of Patalganga Creek and Arabian Sea of Raigad. High content of heavy metals like Iron and Zinc were observed along with Chromium and some amount of Copper and Manganese. The other metals like Cadmium, Lead, Cobalt and Nickel were in trace amount. B.O.D. and C.O.D. values were comparatively higher at Patalganga Creek than those of Arabian Sea.

This study reveals that the water of Patalganga Creek is still under deteriorating condition and it is deleterious to the living being especially to the fishes and other water communities. Compared to Patalganga Creek, the pollution in the Arabian Sea remains within permissible limits.

Key Words : Patalganga Creek, Arabian Sea, Hydrography, Heavy Metals.

INTRODUCTION

A large number of small and large scale industries have sprung up in the last few years in India, focusing a progressive industrial approach. The flourishing industries, urbanization and agricultural activities are causing increasing amount of air, water and noise pollution which are known to affect the quality of life and the environment to a very large extent. Owing to increasing industrialization and urbanization, marine environment has become the final receptacle of substances such as domestic sewage, agricultural wastes, industrial wastes and other wastes which are untreated or inadequately treated and are discharged deliberately or accidentally.

These industrial effluents impart unpleasant taste; odour and colour to the water system, in some cases even raise the temperature causing thermal pollution. Effluent from paint industries colour the River water and the chemical wastes alter the pH of the water, while fertilizer wastes increase nitrogen and phosphorus contents producing heavy algal blooms. Sewage and industrial effluent if present in greater amount can cause mass mortality of the fish population (Mulay 1985). Many workrs have studied the toxicity of industrial effluents and their effects on fishes, (Qamrul, 1984; Athalye & Gokhale, 1989; Desai, 1993; Palanichamy and Rajendran, 2000; Nayar *et al.*, 2000; Swami *et al.*, 2000; Quadros et al., 2001; Athalye 2001).

Polluted waters not only pose a threat to the aquatic species inhabiting in them but also to humans who often come in contact with the water either directly or indirectly by consuming fish or shell fish food. Every chemical released in to the ecosystem has the potential of getting in to the human diet food chain and for most people; diet is the primary means of exposure to environmental contaminants (Nriagu and Simmons, 1992). The present investigation was undertaken to study the hydrobiological parameters like pH, temperature, dissolved oxygen, carbon-dioxide, salinity and nutrients like phosphates, silicates, nitrate and nitrites. The detection of heavy metals of the Patalganga Creek and Arabian Sea has also been carried out to know the quality of water.

MATERIAL AND METHODS

Water samples were collected in clean polythene cans (5 litre) from the Patalganga Creek and Arabian Sea of Raigad (Lat. 18° 45'N and Long. 73° 0' E.). The water samples were analysed for metals using the ICPAES (Inductively Coupled Plasma Atomic Emission Spectroscopy) at RSIC (Regional Sophisticated Instrumentation Center) IIT, Pawai Mumbai – 400 076. Standard methods described in (FAQ, 1975; Trivedy and Goel, 1984 and APHA, 1989) were followed for the physico chemical characterization of sample water.

RESULTS AND DISCUSSION

Present study revealed that pH range at Patalganga Creek and Arabian Sea was 6.5 – 8.5 and was found to be favourable to life in the water body (Figure 1). Salinity varied greatly at Patalganga Creek as well as Arabian Sea and the variation was seasonal. The salinity decreased considerably under the influence of

monsoon fresh water flow during July, August. In summer salinity was maximum 11.39‰ and 34.23‰ where as it was lowest during monsoon period. 0.3‰ and 15.1‰ at Patalganga Creek and Arabian Sea respectively (Figure 2). Dissolved Oxygen observed at Patalganga Creek was very high as compare to Arabian Sea and it was 10.28 and 4.84 mg/l respectively. The lowest dissolved oxygen observed at both the site was 5.24 and 3.83 mg/l respectively (Figure 3). Significantly inverse correlation was observed between dissolved oxygen and carbon-dioxide contents. CO_2 was very high at Arabian Sea 13.5 mg/l as compare to Patalganga Creek 6.5 mg/l. It may be due to the sewage and the wastes discharged in the water. (Figure 4) BOD & COD load was little higher at Patalganga Creek as compared to Arabian sea. B.O.D. measures of Patalganga creek and Arabian Sea were 1.76 and 0.8 µg/l, whereas COD contents were 1.8 and 1.4 µg/l respectively (Figure 5 & 6). Nutrients showed significant seasonal variations. Presence of phosphate, silicate was high at Patalganga Creek as well as Arabian Sea in the rainy season and it was 550 µg/l – 220 µg/l and 160 µg/l – 24.38 µg/l respectively. The nitrate content was very low as compared to nitrites and it was 700 µg/l and 250µg/l respectively (Figure 7,8,9 & 10).

Among the heavy metals, the concentration of Iron and Zinc was very high. The highest values were, for iron 150 & 75 µg/l and for zinc 185 – 34 µg/l at Patalganga Creek and Arabian Sea respectively. The metals Manganese, Copper and Chromium at Patalganga Creek had maximum concentrations 4 µg/l, 20 µg/l and 78 µg/l respectively whereas in the water of Arabian Sea 2 µg/l, 26 µg/l and 10 µg/l respectively. Presence of Lead, Cadmium, Cobalt and Nickel was observed to be negligible and it was less than 1 ppm/l. (Table - 1).

CONCLUSION

The present study reveals that the water of Patalganga Creek is still under deteriorating condition and deleterious to the living beings, as high content of ferrous (Fe) and Zinc (Zn) were observed along with Chromium (Cr), Copper (Cu) and Manganese (Mn). However the concentrations of heavy metals in the Arabian Sea water were low and may not be lethal to the aquatic species immediately, but the fact that long-term exposure may affect the physiology of the animals and it cannot be ruled out.

ACKNOWLEDGEMENT

The authors are greatly in-debted to Dr. M. R. Kurup, Principal V. G. Vaze College, Mulund, Mumbai for his encouragement and support.

Table 1 : Seasonal Variation of heavy Metals mg /l in the water of Paralganga Creek and Arabian Sea.

STATION	SEASON	FERROUS Fe)	ZINC (Zn)	CHROMIUM (Cr)	COPPER (Cu)	MANGANESE (Mn)
	Summer	150	35	78	1	3
PatalGanga Creek	Rainy	134	185	N.D.	4	4
	Winter	76	89	14	20	2
	Summer	33	23	N.D.	21	2
Arabian Sea	Rainy	72	34	10	26	2
	Winter	75	14	N.D.	13	1

Result in µg/lit.

N.D. means less than 1 ppm/lit.

Fig. 1-6 ; Seasonal Variation in pH, Salinity, Oxygen, Carbondioxide, BOD and COD at Patal Ganga Creek and Arabian Sea
KPR - Kopar Patal Ganga Creek
KRJ- Karanija Arabian Sea

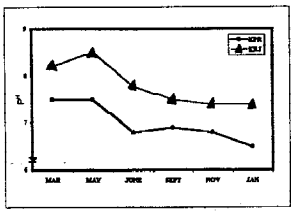


Figure - 1

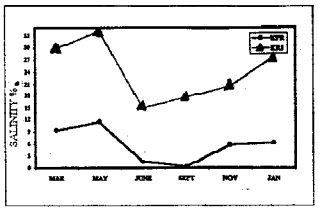


Figure - 2

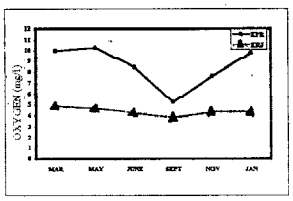


Figure - 3

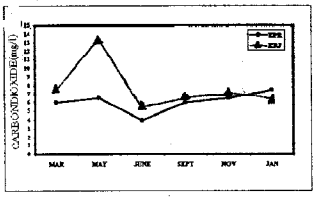


Figure - 4

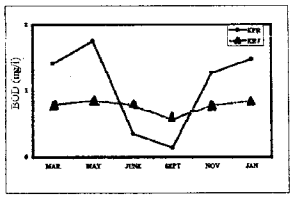


Figure - 5

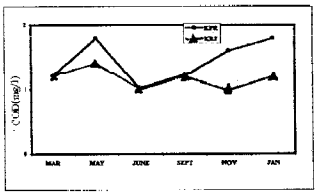


Figure - 6

Fig. 7-10 ; Seasonal Variation in Naturients - Phosphates, Silicates, Nitrite and Nitrates at Patal Ganga Creek and Arabian Sea
KPR - Kopar Patal Ganga Creek
KRJ- Karanija Arabian Sea

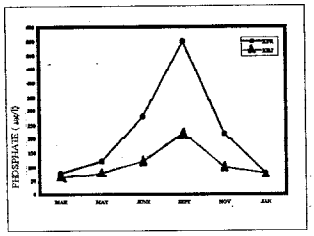


Figure - 7

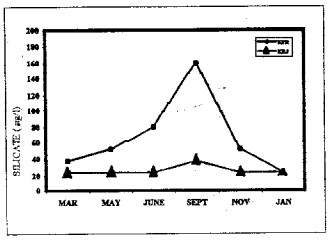


Figure - 8

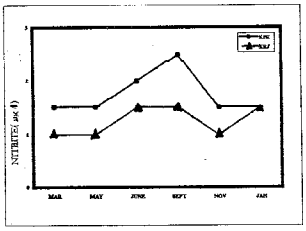


Figure - 9

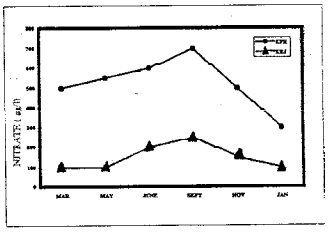


Figure - 10

REFERENCES

APHA-AWWA-WPCF 1989 17th Edition, Standard Methods : For the examination of water and waste water. American Public Health Association and Water Pollution Control Federation.

Athalye, R. P. and Gokhale K. S. 1989 Study of Selected trace metals in the sediments of Thane creek near Thane city. Antagonistic behaviour of zinc and copper. Mahasagar. Bull. Natl. Inst. Oceanogr. 22:185-191

Athalye, R. P., V. Mishra, G. Quadros, V. Ullal, and K. S. Gokhale 2001 Heavy metals in the Abiotic and Biotic components of Thane Creek, India. Ecol. Evn. & Cons. 7 (3) pp 319-325.

Desai, Bhavita 1993 Impact of toxicity and accumulation of Iron and Manganese of some teleost fishes. Ph. D. Thesis, University of Bombay.

F.A.O 1975 Manual of methods in aquatic environment research part I method of detection, measurements and monitoring of water pollution. Food and Agricultural Organization, Rome.

Mulay, D. V. 1985 Effect of Pollutants on Fresh Water Molluscs from Maharashtra State Ph. D. Thesis Marathwada University Aurangabad.

Nriagu, J. O. and M. S. Simmons 1992 Environmental Education and information. Vol. II No. 3

Nayar Sasi, G Gowda and TRC Gupta 2000 Spatial and temporal variation in hydrographical parameters in Talpady lagoon, South West of India. Indian J. Mar. Sci. 29: 77-79.

Palanichamy, S and Rajendran 2000 Heavy metal concentrations in sea water and sediments of Gulf of Mannar and Palk Bay, South East coast of India. Indian J. Mar. Sci. 29: 116-119.

Qamrul Hasan R. A. 1984 Studies on pollution in Ulhas creek with reference to effluents from MIDC Kalyan-Bhiwandi and their effects on Mystus gulio (Hamilton) Ph. D. Thesis University of Bombay.

Quadros, G., V. Mishra, V. Ullal, K. S. Gokhale and R. P. Athalye 2001 Status of water quality of Thane Creek (India), Ecol. Env. & Cons. 7 (3) : 235 – 240.

Swami, B. S., U. G. Syryawanshi and A. A. Karande 2000 Water quality Status of Mumbai harbour an update Indian. J. Mar. Sci. 29 : 111 – 115.

Trivedy, R. K. and P. K. Goel 1984 Chemical and Biological methods for water pollution studies Ed. Environ. Pub. Karad : 35 – 96.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 54-57

PHYSICO CHEMICAL CHARACTERISATION OF WASTE WATER STREAM AND ITS SIGNIFICANCE WITH CREEK POLLUTION DUE TO INDUSTRIAL EFFLUENTS.

C. N. Sathe, Deepali Pimple, R. S. Lokhande,
Dept. of Chemistry, University of Mumbai,
Vidyanagari, Santacruz (E), Mumbai - 400 098.

ABSTRACT : The various processes in the industry, produce waste water of complex nature, which many times is discharged into waterbodies without proper treatment. These effluents may contain organics, suspended solids, heavy metals, oil and grease, micro-organisms which pollutes waterbodies to a great extent. The paper presents one such casestudy where in the effluents from small industrial units of Ambernath are discharged into Waldhuni nalla, which is basically a storm water stream. This Waldhuni nalla finally goes to creek-Ulhas river and pollutes the creek ecosystem to a great extent.

The nalla was monitored for the parameters like colour, temperature, pH, solid content, hardness, chlorides and heavy metals like iron, chromium, cadmium, nickel, zinc, copper & lead. The study revealed that most of the parameters observed above the limiting values prescribed. The attempt was also made to characterize the effluents before entering in the nalla to confirm the presence of these heavy metals is due to industrial effluents in the area.

INTRODUCTION

With the modern technologies coming up, the nature of industrial wastewater getting generated is becoming more complex. Many times because of techno-commercial reasons industries discharge their effluents without proper treatment into the waterstreams like nallas, rivers, creeks, oceans etc. This causes pollution problem not only to the waterbodies where it is discharged but, also to soil, vegetation and ground water quality. (Lokhande and Sathe, 2001). Ambernath is a small town at distance of 67 km from Mumbai. The industrial area of Ambernath is functioning for last 30 years and today more than 300 units are working in two blocks viz. Kansai Block and Morivali Block. The area possesses industries like chemicals, materials for manufacturing various products including chemicals, engineering units, glass-rubber processing units etc. During the manufacturing processes, the effluents are sent out through common drainage without proper treatment. As estimated on 31st March, 1996, the quality of effluent generated was 6500 cum/day. There is only one common effluent treatment plant which takes care of few industries only. Waldhuni nalla, where effluents are discharged, is actually storm water stream passing from Morivali to Ulhasnagar parallel to railway track. Finally, this nalla goes to Ulhas river-estury near Kalyan. The pollution status of Ulhas river creek is reported.(Lokhande and Vaidya, 1998.)

Hence, the study was conducted to monitor the Waldhuni nalla for various physico-chemical parameters, which indicate the pollution load on nalla. The samples were also collected from effluent streams before entering into nalla in order to confirm the pollution is because of the industrial effluents.

EXPERIMENTAL

The study was carried out over a period of 11 months from November 1999 to September 2000. The samples were collected every month and analysed for the parameters like colour, temperature, pH, solid content, hardness, chloride (as Cl^-) and heavy metals like iron (as Fe), chromium (as Cr), cadmium (as Cd), nickel (as Ni), zinc (as Zn), copper (as Cu), lead (as Pb).

The standard methods (A.P.H.A., 1995.) of sample collection preservation and analysis were adapted. The samples were collected in duplicate, one was used for physico-chemical parameters while second was used for heavy metal analysis. The samples for heavy metal were filtered through 0.45 micron millipore membrane filter paper and then acidified to pH 4 by using hydrochloric acid. The A. R. grade reagents and double distilled water was used whenever required. Elico Li-120 model of pH meter is used for pH measurement. The spectrophotometer of schematzu make and Perkin Elymer Atomic Absorption spectrophotometer was used.

RESULTS AND DISCUSSIONS

Table 1 to 3 shows the results of the study conducted for eleven months.

The Waldhuni nalla receives domestic wastes and industrial effluent. The detergent and oil content in nalla in noticeable by naked eye. The pollution of water by detergents (Prat and Girgud, 1961) is a serious problem as far as the hardness of water and aquatic life is concern.

Table 1: Aanalysis of Phosico-Chemical Paramiters of Waldhuni Nalla

	November 1999	December 1999	January 2000	February 2000	March 2000	April 2000	May 2000	June 2000	July 2000	August 2000	September 2000
Color	Colour less	Colour less	Red	Colours less	Colours less	Red	Colour less	Colour less	Colour less	Colour less	Colour less
Temp (°C)	29.7	29.0	29.4	30.2	30.6	31.1	31.6	30.3	29.8	329.4	29.8
pH	3.70	3.42	3.13	3.02	2.87	2.64	2.68	2.71	2.74	2.81	2.69
TS	3463	3418	3439	3562	3573	3587	3612	3644	3447	3412	3508
TDS	3212	3209	3227	3330	3352	3324	3301	3312	3163	3228	3300
TSS	251	209	212	232	221	263	311	332	284	188	208
TH	294	302	295	302	309	305	318	302	281	262	252
Chloride	561.8	548.3	546.7	553.7	564.4	561.0	554.7	546.8	536.9	541.3	544.1

(All values except color, temperature, pH are expressed in mg/L)

Table 2: Aanalysis of Heavy Metal Content of Nalla

	November 1999	December 1999	January 2000	February 2000	March 2000	April 2000	May 2000	June 2000	July 2000	August 2000	September 2000
Fe	2.5	2.0	2.5	2.5	2.0	2.5	3.0	2.0	1.5	1.0	1.0
Cr	1.7	1.6	2.0	2.0	2.2	2.1	1.8	1.4	1.0	1.2	1.4
Cd	5.8	6.3	6.2	6.9	7.4	7.3	8.1	7.5	6.1	5.8	6.3
Ni	5.2	5.4	4.8	4.3	5.0	4.8	5.2	5.2	4.4	4.0	4.2
Zn	6.4	6.6	6.6	7.0	6.8	7.1	7.2	6.9	6.9	6.7	6.8
Cu	2.9	3.0	3.1	3.0	2.9	2.8	3.1	2.6	2.2	2.1	2.7
Pb	2.1	1.8	2.9	2.1	2.7	2.7	2.5	1.7	1.1	1.3	1.7

(All values are expressed in mg/L)

Table 3 : **Aanalysis of Heavy Metal Content in Industrial Effluents.**

	Near ALA Chemicals	**Near dyes and paint industries**
iron	1.0 - 2.5	8.5 - 9.5
chromium	2.5 - 4.4	5.7 - 7.0
cadmium	1.3 - 2.2	6.2 - 7.5
nickel	5.3 - 6.6	5.9 - 7.7
zinc	2.2 - 3.1	6.7 - 7.9
copper	6.2 - 7.3	4.2 - 4.9
lead	0.3 - 1.1	7.6 - 8.3

(All values are expressed in mg/L). (The values indicate the range.)

Most of the time, the samples collected were colourless except those in January and April 2000, where the colour was red. This may be because of discharge of coloured effluents in higher concentrations without proper treatment. The temperatures of the effluents entering in nalla are varying, which reflects in the temperature of samples. It ranges between 29.4^{0}C to 31.6^{0}C. In winter and in monsoon the temperature were less than that of in summer season.

The most important cause of concern is pH; as it is acidic. It is in the range of 2.64 to 3.7. The extensive use of acids in the industry can create such problems. The acidic pH affects the solubility of salts and can also precipitate some metals as their salts. The high acidic conditions for aquatic life are not suitable.

Solid content reflects the amount of inogranic salts and organics presents in the waterbody. The large variation in total solid content indicate the change in the process parameter in the industrial units. The suspended solids were in the range of 188 to 332 mg/l which is mainly in the form of collidal matter, biological matter, organics etc. Dissolved solid content indicate the presence of high inorganic salts. The values revealed that they are above the values prescribed by Indian Standards. Total hardness, which is actually soap consuming capacity or Ca, Mg and other salt content, is found to be minimum as 252 mg/l and maximum as 318 mg/l. The chloride content of the stream was almost constant viz. 544.1 to 561.8 mg/l.

The heavy metals are probably the most harmful and insidious pollutants because of their non-biodegradable nature and their potential to cause adverse effects in human beings on certain levels of exposure and absorption. (Sathe and Lokhande, 2001) Table 4 depicts the summary of factors influencing the toxicity of heavy metals in solution.

The industrial effluents are discharged into the ocean through creeks. The heavy metal pollution of esturies like Mahim (Sabnis, 1984) and Vasai (Lokhande and Kelkar, 1996) is reported to be alarming.

The study revealed that iron content was varying from 1.0 mg/l to 2.5 mg/l; but all the values were below TLV for iron content. As compare to chromium (VI) compounds, chromium (III) compounds are moderately toxic. Thus, it acts as a potential pollutants since amount used industrially is large as compared to normal biological levels. Total chromium was in the range of 1.0 mg/l to 2.1 mg/l.

Cadmium content of the samples was high and none of it was satisfying the criteria for discharge. The accumulation of cadmium in kidney and liver of humanbeings have been reported, as a result of formation of cadmium complex with a protein named thionein to form metallothionein. (Margoshes and Vallee 1957) Nickel content was in the range of 4.0 to 5.4 mg/l while, Zinc content was in the range of 6.4 to 7.1 mg/l.

The study (Zeitseva, 1976) reported enhanced growth of main stem, leaf area and main spike growth in barley due to copper, which at higher concentration showed inhabited growth shoot length reduces with increase in copper. The study showed that copper content was high. Similarly, lead concentrations are alarming and are in the range of 1.1 mg/l to 2.9 mg/l.

Thus, the investigations carried out at site, indicate that the Waldhuni nalla is highly polluted, even at its early stage. During the passage, it gets contaminated extensively and finally reaches to creek near Kalyan. The sampling and analysis at other points i.e. at the streams entering into nalla, showed that, the pollutants are entering into Waldhuni nalla through these industrial runoffs streams. This confirms the effect of industrial effluents discharges on water bodies.

Hence, in looking into the gravity of problem, some alternative for industrial runoffs need to be explored. The only CETP functioning in the area is not sufficient to take the entire load and hence, larger industrial units may be insisted to have their own ETPs to suit their requirement. The assessment of biological aspects of flora and fauna of the area is required.

Table 4 : Factors Incluencing the Toxicity of Heavy Metals in Solution

Form of metal in water	Inorganic		
	Organic	Soluble	Ion
			Complection
			Chelate ion
			Molecule
		Particulate	Colloidal
			Precipitated
			Adsorbed
Presence of other metals or poison	Joint action	More than additive	
	no interaction	additive	
	Antagonism	Less than additive	
Factors influencing physiology of organisms And possibly form of metal in water	Temperature		
	pH		
	Dissolved Oxygen		
	Light		
	Salinity		
Condition of organism	Stage in life history (Egg, larva etc.)		
	Changes in life cycle (eg.moulting, reproduction)		
	Age and size		
	Sex		
	starvation		
	Activity		
	Additional protection (eg. shell)		
	Adaption to metals		
Behavioral response	Altered behavior		

REFERENCES

A.P.H.A., 1995 Standard methods of examination of water and waste water; 19th ed, WEF, AWWA.

Lokhande R. S. and Kelkar Nilima. 1996 A profile of physico chemical aspects of pollution in water of vasai creek at low tide'. Poll Res. 15 (4) : 395.

Lokhande, R.S. and C.N. Sathe. 2001 Assessment to heavy metal content in few soil & vegetable samples from industrial area of Ambernath. 71st session of National Academy of Sciences, at Pune.

Lokhande, R.S. and S.Vaidya. 1998 Monitoring of heavy metals in creek water of Ulhas river'. Second int. conf. on environmental science, Trivendrum.

Margoshes and B.L. Vallee. 1957. Cd protein from equine kidney cortex J. Am. Chem. Soc. 79 : 4813.

Prat H. and A. Girgud. 1961. The pollution of waters by detergents. OECD, Paris. 85pp.

Sabnis M. 1984 Major and minor elements in Mahim river estury. Ph.D. thesis submitted to University of Mumbai.

Sathe C. N. and R.S. Lokhande. 2001 Monitoring and assessment of heavy metal content in the industrial effluents from Ambernath M.I.D.C. area (Maharashtra). Poll. Res. 20(2), 239-243.

Zeitseve, E.V. 1976 Effect of copper on nitrogen, phosphorous and water metabolism of barley during temporary flooding of the soil. Deposited Doc. VINITI, 2846 (76) : 4.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 58-62

PRESENT STATUS OF WATER QUALITY OF THANE CREEK AND ULHAS RIVER ESTUARY.

Goldin Quadros, R. P Athalye, Vaishali U. Somani, Mangal U. Borkar and N.N. Patil.
Zoology department, B.N Bandodkar College of Science, Thane [W] 400 601.

ABSTRACT : The hydrological studies on 26 km. stretch of Thane creek and 40 km. stretch ofUlhas river estuary showed deteriorating condition. The suspended solids were very high, reducing the light penetration. The upstream region of Ulhas river estuary and the entire Thane creek showed hypoxic average dissolved oxygen < 2.5 mg/l. BOD was higher in Thane creek. Extremely high SiO_3-Si is peculiarity of both the ecosystems, whereas PO_4-P was higher in Thane creek and high NO_3-N in Ulhas river estuary. The main causes of deterioration include release of high amount of untreated sewage and industrial effluents, solid waste dumping, reclamation, construction activity and sand dredging (in case of Ulhas river estuary).

Key words: Hydrology, Thane creek, Ulhas river estuary, Pollution.

INTRODUCTION

Study of hydrological parameters is highly essential because the distribution and abundance of the resident and visiting flora and fauna in the estuaries depend primarily on the water quality. With the background of increasing human interference, study of hydrological parameters can reveal the extent of damage caused to the ecosystem..

Thane creek [long 72^0. 55′ to 73^0 00′E& lat. 19^0.00′ to 19^0 15′ N] lies to the south of Bombay harbor and extends northwards joining Ulhas river estuary by minor connection. The creek is tide dominated and is influenced by solid waste dumping, effluent load & construction. Ulhas river estuary [Lat. 18°.45′ to 19° .00′ N and Long. 72° . 45′ to 73°. 20′ E] extends east to west meeting the Arabian sea near Vashi. The river has many tributaries and hence receives more fresh water as compared to Thane creek. There is a significant urbanization and industrialization on its south bank. However similar development is also taking place on its north bank. The river is also subjected to effluent load, solid waste dumping and heavy sand dredging and sand landing activities.

MATERIALS & METHODS

The study was conducted in 40 km. stretch of Ulhas river estuary and 26 km. stretch of Thane creek at 12 stations in each ecosystem, which were grouped in 3 zones. – Zone 1 of fresh water dominance, (Stations 1to 4 and 13 to 16). Zone 2 of mixed influence of fresh and marine water (Stations 5 to 8 and 17 to 20) and Zone 3 having dominance of sea water (Station 9 to 12 and 21 to 24), each zone consisting 4 stations [fig.1].

Surface water samples were collected mainly from September 2001 to August 2002, during spring high tide and spring low tide. The samples were analyzed for different parameters using Standard Methods (APHA, AWWA, WPCF, 1981 ; Trivedi and Goel, 1984). For presentation the data however is pooled to find out averages.

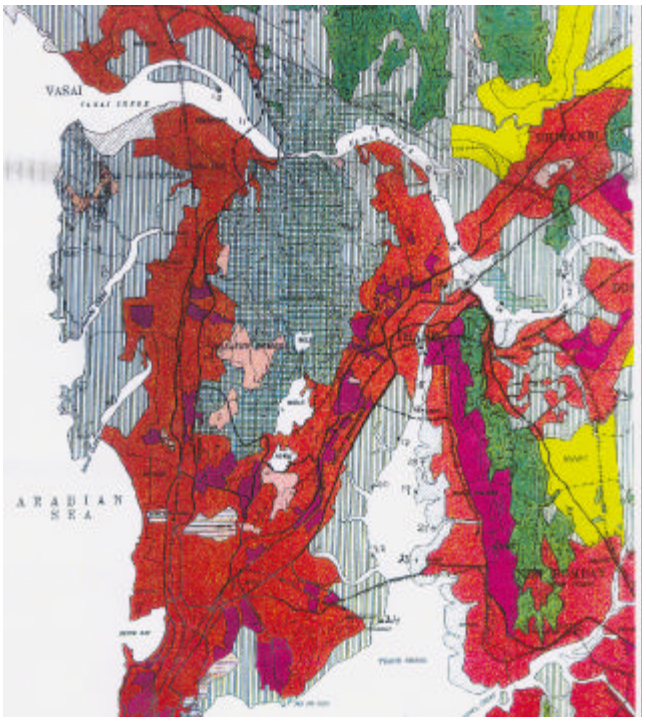


Fig. 1 : Map showing sampling stations in Ulhas river estuary and Thane creek

RESULTS AND DISCUSSION

Table 1& 2 show month wise overall averages of different water parameters of Ulhas river estuary and Thane creek during high tide and low tide. Whereas Table

3 shows zone wise averages of different parameters.

Water temperature fluctuated between 21^0 C to 33.37^{0}C in Ulhas river estuary (Av 28.19^{0}C) and 24.33^{0}C to 34.25^{0}C in Thane creek. (Av. 29.46^{0}C). Thus Thane creek was warmer than Ulhas river estuary probably due to its shallow nature and lower water mass. The peak values were recorded in pre monsoon (summer), as also observed by Quadros *et al*. 2001 in their earlier study on Thane creek.

Light penetration varied from 14.9 cms to 41.083 cms (Av 24.69 cms) in Ulhas river estuary and 21.75 cms to 46.75 cms (Av. 34.63 cms) in Thane creek. The minima was observed during monsoon which can be attributed to light weight slit and clay particles in water. With exception of April and May Thane creek region always exhibited comparatively higher average light penetration than Ulhas river estuary. In Ulhas river estuary, light penetration decreased from zone 1 (riverine) to zone 3 (seaward), this could be due to more tidal turbulence. Poor light penetration in Ulhas river estuary can also be due to extensive sand dredging activity. In Thane creek, however, light penetration was better in the middle zone.

Suspended solids ranged between 0.425 to 2.715 g / l in Ulhas river estuary (Av. 1.89g/l) and 0.67 to 5.077 g/l. (Av. 1.96 g/l) in Thane creek. In both the ecosystems, lower suspended solids were recorded in monsoon period. As compared to many other estuaries and creeks, (Nair *et.al*., 1987, Reddy *et.al*. 1994), the suspended solids in both Ulhas river estuary and Thane creek are exceptionally high indicating polluted state of the environments.

pH ranged between 7.20 to 7.857 in Ulhas river estuary (Av. 7.59) and 7.53 to 8.09 in Thane creek. (Av. 7.73). Average pH was higher in Thane creek than in Ulhas river estuary due to dominance of saline water in the former.

Salinity fluctuated from, 0.796 to 27.341 ppt in Ulhas river estuary (Av. 15.73ppt) and 3.493 to 34.73 ppt in Thane creek. (Av 23.73 ppt). Average salinity values were higher in Thane creek than Ulhas river estuary. In both ecosystems, low tide samples showed lower average salinity as also observed by Quadros *et.al*., 2001 in study of Thane creek. As expected, in both the ecosystems the average salinity increased towards the seaward zone 3. Average salinity of zone 1 of Ulhas river estuary was 8.93 ppt suggesting 1:3 proportion of marine and fresh water.

There is significant gradual lowering of average salinity in Thane creek in past 25 years (1975 – 36.3ppt (Govindan *et al*.,1976) ; 1980 – 29.4ppt (Nair et al 1980); 1984 – 85, 25.13ppt (Athalye, 1988)) if compared to earlier data. As increase in riverine fresh water flow does not seem possible, the change can be attributed to increased effluent load containing fresh water and reduced flow of tidal marine water due to hinderances created by anthropogenic activities.

Dissolved Oxygen ranged between 1.79 to 3.59 mg/l in Ulhas river estuary (Av. 2.71 mg/l) and 0.6838 to 5.00 mg/l in Thane creek.(Av. 2.05 mg/l). Ulhas river estuary always showed higher average Dissolved Oxygen as compared to Thane creek except in April. Higher Dissolved Oxygen in Thane creek recorded in April might be related to phytoplankton production. Dissolved Oxygen in general, improved towards zone 3 of both Ulhas river estuary and Thane creek. This could be due the dilution of pollutant load. Average Dissolved Oxygen in Ulhas river estuary was lower than 2.5mg/l (the hypoxic level of coastal waters given by Laponite and Clark, 1992) in zone 1&2, whereas in Thane creek, it was lower throughout the creek stretch. This showed significant pollution in zone 1 and zone 2 of Ulhas river estuary and the entire stretch of Thane creek. So also average Dissolved Oxygen in comparable region of Ulhas river estuary was lower than average values recorded by Mishra, 2001 (3.9mg/lt), indicating further degradation of water quality in last two years. In Thane creek also average Dissolved Oxygen (2.05 mg/lit) shows degradation of the ecosystem as compared to past data.(1975 – 6.79mg/l (Govindan *et al.,* 1976); 1979 – 80 – 5.21mg/l (Nair et al., 1980) ; 1984 – 85 – 4.09 mg/l (Athalye, 1988); 1999 –2000 – 2.4mg/l (Goldin, 2001)).

With exception of April and may in Thane creek, low tide waters always exhibited lower Dissolved Oxygen, as compared to high tide samples. This can be attributed to influence of industrial and sewage pollutants.

BOD fluctuated from 4.10mg/l to 14.86mg/lin Ulhas river estuary (Av. 9.89 mg/lt) and 5.9mg/l to 27.64mg/l in Thane creek (Av. 16.17mg/l). Higher BOD In Thane creek suggests higher organic pollution compared to Ulhas river estuary. In both the ecosystems, higher BOD was recorded in zone 1 and further decrease up to zone 3. BOD was higher in zone 1 and 2 of Ulhas river estuary and entire Thane creek. Corroborating with observations on Dissolved Oxygen.

Nutrients

Silicate – silicon (SiO_3 – Si) concentrations ranged from 12.74 to 70.37 mg/l in Ulhas river estuary (Av. 32.27mg/l) and from 14.37 to 39.45 mg/l in Thane creek (Av. 21.63mg/l). In both ecosystems, strong pulse of silicates was recorded in monsoon, corroborating with previous observations by Athalye (1988), Goldin (1995) and Quadros *et al* (2001), in their study on Thane creek. In Thane creek there is observed rise in silicate concentration as compared to past available data. (1984 – 85 av. 4.08mg/l (Athalye, 1988); 1991 –93 av. 8.76mg/l (Goldin, 1995); 1999 –2000 av 15.30mg/l (Goldin, 2001)) indicating build up of SiO_3 – Si probably due to increasing influence of construction activities. The geological strata

Table 1 : Monthly variations in the Physico chemical parameters of water during high tide and Low tide in Ulhas River Estuary

Months	Water Temperature C			Light penetration cms			Suspended solids g/l			pH			Salinity ppt			Dissolved oxygen mg/l			B.O.D. mg/l			Phosphates mg/l			Nitrates mg/l			Silicates mg/l		
	High tide	low tide	Ht + Lt avg	High tide	low tide	Ht + Lt avg	High tide	low tide	Ht + Lt avg	High tide	low tide	Ht + Lt avg	High tide	low tide	Ht + Lt avg	High tide	low tide	Ht + Lt avg	High tide	low tide	Ht + Lt avg	High tide	low tide	Ht + Lt avg	High tide	low tide	Ht + Lt avg	High tide	low tide	Ht + Lt avg
Sept 01	30.375	29.25	29.81	29	30.75	29.88	2.617	2.322	2.47	7.496	7.559	7.53	6.248	5.701	5.97	2.733	2.842	2.79	-	-	0.00	0.039	0.039	0.04	1.082	1.11	1.10	70.373	68.31	69.34
Oct	30.75	28.958	29.85	16.417	25	20.71	2.328	2.452	2.39	7.578	7.679	7.63	10.317	9.868	10.09	2.592	2.592	2.59	-	-	0.00	0.057	0.057	0.06	1.812	1.892	1.85	61.119	59.331	60.23
Nov	27.625	26.875	27.25	16.667	23.292	19.98	2.46	2.438	2.45	7.543	7.743	7.64	11.722	11.154	11.44	2.258	2.158	2.21	-	-	0.00	0.054	0.056	0.06	2.223	1.762	1.99	53.776	52.484	53.13
Dec	27.792	27.167	27.48	17.25	22.75	20.00	2.348	2.715	2.53	7.52	7.57	7.55	13.576	12.769	13.17	1.792	1.85	1.82	-	-	0.00	0.06	0.061	0.06	2.573	2.399	2.49	41.511	41.223	41.37
Jan 02	26.542	22.917	24.73	20.333	26.75	23.54	2.623	2.715	2.67	7.518	7.588	7.55	21.887	20.394	21.14	2.283	2.508	2.40	-	-	0.00	0.048	0.04	0.04	1.794	1.794	1.79	30.484	19.25	24.87
Feb	25.958	21.958	23.96	25.833	33.583	29.71	1.25	2.583	1.92	7.568	7.662	7.62	26.992	23.474	25.23	2.617	2.256	2.44	12.117	12.278	12.20	0.073	0.072	0.07	1.251	1.094	1.17	15.249	16.308	15.78
Mar	28.167	21	24.58	22.917	41.083	32.00	2.433	2.762	2.60	7.496	7.675	7.59	27.114	25.53	26.32	3.525	2.546	3.04	14.867	14.108	14.49	0.065	0.061	0.06	1.444	1.037	1.24	22.289	15.689	18.99
Apr	31.396	31	31.20	23.417	38.333	30.88	1.107	1.995	1.55	7.553	7.716	7.63	25.697	19.945	22.82	2.95	3.254	3.10	13.767	13.8	13.78	0.064	0.061	0.06	1.626	1.569	1.60	22.096	14.658	18.38
May	31.083	30.292	30.69	21.583	36.333	28.96	1.622	2.687	2.15	7.237	7.201	7.22	27.341	25.815	26.58	2.958	2.088	2.52	13.867	13.217	13.54	0.06	0.047	0.05	1.62	1.511	1.57	14.218	14.451	14.33
Jun	29	33.375	31.19	23.583	26.833	25.21	1.1	0.697	0.90	7.722	7.857	7.79	24.338	23.474	23.91	3.175	3.117	3.15	6.958	6.108	6.53	0.041	0.036	0.04	1.509	1.437	1.47	13.626	12.746	13.19
Jul	28.792	28.375	28.58	17.333	16.167	16.75	0.595	0.653	0.62	7.566	7.695	7.63	1.418	1.057	1.24	3.592	2.721	3.16	4.725	4.442	4.58	0.049	0.049	0.05	1.848	1.831	1.84	21.478	27.074	24.28
Aug	28.208	29.667	28.94	14.917	22.333	18.63	0.43	0.425	0.43	7.632	7.726	7.68	0.906	0.796	0.85	3.417	3.192	3.30	4.142	4.1	4.12	0.052	0.048	0.05	1.729	2.03	1.88	30.319	36.506	33.41
Avg	28.807	27.569	28.19	20.771	28.601	24.69	1.743	2.037	1.89	7.536	7.639	7.59	16.463	14.998	15.73	2.824	2.594	2.71	10.063	9.722	9.89	0.055	0.052	0.05	1.709	1.622	1.67	33.045	31.502	32.27

Table 2 : Monthly variations in the Physico chemical parameters of water during high tide and Low tide in Thane Creek

Months	Water Temperature C			Light penetration cms			Suspended solids g/l			pH			Salinity ppt			Dissolved oxygen mg/l			B.O.D. mg/l			Phosphates mg/l			Nitrates mg/l			Silicates mg/l		
	High tide	low tide	Ht + Lt avg	High tide	low tide	Ht + Lt avg	High tide	low tide	Ht + Lt avg	High tide	low tide	Ht + Lt avg	High tide	low tide	Ht + Lt avg	High tide	low tide	Ht + Lt avg	High tide	low tide	Ht + Lt avg	High tide	low tide	Ht + Lt avg	High tide	low tide	Ht + Lt avg	High tide	low tide	Ht + Lt avg
Sept 01	29.417	28.292	28.85	46.75	38	42.38	1.733	2.183	1.96	7.654	7.719	7.69	17.194	14.383	15.79	2.817	2.606	2.71	-	-	0.00	0.103	0.103	0.10	0.513	0.446	0.48	39.05	8.676	23.86
Oct	30.706	29	29.85	36.417	37.833	36.13	1.65	2.025	1.84	7.686	7.738	7.70	19.616	17.732	18.67	2.283	2.175	2.23	-	-	0.00	0.119	0.119	0.12	1.171	0.731	0.95	33.141	24.764	23.95
Nov	28	27	27.50	42.25	37.333	39.79	1.775	2.042	1.91	7.721	7.663	7.69	22.756	20.680	21.72	1.183	1.15	1.17	-	-	0.00	0.107	0.107	0.11	1.481	1.85	1.67	19.484	15.648	17.57
Dec	27.958	26.875	27.42	41.75	35.75	38.75	1.842	2.25	2.05	7.718	7.545	7.63	24.162	22.306	23.24	0.708	0.683	0.70	-	-	0.00	0.126	0.125	0.13	0.968	1.079	1.02	24.118	18.893	21.51
Jan 02	26.25	25.417	25.83	36.667	43.083	39.88	1.813	1.933	1.87	7.575	7.575	7.58	28.113	28.113	28.11	1.9	1.7	1.80	-	-	0.00	0.102	0.104	0.10	1.389	1.134	1.26	18.26	18.04	18.15
Feb	26.125	24.333	25.23	33.833	45.833	39.83	1.752	1.878	1.82	7.748	7.748	7.75	34.162	34.162	34.16	2.063	1.8	1.93	24.958	25.242	25.10	0.103	0.102	0.10	1.481	1.368	1.42	17.889	16.981	17.44
Mar	29.667	29.042	29.35	34.083	43.25	38.67	2.586	2.767	2.68	7.538	7.538	7.54	32.455	32.455	32.46	1.883	1.754	1.82	24.306	20.508	22.41	0.083	0.095	0.09	0.675	0.725	0.70	17.5	16.28	16.94
Apr	32.667	32.167	32.42	30.833	21.75	26.29	2.247	5.077	3.66	7.998	7.998	8.00	30.503	30.503	30.50	1.958	5.008	3.48	20.267	18.1	19.18	0.113	0.1	0.11	0.752	0.858	0.71	39.435	16.048	27.74
May	32.042	31.417	31.73	26.833	25.417	26.13	1.857	2.912	2.38	7.835	7.835	7.84	34.738	34.738	34.74	1.871	2.554	2.21	27.642	25.2	26.42	0.088	0.089	0.09	0.997	0.798	0.90	14.369	17.427	15.90
Jun	34.25	33.483	33.87	24.333	32.083	28.21	1.485	1.882	1.68	8.093	8.093	8.09	30.703	30.703	30.70	2.121	1.65	1.89	8.333	6.25	7.29	0.044	0.042	0.04	1.131	0.899	1.02	39.215	29.109	34.16
Jul	30.583	29.792	30.19	27.25	26.75	27.00	0.838	1.057	0.95	7.654	7.654	7.65	3.493	3.493	3.49	2.767	1.713	2.24	7.867	5.175	6.42	0.069	0.064	0.07	1.18	0.863	1.02	15.799	21.863	18.83
Aug	31.792	30.875	31.33	25.583	35.417	30.50	0.73	0.678	0.70	7.572	7.572	7.57	11.166	11.186	11.19	2.942	1.813	2.38	6.767	5.9	6.33	0.055	0.052	0.05	0.396	0.176	0.29	18.054	28.916	23.49
Avg	29.956	28.974	29.46	34.049	35.208	34.63	1.680	2.224	1.96	7.731	7.723	7.73	24.09	23.372	23.73	2.041	2.051	2.05	17.135	15.196	16.17	0.093	0.091	0.09	1.011	0.894	0.95	23.868	19.387	21.63

of this area is of volcanic origin (Blasco, 1975). This might be the other factor responsible for the high silicates. Higher average of SiO_3 – Si in Ulhas river estuary could be due to fresh water inflow and more sand dredging activity. Due to fresh water inflow, the SiO_3 – Si was higher in the Riverine zones (zone 1) of both the ecosystems.

Phosphate – phosphorus – (PO_4 – P) fluctuated from 0.038 to 0.073 mg/lt in Ulhas river estuary (Av. 0.05) and 0.044 to 0.126 mg/l in Thane creek (Av. 0.09 mg/l). On an average PO_4 – P were marginally higher in high tide water samples, as also observed by Qasim and Gopinathan (1969) in Cochin back waters and Singbal (1973), in Zuari estuary. In contrast, Goldin (1995) recorded higher PO_4 – P in low tide samples in upstream stretches of Thane creek.

In both the ecosystems, PO_4 -P was higher at the Riverine end and it lowered towards seaward side. However Thane creek showed higher PO_4 –P

Table 3 : Zone wise averages of physico chemical parameters of water in Ulhas river estuary and Thane creek

Parameters		Ulhas				Thane			
		Zone 1	Zone 2	Zone 3	Avg	Zone 1	Zone 2	Zone 3	Avg
Water Temperature C	High tide	28.865	28.724	28.833	28.807	29.167	29.948	30.75	29.955
	low tide	27.198	27.646	27.865	27.569	28.333	28.788	29.802	28.974
	Ht + Lt avg	28.031	28.185	28.349	28.188	28.75	29.368	30.276	29.465
Light penetration cms	High tide	25.594	20.344	16.375	20.771	32.104	40.063	29.979	34.049
	low tide	35.406	34.542	15.854	28.601	34.917	39.563	31.146	35.208
	Ht + Lt avg	30.5	27.44	16.11	24.69	33.51	39.81	30.56	34.63
Suspended solids g/l	High tide	0.53	1.123	3.575	1.743	1.905	1.839	1.336	1.693
	low tide	0.579	1.376	4.156	2.037	1.918	2.988	1.765	2.224
	Ht + Lt avg	0.555	1.249	3.865	1.89	1.911	2.414	1.551	1.958
pH	High tide	7.375	7.512	7.72	7.536	7.663	7.763	7.766	7.731
	low tide	7.503	7.577	7.838	7.639	7.672	7.714	7.784	7.723
	Ht + Lt avg	7.44	7.54	7.78	7.59	7.67	7.74	7.78	7.73
Salinity ppt	High tide	9.5	16.42	23.468	16.463	20.133	24.281	27.856	24.09
	low tide	8.356	14.251	22.387	14.998	19.198	23.676	27.243	23.372
	Ht + Lt avg	8.93	15.34	22.93	15.73	19.67	23.98	27.55	23.73
Dissolved oxygen mg/l	High tide	2.294	2.556	3.623	2.824	2.015	1.998	2.111	2.041
	low tide	1.915	2.275	3.591	2.594	1.449	2.38	2.323	2.051
	Ht + Lt avg	2.1	2.42	3.61	2.71	1.73	2.19	2.22	2.05
B.O.D. mg/l	High tide	15.786	8.846	5.557	10.063	26.129	13.675	11.6	17.135
	low tide	16.721	7.835	4.609	9.722	23.207	12.411	9.971	15.196
	Ht + Lt avg	16.254	8.341	5.083	9.892	24.668	13.043	10.786	16.165
Phosphates mg/l	High tide	0.063	0.056	0.046	0.055	0.131	0.076	0.071	0.093
	low tide	0.056	0.054	0.047	0.052	0.133	0.072	0.068	0.091
	Ht + Lt avg	0.06	0.055	0.047	0.054	0.132	0.074	0.069	0.092
Nitrates mg/l	High tide	1.414	1.976	1.737	1.709	1.064	0.951	1.019	1.011
	low tide	1.567	1.805	1.494	1.622	0.979	0.755	0.948	0.894
	Ht + Lt avg	1.491	1.89	1.616	1.666	1.022	0.853	0.983	0.953
Silicates mg/l	High tide	33.333	36.496	29.305	33.045	26.802	28.469	16.332	23.868
	low tide	34.014	31.649	28.844	31.502	26.52	16.215	15.425	19.387
	Ht + Lt avg	33.67	34.07	29.07	32.27	26.66	22.34	15.88	21.63

concentrations as compared to Ulhas river estuary. In Thane creek, 66.66 % samples exhibited PO_4 –P range higher than the limit of 0.086mg/l as suggested by Yentsch and Ryther (1957) for unpolluted waters. On the other hand, in Ulhas river estuary, PO4 – P values were always less than this limit, indicating comparatively higher sewage pollution in Thane creek.

Nitrate – Nitrogen (NO_3 – N) was in the range of 1.08 to 2.57 mg/l in Ulhas river estuary (Av. 1.67mg/l) and 0.17 to 1.85 mg/l in Thane creek (Av. 0.95mg / l) Ulhas river estuary showed higher average nitrates as compared to Thane creek region. In both the ecosystems, nitrates are observed to be lower in comparison with past data. High tide samples exhibited marginally higher NO_3 – N than low tide samples due to upstream transport of pollution load.

CONCLUSION

1. Ulhas river estuary showed marginally higher Dissolved Oxygen than Thane creek.
2. The suspended solids, silicates and nitrates were higher and light penetration lower in Ulhas river estuary as compared to Thane creek.
3. Thane creek showed comparatively higher PO_4 – P concentrations.
4. Salinity in Thane creek since last few years was observed to lower gradually due to increasing sewage load, accompanied with the lowering of Dissolved Oxygen level, indicating deterioration of the water quality.
5. In general, upstream region of Ulhas river estuary and entire stretch of Thane creek showed heavy pollution.

It is essential to implement mitigation measures on a war footing.

Acknowledgement : The authors are grateful for the financial assistance provided by Mumbai Metropolitian Region - Environment Inprovement Society C/o MMRDA, Mumbai.

REFERENCES

APHA, AWWA, WPCF, 1981. International standard methods for the examination of water and waste water. 15th Edition Washington D.C., 874 pp.

Athalye R.P. 1988. Status of Macrobenthos in detritus food chain of Thane creek near Thane city. Ph.D. Thesis, University of Mumbai, 197.pp

Blasco F., 1975. The mangroves of India. Inst. Francais, Pondichery. Trav. Sect. Sci Tech. 175 pp.

Goldin Quadros 1995. Study of hydrological parameters of Thane creek M.Sc. Thesis University of Bombay 204pp.

Goldin Quadros, 2001 Study of intertidal fauna of Thane creek. Ph.D. Thesis University of Mumbai, 264 pp.

Govindan, K., R. Kashinathan and B.N. Desai 1976Quantitative studies on macrobenthic fauna in the polluted Thana creek and Bombay harbour. Journal of the Indian Fisheries Association. Vol. 6 : 127 – 139.

Laponite, B.E. and M.W. Clark, 1992. Nutrient inputs from the water shed and coastal eutrophication in Florida keys. Estuaries 15 (4) : 465 – 476.

Mishra Vidya 2002. Study of macrofauna of Mangrove mudflats of Ulhas river estuary. Ph.D. Thesis University of Mumbai. 233 pp.

Nair, M.N.M., C.M. Harish, and K. Premchand 1987. Vertical suspended sediment distribution in Beypore estuary. Proc. Natn. Sem. Estuarine Management, Trivandrum, 38 – 43.

Nair, V.R., S. N. Gajbhiye and B.N. Desai. 1980 Distribution of Chaetognaths in the polluted and unpolluted waters around Bombay. Indian Journal of Marine Sciences. 10 : 66 – 69.

Qasim, S.Z. and C.K. Gopinathan 1969. Tidal cycle and the environmental features of Cochin backwaters (a tropical estuary). Proc. Of Indian Aca. Sci. 69 (B 6) : 336 – 348.

Quadros Goldin, Vidya Mishra, Vidya Ullal, K.S. Gokhale and R.P. Athalye. 2001 Status of water quality of Thane creek (India). Ecology, Environment and Conservation. 7(3) : 17 – 22.

Reddy, N.P.C., B.P. Rao, K.M. Rao and V.S. Rao 1994 Seasonal changes in suspended sediment load in the Gautami Godavari Estuary. Mahasagar – Bulletin of National Institute of Oceanography. 27 (1) : 47 – 53.

Singbal, S.Y.S., 1973 Diurnal variation of some physico chemical factors in the Zuari estuary of Goa. Indian Journal of Marine Sciences. 2 : 90 – 93.

Trivedi R.K. and P.K. Goel, 1984 Chemical and Biological methods for water pollution studies. Environmental publications, Karad. 181 pp.

Yentsch, C.S. and J.H. Ryther 1957. Short term variations in Phytoplankton, Chlorophyll and their significance. Limnology and Oceanography 2 (2) : 140 – 142

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 63-65

NATURE AND PROPERTIES OF MANGROVE SOILS OF SUNDARBANS, INDIA

Dolanchampa Ghosh (Sarkar), Kumudranjan Naskar* and G.N. Chattopadhyay
Soil Testing Laboratory, Institute of Agriculture, Visva-Bharati
Sriniketan - 731 236, W. Bengal, India
*Central Inland Capture Fisheries Research Institute, CGO Complex,
Bidhan Nagar, Kolkata - 91

ABSTRACT : Mangrove forests cover a large part of the deltaic area of Sundarbans in West Bengal, India. Importance of this forest in providing sustenance to different aquatic and terrestrial lives is well documented. Soil phase plays a significant role in influencing such activities, directly and indirectly. However, in spite of considerable studies on contribution of mangrove vegetation on productivity of the estuarine ecosystem, little information has so far been available on specific impacts of these forests on fertility status of mangrove soils. In the present study, the nature and properties of different mangrove soils of Sundarbans were studied with relation to non-mangrove soils of respective areas for developing an idea on contribution of the mangrove vegetation to different soil properties. For this purpose, soil samples were collected from various mangroves and nearby non-mangrove areas covering different parts of Sundarbans and were analyzed for relevant electro-chemical and nutritional properties. The study revealed the soils from mangrove dominated areas to be, in general, better supplied with major nutrient elements. Variations in some other soil properties in mangrove and non-mangrove soils were also observed.

Key words *:* Sundarbans, Mangrove soil, nutritional properties.

INTRODUCTION

Sundarbans, situated at the Ganga-Brahmaputra deltaic region of India and Bangladesh, forms the largest delta of the world occupying a total area of 4266.6 sq. km. (Naskar and Guha Bakshi, 1987). The mangroves in this area have great significance both in terms of their direct role in resource utilization for forestry and fishery productions and also their indirect potentials in protecting coastline and maintaining estuarine ecological balance. Although considerable studies have been made to assess the characters of these mangrove soils (Sahoo *et al,* 1985; Maji and Bandyopadhyay, 2000), yet information with regard to specific variations in different properties of such soils due to occurrence of the mangrove vegetation are meager. In the present study, an effort has been made to compare some important properties of the mangrove soils of Sundarbans with those under nearby non-mangrove zones. It is hoped that the study will be able to generate some information on how the mangrove soils of Sundarbans differ from the non-mangrove ones and will thereby, help to provide the basic data for adoption of soil specific environment management practices for this mangrove forests.

MATERIALS AND METHODS:

For this study, soil samples were collected from different places of Sundarbans, India. For each location, composite samples were collected at 0-15 cm depth from a mangrove dominated and another from a nearby non-mangrove area making a total of 20 nos. of samples from 10 places of the forest.

After collection, the soils were air dried, ground, sieved primarily with 2 mm and finally an 80 mesh sieve and used for different analyses. Electrical conductivity (EC) and pH were determined using 1: 1 soil: water extracts. Organic carbon, cation exchange capacity (CEC), available nitrogen, available phosphorous and exchangeable bases like potassium, calcium, sodium and magnesium were estimated by following Piper (1966) and Jackson (1973). Availability of some micronutrients viz. iron, copper, manganese and zinc were assessed by following the principle of Lindsay and Norvell (1978) with the help of an atomic absorption spectrophotometer.

RESULTS AND DISCUSSION

Electro-chemical properties of the studied soils have been presented in table-1. As evidenced from the table, the soils exhibited moderate to high EC values, obviously owing to their occurrence in the estuarine zone. However, although the mangrove soils of the forest were situated mostly under inter-tidal zones and the non-mangrove soils were located, in general, at slightly higher elevations, yet there was no distinct difference in EC values of these two kinds of soils. Presence of a highly saline ground water table below the surface of the forest area probably played a major role in contributing to salinity of these soils.

pH values of the soils varied from neutral to slightly alkaline range. This behavior may be attributed towards high salt content of the soils, as discussed earlier. pH values of the mangrove soils showed a slightly decreasing trend as compared to those under non-

mangrove zones. However, the differences were not very prominent. This behavior could be due to effects of the mangrove leaf litters in the former soils and formation of different organic and inorganic acids under the anaerobic or semi-aerobic conditions prevailing in these inter-tidal soils. However, high buffering capacity of the estuarine water (Reid, 1961) probably restricted the fall of pH values to considerably lower ranges and the differences were not very significant.

Table – 1 : Electro-chemical properties of some mangrove and non-mangrove soils of Sundarbans.

Property	Mangrove soils	Non-mangrove soils
$E.C._{1:1}$ (dsm^{-1})	1.24 - 10.80 (5.01)	0.13 - 12.10 (5.24)
$PH_{1:1}$ (m^{-1})	7.10 - 8.57 (7.95)	7.13 - 8.54 (8.10)
C.E.C. [cmole (P^+) kg^{-1}]	25.20 - 72.00 (44.05)	23.20 - 64.80 (42.00)
Exch. Ca^{2+} [cmole (P^+) kg^{-1}]	2.60 - 12.00 (5.50)	1.10 - 14.00 (5.35)
Exch. Mg^{2+} [cmole (P^+) kg^{-1}]	2.90 - 14.40 (9.55)	5.30 - 18.30 (11.70)
Exch. K^+ [cmole (P^+) kg^{-1}]	0.56 - 1.97 (1.10)	0.32 - 1.92 (0.95)
Exch. Na^+ [cmole (P^+) kg^{-1}]	5.76 - 35.65 (14.15)	5.00 - 36.30 (16.50)
ESP	14.60 - 40.69 (31.41)	8.39-57.71 (36.14)

Figures in parenthesis indicate average values.

Cation exchange capacities of the soils were moderately high under both the soil groups. Occurrence of 2:1 type of clay minerals in coastal saline soils of Sundarbans has been described by Mukherjee *et al* (1971). Since these clay minerals exhibit high CEC values, such high range of CEC in the studied soils was likely to be observed. Between the two groups, the mangrove soils exhibited slightly higher CEC values over the non-mangrove soils probably owing to higher occurrence of organic matter in the former group of soils. High CEC status of organic matter has been described by Brady (1974) and others. Since high CEC values of soils tend to hold more numbers of cations in soil exchangeable phase, the observed results indicated the mangrove soils to be more efficient in retaining various macro and micro nutrient cations in the soil phase.

As regards exchangeable bases, concentrations of exchangeable Ca^{2+} and K^+ increased marginally in the mangrove soils. On the other hand, the values of exchangeable Na^+ and Mg^{2+} showed a slight declining trend in such soils. Similar was the behavior in case of exchangeable sodium percentage (ESP) of the soils which also showed a reduction in the mangrove soils. Since higher concentrations of Na^+ and Mg^{2+} are considered to be deleterious to productivity levels of soils, such decline in the occurrence of these two ions in mangrove soils may be considered to be beneficial for the mangrove influenced eco-system.

Table – 2 : Occurrences of some major nutrient elements in mangrove and non-mangrove soils of Sundarbans.

Property	Mangrove soils	Non-mangrove soils
Organic C (%)	0.56 - 1.82 (0.91)	0.13 - 0.82 (0.51)
Easily min. N (mg kg^{-1})	50.40 - 252.00 (172.10)	44.8 - 249.20 (160.90)
Available P (mg kg^{-1})	42.00 - 152.00 (103.20)	40.00 - 124.00 (64.50)

Figures in parenthesis indicate average values.

Occurrences of three major nutrient elements viz. organic carbon, nitrogen and phosphorous in both the soil groups have been presented in table - 2. Organic C values of the soils under mangrove influenced zones recorded distinct differences as compared to the soils devoid of mangroves. Higher concentrations of organic C in mangrove soils owing to regular accumulation of mangrove leaves has been reported by Parulekar (1985) and others. This behavior helped to maintain higher concentrations of organic C in the studied mangrove soils over the soils without mangrove vegetations.

Availability of N tended to exhibit higher values in mangrove soils. Since organic matter forms the major source of N in soils (Brady, 1974), it was likely that mangrove soils with larger occurrence of organic matter also maintained higher amount of easily mineralized nitrogen. However, as compared to the variations in organic C content of mangrove and non-mangrove soils, the differences in available N status of these two kinds of soils were much narrower. This behavior was attributed to lower rate of mineralization of organic N to available forms under the prevailing saline environment (Chattopadhyay and Mandal, 1980) associated with slower decomposability of mangrove plants due to high lignins and wax contents (Bandyopadhyay, 2000). Moreover, regular tidal action in the mangrove swamps tended to wash away considerable amount of the soluble N from these soils thus reducing the difference further. However, this behavior is likely to enrich the water phase of the eco-system with regard to their N content.

Both the soil groups were observed to be moderate to well supplied with available form of phosphorus. Between the two groups, mangrove soils

exhibited higher occurrence of this nutrient element recording an average occurrence of 103.20 mg P kg^{-1} soil as against 64.50 mg kg^{-1} of P in non-mangrove soils. Such distinct increment in available P status under mangrove influenced soils may be primarily attributed to higher occurrence of organic matter in these soils which helped to reduce the fixation of P into insoluble forms (Chattopadhyay and Mandal, 1980a) and at the same time released P from organic to mineralized forms during the course of its decomposition.

Table – 3 :Availability of some micronutrients in mangrove and non-mangrove soils of Sundarbans.

Property	Mangrove soils	Non-mangrove soils
Fe (mg kg^{-1})	0.72 - 13.40 (3.77)	0.20 - 13.60 (3.69)
Cu (mg kg^{-1})	2.20 - 3.90 (3.20)	2.20 - 4.60 (3.25)
Mn (mg kg^{-1})	4.00 - 30.00 (16.25)	2.20 - 24.60 (13.70)
Zn (mg kg^{-1})	0.80 - 3.40 (2.15)	1.60 - 5.80 (2.78)

Figures in parenthesis indicate average values.

Occurrences of four micronutrient cations viz. Fe, Cu, Mn and Zn in the studied soils have been presented in table-3. As evidenced from the table, the soils, in general, contained good amount of these micronutrients in available form. Similar availability of these micronutrients in coastal saline soils of Sundarbans have been reported by Chattopadhyay and Saha (1980) and others. Among the micronutrients studied, Mn occurred in highest concentrations and was followed by Fe, Cu and Zn respectively. High occurrences of Mn and Fe in coastal saline soils of Sundarbans have been reported by Bandyopadhyay (2000) also. Mangrove soils appeared to exhibit higher range of availability of Mn. Presence of more amount of decomposable organic matter and development of anaerobic or semi-aerobic condition in such inter-tidal soils probability reduced the redox potential values of these soils and thus increased the solubility of Mn and Fe through different reduction reactions. Since Mn occurred in higher concentration in mangrove soils, the impact of such reduction reaction became more prominent for this micronutrient. Availability of Zn, on the other hand, appeared to be low in mangrove soils but the differences were only marginal.

The study revealed mangrove soils of Sundarbans to be more productive than their nearby non-mangrove zones. This beneficial effect could largely be attributed to accumulation of higher amount of organic matter in the mangrove soils which practically influenced the availability of different nutrients elements and also various electrochemical properties.

ACKNOWLEDGEMENT:

First and second authors are thankful to Indian Council of Agricultural Research for providing opportunity to undertake the study under National Fellow Project of the Council.

REFERENCES

Bandyopadhyay, B.K. (2000) Soil related problems and fertility of coastal soil of Sundarbans, West Bengal. In : Sundarbans Mangal pp. 205-212.

Brady, Nyle, C. (1974) Nature and Properties of Soils. Eurasia Publ. House (P) Ltd. New Delhi. p 639.

Chattopadhyay, G.N. and Mandal, L.N. (1980) Effect of different levels of water salinity on the decomposition of organic manure in brackishwater fish pond soil. Hydrobiologia. 72(3) : 287-292.

Chattopadhyay, G.N. and Mandal, L.N. (1980a) Inorganic transformation of applied phosphorus in brackishwater fish pond soil under different water salinity levels. Hydrobiologia 71(1&2) : 125-130.

Chattopadhyay, G.N. and Saha M.N. (1980) Distribution of DTPA extractable iron, manganese, copper and zinc in some brackishwater fish pond soils of West Bengal. J. Inland Fish. Soc. India. 12 (2) : 56-62.

Jackson, M.L. (1973) Soil Chemical Analysis. Prentice Hall of India Pvt. Ltd., New Delhi, p. 498.

Lindsey W.L. and Norvell, W.A. (1978) Development of a DTPA soil test for zinc, iron, manganese and copper J. Soil Sci. Soc. Am. 42 : 421-428.

Maji, B. and Bandyopadhyay, B.K. (1995) Characterisation and classification of coastal saline soils of various groups in Sundarbans, West Bengal. J. Indian Soc. Soil. Sci. 48 : 103-107.

Mukherjee, S.K.; Das, S.C and Raman, K.V. (1971) Soil mineralogy. In : Review of Soil Research in India. Indian Council of Agril. Research. New Delhi.

Naskar, K.R. and Guha Bakshi, D.N. (1987) Mangrove Swamps of Sundarbans - an Ecological Perspective. Naya Prakash. Kolkata, pp. 264.

Parulekar, A. (1985) Aquaculture in mangrove ecosystem of India - state of arts and prospects. In : The Mangroves : Proc. Nat. Symp. Biol. Util. Cons. Mangroves p. 112-118.

Piper, C.S. (1966) Soil and Plant Analysis. Hans. Publ. Mumbai.

Reid, G.K. (1961) Ecology of Inland Water and Estuaries. Reinhold Publishing Corpn, New York.

Sahoo, A.K..; Sah, K.D. and Gupta, S.K. (1985) Studies on nutrient status of some mangrove muds of the Sundarbans. In : The Mangroves : Proc. Nat. Symp. Biol. Util. Cons. Mangroves. p. 375-377.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 66-71

STUDIES ON THE INTERTIDAL SEDIMENTS OF THANE CREEK AND ULHAS RIVER ESTUARY.

R.P.Athalye and Goldin Quadros
Zoology Department
B.N.Bandodkar College of Science, Chendani, Thane 400 601

ABSTRACT : The intertidal sediments of Thane creek and Ulhas river estuary were studied during period September 2001to August 2002 by selecting 12 stations from both the ecosystems. The data on Texture (Sand, silt, clay), Organic Carbon, Total Phosphorus and Total Nitrogen was consolidated zonewise as Riverine zone, Middle zone and Seaward zone. The study revealed growing siltation and organic pollution in both the ecosystems, the severity being more in the riverine zones. It is suggested to stop reclamation, construction and dumping, conduct mangrove plantation drives along the banks, remove obstructions in tidal incursion and flushing and minimize sewage and solid wastes load by giving top priority to process and recycle them.

Key words : Thane Creek, Ulhas river estuary, Sediment Texture, Organic Carbon, Nutrients.

INTRODUCTION

Thane Creek (Long.72^0 55" to 73^0 .00"E; Lat.19^0.00" 19^0.15" N) and Ulhas river estuary (Long.73 ^{0} 20" E to 72 ^{0} 45" E ; Lat.18^0.45"N to 19^0.16" N) are known to suffer adverse effects of heavy urbanization and industrialization. They are recipient of large quantity of sewage and industrial effluents and are also subjected to solid waste dumping, reclamation and sand dredging (Ulhas river mainly). To assess the impact of these on the sediments, the present study was conducted.

MATERIALS AND METHODS

The sediment samples were collected monthly during period September 2001 to August 2002 from 12 stations each of Ulhas river estuary and Thane creek (Fig. 1). The surface sediments were collected during low tide from three levels of the mudflats namely Low, Mid and High water level marks (LWLM, MWLM, HWLM) using a metal scoop of 0.01m^2 (10 cm x 10 cm) dimension. Five random samples from each level were pooled together and treated as one sample. The samples were oven dried at 70 C and analysed for different parameters using standard methods as shown below.

Parameter	Method
Soil texture (% Silt, Clay, Sand)	Buchnan's Pipette method
Organic Carbon %	Walkley and Black method)
Total Phosphorus %	Ammonium Molybdate method
Total Nitrogen %	Kjeldhal distillation method
Important water parameter	Standard Methods (APHA, AWWA, WPCF, 1981)

The data was consolidated zone wise by calculating averages. The zones were made as below.

	Ulhas River estuary	Thane Creek
Zone 1 (Riverine zone)	Stations 1 to 4	Stations 13 to 16
Zone 2 (Middle zone)	Stations 5 to 8	Stations 17 to 20
Zone 3 (Seaward zone)	Stations 9 to 12	Stations 21 to 24

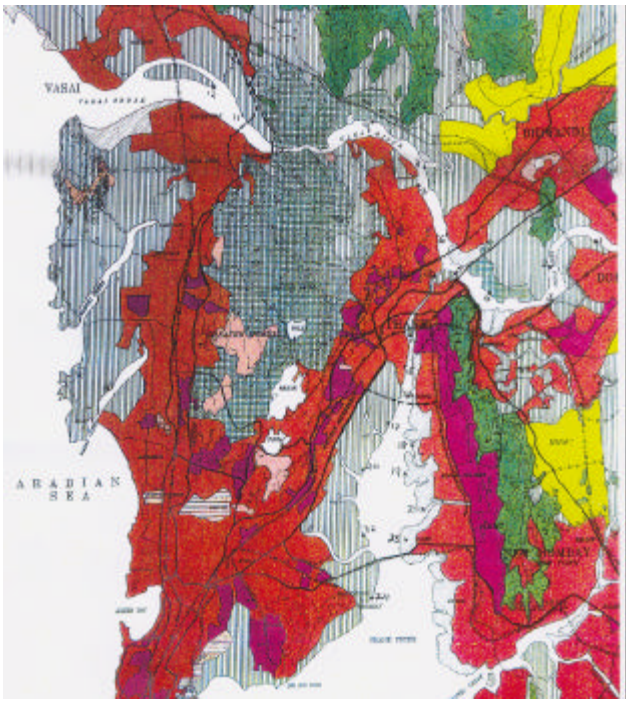


Fig. 1 : Map showing sampling stations in Ulhas river estuary and Thane creek

RESULTS AND DISCUSSION

Water Parameters : The zonewise and monthwise averages of important water parameters are given in Table 1. Acordingly, Thane creek had slightly warmer water temperature, higher pH, and higher PO4-P as compared to Ulhas river estuary, but it had low NO3-N and dissolved oxygen below hypoxic level of 2.5 mg/l (Laponite & Clark, 1992). Salinity of Ulhas river estuary was lower than Thane creek, which was due to the dominance of freshwater in the former. Though the monthly variations were studied only the average values are presented.

Table 1 : Water parameters of Ulhas river estuary and Thane Creek.

Water Parameters	Ulhas River Estuary										Thane Creek									
	Zone 1			Zone 2			Zone 3			Total	Zone 1			Zone 2			Zone 3			Total
	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Avg
Water Temperature C	21.25	33.13	28.03	21	31.5	28.19	22.75	33.25	28.35	28.18	821.5	33.75	28.75	22.5	33.45	29.37	26.38	34.88	30.28	29.71
Light Penetration	14	50.75	30.5	13.38	57.5	27.44	7.75	27.25	16.11	24.69	22	57.75	33.51	19.75	59.25	39.81	13	42.5	30.56	34.63
Suspended solids gm/l	0.16	0.96	0.555	0.15	2.375	1.249	0.205	6.15	3.865	1.89	0.43	3.385	1.911	0.6	13.5	2.414	0.535	3.17	1.551	1.958
pH	6.93	7.76	7.44	7.22	7.8	7.54	7.4	8.04	7.78	7.59	7.19	8.09	7.67	7.4	8.19	7.74	7.57	8.193	7.78	7.73
Salinity ppt.	0.389	18.51	8.93	0.73	30.28	15.34	1.035	34.92	22.93	15.73	0.803	32.48	19.67	2.85	34.6	23.93	6.825	37.14	27.55	23.73
Dissolved oxygen mg/l	0.75	3.825	2.29	1.425	3.35	2.55	1.983	4.8	3.62	2.82	0.375	2.925	2.015	0.7	8.2	1.998	0.925	4	2.11	2.041
PO_4-P mg/l	0.03	0.094	0.06	0.03	0.092	0.055	0.023	0.061	0.047	0.054	0.061	0.162	0.132	0.033	0.096	0.074	0.027	0.094	0.069	0.092
NO_3-N mg/l	0.292	2.521	1.491	0.905	3.533	1.89	0.189	2.275	1.616	1.666	0.471	1.458	1.022	0.145	2.099	0.853	0.145	1.383	0.983	0.953

Sediment Parameters : The zone wise and monthwise variations in the sediment parameters are given in Tables 2 to7.

Table 2 : Zonewise and monthwise variations in Sand (%)

	Ulhas				Thane			
Months	Zone 1	Zone 2	Zone 3	Avg	Zone 1	Zone 2	Zone 3	Avg
Sept 2001	11.250	17.500	20.000	16.250	10.000	10.000	11.250	10.417
Oct	11.250	17.500	20.000	16.250	10.000	10.000	12.500	10.833
Nov	11.250	17.500	20.000	16.250	10.000	10.000	12.500	10.833
Dec	11.250	17.500	20.000	16.250	10.000	10.000	11.250	10.417
Jan 2002	6.125	9.400	14.125	9.883	6.925	6.290	9.038	7.418
Feb	5.020	8.940	14.175	9.378	5.000	5.643	9.438	6.693
Mar	4.230	9.373	15.950	9.851	2.925	3.380	8.183	4.829
Apr	3.700	8.528	18.050	10.093	2.438	3.045	7.533	4.338
May	4.853	10.745	20.660	12.086	1.900	4.030	7.330	4.420
Jun	6.110	12.685	21.905	13.567	0.875	2.838	4.975	2.896
Jul	10.838	11.318	20.103	14.086	1.150	3.068	5.980	3.399
Aug	15.000	10.748	17.363	14.370	0.950	4.508	7.775	4.411
Avg	8.406	12.645	18.528	13.193	5.180	6.067	8.979	6.742

Table 3 : Zonewise and monthwise variations in Silt (%)

Months	Ulhas				Thane			
	Zone 1	Zone 2	Zone 3	Avg	Zone 1	Zone 2	Zone 3	Avg
Sept 2001	48.750	30.000	30.000	36.250	62.500	70.000	65.000	65.833
Oct	48.750	30.000	30.000	36.250	70.000	70.000	75.000	71.667
Nov	48.750	30.000	30.000	36.250	75.000	67.500	67.500	70.000
Dec	48.750	30.000	30.000	36.250	72.500	70.000	72.500	71.667
Jan 2002	56.710	39.085	33.170	42.988	76.075	71.048	64.475	70.533
Feb	56.810	40.500	46.550	47.953	77.338	63.383	61.463	67.394
Mar	57.933	47.140	49.630	51.568	81.163	63.358	62.905	69.142
Apr	62.520	43.228	54.985	53.578	79.583	64.355	61.895	68.611
May	72.283	55.520	57.645	61.816	82.225	68.658	60.565	70.483
Jun	74.103	50.535	63.323	62.653	80.613	71.250	65.810	72.558
Jul	72.298	48.865	69.683	63.615	77.863	81.070	66.013	74.982
Aug	68.660	53.340	67.545	63.182	81.263	77.993	63.200	74.152
Avg	59.693	41.518	46.878	49.363	76.343	69.884	65.527	70.585

Table 4 : Zonewise and monthwise variations in clay (%)

Months	Ulhas				Thane			
	Zone 1	Zone 2	Zone 3	Avg	Zone 1	Zone 2	Zone 3	Avg
Sept 2001	40.000	52.500	50.000	47.500	27.500	20.000	25.000	24.167
Oct	40.000	52.500	50.000	47.500	20.000	20.000	13.750	17.917
Nov	40.000	52.500	50.000	47.500	15.000	22.500	21.250	19.583
Dec	40.000	52.500	50.000	47.500	17.500	20.000	16.250	17.917
Jan 2002	37.165	51.515	52.705	47.128	17.000	22.663	26.488	22.050
Feb	38.170	50.560	39.275	42.668	17.663	30.975	29.100	25.913
Mar	37.838	43.488	34.420	38.582	15.913	33.263	28.913	26.029
Apr	33.780	48.245	26.965	36.330	17.980	32.600	30.573	27.051
May	22.865	33.735	21.695	26.098	15.875	27.313	32.105	25.098
Jun	19.788	36.780	14.773	23.780	18.513	25.913	29.215	24.547
Jul	16.865	39.818	10.215	22.299	20.988	15.863	28.008	21.619
Aug	16.340	35.913	15.093	22.448	17.788	17.500	29.025	21.438
Avg	31.901	45.838	34.595	37.445	18.476	24.049	25.806	22.777

Sediment texture –In general the intertidal sediments of both Ulhas river estuary and Thane creek had high percentage of silt and clay (averages 86 % and 92 % respectively) with low sand (averages 13 % and 6.7 % respectively). As the Ulhas river has significant fresh water flow as compared to Thane creek, it had higher percentage of sand. The sand proportion showed increasing trend towards the seaward zone in both the ecosystems (Fig. 2). Silt and clay components showed antagonistic pattern (Figs 3 & 4). However silt component was higher than clay. Parulekar *et al*. (1976) described the Bombay coastal sediments to be silty-clay i.e. more clay and less silt. Athalye (1988) also observed silty clay sediments in Thane creek during 1984-85. As compared to these reports the present sediments show growing proportion of silt making the sediment clayey-silt. Gokhale and Athalye (1995) observed such change in the upstream 5 Km stretch of Thane creek near Thane

city during 1991 – 93. They attributed it to extensive reclamation, construction activities hindering the tidal flushing and high load of sewage. It is important to note that such heavy siltation is seen in Ulhas river estuary in the upstream Riverine zone and throughout the Thane creek. (Fig. 3). The siltation has made the sediments soft, sinking, unstable and rich in organic matter. Due to this especially prawns and mudskippers have disappeared from the zones where silt is more than 60 % (i.e. Zone 1 of Ulhas and entire stretch of Thane creek). To prevent siltation significant measures need to be taken.

Organic Carbon (%) – The organic carbon ranged between 1.580 & 4.183 % in Ulhas river estuary and for Thane creek the range was 2.185 to 4.568 %. Though Ulhas river intertidal sediments showed lower organic carbon than Thane creek, both have organic carbon significantly higher than 1.5 % which according to Raman and Ganapati (1983) indicates very polluted sediments. Average organic carbon in Thane creek has crossed 3.5 % while it is 2.88 % in Ulhas river estuary (Fig 5). Thus the organic pollution is more severe in Thane creek.

Table 5 : Zonewise and monthwise variations in Organic carbon (%)

	Ulhas				Thane			
months	Zone 1	Zone 2	Zone 3	Avg	Zone 1	Zone 2	Zone 3	Avg
Sept 2001	2.276	2.111	1.653	2.013	3.538	3.132	3.628	3.433
Oct	2.278	2.045	1.588	1.970	3.099	2.944	2.231	2.758
Nov	1.906	2.045	1.580	1.844	3.138	2.766	2.185	2.696
Dec	1.968	2.068	1.580	1.872	2.727	2.688	2.192	2.536
Jan 2002	3.864	3.878	3.595	3.779	3.733	3.305	3.675	3.571
Feb	2.847	3.072	2.949	2.956	4.365	4.568	3.668	4.200
Mar	3.944	3.878	3.530	3.784	4.416	4.561	3.675	4.217
Apr	4.183	3.689	3.779	3.884	4.512	4.228	4.003	4.248
May	4.005	3.618	2.936	3.520	4.207	3.781	3.633	3.874
Jun	3.192	2.975	2.820	2.996	4.160	3.657	3.463	3.760
Jul	3.277	2.789	2.549	2.872	3.990	3.587	3.285	3.620
Aug	3.487	2.948	2.769	3.068	3.839	3.435	3.023	3.432
Avg	3.102	2.926	2.611	2.880	3.810	3.554	3.222	3.529

Total Nitrogen (%) – ranged between 0.158 to 0.434 % in Ulhas river estuary (avg. 0.250 %) whereas 0.151 to 0.352 % (avg. 0.247) in Thane creek. Thus Total Nitrogen was marginally higher in Ulhas river estuary. This could be due to higher nitrates in the overlying water (Table 1), probably due to the runoff from the agricultural fields around, in which fertilizers are added. The Total Nitrogen showed decreasing trend from Riverine zone to seaward zone in both the ecosystems (Fig.6)

Total Phosphorus (%) – ranged between 0.044 to 0.146 % (avg. 0.094 %) in Ulhas river estuary and 0.132 to 2.142 % (avg. 0.685 %) in Thane creek. The total phosphorus in the intertidal sediments of Ulhas river estuary are comparable to other Indian estuaries (Goldin, 2001), but they are significantly high in Thane creek sediments. Chandran (1987) has reported very high total phosphorus (0.345 to 28.816 %) in Vellar estuary. High total phosphorus in Thane creek sediments can be attributed to high sewage and organic pollution as compared to Ulhas river estuary (Fig. 7).

CONCLUSION

The studies lead to the following conclusions

1. Sediment texture in Ulhas river estuary and Thane creek indicate siltation in Riverine zone of Ulhas river estuary and the entire stretch of Thane creek. This has resulted due to increasing sewage load, solid waste dumping and hindrance in flushing and has adversely affected fishery especially prawns and mudskippers.

2. Both the ecosystems show heavy organic pollution which is more predominant in upstream Riverine zone.

3. Sewage pollution is more predominant in Thane creek as indicated by organic carbon and total phosphorus contents of the sediments.

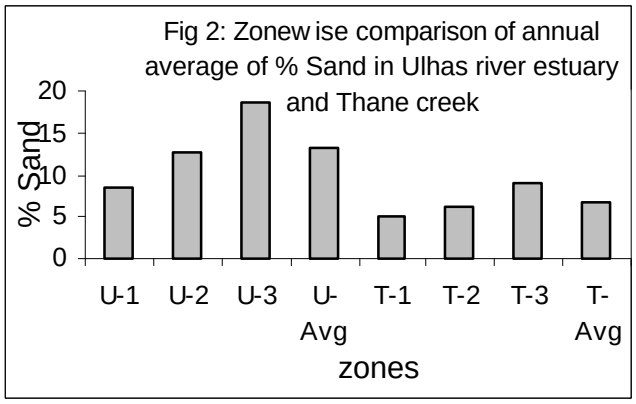
Based on the above it is suggested that :-

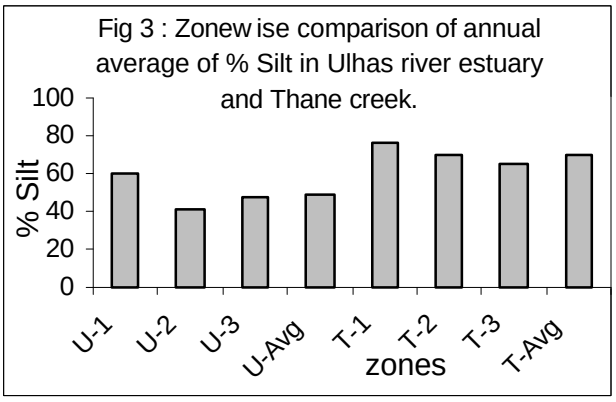
· Reclamation construction, dumping along the creek should be stopped.

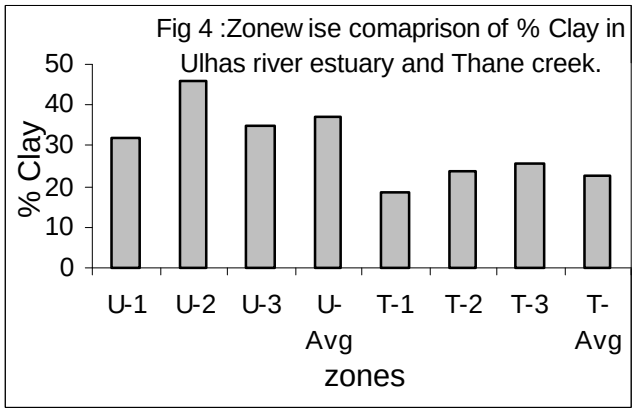
· Mangrove plantation should be done along the creek to increase the mangrove belt.

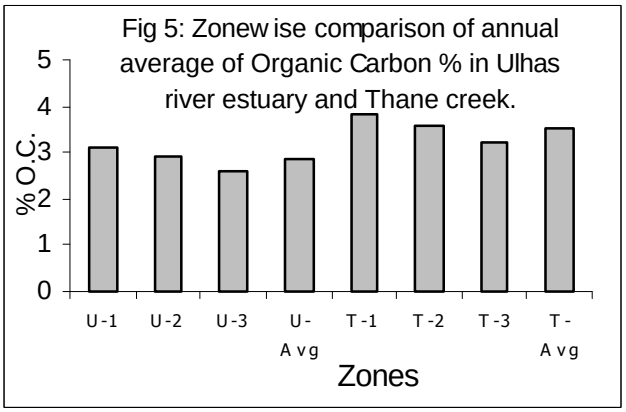
· obstructions in the tidal flow should be located and removed. While constructing bridges, etc care should be taken not to obstruct the tidal flow and flushing.

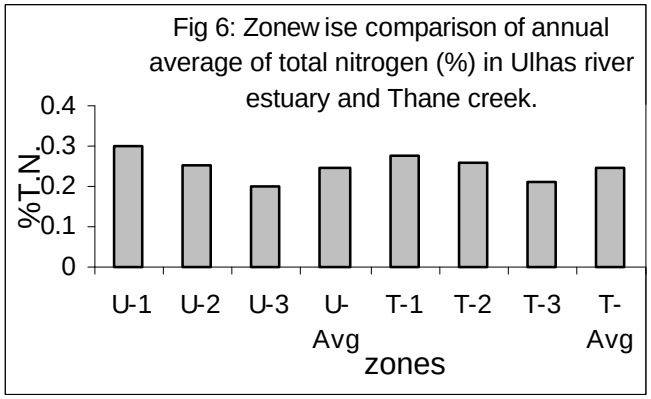
· Sewage and solid waste load be minimized by processing and recycling it.

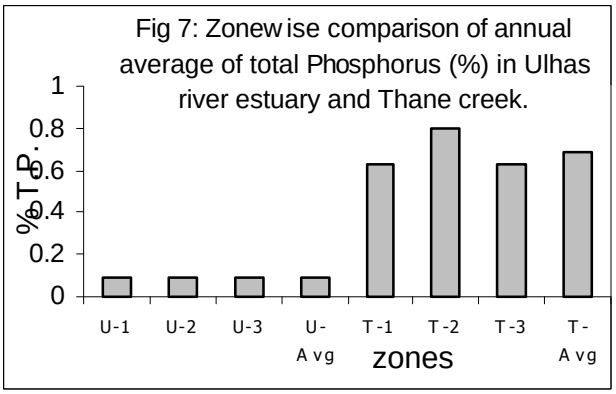












U-1, U-2, U-3, U-Avg. indicate 3 zones and overall averages respectively in Ulhas river estuary.

T-1, T-2, T-3, T-Avg. indicate 3 zones and overall averages respectively in Thane creek.

Table 6 : Zonewise and monthwise variations in Total Nitrogen (%)

Months	Ulhas				Thane			
	Zone 1	Zone 2	Zone 3	Avg	Zone 1	Zone 2	Zone 3	Avg
Sept 2001	0.317	0.252	0.214	0.261	0.352	0.305	0.266	0.307
Oct	0.270	0.235	0.214	0.239	0.259	0.231	0.151	0.214
Nov	0.252	0.249	0.210	0.237	0.243	0.228	0.159	0.210
Dec	0.266	0.245	0.217	0.243	0.222	0.214	0.161	0.199
Jan 2002	0.242	0.238	0.186	0.222	0.256	0.228	0.198	0.227
Feb	0.245	0.245	0.172	0.221	0.270	0.252	0.210	0.244
Mar	0.259	0.238	0.182	0.226	0.264	0.259	0.222	0.249
Apr	0.235	0.238	0.163	0.212	0.282	0.270	0.238	0.263
May	0.284	0.231	0.158	0.224	0.294	0.268	0.249	0.270
Jun	0.399	0.284	0.200	0.294	0.291	0.266	0.210	0.256
Jul	0.403	0.298	0.235	0.312	0.308	0.275	0.222	0.268
Aug	0.434	0.280	0.235	0.316	0.298	0.273	0.217	0.263
Avg	0.300	0.253	0.198	0.250	0.278	0.256	0.209	0.247

Table 7 : Zonewise and monthwise variations in Total Phosphorus (%)

Months	Ulhas				Thane			
	Zone 1	Zone 2	Zone 3	Avg	Zone 1	Zone 2	Zone 3	Avg
Sept 2001	0.044	0.090	0.090	0.075	0.185	0.164	0.132	0.160
Oct	0.064	0.089	0.086	0.080	1.551	1.341	1.099	1.330
Nov	0.084	0.097	0.093	0.092	0.977	0.884	0.919	0.927
Dec	0.100	0.114	0.109	0.108	2.142	2.057	1.999	2.066
Jan 2002	0.084	0.091	0.106	0.093	0.595	0.782	0.746	0.708
Feb	0.090	0.091	0.105	0.095	0.448	0.618	0.604	0.557
Mar	0.106	0.092	0.112	0.103	0.331	0.947	0.331	0.536
Apr	0.146	0.088	0.079	0.104	0.193	0.182	0.213	0.196
May	0.138	0.091	0.089	0.106	0.342	0.759	0.303	0.468
Jun	0.141	0.094	0.084	0.107	0.305	0.950	0.306	0.520
Jul	0.078	0.092	0.086	0.085	0.219	0.410	0.387	0.339
Aug	0.071	0.086	0.089	0.082	0.225	0.506	0.515	0.416
Avg	0.095	0.093	0.094	0.094	0.626	0.800	0.630	0.685

ACKNOWLEDGEMENT

The authors thank Mumbai Metropolitian Region – Environment Improvement Society C/o MMRDA, Mumbai for financial support.

REFERENCES

APHA, AWWA, WPCF, 1981 International standard methods for the examination of water and waste water. 15th edition, Washington D.C., 874 pp.

Laponite, B.E. and M.W. Clark, 1992 Nutrient inputs from the water shed and coastal eutrophication in Florida Keys.Estuaries, 15 (4) : 465 – 476.

Parulekar A.H., S.A. Nair, S.N. Harkantra and Z.A. Ansari 1976. Some quantitative studies on the benthos of Bombay. Mahasagar Bulletin of National Institute of Oceanography. 9(1 & 2) :51 – 56.

Athalye, R.P. 1988. Status of macrobenthos in detritus food chain of Thane creek near Thane city. Ph.D. Thesis, University of Bombay. 197 pp.

Gokhale K.S. and R.P. Athalye 1995. Study of impact of pollution on mangrove fauna of Thane creek near Thane city. Report submitted to the Ministry of Environment and Forests, New Delhi. 40 pp.

Raman, A.V. and P.N. Ganapati 1983. Pollution effects on ecobiology of Benthic polychaetes in Visakhapatnam harbour (Bay of Bengal) Marine Pollution Bulletin. 14 (2) : 46 – 52.

Goldin Quadros. 2001 Study of Intertidal Fauna of Thane creek. Ph.D. Thesis, University of Mumbai 264 pp.

Chandran, R. 1987 Hydrobiological studies in the gradient zone of velar estuary. IV Benthic fauna. Mahasagar Bulletin of National Institute of Oceanography. 20 (1) : 1 –13.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 72-77

BIODIVERSITY, ECOLOGY AND CONSERVATION OF MANGROVES IN DEVBAGH CREEK OF KALI ESTUARY NEAR KARWAR, KARNATAKA, INDIA

V. S. Achari, L. V. Andrade and V. N. Nayak
Department of Marine Biology, Karnatak University Post Graduate Centre,
Kodibag, Karwar-581303, India

ABSTRACT : Devbagh creek in Kali estuary near Karwar came to light with starting of a resort alongside by Jungle Lodges of Forest Department. As it was found to be rich in floral content, a systematic study was undertaken to record the biodiversity and ecology of the mangrovephytes. A qualitative study of faunal members of the creek was limited to only listing. Towards conservation of mangroves, in association with forest department certain mangrove seedlings were raised. These seedlings were transplanted in the creek with moderate success. The result of the present work shows a high degree of biodiversity and salt tolerance by the mangrovephytes in the creek. Solid waste pollution by tourists and felling of trees by villagers are the likely threats to the creek. In view of its closeness to the town and Jungle Resort that attracts tourists from India and abroad, suitability of this scenically unique creek in declaring as a mangrove Bio-Reserve/Marine park is suggested.

Key words *:* Devbagh Creek – Kali Estuary - Mangrove Biodiversity – Conservation – Marine park

INTRODUCTION

The distribution of mangrove forests in the world is known to coincide with the 20°C Summer Isotherm Line (Duke N.C., 1991). The total cover of mangroves in India is estimated at about 6819 sq.km [Sidhu S.S.1963]. About 80% of the Indian mangroves are present on the East Coast and the Andaman and Nicobar group of Islands (Snedakar and Snedakar, 1984). The rest is present on the West Coast and a small percentage on the Lakshwadeep group of islands.

Karnataka coast on the western boundary of India has about 9 major rivers and a few more minor rivers that meet the Arabian Sea. According to an estimate Karnataka has about 50 sq.kms. of mangrove cover composed of 14 species belonging to 9 genera under 7 families (Untawale A.G. and Wafar, S., 1986).

Mangrove ecosystem is an open ecosystem, which is sustained by flow of energy and nutrients from marine and land drainage, that in turn affects or influences these ecosystems (Govindaswamy *et. al.*, 1987). Mangroves are one of the biologically diverse ecosystems in the world. As this ecosystem is rich in organic matter and nutrients, it supports very large biomass of flora and fauna. Therefore, mangroves are amongst one of the most productive ecosystems in the tropics (Robin L.E. and Bazelevic N.I., 1966).

Nowadays almost every estuary and backwater is being commercialised either by construction of salt pans, aquaculture ponds or going in for land reclamation for building and other anthropogenic activities. Some of these activities associated with mangrove ecosystem are indiscriminate tree felling, sand and shell mining land encroachment for agricultural and horticulture purpose, unscientific and indiscriminate fishing, disposal of domestic and industrial wastes etc.

These problems cannot be nullified but atleast the intensity with which it is carried out needs to be taken care off. Even though almost all the estuaries these days are prone to large-scale anthropogenic activities. There are still some mangrove regions or ecosystems that face less threat if not any at all from human activity as in the present case study of an unique undisturbed hitherto unreported habitat of mangroves at the Devbagh creek right at the mouth of river Kali in Karwar, Karnataka.

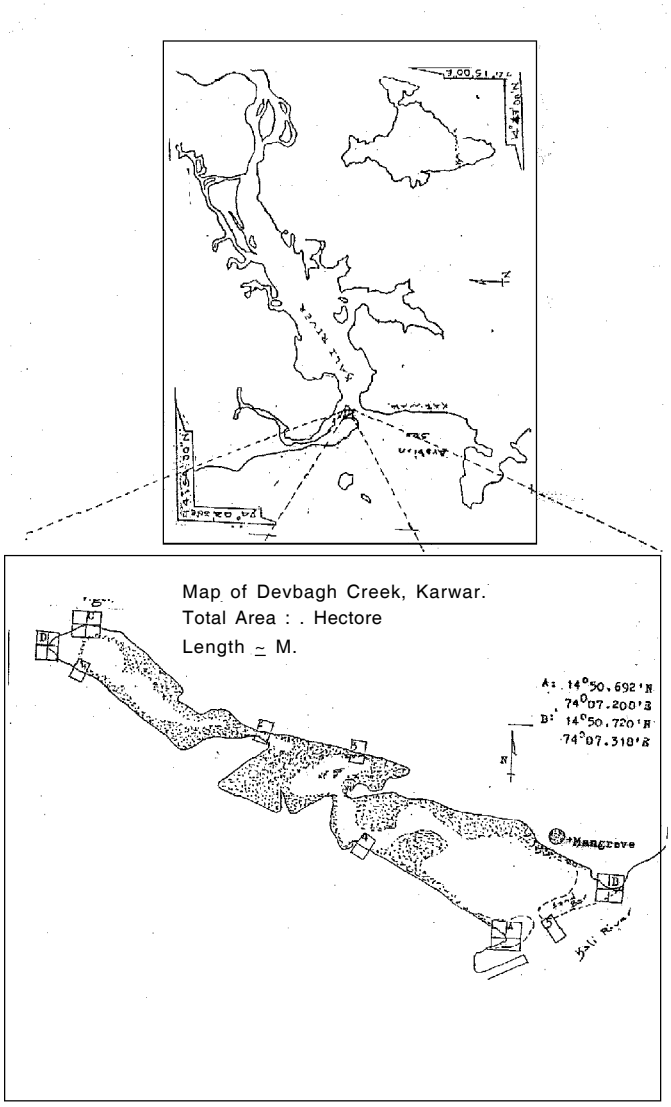
Focus of the present work was to study the floral biodiversity, some hydrological parameters and listing of the observed faunal members and threat of pollution by solid waste dumping.

STUDY AREA

The study area selected for the present work is a tidal creek present on the north bank of the mouth of river Kali, at Devbagh, Karwar of Uttara Kannada district in Karnataka. Rao and Suresh (2001) while dealing with Kali estuary in their book, 'Coastal Ecosystems of the Karnataka state, India, I. Mangroves' show village Devbagh wrongly on the right bank of Mavina halla (p.184) whereas it is actually on the left bank. Also, the creek under present consideration is shown as a mudflat (p.276).

The Devbagh creek is located amidst Casuarina plantation in the village of Devbagh. This creek is located at a distance of about 2 kms. from the nearest human habitation the Devbagh village. The geographic position of the mouth of this creek lies between 14°50.692'N, 74°07.208'E and 14°15.720'N 74°07.318'E. The total area of the creek is about 6.6 hectares and the linear length of the creek is about 764mt during spring low tides.

MAP - I



This particular creek was chosen for the present study as it happens to be a new found mangrove habitat and no research work of any sort was carried out on this creek. The creek was exposed to very limited anthropogenic activity such as minimum solid waste dumping by tourists. The only other human activity visible in this creek was small-scale self sustenance fishery carried out by village fishermen. The place is accessible by motorboat or trek through Casuarina plantation or along the sea beach from the village.

METHODOLOGY

Initially, with the help of survey equipments extent of the creek was measured [map I]. Mangrove vegetation was studied by using Quadrat method as described in Shukla and Chandel (1972). These quadrats of 100 sq.m. each were placed in a direction at right angles to the creek at various heterogeneous sites, during the study period of 2001-2002.

The parameters noted in each Quadrat are as follows:

1. Total number of species present.

2. Total number of plants belonging to each species present.

3. Girth of each plant at breast height i.e. 1.3m above the ground level was noted and used to calculate diameter.

To characterize the floristic community as a whole certain numerical figures called Parameters are used to give a clear picture of the community structure. The various parameters that were used in the present study were **1**. Density **2**. Frequency **3**. Basal Area Per Tree and **4**. Abundance. The relative values of Density, Frequency and Dominance were calculated from the above initial three parameters respectively. The Importance Value Index [IVI] was also calculated. All the above parameters were determined following Shukla and Chandel (1972).

Faunal composition was studied in the exposed part of the creek by observations and also, with the help of dragnets. The faunal studies were only qualitative in nature.

Limited Environmental parameters such as temperature, salinity, pH and dissolved oxygen of water; sediment temperature and pH; and soil characteristics were studied.

FLORAL STUDIES

In all 27 species of mangrovephytes and associated plants are recorded.Since some of these were present in insignificant numbers, only plants that were present in statistically significant number were analysed for their community structure. The present study revealed that in this creek there were a total of 19 species of plants in significant number, including 14 species of eumangroves belonging to 7 families and remaining 5 species were of associate flora belonging to 5 different families. The distribution of mangrove plants was in thick patches all along the length of the creek.

OBSERVATIONS AND RESULTS

Environmental parameters:

The following variations were found in different environmental parameters recorded during the study period at the Devbagh Creek.

Parameter	Minimum	Maximum	Average Min.	Average Max.
Air temperature	24.5 ^{0}C	33.0 ^{0} C	28.8^0 C	29.9 ^{0} C
Water temp.	27.0 ^{0} C	37.0 ^{0} C	29.9 ^{0} C	34.0 ^{0} C
Sediment temp.	26.0 ^{0}C	35.0 ^{0} C	29.0 ^{0} C	31.0 ^{0} C
Water Salinity	0.0 PPT	32.0 PPT	13.3 PPT	20.16 PPT
D.O. in Water	6.12 mg/ltr	7.82 mg/ltr	6.37 mg/ltr	7.63 mg/ltr
Suspended load of Water	0.08 gm/ltr	0.76 gm/ltr	0.24 gm/ltr	0.33gm/ltr
Water pH	6.46	7.93	6.97	7.39
Sediment pH	5.8	6.8	6.16	6.5
Sand fraction	38.36%	86.86%	49.03%	81.14%
Silt	10.17%	41.24%	13.59%	38.46%
Clay	1.12%	20.4%	2.38%	12.66%
Organic Carbon	1.24%	4.52%	1.68%	3.82%

Family-wise list of plants recorded is as follows:

Exclusive Mangrove Species:

Family: Rhizophoraceae

Rhizophora mucronata Lamk.

Rhizophora apiculata Blume.

Kandelia candel [L.] Druce

Bruguiera cylindrica [L.] Bl.

Bruguiera gymnorrhiza [L.] Lamk.

Family :Avicenniaceae

Avicennia alba Bl.

Avicennia marina Stapf & Mold

Avicennia officinalis L.

Family: Sonneratiaceae

Sonneratia alba J. Smith

Sonneratia caseolaris [L] Engl.

Family: Acanthaceae

Acanthus ilicifolius L.

Family: Combretaceae

Lumnitzera racemosa Willd.

Family: Myrsinaceae

Aegiceras corniculatum Blanco

Family: Euphorbiaceae

Excoecaria agallocha [L].

Associated floral members:

Family: Verbenaceae

Clerodendron inerme Gaertn.

Premna corymbosa [Burm. F.] Rottl. & Wild.

Family: Fabaceae

Derris trifoliata Lour.

Erythrina indica *Lam.*

Family: Aizoaceae

Sesuvium portulacastrum L.

Family: Convolvulaceae

Ipomea pes-capre [L] Sweet.

Family: Malvaceae

Thespesia populnea Soland ex Corr.

Family: Salvadoraceae

Salvadora persica L.

Family: Cyperaceae

Scirpus littoralis Schred.

Family: Guttiferae

Calophyllum inophyllum L.

Family: Apocynaceae

Rawuolfia tetraphylla

Family: Casuarinaceae

Casuarina equisetifolia L.

Family: Poaceae

Cynodon dactylon [L] Pers.

*Scientific names as per Naskar K. and Mandal R.,[1999]

Community Structure (Table 1 & 2)

Family Dominance

Among the eumangroves the most dominant family was Rhizophoraceae represented by 5 species belonging to 3 genera. This was followed by Avicenniaceae represented by 3 species all belonging to a single genus *Avicennia*. Sonneratiaceae was the third dominant family represented by 2 species belonging to a single genus *Sonneratia*. All the other 4 families viz: Acanthaceae , Combretaceae, Euphorbiaceae and Myrsinaceae were represented by plants of a single genus and a single species. The associated mangrove flora were represented by 5 families each with a single genus and species.

Basal Diameter Class [BDC]

Basal Diameter of only 13 out of the 14 eumangrove plants could be determined [except *Acanthus ilicifolius*]. The plants were grouped into 7 BDCs. *Avicennia marina* was the only plant to be represented in 6 of the 7 BDCs. *A. alba, A. officinalis* were found to belong to 5 out of the 7 BDCs, followed by *Lumnitzera racemosa* belonging to 4 of the 7 BDCs.

Rhizophora apiculata and *R.. mucronata, Bruguiera cylindrica* and *Sonneratia caseolaris* were found in the first three BDCs, while *Kandelia candel* and *Aegiceras corniculatum* were found in only 1 of the 7 BDCs.

Density [n/10 sq.m.], Basal Area Per Tree [BA/ T], Frequency [%] & Abundance (n/100 sq. m .) : *Aegiceras corniculatum* had the highest Density of 1.39n/ 10 sq.m., followed by *A. ilicifolius* with 0.84 n/10 sq.m. The next dense distribution was observed in case of *A. officinalis* with 0.67 n/10 sq.m. In terms of BA/T measured in sq.m. *A. marina* had the highest of 1.7824 sq.m., the second highest was *A. alba,* followed by *S. alba.*

Frequency of *A. marina* was highest i.e. 90% followed by *A.corniculatum* with 80%, third place was occupied by *A. alba, A. officinalis* and *L.racemosa* with a frequency of 70% each. Lowest frequency of 10% was recorded by associate flora *Ipomea pes-caprae, Sesuvium portulacstrum* and *Cynodon dactylon.*

Abundance wise *A. corniculatum* was the most abundant with an abundance of 17.37n/100 sq.m, followed by *A. ilicifolius* with 16.8 n/100sq.m. *A. officinalis* with 9.57 n/100 sq.m, *L. racemosa* with 5.43 n/100 sq.m. and *R. apiculata* with 5.16 n/100 sq.m. The lowest abundance was recorded in case of associate flora of *I. pescaprae* [3.0n/100 sq.m.], *Derris trifoliata* [2.0 n/100 sq.m.] and *S. portulacastrum*[1.0n/100 sq.m.].

Relative values of Density, Frequency and Dominance:

A. corniculatum recorded the highest Relative Density of 28.65%, followed by *A. ilicifolius,* 17.32%, *A. officinalis* 13.81%, the least R.De. of 0.21% in case of *S. portulacastrum.* In terms of Relative Frequency, *A. marina* was the most frequent with a R. F. of 9.99%, followed by *A. corniculatum* with 8.88%, while *A.alba, A. officinalis* and *L. racemosa* had a R. F. of 7.77% each. In terms of Relative Dominance, *A. marina* had the highest R. D. of 42.153% followed by *A. alba* with 10.777%, the least R. D. of 0.471% was recorded in case of *D. trifoliata.*

Importance Value Index [IVI]

IVI was the highest in case of *A. marina* followed by *A. corniculatum* third highest IVI was recorded in case of *A.officianalis*. The least IVI was recorded in case of *Bruguiera gymnorrhiza.*

During the course of study, seedlings of *R. mucronata, R. apiculata, K. candel, B. gymnorrhiza, B. cylindrica, A. corniculatum,* and *A. officinalis* were raised by Forest Department as per our suggestions and were transplanted at suitable spots with moderate success. However, because of continuous changes in the contours, depth and sandbars at the mouth of the creek resulted in mortality of standing vegetation and seedlings.

Faunal Studies:

The macrofauna of 34 species were recorded from the creek area. The animals that were found at Devbagh can be grouped into aquatic and terrestrial forms. The various aquatic animals that were found at Devbagh are:

Crustaceans: *Thallasina anamola;* Crabs - *Metapograpsus messar, M. annulata, Scylla serrata, S. trancubarica, Matuta lunaris, Dotilla malabarica, Uca anulips;* Prawns *Metapenaeus dobsoni, M. affinis, Penaeus merguiensis, P. indicus, P.* semisulcatus and among cariedians *Macrobrachium malcomsoni.* Various other crustaceans like Alpheid shrimp, Isopods, Amphipods etc. Hermit crabs formed a prominent part of the benthic fauna present in the shells of *Cerethedia* and *Telescopium.*

The various molluscans that were observed are *Gellonia bengalensis, Sanguinolaria diphos, Cerethedia sp., Telescopium sp., Hominoea tenera, Cassidula nucltus, Crossostrea sps* etc. Only dead shells of *Sanguinolaria diphos* were found at the mouth of the creek being buried below the sand bar. The Brachiopod *Lingula anatina* was observed to live in the silty patch that remained at the mouth of the creek.

The terrestrial fauna that were found at Devbagh are frogs during monsoon; Varanus, Calotes, Snakes, Buffaloes, Cows, Oxes, Rats, Fox etc.

DISCUSSION

The mangrovephytes studied in Devbagh creek present a well established vegetation pattern as is clearly visible from the table depicting BDC. The presence of *Avicennia marina* in 6 of the 7 BDCs indicates the success with which this plant is capable to colonise and estasblish itself along the creek. The presence of *A. alba* and *A.officinalis* in 4 of the 7 BDCs also indicates the success ability of all the representatives of family Avicenniaceae to be able to colonise, establish and dominate in a tidal creek. The presence of *Kandelia candel* and *Aegiceras corniculatum* in only the first BDC can be an indication of its recent introduction and its existence in such a physical form throughout its life span respectively. The absence of *Sonneratia alba* from the first BDC is a bit alarming as it indicates that there are no propagules or the ones produced were unable to survive. The reason for this could be that all the plants that belonged to this species were either diseased or dead standing trees. The presence of all the other plants in the First BDC indicates their reproductive and propagational success at this creek.

The observation of high density of 1.39 n/100 sq.m in case of *A. corniculatum* and 0.84 n/10 sq.m in case of *Acanthus ilicifolius* indicates that the plants that grow in the undrerstorey of tall mangrove trees can play an important role in their contribution to the mangrove ecosystem by providing shelter to organisms that inhabit the mangroves and also contribute to the organic content of the estuary or tidal creek.

Table No 1. Density [Den], Basal Area Per Tree [BA/T], Frequency [Freq], Abundance [Abun], Relative values of Density [R.De], Frequency [R. Freq.] & Dominance [R. Do.], and Importance Value Index [IVI] of Plants analysed from Devabagh Creek

Genus species	Den. [n/10sq.m]	BA/T [Sq.m]	Freq. [%]	Abun. [n/100 sq.m]	R. De. [%]	R. Freq. [%]	R.Do. [%]	I VI
Rhizophora apiculata	0.31	0.141	60.0	5.16	6.38	6.66	3.133	16.173
Rhizophora mucronata	0.13	0.244	40.0	3.25	2.68	4.44	2.274	9.394
Bruguiera cylindrica	0.14	0.436	60.0	2.33	2.88	6.66	4.381	13.921
Bruguiera gymnorrhiza	0.05	0.071	20.0	2.50	1.03	2.22	0.254	3.504
Kandelia candel	0.06	0.051	20.0	3.00	1.24	2.22	0.254	3.504
Avicennia marina	0.33	1.782	90.0	3.66	6.80	9.99	42.153	58.943
Avicennia alba	0.09	1.670	70.0	1.29	1.86	7.77	10.777	20.407
Avicennia officinalis	0.67	0.224	70.0	9.57	13.81	7.77	1.767	32.347
Lumnitzera racemosa	0.38	0.309	70.0	5.43	7.84	7.77	1.767	32.347
Sonneratia alba	0.13	1.056	60.0	2.17	2.68	6.66	9.845	19.845
Sonneratia caseolaris	0.07	0.298	40.0	1.75	1.44	4.44	1.497	7.377
Aegiceras corniculatum	1.39	0.029	80.0	17.37	28.65	8.88	2.945	40.475
Exoceria agallocha	0.16	0.250	60.0	2.67	3.30	6.66	2.867	12.827
Acanthus ilicifolius	0.84	---	50.0	16.8	17.32	5.55	---	---
Derris trifoliatas	0.04	0.164	20.0	2.0	0.82	2.22	0.471	3.511
Ipomea pes-capre	0.03	---	10.0	3.0	0.62	1.11	---	---
Sesuvium portulacastrum	0.01	---	10.0	1.0	0.21	1.11	---	---
Clerodendron inerme	---	---	60.0	---	---	6.66	---	---
Cynodon dactylon	0.02	---	10.0	---	---	---	---	---

Table No 2 Percentage of plants at Devbagh creek of different Basal Diameter Class [in cms]

Genus species	0.1-5.9	6.0-10.9	11.0-15.9	16.0-20.9	21.0-25.9	26.0-30.9	>31.0
Rhizophora apiculata	90.32	6.45	3.23	---	---	---	---
Rhizophora mucronata	69.23	23.07	7.69	---	---	---	---
Bruguiera cylindrica	35.71	50.00	14.28	---	---	---	---
Bruguiera gymnorrhiza	80.00	20.00	---	---	---	---	---
Kandelia candel	100.00	---	---	---	---	---	---
Avicennia marina	24.24	24.24	9.09	30.30	9.09	---	3.03
Avicennia alba	11.11	22.22	33.33	11.11	22.22	---	---
Avicennia officinalis	88.06	4.35	1.45	4.35	1.45	---	---
Lumnitzera racemosa	63.16	23.68	10.52	---	---	---	---
Sonneratia alba	---	46.15	53.85	---	---	---	---
Sonneratia caseolaris	42.86	42.86	14.29	---	---	---	---
Aegiceras corniculatum	100	---	---	---	---	---	---
Exoceria agallocha	62.50	37.50	---	---	---	---	---

Avicennia marina occurred most frequently in this case study with Frequency of 90%. Its occurrence in 6 BDCs with maximum Basal Area Per Tree and a Relative Dominance of 42.153%, shows the importance and success this plant has achieved in surviving under the varied environmental conditions that exist in this tidal creek.

Aegiceras corniculatum was the next most important species in the present case with an IVI of 40.475 second only to *A. marina* that showed an IVI of 58.943%. A look at the values of the IVI of each species reveals maximum of 58.943% in case of *A. marina* and a lowest of 3.511 in case of *Derris trifoliata*. With all other species with an intermediate IVI. This gives us a picture of an ecosystem in which the scene is dominated by *A. marina*, followed by *A. corniculatum, L. racemosa, R. apiculata* etc. The plants belonging to the family Avicenniaceae were most dominant followed by Rhizophoraceae indicating the manner in which a particular family of plant colonises an estuary or tidal creek. This shows the heterogeneity that exists in a mangrove ecosystem and how the plants of different species contribute to the well being of the ecosystem.

A very interesting observation made during the present investigation is that, some of the plants that grow in low salinity such as *B. cylindrica, B. gymnorrhiza E. agallocha, S. alba, A. ilicifolius* and *A. officinalis* share the habitat with plants growing in high salinity zone like *A. marina,* and *R. mucronata.*

The contours, depth, vegetation and the sand bars at the mouth of the creek keep changing. This could be due to the breakwater built to protect Karwar harbor having something to do with changing direction of the current and intensity of the waves and tides leading to its impact on the creek mouth. The pillars of National Highway Bridge built across river Kali also may have some role in the change of direction of down flow of water.

CONCLUSION AND SUGGESTIONS

Devbagh creek being a new found mangrove habitat, this is the first research work carried out. In this work, *Bruguiera cylindrica*, an eumangrove, along with *Sesuvium portulacastrum* a psammophyte are reported for the first time from Karwar region. A medicinal plant, *Rauwolfia tetraphylla* is abundant in the surrounding Casuarina plantation.

Devbagh creek, being away from human settlement and fenced by the Forest Department for their mangrove nursery and Casuarina plantation, is not under much of anthropogenic activity. In view of tourism potential this place could be considered for declaration as a Bio-reserve or Marine park as it has very significant growth of mangroves with water ways and a high degree of biodiversity next only to the Sunderbans. A few plants that are not found here but in other parts of Kali estuary could be introduced here to make this place biologically richer. The place appears to be ideal to setup a germ plasm bank of mangroves for the West Coast.

This creek is lying close to the Devbagh resort run by Jungle Lodges, a tourism development wing of Forest Department. Being an attractive tourist spot it is prone to pollution. Also, evacuees from the project 'sea bird' are provided settlement space nearby and therefore there is likely destruction of this mangrove for firewood. It could be ideally developed, by fencing all around, a little dredging of water ways and the main lake, building a trekking path all around, a stone wall with gate for tidal flow at the mouth of the creek. This will be a good Eco-tourism spot with boating, hiking and camping facilities for the tourists, students of schools and colleges visiting for education and entertainment purpose. The scenic beauty of this area is unique as it overlooks Kali river mouth, Kodibag sand bar, estuary, bridge, hills around, sea-islands, Karwar beach and harbor.

REFERENCES

Duke, N.C., 1991. Mangrove floristics and biogeography in Robertson, A.I. and D.M. Alongi (ed.) Tropical Mangrove ecosystems. S. 101 – 136. Coastal and estuarine Studies, 41. American Geophysical Union, Washington, 63-100.

Govindaswamy C., A.G. Viji Roy, C. Prabhahar, S. Valarmath and Jayapaul Azariah, 1997. 57. Mangrove Bioethics and the environment. Bioethics in India. Proceedings of the International Bioethics Workshop in Madras. Biomanagement of Biogeoresources 16 -19 Jan. 1997.

Naskar K.R. and R. Mandal , 1999. Ecology and Biodiversity of Indian Mangroves Vol. I & II.

Rao, T.A., and P.V. Suresh, 2001. Coastal ecosystems of the Karnataka State, India. I. Mangroves

Robin, L.E. and Bazelevic, N.I., 1966. The biological production of main vegetation types in the Northern Hemisphere of the Old World For abs. 27 : 369 – 372.

Shukla, R.S. and P.S. Chandel, 1972. Plant ecology. S. Chand and Company, New Delhi. Sidhu, S.S., 1963. Studies on the mangroves of India. I. East Godavary region. Indian Forester, 89: 337 – 351.

Snedaker C.S. and J.S. Snedakar, 1984. The mangrove ecosystem. Research methods. Monographs on Oceanographic methodology, 8. UNESCO, Paris, 251.

Untawale A.G. and Wafar, S., 1986. Coastal Karnataka and its ecodevelopment in Karnataka state of Environment report 1984-85. Ed. J. Saldanha, Centre of Taxonomic studies, Bangalore (Chapter I.) : 1-11.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 78-83

BIODIVERSITY AND ECOLOGY OF THE GULF OF KACHCHH MANGROVES, GUJARAT

Oswin D. Stanley
Gujarat Ecology Commission
Govertment of India, Race Course Road
Vadodara, Gujarat, India.
oswinbaby@yahoo.com

ABSTRACT : Biodiversity studies in the Gulf of Kachchh, the northwestern coastal mangrove formations of India exhibited a wide-ranging assemblage of biota. *Avicennia marina* dominated the floral components whereas Rhizophoracean members occurred exclusively in a few pockets. The plant such as *Bruiguiera* is presently absent; *Sonneratia, Rhizophora* and *Ceriops* were vulnerable and *Aegiceros* was in the endangered category. The height of the trees varied up to 10m. In Jakhau port the valuable fish catch estimate was 7,77,742 Tonnes per annum. Pipefish *Syngnathus* sp was recorded for the first time in the creek waters of Kachchhh. Mangroves of Kachchh shelters 87 species of water birds. Dredging for private port activities, oil and chemical spillage from existing ports and industries, illegal trawling and grazing are the few threats faced by the mangrove that needs immediate attention. Studies on the mangrove seedling recruitment pattern are recommended.

Keyword : Gulf of Kachchh, Ecology, Floral and Faunal diversity, Threats.

INTRODUCTION

Biodiversity is an index of the incredible health of habitat. The conservation of the biotic diversity is not only a matter of protecting the flora and fauna, but also to safe-guard the whole life support system including the earth's biosphere, soil, water and gases for the present and future. West coast mangroves of India are mainly located in the Gujarat coastline, with about two lakhs km sq. (124300.808 sq. miles) of EEZ and about 1.6 km sq. of the continental shelf. Gujarat is endowed with two gulfs viz., Gulf of Kachchh and Gulf of Khambhat, which shelter the entire mangrove forest of the state (nearly 89% of mangroves in Gulf Kachchh and 11% in Gulf of Khambat). An intricate network of 42 islands has a diversified assemblage of flora and fauna, out of which 22 islands have mangroves. The Government of Gujarat has declared an area of 457 km sq. as Marine Sanctuary and 162 km sq. as Marine National Park during 1982 (Anjali *et al*, 1997). Conservation of mangrove ecosystem is essential to protect many marine species from extinction. However, the basic information essential for mangrove management such as species diversity, zonation pattern, hydrological and physico-chemical parameters, are dreadfully meager from the Kachchh mangroves. Hence it is attempted to study the ecology and biodiversity of Gulf of Kachchh mangroves.

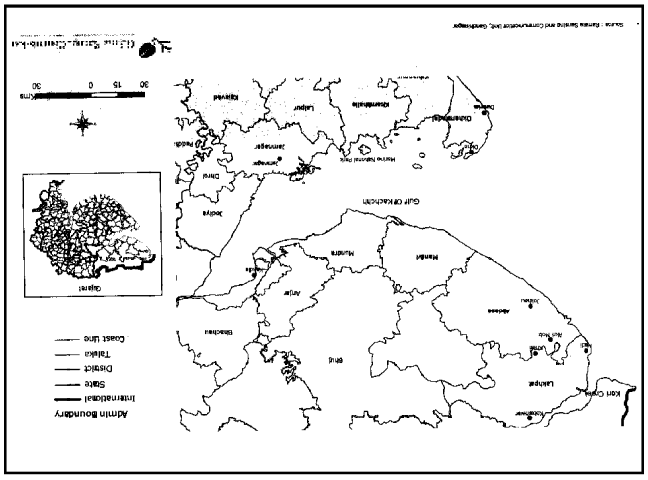
ECOLOGY OF THE GULF OF KACHCHH

The Gulf of Kachchh lie at $22^0$15'-$23^0$40'N; $68^0$20'-$70^0$40'E and is the largest inlet of the Arabian Sea about 60 km wide and tapering north eastward for 170 km **(Figure 1).** The climate of the Gulf is dry with ambient temperature ranging from 7.8^0C in January to 44.8^0C in May. The water temperature varies from 18^0C in winter to 34^0C during summer, in the secluded water bodies. The southwest monsoon breaks around the end of June and continues till September. The average rainfall is about 400mm for about 14days. Annual ratio of precipitation to evapotranspiration in Kachchh mangroves ranged between 0.3 and 0.5. The humidity varies from 50 % (November to December) to 80 % during monsoon. Since perennial rivers are absent, the land run off is little. The streams, which discharge into the Gulf are short; less than 20 km long and are estuarine; receive freshwater only during monsoon (Desai, 1997), whereas in Gulf of Khambat, estuaries of Narmada and Tapti rivers receive freshwater throughout the year.

The average tidal amplitude is 3.1 m and 5.9 m at Okha and Kandla respectively. The tidal amplitude is less pronounced towards northern part of Kori creek with a range of 1.6 m to 3.0 m. In Suraj bari ($23^0$12'N-$70^0$45'E) the tidal amplitude is 1.14-6.10 m. The inner Gulf of Kachchh has waves with height of 3.6 m and wavelengths of about 150 - 350 m near Kandla (Desai, 1987).

Surface salinity varies between 35 and 45 ppt and goes up to 48 ppt during summer. Desai (1997) earlier has observed the salinity variation of 35.2 and 39.4 ppt and a wide variation in suspended solids from 15 – 698 mg/litre. The high and variable suspended solids in the inner Gulf is resulted from the dispersion of sediment in the water column by strong current (Desai, 1997). A gradual increase of salinity was observed from Mundra to Kori creek (Thivakaran *et al*, 1999). The reason perhaps due to the current pattern and current direction from the North to South; Mundra being located inside the gulf and the water revolves around that area for more

Fig. 1 Map showing Gulf of Kachchh



time causing evaporation and stagnation than Kori which is situated open seaward. Soil pH varied from 7.1 (Jakhau and Medi) to 9.2 (Navinal creek to Mundra). Water pH varied from 6.9-8.0.

There is a wide variation of Dissolved oxygen between stations, months and sites within stations. The open sea waters had a DO of 4.8 to 5.6; the mouth which is deep up to 22m but turbulent had the values around 4.2 whereas, the creek system with rhythmic tidal action showed DO between 2.1 to 4.2. DO level range from 3.01 ml^{-1} (Medipost) to 6.7ml^{-1}at Kori creek. In general the dissolved oxygen of the Gulf water is often close to saturation and BOD is low (<3mg/litre).

EXTENT OF KACHCHH MANGROVES

In Kachchh the mangroves are locally called as 'cher'. FSI (1997) using Remote sensing study has calculated forest area as 991 sq.km whereas, the recent survey using IRS LISS III data by GEER foundation during 1998 has estimated as 938.4sq.km (455.6 sq.km dense and 482.8sq.km sparse mangroves). Kachchh has the maximum mangrove area of 727.4 sq.km. The Indus deltaic mangroves from Abdasa and Lakhpat talukas are the largest mangroves in Gujarat. The best mangroves are found in Kori, Laki, Akri, Medi and Jakhau. Added to these, islands of Marine National Park, Pirotan, Kalubtar, Dadeka – Mundeka, Bhaider, Bhensbid, Chhad, Zindra, Noru, Chank and Dhani have partially fringed mangroves along and at the mouths of creeks. Coasts of Jodia Khijadia, Navabander and Sachana have a thick cover of fringe mangrove vegetation.

FLORAL DIVERSITY

The major proportion of the Kachchh mangroves are shrubs with the average height of 2 to 4 m ($4B/TS_1$) based on the classification of Champion and Seth (1968). The luxurious mangroves of Kori creek and few islands could be classified as $4B/TS_2$. Network of Kori creek shelters the best mangrove formation of Kachchh.

Kachchh mangroves can be viewed as fringe mangroves on the shoreline, patchy mangroves along the tidal rivers and creeks, stunted mangroves towards hyper saline mudflats and an inland mangrove pocket of Shravan Kavadya. A considerable range of fringe mangroves along the shoreline was destroyed before the initiation of conservation programs. At present fringe type of mangroves are found in Poshitra, Salaya, Amla, Singach, Betnarara, Razibander, Khijadia, Sachana and Jodiya in Marine National Park, Kandla, Mundra and Abdosa. The tree heights of *Avicennia* spp. vary from 2m to 8m. In Singach to Khijadia and in Jodiaya, a new good fringing vegetation has formed. The flowering season of the mangroves, especially *Avicennia marina* in Gulf of Kachchh starts during June and the fruits mature during August and the fruit fall coincides with the monsoon as it was recorded in the east coast mangroves of Pichavaram and Muthupet (Oswin, 1997).

In the mouth of the small and larger creeks of Gulf of Kachchh, mangrove occur as patch. The height and GBH of the trees are between 2m to 10m and 11cm to 170cm respectively. These areas are unique by the regular tidal flushing with high rates of organic exchange. *A.marina, A.officinalis, A.alba, Rhizophora mucronata, Ceriops tagal, Aegiceros corniculatum* occur in this type of forests. *Avicennia* is found at the water front vegetation in all the creeks and in few islands of the Marine National Park. *Rhizophora* grows in the mouth of the creek, paving way for an ideal condition for regeneration.

Stunted mangrove formations occur towards the hyper saline mudflats and individual plants rarely exceed 1.5 m height. *Avicennia alba* dominates in Marine National Park. Pure patch of *Suaeda fruticosa* or mixed vegetation of *Avicennia* and *Salvadora persica* occurs towards the central portion of islands. Mixed vegetation of *Avicennia, Aegiceros* and *Ceriops* are present in a few islands.

Gulf Mangroves were in remarkable condition in the past during 1950's. The trees were often reaching up to 14 m, represented by *Bruiguiera* sp, *Avicennia, Rhizophora, Aegiceros corniculatum, Ceriops tagal and Sonneratia apetala* (Chavan, 1985). *Bruiguiera* is presently absent whereas, *Sonneratia, Rhizophora* and *Ceriops* are pushed into vulnerable and *Aegiceros* into endangered category (Anjali *et al*, 1997). In the less disturbed area towards the sea, dense homogenous *Rhizophora* patches occur followed by *Avicennia* stands of medium density; 20% - 40% crown density (Anjali *et al*, 1997). In Jakhau both the tree and shrub formations exists. In extremely disturbed areas, dense *Avicennia* delineate seaward edges followed by *Avicennia* of medium density and more on landward side with sparse density. *Rhizophora* is conspicuously absent on disturbed areas.

The composition of mangroves in Kachchh depends on water depth during high tides, which varies from 3.1 to 5.9m, with an average of 4m. The associated flora on islands are *Salicornia brachiata, Suaeda fruticosa, Suaeda nudiflora, Atriplex stockssii, Aleurops lagopoides, Sporobolus* spp., *Cressa cretica, Cyperus conglomerates, C.pargorei, Bergia odorata, Asparagus demosus, Urochondria setulosa, Halopysum mucronatum, Ipomaea pes-caprae, Balanites aegyptica, Salvadora persica, Tamarix* sp., *Eragrostis* sp., *Eluesine* spp. and *Aristida* sp.

Sharavan Kavadiya is a land locked patch of 0.7ha mangroves located at about 40 km in northeast direction of Bhuj. Most of the trees were damaged in 1998 cyclone. The partially damaged or top broken still serving trees count around thirty-six. Average stand height was measured about 18.5m and the average girth about 240cm. The unique inland mangrove patch is an evidence of the ancient shoreline proving the historical evidence for geomorphologic change in this region. Geological survey reports that a rise of the gulf region at a rate of 1.3 cm/year is obvious due to the Holocene transgression of the sea.

Besides, the Kachchh coast has remarkable seaweed diversity. Twenty-nine species of Chlorophyceae, 30 species of Phaeophyceae and 49 species of Rhodophyceae were recorded in the Gulf of Kachchh (Naik *et al*, 1991). There are no recent studies on the seaweed diversity.

SEEDLING DISTRIBUTION

Propagule dispersion has numerous limiting factors such as the velocity of fruit fall, tidal amplitude, current pattern, soil texture etc. The soil, which is soft and clayey, accomplish in trapping the seedling to some extent by overcoming the external forces. Hence, the current velocity is extremely high in Gulf of Kachchh; seeds are trapped in the favorable sites with loose mud, elevated mud flats with depression inside and moderately to some extent between pneumatophores underneath the parent trees'. Seedling availability was high and enumerated as 97 to 750/m^2; an area of approximately 9ha in Jakhau 12ha in Medi was estimated to support better seedling growth. The survival of the seedlings till the next season is always at risk in the mangrove environment due to sun scorch, predation and natural selection. However, in Muthupet mangroves out of 900 seedlings/m2, an average of 3 seedlings/m^2 survived until the next season (Oswin, 1997). Therefore, a study on the seedling recruitment pattern is important to promote regeneration management strategies.

FAUNAL DIVERSITY

Though the productivity of the forests is directly related to the bacterial and fungal population in the ecosystem, which recycles the litter and provides the nitrogen and other nutrients in an assimilated form; the microbial assemblage is basically neglected in many eco-biological studies. There is no baseline information on the microbes of Gulf of Kachchh.

PLANKTON

The phyto and zooplankton, the primary producers of the mangrove ecosystem, form the basic strata of the tropic level. 33 genera of phytoplankton and 48 species of zooplankton were identified. Diatoms dominated the other groups among phytoplankton and decapods larvae, fish larvae and copepods dominated the zooplankton.

INVERTEBRATES

Invertebrates' population in mangroves is considerable. The diversity studies need priority attention. Thivakaran *et al*, (1999) has recorded 21 species of crustaceans, 16 species of polychaetes and 2 species of Gobiid fish. Maximum density was observed in Jakhau and minimum in Laki. Mangroves and corals of the Kachchh coast harbour 30 species of crabs, 200 species of molluscs and 3 species of oysters (Singh, 1997). The dominant species of crabs are *Metagrapsus messor, M.maculates, Uca lactea, U. annulipes, Scylla serrata, Portunus plagicus, Macropthalmus deprussus, Neoepiseasrma* sp. and *Nanosesarma minutum*. The hermit crabs *Diogenes* sp. and *Clibanarius longitarsus* are common. Three species of barnacles, *Balanus balanoides, B.tintinabulum* and *B. amphitrite* were invariably recorded on the tree stems, trunks and foliage. *Peneaus indicus, Metapenaeus* sp and *Macorbrachium* sp. were also recorded. The *Gobiids Periophthalmus* and *Boleophthalmus sp*. are abundant in the marshy water margins. However, the size of the animals is comparatively smaller (7 to 15cm) than the ones (<20cm) observed in the Cauvery deltaic Muthupet mangroves and Adirampattinam, southeast coast of Tamil Nadu (Oswin, 1998). Gastropods *Assiminea* sp, *Cerithidea singulata, Telescopium telescopium, Littorina scabra and Planaxis* sp. are the dominant species inhabiting the muddy substratum, *Cerithidium scabridum, Nassa stolata, N. dorsata, Pollinces* sp., *Thais rugosa and Planaxis sulcatus* were less abundant. Ophiobranchs such as *Onchidium verruculatum, Melampus* sp. and *Cassidula* sp. are also abundant. bivalves, oyster spats, beds of *Saccostrea* sp. and *Crasosstrea* sp. were recorded in abundant at Jakhau and Medi. Others like *Pholas* sp., *Katelysia* sp., *Tellina* sp., *Donax* sp., *Anadora rhombeae, Mactra mera, Angulus sinuta* and *Phapia* sp. do occur.

FISHERY RESOURCES

Mangroves are mostly valued for the fishery resources. It is the feeding and breeding ground for the Icthyofauna. Visually the density of the fingerlings or schooling of juvenile population in the mangrove waters is comparatively more than open waters. From various

studies on mangroves and corals 180 species of fish including 8 types of sharks were recorded (Singh, 1997). Wild fish catch is directly proportional to the health and area of mangrove. Fishermen claimed that increase in the mangrove area in Kori creek has made a direct positive influence in the fish catch. They accept that the damages caused to the mangrove formation had the negative impact on the fish catch in the earlier period and regret for the past improper management of the mangrove ecosystem.

There are 37 fish landing centers in Kachchh and 25 are the major fish landings in the Gulf region, which contributed 85,600 tones of fish from 27 landing centers. Fish such as White and black pomfrets, bombay duck, threadfin, jew fish, Hilsa, clupeids, Coilia, seerfish, Indian salmon, ribbon fish, silver bar, perch, small scianeids, crustaceans such as shrimp, lobster, crab, levta, cuttle squids and some other miscellaneous fish contribute the major catch. Bombay duck is the seasonal fish (November to February) commercially utilized in Kachchh both as raw and dried. In port Okha, prawns such as *Metapenaeus kutchensis, Parapenaeopsis hardurckii, Penaeus stylifera, P. merguiensis* and *P.penicillatus, Solenocera crassicornis, M.monoceros, M.brevicornis, P.semisuleatus* and *M.affinis* were seasonally seen in bulk and poorly represented species include, *P.sculplilis, P.monodon* and *P.caraliculatus* (Singh, 1997). The maximum representation of different prawn species was noticed during April. The whale shark *Rhiniodon typus* of Gujarat been reduced over a period and species such as *Polynemus indicus* (Dara), *P.heptadactylus* (Karkara), *Pomadasys hasta* (Koth), *Otolithoides brunneus*(Ghol), *Protonibea diacanthus* (Wam), *Congresox talabanoides, Muraenesox cinereus* from Gujarat and Maharastra coast have become non existent some time ago (Singh,1997).

Pipe fish *Syngnathus* sp measuring 6. 2 cm was identified for the first time in the mangrove waters of Kachchh from the Kharo creek, during the month of December 2000. The upcoming private industrial complex on the banks of Kharo creek will influence negative impact on the mangrove formations within the network of creeks and fishery reserve. Creeks are rich in the fish seedling resource. Fingerling or young ones diversity comprised prawns (37.36%), carangids (17.80%), Nematolosa (12.75%), Mugil (8.97%), Lutjanus (5.71%), Sillago (4.6%), Liza (3.3%), Stoliferous (1.54%), sardines (1.54%), ophiobranchs (1.32%), flat fish (0.88%), lobster (0.44%) and jellyfish (3.96%). Stoliferous and sardines were recorded immediately after the highest high tide. Illegal trawling was extensively observed inside the mangrove creek waters; for instance 127 fishing trawlers were found trawling during April 2001.

The estimated number of fishers utilizing the ecosystem is 6243. The fishers engage 1429 mechanized trawlers and 695 non-mechanized boats to fish in the Gulf. The capacity of the boats varied from 1 to 28 Tonnes. During fishing season the neighboring fishers too join to exploit fishery resource in the mangrove waters and in the off shore. An approximate calculation (Customs Department) of the native and neighbor seasonal trawlers, fishing in Jakhau alone during the period of 3 months from December 2000 to January 2001 were 400 and 1200 respectively. In Jakhau port the annual exploitation of fish was just about calculated as 8,00,240 Tonnes for mechanized trawlers and 19,460 Tonnes for non-mechanized boats. The valuable fish catch estimate of Jakhau port was 17,514 Tonnes and 7,60,228 Tonnes respectively and the total was 7,77,742 Tonnes. The juvenile population exploitation in the form of trash fish was at least calculated as 40,012 Tonnes and 1.946 Tonnes for trawlers and boats respectively. Though the magnitude of the indirect damages to the seafloor and creek beds due to trawling and improper utilization of resources are enormous, the damages are not economically quantified.

HERPETOFAUNA

There is a lack of information with regard to the herpetofaunal diversity in Kachchh. Three species of sea turtles *Chelonia mydas, Lepidochelys olivacea* and *Dermochelys coriacea* utilize mangroves waters and *C. mydas* was seen breeding in the sandy beaches of Gulf in places such as Mundra to Mandvi. The Kachchh region being typically silt-clay and as the sandy area is very limited, turtles restrict their home range to sandy shore. They were recorded abundantly in the Saurashtra coast from Jamnager to Okha. Green turtles (*C. mydas*) were found to nest and breed in the coast during August to January. The forest department of Gujarat has taken efforts to collect a maximum of 4395 eggs of Green turtles from the Kachchch coast during 1999-2000 and released hatchlings into the sea as a conservation measure.

AVES

Diversified habitats within the coastal ecosystem such as mangrove vegetation, creeks, open mudflats, shallow inter tidal areas, sandy beach and coral reefs provide a compliant niche for the myriad resident as well as passage migrant aquatic birds, which utilize the system in varying degrees from feeding, roosting and breeding. In the present study 87 species of water birds were identified from the Kachchh mangroves. The maximum number of 27 species was from the family Charadridae followed by the families Laridae (19), Ardeidae (10), Anatidae (5), Phalacrocoracidae (4), Threskiornithidae (3), Accipitridae (3), Podicipidae (2), Accipitridae (3), Pelicanidae (2), Ciconidae (2), Phoenicopteridae (2), Gruidae (2), and Recurvirostridae (2). Earlier reports from the mangroves and corals of Kachchh harbored 190 species of birds including 94 species of water birds (Singh, 1997).

MAMMALS

Mammals are another unexplored group in the Kachchh mangrove biodiversity. During the low tide, almost all the mudflats and corals are exposed and the Jackal (*Canis aureus*) and Jungle cat (*Felis chaus*) invade these areas for their easy prey. Jungle cat, moving on the exposed mudflats in Jakhau was recorded on January 24,2001; occurrence of jungle cat in Azad and Bhaider bet was reported by Singh (2000). Musk shrews, rodents and bats are common. Chinkara (*Gazella gazella*) feeds on the tender leaves of mangroves. Camels are the real menace in the mangrove vegetation; 4500 camels were recorded feeding mangroves on the stretch of Koteswar to Jakhau coast. Each camel consumes approximately 30 kg of *Avicennia* leaves. Therefore, there was at least a minimum mangrove leaf loss of 1.35 Tonnes/day. The individuals collect mangrove leaves regularly for fodder accounted around 75 including fishermen and women. During summer, special boat trips were engaged to collect leaves and each boat brings about 25–30 bags, each bag weighing about 40–50 kg i.e., around 1250 kg/day. The mangrove leaf loss due to fodder collection is 3.50 Tonnes/ season. Dolphins use the mangrove creeks and open waters for resting and feeding. Six dolphins approximately 4 to 5 feet long were regularly spotted in the Kharo creek since November 1998 and pair of dolphins was observed in the Sir creek of Medi post during April 2001. Though Dugongs were reported from the Gulf of Kachchh for over a century (1877 to1987), the carcasses were alone identified and reported. It was doubted by the researchers that there must be a regular distance migrations into and out of this area as the gut content of the animals confirmed that the feeding grounds were not Gulf of Kachchh.

CONCLUSION

Kachchh Mangroves are not scientifically explored as that of the east coast mangroves and other western mangroves. Biodiversity study in-depth is recommended to bridge gap information. Apart from the industrial pollutions and natural vagaries dredging, trawling and grazing threaten Kachchh mangroves. Dredging for private port activities in Kharo creek in every way would have negative impacts on the environment such as loss of biodiversity, creation of new mudflats and deltas, perhaps would change current pattern which in - turn would definitely destruct or alter the mangrove formations in the Gulf of Kachchh. Silt interferes the filter feeding mechanism of the molluscan forms and benthic faunal assemblage and turbidity may alter the plankton diversity, the primary producers of the ecosystem. Illegal trawling in the creek system and mangrove waters needs check and abrupt nullification of the act. Grazing, fodder collection and fuel wood collection could be minimized by providing alternative arrangements. It is necessary to take up awareness programme, to enlighten the stakeholders and framing and implementing management strategies with stakeholders' participation.

ACKNOWLEDGEMENT

The author thanks the Scientists of Gujarat Institute of Desert Ecology, Bhuj-Kachchh and Gujarat Ecology Commission, Vadodara for providing facilities.

PROSPECTS FOR BIODIVERSITY RESEARCH IN KACHCHH AND RECOMMENDATIONS

1. Predicting the season or monsoon by watching the wind direction, velocity and period of wind, by assessing the bird population, nesting season, nesting tree height and flight direction could be studied specifically. Therefore the indigenous knowledge of the locals at Kachchh could be explored and utilized for developing scientific technologies or developmental strategies.

2. A study on the seedling recruitment pattern is important to promote regeneration management strategies.

3. Baseline information on the microbial population and ecologically crucial microbial organisms and their significance from Gulf of Kachchh need in depth research.

4. Diversity of invertebrates particularly the crustacean species, their area of occurrence, population diversity and food web requires specific consideration as these components form the major proportion of the valuable fish catch.

5. There is a lack of information with regard to the general herpetofaunal population diversity, reproduction and migration biology and impact of trawling and industrialization on the diversity / density of herpetofauna in Kachchh.

6. Migratory pattern of birds, impact of developmental activities on the population and survival of birds could be given due importance, as they are one of the bio-monitors of the mangrove environment.

7. The population divesity of mammals at Kachchh is an unexplored side. Dolphins of Kachchh require systematic study. The occurrence of Dugongs is an explicit suspicion among researchers.

8. Impact of Port & Jetties and reckless trawling on the biodiversity components of Kachchh are the two major issues to be assessed without preconception.

9. Grazing is another major issue observed in Kachchh during the study. Maldharis are blamed to have the major stake over mangrove utilization for their camel herds. Implementing Rotational Grazing or other strategy studies on sustainable resource utilization and management need

immediate attention.

REFERENCES

Anjali B, H.B.Chauhan and S. Nayak, 1997. Coastal vegetation of Gujarat, Proc. Workshop on Integrated Coastal Zone Management, ISRO and Department of Forests and Environment, Ahmedabad, Gujarat, India: 88.

Champion and Seth, 1968. A revised survey of the forest types of India. XXV+245, pl-103. map.7. Manager of publications, Dselhi. Floristics in various types of forests in India.

Chavan, S.A. 1985. Status of the mangrove Ecosystem in the Gulf of Kachchh. Proc. Symp. Endangered Marine Animals and Marine parks. 1:475 – 482.

Desai, N.1997. Coastal Marine Environment of Gujarat – A Bench mark survey Report 1, Gulf of Kachchh, Gujarat Ecological Society, Vadodara: 16.

FSI 1997. The state of forest report, Forest Survey of India, Ministry of environment and Forests, Dehradun.

Naik, R.M, M.S. Murthy, A.P. Mansuri, Y.N.Rao, R.Pravez, T. Mundkur, Smithakrishnan, P.J.Faldu, TSVR.Krishna, 1991.Coastal Marine Ecosystems and Anthropogenic pressure in the gulf of Kachchh, Final Report to WWF. Saurashtra University, Rajkot, India:12-75.

Oswin, S.D.1997. Survey Utilization and Conservation of Natural Resources of Muthupet Mangroves, South East Coast of India. Thesis submitted to Bharthidhasan University, Tiruchirapalli.

Oswin, S.D.1998. Biodiversity of the Muthupet mangroves, southeast coast of India. Seshaiyana, 6 (1): 9-11.

Singh, H.S. 1997. Issues and problems involved in managing marine protected area: A case study in Marine National Park, Jamnager, Proc. Workshop on Integrated Coastal Zone Management, ISRO and Department of Forests and Environment, Ahmedabad, Gujarat, India: 105.

Singh, H.S. 2000. Mangroves in India: Current status and strategy for conservation, GEER Foundation, Gandhinager, India.

Thivakaran, G.A. 2000. An Ecological Study of Kachchh Mangroves and its Associated Fauna with Reference to its Management and Conservation. *Phase I* Final Report: 1-68

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 84-85

SEASONAL VARIATION OF PHYTOPLANKTON IN URAN ESTUARY

K. N. Babu, S. G. Yeragi and S. S. Yeragi
K. J. Somaiya College of Science, Vidyavihar, Mumbai – 400 077.

ABSTRACT : The standing crop of phytoplankton, interms of biomass, and total cells, recorded high values during the rise as well as maturity of the mud bank. Qualitatively, a total of 37 species of phytoplankters were present. A notable feature seen in association with the mud bank was the blooming of *Noctiluca miliaris*. The present investigation was worked out in Uran estuary (Lat. 20° 29'N & Lon. 77° 32'E) during March 1997 to February 1998. The possible relationship of phytoplankton to and the role it plays at the mud bank is briefly discussed.

Key Words *:* Phytoplankton, Uran Estuary.

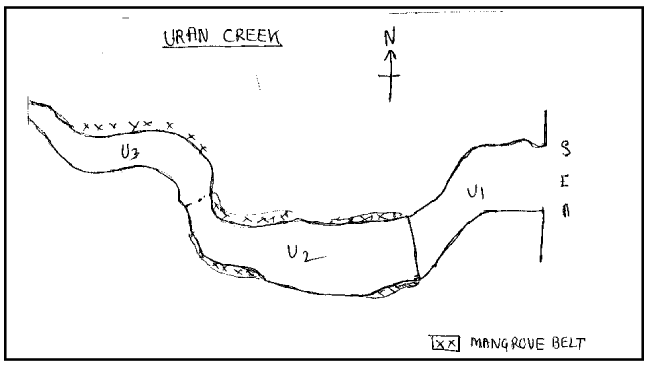
INTRODUCTION

The phytoplankton have great significance in the biology of the estuary as they provide the principal source of primary nourishment. The plankton form an important item of the food of many fishes as well as other organisms. The physico-chemical characteristics are always associated with the density of the plankton. The phytoplankton constitute 95% of the total marine production, so they form a vital source of energy of the first tropical tier and also serve as a direct source of food to several aquatic animals.

In India, studies on marine phytoplankton, systematics, species composition, community structure, distribution and productivity in relation to environmental parameters were carried out extensively from both the east and west coasts (Gopinathan, 1975). The present investigation was carried out to focus attention on the species composition and population density of phytoplankton of Uran estuary in relation to the environmental parameters.

MATERIALS AND METHODS

With a view to having a general picture of the phytoplankton productivity of the Uran estuary fortnightly collections of phytoplankton (net samples by using a half meter bolting nylon net, No. 21, mesh size 0.069 mm) were made from three stations. U_1, U_2, U_3 (fig. 1).



The relative abundance of different phytoplankton present in the net samples were recorded. The total volume of plankton was determined from an aliquot of 1/5 of the sample by the displacement method, after removing the zooplankton by means of an organdy cloth. The sample having brought to the laboratory were transferred to a 50 ml settling chamber and kept for 24 hours, adding few drops of formalin.

RESULTS AND DISCUSSION

Species composition of phytoplankton revealed a total 37 species from all the three stations. A checklist of phytoplankton recorded from the stations during the study period is given in Table. 1. Generally the diatoms, ranked first in species composition followed by dinoflagellates and blue green algae. This tendency was observed throughout the study period of all the stations.

Table 1 Seasonal variations of different phytoplankton in one litre of surface water

Bacillariophyceae (Diatoms)

1) *Melosira sulcata*
2) *Hyalodiscus subtilis*
3) *Skeletonema costatum*
4) *Thalassiosira decipiens*
5) *Coscinodiscus spp*
6) *Planktoniella spp*
7) *Rhizpsolenia spp*
8) *Bacteriastrum varans*
9) *Chaetoceros loreianus*
10) *C. affinis*
11) *Streptthea themesis*
12) *Ditylum brightwelli*
13) *Triceratium favus*
14) *Biddulphia sinensis*
15) *B.mobiliensis*
16) *Hemidiscus hardmannianus*
17) *Fragilaria oceanica*
18) *Thalassionema spp*
19) *Asterionella japonica*

20) Pleurosigma elongatum
21) P. normanni
22) P. directum
23) Navicula spp.
24) Nitzschia longissima
25) N. seriata

Silicoflagellats

26) Dictyota fibula
27) Distephanus speculum
28) Coccolithophora
29) Coccolithus spp

Cyanophyceae

30) Oscillatoria spp
31) Tricodesmium spp

Dinophyceae

32) Dinophysia caudate
33) Ornithocerus magnificus
34) Notiluca miliaris
35) Peridinium depressum
36) P. pentagomum
37) Ceratium furca
38) C. fusus

The fluctuations in phytoplankton population density were wide in different months of the present study period (Fig. 2). The maximum density was recorded during monsoon and the minimum in post monsoon season. In monsoon, phytoplankton density was 893 x 195 cells/l, and highest in the month of June-July and then decline. In post monsoon the density was 436 x 105 cells/l but in pre monsoon again rise to 552 x 105 cells/l.

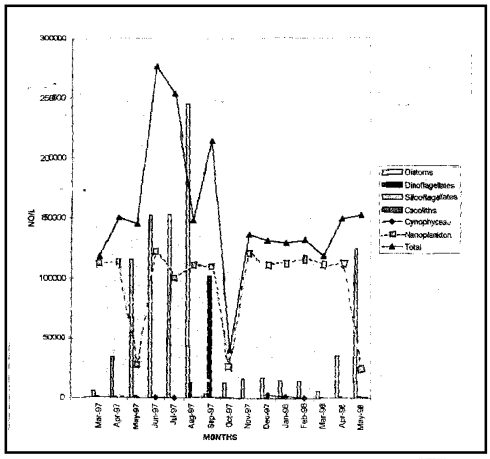


Fig. 2: Seasonal Abundance of Phytoplankton

The quantitative distribution of phytoplankton present in one litre of water collected from the surface in the mangrove area during the period of investigation is presented in the Fig.2. Diatoms dominated during the monsoon but their ratio decline in post-monsoon and again rise from the month of May onward. In compare to diatom, the density of dinoflagellates was less. However, nannoplankters were equally abundant throughout the investigation period. The blooming of the harmful dinoflagellates, *Noctiluca miliaris*, was a high noticeable feature in the month of November to January. Silicoflagellates, and coccolithophores were found to be very rare and blue-green algae (*Trichodesmium* sp.) was found to be abundant during May to July.

From one litre of water sample examined 37 common species of phytoplankters were identified, among which diatoms constituted 25 species, dinoflagellates 7 species, silicoflagellates 2, coccolithophore 1, and blue green algae 2.

The plankton volume showed a gradually increasing trend from April onwards, reaching its maximum in the month of July primarily due to high abundance of the *Noticula*. After August there was a gradual decline in the volume of plankton, reaching the lowest in December at all the three stations. (Fig. 3).

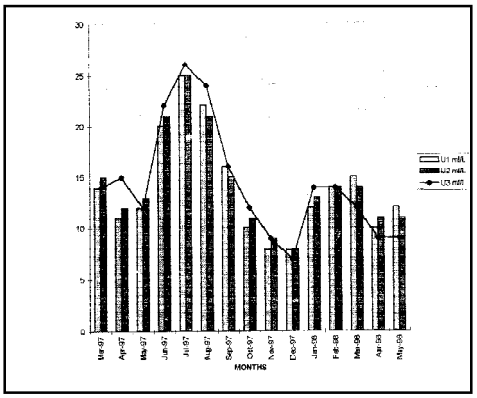


Fig. 3 : Phytoplankton Displacement Volume

The biomass of phytoplankton is totally related with the environmental parameters. The maximum biomass was recorded in monsoon due to availability of nutrient. The productivity of phytoplankton was low in post monsoon due to high temperature. The phytoplankton showed a negative correlation with temperature. Williams and Murdock (1976), noticed the coincidence of low temperature with low phytoplankton density in the backwater. Hence influence of surface water temperature on phytoplankton density is rather obscure in tropical marine environment.

Much more research is needed to understand this part of the nutrient cycle in mangrove brackish waters, and useful for guidance in the search of best to develop an aquaculture without destruction of mangroves.

BIBLIOGRAPHY

Gopinathan, C. P. 1975. Studies on the estuarine diatoms of India. Bull. Dept. Mar. Sci. Univ. Cochin. 7 : 995 – 1000.

Williams R. B. and M. B. Murdoch. 1976. Phytoplankton production and chlorophyll concentration in the Beaufort channel. North Carolina Limnol. Oceanogr. L1 : 73 – 82.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 86-92

PHYTOPLANKTON OF ULHAS RIVER ESTUARY AND THANE CREEK

Mangal U. Borkar, Goldin Quadros and R.P. Athalye
Zoology department, B.N.Bandodkar college of Science, Thane (W) 400 601.

ABSTRACT : The study of phytoplankton at 12 stations each of Ulhas river estuary (40 km stretch) and Thane creek (26 km stretch) during period September 2001 to August 2002 showed dominance of Bacillariophyceae (Diatoms) probably due to extremely high silicates and polluted status of the ecosystems. Total 38 phytoplankton types were reported including Bacillariophyceae (22 genera), Chlorophyceae (8 genera), Cyanophyceae (6 genera), Xanthophyceae (1 genera) and Noctiluca. The density of phytoplankton was high in Thane creek but the diversity was high in Ulhas river estuary. The overall proportion of phytoplankton in Ulhas river estuary was Bacillariophyceae 78 %, Chlorophyceae 9 %, Cyanophyceae 6 % and Xanthophyceae 5 %. In Thane creek it was 91 %, 3 %, 4 %, and 0.35 % respectively.

Though the species composition of both the ecosystems was similar, the dominant genera differed. In Ulhas river estuary the most dominant genera were *Cyclotella spp*. > *Thalassiosira spp.* > *Navicula spp., Thalassiosira spp*. was the most successful genera. The proportion of phytoplankton was more even in Ulhas river estuary as compared to Thane creek.

Key words : Ulhas river estuary, Thane creek, Phytoplankton. Diatoms.

INTRODUCTION

The phytoplankton are the primary producers of the aquatic food chain. They play a pivotal role in fixation of solar energy to make it available to the higher organisms. They form an important link between the abiotic factors and the biota in the aquatic ecosystem (Saha, 2000). The planktonic flora of the water body is influenced by various environmental factors which show seasonal and regional variations, (McCombie, 1953; Cholonky, 1960). Also due to urbanization there is tremendous pollution pressure on the waters of the creeks and estuaries, which affects the phytoplankton.

Phytoplankton of coastal water bodies have been studied by various workers like Krishnamurthy *et al* (1974), Santhanam *et al* (1975), Vijayalaxmi and Venugopalan (1975), Mani (1992), De *et al(* 1994) , Ramaiah and Ramaiah (1998). Present paper describes the phytoplankton of Ulhas river estuary and Thane creek.

MATERIALS AND METHODS

The present study, was carried out in the Ulhas river estuary (Long.73 ^{0} 20' E to 72 ^{0} 45' E ;Lat.18^0.45' N to 19^0.16' N) and Thane creek (72^0. 55' to 73^0 .00' E; Lat.19^0.00' to 19^0.15' N) between Sept 2001-Aug 2002. Three zones were imagined in the two ecosystems namely Riverine zone (Stations 1 to 4 and 13 to 16), middle zone (stations 5 to 8 and 17 to 20) and seaward zone (stations 9 to 12 and 21 to 24), (Fig. 1). The water samples for phytoplankton were collected from the intertidal region. The collected sample were fixed in the field itself using Lugol's iodine and brought to the laboratory, observed under compound microscope. The count was obtained by Lackeys drop method (Trivedy and Goel 1984) The genera observed were classified, the organic pollution indicator were listed according to Palmer (1969). The data was compared with the available past data from the Ulhas river estuary and the Thane creek (Ramaiah and Ramaiah, 1998; Goldin, 2001).

Important water parameters were analysed using standard methods (APHA, AWWA, WPCF, 1981). The data has been presented zonewise.

RESULTS AND DISCUSSION

The physico-chemical characters of the water of Ulhas river estuary and Thane creek are presented in Table 1. In general, as compared to Thane creek Ulhas river estuary showed lower light penetration, high suspended solids, better dissolved oxygen, lower salinity, lower B.O.D., lower Phosphate-Phosphorus and higher Silicate-Silicon and Nitrate-Nitrogen. Thane creek has higher sewage pollution as compared to Ulhas river estuary. Further, Thane creek was more tide dominated and showed lower salinities only during monsoon. In Ulhas river estuary freshwater influence was relatively more.

The phytoplankton observed in Ulhas river estuary and Thane creek included total 38 types belonging to classes Bacillariophyceae (22 genera), Chlorophyceae (8 genera), Cyanophyceae (6 genera) Xanthophyceae (1 genus) and Noctiluca. The phytoplankton density in general was higher in Thane creek (Av. 1149.9 x 10^3/l) as compared to Ulhas river estuary (Av. 1033.9 x 10^3/l) (Table 2). Ulhas river had

Table 1 : Water and sediment parameters of Ulhas river estuary and Thane Creek.

	Ulhas River Estuary										Thane Creek									
	Zone 1			Zone 2			Zone 3			Total	Zone1			Zone2			Zone3			Total
Water Parameters ❋	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Avg
Water Temperature^{0}C	21.25	33.13	28.03	21	31.5	28.19	22.75	33.25	28.35	28.18	21.5	33.75	28.75	22.5	33.45	29.37	26.38	34.88	30.28	29.71
Light Penetration	14	50.75	30.5	13.38	57.5	27.44	7.75	27.25	16.11	24.69	22	57.75	33.51	19.75	59.25	39.81	13	42.5	30.56	34.63
Suspended solids gm/l	0.16	0.96	0.555	0.15	2.375	1.249	0.205	6.15	3.865	1.89	0.43	3.385	1.911	0.6	13.5	2.414	0.535	3.17	1.551	1.958
pH	6.93	7.76	7.44	7.22	7.8	7.54	7.4	8.04	7.78	7.59	7.19	8.09	7.67	7.4	8.19	7.74	7.57	8.193	7.78	7.73
Salinity ppt.	0.389	18.51	8.93	0.73	30.28	15.34	1.035	34.92	22.93	15.73	0.803	32.48	19.67	2.85	34.6	23.93	6.825	37.14	27.55	23.73
Dissolved oxygen mg/l	0.75	3.825	2.29	1.425	3.35	2.55	1.983	4.8	3.62	2.82	0.375	2.925	2.015	0.7	8.2	1.998	0.925	4	2.11	2.041
B.O.D. mg/l	5.375	24.43	16.25	2.225	13.48	8.341	0.55	8.45	5.083	9.892	9.75	42.75	24.67	2.125	24.13	13.04	1.9	20.05	10.79	16.17
PO4-P mg/l	0.03	0.094	0.06	0.03	0.092	0.055	0.023	0.061	0.047	0.054	0.061	0.162	0.132	0.033	0.096	0.074	0.027	0.094	0.069	0.092
NO3-N mg/l	0.292	2.521	1.491	0.905	3.533	1.89	0.189	2.275	1.616	1.666	0.471	1.458	1.022	0.145	2.099	0.853	0.145	1.383	0.983	0.953
SiO3-Si mg/l	12.66	77.43	33.67	11.1	72.6	34.07	11.72	61.09	29.07	32.27	12.25	43.02	26.66	8.498	35.15	22.34	5.734	38.98	15.88	21.63



Fig. 1 - Map showing sampling stations in Ulhas river estuary and Thane creek.

marginally higher species variety than Thane creek. The species number reduced from riverine to seaward zone. At least 12 genera from Thane creek and 20 from Ulhas river estuary showed bloom conditions.

When season wise distribution of phytoplankton was studied in the two ecosystems it was noticed that in the Ulhas river estuary, phytoplankton count was the highest during post monsoon (1385.2 x 10^3/l) followed by premonsoon (1216.311 x 10^3/l) and monsoon (811.31 x 10^3/l). Whereas in Thane creek phytoplankton was highest in the premonsoon (2714.54 x 10^3/l) followed by post monsoon (585.767 x 10^3/l) and monsoon (934.61 x 10^3/l). Saha *et al*. (2000) observed that in sewage polluted brackish water the phytoplankton count was the highest during monsoon followed by pre monsoon and post monsoon respectively this does not corroborate with the present observations.

Of the different phytoplanktons observed the diatoms dominated in the study period in both the ecosystems. Certain genera were seen only at the riverine end, preferring low salinity, while others were seen surviving in regions of high salinity. The fresh water genera included diatoms *Amphora spp. Biddulphia spp., Cosinodiscus spp.. Gomphonema spp*., and *Leptocylindrus* spp; the chlorophycean genera *Crucigenia spp*.and *Scenedesmus spp*. and cyanophyceae genera *Anabaena spp. Oscillatoria spp.* The genera at riverine end showed preference towards the low salinity that ranged between 0.389 ppt. – 18.51 ppt .*Volvox* a typical fresh water alga was seen only in the region with low salinity, 0.389 - 0.73.ppt. The genera occurring on seaward end included diatoms *Triceratium spp*., Chlorophyceae *Koliella spp., Golenkenia spp*. the other species occurred in all the zones.

The zonewise details of the phytoplankton distribution are discussed below

ULHAS RIVER ESTUARY.

Zone 1 (riverine end)

The stations included in this region were 1-4. (Fig.1) The salinity ranged between 0.389 ppt. to 18.51 ppt. (Av. 8.93 ppt.). The suspended solids were also in excess ranging between 0.15 - 0.96 gm/l (Av.0.555gm/l) and the light

Table 2: Zonewise variations in Phytoplankton density no x 10^3/l in Ulhas river estuary and Thane creek.

.	Ulhas River Estuary						Thane Creek					
Phytplankton genera	Zone 1	Zone 2	Zone 3	Total	Avg	%	Zone 1	Zone 2	Zone 3	Total	Avg	%
Bacillariophyceae												
Cyclotella spp.	304.8	324	22.63	651.43	217.14	21.00	24.72	28.56	22.63	75.91	25.30	2.20
Gomphonema spp.	2.058	0	0	2.06	0.69	0.07	2.058	0	0	2.06	0.69	0.06
Leptocylindrus spp.	29.47	24.69	6.173	60.33	20.11	1.94	32.92	20.58	0	53.5	17.83	1.55
Melosira spp.	72.51	94.61	14.4	181.52	60.51	5.85	447.2	517.2	235.6	1200	400.00	34.79
Navicula spp.	50.07	43.02	24.69	117.78	39.26	3.80	122.4	70.98	106	299.38	99.79	8.68
Pleurosigma spp.	116.7	10.29	12.35	139.34	46.45	4.49	17.15	30.85	14.4	62.4	20.80	1.81
Navicula closterium	6.173	0	0	6.17	2.06	0.20	0	0	0	0	0.00	0.00
Thalassiosira spp.	223.4	83.91	87.45	394.76	131.59	12.73	634.9	385.8	166.7	1187.4	395.80	34.42
Amphora spp.	12.35	20.58	0	32.93	10.98	1.06	6.173	25.72	4.115	36.01	12.00	1.04
Biddulphia spp.	26.85	30.87	20.58	78.3	26.10	2.52	4.115	4.115	0	8.23	2.74	0.24
Nitzschia spp.	33.95	88.99	65.84	188.78	62.93	6.09	58.13	44.24	23.67	126.04	42.01	3.65
Pinnularia spp.	2.058	0	2.058	4.12	1.37	0.13	6.688	4.115	0	10.8	3.60	0.31
Thalassionema spp.	0	0	0	0	0.00	0.00	32.92	0	0	32.92	10.97	0.95
Rhizosolenia spp.	2.058	4.115	10.29	16.46	5.49	0.53	16.46	4.115	7.202	27.78	9.26	0.81
Synedra spp.	0	0	0	0	0.00	0.00	2.058	0	0	2.06	0.69	0.06
Coscinodicus spp.	4.116	0	6.173	10.29	3.43	0.33	10.29	5.144	0	15.43	5.14	0.45
Surirella spp.	14.4	2.058	4.115	20.57	6.86	0.66	2.058	0	0	2.06	0.69	0.06
Cymbella spp.	4.115	0	0	4.12	1.37	0.13	0	2.058	0	2.06	0.69	0.06
Chlorophyceae												
Skeletonema spp.	28.29	7.202	102.9	138.39	46.13	4.46	6.173	0	4.115	10.29	3.43	0.30
Asterionella spp.	2.058	316.9	53.5	372.46	124.15	12.01	0	0	0	0	0.00	0.00
Gyrosigma spp.	4.115	2.058	2.058	8.23	2.74	0.27	6.173	0	0	6.17	2.06	0.18
Triceratium spp.	0	0	12.35	12.35	4.12	0.40	0	0	0	0	0.00	0.00
Chlorophyceae												
Ankiisteodesmus spp.	0	0	0	0	0.00	0.00	2.058	0	0	2.06	0.69	0.06
Crucigenia spp.	135	6.173	0	141.17	47.06	4.55	4.115	6.198	0	10.31	3.44	0.30
Scenedesmus spp.	4.115	10.29	4.116	18.52	6.17	0.60	10.29	0	0	10.29	3.43	0.30
Volvox spp.	14.4	100.8	0	115.2	38.40	3.71	0	0	0	0	0.00	0.00
Gonium spp.	0	0	0	0	0.00	0.00	0	0	2.058	2.06	0.69	0.06
Koliella spiculiformis	0	0	0	0	0.00	0.00	0	0	26.75	26.75	8.92	0.78
Golenkenia spp.	4.115	0	0	4.12	1.37	0.13	0	0	67.9	67.9	22.63	1.97
Tetredron spp.	2.058	0	0	2.06	0.69	0.07	0	0	0	0	0.00	0.00
Spirullina spp.	6.173	12.35	0	18.52	6.17	0.60	6.173	8.231	0	14.4	4.80	0.42
Cyanophyceae												
Anabaena spp.	114.6	8.231	0	122.83	40.94	3.96	4.115	2.058	2.058	8.23	2.74	0.24
Oscillatoria spp.	33.95	26.75	4.115	64.82	21.61	2.09	57.61	14.4	12.35	84.36	28.12	2.45
Nostoc spp.	0	2.058	0	2.06	0.69	0.07	0	0	0	0	0.00	0.00
Gleocapsa spp.	4.115	0	0	4.12	1.37	0.13	0	0	0	0	0.00	0.00
Lyngbya spp.	0	0	0	0	0.00	0.00	51.44	0	0	51.44	17.15	1.49
Tribonema spp.	57.62	100.2	2.058	159.88	53.29	5.15	2.058	4.115	6.173	12.35	4.12	0.36
Nocticuluca spp.	6.173	2.058	0	8.23	2.74	0.27	0	0	0	0	0.00	0.00
Total	1322	1322	457.8	3101.8	1033.93	100.00	1570	1178	701.7	3449.7	1149.90	100.00
Total no. of species	30	23	19	32	—	—	27	18	16	31	—	—

Table 3 : Zone wise total of Phytoplankton classes and Percentage composition in Ulhas river estuary and Thane creek.

	Ulhas river estuary					Thane creek				
Phytoplankton Classes	Zone 1	Zone 2	Zone 3	Total	Avg	Zone 1	Zone 2	Zone 3	Total	Avg
Bacillariophyceae	939.54	1053.29	447.56	2440.39	813.46	1432.59	1143.48	584.43	3160.5	1053.5
Chlorophyceae	159.69	117.26	4.12	281.07	93.69	16.46	6.20	96.71	119.37	39.79
Cyanophyceae	158.84	49.39	4.12	212.35	70.78	119.34	24.69	14.41	158.43	52.81
Xanthophyceae	57.62	100.2	2.058	159.88	53.29	2.058	4.115	6.173	12.35	4.12
Noctiluca	6.173	2.058	0	8.23	2.74	0	0	0	0	0.00
	Ulhas river estuary					Thane creek				
Percentage composition of Phytoplankton classes	Zone 1	Zone 2	Zone 3	Total	Avg	Zone 1	Zone 2	Zone 3	Total	Avg
Bacillariophyceae	71.070	79.674	97.763	78.677	78.677	91.248	97.069	83.288	91.617	91.617
Chlorophyceae	12.079	8.870	0.899	9.062	9.062	1.049	0.526	13.782	3.460	3.460
Cyanophyceae	12.015	3.736	0.899	6.846	6.846	7.601	2.096	2.053	4.593	4.593
Xanthophyceae	4.359	7.579	0.450	5.154	5.154	0.131	0.349	0.880	0.358	0.358
Noctiluca	0.467	0.156	0.000	0.265	0.265	0.000	0.000	0.000	0.000	0.000

penetration was low in accordance with the excess suspended solids that blocked the light (14 - 50.75 cms., Av. 30.50 cms). The average phytoplankton was 1322 x10^3/l. Bacillariophyceae genera dominated (71 %) (Table 3) the phytoplankton followed by Chlorophyceae 12 %, Cyanophyceae 12 %, and Xanthophyceae 4 % represented by a single genus *Tribonema*. Bacillariophyceae genera were 19 of which *Cyclotella* spp. was the most dominant followed by *Thalassiosira spp., Melosira spp., Navicula spp*. and *Nitzschia spp.* (Table 2). The dominant Chlorophyceae was *Crucigenia spp*., whereas A*nabaena spp*. was the dominant *Cyanophyceae spp*. Eight of the Palmers pollution indicator genera were observed in zone 1. namely *Melosira, ,Navicula, Nitzschia, Pinnularia, Cymbella, Asterionella, Crucigenia, Golenkinia*

Zone 2 (middle zone)

This zone had the stations 5- 8 (Fig1) with the salinity slightly higher between 0.73ppt. –30.28ppt. (Avg. 15.34 ppt.) thus showing the influence of creek water. The suspended solids were higher than the zone 1 ranged between 0.15 gm/l- 2.375 gm/l (Avg.1.249 gms/ l) and light penetration was between 13.38 .- 57.5 cms. (Avg.27.44 cms.)The total count of phytoplankton in this region was 15867x10^3/l (Avg.1322x10^3/l)

In this zone also class Bacillariophyceae dominated (79 %) with 15 genera followed by Chlorophyceae (8 %) with 3 genera then Cyanophyceae (3 %) with 4 genera.. The maximum count of diatom was of *Cyclotella* which was also seen in the zone 1 as a dominant genus , followed by *Asterionella, Melosira*, *Thalassiosira.* The least count was of *Gyrosigma* and *Surirella*. Among the Chlorophyceae dominance was of the freshwater alga Volvox followed by *Scenedesmus*, while in Cyanophyceae *Oscillatoria* dominated.

Six Palmers' pollution indicating genera were observed viz. *Anabaena, Asterionella, Crucigenia, Melosira, Navicula, Nitzschia*.

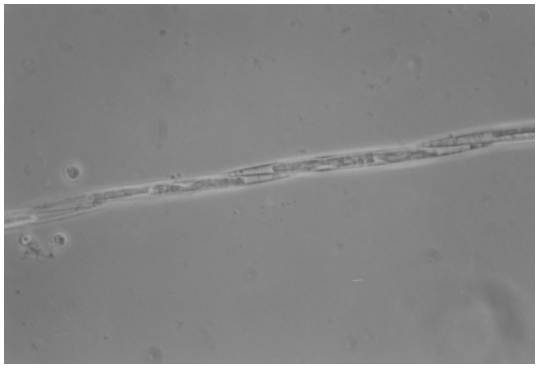
ZONE 3

The stations in this zone were 9-12 (Fig.1) the salinity was higher as compared to the earlier zones it ranged between 1.035ppt- 34.92 ppt (Av.22.93 ppt), the suspended solids were between 0.205 gms./l- 6.15 gms./ l (Av. 3.865 gm/l) and the light penetration was between 7.75 cms- 27.25 cms.(Av. 16.11 cms.). The total count of phytoplankton was less as compared to the other zones (Avg.457.8x10^3/l) .In this zone also the class Bacillariophyceae (97 %) dominated with 16 genera followed by Chlorophyceae (0.899 %) with only one genus *Scenedesmus* thus at the seaward end with higher salinity the chlorophyceae members were almost absent. Cyanophyceae was also low (0.9 %) represented by a single genus *Oscillatoria.*

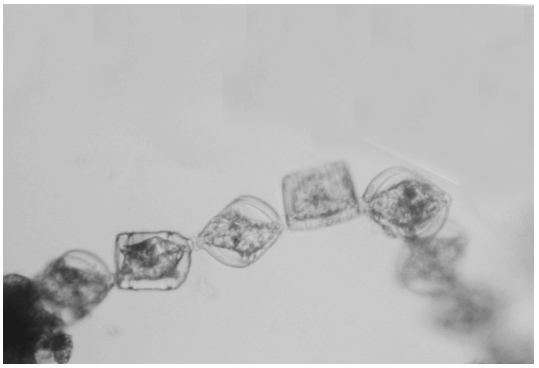
The diatom genus that dominated at the seaward end was *Skeletonema*, followed by *Thalassiosira, Nitzschia, Navicula,* and *Cyclotella*.

The Palmers' organic pollution indicators

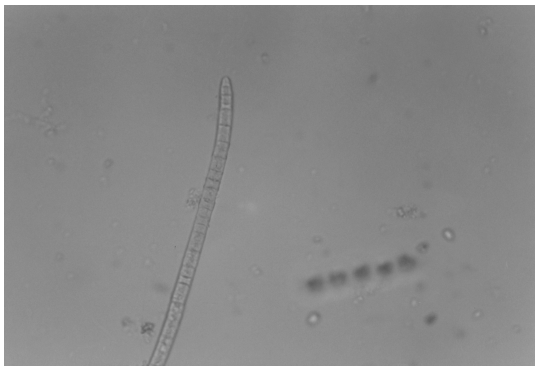
PHYTOPLANKTON OF THANE CREEK & ULHAS RIVER ESTUARY



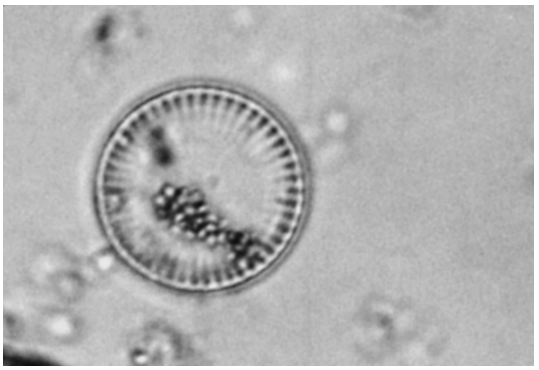
Nitzschia spp.



Thalassiosira spp.



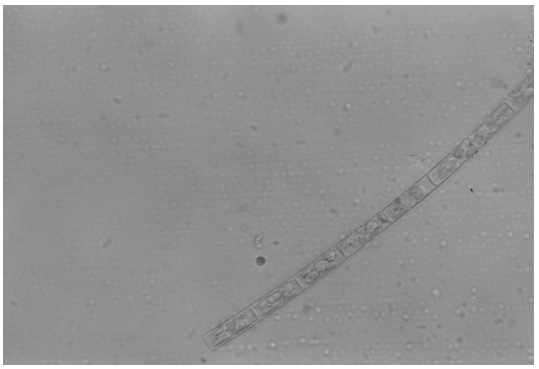
Oscillatoria spp.



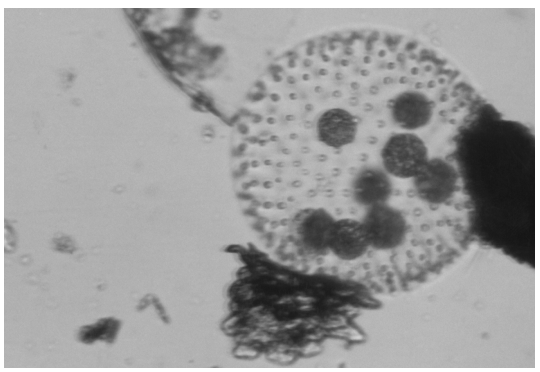
Cyclotella spp.



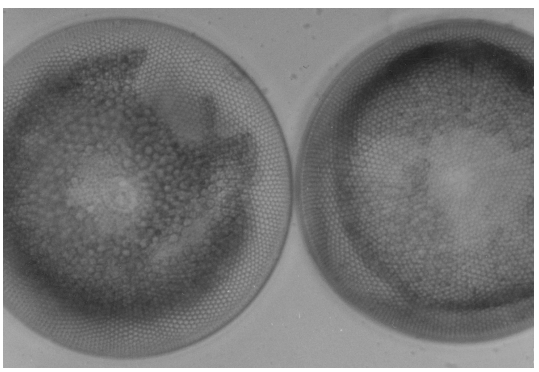
Pleurosigma spp.



Tribonema spp.



Volvox spp.



Coscinodiscus spp.

included 5 genera *Asterionella, Melosira, Navicula, Nitzschia, Pinnularia.*

Thus when all the three zones of Ulhas river estuary were compared it became clear that the phytoplankton count was more towards riverine end than the seaward end . The diversity also reduced from riverine end to seaward end as 30 > 23 > 19, which could be due to increasing salinity. The Palmers pollution indicator genera also reduced from riverine to seaward end (8 to 6 to 5). This however cannot be used to compare zonal pollution status because the change could also be due to the effect of salinity.

THANE CREEK

Zone 1

Include the stations 13 to 16 (Fig1) from Balkum- Vitawa. In this zone there was moderate influence of fresh water and the salinity ranged between 0.803 to 32.48 ppt (Avg. 19.67 ppt), suspended solids between 0.43 to 3.385 gm/l (Av.1.911 gm/l) while the light penetration ranged from 22.00 to 57.75 cms. (Av. 33.51 cms), indicating that the transparency of water was more in the Thane creek than in the Ulhas river. The total count of phytoplankton was 18845 $x10^3$/l (Avg.1570x 10^3/l). In this zone also the members of class Bacillariophyceae dominated (91 %) with 19 generic types followed by Cyanophyceae (7 %) with 3 genera, Chlorophceae (1 %) with 3 genera. The diatom genus that dominated in this zone was *Thalassiosira* followed by *Melosira* and *Navicula.* The least count was of *Gomphonema, Synedra*, and *Ankistrodesmus*. Cyanophyceae was dominated by Oscillatoria followed by *Anabaena spp.*. The Chlorophyceae members that dominated were *Scenedesmus spp.* and *Crucigenia spp.*

The pollution indicator genera (Palmer, 1969) included *Anabaena, Crucigenia, Lyngbya,Melosira, Navicula, Nitzschia, Pinnularia,* (Total 7).

ZONE 2 (middle zone)

In this zone stations 17-20 were included (Vashi to Koparkhairane). The salinity ranged between 2.850 to 34.5 ppt (Avg.23.93 ppt), suspended solids 0.6 to 13.5 gm/l (Av. 2.414 gm/l) and the light penetration 19.750 to 59.25 cms. (Av. 39.81 cms). The total average count of phytoplankton was 1178x10^3/l. Of the different classes Bacillariophyceae dominated (97 %) represented by 14 genera followed by Cyanophyceae (2 %) with 2 genera and Chlorophyceae (0.5 %) represented by a single genus *Crucigenia.*

Of the Bacillariophyceae, the diatom that dominated in this zone was *Melosira* followed by *Thalassiosira* and *Navicula*. Cyanophyceae had the dominant genus *Oscillatoria* followed by Anabaena.

Palmers' Pollution indicator genera included *Anabaena, Crucigenia, Cymbella, Melosira, Navicula, Nitzschia, Pinnularia,, Oscillatoria* (Total 8).

ZONE 3 (Seaward zone)

This had the stations between 18 to 21 (Fig.1) here the salinity was much higher ranging from 6.825 to 37.14 ppt.(Avg.27.55 gms/l) and the suspended solids were 0.535 to 3.17 gms./l (Avg. 1.55 gms/l), and the light penetration was 13 to 42.5 cms. (Avg.30.56 cms). The total count of phytoplankton was comparatively less 8420 x 10^3/l (Avg. 701.7 x 10^3/l) Bacillariophyceae dominated, being 83 % with 9 genera followed by Chlorophyceae 13 % with 3 genera, Cyanophyceae 2 % with 2 genera. in this zone chlorophyceae had relatively more density as compared to the seaward zone of Ulhas river estuary.

Of the Bacillariophyceae the diatom genus that dominated was *Melosira* followed by *Thalassiosira* and *Nitzschia*. While from chlorophyceae there was dominance of *Golenkinia,* and *Oscillatoria* from Cyanophyceae

The Palmers pollution indicator Species included *Anabaena, Golenkinia, Gonium, Melosira, Navicula, Nitzschia* (Total 6).

In Thane creek in general, there was more dominance of diatoms as compared to Ulhas river estuary. High occurrence of diatoms in both the ecosystems can be attributed to exceptionally high silicates in the water due to the volcanic origin of the rocks of this region (Blasco, 1975).

CONCLUSION

Though the species composition of Ulhas river estuary and Thane creek was similar, the trend of dominance was different in them

1) In Ulhas river estuary the proportion of phytoplankton was relatively more even, because the proportion of the first three most dominant phytoplankton was 21, 12, 12 percent. Where as in Thane creek it was 34, 34, 3.65 percent showing relative unevenness.

2) In Ulhas river estuary the most dominant phytoplankton were *Cyclotella spp. > Thalassiosira spp. > Asterionella spp.* Whereas in Thane creek they were *Melosira spp. > Thalassiosira spp.> Navicula spp.* In both the ecosystems *Thalassiosira spp*. Was the most successful phytoplankton.

REFERENCES

APHA, AWWA, WPCF, 1981. International standard methods for the examination of water and waste water. 15th edition Washington DC. 874 pp.

Blasco,F. 1975. The mangroves of India. Inst.Francais, Pondicherry. Trav.Sect. Sci., Tech.14:1-175

Cholonky, B.J. 1960. The relationship between algae and

chemistry of natural waters. Proc.Spl.Mtg.Wat.Trt.,CSIR Pub. RW No. 129,215-225

De, T.K., A. Choudhary and T. K Jana 1994. Phytoplankton community organization and the species diversity in the Hugli estuary, north east coast of India.Indian J. Mar. Sci..23 : 153- 156.

Gokhale, K.S. and R.P. Athalye. 1995 Study of impact of pollution on mangrove fauna of Thane creek near Thane city. Report submitted to the Ministry of Environment and Forests. New Delhi. 40 pp.

Goldin Quadros. 2001. Study of intertidal fauna of Thane creek. Ph.D. Thesis University of Mumbai. 264 pp.

Krishnamurthy, K.,R. Santhanathan and V. Sundararaj. 1974 Species distribution in aquatic environment. Indian J. Mar. Sci., 3, 135-138.

Mani, P 1992. Natural phytoplankton community in Pichavaram mangroves. Indian J. Mar. Sci., 21: 278 – 280.

McCombie, A.M. 1953 Factors influencing the growth of phytoplankton. J.Fish. Res. Bd. Canada, 1 : 253-282.

Palmer (1969) Cited in Trivedi, R. K. and P. K. Goel, (1984).

Ramaiah Neelam and N.Ramaiah, 1998, Phytoplankton characteristics in a polluted Bombay harbour-Thana-Bassein creek estuarine complex. Indian J. Mar. Sci. Vol 27, Sept &Dec. .pp.281- 285.

Saha, S.B., S.B. Bhattacharya, and Amalesh Choudhary. 2000.Diversity of phytoplankton of a sewage polluted brackish water tidal ecosystem. J.Environ.Biol. 21 (1), 9-14.

Santhanam,R,, K.Krishmamurthy and V.Sundararaj 1975. Quantitative phytoplankton ecology. Bull.Dept.Mar. Sci., Univ.Cochin,7 : 899 - 911.

Trivedi R.K. and P.K. Goel, 1984. Chemical and biological methods for water pollution studies. Environmental Publications, Karad. 181 pp.

Vijayalakshmi, G.S. and V.K. Venugoplalan 1975 Studies on diversity of phytoplankton species, pigments and succession with a note on primary production at a tiadal zone in the Vellar estuary.. In: Recent researches in estuarine biology (Ed:R.Natarajan) pp 237-246. Hindustan Publishing Corporation, New Delhi.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 93-95

ESTIMATION OF GROSS PRIMARY PRODUCTION OF URAN CREEK

S. G. Yeragi, K. N. Babu and S. S. Yeragi.
Dept. of Bio sciences, K. J. Somaiya College of Science,Vidyavihar, Mumbai – 400 077.

ABSTRACT :- In an aquatic ecosystem, the solar energy is transformed through photosynthesis is called primary production. It plays an important role in regulating community metabolism. Different ecosystem, have different primary productivities due to temperature, light, concentration of carbon dioxide, minerals, age and conditions of cells and concentration of photo pigments.

To estimate primary production, one can measure the carbon uptake as well as oxygen production. GPP is the rate of photosynthetic activity and includes the organic matter used in respiration during the period of measurement.

The present investigation was carried out in Uran Creek (Lat. 20° 29'N, Log. 77° 32'E) during March 1997 – February 1998. It was noticed that the Gross primary production varied from 14.2 to 60.2 mgC/m^3/h. The maximum value was obtained during post monsoon and the minimum in monsoon period.

Key Words :- Uran Creek, Gross Primary Production.

INTRODUCTION

Photosynthesis plays a major role in regulating community metabolism. The production of organic matter by phytoplankton is the most important aspect which initiates the whole aquatic food chain. The coastal fisheries are totally depended on the primary production of such coastal areas only. Thus, it is directly correlated to the production of organic matter in an aquatic ecosystem. The primary producers are the photic zone of the water mass. The photic zone is the major commercially important zone in which various food chain and webs are interconnected for gain of energy. The photic zone is the energy trapping and conservation zone of an aquatic ecosystem.

Photosynthesis involves the intake of radiant energy and carbon dioxide and release of oxygen. Respiration involves the uptake of oxygen and release of the carbon dioxide and energy. In the absence of light, photosynthesis is arrested but respiration continues. The photic zone is important zone for various purposes like feeding, breeding, spawning and luxuriant growth. Therefore a measure of standing crop and rate of production of plant material is of greatest importance in fisheries research. The production in the total increase in biomass observed over a certain period, while productivity is the rate of production divided by the period of time.

MATERIALS AND METHODS

Fortnightly water samples for the estimation of Gross primary production were collected from the surface during high tide and incubated 'insitu' for six hours. The oxygen content of the sample was estimated by standard Winkler's method as given by Strickland and Parsons (1968). The gross primary production was calculated by finding the differences in light and dark bottles at the end of the experiment and expressed in mgC/m^3/h. The salinity was estimated by salinometer and secchi's disc was used to measure the transparency of the water and expressed in cm.

RESULT AND DISCUSSIONS

Salinity and Temperature

The salinity of the Creek varied at U_1, U_2 and U_3 stations. Average salinity range of the creek was 9.1 ppm to 32.2 ppm. The salinities of U_1 and U_2 stations were recorded more or less similar with remarkable differences at U_3 region, due to addition of fresh water from the adjacent agriculture areas upto November. The salinity values of U_1 and U_2 regions were 18.2 to 32.2 ppm and 15.2 to 31.2 ppm respectively. The water temperature compared to U_1, U_2 regions was high than U_3 region due to shallowness. The temperature was fluctuating between 25 – 29°C throughout the year of study period.

Transparency

Turbidity is an important ecological parameter in an aquatic ecosystem in relation to the primary production. The rate of penetration of photon of light is negatively correlated to the turbidity. The maximum light penetration was observed during post monsoon periods which make high Gross production. The maximum and minimum secchi disc readings were recorded in post

monsoon (45 cm) and in monsoon (18 cm).

Gross primary production

The gross primary production of Uran creek was not uniform throughout the year but varied month to month and region to region. The standard deviation of Gross primary production was observed between 14.2 to 60.2 mgC/ $m^{3/}$h. The maximum production was recorded at U_3 station during post monsoon but steadily declined further in monsoon at all the stations. The highest was noted in the month of January 1998 at U_3 and U_2 but March at U_1 region.

It is clearly understood that the primary production was the highest in post monsoon, latter decreased in pre monsoon and the lowest in monsoon. In monsoon, the turbidity was high and almost all the parameters were not correlated with each other.

In post monsoon, the population density of phytoplankton was high. The common phytoplankton identified from the water were mostly composed of the genera *Coscinodiscus, Ceratium, Navicula, Rhizosolenia* and *Chaetoceros.* Among all the important ecological parameters controlling the primary production, light is an indispensable parameter necessary for the luxuriant growth and propagation of phytoplankton and hence, the transparency of the water can be used as a good indices of productivity. The water of shallow estuarine areas close to the sea remain more or less turbid due to strong tide induced current and the effect of south-west monsoonal gyre. The sediments churning in water column, due to high velocity of wind are responsible for cutting off the transmission of light.

The data published by various researches of different aquatic environments of India is immense importance. The Gross primary production of the surface of the Vellar estuary estimated by Venugopalan (1969) was 251.50 mgC/m^3/h. In Goa estuaries Qasim (1979) recorded 135 to 550 mgC/m^3/day and 150 – 580 mgC/ m^3/day in Mandavi and Zuari estuaries respectively. The data obtained during the present investigation shared lower productivity than the above mentioned estuaries because of high rates of sedimentation and adverse effect of pollutants.

The Gross primary production of Uran Creek was recorded more than those of the Konkan estuaries (Yeragi 1979). The water of Uran Creek was less turbulant with low variations in salinity. The mean values of primary production along with other parameters are given in Fig. 1,2 and 3. It is clearly seen that the post monsoon was the peak period for Gross primary production in which salinity, temperature and transmission were high.

Uran Creek is lined by dense belts of mangrove forest, which also help to add the primary production. The Creek supports high production of edible resource organisms. High natural productivity and shallow creek

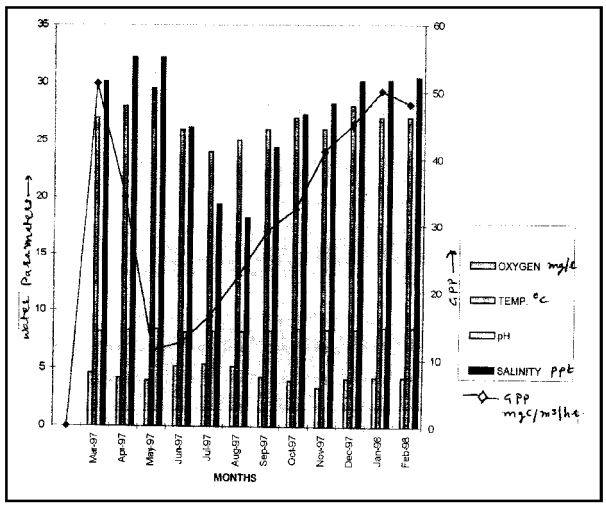


Fig. 1 : Mean Values of Gross Primary Production and other Parameters at U1 Region

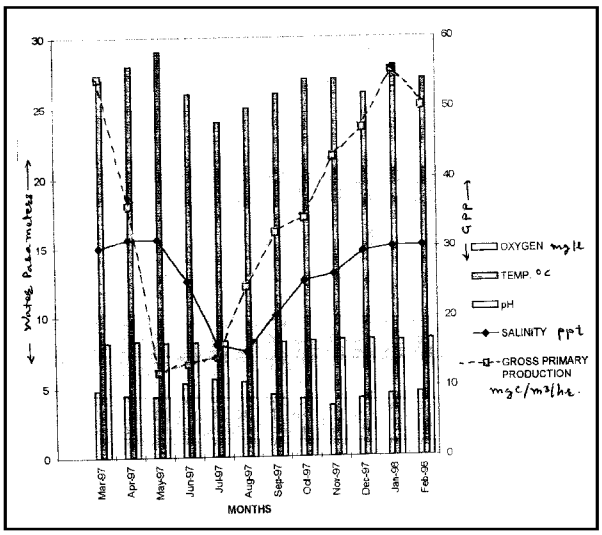


Fig. 2 : Mean Values of Gross Primary Production and other Parameters at U2 Region

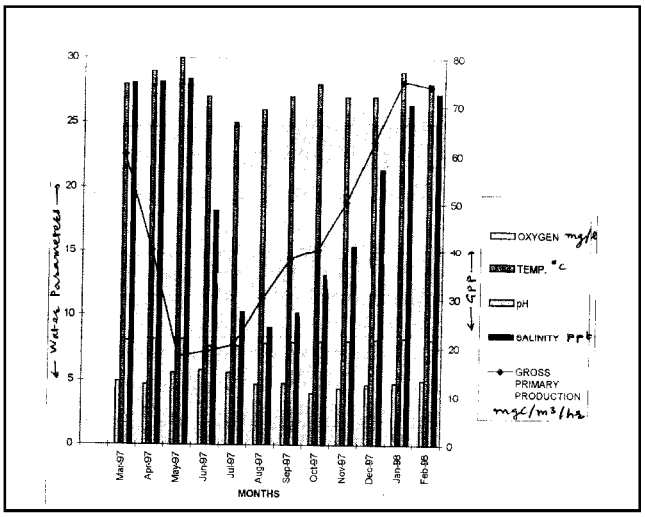


Fig. 3 : Mean Values of Gross Primary Production and other Parameters at U3 Region

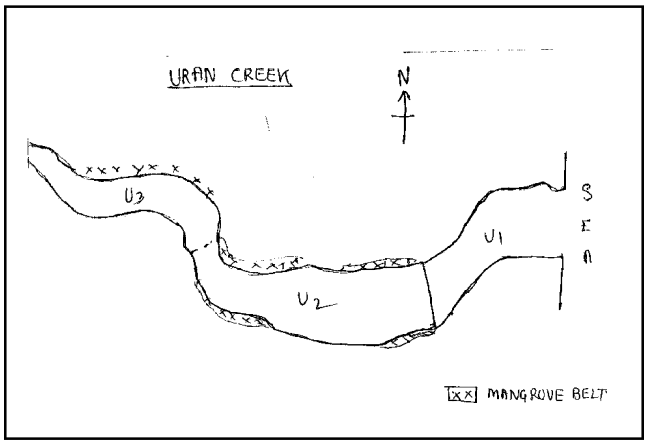


Fig. 4 :

water provide conductive environment for a wide variety of biota in different stages of life cycle. A major part of the large primary production is consumed directly by animals. This is the main reason behind this creek to support major fisheries throughout the year.

REFERENCES

Patwardhan, D. D. (1990). A study of estuarine ecology of south Konkan Ph. D. Thesis, University of Mumbai.

Qasim, S. Z. (1979). In marine production mechanism No. 29. P. 31 – 69. Dunbar, M. J. IBP.

Strickland, J. D. H. and Parsons T. R. (1968). A practical handbook of sea water analysis, Bulletin, 167. Fisheries Research Board of Canada.

Venugopalan, V. K. (1969). Bulletin National Inst. India, 38(2) : 743 – 746.

Yeragi, S. G. (1979). Estimation of Gross primary production of estuary Mithbav of South Konkan. J. Aqua. Bio. Vol. 10(1), 1995, 28 – 30.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 96-102

PLANKTON BIODIVERSITY OF DHARAMTAR CREEK ADJOINING MUMBAI HARBOUR.

L.R.Tiwari and Vijayalakshmi R.Nair*
M.D.College, Parel, Mumbai- 400 012
*National Institute of Oceanography, Regional Center, Kochi 682014.

ABSTRACT : Marine biodiversity is highest in the coast rather than the open sea as there is a greater range of habitat near the coast. Contemplating on this the phytoplankton and zooplankton diversity of Dharamtar creek, a vital system adjoining the Mumbai harbour were assessed to obtain baseline information. A total of 58 genera of phytoplankton were encountered from the area which included 46 diatoms, 6 dinoflagellates and 6 other algae. Variation in phytoplankton cell count was enormous (17-5980 x 10^3 l^{-1}) with an average cell count of 266 x 10^3 l^{-1} . The phytoplankton community was dominated by diatoms (97.6%) followed by dinoflagellates (2%) and other algae (0.4%). Blooms of *Skeletonema* and *Peridinium* were respectively observed during October – November and December. Shannon and Weaver's diversity index H/ ranged from 0.29 - 3.6 (av. 2.42) while Margalef's D varied from 1.4-4.93 (av. 2.96).

Zooplankton population density varied between 3091 &1723786/100m^3 (av.126986/100m^3). Copepods formed the largest group of zooplankton population (71.9%) comprising 46 species belonging to 23 genera. Calanoid copepods were the predominant species. Diversity index H/ for copepods ranged between 0.4 and 3.4 (av. 2.54) whereas D varied from 0.35 to 2.09 (av.1.13). Decapods largely constituted by larval stages formed the second largest group of zooplankton (11.4%). Brachyuran larvae predominated among the decapods. Swarming of *Lucifer* was observed in November at outer zone. Chaetognaths contributed 8.3% to the zooplankton population. 3 species of chaetognaths were found in the area and *Sagitta bedoti* was the true inhabitant. Other groups of zooplankton formed 8.4% of the zooplankton population and were represented by coelenterate medusae, siphonophores , ctenophores, platyhelminths, polychaetes, cladocerans, ostracods, mysids, cumaceans, isopods, amphipods, stomatopods, crustacean naupli, pygnogonids, molluscs, echinoderms, tunicates, fish eggs and fish larvae.

In general, Dharamtar creek sustains a rich plankton community. However, recent industrial evelopment along the banks of creek may pose the problem due to waste disposal into this creek system. Losses of marine life diversity are largely the results of conflicting uses, in particular coastal habitat which leads to degradation of habitats. The best way to conserve biodiversity is to protect habitat diversity which requires periodic monitoring of this creek system in order to compare with the baseline for checking the loss of biodiversity.

Key Word *:* Plankton biodiversit : dharamtar creek

INTRODUCTION

Information on plankton biodiversity around the coast of Mumbai is meagre. Variation in seasonal composition of plankton for the Mumbai harbour was reported by Gonzalves (1947). Earlier studies on zooplankton are mostly confined to Mumbai harbour. The study of plankton from polluted and unpolluted environment included a few locations off Bombay(Gajbhiye,1982; Ram,1985). Later an extensive study of plankton from Mumbai harbour – Thana – Bassein system was carried out by Lodh (1990). Dharamtar creek, the estuarine complex of Amba river is a major estuarine system opening into the southern limits of Mumbai harbour. The contribution of the creek system in terms of plankton to the bioproductivity potential of the near shore waters of Mumbai is significant. The present study gives an account of biodiversity with reference to phytoplankton and zooplankton and provides baseline information for future monitoring of the system considering the industrial growth around the creek.

MATERIALS AND METHODS

Five stations were selected within a stretch of about 30 Km from Mumbai harbour to Dharamtar located between lat $18^0 42' 11''$- $18^0 51' 52''$ N and long $72^0 51' 29''$ - $73^0 01' 42''$E (Fig. 1). This covers the outer zone (stns. 1 and 2) located in the open sea off the creek where influence of rain water is negligible and the inner zone (stns. 3-5) located towards the upper reaches of the creek predominantly influenced by the tide. Depth of the water column varied from 2.5 to 14 m. Sampling was done monthly (September 1984 – November 1985) covering intermediate phase of the tide to avoid tidal effect if any. Water samples for selected physicochemical parameters and phytoplankton were collected from the surface and bottom using clean plastic bucket and Niskin water sampler respectively. The physicochemical parameters of water (temperature, pH, salinity, DO, BOD, PO_4-P, NO_2-N, NO_3-N and NH_3-N) were estimated using standard methods (Carlberg,1972; Strickland & Parsons,1972; Grasshoff *et al*., 1983). Qualitative and

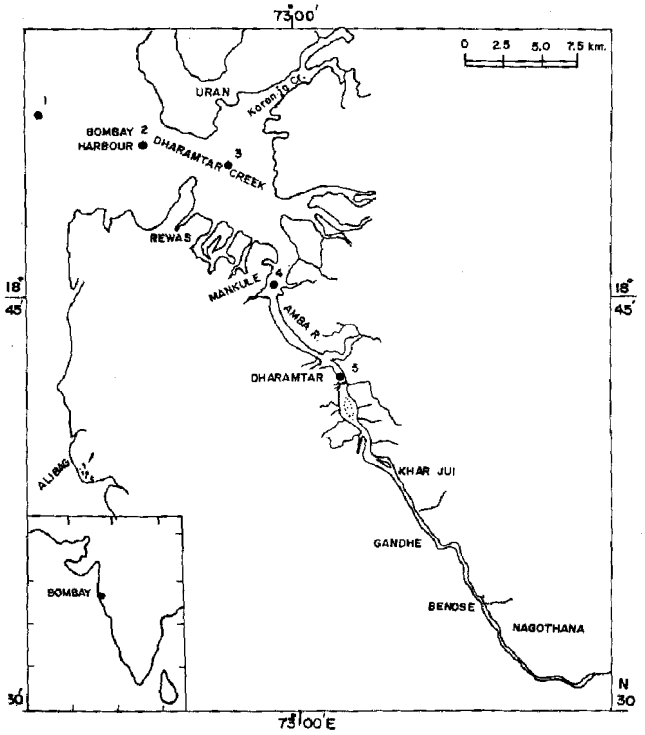


Fig. 1 :Map showing location of stations.

Table 1 – Variations in different physicochemical parameters of surface and bottom waters. (Mean values represented in parentheses).

	Stations				
	1	2	3	4	5
Temperature (°C)	24.7-31.5 27.6)	23.6- 32.0 (27.7)	24.0- 32.2 (27.8)	24.0- 32.4 (28.1)	24.4-33.6 (27.9)
pH	7.5-8.3 (7.8)	7.5-8.2 (7.8)	7.5-8.4 (7.8)	7.5-8.3 (7.7)	7.5-8.3 (7.7)
Salinity (x 10^{-3})	23.6-36.6 (32.8)	8.1-36.9 (31.6)	1.7-36.5 (27.7)	0.2-37.2 (23.9)	0.1-38.0 (21.2)
DO (ml l^{-1})	3.1-6.3 (4.1)	3.4-5.4 (4.3)	3-5.3 (4.4)	3.1-5.3 (4.2)	3-5.2 (4.3)
BOD (ml l^{-1})	0.2-3.8 (1.4)	0.2-3.4 (1.3)	0.4-2.9 (1.3)	0.4-3.3 (1.4)	0.2-2.9 (1.4)
PO_4 –P(µg .at l^{-1})	0.6-3.4 (1.9)	0.6-3.5 (2)	0.6-3.1 (1.7)	0.4-3.6 (1.8)	0.6-3 (1.7)
NO_2-N (µg.at l^{-1})	0.2-3.1 (1.1)	0.1-1.9 (0.7)	0.2-2.2 (0.9)	0.2-2.3 (0.8)	0.2-2.8 (0.9)
NO_3-N (µg.at l^{-1})	5.1-21.8 (13.7)	1.0-33.9 (15.1)	3.6-24.3 (16.1)	3.9-30.6 (17.9)	4.2-42.4 (18.8)
NH_3-N (µg.at l^{-1})	0.2-6.6 (1.5)	0.1-6.8 (1.5)	0.1-5.1 (1.2)	0.1-4.9 (1.5)	0.1-5.6 (1.7)

quantitative enumeration of phytoplankton was carried out adopting Lugol's iodine technique (UNESCO,1978). Cell count was done using a Sedgwick Rafter counting chamber . Identification of phytoplankton was done as per Subramanyan(1948), Desikachari(1959) and Nair(1959). Phytoplankton diversity indices Shannon and Weaver(1963) H/ and Margalef(1968) D were calculated. Evenness (E) was also worked out (Pielou, 1966). Zooplankton was collected by oblique haul using HT net (mesh 0.3mm, mouth area 0.25m^2)fitted with TSK flowmeter. Biomass(ml/100m^{-3}) was measured by displacement method and population density (no/100m^{-3}) was determined by analyzing aliquots of 25-50% of the sample for common forms and the entire sample for rare groups.

RESULTS AND DISCUSSION

Physicochemical parameters

Variations in water quantity parameters were within the expected levels for a tropical estuary indicating that area was free from any environmental perturbation. Tides and monsoon were main factors influencing the temporal and spatial variations of some of the parameters (Table1). Though temperature varied from 23.6 to 33.6 ^{0}C (av. 27.8 ^{0}C), the difference between surface and bottom temperature was insignificant (0.5^{0}C) indicating lack of vertical stratification. The pH variation was in the range of 7.48 – 8.37 (av. 7.76). Relatively low values were obtained during monsoon due to influence of riverine flow. Marked variation in salinity was observed ranging from 0.07 x 10^{-3} to 37.99 x 10^{-3} (av.27.37 x10^{-3}). The entire water column was homogeneous during premonsoon period due to limited influence of freshwater and the creek was completely tide dominated. With the onset of the monsoon the creek became fresh water dominated due to influx of fresh water from Amba river. Salt wedge formation was also noticed near the mouth during peak monsoon period when salinity at Stns. 4 and 5 decreased to almost freshwater condition. During postmonsoon period the stratification was broken as the creek became tide dominated. Fairly high level of DO (3.02 – 6.32 ml l^{-1},av. 4.25 ml l^{-1}) and low BOD (0.22-3.6 ml l^{-1},av.1.34 ml l^{-1}) indicated effective assimilation of organic load. Nutrients in Dharamtar creek indicated seasonal variations with maximum concentration during the monsoon period(Tiwari,1990). In general the range in nutrients showed comparable values at all stations though the levels of nitrate were higher at the interior locations.

Phytoplankton diversity

Phytoplankton cell count showed enormous variation (17-598 x 10^3 l^{-1}) with an average cell count of 266 x 10^3 l^{-1}. The overall distribution of phytoplankton indicated a bimodal pattern with population maximum during September-October followed by a secondary peak in April. Outburst of phytoplankton during monsoon period synchronized with low salinity and high nutrients values,

similar to the observations made from Cochin backwaters(Gopinathan,1972). In general, the area between stns. 1 – 3 showed peak phytoplankton production during monsoon period while at stns. 4 and 5, peaks were restricted to monsoon season. The interior most locations of Dharamtar creek showed very low salinity during monsoon season and almost freshwater dominated the area. Probably this would have led to the shifting of population maximum for the post monsoon period along the interior part of the creek.

A total of 58 genera of phytoplankton were recorded from the area of which 46 belonged to diatoms, 6 to dinoflagellates and 6 to other algae. Diatoms were represented by *Amphiprora, Amphora, Asterionella., Bacteriastrum, Biddulphia, Campylodiscus, Cerataulina, Coscinosira, Cyclotella, Denticula, Detonula, Diploneis, Ditylum, Eucampia, Fragilria, Grammatophora, Guinardia, Gyrosigma, Hemidiscus, Hyalodiscus, Lauderia, Leptocylindrus, Licmophora, Melosira, Navicula, Nitzschia, Pinnularia, Planktoneilla, Pleurosigma, Rhabdonema, Rhizosolenia, Skeletonema, Streptotheca, Surirella, Synedra, Thalassionema, Thalossiosira, Thalassiothrix, Triceratium and Tropidoneis.* The dinoflagellates encountered were *Ceratium, Dinophysis, Goniaulax, Noctiluca, Peridinium* and *Prorocentrum*. Other algae included *Anabaena, Gloeothece, Nodularia, Oscillatoria, Phaeocystis* and *Spirulina*.

The average contribution of diatoms, dinoflagellates and other algae to phytoplankton was respectively 97.6, 2.0 & 0.4% . *Thalassiosira* exhibited the maximum percentage contribution (av. 34.5%) to the phytoplankton community followed by S*keletonema* (22.2%). *Coscinodiscus, Nitzschia, Thalassiosira* and *Thalassiothrix* were encountered at all the stations throughout the period of study. *Biddulphia, Cerataulina*, *Navicula, Pleurosigma, Rhizosolenia, Surirella* and *Synedra* were the other genera occurring very frequently in the area. The most common genera of dinoflagellate were *Peridinium* and *Dinophysis*. A bloom of *Skeletonema* occurred during October – November which was more prevalent in the interior creek stations (stns 2-5) . In October '84 it formed 96.8% of phytoplankton population Curl & McLeod(1961) deduced the optimum salinity range for *Skeletonema* as 15 – 20 x 10^{-3} whereas Nakanishi & Monsi(1965) reported 18 x 10^{-3} as the optimum salinity. The highest peak of *Skeletonema* observed in the present study coincided with a salinity range of 20.23 – 21.7x 10^{-3} . Gonzalves(1947) also reported increase in number of *Skeletonema* during September – October from Mumbai waters. Dinoflagellate *Peridinium* led to a bloom in December accounting for 76% of the total phytoplankton count at stn .4 .

Shannon's diversity index $H^{/}$ varied in the range of 0.29 –3.61 while Margalef's D ranged from 1.14 to 4.93 (fig. 2).The lowest value of $H^{/}$ and D coincided with either the bloom or with the minimum number of genera. The average diversity index $H^{/}$ for the outer zone was 2.45 and that for the interior zone was 2.41. The respective D values were 3.05 and 2.9. Reduction in the number of species and species diversity and an increase in the number of *Skeletonema costatum* are some of the changes associated with the domestic and industrially polluted environment(Patrick,1967) . Occurrence of *Skeletonema* bloom in October'84 in the present study appears to be a recurring phenomenon as it was repeated in October'85. Hendey(1977) classified marine habitat on the basis of species diversity as severely (0-1), moderately (1-2) and slightly (2-3) polluted. Considering the mean diversity indices ($H^{/}$:2.42 and D : 2.96), it can be concluded that Dharamtar creek sustained fairly healthy phytoplankton community. Relatively higher diversity indices in the outer zone may be attributed to higher salinity and contribution of immigrant population from the offshore waters.

Zooplankton diversity

While zooplankton biomass varied from 1.12 to 135.33 ml /100m^3 (av. 30.28 ml / 100m^3) population density range was between 3091 and 1723786 / 100m^3 (av.126986/100m^3). A clear cut increase in biomass and population was noticed from the outer to the inner zone (Fig. 3) and the respective average values were 24.97ml/ 100m^3, 81755/100m^3 & 33.84ml/100m^3; 157040/ 100m^3. Positive and very significant correlation was found between zooplankton biomass and population. High standing stock of zooplankton very often synchronized with phytoplankton abundance indicating a direct relationship(Tiwari,1990) though individual samples did not always show a proportionate correlation probably due to variation in composition of flora and fauna or grazing by zooplankton.

Abundance of various zooplankton in the estuary fluctuated in accordance with salinity regime. Copepods, decapods and chaetognaths which formed the major part of zooplankton were studied in detail while remaining groups were clubbed as other taxonomic group.

Copepods : Copepods formed the largest group of zooplankton contributing 71.8% with a population density ranging from 731 to 1686611/100m^3 (av. 109252 / 100m^3). Peak in copepod population was observed during August-October. A total of 46 species belonging to 26 genera were encountered in the collections(Table 2). Calanoid copepods formed the largest share (98.7%) followed by cyclopoids (1.1%) and harpacticoids (0.2%). The most common species were *Acartia spinicauda*, *Acrocalanus sp*., *Eucalanus pileatus* and A.c*entrura*. A *spinicauda* was the dominant species in the outer zone while the *Acrocalanus* sp.was predominant in the creek area. Shannon and Weaver diversity index $H^{/}$ ranged between 0.44 and 3.4 (av. 2.54) and Margalef's D varied

from 0.35 to 2.09 (av.1.13). Interior creek area showed relatively lower diversity than that of the outer zone (fig. 4). *Paracalanus parvus, Euchaeta wolfendeni, Euchaeta sp., Centropages tenuiremis, Centropages sp.Temora discaudata,Pontella securifer,Microsetella sp.*, and *Corycaeus sp.* were restricted exclusively to stn.1 while *Heliodioptomus sp., Neodiaptomus sp., Pseudodiaptomus annandalei, P. sewelli, P.tollingerae, Temora sp., Acartiella gravelyi, Miracia sp. and Mesocyclops sp.* were observed only during the monsoon months suggesting their preference to very low saline or limnetic conditions. *Pseudodiaptomidae* and *Acartiidae* were the most successful copepods in Dharamtar creek.

Decapods **:** This group was largely constituted by larval stages and formed the second largest group of zooplankton. Their population varied between 151 and 80217/100m^3 (av. 7508/100m^3) with average contribution of 11.44 % to the total zooplankton population. Highest density (80082/100m^3) was recorded in January at stn 4 which was associated with an outburst of crab zoeae . Seasonally, postmonsoon period sustained higher population than other seasons. Twenty six forms of planktonic decapods belonging to Penaeidae, Sergestidae, Caridea, Scyllaridae, Stenopidae, Thalassinidae, Anomura and Brachyura were encountered in the present collections. On an average brachyuran larvae formed major part of the decapod population throughout except at stn. 1 where the members of Sergestidae outnumbered them. Penaeidae was represented by protozoeae and mysid stages of *Metapenaeus, Parapenaeiopsis* and *Penaeus* with the first dominating all over. Larvae of *Penaeus* were observed only at stns. 1 and 2. Sergestidae was represented by *Sergestes, Acetes, Lucifer hanseni, Lucifer typus* and protozoeae of *Lucifer* and *Acetes*. An outburst of *Lucifer* was observed at st.1 in November`85 with population density of 28504 and 3455/100m^3 respectively for *L.hanseni* and *L.typus*. Caridean larvae belonged to the families Pasipheidae, Pandalidate, Hippolytidae, Processidae, Alpheidae and Palaemonidae. While Alpheidae was dominant at stn. 1, Palaemonidae dominated at the remaining stations. Scyllaridae, represented by phyllosoma larvae, was restricted only to the outer zone of the creek. Stenopidae larvae were confined to stn. 1. Thalassinidae was represented by members of families Axiidae and Upogebidae. Porcellanid and pagurid larvae were the representative of Anomura. Zoea, megalopa and glaucothoeae of crabs represented Brachyura which dominated over other decapods.

Occurrence of epiplanktonic species of *Lucifer* and *Acetes* which form a major diet of shore fishes and larger shrimps, and those of palaemonid carideans and brachyuran larvae in good numbers is an indication of non- penaeid prawn and crab resources of the Dharamtar creek.

Chaetognaths: The group contributed 8.3% of total zooplankton population forming the third largest group of zooplankton. Variation in chaetognath population was from 0 to 40818/100m^3 (av. 5373 /100 m^3). *Sagitta bedoti* was common at all stations while *S.enflata* was largely noticed towards the lower reaches. *S. oceania* was more abundant at the interior region than the outer zone. At stns. 1 and 2 with salinity ranging from 8 to 36.9 x 10^{-3} , chaetognaths were fairly abundant throughout with peaks recorded in September and November. At stn. 5 their population rose to a peak only in May coinciding with the maximum salinity of 37.8 x 10^{-3}. During monsoon months when freshwater dominated the estuary, chaetognaths were either absent or very sparse.

Other groups : Many other groups were also represented in the collections whose occurrence and abundance were sporadic, even though they collectively dominated zooplankton at times. Medusae were common in the area except during June to August at the interior zone. Population density of hydromedusae fluctuated between 10 to 1670 , 10 to 500 and 10 to 6660/100m^3 in the monsoon , premonsoon and postmonsoon respectively. 26 species belonging to 21 genera of hydromedusae were obtained from this estuarine system. They included Anthomedusae *: Euphysora bigelowi, Hybocodon forbesi, H.unicus, Baugainvillia fulva,* Leptomedusae*,Obelia spp, Phialidium hemisphaericum, Phialidium brunescens, P.globossum, P.simplex, Blackfordia virginica, Eucheilota menoni, Helgicirrha malayensis, Phialucium condensum, Octophialucium indicum, Phialella fragilis, Eutima mira ,E.commensalis, Amphinema rugosum, Aequorea tenueis,A.conica,A.pensilis;*Limnomedusae:*Ostroumovia inkermanica*; Trachymedusae: *Aqlaura hemistoma, Liriope tetraphylla, Gerionia proboscidalis and* Narcomedusae: *Solmundella bitentaculata.* High density of hydromedusae at the outer zone was the result of high number of holoplanktonic species like *Liriope tetraphyla,Solmundella bitentaculata and Aqlaura hemistoma* which are also indicative of high saline waters evident at stns. 1-3. In general, a downward trend in species richness was discernible towards the upper reaches of the estuary. The numbers of species recorded at stns. 1 to 5 were respectively 20,18, 13,9 and 5. Siphonophores also were more abundant at stns. 1- 3 than the remaining locations. Eventhough ctenophores were well represented in the creek, the population density was low during the monsoon period. Planktonic platyhelminths, a rare group was represented solely by marine flukes. Polychaetes were more frequent at stn. 1. *Evadne* and *Moina* contributed to the cladoceran community. During June-July freshwater *Moina* became abundant at the interior part of the creek. It formed the most dominant group at stn. 5 in June contributing 56.2% to total zooplankton population . *Cypridina dentata* was the single ostracod species rarely found in the collections. Mysids were common at all stations and were represented by *Mesopodopsis zeylanica* and *Lycomysis*

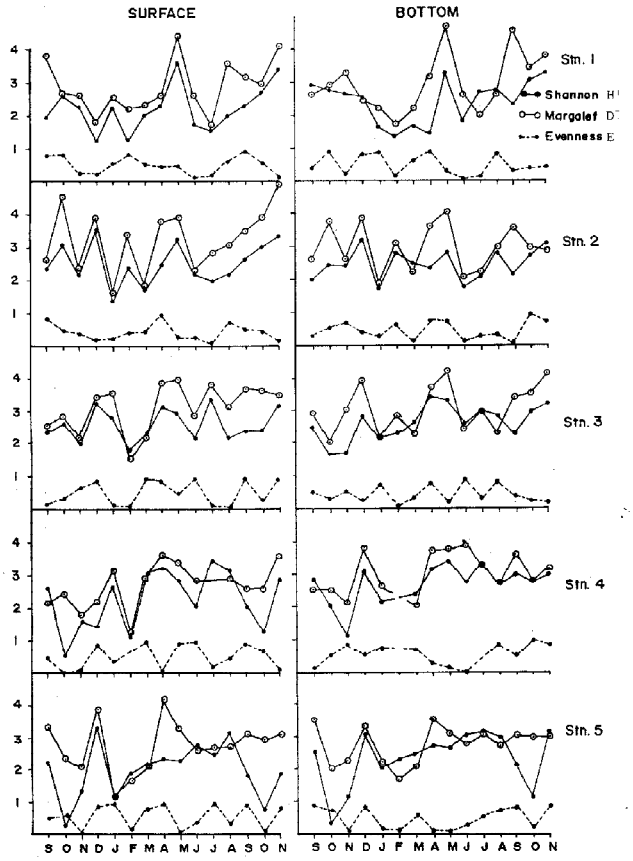


Fig. 2: Trend in diversity indices of phytoplankton at different stations during 1984-85.

platycauda. Cumaceans, pycnogonids and echinoderm larvae were rare in the area while isopods and amphipods were found in fairly large numbers. Naupli of crustaceans and alima larvae contributed in fairly large proportion to the total zooplankton population. Planktonic gastropods and bivalves were common at all stations, the latter being less frequent as compared to gastropods. However, at st 2 in November ' 85 bivalves became the second largest group contributing 23% to the total zooplankton community. Copelates were more common towards the outer zone. Salps and doliolids were sparsely represented towards the creek mouth.

Fish eggs were commonly found at all stations and occasionally found in large numbers. They occurred less frequently at stn. 5. Their maximum population (739/ $100m^3$) was recorded from stn. 3 in December. Fish larvae constituted another very common group in Dharamtar creek. Their population maximum (6031/ $100m^3$) was encountered at stn 5 during August. On an average the outerzone sustained relatively higher population of fish eggs and larvae than the interior zone. This is in contrary to the assumption that the interior creek area are more congenial for the development of these larvae. The possibility of predation of fish eggs and larvae by carnivores like medusae leading to depletion of fish eggs and larvae can not be ruled out. In this context, higher population of medusae towards the interior part of the creek coinciding with lower population density of fish eggs and larvae is significant. However, the occurrence of fish eggs and larvae within the entire creek system in fairly good number suggests the existence of breeding ground of fishes in the vicinity of this creek.

CONCLUSION

It is an accepted fact that the greatest levels of marine diversity are found in tropical countries and this assumption is true for Dharamtar creek system. Losses of biodiversity are largely the result of conflicting uses of the near shore environment which leads to degradation, fragmentation and losses of habitats due to human interference. Considering the industrial development along the banks of this creek system, periodic monitoring of the fauna and flora is required in order to check the variation in diversity, if any.

ACKNOWLEDGEMENT

The authors are grateful to the Director, National Institute of Oceanography, Goa, and Scientist-in- charge, RC, N.I.O., Mumbai for granting permission and providing facilities to conduct the studies at the Institute.

REFERENCES

Carlberg R. (1972) New Baltic Manual, Cooperative research report series A No. 29 (International Council of Exploration of the Sea, Denmark). pp 140 .

Curl H J and Mc Leod G.C (1961). The Physiological ecology of a marine diatom; Skeletonema costaturn (Grev) Cleve. J.Mar. Res , 19 : 70-88.

Desikachari T V, (1959). Cynophyta. ICAR monograph on algae. (Indian Council of Agricultural Research, New Delhi): pp 686.

Gajbhiye S.N & Desai B.N (1981).Zooplankton variability in polluted and unpolluted water around Bombay.Mahasagar – Bull Natn. Inst. Occanogr, 14:173-182

Gajbhiye S.N (1982). The ecology of zooplankton with special reference to polluted and unpolluted environments off Bombay, Ph.D Thesis, University of Bombay.

Gonzalves E.A (1947). Variation in the seasonal composition of the phytoplankton of Bombay harbour. Current sc, 16 : 304-305.

Gopinathan C.P (1972). Seasonal abundance of phytoplankton in the Cochin backwaters J. Mar. Biol.Ass. India 14: 568- 577.

Grasshoff K. Ehrhardt M and Kremling K (1983). methods of seawater analysis (Verlag Chemice, Basel). pp. 419.

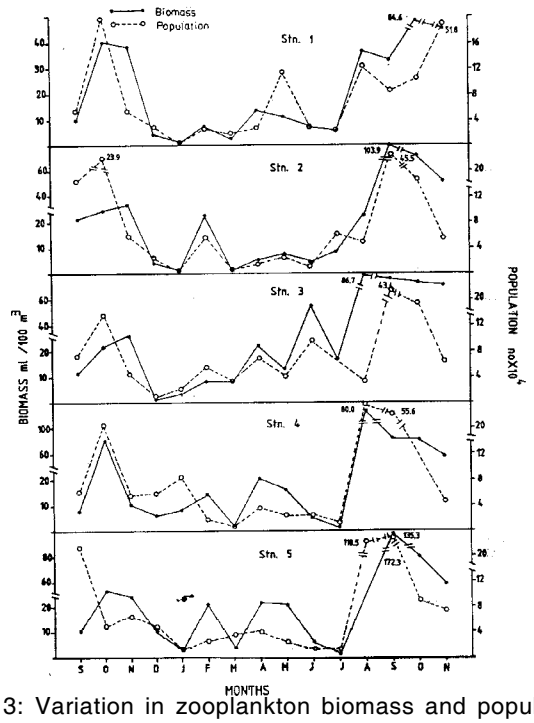


Fig. 3: Variation in zooplankton biomass and population at different stations during 1984-85.

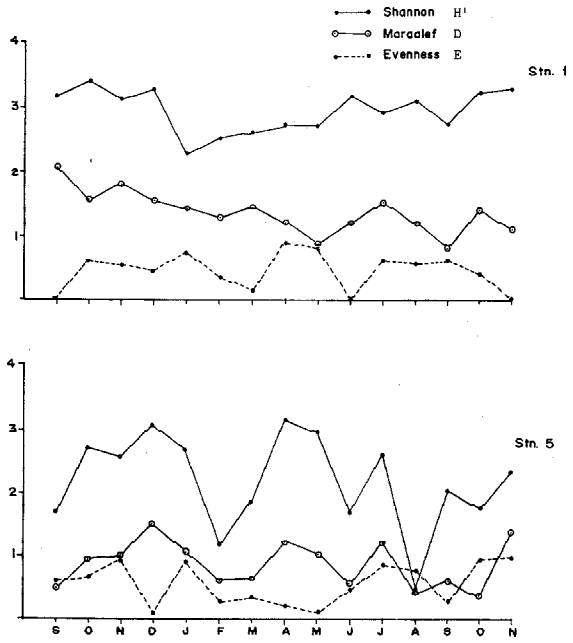


Fig. 4: Variation in diversity indices of copepods at different stations during 1984-85.

Table 2 : List of copepod species recorded from stations 1 to 5. (+ indicates occurrence of species)

Name of species	Station 1	Station 5
Calanus sp.	+	+
Canthocalanus pauper	+	+
Eucalanus crassus	+	+
E. pileatus	+	+
E.subcrassus	+	+
Paracalanus aculeatus	+	+
P.parvus	+	-
Acrocalanus sp	+	+
Euchaeta marina	+	+
E.wolfendeni	+	-
Euchaeta sp.	+	-
Centropages dorispinatus	+	+
C.tenuiremis	+	+
Centropages sp.	+	-
Heliodiaptomus sp.	-	+
Neodiaptomus sp.	-	+
Pseudodiaptomus annandalei	-	+
P.aurivilli	+	+
P.serricaudatus	+	+
P.sewelli	-	+
P.tollingerae	-	+
Psedodiaptomus sp.	+	+
Temora discaudata	+	-
Temora turbinata	+	+
Temora sp.	-	+
Labidocera pectinata	+	+
Labidocera sp.	+	+
Pontella securifer	+	-
Pontella sp.	+	+
Acartia centrura	+	+
A. pacifica	+	+
A. plumosa	+	+
A.spinicauda	+	+
Acaretia sp.	+	+
Acartiella gravelyi	-	+
A.keralensis	+	+
A.sewelli	+	+
Tortanus barbatus	+	+
T.gracilis	+	+
Microsetella sp.	+	-
Miracia sp.	-	+
Clitemnestra sp.	+	+
Euterpinna acutifrons	+	+
Oithona sp.	+	+
Corycaeus sp.	+	-
Mesocyclops sp.	-	+

Hendey, N I. (1977). Diatom communities and its use in assessing the degree of pollution insult on parts of the north-west of Cornwall. Proc 4th Symp. Recent and Fossil Marine Diatoms, University of Oslo, Nova Hedwig, 355-378.

Lodh N. M (1990) Ecological studies of plankton from nearshore water of Bombay, Ph.D thesis, University of Bombay.

Margalef R. (1968). Perspective in ecological theory (University Chicago Press, Chicago) :pp 111.

Nair PVR (1959). The marine planktonic diatoms of the Trivendrum coast. Bull Res Inst. Univ. Kerala Ser C-7 : 3 –63.

Nakanishi M & Monsi M. (1965). Effects of variation in salinity on photo synthesis of phytoplankton growing in estuaries J.Fac.Sci. Tokyo Univ (3). 9 : 19-42.

Patrick R. (1967). Diatom communities in estuaries In: Estuaries, American Association of Advanced Science Publications No. 83, Washington D.C, 311-315.

Pielou E.C. (1966) The measurement of diversity in different types of biological collections. J.Theor. Biol. 13:131-144.

Ram J. (1985) studies of phytoplankton in polluted and unpolluted aquatic environments of the north west coast of India. Ph.D. Thesis, University of Bombay, 1985.

Shannon C.E.s Weaver W, (1963). The mathematical theory of communication, (University of Illinois Press, Urbana) :pp 117.

Strickland JDH and Parsons T.R (1972). A Practical Handbook of Sea water 16analysis, Bull No. 167 (Fish Res.Bd of Canada, Ottowa) pp 311.

Subramanyan R. (1948). A systematic account of the marine plankton diatoms of the Madras coast Proc Acad. Sci 24B : 85 – 197.

Tiwari L.R.(1990) Ecological Studies on plankton from Dharamtar creek, Ph.D Thesis, University of Bombay.

UNESCO, (1978). Physaplankton manual, (UNESCO, Paris). pp 337.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 103-105

STUDY OF ROTIFERS IN THANE CREEK AND ULHAS RIVER ESTUARY.

Vaishali U. Somani, N.N. Patil, Goldin Quadros, R.P. Athalye
Zoology department, B.N.Bandodkar College of Science, Thane (W) 400 601.

ABSTRACT : Study of rotifers from Thane creek and Ulhas river estuary showed dominance of pollution tolerant *Brachionus spp.* Salinity acted as main factor governing the abundance and distribution of the rotifers. The diference in temporal trend of rotifers in Ulhas river estuary and Thane creek also could be attributed to the different salinity profile of the two ecosystems.

Keywords *:* Rotifers, Thane creek, Ulhas river estuary, Brachionus spp.

INTRODUCTION

Zooplankton constitute one of the important links in the food webs of aquatic biotope. Though rotifers are not as diverse or abundant in marine environments as microcrustaceans, they are common in many nearshore (Heinbokel, 1978) and intertistial marine communities (Mishra, 2002). They play a key role in cycling of organic material and constitute a large portion of diet of larval fish (Polgar and Souza, 1981). Hence rotifer study is significant in tide dominated habitats like Thane creek – Ulhas river estuary which receive heavy load of domestic and industrial effluents.

MATERIALS AND METHODS

The study was conducted in Thane creek and Ulhas river estuary for a period of one year – September 2001 to August 2002. For study in both the ecosystems 3 zones were considered as 1) Riverine zone (Station 1 to 4 and 13 to 16), 2) Middle zone (Station 5 to 8 and 17 to 20), 3) Seaward zone (station 9 to 12 and 21 to 24). (Fig. 1) Important water parameters were analysed for spring high tide samples using standard methods (APHA,AWWA, WPCF, 1981). Zooplankton samples were collected during high tide from each station the samples were preserved in 10 % formaldehyde solution prepared in filtered creek water and the data was pooled to calculate zone wise abundance.

RESULTS AND DISCUSION.

Variations in important water parameters are given Table 1. Accordingly it can be inferred that Ulhas river estuary had lower salinity than Thane creek suggesting more influence of fresh water. The dissolved oxygen levels were better in Ulhas river estuary. Both the ecosystems had high silicates, phosphates were higher in Thane creek and nitrates higher in Ulhas river estuary. Higher BOD, low dissolved oxygen and high phosphates in Thane creek indicate higher organic (sewage) pollution.

The monthly rotifer density fluctuated from 0 to 2664 no/m^3 (Table 2). The contribution of rotifers in total

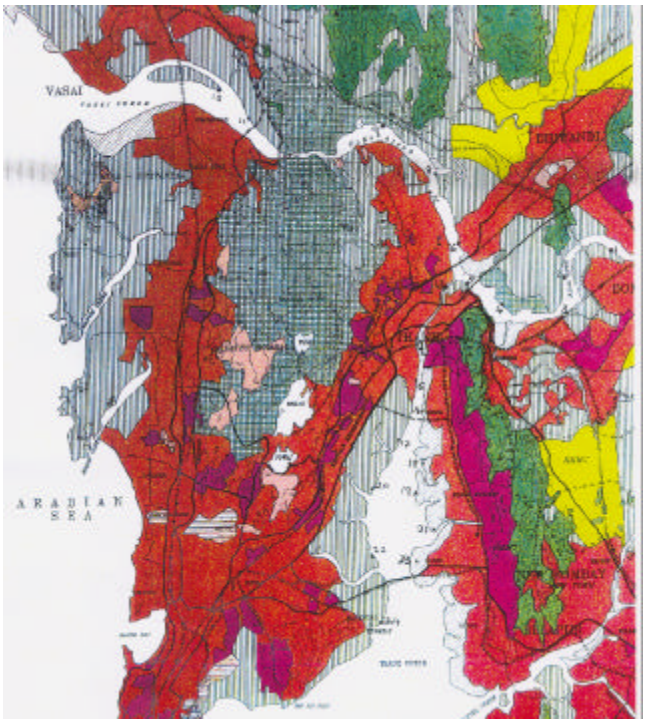


Fig. 1 : Map showing sampling stations in Ulhas river estuary and Thane creek

zooplankton density (data not presented in this figures) was 57.83 % in Ulhas river estuary and 6.63 % in Thane creek, which is higher than that recorded in earlier studies on Ulhas river estuary.(29 %, Mishra, 2002) and Thane creek (Scarce presence, Goldin, 2001). *Brachionus spp* was the dominant genus noted in both the ecosystems *Asplanchana spp* occurred occasionally in winter in zone 1 and zone 2 of Ulhas river estuary. While *Filinia spp.* was observed once in monsoon in zone 2 of Thane creek. Brachionus is cosmopolitian in distribution and by far the best known genus in India (Battish , 1992).

Table 1 : Water parameters of Ulhas river estuary and Thane Creek.

Water Parameters	Ulhas River										Estuary Thane Creek									
	Zone 1			Zone 2			Zone 3			Total	Zone 1		Zone 2			Zone 3			Total	
	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Avg.	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Avg.
Water Temperature C	21.25	33.13	28.03	21	31.5	28.19	22.75	33.25	28.35	28.18	21.5	33.75	28.75	22.5	33.45	29.37	26.38	34.88	30.28	29.71
Light Penetration	14	50.75	30.5	13.38	57.5	27.44	7.75	27.25	16.11	24.69	22	57.75	33.51	19.75	59.25	39.81	13	42.5	30.56	34.63
Suspended solids gm/l	0.16	0.96	0.555	0.15	2.375	1.249	0.205	6.15	3.865	1.89	0.43	3.385	1.911	0.6	13.5	2.414	0.535	3.17	1.551	1.958
pH	6.93	7.76	7.44	7.22	7.8	7.54	7.4	8.04	7.78	7.59	7.19	8.09	7.67	7.4	8.19	7.74	7.57	8.193	7.78	7.73
Salinity ppt.	0.389	18.51	8.93	0.73	30.28	15.34	1.035	34.92	22.93	15.73	0.80	332.48	19.67	2.85	34.6	23.93	6.825	37.14	27.55	23.73
Dissolved oxygen mg/l	0.75	3.825	2.29	1.425	3.35	2.55	1.983	4.8	3.62	2.82	0.375	2.925	2.015	0.7	8.2	1.998	0.925	4	2.11	2.041
B.O.D. mg/l	5.375	24.43	16.25	2.225	13.48	8.341	0.55	8.45	5.083	9.892	9.75	42.75	24.67	2.125	24.13	13.04	1.9	20.05	10.79	16.17
PO4-P mg/l	0.03	0.094	0.06	0.03	0.092	0.055	0.023	0.061	0.047	0.054	0.061	0.162	0.132	0.033	0.096	0.074	0.027	0.094	0.069	0.092
NO3-N mg/l	0.292	2.521	1.491	0.905	3.533	1.89	0.189	2.275	1.616	1.666	0.471	1.458	1.022	0.145	2.099	0.853	0.145	1.383	0.983	0.953
SiO3-Si mg/l	12.66	77.43	33.67	11.1	72.6	34.07	11.72	61.09	29.07	32.27	12.25	43.02	26.66	8.498	35.15	22.34	5.734	38.98	15.88	21.63

Table 2 : Monthly zonewise variation of rotifer density (no/m^3) in Ulhas river estuary and Thane crek..

Months	Ulhas river estuary				Thane Creek			
	Zone 1	Zone 2	Zone 3	Total	Zone 1	Zone 2	Zone 3	Total
Sept	2	2	0	4	1	0	25	26
Oct	2	0	0	2	2	0	5	7
Nov	2	2	0	4	2	2	0	4
Dec	0	4	0	4	0	0	2	2
Jan	130	0	0	130	5	1	0	6
Feb	227	0	0	227	0	0	0	0
Mar	875	23	0	898	2	0	0	2
Apr	2624	40	0	2664	0	0	0	0
May	1526	35	0	1561	0	0	0	0
Jun	20	0	0	20	0	0	0	0
Jul	0	65	0	65	378	0	0	553
Aug	0	4	20	24	1857	157	18	2186
total	5138	175	20	5603	2247	325	4	2786
Avg	428.2	14.58	1.67	466.92	187.25	13.33	4.17	232.17

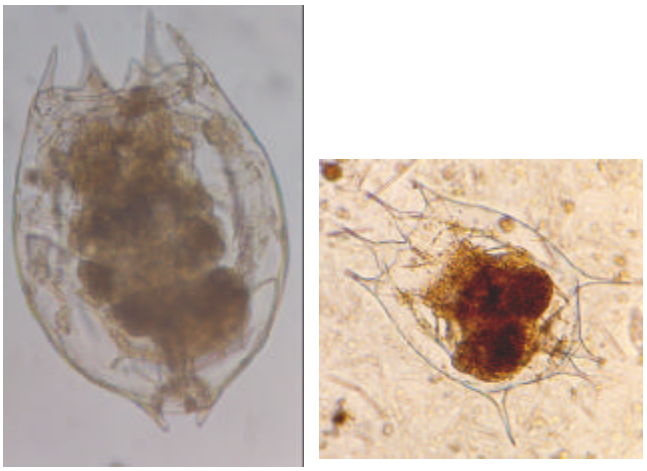


Fig 2 : Brachionus calyciflorus

During this study Brachionus was observed to be the most successful rotifer, chiefly represented by *Brachionus calyciflorus* (Fig 2) and *Brachionus caudatus* and 2 other (unidentified *Brachionus spp*.). Ocurrance of *Brachionus spp.* in estuarine habitats has been supported by observations of Karuppasamy and Perumal (2000) in Pitchavaram mangroves and Varethiah (1999) in Thengapatanam estuary. It is considered as pollution tolerant genus and its presence emphasized pollution load in Ulhas river estuary and Thane creek.

On an average abundance of rotifers was the maximum in Zone 1 and decreased thereafter showing minimum density in Zone 3. in both Ulhas river estuary and Thane creek. Average rotifer density was almost double (466.92 no/m^3) in Ulhas river estuary as compared to 232.17 no/m^3 of Thane creek (Table 2).

In Ulhas river estuary zone 1 was characterized by maximum rotifers abundance, including gravid individuals. In this zone rotifer flourished well in premonsoon (January to June) with peak observed in April. Zone 2 also showed higher average rotifer density in premonson. However peak density was recorded in July i.e. in monsoon. In zone 3 rotifers were noted only once during monsoon (August) in low density. Presence of rotifers in Ulhas river estuary during the monsoon was in contrast to the observations by Mishra (2002) but corroborated with her observations reporting higher rotifer abundance in zone 1during the earlier study.

In Thane creek, Zone 1 and 2 showed higher abundance of rotifers mainly in monsoon months (July and August) in zone 3 however the density was comparatively very low. The trend in rotifer occurrence was different in both the ecosystems, the higher density in premonsoon season in Ulhas river estuary and better in monsoon season in Thane creek. This difference in the trends could be due to different salinity profile of the two ecosystems. In Ulhas river estuary the salinity in general was lower especially in zone 1. whereas in Thane creek the salinity was higher almost throughout the year except monsoon.

In the present study rotifers were found to be affected by salinity gradient, as their density was pronounced in oligohaline region, as was observed by Park and Marshall (2000). High density was recorded in monsoon, as a response to inflow of fresh water which lowered the salinity optimally.

In zone 1 of Ulhas river estuary the salinity did not act as the primary governing factor to rotifer abundance. The zone is dominated by freshwaters (maximum salinity 9.5 ppt.) and rotifers reached their maxima in April 2002 which can also be attributed to peak phytoplankton density in the same month (MMR-EIS, project II stage report.).

Tolerance of rotifers to the higher salinity was observed as the rotifers were also recorded though in low numbers in higher salinities ranging from 22.457 to 34.248 ppt.

Brachionus calyciflorus (the main rotifer species of Ulhas river estuary and Thane creek) is recorded as a species, tolerant to low and varied dissolved oxygen concentration (Dhanapathi, 2000). Load of industrial and domestic effluents created low dissolved oxygen conditions in both these ecosystems. Still rotifers flourished well in dissolved oxygen range of 1.35 to 3.45 mg/l, showing their pollution tolerance.

Thus salinity, and not dissolved oxygen probably acted as the main limiting factor for the rotifer abundance and distribution.

CONCLUSIONS

The study revealed

1) Dominance of pollution indicator, *Brachionus spp*. in the rotifers of Ulhas river estuary and Thane creek, indicating stressed condition of both the ecosystem.

2) Higher average rotifer density as compared to past observations in Ulhas river estuary and Thane creek indicating further deterioration of the two ecosystems.

3) Increasing tolerance of rotifers to higher salinities though they flourish well in an average salinity of 2.294 ppt.

4) Tolerance of rotifer population to nearly hypoxic condition in these ecosystem.

5) Under favourable conditions of salinity phytoplankton abundance mainly affected rotifer abundance.

REFERENCES

APHA, AWWA, WPCF, 1981 International standard methods for examination of water and waste water. 15th edition, Washington D.C. 874 pp.

Battish S.K. 1992 Freshwater zooplankton of India Oxford and IBH publication 233 pp.

Dhanapathi M.V.S.S. 2000. Taxonomic notes on the rotifers from India. IAAB publications, Hyderabad 175 pp.

Goldin Quadros. 2001 Study of intertidal fauna of Thane creek. Ph.D. Thesis, University of Mumbai. 264 pp.

Heinbokel J.F., 1978. Marine Biology 47 : 177 pp.

Karuppasamy P.K. and P. Perumal. 2000. Biodiversity of zooplankton at Pitchavaram mangroves, South India. Ad. Bios. Vol. 19 (11) 23 –32.

Mishra Vidya. 2002 Study of macrofauna of mangrove mudflats of Ulhas river estuary. Ph.D. Thesis. Univ. Of Mumbai. 233 pp,

Park G.S. and H.G. Marshall 2000 The trophic contributions of rotifers in tidal freshwater and estuarine habitats. Estuarine, Coastal and Shelf Science. 51 : 729 – 742.

Polgar T.T. & P. Souza. 1981 Analysis of striped bass larval feeding habits in the Potomac estuary, 1976 – 1977. Proceedings Am. Fish. Society. 5th Annual Meeting, 115 – 138.

Vareethiah K. 1999. Zooplankton composition in a bar-Built estuary, south west coast of India. Indian J. Fish, 46 (2) : 179 – 183.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 106-108

LIVING DINOFLAGELLATE CYSTS OF *GYMNODINIUM CATENATUM* AND *ALEXANDRIUM CATENELLA* FROM THE RECENT SEDIMENTS OF BHATYE ESTUARY, RATNAGIRI, MAHARASHTRA

Sameer Terdalkar, S.N.Kumbhar and A.S.Kulkarni
Department of Zoology, Gogate Jogalekar College, Ratnagiri, Maharashtra.

ABSTRACT : Sediment samples were collected from seven sampling stations of the Bhatye Estuary, Ratnagiri, and were analyzed for the qualitatively and quantitatively for the presence of dinoflagellate cysts. The studies revealed presence of two key cysts forming species – *Alexandrium catenella* and *Gymnodinium catenatum*. Their numerical abundance ranged from – 1.06 to 12.4 X 10^5 cysts/m^2 and 1.42 to 7.11X10^5 cysts/m^2 respectively. Most of the cysts encountered were present at the sediment-water interface and exhibited chances of resuspension, survival and germination only in the presence of benthic biological activity.

Key Words: Bhatye estuary, dinoflagellate, cysts.

INTRODUCTION

Dinoflagellates or Red Tide organisms as they are often known form one of the most important component of plant and serve as an important link in the aquatic food webs. They are the largest number of species of the plankton community and form critical food for filter feeding bivalve shellfish as well as larvae of commercially important crustaceans and finfish (Dodge, 1985).

Unfortunately, a small number of species produce potent neurotoxins those are transferred to the food web where they kill the fish and even higher form of life. Scientists now prefer the term "Harmful Algal Blooms" (HAB's) to refer to blooming of toxic species. Many of dinoflagellate species are known to have a resting stage termed as "cyst". The functions attributed to the cysts are:

(1) Role in species dispersal

(2) Bloom initiation

(3) Bloom termination and

(4) Survival through the adverse climatic conditions (Anderson *et al*., 1985)

Further, dinoflagellates belonging to *Gonyaulax, Noctiluca, Gymnodinium*, *Alexandrium* species etc. are known to cause a variety of gastrointestinal illnesses like Paralytic Shellfish Poisoning (PSP), Diarrhetic Shellfish Poisoning (DSP) and Neurotoxic Shellfish Poisoning (NSP) in humans.

Research along the Indian Coasts mainly emphasizes on the observation of the *Trichodesmium* blooms, Incidences of Red Water along South Kerala coast, blooms along Southwest coast of Kerala, phytoplankton bloom in the Hooghly Estuary and studies on bloom forming species of phytoplankton along the Southeast coast of India (Verlancar, 1978, Venugopal *et al.,* 1979, Sargunam and Rao, 1989, De e*t al.,* 1991, Perumal *et al.*, 1999). But there is a dearth of information on the abundance of living cysts of dinoflagellates and their vertical and horizontal distributions in the different sedimentary environments along both coasts of India.

The study area. Ratnagiri, is situated at 17^0 North and 73^0 East, and has an area of about 5,020,9 square miles. Geographically, it the southern most district of Maharashtra State. The coastline of Ratnagiri district is 250 miles and is marked with several islands, which is a result of drowned topography. Alternating bluff and curving bays irregularly marks the coastline, but it is shallow and hence has limited use for navigation. The Bhatye Estuary is situated at 73^0 15' East and $16^0$51'North near Ratnagiri and also known for abundant clam fauna especially *Meretrix meretrix* and hence commercially important for clam fishery. A total of seven sampling stations were selected in the estuary for the collection of sediment samples.

In the present studies, a preliminary attempt has been made to study the presence of dinoflagellate cysts, their qualitative and quantitative analysis and potential areas in the sediments of Bhatye Estuary, Ratnagiri.

MATERIALS AND METHODS

The sediment samples from seven sampling stations in the Bhatye Estuary were collected by using a specially designed PVC plastic tube (2cm long and 5cm in diameter). The sediment samples were stored in polythene bags, labeled and maintained at 4^0C in the laboratory until processed. The cores were then extruded cleanly so as to obtain sediment cake, which was cut at 2-cm interval. The sediment sub samples thus obtained were processed by following standard methods of Hallegraeff *et al*. (1995), with sonication for one minute

to disaggregate the sediment followed by size fractionation of the slurry through Nitex sieves of 28-95mm ranges. The processed sediment sub samples were then examined under light microscope in Sedgwick Rafter slides for numerical analysis of cysts. The cysts were identified by using standard literature for cysts identification (Wall and Dale, 1968, Anderson and Wall, 1978, Kobayashi S., 1981, Dodge, 1985, Matsuoka and Fukuyo, 1987, Anderson *et al*., 1988, Lewis, 1989, Bolch *et al*., 1991, Hallegraeff and Bolch, 1992, Hallegraeff *et al*., 1995 and Qi *et al*., 1996). The live cysts were detected by observing the Brownian motion of the cytoplasm in the cysts. Further, the identified cysts were photographed by using attached camera.

RESULTS AND DISCUSSION

The qualitative analysis of the estuarine sediments indicated presence of two species of dinoflagellate cysts viz., *Alexandrium catenella* and *Gymnodinium catenatum*. Their numerical abundance ranged from 1.06 to 12.4x10^5 cysts/m^2 and 1.42 to 7.11x10^5 cysts/m^2 of the sediment respectively. (Table I)

Table I: Numerical abundance of dinoflagellate cysts species in the sediments of Bhatye Estuary, Ratnagiri, Maharashtra. (Cysts/m^2)

Station No.	Numerical abundance of dinoflagellate cysts	
	Alexandrium catenella	***Gymnodinium catenella***
I	2.37 X 10^5	1.42 X 10^5
II	3.62 X10^5	2.49 X 10^5
III	2.62 X 10^5	5.58 X 10^5
IV	1.06 X 10^5	5.27 X 10^5
V	4.15 X 10^5	6.29 X 10^5
VI	6.25 X 10^5	3.55 X 10^5
VII	12.4 X 10^5	7.11 X 10^5

TECHNICAL IDENTIFICATION OF THE CYST SPECIES

1. Alexandrium catenella

⇒ Ovoid shape, slightly elongated

⇒ Single layered wall, red pigment visible (3mm)

⇒ Maximum length 27mm, maximum width 25mm

⇒ Toxins produced: saxitoxins

⇒ Known to cause Paralytic Shellfish poisoning (PSP)

1. Gymnodinium catenatum

⇒ Dark brown spherical cyst (38-45mm in diameter)

⇒ Globular contents, single layered wall

⇒ Toxins produced- saxitoxins and derivatives

⇒ Known to cause Paralytic shellfish poisoning (PSP)

The studies show that, dinoflagellate cysts will reach the coastal or the estuarine sediments before they are sufficiently mature to germinate. Once they reach the sediment, they will be exposed to a variety of chemical and biological factors, which can affect germination (Anderson *et al.,* 1985). So a major unknown is the impact of resuspension of these deposited cysts. As seen in these studies, the cysts are present at the sediment surface, hence withstand better chances of survival and germination. Also, much is unknown about the benthic activity in these sediments, which may play an important role in resuspension of other buried dinoflagellate cyst species present if any, in the deeper layers.

These studies are first of its kind (at least in this region along the West Coast) and may be suggestive in understanding the bloom initiation through the germination of the cysts present in different layers of the sediment. These studies also indicate the inoculum potential and “point source” origins of the toxic resting cysts overlying the Bhatye sediments.

Hence, more studies are further needed to analyze the potential cyst areas in the estuary and adjacent coastal areas, with more emphasis on the vertical distribution of the dinoflagellate cysts.

ACKNOWLEDGEMENTS

The authors are grateful to the authorities of UGC for sanctioning a minor research project to ASK. The authors are also thankful to Principal Dr. Subhash Dev for providing the laboratory facilities.

REFERENCES

Anderson D.M., and Wall D.. 1978. Potential importance of benthic cysts of *Gonyualax tamarensis* and *G. excavata* in initiating toxic dinoflagellate blooms. *Journal of Phycology*, 14(2): 224-234.

Anderson D.M., Jacobson D.M., Bravo I., and Wrenn J.H.. 1988. The unique microreticulate cyst of *Gymnodinium catenatum*. *Journal of Phycology*, 24:255-262.

Anderson D.M., Lively J.J., Reardon E.M., and Price C.A.. 1985. Sinking characteristics of dinoflagellate cysts. *Limnology and Oceanography*, 30 (5), 1000-09.

Bolch C.J., Blackburn S.I., Cannon J.A., and Hallegraeff G.M.. 1991. The resting cyst of the red tide dinoflagellate *Alexandrium minutum* (Dinophycaea), *Phycologia,* 30 (2), 215-219.

De T.K., Ghosh S.K., Jana T.K., and Choudhary A. 1991. Phytoplankton bloom in the Hooghly estuary. *Indian Journal of Marine Sciences*, Vol. 20, 134-137.

Dodge J.D.1985. Atlas of Dinoflagellates. Blackwell Scientific Publications. Palo Alto.

Hallegraeff G.M., and Bolch C.J. 1992. Transport of diatom and dinoflagellate resting spores in ships' ballast water: Implications for plankton biogeography and aquaculture. *Journal of Plankton Research*, 14(8), 1067-1084.

Hallegraeff G.M., Anderson D.M., and Cembella A.D.. 1995. Mannual on Harmful Marine Microalgae, IOC Manuals and Guides, No. 33, UNESCO.

Kobayashi S. 1981. First record of cysts of *Gonyaulax polyedra* Stein in bottom sediment from Omura Bay, Nagasaki Prefecture, Japan. *Bulletin of the Plankton Society of Japan*, 28, 53-57.

Lewis J. 1989. Cyst-Theca relationship in *Scripsiella* (Peridiniales) and related Orthoperidinoid genera, IVth International Conference on Modern and Fossil Dinoflagellates, Woods Hole, MA.

Matsuoka K., and Fukuyo Y.. 1987. Manual for Modern Dinoflagellate Cyst study, IInd Edn. Presented at the training workshop on monitoring of PSP plankton and shellfish toxicity by WEST PAC-IOC (UNESCO) at Kitasato University, July 17-22, 1995.

Perumal P., SampathkumarP., and Karuppasamy P.K.. 1999. Studies on the bloom forming species of phytoplankton in the Vellar estuary, southeast coast of India. *Indian Journal of Marine Sciences*, Vol. 28, 400-403.

Qi Y.Z., Ying H., Lei Z., Kulis D.M., and Anderson D.M. 1996. Dinoflagellate cysts from the recent marine sediments of the south and East China Sea. *Asian Marine Biology,* 13, 87-103.

Sargunam C.A., and Rao V.N.R. 1989. Occurrence of *Noctiluca* bloom in Kalpakkam coastal waters, East Coast of India. *Indian Journal of Marine Sciences*, Vol.18, 289-90.

Venugopal P., Haridas P., Madhupratap M., and Rao T.S.S.. 1979. Incidence of Red Water along south Kerala coast. *Indian Journal of Marine Sciences*, Vol.8, 94-97.

Verlancar X.N. 1978. Some observations on the *Trichodesmium* bloom along the South West coast of India*. Mahasagar*, 11 (3 and 4), 221-224.

Wall D., and B. Dale. 1968. Modern dinoflagellate cyst and evolution of Peridiniales, *Micropalaeontology*, 14(3), 265-304.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 109-115

STUDY OF ZOOPLANKTON DISTRIBUTION FROM ULHAS RIVER ESTUARY AND THANE CREEK

N.N. Patil, Goldin Quadros, V.U. Somani, P.N. Kurve and R.P. Athalye
Department of Zoology, B.N. Bandodkar College of Science, Thane (W) 400 601.

ABSTRACT : Zooplankton were studied from three zones of Ulhas estuary and Thane creek for a period of one year (Sept.2001 to Aug. 2002). Total 25 types were recorded in Ulhas river estuary and 23 in Thane creek. Rotifers, nauplii, copepods and eggs were the dominant types in Ulhas river estuary while nematodes, polychaete larvae, molluscan larvae, nauplii and eggs were dominant in Thane creek. Thane creek showed higher population density of zooplankton than Ulhas river estuary. Physicochemical parameters of water except salinity showed very little influence on the occurrence of zooplankton.

Key words : zooplankton; Ulhas river estuary; Thane creek; population density.

INTRODUCTION

Zooplankton are small heterotrophic animals inhabiting almost every type of aquatic environment. They mostly consist of invertebrates and larval or immature stages of both invertebrates and vertebrates. According to Nair *et.al*. (1999), the zooplankton community comprises of herbivores, omnivores and carnivores, of which generally herbivores form a major fraction. Zooplankton as primary consumers form a major link in food chain. They constitute a major food item for crustaceans, mollusks and fishes. Thus the abundance of zooplankton practically acts as an index to assess the fertility of water mass. Hence correlative study of zooplankton distribution, their intensity and abundance in relation to environmental parameters is necessary for correct understanding of fishery resources (Sarkar *et.al*; 1985). According to Nasser *et.al*. (1998), some fishes are exclusively zooplankton feeder and therefore their abundance is directly linked to their presence. Furthermore many zooplankton species are used as the indicators of water quality and pollution (Mishra and Panigrahy,1999). In recognition to these views the zooplankton have been extensively studied. The zooplankton studies on Indian waters are mainly reported by biologists like Nair *et.al* (1991), Desai *et.al*. (1983), Madhupratap (1987), Srinivasa and Santhanum (1991) The zooplankton data on the Thane creek, have been reported by Desai *et.al*. (1977), Gajbhiye (1979 & 1982), Lodh (1990), Gokhale & Athalye (1995), and Goldin (2001). Lodh (1990) studied both phytoplankton and zooplankton distribution from nearshore waters of Mumbai including a part of Ulhas river estuary.

MATERIALS AND METHODS

For sample collection in 40 km stretch of Ulhas river estuary (Long. 73°.20" to 72°.45"; Lat. 18°.45" N to 19°. 16 N) from Kalyan to Bhayandar and 26 km. Stretch of Thane creek from Balkum to Trombay (Long, 72°55" to 73°.00"E; Lat.19°.00" to19°.15" N) three zones were imagined namely Zone 1. Riverine with more influence of fresh water (stations 1-4 & 13-16). Zone 2. Middle region with intermediate salinity (stations 5-8 & 17-20) Zone 3. Seaward region (stations 9-12 & 21-24) [fig. 1.]

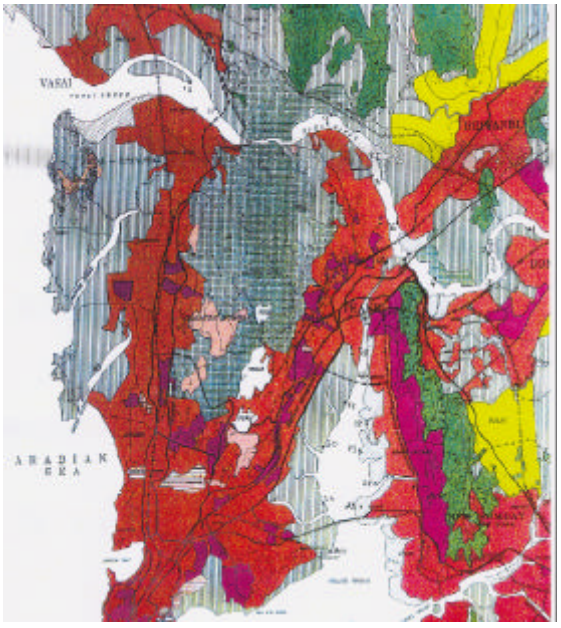


Fig. 1 : Map showing sampling stations in Ulhas river estuary and Thane Creek

The collection was done monthly from Sept. 2001 to Aug. 2002 during high tide by using a 30 number plankton net (41 µm. mesh size). The net was towed for a fixed time of 5 min during high tide. Total water filtered was computed with the help of the current speed and mouth area of the sampling net and the towing time. The filtered zooplankton samples were collected and preserved in 10% formalin solution prepared in filtered marine water. The entire sample was observed for rare and larger organisms. The zooplankton count was done

for abundance by observing sub samples under compound microscope; number/m^3 was calculated. Standard keys were used for identification of the zooplankton groups. (Wimpenny 1966; Krishnapillai 1986; Battish 1992 and Santhanam & Srinivasan 1994).

Physicochemical parameters of water were studied using standard methods (APHA, AWWA & WPCF 1971).

RESULT AND DISCUSSION

In the present investigation, total 25 types of zooplankton were observed in Ulhas river estuary and 23 types in Thane creek (table1). The dominant zooplankton included Copepods, Rotifers, Nauplii, Polychaete larvae, Gastropod and Bivalve larvae, Nematodes and eggs. Zone wise ranges and averages of important parameters of water are presented in table 2. Average population density of zooplankton in Ulhas river estuary was 590/m^3 which was lower than that of Thane creek (1169 /m3). Mustafa *et. al*. (1999) observed mean population density of 1869/m^3 in Ulhas river towards the seaward end and Goldin (2001) recorded mean zooplankton density of 27917/m^3 in the entire Thane creek during period May 99 to April 2000. Mishra (2002) recorded average population density of 127/m^3 in Ulhas river estuary during the period May 1999 to April 2000. Present investigation showed decrease in

Table –1 (Population density of Zooplanktons in no/m3)

	Ulhas river estuary					Thane creek				
Types	*zone 1*	*zone2*	*zone3*	*total*	*Avg.*	*zone 1*	*zone2*	*zone3*	*total .*	*Avg.*
Foraminifera	0.00	0.67	0.58	1.25	0.42	0.07	0.33	22.58	29.58	9.86
Tintinids	0.00	0.17	0.33	0.50	0.17	1.08	0.25	20.00	21.33	7.11
Noctiluca	0.50	47.17	0.00	47.67	15.89	0.92	0.00	0.00	0.92	0.31
Coelenterata & Ctenophora	1.00	4.83	2.67	8.50	2.83	1.67	3.33	7.50	12.50	4.17
Rotifer	428.20	14.58	1.67	444.44	148.15	187.30	40.42	4.50	232.22	77.41
Nematode	0.58	0.33	0.00	0.92	0.31	7.58	1.67	1.58	10.83	3.61
Oligochaete	0.25	0.33	0.00	0.58	0.19	0.08	0.00	0.00	0.08	0.03
Polychaete Larvae	4.75	5.58	1.33	11.66	3.89	168.40	251.10	99.42	513.92	172.97
Calanoid Copepod	51.75	281.60	87.33	420.68	140.23	14.67	699.99	534.70	1249.27	416.45
Cyclopoid Copepod	241.00	155.30	35.17	431.47	143.82	0.50	47.17	75.67	133.34	44.45
Harpactcoid Copepod	0.17	0.75	0.58	1.50	0.08	1.58	0.42	6.42	8.42	2.81
Nauplius	22.00	101.30	74.58	197.88	65.96	23.67	197.20	124.80	345.67	115.22
Acetes & Acetes larvae	0.33	0.17	3.50	4.00	1.33	0.00	6.33	6.67	13.00	4.33
Zoea	1.17	1.08	2.50	0.83	0.00	9.17	1.00	10.17	3.39	0.29
Prawn Juvenile	0.25	0.00	0.00	0.25	0.08	0.00	0.00	0.00	0.00	0.00
Cladocera	0.00	0.33	0.00	0.33	0.11	0.00	0.00	0.00	0.00	0.00
Ostracod	3.00	2.42	0.42	5.83	1.94	0.17	0.17	3.75	4.08	1.36
Cypris	0.00	0.17	2.92	1.03	0.17	1.92	7.75	8.08	17.75	5.92
Mite	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.25	0.0
Other arthropod	0.33	0.00	0.25	0.58	0.19	0.03	75.83	0.58	76.41	25.47
Bivalve larvae	4.58	0.00	5.50	10.08	3.36	5.00	0.00	51.58	56.58	18.86
Gastropod larvae	14.42	6.08	8.92	29.42	9.81	24.50	255.60	115.30	395.40	131.80
Eggs	47.50	74.25	23.50	145.25	48.42	11.92	109.80	247.70	368.72	123.14
Total	821.78	697.12	249.50	1768.39	589.47	467.88	1706.53	1331.83	3500.45	1168.75
Total types	20	22	19	25		19	19	19	23	

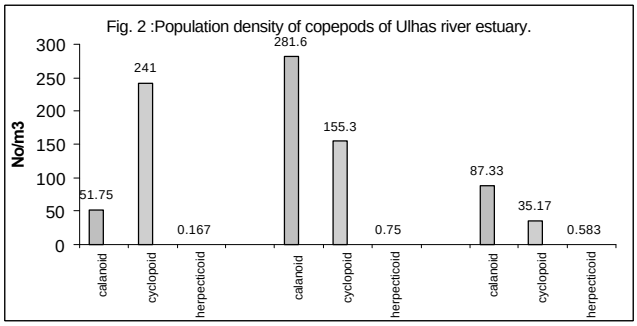
Table 2 : Water parameters of Ulhas river estuary and Thane Creek.

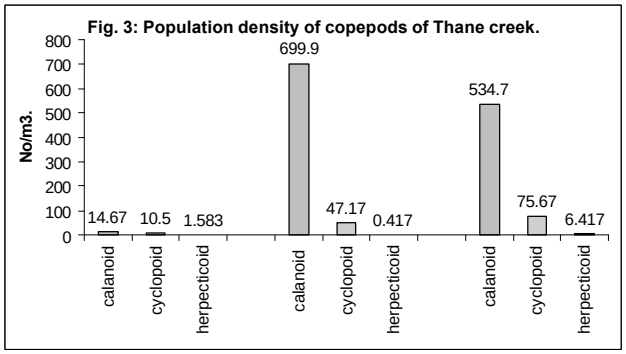
Water Parameters	Ulhas River Estuary											Thane Creek								
	Zone 1			Zone 2			Zone 3			Total		Zone 1	Zone 2			Zone 3			Total Avg.	
	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Avg.	Avg.
Water Temperature C	21.25	33.13	28.03	21	31.5	28.19	22.75	33.25	28.35	28.18	21.5	33.75	28.75	22.5	33.45	29.37	26.38	34.88	30.28	29.71
Light Penetration	14	50.75	30.5	13.38	57.5	27.44	7.75	27.25	16.11	24.69	22	57.75	33.51	19.75	59.25	39.81	13	42.5	30.56	34.63
Suspended solids gm/l	0.16	0.96	0.555	0.15	2.375	1.249	0.205	6.15	3.865	1.89	0.43	3.385	1.911	0.6	13.5	2.414	0.535	3.17	1.551	1.958
pH	6.93	7.76	7.44	7.22	7.8	7.54	7.4	8.04	7.78	7.59	7.19	8.09	7.67	7.4	8.19	7.74	7.57	8.193	7.78	7.73
Salinity ppt.	0.389	18.51	8.93	0.73	30.28	15.34	1.035	34.92	22.93	15.73	0.803	32.48	19.67	2.85	34.6	23.93	6.825	37.14	27.55	23.73
Dissolved oxygen mg/l	0.75	3.825	2.29	1.425	3.35	2.55	1.983	4.8	3.62	2.82	0.375	2.925	2.015	0.7	8.2	1.998	0.925	4	2.11	2.041

population density in Thane creek and its increase in Ulhas river estuary as compared to the previous records. However as compared to the densities recorded from the other Indian estuaries and creeks (Godavari estuary, Chandramohan, 1963; Cochin backwaters, Madhupratap & Haridas, 1975; Sundarbans, Sarkar *et al.,* 1985; Pullavazhi backwaters, Srinivasan & Santhanam, 1991), the present study showed lower zooplankton densities in Thane creek and Ulhas river estuary.

COPEPODS

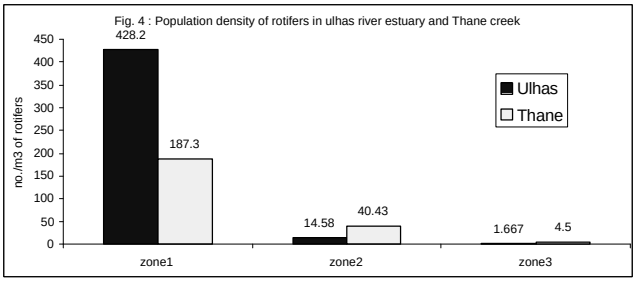
Copepods formed one of the major components of zooplankton community in both the ecosystems and were represented by three types, calanoid, cyclopoid and herpecticoid. Copepods have been recorded as dominant zooplankton in many estuaries (Sarkar *et al.,* 1986, Vareethiah K. 1999,Chandramohan et al., 1999 Desai *et al.* 1983). Lodh (1990) observed increase in density of copepods from Thane creek to offshore stations in Arabian Sea. Nair et al. (1999) recorded dominance of copepods at seaward location in Ulhas river estuary. In present observations also percentage of copepods increased from riverine end to seaward stations. As copepods dominate the marine zooplankton community, they often contribute over 80% to 90% of total zooplankton count, but present study showed relative percentage of copepods to be 48% in Ulhas river estuary and 40% in Thane creek inspite of higher density of copepods in Thane creek. This may be due to increase in pollution by domestic sewage and industrial wastes. Though copepod percentage was less they were represented in all the three zones of both the ecosystems. The middle zone showed comparatively good population density of copepods than the other two zones (Fig 2 & 3). In low salinity regions of both ecosystems, calanoid copepods occurred in less number. Zone 1 of Thane creek showed very low density of copepods probably due to heavy organic pollution in this zone. Cyclopoid copepods were the dominant group in Ulhas river estuary due to more influence of fresh water whereas calanoid copepods dominated in Thane creek due to its higher salinity. Harpacticoid copepods were poorly represented in both the ecosystems.





Rotifers

It was observed that the occurrence of rotifers was under the influence of salinity. As compared to Thane creek, Ulhas river showed less salinity (Table 2) Towards the riverine end, the estuary had almost fresh water condition hence the percentage of rotifers was higher in this region(Fig. 4). The proportion of rotifers in Ulhas river estuary was 25%, which was higher in comparison with 6.6% of Thane creek. In Thane creek also the dominance of rotifers was on riverine side especially in monsoon season.



Polychaete Larvae

Polychaete larval form setiger, occurred in almost all zones of the creek but was most abundant at the middle zone of the Thane creek (Fig. 5). Different stages of setiger were observed during the months January to May. They formed 14.68% of total zooplankton density in the creek. Relatively higher numerical abundance and dominance were often considered as measures of successful adaptation (Briggs 1974). Goldin (2001) recorded abundance of benthic polychaete population in Thane creek, which also justifies for the higher percentage of their larval forms in the creek water. In Ulhas River estuary only 0.65% of polychaete larval forms were noted.

Molluscan larvae

The larval stages of mollusca (Gastropoda and Bivalvia) were next to polychaete larvae in dominance. In both ecosystems they formed about 15% in population density. Annie Mathew (1989) and Goldin (2001) reported increase in molluscan founa of Thane creek and

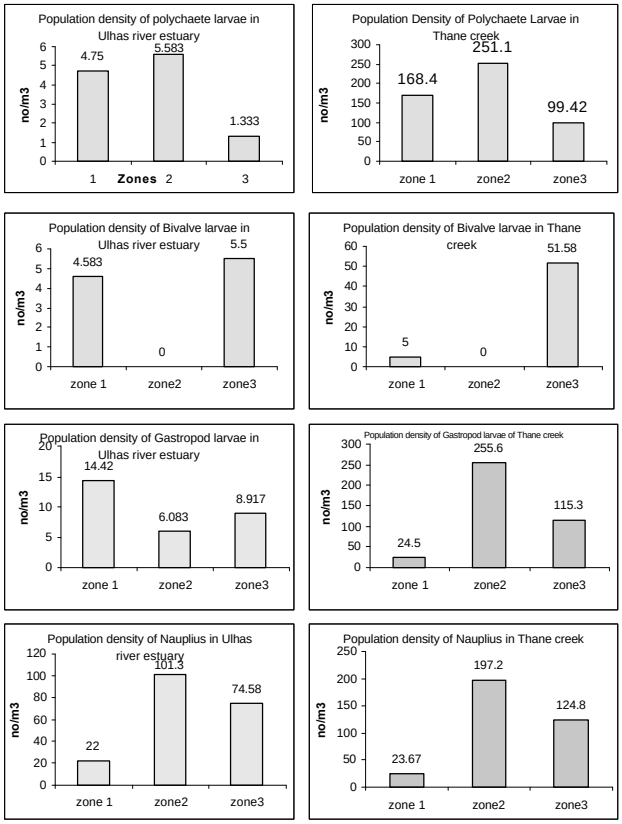


Fig 5 : Population density of various zooplankton groups.

attributed it to the slow currents and sheltered nature of the creek. This could have facilitated the proliferation of molluscan larvae in the creek water. (Fig 5).

Crustacean larvae

The Nauplii of various crustacean groups were one of the dominant types occurring in all the three zones of both the ecosystems (Fig 5). They had 11.18% proportion in Ulhas river estuary and 9.8% in Thane creek. Among the various nauplii the copepod nauplii were observed in large numbers. The larval form mysis also occurred in the samples of both ecosystems but their number was not significant.

Nematodes

The nematodes though not pure planktonic forms, were observed in entire creek as well as in the estuary. Similar observations were also made by Goldin (2001) in Thane creek. In the creek they were observed in significant numbers during post monsoon period and did not show any particular trend.

Eggs

Different types of eggs were observed in both the ecosystems. Their population density clearly indicated that both ecosystems have potential for secondary production but survival of eggs is at the risk of pollution. Similar observations were also made by Mishra (2002) in Ulhas river estuary and Goldin (2001) in Thane creek.

The other zooplankton noted in both the ecosystems were mainly foraminiferans, tintinids, hydromedusae, ctenophores, noctiluca, mites, *Acetes spp*., cypris and ostracods. Except noctiluca, they were mainly observed towards seaward end of both the ecosystems. According to Nair and Selvakumar (1979) neritic species are found to thrive well in high saline region and their presence is indicative of saline regime.

Ctenophores were represented by comb jelly and Beroe. Together with coelenterates they often function as key organisms in pelagic ecosystems and contribute substantially to the total zooplankton standing stock in estuaries and near shore waters (Alldredge 1984).In Thane creek these forms occurred in dense swarms during post monsoon months. Shantakumari and Nair (1999) are of the opinion that these organisms are ecologically important as they are carnivores and compete with other predators like fish larvae. They also mentioned that in estuarine environment, the Hydromedusae and Ctenophores serve as index of industrial pollution.

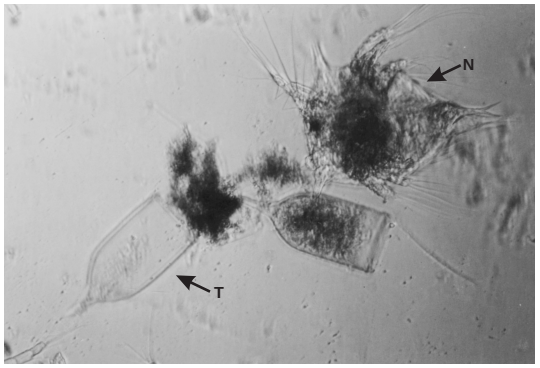
The next important group was Tintinids, predominantly marine organisms. According to Godhantaraman and Krishnamurty (1997), tintinids and rotifers form the dominant group feeding on small diatoms and nanoplanktons. Goldin (2001) reported significant number of tintinids in Thane creek.

The foraminiferans are marine organisms hence occurred predominantly in the samples of seaward end. The form, which is considered as pollution indicator, is Noctiluca was also observed in insignificant numbers in both the ecosystems. The larval forms of prawns were noted at both the ends of the estuary and creek, which indicated that both freshwater as well as marine prawns must have been using creeks and estuaries as nursery grounds. The ostracods, water mites and cypris were also represented in insignificant numbers in both the ecosystems.

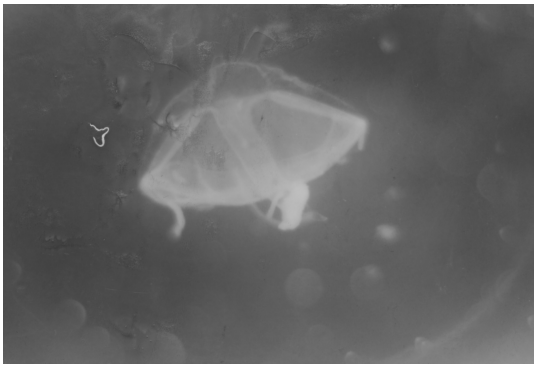
Salinity was the main water parameter that can be attributed as the limiting factor to the plankton diversity that influenced the planktonic community and its distribution. During the present investigations salinity showed an increasing trend from riverine to seaward end and though some types were cosmopolitan in their occurrence, some types were restricted to riverine end and some to the seaward end. However, in both the ecosystems most of the zooplankton had insignificant correlation with other parameters.

In general low diversity, patchiness and low population density of zooplankton were the

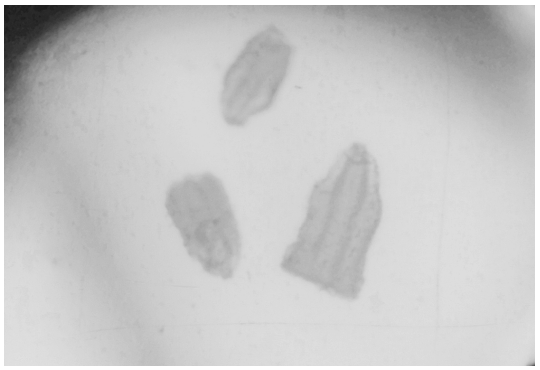
ZOOPLANKTON OF THANE CREEK & ULHAS RIVER ESTUARY



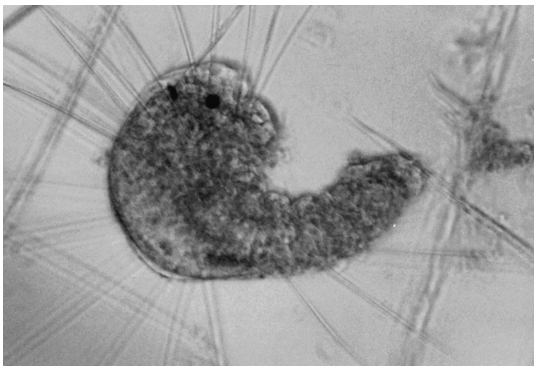
Tintinids (T) & Nauplius (N)



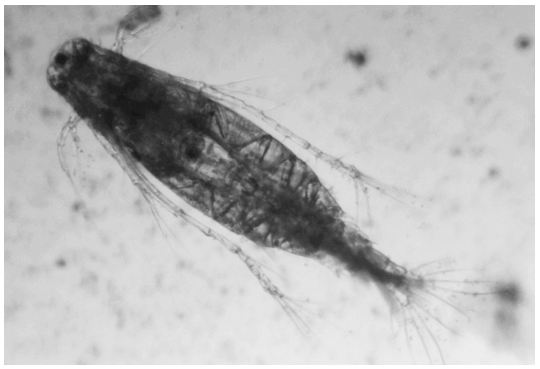
Medusae



Beroe spp.



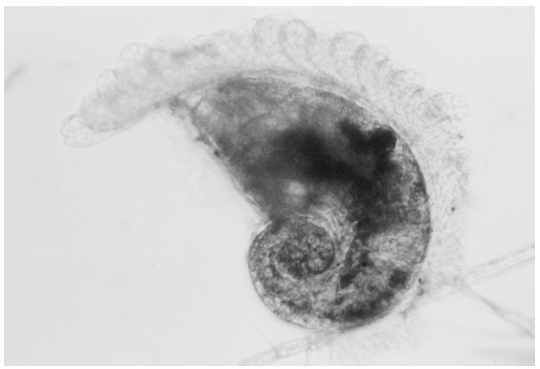
Polychaete Setiger larva



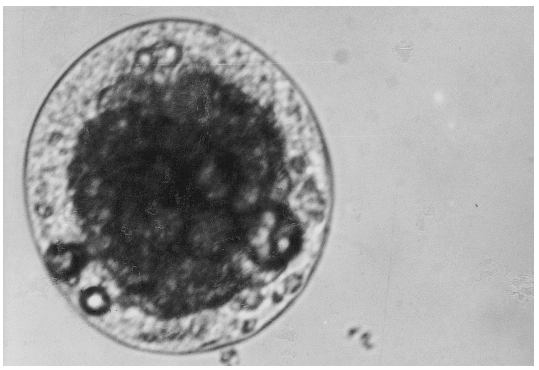
Calanoid copepod



Harpacticoid Copepod



Veliger larva



Egg

characteristics of both the ecosystems. This observation corroborates with the observations of Nair *et al*.(1981) who mentioned variability and patchiness as unique feature in plankton distribution and related it to the effect of additional environmental stress imposed by pollution or any other manmade modification Lodh (1990)also reported high pressure of anthropogenic activities and pollution pressure causing patchy distribution of zooplankton. Similar observations were also reported from the regions of east coast of India receiving industrial and sewage effluents (Sivaswamy 1990). Thus low population density and diversity in Ulhas river estuary and Thane creek can be considered as an index of poor and deteriorating water conditions of the two ecosystems.

ACKNOWLEDGEMENT

The financial assistance provided by Mumbai Metropolitian Region – Environment Improvement Society C/o MMRDA, Mumbai is gratefully acknowledged.

REFERENCES

Alldredge, A.L., 1984, in Flows of energy and materials in marine ecosystem. Theory & Practice, M.J.R, Fusham (ed.) Pentenum Press, London.407.pp.

APHA, AWWA, WPCF., 1981. of water and waste water,15th Edition. Washington DC. 874 pp.

Battish, S.K. 1992. Fresh water zooplankton of India Oxford and IBH Publication. 233 pp.

c.f. Bridges J.C., 1974, Marine Zoogeography, McGrow Hill New Work.

Chandramohan, P. 1963 Studies on the zooplankton of Godavari Estuary Ph.D. Thesis .

Chandramohan, P., A.V.Raman, N. Sreenivas. 1999 Distribution of zooplankton in relation to water movements in Kakinada Bay, east coast of India., Indian Journal of Marine Science,Vol.28 : 192-197.

Desai, B.N., S.N.Gajabhiye M.Jiyalal Ram, and V.R. Nair 1983 Comparative account on zooplankton in polluted and unpolluted Estuaries of Gujarat., Mahasagar Bulletin of National Institute of Oceanography 16(3) : 281-291.

Desai, B.N., S.N.Gajabhiye and M.Jiyalal Ram 1977 Zooplankton popullation in the polluted environment of Thane Creek and Bombay harbour. Journal of the Indian Fisheries Association 7 (1 & 2) : 46-56.

Gajbhiye, S.N. 1979 Comparative study of zooplankton in polluted and unpolluted region of Bombay. M. Sc. thesis, University of Bombay. 138 pp.

Gajbhiye, S.N. 1982 The ecology zooplankton with special reference to polluted environment of Bombay Ph.D.Thesis, University of Bombay. 497 pp.

Godhantaraman, N. and K.Krishamurthy 1997 Experimental studies on food habits of tropical microzooplankton . Indian Journal of Marine Sciences 26: 345-349.

Gokhale, K.S. and R. P. Athalye, 1995, Study of impact of Pollution on mangrove fauna of Thane creek near Thane city. Report submitted to Ministry of Environment and Forest; New Delhi. 40pp.

Goldin Quadros, 2001 The study of intertidal fauna of Thane creek. Ph.D. Thesis. University of Mumbai. 264 pp.

Krishnapillai, K. 1986 Introduction to planktonology Himalayan publishing House, 104 pp

Lodh, N.M. 1990 Ecological studies on planktonfrom near shore waters of Bombay, Ph.D. thesis, University of Bombay, India. 203 pp.

Madhupratap, M. 1987, Status and Strategy of zooplankton of tropical Indian estuaries, A review, Bull. Plankton Soc. Japan, Vol 34 :.65-81.

Madhupratap, M., T.Haridas, T.S.S. Rao and H. Krishna Iyer. 1975. species associations of calanoid copepods in an estuary. Indian Journal of Marine Sciences. 4 : 177-180.

Mathew, A. 1989, *Marine benthos of the creek &coastal environment of Bombay*, Ph.D.thesis, Univ.of Bombay,138 pp.

Mishra, S. and R.C. Panigrahy 1999 Zooplankton ecology of Bahuda estuary (Orrisa) , east coast of India. Indian Journal of Marine Science. 28 : 297-301.

Mishra, V. 2002 *Study of Macrafauna of mangrove, mudflats of Ulhas river estuary* Ph.D. thesis, Mumbai University.

Mustafa S., V.R. Nair and K. Govindan, 1999. Zooplankton community of Bhayender and Thane saltpans around Bombay. . Indian Journal of Marine Sciences 28(2) : 184 – 191.

Nair, V.R, S.N. Gajbhiye, M.J. Ram, B. N. Desai, 1981, Biomass and Composition of zooplankton in Ayuranga, Ambika Purva and Mindola estuaries of South Gujarat, Indian Journal Marine Sciences Vol.10 : 116-122.

Nai,r V.R, S.N.Gajabiye, D.N.Desai.1991, Effect of Pollution on the distributon of chaetognaths in the near shore waters of Bombay, Indian Journal Marine Sciences. Vol 20,pp43-48.

Nair, V.R. and R.A. Selvakumar, 1979, The ecology of Chaetognaths in the estuarine system of Goa, Mahasagar, 12(1) : 17-29.

Nair, V.R., A.J. Krishnamurthi and S.N. Gajbhiye. 1999. Trophic structure and levels of selected metals in the zooplankton community of Thane – Bassein creek, Bombay. Indian Journal of Marine Sciences 28(2) : 173 – 183.

Nasser, A.K., Pon Siraimeetan 1998. Zooplankton abundance and distribution at Minicoy Lagoon , Lakshadweep. Indian Journal Marine Sciences. 27: 346-350.

Santanam, R., K. Krishnamurthy and V. Sundararaj. 1975. Quantitative plankton ecology. Bulletin of department of marine science. University of Cochin. 7 : 899-911.

Santhanam, R. and A. Srinivasan, 1994, A manual of Marine zooplankton Oxford & IBH publication, New Delhi, 160pp.

Sarkar, S.K., B.N. Singh, A. Chaudhari 1985. Composition and abundance of epizoolankton of in Bay of Bengal off Deltaic Sunderban's, India. In The mangroves proceedings of the national symposium on biology,utilization, and conservation of mangroves. Shivaji University, Kolhapur. 432 –437 pp.

Sarkar, S.K., B.N. Singh, A. Chaudhari 1986 The ecology of copepods from Hooghly estuary, West Bengal, India, Mahasager Bulletin of NIO, Vol 19 No. 2,pp 103-112.

Shantakumari V. and V.R. Nair 1999 Distribution of Hydromedusae from the exclusive economic zone of the West coast of India. Indian Journal of Marine Sciences. 28 (2): 150-157.

Sivaswamy, S.N. 1990 Indian J. of Marine Sciences Vol 19 :115

Srinivasan, A. and R Santhanam. 1991. Tidal and seasonal variation of zooplankton of Pullavazhi brackish water, South east coast of India. Indian journal of marine sciences. 20 : 182-186.

Srinivasan, A. and R. Santhanam, 1991. Tidal and seasonal variations in zooplankton of Pullavazhi brackish water, South east coast of India. Indian Journal of Marine Sciences 20: 182 –186.

Vareethiah, K 1999. Zooplankton Composition in a bar built estuary, South west coast of India, Indian J. Fish Vol.46.N0.2 : 179-183.

Wimpenny, R.S. 1966 The plankton of the sea Faber and Faber eds. London 426 pp.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 116-119

FOOD AND FEEDING HABITS OF *METAPENAEUS MONOCEROS* FOUND IN THANE CREEK

Pejaver M. K. and K. S. Gokhale
B. N. Bandodkar College of Scinece, Thane-400601.

ABSTRACT: Food feeding habits of *Metapenaeus monoceros* from Thane creek reveal the fact that they are carnivorous in diet and show preference to polychaetes and crutaceans in the diet. These prawns neither are total detritus feeder nor prefer diatoms though available in large quantity.

Key Words: Food-feeding, Prawn, *M. monoceros,* Creek

INTRODUCTION

The food and feeding habits of different animals explain the distribution, migration and growth of them. Similarly it also helps to establish the trophic links. The study of food and feeding even help in culturing of those animals as feeding habits of an organism are directly related to their habitats.

M. monoceros is a commercially important prawn, commonly found in estuaries, as estuaries are the feeding grounds for the young ones of this prawn. But the references of food feeding habits of this prawn are scanty. Hence the food feeding habits of M. monoceros from Thane creek were studied.

MATERIALS AND METHODS

Two stations placed 6 km. apart, were selected on the Thane creek for the present study. The first station (Stn. I) or Thane station was near Thane Railway Bridge, where the main drainage pipe carrying domestic sewage and industrial effluents opens into the creek. The second station (Stn. II) or Kasheli station was near the junction of the creek and Ulhas river, where freshwater inflow is more and large expanse of water was seen through out the year.

The collection of prawn samples was made from commercial nets at both the stations twice a month from May 1981 to April 1982. At stn.II the fishing is terminated from January to April as it becomes uneconomical. The randomly selected samples were brought to the laboratory in icebox. The stomachs were removed and immediately preserved in 5% formalin prepared in seawater.

The feeding intensity was measured by eye estimation method of Pillay (1952). Analysis of different food items was done by the 'point method' (Bapat and Bal, 1950) and their percentage composition was calculated according to the method of Hynes (1950). Later the data was pooled together and is represented monthly.

RESULTS AND DISCUSSION

The prawns have well developed masticatory apparatus hence it was difficult to analyze the food till its species level. Similarly no difference was noticed in the food and feeding habits according to the size or sex.

During the present study the gut contents of *M. monoceros*, at both the stations consisted of crustaceans, polychaetes, fish, mollusks and nematodes remains, plant matter algae, sand, diatoms and mud (Table 1). The crustaceans remains could be identified by the pieces of exoskeleton, broken appendages, compound stalked eyes, while polychaete remains were mostly setae, acicula and muscle debris. Fish remains were mostly cycloid scales while pieces of molluscan shells and plant epidermal tissue with chlorophyll were also noticed in the gut contents.

The main diet of *M. monoceros* at stn.I and stn.II appeared to be polychaetes and crustaceans, while mud forms the third component (Table 1). Other food items were found to be in negligible amount.

At stn.I crustaceans formed the major part of the diet in summer months (March to June) and in post monsoon months (September and October), while in the remaining months polychaetes were the major food. Polychaetes thus show inverse relation with crustaceans but direct relation with mud (Fig 1 & 2). This might be due to the feeding habits of the prawn, as it feeds on the crawling polychaetes in mud, which may also explain the presence of mud in the gut contents. During monsoon period prawn biomass showed positive relation with polychaetes (Athalye *et. al.* 2001) and polychaetes abundance was also noticed in their gut contents showing the preference to polychaetes as food.

At stn. II polychaetes were seen to form the major portion of food contents throughout the fishing season. Similarly, the percentage of mud was much higher reaching 80 % as against 33.33 % at stn.I.

Table 1: Monthly fluctuations in percentage composition of different food items of *Metapenaeus monoceros* from stn.I and stn.II

	Crustaceans		Polychaetes		Mud		Fish		Mollusca		Plant		Algae		Diatoms		Sand		Nematodes	
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
May	44.44	8.33	34.35	70	12.5	15	0	0	0	0	0.4	0	0	0	3	6.67	3.5	0	1.85	0
June	55.56	46.84	26.67	14.21	5.56	23.16	0	0	0	0	0	0	0	0	2.22	3.16	10	0	0	0
July	30.07	0	53.15	0	14.23	0	0.27	0	0	0	0	0	1.34	0	0.94	0	0	0	0	0
August	19.04	22.81	69.09	43.64	10.85	31.71	0	0	0	0	0	1.49	0.23	0	0	0.17	1.81	0	0	0
September	43.3	13.64	38	50	16.78	36.36	0.17	0	1.74	0	0	0	0	0.17	0	0	0	0	0	0
October	50.16	16.67	32.66	53.33	14.38	20	0	0	0	0	0.31	0	0.31	0	0.83	0	1.56	10	0	0
November	22.13	0	57.05	80	20	80	0	0	0	0	0	0	0	0	0.85	0	0	0	0	0
December	0	0	66.67	80	33.33	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0
January	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
February	24.12	0	60.72	0	5.98	0	0	0	0	0	0.41	0	0.93	0	7.84	0	0	0	0	0
March	46.91	0	40.05	0	9.95	0	0	0	0	0	0	0	0.32	0	2.77	0	0	0	0	0
April	42.14	0	34	0	13	0	0	0	0	0	0.29	0	0	0	2.14	0	0.29	0	8.14	0

Table 2: Monthly fluctuations in percentage of feeding intensity of *Metapenaeus monoceros* from stn.I and stn.II

	G		F		3/4 F		1/2 F		1/4 F		E	
Stations	I	II	I	II	I	II	I	II	I	II	I	II
Month												
May	13.33	0	40	27.03	2.67	0	12	27.03	3	0	24	45.94
Jun	0	0	13.33	14.29	6.67	0	13.33	14.29	20	8.57	46.67	60
Jul	4.05	2.86	40.54	0	0	0	3.11	0	2.7	0	44.59	0
Aug	3.23	0	62.9	35.44	1.61	0	3.23	3.8	6.45	3.8	22.58	56.96
Sept	1.75	0	38.6	13.33	3.51	0	10.53	6.67	7.02	6.67	38.6	73.33
Oct	1.11	0	12.22	0	0	0	1.11	21.43	14.44	0	71.11	78.57
Nov	2.78	0	27.78	9.09	0	0	2.78	0	0	0	66.67	90.91
Dec	0	0	0	16.67	0	0	100	0	0	0	0	83.33
Jan	0	0	0	0	0	0	0	0	0	0	0	0
Feb	8.57	0	42.86	0	5.71	0	11.43	0	22.86	0	8.57	0
Mar	8.77	0	14.91	0	2.63	0	19.3	0	14.91	0	39.47	0
Apr	12.5	0	33.93	0	1.79	0	14.29	0	17.86	0	19.64	0

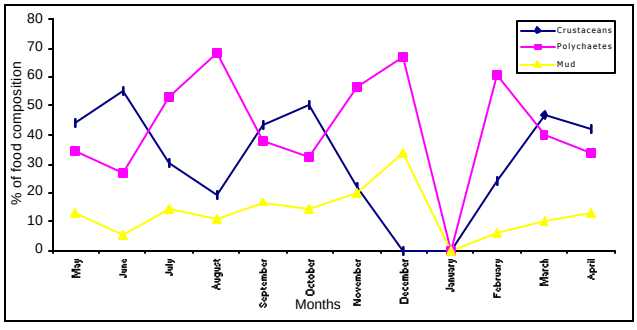


Fig. 1 : Comparison of food components at station 1

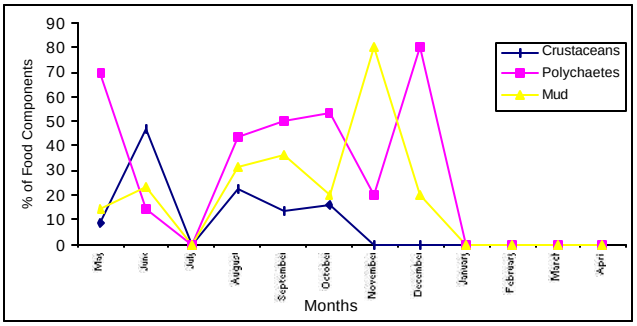


Fig. 2: Comparison of Food Components at Station II

Mollusks, fish remains and nematodes were found to be totally absent from the diet of this prawn from station II.

At both the stations when the feeding intensity was maximum, polychaetes formed the major part of the diet. Polychaetes are also reported in the gut content of *Mugil cephalus* from the same study stations (Tandel,1984, 1986).

Prawns are considered to be omnivorous in diet (Hunts, 1925; Chopra,1939; Gopalkrishnan,1953; Subrahmanyam,1963; Gunter,1964 and Rao,1967). Subrahmanyam (1963) observed that bottom fauna formed predominant part of the diet of *M. affinis*. Pillay (1954) commented that *M. monoceros* fed mainly on detritus, besides copepods, filamentous algae and diatoms, while Mehendale (1959) observed it to feed on detritus along with algae, crustaceans, foraminiferans, polychaetes and miscellaneous items like eggs, fish scales, nematodes. Kathuria (1967) also found *M. monoceros* to be detritus feeder while *M. brevicornis* preferred crustaceans to algae and detritus.

In the study of Godavari estuary Subrahmanyam (1973) commented that *M. monoceros* fed mainly on plant matter, organic detritus, small crustaceans and foraminiferan shells. Athalye *et. al.* (2001) reported phytoplankton, plant matter, annelids, arthropods and mud as food content of *M. monoceros* from Thane creek. George (1974) observed size wise difference in the diet of the prawn, small sized prawn fed mainly on small crustaceans, mud and detritus while in large sized group detritus was found to be in very large proportion.

Though most of the scientists suggest *M. monoceros* to be detritus feeder it is not true for the present study, because though detritus forms 80% of the diet in November at stn.II, 90.90% of the animals had empty stomachs in that month.

Very low percentage of diatoms in the diet is also intriguing, as diatoms formed the major component of the food in *Mugil cephalus* and *Boleopthalmus dussumierei* from the same area during certain months (Tandel,1984) indicating abundance of phytoplankton. Quadros (2001) observed, among crustaceans *Illyoplex gangetica* and *Scylla serrata* found in the area under study, fed predominantly on phytoplankton mainly diatoms. This shows that diatoms are not preferred by *M. monoceros* from this area as food.

Similarly nematodes form 90% of the food contents of *Mystus gulio* (Tandel,1984,1986) from the same locality in certain months, but almost complete absence of them in the diet of *M. monoceros* indicate non preference of the prawn to nematodes.

Overall the feeding intensity of *M. monoceros* at both the stations appeared to be low (Table 2) but comparatively it was better at stn.I where gorged and full stomachs were seen for the entire study period. Similarly the percentage of empty stomachs was lower at stn. I than stn.II where it reached to the level of 90.90 %in November.

Mehendale (1959) commented that feeding activity in *M. monoceros* from Mahim backwaters in general seemed low from October to December and high from June to August. During the present study feeding activity was low in October and November whereas it was high from February to May and in August-September at stn. I. While at stn. II mostly it was lower throughout the fishing season and the lowest in November and December. Gorged stomachs were noted at least to little extent at stn. I but at stn.II they were noticed only once.

Thus it can be concluded that *M. monoceros* in the area under study is largely carnivorous in diet showing the preference for polychaetes and crustaceans as food. Similarly their feeding intensity in the study area was also low.

Athalye *et. al.* (2001) during their investigation in 1991-1993 could get some M. monoceros in the catch but now the fishing is totally stopped at stn.II, Quadros (2001) during his investigations from 1999-2001 could not get this prawn in the commercial catches from Thane creek.

ACKNOWLEDGEMENT

The authors are thankful to the principal, staff of zoology department and the research students for their constant encouragement and cooperation.

REFERENCES

Athalye R. P., G. Quadros, V. Ullal, V. Mishra and K. S. Gokhale 2001 Status of Fishery of Thane Creek Ecol. Env. & Cons. 7(3), 273-279.

Athalye R. P., S. S. Tandel, M. K. Pejaver& K. S. Gokhale 2001 Factors governing Polychaete biomass in Thane Creek, Maharashtra State, India. 2001. J. Aqua. Biol. 16(2), 2001, 15-17.

Bapat, S. V. and Bal, D. V. 1950 The food of some young clupeids. Proc. Ind. Acad. Sci. (B), 32-39.

Chopra, B. N. 1939 Some food prawns and crabs of India and their fisherie. J. Bomb. Nat. Hist. Soc., 41, 221-234.

George, M. J. 1974 The food of the shrimp *Metapenaeus monoceros* (Fabricius) caught from the backwaters of Cochin. Ind. J. Fish., 21(2), 495-500.

Gopalkrishnan, V. 1953 Seasonal fluctuations in the fat content of the prawn, *Penaeus indicus* (M. Edw.), J. Madras Univ., 23, 193.

Gunter G. J. 1964 Relation of salinity to population of penaeid shrimps. Ecology, 45-181.

Hunts O. D. 1925 The food of the bottom fauna of the Plymouth fishing grounds. J. Mar. Biol. Ass.U. K., 13, 560-599.

Hynes, H. B. N. 1950 The food of the freshwater sticklebacks (*Gastrosteus aculeaths* and *Pygosteus pungitius*) with a review of methods used in the studies of the food of fishes. J. Anim. Ecol., 19, 36-58.

Kathuria, J. 1967 Study of Bombay prawns. Ph.D. thesis, University of Mumbai. (unpublished).

Mehendale D. D. 1959 A study of prawns. M. Sc. Thesis . University of Mumbai. (unpublished).

Pillay, T. V. R. 1952 A critic method of the study of food of fishes. J. Zool. Soc. India, 4, 185-200.

Pillay T. V. R. 1953 Studies on the food feeding habits and alimentary tract of the grey mullet *Mugil tada* (Forskal). Proc. Nat. Inst. Sc., India 19(6), 777-827.

Rao, Malikarjuna 1967 Studies on the biology of *Macrobrachium rosenbergii* (de man) in Hooghly estury with a note on its fishery. Proc. Natn. Inst. Sci. India, 33(B), 5 and 6, 252-279.

Subrahmanyam , C. B. 1963 Notes on bionomics of the pinaeid prawn *Metapenaeus affinis* (Milne-Edwards)of the Malabar coast. Ind. J. Fish., 10, 11-12.

Subrahmanyam M. 1973 Fishery and biology of *Metapenaeus monoceros* (Frabricius)from the Godavari Riverine system.Ind. J. Fish., 20(1), 95-107.

Tandel S. S. 1984 Biology of some fishes of the creek near thane. M. Sc. Thesis, University of Mumbai. (unpublished)

Tandel S. S. , R. P. Athalye and K. S. Gokhale 1986 On the seasonal changes in food habit of *Mugil cephalus* of the Thane creek Indian J. Fish., Vol. 33 no. (3) 270-276.

Quadros G. 2001 A study of intertidal fauna of Thane creek. Ph.D. Thesis, University of Mumbai. (unpublished).

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 120-124

SURVEY OF MANGROVE CLAM (*GELOINA PROXIMA*) FISHERY IN RATNAGIRI DISTRICT

R.B.Kale and B.K.Pawar *
Department of Zoology, Gogate -Jogaleker College, Ratnagiri, (Maharashtra).
*Department of Zoology, Shivaji University, Kolhapur,(Maharashtra).

ABSTRACT : Survey of G.proxima fishery was undertaken with a view to evaluate the present status of mangrove clam fishery in Ratnagiri district and suggesting posssible ways and means of improving the fishery Considering the salient features of the mangrove clam fishery in different taluka places in Ratnagiri district , the following significant findings are listed (1) The district has about 167 Kms. coastal line which includes about 30 small and big creeks .(2) The brackish water area which supports mangrove vegetation is about 2,383.85 hect.^{2} distributed in nine talukas. (3) The maximum area of mangrove vegetation is under the jurisdiction of Rajapur taluka , that is , about 510.49 hect.^{2} and minimum in the jurisdiction of Sangmeshwar taluka , that is ,about 13.88hect.^{2} (4) The ranking of the talukas is made by considering estimated catch in Kgs./yr . and approximate value thereof in rupees. Ratnagiri taluka stands first in the mangrove clam fishery of the district , Rajapur taluka second , Mandangad taluka third , Chiplun , Dapoli ,Guhagar , Khed , Sangameshwar and Lanja talukas 4th to 9th respectively.

Key Words *:* Mangrove clams Geloina proxima;Mangal vegetation;Sheni method;Creek,Canning.

INTRODUCTION

The molluscs form an important group of invertebrates of commercial value . Amoung them the bivalves have far excelled the gastropods and cephalopds as cultivable source of food, most of them serve as good source of protein, glycogen, lipid and minerals. The food resources and productivity of mangrove swamp support a variety of edible shellfishes including snails, cockles, oysters, crab and shrimps . The mangroves can be developed profitably for the pond culture of both finfishes and shellfishes and may serve as nursery areas for juvenile fish and prawns and mangrove clams, being a rich source of seed for aquaculture. Ranade (1964), surveyed clam fishery of Maharashtra. He concluded that, the clam fishery is mainly dependent on three species of clams, namely, *Meretrix meretrix*, *Katelysia opima* and *Paphia laterisulcs*. Davis (1969), summarized the history of development of shellfish hatcheries. Mane (1973), considered that there are 70 creeks along the coastline, out of which 36 creeks are devoid of clam fishery and 34 support the clam fishery. Villalobos and Baez (1983), studied growth rate and mortality in *Anadara tuberculosa* under two culture systems. They found that, length increments were slightly greater in individuals suspended in platforms than in those placed on muddy substratum. Alcazar *et al*. (1987) found that, the China clam was successfully induced to spawn sperms and eggs using intragonadal injections of serotonin, with normal larval development. Holiday *et al*. (1990) conducted experiments on cold storage effects on setting of larvae of the Sydeny rock oyster , *Sacostria commercialis* and concluded that ,remote setting techniques have considerable potential for the species and larvae. Sugawar and Okoshi (1991) studied an important problem for oyster farming in enclosed coastal water. Kalyanasundaram (1992), studied larval development of edible oyster, *Crassostrea madrasensis* and larval settlement pattern. Since the submission of Mane's report in the year 1973, nothing has been done to evaluate properly the clam resources of the Ratnagiri district. The present investigation was, therefore, undertaken with a view to evaluate the present status of mangrove clam fishery in the Ratnagiri district and suggesting possible means of improving the same.

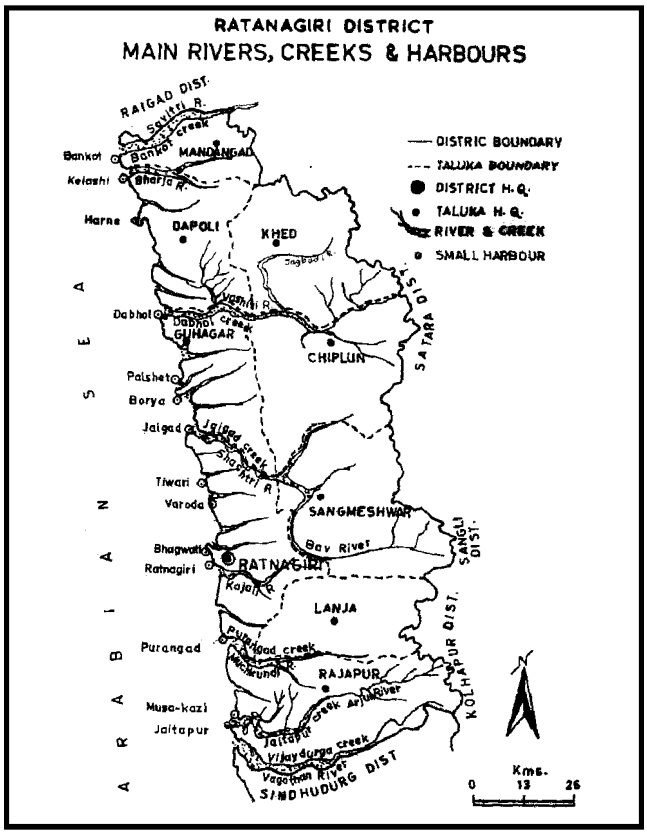
MATERIAL AND METHODS

In order to collect data on the present status of mangrove clam fishery of Ratnagiri district, a proforma covering most of the aspects of the fishery, was drawn. The author personally visited all the major and minor creeks present in newly formed Ratnagiri district .He personally interviewed about 5-6 people at each village or town situated near each creek. Also, he collected information from chairmen of different fishing co-operative societies present in the district .He collected information from fishery development offices and statistics department present at the district place. The total number of people surveyed in the interview including government offices was about 500, by using the proforma the data so collected were analysed and the following are the results of the mangrove clam fishery of Ratnagiri district.

RESULT

Fig.No.01 shows newly formed Ratnagiri district which is extended in between Raigad and Sindhudurg

Fig. 1 : Map of Ratnagiri District showing main Rivers, Creeks & Harbours



districts towards north and south respectively along the coast line. It has about 167 Kms. sea-shore and area of about 8,31,880.00 hect.^{2} The district includes nine taluka places, of which 5 talukas are maritime places while the remaining four are marketing places for different types of fish products. According to the 1991 census the population of the district is 15,44,057. The percentage of population distribution according to talukas is, Ratnagiri-16.30, Chiplun-16.11, Guhagar-10.19, Sangameshwar-13.38, Khed-11.78, Rajapur-11.62, Dapoli-11.61, Lanja-6.87. Minimum percentage of population is shown by Mandangad taluka, that is, 4.42. This data give an idea about the sufficient manpower present in the district for exploitation of mangrove clam fishery along with other fisheries and agriculture. But very little attention is paid by these people to this aspect of fisheries owing to the lack of proper guidance. For the sake of convenience the information collected was analysed talukawise from north to south.

(1) Mandangad Taluka :

It is the northern-most maritime taluka of the Ratnagiri district and extends from Savitri river in the north to Dapoli taluka in the south .The Savitri river forms Bankot creek ,which has an area of about 483.52hect.^{2} of mangrove vegetation. From Table No.01 it could be seen that, about 100 persons are engaged in the mangrove clam fishery. This number is very small as compared to the number of persons engaged in other clam fishery or fishery of a fish. These people together produce about 54,000Kgs. of mangrove clam per year valued approximately at Rs.1,62,00.About 55% of total catch is transported to Mahad, 20% to Dapoli by buses and lorries , while the remaining 25% is consumed locally. The Mandangad taluka stands third in the Ratnagiri district in respect of total catch. Extraction of lime is carried out only by burnig with 'Sheni' (cow dung loacally used for burning) method.

(2) Dapoli Taluka

This taluka has the area of about 84,670 hect.^{2} and includes 175 villages and one town. There are about seven small or big creeks. Dabhol creek is significant as compared to other creeks. All creeks provide an area of about 274.19hect.^{2} From Table No.01 it could be seen that, about 61 persons are engaged in fishery and they catch about 32,940 kgs. of mangrove clams annually, valued approximately at Rs.98,820.Nearly 60 % to 70% of the catch is sent to Mumbai along with other clams by lorries and the remaining catch is consumed by local people and at Dapoli market place. The commercial extraction of lime from the shells of mangrove clam is not seen in the different villages.

(3) Khed Taluka

This taluka is having 99,920 hect.^{2} area and about 215 villages and one town. This taluka is without the coast. The brackish water and mangrove vegetation is about 170.34hect.^{2}, which includes government and private marshy land due to rivers Vashishti and Jagbudi. Table No.01 shows that, there are about 30 persons engaged in fishing of the mangrove clam. The total estimated catch is about 16,200Kgs./yr.valued at Rs.48,600 approximately. Major catch is from Bahiravali from Dabhol creek. About 80% of the total catch is transported to Khed which is a good market place while the remaining catch is consumed locally or in the villages in the vicinity. The villagers extract lime from the shell by burning with sheni.

(4) Guhagar Taluka

It is a maritime taluka with an area of about 62,730 hect.^{2}, consisting of 112 villages and a town, it exhibits 38 km coastal line with approximate area of the creek about 149.68 hect.^{2}. Fig.No.01 shows two major creeks represented by Dabhol and Jaigad, whereas, Palshet is an additional small creek. About 40 persons are engaged in this fishery. The total production of clams in this taluka is estimated to be 21,600 kgs/yr annually valued approximately at Rs.64,800. About 55% of the total catch is transported to Chiplun by lorries and 10% to Sangameshwar and Khed. The remaining catch is consumed by local villagers. Though Guhagar taluka is having two big creeks, the people are attracted by fin-fish fishery and other fisheries. The extraction of lime from dried shells of G.proxima is carried out.

Table 1 : Summarised data of mangrove clam (G. Proxma) fishery in Ratnagiri district. (Ranking is given by considering esitmated catch is kgs/year)

Sr No.	Name of the Taluka	Number of Creeks present in Taluka	Number of villages along the sides of creeks	Approximate aras of the creeks in the sq. hectors	Approximate number of persons engaged in fishing	Approximate esitmaed catch in Kgs/year	Approximate value in Rupees	Rank to estimated catches/yr
1	Ratnagiri	7	17	462.83	110	59400	178200	1
2.	Rajapur	3	15	510.49	106	57240	171720	2
3.	Mandangad	1	16	483.52	100	54000	162200	3
4.	Chiplun	2	10	288.66	88	47520	142560	4
5.	Dapoli	7	11	274.19	61	32940	98820	5
6.	Guhagar	3	11	149.68	40	21600	64800	6
7.	Khed	3	5	170.34	30	16200	48600	7
8.	Sangmeshwar	2	3	13.88	11	5940	17820	8
9.	Lanja	2	2	30.26	7	3780	11340	9
10.	Total	30	90	2383.85	553	298620	896060	

(5) Chiplun Taluka

This taluka possesses an area of about 1,12,510 hect.^{2}. It has 163 villages and four towns. Though it is not maritime taluka ,brackish water in the taluka enters through creek and provides mangrove vegetation which accounts for about 288.66 hect.^{2} About 88 persons are engaged in fishing of clams and produce estimated catch of about 47,520 kgs/yr, valued at Rs.1,42,560 approximately. About 85% of the total catch is sold at Chiplun market, while the remaining 15% catch is consumed by the villagers. Chiplun taluka stands 4th in estimated catch and value. Local people near the creeks extract lime by sheni method.

(6) Sangameshwar Taluka :

It has an area of about 1,29,260 hect.^{2} and shows the distribution of 194 villages and single town. The taluka has no coastal belt but the brackish water enters through Shastri river to some extent, which provides shelter to the mangal vegetation. Jaigad is the main creek from which brackish water enters in the mangrove area of about 13.88 hect.^{2}of government sector only. From Table No.01, it could be seen that, about 11 persons are engaged in fishery which together produce about 5,940 kgs. catch per year, valued approximately at Rs. 17,820.Though the taluka stands first in area in the district, the mangrove clam fishery is very less. Major estimated catch is brought to Sangmeshwar market, while the remaining catch is consumed by villagers. Extraction of lime is not observed.

(7) Ratnagiri Taluka

This taluka is protected by Arabian sea from western side by providing maximum coastal line of about 56 kms. The area of the taluka is about 99,590 hect.^{2} with 119 villages and one town. The rivers Shastri, Bav, Kajali, Sakhar and Muchkundi form the brackish water area in the district. This area of brackish water is about 146.13 hect.^{2} From Table No.01, it could be seen that, 462.83 hect.^{2}area comes under brackish water with mangrove vegetation. Some 110 people are engaged in mangrove clam fishery .An estimated catch is about 59,400 kgs/yr, valued at Rs. 1,78,200.This valuation is of the maximum yield in Ratnagiri district which fulfils demand of the market. About 65 % of the total catch is transported to towns in the vicinity such as Lanja, Pali, Harchiri etc. by carts and trucks. About 20% of the total catch is sold at Ratnagiri fish market, while the remaining 15% is sold to local people at landing centres only. Though the Ratnagiri taluka is having less brackish water area with mangrove vegetation, the local fishermen have realised the profit and demand of customers which stimulates them to fish more mangrove clams. Near Ratnagiri, in Juve village, extraction of lime is carried on a large commercial scale.

(8) Lanja Taluka

It has an area of about 733.03 hect.^{2} and no coastal line. This taluka comprises one town and 122 villages. Total brackish water area measures about 30.26 hect.^{2} which provides less potential for the growth of mangrove bivalve. Mainly two minor creeks originate from the Purnagad creek viz., Harche and Beni (Bdk.). Some seven fishermen are collecting the mangrove bivalves. Together they catch approximately about 3,780 Kgs/yr, valued at Rs.11,340.No extraction of lime is done on

commercial scale.

(9) Rajapur Taluka

Rajapur is one of the best maritime talukas in Ratnagiri district. It has 1,28,380 hect.^{2} area and about 18 Kms. of coastal belt. The taluka includes some 216 villages and two towns. Jaitapur and Vijaydurg creeks are important from the point of view of mangrove clam fishery, while Purnagad is having moderate fishing. From Table No.01 it could be seen that, there are about 15 villages which exhibit big or small brackish water area of about 510.49 hect.^{2} with mangrove vegetation. About 106 persons are engaged in fishing mangrove clams. The total estimated catch is about 57,240 Kgs/yr., valued at Rs.1,71,720 which keeps this taluka at second position in the district. About 55% of the total catch is sold at Rajapur fish market and about 35% of the catch is transported to Lanja taluka, while the remaining 10% catch is consumed by local people in the taluka. No extraction of lime from the bivalve shells is done in this taluka also.

DISCUSSION

Considering the salient features of the mangrove clam *G.proxima* fishery in different taluka places in the Ratnagiri district, which is summarized in Table No.01, it could be seen that, there are about 30 small or big creeks along the coastal line which is about 167 Kms., available to the district, supporting about 90 villages and 15 towns. The total brackish water area which supports mangrove vegetation is about 2,383.85 hect.^{2} Maximum area of mangrove vegetation is under the jurisdiction of Rajapur taluka, that is, about 510.49 hect.^{2} and minimum area is acquired by Sangmeshwar taluka, that is ,about 13.88 hect.^{2} Table No.01 shows ranking of the talukas in the district by considering estimated catch in Kgs/yr and approximate value in rupees.

Ratnagiri taluka stands first in the mangrove clam fishery of the district. Though it is having less brackish water area, that is ,about 462.83 hect.^{2} as compared to the Rajapur and Mandangad talukas , it possesses a high potential as regards production of mangrove clams .Average number of fishermen engaged in fishing is about 110, together producing an estimated catch of approximately 59,400 Kgs/yr valued at Rs.1,78,200. The reason behind the first rank may be due to the demand of people from all classes for protein-rich food which is easily available from clam meat at cheaper rate than other meat proteins. This demand will increase as Ratnagiri city is expanding due to the industrial development and needs a large number of employees. This forecasts for the systematic culture and farming of the clams.

Rajapur taluka stands second in the district. It possesses the highest area, that is, about 510.49 hect.^{2} The average number of fishermen engaged in production of mangrove clams is about 106, together producing an estimated catch of about 57,240 Kgs./yr, valued at Rs.1,71,720. From Table No.01 it could be seen that, this taluka is having more brackish water area than Ratnagiri taluka but the total yield is less. The reason behind it may be less demand of clam meat-proteins by the population and more attraction towards finfish. Also, the fishermen have given less attention to the exploitation of mangrove clams.

Similar conclusion as above can be drawn regarding Mandangad taluka which ranks third in the district in respect of the total yield. Mandangad taluka is having comparatively more area, viz.483.52 hect.^{2} Some 100 fishermen are engaged in estimating about 54,000 Kgs/yr, valued at Rs. 1,62,200. The reason behind that may be more potential of fin fishery in the vicinity of Bankot creek. In the interviews of the fishermen in this area it was experienced that, they were not aware of the existence of *G.proxima* in some of the mangrove areas of Bankot and smaller creeks along the south bank of the Savitri river.

Chiplun taluka occupies fourth rank in the district. Fig.No.01 and Table No.01 shows that though this taluka is not maritime, the back water of Dabhol creek enters through the river Vashishti in the taluka and shelters considerable mangrove vegetation which has greater potential for mangrove clam culture .Tremendous industrial development is seen near Chiplun at Lote-Mal and in proper Chiplun which shows a large number of workers and will have greater demand for cheaper protein rich clam meat.

Dapoli,Guhagar,Khed and Sangmeshwar talukas rank 5th, 6th, 7th and 8th places respectively. Lanja acquires 9th position in the district. It is acting purely as market place and provides only 30.26 hect.^{2} of brackish water area which is less. On the other hand, though Lanja taluka is along the National Highway, less industrial development is seen and smaller number of workers are present there, which also affects the demand of clams.

There are three methods adopted for marketing of clams, viz., (a) Sale of living clams, (b) Sale of meat, (c) Dry clam meat. But recently, (d) Clam meat pickle, (e) Frozen clam meat and (f) Canned clam meat methods are in practice. In Ratnagiri district, all other methods of selling of mangrove clams *G.proxima* are not followed, except sale of live clams.

The mangrove environment which forms the border of the estuarine environment is a highly productive zone. Mangrove clams form an important group of molluscs of commercial value in view of varied use of their shells and soft edible parts. These mud-dwelling clams in the vicinity of mangrove served as good source of protein, glycogen and minerals. Large scale cultivation and

transportation of bivalves have been done successfully in Scotland, Panama, France, China, Philippines, England, Mexico, Japan and Israel etc.

In Indian waters, viz., Utter Kannada, Goa, Cochin, West Bengal have tried for culturing marine clams successfully .In Maharashtra, at Mumbai, large quantities of seed clams are brought from Alibag for stocking them in Mahim creek. Similarly, at Kelwa-Mahim, a small fishing village in north Mumbai, the fishermen collect seed oysters and grow them in the so-called oyster farms. Ranade (1964) transplanted clam seeds in Kolamb creek from Tarkarli creek. From Table No.01 it could be seen that, the total estimated catch is about 2,98,620 kgs./yr. and the area of the clam is approximately 2,383.85 hect.^{2} in Ratnagiri district. This gives an idea about very low catch per day, that is due to unhealthy population of mangrove clams, in muddy area and disturbance by thick vegetation while fishing.

The project of transplantation and cultivation should be undertaken in the future. Low fishing results in the indiscriminate fishing on the part of the diggers who fish any size of clam that comes in their way. At these thirty creeks excluding very small brackish water area, it would be necessary to start clam farming, also by creating brood clam reserves to help recruitment. This will provide an alternative protein-rich food with low cost to the people residing near coast.

REFERENCES

Alcazar, S.N., Solos, E.P. and Alcala,A.C.1987 Aquaculture 66 : 359-268.

Davis, H.S.(1969) Transactions Of The American Fisheries Society, 98 (4) : 743- 750.

Holiday, J.E., Allan, G.L. and Franes,J.1991 Am. Ma1acol. Bull. 4 (1): 79-185.

Kalyanasundaram, M. 1992 Mahasagar, 25 (1) : 51-54.

Mane, U.H. 1973 Study On The Biology Of Marine Clam *Katelysia opima*, Ph.D. Thesis, Marathwada Univ., Aurangabad, India.

Ranade 1964 Studies On The Biology, Ecology and Physiology Of The Marine Clams. Ph.D. Thesis submitted to University of Bombay, India.

Sugawar,Y. and Okoshi,K.1991 Environmental Management And Appropriate Use Of Enclosed Coastal Seas EMECS Goda T. *et al* .eds.,23 : 271-274.

Villalobos, C.R. and Baez A.L.1983 Rev. Latinoam Aquicult.17: 9-18.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 125-131

ON PRESENTING A SUITABLE METHOD OF COMBINED CULTURE COMPRISING *ARTEMIA SALINA* (SFB STRAIN) AND *INDOMYSIS ANNANDALEI* W.M.TATTERSALL UNDER LABORATORY CONDITIONS.

S.V.Deshmukh,
Head of Zoology Dept.,
K.J.Somaiya College of Science and Commerce.
Vidyavihar, Mumbai 400-077

ABSTRACT : Detailed faunal studies undertaken in the salt-pan reservoirs located at Mulund (East), Mumbai, bordering the Thane creek have indicated that the mysid shrimps(opossum shrimps) namely *Indomysis annandalei* W.M.Tattersall constituted a significant "Kolim Fishery". It was also found that *Indomysis* were reaching a peak population density in the month of February. However the studies showed that their population density was in the declining trend in the recent years.Therefore as a measure of conservation and providing these organisms as and when needed for bioassay studies,it becomes imperative to undertake laboratory culture studies. Hence studies were undertaken under laboratory conditions for culturing both *Indomysis annandalei* in combination with *Artemia salina* which provided nauplii as forage organisms.

Thus systematic experiments were carried out to evaluate survival range of salinities, reproductive range of salinities, breeding life span, fecundity and total life-span of both the species to assess parallel aspects of combined culture.

The results indicated that in the common culture media around 40-45 ppt, the *Artemia* were reproducing by ovo-viviparity i.e. nauplii were produced without cyst formation thereby providing forage to the mysids. In case of both *Artemia* and *Indomysis* phased fertilisation techniques in addition to particulate feeding techniques were adopted.The cultures were maintained under the prevailing atmospheric conditions .

Key words *: Indomysis annandalei, Artemia salina,* Combined culture, Laboratory culture, Plastic pool culture.

INTRODUCTION

Laboratory studies were undertaken at Taraporewala Marine Biological Research Station (TMBRS) , Mumbai 400002 during the year 1991-1995. Simultaneously the field studies were undertaken in the salt-pan reservoirs and salt-pans located at Mulund (East) Mumbai 400081 bordering Thane creek . The impounded water of Thane creek into the main reservoirs were sampled every fortnightly on new and full moon days .

On the basis of the detailed studies on various aspects (Deshmukh and Shirgur 1996 a & b; Shirgur and Deshmukh, 1994 ; Shirgur and Deshmukh, 1995 a & b ; Shirgur and Deshmukh, 1996; Shirgur *et.al.*1997) the aspects highlighted as shown in the above title is significant as it provides valuable information of undertaking combined culture of both *Indomysis annandalei* and *Artemia salina* . The organisms are in much demand in the laboratories for bioassay studies and culturing the important species of fishes under laboratory conditions.

MATERIALS AND METHODS

The abundantly occuring mysid shrimps (opossum shrimps), *Indomysis annandalei* were transported from the main salt-pan reservoirs into the laboratory. These were maintained in saline water conditions as that of the habitat waters. On the basis of pilot studies the optimal saline and feeding conditions for their culture and maintenance were determined . pH of the medium was adjusted according to the field records . The experiments were carried out at ambient temperatures. Thus the stock cultures were maintained in the aquarium tanks using the aeration In case of both *Artemia salina* and *Indomysis annandalei* phased fertilisation techniques and particulate feeding techniques were followed . Under these techniques DOCG (De-oiled cake of groundnut) and rice bran were administered (Shirgur, 1991) Suitable live feed organisms such as *Dunaliella* were also added under culture conditions..

Using information of laboratory cultures and field records of the species, pilot experiment was carried out in outdoor plastic pool containing culture media of 40-45 ppt. The specific laboratory techniques were evolved in relation to the experimental conditions. As the information has been very extensive all those details are not shown for the sake of brevity. The details are presented in the previous papers.

RESULTS

Experimental results are very elaborative hence only optimal results are shown in Table no. I-VI & Graph No. 1-3.

The results shown in the above Tables are self-

TABLE 1 : STATEMENT SHOWING OPTIMAL AND PARA-OPTIMAL VALUES IN RESPECT OF *ARTEMIA SALINA*

Sr.no.	Experimental Aspects	Optimal Value	Para-optimal Value
1	Hatchability of Artemia in different salinities (ppt)	25	15-20 30-45
2	Growth of Artemia in different salinities (ppt)	95-100	85-90
3	Early maturation in different salinities (ppt)	100	95
4	Fecundity in different madia (ppt)	100	80-90
5	Ovoviviparity in different madia (ppt)	40-60	70
6	Oviparity in different madia (ppt)	100	80-90
7	Life span in days in 40-100 ppt. Saline media	52-62	
		Range	**Grand Average**
8-a	Temp. during growth and maturation period (c)	21.0-23.5	23.18
b	Temp. during breeding life span (c)	22.2-23.5	22.86
c	Temp. during whole life span (c)	21.0-24.0	22.54

Table-2 A. Mysid Sub-groups

Sr. NO.	Sub-group nomenclature	Respective instar no.
1	Pre-juveniles (intra-marsupial)	I &II
2	Juveniles	III & IV
3	Immature males	V &VI
4	Mature males	VII TO XIV
5	Immature females	V & VI
6	Mature females	VII
7	Ovigerous females	VII TO XIII
8	Empty (senile) females	XIV

B. ABSTRACT RESULTS OF VARIOUS EXPERENTS ON SALINITY AND REPRODUCTION OF *Indomysis annandalei* , ADULTS AND JUVENILES

Sr. No.	Experimental aspects	Optimal range	Para-optimal range
1	Broad range salinity (ppt) :Adults	35-45	30, 50-55
2	Broad range salinity (ppt) :Juveniles	30-40	15-25 45-55
3	Narrow range salinity (ppt) :Adult	35-39	40-45
4	Narrow range salinity (ppt) :Juvenile	33-38	30-32 39-40
5	Reproductive range of salinities (ppt)	35-45	30, 50-55
6	PH : Adults	8.0-8.5	7.5
7	PH :Juvenile	8.0-8.5	7.5
8	Feeding conditions :Adults	Mixure of Rice bran *Artemia* nauplii+ Cladocerans + Dunalialla	Rice bran + +*Artemia* nauplii
9	Feeding conditions :Juveniles	Mixure of Rice bran , *Artemia* nauplii , + Dunalialla *Brachious*	1) Rice bran + *Artemia* nauplii 2) Rice bran Dunalialla,
10	Average temp. range (°c) : Adults and Juveniles	21.7-26.5	-
11	Assessment of period taken for intra-marsupial development of eggs upto early juveniles	4-5 days (96-120 hrs)	-
12	Assessment of growth of early juveniles in different salinities (ppt)	35	40-45
13	Assessment of entire life-cycle (days)	Range (days)	Average (days)
	A) Maturation period	18-24	21
	B) Breeding period	35-37	36
	C) Post-breeding period	1-12	8
	D) Total life-span	58-70	65

Table : 3 ABSTRACT RESULTS OF VARIOUS EXPERENTS ON SURVIVAL AND DURATION OF *Indomysis annandalei*, ADULTS AND JUVENILES

Sr.No.	Experimental aspects	Survival % pertaining to		Duration of survival in days	
		Optimal range	Para-optimal range	Optimal range	Para-optimal range
1	Broad range salinity (ppt): Adults	80	60-65	10	10
2	Broad range salinity (ppt): Juveniles	65-70	50-60	10	10
3	Narrow range salinity (ppt): Adults	80	70-75	10	10
4	Narrow range salinity (ppt): Juveniles	60-70	50-60	10	10
5	Reproductive range of salinities (ppt)	80	70	10	10
6	PH: Adults	80	70	10	10
7	PH: Juveniles	70-75	40	10	10
8	Feeding conditions: Adults	90	85	10	10
9	Feeding conditions: Juveniles	75	70	10	10

Table 4 : COMPARATIVE HYDROBIOLOGYCAL PARAMETERS OF NATURAL HABITATS (Main Reservoir R1) AND LABORATORY STUDIES OF *Indomysis annandalei*

Sr.No.	Particulars	Concerned details Laboratory studies (10 days duration)	Habitat studies (2 years)
1	Water temp.		
	a) Range	21.0-27.0	23.0-32.0
	b) Average	24.26	26.46
2	Salinities (ppt)		
	a) Range	15-60	4.0-51.0
	b) Average	35	30.61
3	PH		
	a) Range	7.0-9.0	7.30-8.36
	b) Average	8	7.84
4	DO2 (ppm)		
	a) Range	-	2.10-4.90
	b) Average	-	3.88
5	Feeding conditions	Rice bran, *Dunaliella*, rotifers, *Artemia* nauplii & Cladocerans	Diatoms, ciliates, flagellats, rotifers, larvae of invertibrate, organic matter & detritus etc.

* Occurance of Indomysis in natural habitat upto primary stage condenser (Rs.) with salinity around 114 ppt (Beaume Degree: 10° Be')

Table 5 : NORMS FOR CONDUCTING PLASTIC POOL COMBINED MASS-CULTURE STUDIES ON *Indomysis annandalei* AND *Artemia salina* (SFB – strain)

GENERAL FEATURES

1. A suitable salinity medium around 40-45 ppt. Was selected commonly for both *Artemia* and *Indomysis* annandalei.

2. This salinity favours ovoviviparity in case of Artemia there by providing nauplii for foraging of *Indomysis annandalei.*

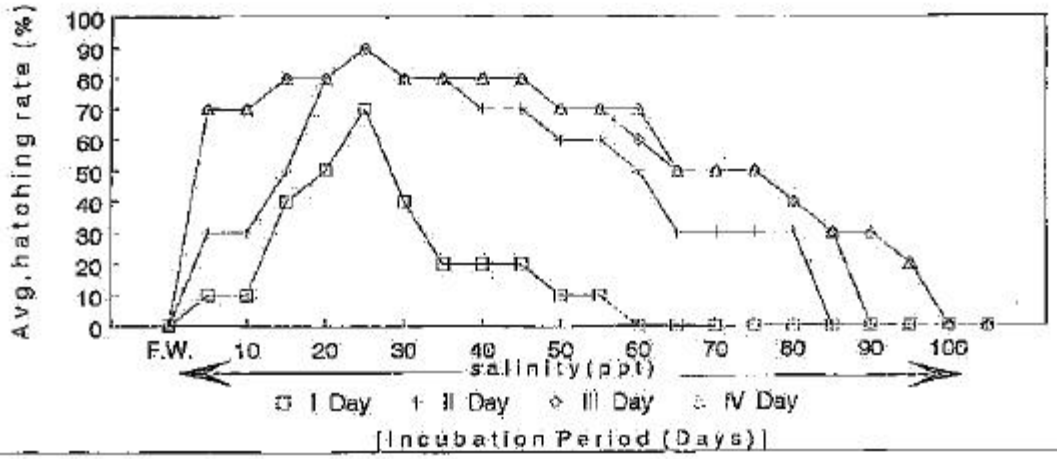
Sr. No.	Particulars	Quantification
1	Dimension of plastic pool (mtrs)	0.9 x 0.6
2	Total volume of culture medium (lit.)	286
3	Location	Garden place of Taraporevala aquarium,Mumbai
4	Salinity of water medium (ppt)	40-45
5	PH of water medium	8.0-8.5
6	Starting date of phase fertilization using DOCG solution at 4 ppm soluble rate (solubility-26%)	15-4-94
7	Gross quantity of DOCG required (gms)	4.4
8	Date of seeding of ***Indomysis & Artemia***	17-4-1994
9	Number of specimens per litter of plastic pool water	a) pair of mature male and female *Artemia* b) pair of mature male and female *Indomysis*
10	Date of rice bran input and quantity required (gms) at 4 ppm soluble rate (solubility 24 %)	17-4-1994 4.76
11	Frequency of phase fertilization (DOCG)	Every 7th day
12	Frequency of rice bran input	Every 3rd day
13	Supplementary feed given on every 3rd day	Rotifers, Dunallella, live or frozen Cladocerans
14	Temperature recording	Every day at fixed time
15	Aeration arrangement	Mild aeration given
16	Biomass testing	On 15th and 30th day
17	Method for biomass testing	a) stir the plastic pool water, allow the water to settle, then take 10lts of plastic pool water for filtering out the or ganisms. Add filtrate water back to plastic pool. Live material was taken in a beaker containing little quantity of water. b) Wet weight of biomass was taken on electric balance.

Table 6 :RESULTS OF PLASTIC POOL EXPERIMENTS IN RESPECT OF *Indomysis annandalei* AND *Artemia salina* (SFB – strain)

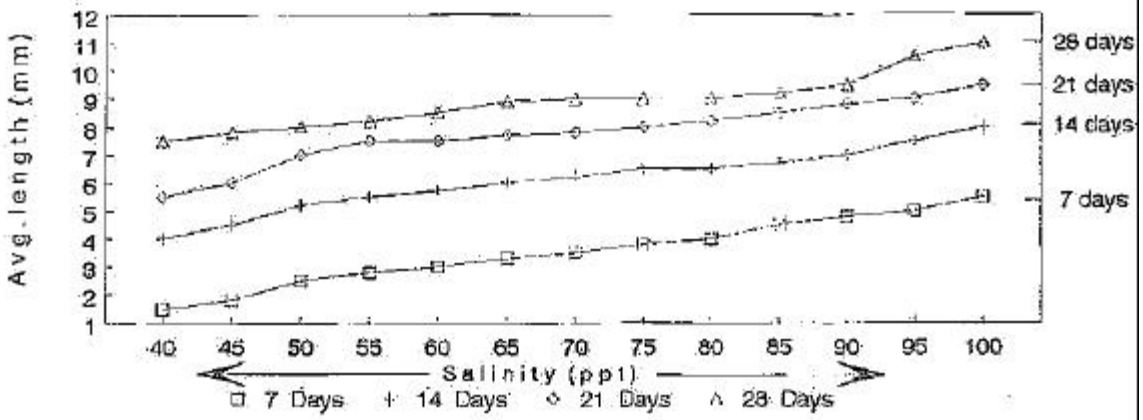
Sr. No.	Particulars	Respective results
1	Duration of experiments in days	30
2	Water temp. range during experiment with avg. temp. (°c) shown in bracket	26.0-27.5 -26.8
3	Initial biomass perticulars	
	a) Initial total wet weight of biomass of *Indomysis* and *Artemia*, mgs/ 10L of plastic pool water	40
	b) Initial size range of *Indomysis* (males and females) (mm) and Initial size range of *Artemia* (males & females) (mm)	40-50 7.0-7.5
4	Biomass perticulars on 15th day	
	a) Total wet weight of biomass of *Indomysis* & *Artemia*, mgs/10L of plastic pool water.	*52*
	Indomysis biomass+ *Artemia* biomass (mgs/10L)	28.9 + 23.1
	b) Size range of *Indomysis* (mm)	2.5-6.0
	c) Size range of *Artemia* (mm)	0.5-10.0
5	Biomass perticulars on 30th day	
	a) Total wet weight of biomass of *Indomysis* and *Artemia*, mgs/10L of plastic pool water.	73
	Indomysis biomass + *Artemia* biomass mgs/10L	33.7 + 39.3
	b) Size range of *Indomysis* (mm)	2.0-7.0
	c) Size range of *Artemia* (mm)	0.5-11.0
6	Assessed gain in biomass g/m3	
	a) At the end of 15th day	30%
	b) At the end of 30th day	82.50%

Graph No. 1.

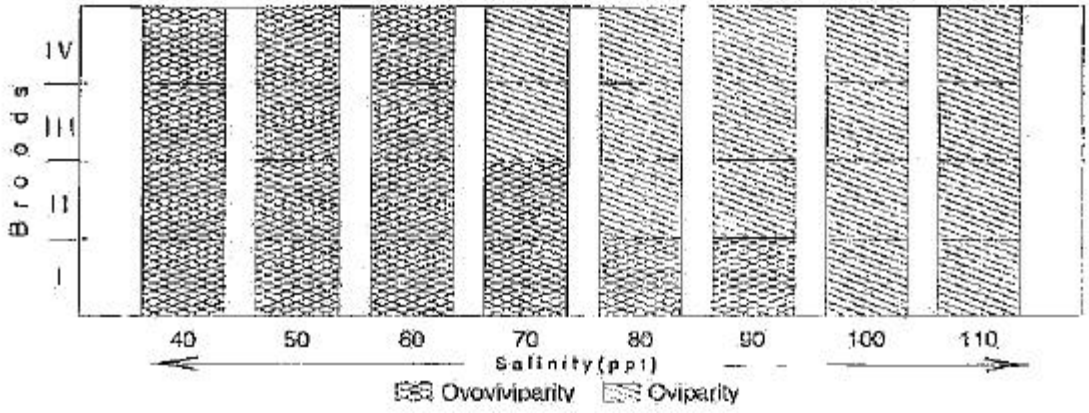
Hatching of Artemia Cysts with effect of light under different salinities.



Graph No. 2. **Growth of Artemia in different salinities**



Graph No. 3. **Reproduction in Artemia Ovoviviparity / Oviparity**



explanatory. On the basis of laboratory studies it was possible to conduct the culture trials in the plastic pool . At the end of 15 and 30 days of culture the biomass increment of both species was observed .

DISCUSSION AND CONCLUSIONS

Hydrobiological studies of *Indomysis annandalei* showed that it is euryhaline and eurythermal and hence very hardy species for considering culture along with *Artemia salina* having similar characteristics.

The overall studies indicated that both *Artemia salina* and *Indomysis annandalei* can be suitably cultured in the plastic pools and nursery ponds using optimal culture conditions.

ACKNOWLEDGEMENTS

The author is very grateful to Dr. G.A.Shirgur, the Guide and the retired Research Officer (Prof and Head) of Taraporewala Marine Biological Research Station, Mumbai 400002 , for his thorough guidance in the subject.

REFERENCES

Deshmukh , S.V. and G.A Shirgur , 1997, On ambient ecology and fisheries potentials of salt-pan reservoirs around Bombay . Presented for Imternational seminar School of Studies in Zoology, Vikram University,Ujjain(M.P.).

Deshmukh , S.V. 1989, Studies on ecology of salt-pans at Mulund , Bombay. M.Phil (Zoology) Dissertation, University of Bombay :- 1-88.

Deshmukh , S.V. 1995, On Bionomics and culture prospects of opossum shrimps i) *Indomysis annandalei* W.M.Tattersall and ii) *Mesopodopsis orientalis* (W.M.Tattersall) from Bombay coastal waters. Ph.D. Thesis submitted to Konkan Krishi Vidyapeeth, Dapoli : 527 pp.

Deshmukh , S.V. and G.A. Shirgur , 1996 a, On assessment of optimal hydrobiological parameters and feeding conditions for culturing euryhaline mysid ,*Indomysis annandalei* W.M.Tattersall , presented at the National Seminar on recent advances in Biological Oceanography , NIO , Goa .

Deshmukh , S.V. and G.A. Shirgur , 1996 b, On assessment of intra and extra marsupial instars covering the entire life cycle of *Indomysis annandalei* W.M.Tattersall , Fourth Indian fisheries forum , Cochin India , organised by Asian Fisheries Society , Indian Branch Mangalore.

Shirgur , G.A. 1991 Aquacultural activities in the coastal regions of Maharashtra State . J. Indian Society Coastal Agric. Res. 9(1&2) : 111-116 .

Shirgur , G.A. and S.V. Deshmukh, 1995, On assessment of mysid fishery potential co-related to biomass estimation around Bombay coastal waters . Seminar on Recent Advances in Ocean Engineering and Underwater Technology at CIFE,Versova, Mumbai .

Shirgur, G.A. and S.V. Deshmukh, 1996, On optimal aqua environmental conditions for culturing *Mesopodopsis orientalis* (W.M.Tattersall), a mysid from inshore waters around Mumbai . National seminar on recent advances in Biological Oceanography , NIO, Goa .

Shirgur , G.A., S.V. Deshmukh, S.N. Gaonkar 1997 Synoptic account of binomics, culture prospects and fishery of the mysids from the inshore waters around Mumbai. Bioresearch journal vol (1) :3.

Tattersall,W.M., 1914. Further records of Indian brackish water Mysidae with description of a new genus and species. Rec. Ind Mus .X : 75-80.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 132-134

PARASITIC COPEPODS IN *SACCOSTREA CUCULLATA* (BORN, 1778), A MANGROVE ASSOCIATED OYSTER AT PITCHAVARAM BACKWATERS, SOUTHEAST COAST OF INDIA

B. A. Venmathi Maran* and K. Ayyakkannu
Center of Advanced Study in Marine Biology,
Annamalai University, Parangipettai - 608 502 Tamil Nadu, India

ABSTRACT : Parasitic copepods have been identified from the edible oyster *Saccostrea cucullata* (Born, 1778) (Ostreidae: Bivalvia). These oysters are always found around the mangrove-associated areas and they are consumed by the local coastal populace around Pitchavaram backwaters. It is found that these oysters are affected by parasitic copepods, each host invariably contains 0-6 in number. They were identified as *Ostrincola portonoviensis* (Reddiah) (Myicolidae). These myicolid copepods are also reported in clams of Parangipettai coastal waters. The rate of infestation was not very high in oysters. Through microbial assays, the association of pathogenic bacteria *Vibrio* spp. with the copepods has also been studied. The association of parasitic copepods and pathogenic bacteria can cause further stress and irritation to the oysters.

Key words: *copepods, mangrove, oyster, association, pathogen and stress*

INTRODUCTION

It is well known among marine biologists that copepods are the most common and most abundant metazoans in the sea (Castro and Huber, 1997). Humes (1985) was the first to provide information on symbiotic copepods in invertebrates. Many species of parasitic copepods have been identified from the marine invertebrates. Parasitic copepods of fishes are known to cause problems in aquaculture (Ho, 2001). With the rapid growth of aquacultural industry around the world in the last few decades, the problem of parasitic copepods in this enterprise has been compounding.

In India, Reddiah (1960) identified *Conchyliurus bombasticus* and *C. fragilis* in the mantle cavity of *Meretrix meretrix* and *C. maximus* in *Sanguinolaria diphos. Ostrincola portonoviensis* was identified from the Indian molluscs (Reddiah 1961, 1962). In 1966, Reddiah isolated *Anthessius mytilicolus* from *Mytilus viridis*. Reddiah and Mammen (1966) found out the association of *C. bombasticus* and *C. fragilis* in *Merertix casta*. Venmathimaran (1996) found out the presence of parasitic copepods in *Katelysia opima, M. meretrix, M. casta* and *Anadara rhombea* from Parangipettai coastal waters, southeast coast of India and from the oyster *Crassostrea madrasensis* (Venmathimaran, 1998). The copepod *Mytilicola intestinalis* (Steuer) from intestine of the copepod was the major parasite observed in *Perna viridis* from different places by investigators such as Hockley (1951), Paul (1983) and Robledo *et al*. (1994). *Mytilicola* spp. have greatly modified bodies and live as endoparasites in the intestine. Most of the copepods associated with molluscs are cyclopoids; only a few members of the Caligoida, Harpacticoida, Lernaeioda and Monstrilloida are parasitic on molluscs and Calanoida and Notodelphyoida have not been reported from this host class (Lauckner, 1983). Ho and Kim (1992) identified a new genus of poecilostome copepod parasites in a commercial clam from Malaysia. In China, Ho and Zheng (1994) identified *Ostrincola koe* in the cultured hard clam *M. meretrix*. Ho and Yoosukh (1994) identified a myicolid copepod *O. humesi* as a parasite in rock oysters cultured in the Gulf of Thailand.

Microbial analysis was carried out to assess the presence of bacterial pathogens associated with the parasites, which may cause stress and secondary infection in the host. Kaneko *et al.* (1975) and Ho (1996) have reported the role of potential pathogens in the mass mortality of clams in various parts of the world. Robledo *et al*. (1994) observed the histopathology in the tissues of infected bivalves. In view of the above statements, the present research work was focussed to evaluate the association of parasites with the bivalve and its effects on the host.

STUDY AREA

The present study was carried out at Pitchavaram backwaters, southeast coast of India. The oysters are always found in and around the mangrove areas and are called as rock oysters. Pitchavaram mangrove forest is located about 200 km south of Chennai (Madras) city in the southeast coast of India. This mangrove is actually sandwiched between two prominent estuaries, the Vellar estuary in the north and Coleroon estuary in the south. The Vellar - Coleroon estuarine complex forms the Killai backwater and Pitchavaram mangroves. Pitchavaram mangrove (Lat. 11° 21" N; Long. 79° 50" E) is present in the higher land of Vellar-Coleroon estuarine complex. The mangrove extends to an area of 1,100 hectares, representing a heterogeneous mixture of mangrove elements. The

source of freshwater to this mangrove is from both the estuaries and that of seawater is Bay of Bengal.

Material and Methods

The oysters *Saccostrea cucullata* (Ostreidae: Bivalvia) have been collected from the Pitchavaram backwaters, southeast coast of India. The collected bivalves were brought to the laboratory, and washed and scrubbed thoroughly to remove all epizoons and epiphytes. The cleared oysters were opened in petridishes and washed in 1000 or 2000 ml beaker half filled with filtered sea water. The water from the beaker was then poured through a plankton net. The collected "soup" was observed under a dissection microscope. The copepods present in the soup were pipetted out carefully and preserved in 70% alcohol. Every 48 hours, the alcohol was changed. The preserved copepods were put into a watch glass filled with lactic acid for 2 - 3 hours, until they became semi-transparent (Humes and Gooding, 1964). The cleared copepods were observed through a binocular microscope and sketches prepared through a camera lucida for identification at the genus and species level of the parasitic copepod.

Microbial analysis was carried out to identify the pathogens associated with the copepods. The sterile sea water containing homogenised copepods was enriched using alkaline peptone water. A loopful was then streaked on to TCBS Agar (Hi-media, Mumbai) plates. For isolation, the colonies were repeatedly streaked onto nutrient agar medium and the pure cultures were maintained in nutrient agar.

RESULTS AND DISCUSSION

Two hundred specimens of *S. cucullata* were collected and examined for the presence of parasitic copepods from mantle cavity and gills region. The collected copepods were taken in a petri dish and observed under the microscope and the measurements were also made. From each bivalve around 0-6 number of parasitic copepods were recovered from the mantle cavity and also from the gill region. The adult size of the parasitic copepod ranged from 1.0 to 1.2 mm. The results showed that most of the bivalves were infested by copepods, the percentage being 79. The collected parasitic copepods were identified as *Ostrincola portonoviensis* (Reddiah) (Fig.1). It revealed that there is no barrier in the parasitic attack related with size groups Among the copepod crustaceans, numerous species have been reported as parasites or as commensals of molluscs including several commercially important marine bivalve species. Currently more than 430 species of copepods are known to occur as symbionts in molluscs with bivalves as the most preferred hosts enlisting more than half of the reported copepod symbionts. A great majority of these bivalves harbouring the copepods are tracers inside the mantle cavity of their hosts, often reported as "associates" of bivalves (Gooding, 1957;

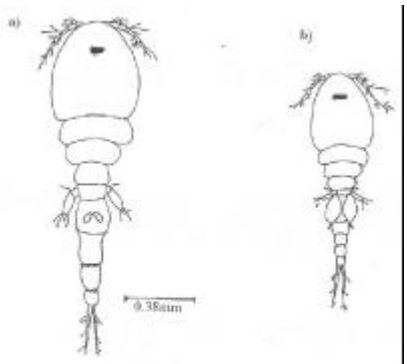


Fig. 1 : Ostrincola portoponoviensis (Reddiah)
a) Adult female (Dorsal view)
b) Adult male (Dorsal view)

Reddiah, 1960; Ho and Perkins, 1985). The symbiotic copepods found in the mantle cavities of bivalves are mostly members of the order Poecilostomatoida. So far eight of the 47 families of poecilostome copepods are known to utilize marine bivalves as hosts. Among those, the family Myicolidae is the one showing the highest host specificity to the bivalve molluscs (Ho, 1992). Among most of the copepods reported from molluscs, host specificity does not seem to be very strict, but further study is required to ascertain this.

The myicolid *O. portonoviensis* has already been identified in *M. meretrix, M. casta and Sanguinolaria diphos* (Reddiah, 1960), *K. opima* and *A. rhombea* (Venmathimaran, 1996). This has also been recorded in *Mesoderma trigona* from Kerala (Pillai, 1963). The copepod *Ostrincola breveseti* identified in *Saccostrea cucullata* mangrove associated oyster off Penang, Malaysia (Ho and Kim, 1990) and *O. humesi* in *S. cucullata* from Gulf of Thailand (Ho and Yoosukh, 1994). All the three species are found in the bivalves occurring in southeast Asia. Many species of bivalves are yet to be examined for their copepod parasites. These myicolid copepods are recognized as a potential causative agent for clam mortality in southeast Asia (Ho, 1996).

Many parts of the world experience mass mortality of bivalves mainly due to the copepods. In several parts of Asia, particularly in Japan, Korea, China and in Taiwan farming of hard clams (*Meretrix* spp.) has been practiced and recently mass mortality of cultured hard clams have been reported (Ho, 1996) The mortality has lead to severe economic loss in these countries. Due to the loss of mucus and injuries on the gills through parasites sucking, piercing and rasping the host's natural barrier to bacterial invasion has been damaged. The clams infested by copepods were all heavily infected with pathogenic bacteria these pathogens, associated with the copepods were identified.

Through microbial analysis, the bacteria *Vibrio sp.* were identified in my study and also confirmed that the association of bacterial pathogens with the copepods. In South Korea, *Pseudomonas ichthyodermis* was

suspected to be the causative agent for the mass mortality and in Taiwan *V. parahemolyticus* was identified as the causative agent and *V. alginolyticus* another pathogenic bacteria identified from the diseased clams in Southern Jiansu of China, lead to the mass mortality (Ho, 1996). Venmathimaran (1996) found out the association of bacterial pathogen V. *parahemolyticus* from hard clams.

Kaneko *et al*., 1975 identified a member of Enterobacteriaceae and *Vibrio* sp. which were considered to be potential pathogens, for the soft-shell clam *Mya arenaria* and their moralities in several areas of Chesapeake Bay in 1970 and through 1971. The pathogenic bacteria are distributed world wide in coastal waters. According to Ho (1996) under normal situations the bacteria are not pathogenic to the clam. However, once the factor of stress is augmented through these copepods, the clams are subjected to irritation and the bacteria acts as a potential pathogenic to the clams ending up in mass mortality.

ACKNOWLEDGEMENT

We would like to thank Annamalai University authorities for providing facilities and also thank Prof. Purushothaman, CIFE, Mumbai for correcting the manuscript.

REFERENCES

Castro, P. and Huber, M.E. 1997 **Marine Biology.** W.C. Brown Publishers, Dubuque, Iowa: 450pp.

Gooding, R.U. 1957. **On some copepoda from Plymouth mainly associated with invertebrates, including three new sp.** Jour. Mar. Biol. Assn. UK. 36: 195-221.

Ho, J.S. 1992 **Phylogenetic analysis of the Myicolidae, a family of oecilostome copepods chiefly parasitic in marine bivalve molluscs.** Acta. Zool. Taiwanica, 3: 67-77.

Ho, J.S., 1996 **Myicolid parasitic copepods and mass mortality of cultured hard clams (*Meretrix*).** Phuket Mar. Bio. Cent. Specl. Publ. No. 16: 61-70

Ho, J.S. 2001 **Why do symbiotic copepods matter?** Hydrobiologia 453/454: 1-7.

Ho, J.S. and Kim, I.H. 1990 ***Ostrincola breviseti* nov. sp. A copepod parasite of an oyster from Penang, Malaysia.** Beaufortia, 41: 91-95.

Ho, J.S. and Kim, I.H. 1992 **A new genus of poecilostome copepod of the family Myicolidae parasitic in a commercial clam from Malaysia.** Jour. Of Natural History, 26: 303-309.

Ho, J.S. and Perkins, P.S. 1985 **Symbionts of Marine Copepoda-An overview.** Bulletin of Marine Science. Vol. 37(2) 586-598.

Ho, J.S. and Yoosukh, W. 1994 ***Ostrincola humesi* sp. nov., a myicolid copepod (Poecilostomatoida) parasitic in rock oysters cultured in the Gulf of Thailand.** Hydrobiologia, 288: 151-155.

Ho, J.S. and Zheng, G.X. 1994 ***Ostrincola koe* (Myicolidae) and mass mortality in cultured hard clam (*Meretrix*) in China.** Hydrobiologia, 284: 169-173.

Hockley, A.R. 1951 **On the biology of *Mytilicola intestinalis* Steuer,** Jour. Mar. Biol. Assn. UK. 30: 223-232.

Humes, A.G. 1985 **Cnidarians and Copepods: A success story**. Trans. am. microsc. Soc. 104: 313-320.

Humes, A.G. and Gooding, R.U. 1964 **A method for studying the external anatomy of copepods.** Crustaceana 6: 238- 240.

Kaneko, T., Colwell, R.R. and Hamons, F. 1975 **Bacteriological studies of Wicomico river soft – shell clam (*Mya arenaria*) mortalities.** Chesapeake Science. Vol. 16(1), 3-13.

Lauckner, G. 1983 **Diseases of Mollusca: Bivalvia pp.817-833. In Diseases of marine animals** (Kinney O ed.), Biologische Anstalt Helgoland, Hamburg.

Paul, J.D. 1983 **The incidence and effects of *Mytilicola intestinalis* in *Mytilus edulis* from the Rias of Galicia, Northwest of Spain.** Aquaculture, 31: 1-10.

Pillai, N.K. 1963 **Copepods associated with southIndian invertebrates.** Proc. Indian Acad. Scie. 58: 235-247.

Reddiah, K. 1960 **Copepods associated with Indian molluscs (a) Description of *Conchyliurus maximus* nov. sp..** Jour. of Zool. Survey of India. Vol.12 (2). 137-146.

Reddiah, K. 1961 **Copepods associated with Indian molluscs (b). Description of two new species from *Meretrix meretrix.*** Crustaceana Vol.2, 300-312.

Reddiah, K. 1962 **Copepods associated with Indian molluscs(c). *Ostrincola portonoviensis* n. sp. from commercial bivalves at Portonovo, South India.** Crustaceana Vol.4 (1): 1-6

Reddiah, K. 1966 **Copepods associated with Indian molluscs *Anthessius mytilicolus* from *Mytilus viridis*.** Jour. Mar. Biol. Assn. India. 8(2): 290-294.

Reddiah, K. and Mammen, M.A. 1966 **Copepods associated with Indian molluscs from *Meretrix casta*.** Jour. Mar. Biol. Assn. India 8(1): 141-145.

Robledo, J.A.F., Santaram M.M. and Figueras A.1994 **Parasite loads of rafted blue mussels (*Mytilus galloprovincialis*) in Spain with special reference to the copepod *Mytilicola intestinalis.*** Aquaculture 127: 287-302.

Venmathimaran, B. A. 1996 **Parasitic infestation in some of the commercially important marine bivalves and gastropods**. M. Phil. Thesis, Annamalai University, India, 95pp.

Venmathimaran, B. A. 1998 **Parasitic copepods associated with the oyster Crassostrea madrasensis in Parangipettai coastal waters, southeast coast of India.** Abstract presented at "Integrated coastal Zone Management" National symposium at Calcutta, West Bengal.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 135-141

QUALITATIVE STUDY OF FIN FISH AND SHELL FISH FAUNA OF THANE CREEK AND ULHAS RIVER ESTUARY

Sudesh D. Rathod, N. N. Patil, Goldin Quadros and R. P. Athalye
Zoology Department, B. N. Bandodkar College of Science, Thane (W) 400 601.

ABSTRACT : An attempt has been made to obtain the comparative finfish & Shellfish fauna qualitatively from the Thane creek and Ulhas river estuary during Nov. 2001 to Oct. 2002 dividing each of these two coastal water bodies into three zones (Riverine zone I, Middle zone II, Seaward zone III). Although the total no. of species found in the Thane creek was high (67 spp.) as compared to Ulhas river estuary (58 spp.), the upper zones (I & II) of the former and zone I of the later contain very low diversity of fish fauna. The salinity trend of zone –I of Thane Creek is fairly nearer to zone –II of Ulhas River Estuary but there is considerable difference in the fishery composition. It seems that various human activities like industrial effluents, domestic waste disposal, reclamation, sand dredging and eradication of mangrove flora have deteriorated these dynamic habitats causing decline in their fin fish & shell fish fauna during last two decades. It has been observed that the mudskippers, prawns have been completely eradicated from the entire stretch of the Thane creek due to heavy industrial & domestic waste disposal although there is fairly good mangrove vegetation along its west bank. Incase of Ulhas river estuary, the sand dredging, occurring on its southern bank has forced the bottom dwellers like mudskippers, prawns & crabs to shift towards northern bank in zone II and III.

A fairly good variety of fishery at the mouth of Thane creek and Ulhas river estuary indicated that timely implementation of mitigation measures may revive the fishery of the two ecosystems.

Keywords: Qualitative Fish Fauna, Thane creek, Ulhas river estuary, anthropogenic activities.

INTRODUCTION

The coastal inward waters play important role as refuge to the fishes from marine as well as adjacent water bodies. Various fish and non-fish spp. visiting the inward waters like estuaries, lagoons, creeks and marshes in addition to the endemic species increase the diversity of their fauna. These habitats holding halophyte vegetation like mangroves and organic rich mudflats prove to be ideal for their feeding and breeding activities. The environments like creeks and estuaries along the coastal regions exhibit seasonal change in the species composition as different fin fish and shell fish species are attracted during the seasons to their feeding or breeding niche. Therefore these habitats overall hold rich fish faunal diversity.

The two dynamic environments, the Thane creek and Ulhas river estuary situated in the vicinity of the Mumbai-Thane complex, are the major water bodies supporting the local fisher folk for their livelihood from many decades. They are experiencing declined productivity and a miserable condition at present as these two aquatic habitats are heavily burdened by the industrial and urban activities, since long. Comparison of data with the earlier studies reveal that several species of prawns, crabs, bivalves, gastropods and fin fish which were caught in the upper reaches of these two environments (Mutsaddi, 1964, Qamrul, 1980; Tandel, 1984; Pejavar, 1984), are now a days vanished completely from the areas.

The Thane creek (Lat. 19°.00 to 19°. 15 N; Long. 72°. 55 to 73°. 55) situated eastwards of Thane City is 26 km long opening at its southwest approach to Mumbai Harbour bay and is connected at its northern end to the Ulhas River Estuary by a narrow connection. The creek has basin about 2.5 m at high tide traversed with rocky floor intermittently. The slow tidal current encourage formation of mudflats. Mangroves are densely populated on the west bank of the creek. The creek receives treated and untreated domestic wastes and effluents from industries like chemical, petrochemical, fertilizers etc. situated throughout the Belapur belt on east bank (Athalye, 1988; Goldin, 2001).

Ulhas river (Lat. 18°.45' to 19° .00' N ; Long. 72° . 45' to 73°. 20' E).being very long and having big catchment area as it confluents with a number of tributaries (Qamrul, 1980); covering almost the Thane district measuring total of 122 km. in length, with an influence of the tidal water to about 40 km. upstream upto Dombivali - Kalyan stations forming an estuary ; meanders through Mumbra, Thane city, Kasheli, Kavani (Diva), Gaimukh, Ghodbunder and Bhayander before it joins the Arabian Sea at Vasai creek. The river annually collects about 2433.82 million cubic metres of water from Karjat, Kalyan and Murbad Talukas. It holds rich and diverse fish fauna since it not only carries the brackish waters in the lower reaches but also the fresh water in the upper reaches.

The rivers appear as the major sources of sediment for the beach deposits and sand on the Indian coast (Chandramohan *et. al.,* 2001). The Ulhas river estuary is exploited since long for its sand resources along with fisheries.

The estuary is influenced considerably by industrial effluents from M.I.D.C., Bhiwandi (Qamrul, 1980) and domestic waste regularly added from the adjacent areas. Thus due to the decline in fisheries most of the fisher folk have turned down to sand extraction business being easily adoptable as they already have boats as a requirement for the sand extraction. However, the sand dredging affects the floor of channel of the estuary and disturbs the sedentary or bottom dwelling organisms. On the top of that the mangrove vegetation has been totally removed from the sand landing stations.

In the present paper aspects like important stress factors, fishing nets and qualitative fishery are recorded to show the zone wise extent of pollution.

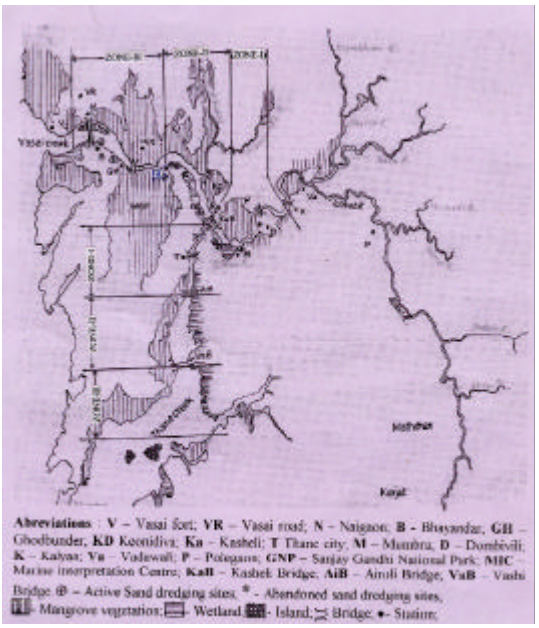


Fig. 1 : Map showing Ulhas river estuary and Thane Creek

MATERIALS AND METHODS

For the study three zones were imagined in each of the two environments the Thane Creek and Ulhas River Estuary as Zone I (Riverine end), Zone II (Middle region), Zone III (Seaward end) (Fig. 1).

Water and Sediment study

Monthly water and sediment samples were studied from four stations from each zone during period of Nov. 2001 to Oct. 2002 using Standard Methods (APHA, AWWA, WPCF, 1981) to assess important parameters and zone wise averages were calculated.

FISH FAUNA STUDY

Zone wise samples of the fishes were collected directly from the net, from Nov. 2001 to Oct. 2002 and carried to the laboratory in icebox for further investigation. Identification was performed using the keys given in 'Fishes of India' (Day, 1889). Care was taken to ensure the collection from all possible type of the gears used along the estuary by the local fishermen viz. barrier net (Vana), hand net (Yeri), bag net (Bokshi & Dol), drift net (Disco jali) and hand picking in predominant fishing areas. The fishing intensity in most of the parts of these ecosystems fluctuates seasonally and even daily on an account of unattractive yield. Due to this reason the quantitative data was approximate and hence not considered for this presentation.

At each station the data on different types of fishing net used for different methods of fishing, polluting sources and sand dredging etc. was recorded through observation and interview with the fishermen.

Though the study was done at each station for convenience data has been consolidated zone wise.

Table 1 : Water amd sediment parameters of Ulhas river estuary and Thane creek

	Ulhas River Estuary										Thane Creek									
	Zone 1			Zone 2			Zone 3			Total	Zone 1			Zone 2			Zone 3			Total
Water Parameters ↓	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Avg.
Water Temperature °C	21.25	33.13	28.03	21	31.5	28.19	22.75	33.25	28.35	28.18	21.5	33.75	28.75	22.5	33.45	29.37	26.38	34.88	30.28	29.71
Suspended. solids gm/l	0.16	0.96	0.555	0.15	2.375	1.249	0.205	6.15	3.865	1.89	0.43	3.385	1.911	0.6	13.5	2.414	0.535	3.17	1.551	1.958
Salinity ppt.	0.389	18.51	8.93	0.73	30.28	15.34	1.035	34.92	22.93	15.73	0.803	32.48	19.67	2.85	34.6	23.93	6.825	37.14	27.55	23.73
Dissolved oxygen mg/l	0.75	3.825	2.29	1.425	3.35	2.55	1.983	4.8	3.62	2.82	0.375	2.925	2.015	0.7	8.2	1.998	0.925	4	2.11	2.041
B.O.D. mg/l	5.375	24.43	16.25	2.225	13.48	8.341	0.55	8.45	5.083	9.892	9.75	42.75	24.67	2.125	24.13	13.04	1.9	20.05	10.79	16.17
PO_4-P mg/l	0.03	0.094	0.06	0.03	0.092	0.055	0.023	0.061	0.047	0.054	0.061	0.162	0.132	0.033	0.096	0.074	0.027	0.094	0.069	0.092
NO_3-N mg/l	0.292	2.521	1.491	0.905	3.533	1.89	0.189	2.275	1.616	1.666	0.471	1.458	1.022	0.145	2.099	0.853	0.145	1.383	0.983	0.953
SiO_3-Si mg/l	12.66	77.43	33.67	11.1	72.6	34.07	11.72	61.09	29.07	32.27	12.25	43.02	26.66	8.498	35.15	22.34	5.734	38.98	15.88	21.63
Sediment parameters ↓																				
Organic Carbon %	1.906	4.183	3.102	2.045	3.878	2.926	1.58	3.595	2.611	2.88	2.727	4.512	3.81	2.688	4.568	3.554	2.185	4.003	3.222	3.529
Sand %	3.7	15	8.406	8.528	17.5	12.65	14.13	21.91	18.53	13.19	0.895	10	5.18	2.838	10	6.067	4.975	12.5	8.979	6.742
Silt %	48.75	74.1	59.69	30	55.52	41.52	30	69.68	48.88	49.36	62.5	82.23	76.34	63.36	81.07	69.88	60.57	75	65.53	70.59
Clay %	16.34	40	31.9	33.74	52.5	45.84	10.22	52.71	34.6	37.45	15	27.5	18.48	15.86	32.6	24.05	13.75	32.11	25.81	22.77

Table 2 : Types of disturbances observed in Ulhas river estuary and Thane creek.

No	Sand dredging activity	Ulhas River estuary			Thane creek		
	A	Z-I	Z-II	Z-III	Z-I	Z-II	Z-III
1.	No. of boats engaged in sand excavation	11	83	8	-	-	-
2.	Sand landing stations	2	7	2	-	-	-
	Total A	13	90	10	-	-	-
No.	B Other anthropogenic activities						
1.	Major sewage & industrial effluent outlets	4	3	5	12	9	1
2.	Distruction of mangrove sites through	3	4	3	2	2	1
	solid waste dumping and reclamations.	6	5	4	4	4	4
	Total B	13	12	12	18	15	6

Table 3 : Types of Fishing activities in Ulhas river estuary and Thane creek.

No	FISHING TYPE	Ulhas River estuary			Thane creek		
		Z-I	Z-II	Z-III	Z-I	Z-II	Z-III
1.	Mudskipper fishing	2	2	24	-	-	-
2.	Bag net (Dol/Bokshi)	-	20	71	-	-	11
3.	Barrier net (Vana)	2	15	12	1	4	35
4.	Driftnet (Disco jail)	-	2	-	1	45	250
5.	Dragnet (Yeri)	1	-	-	-	-	10 (150)*
	Total	5	38	107	2	49	306

* The gear was used extensively for prawn fishing from March to May and August to October, when water temperature was high.

RESULT AND DISCUSSION

The important water parameters (Table 1) clearly indicate higher level of pollution in Thane creek as compared to Ulhas river estuary.

Thane creek had hypoxic dissolved oxygen (avg < 2.5 mg / l) through out the creek whereas Ulhas river estuary had hypoxia mainly in zone I. Both ecosystems have very high suspended solids and high nutrients, especially SiO_3-Si. Sediment parameters (Table 1) also indicate high organic carbon contents in the sediment of Ulhas river estuary and Thane creek (significantly higher in the later). In general significant pollution is observed in zone I of Ulhas river estuary and the entire stretch of Thane creek.

Table 2 shows different factors causing of pollution in Ulhas river estuary and Thane creek which include mainly sewage and industrial outlets, reclamation and destruction of mangroves through various activities like solid waste dumping or sand landing etc. In Thane creek zone I and II have more pollution causing factors than zone III whereas in Ulhas river estuary they are almost the same in all the zones but they prove more damaging in zone I as it is narrower with lesser water mass. Ulhas river estuary has an additional stress in form of sand excavation activity which is high especially in zone II. The sand extraction and landing activities are concentrated on the south bank of the river (due to easy access to the city and the road transport). Previously mechanised dredgers were used which have been banned since 1995. Sand excavation however has kept the riverbed deep and has helped in retaining flushing characteristic of the estuary. Due to this siltation in zone II and III is less as compare to zone I (Table 1). It has however increased the suspended solids and also the silicates in Ulhas river estuary.

The above stress conditions have affected fishery and the effects are felt by the native fisherfolks. They avoid fishing in the area where fish is not available. Table 3 shows fishing gears / nets operated in each zone. The fishing activity in both ecosystems is maximum near the mouth, intermediate in the middle zone and very poor in the riverine zone I. This infact is logical even in an unpolluted creek or estuary. However the present number

Table 4 : Zone wise occurrence of the Fin fish fauna in the Ulhas river estuary Thane Creek

Table 5 : Zone wise occurrence of shell fish in Ulhas river estuary and Thane creek.

Shell Fish Fauna			Ulhas river estuary			Thane creek		
No	SPECIES	FAMILY	Z-I	Z-II	Z-III	Z-I	Z-II	Z-III
1	*Parapenaeopsis sculptilis*	Penaeidae	-	+++	++	-	-	-
2	*Peneaus sp.*		-	+++	+++	-	+	+
3	*Metapenaeus monoceros*		-	+	++	-	-	++
4	*Metapeneaus sp*		-	-	++	-	-	-
5	*Penaeus indicus*		-	-	++	-	-	+
6	*Trachypenaeus sp.*		-	-	+	-	-	-
7	*Macrobrachium rosenbergii.*	Palaemonidae	_	++	+	-	-	-
8	*Acetus sp.*	Sergestidae	-	+	+	-	-	+
9	*Alpheus sp.*	-	-	-	+	+	-	++
10	*Cardium sp.*	-	-	-	++	-	-	++
11	*Paphia sp.*	-	-	++	+	-	-	-
12	*Katelysia*	-	-	-	++	-	-	-
13	*Portunus sanguinolentus*	-	-	-	++	-	-	+
14	*Charybdis sp.*	-	-	-	++	-	-	-
15	*Scylla serrata.*	-	++	++++	++	-	-	+
16	*Octopus sp*	-	-	-	-	-	-	+
17	*Loligo sp..*	-	-	-	-	-	-	+
	Total No of spp.		3	9	15	1	6	12

Table 6 : Fish composition in Ulhas river estuary and Thane creek.

No	FISHING	Z-I	Z-II	Z-III	Total	Z-I	Z-II	Z-III	Total
1.	Fin fishery	10	34	41	43	5	11	55	55
2.	Shell fishery	3	9	15	15	1	6	12	12
	Total fishery	13	43	56	58	6	17	67	67
	Percentage	22	74	97	100	9	25	100	100

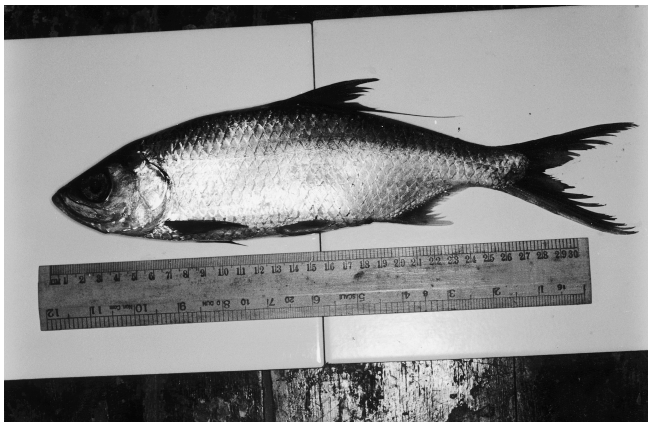
of the fishing nets is at least 1/8 th of the nets operated 15 year ago. The fishery yield of these ecosystems, is drastically reduced to such an extent that the fishermen are taking up other jobs for their living. Gokhale & Athalye (1995) have reported 67 % decrease in the fishery in zone I of Thane creek. In Ulhas river estuary very few nets are operated on the south bank due to sand excavation and sand landing activities concentrated on this bank.

Tables 4 & 5 show the types of fin and shell fishery respectively, obtained in each zone of Thane creek and Ulhas river estuary. In general there is more shell fishery variety in Ulhas river estuary as compared to Thane creek whereas types of fin fishery are more in Thane creek. However it is important to note that in Thane creek higher variety of fin & shell fishery types is obtained in the seaward region which is much broader than the mouth of Ulhas river estuary. In the fishery types of Ulhas river estuary, strictly marine types of fish are absent, hence the diversity of Ulhas river estuary is slightly lower than Thane creek. However in Ulhas river estuary 74 % of the fishery types penetrate upto zone II and 22 % upto zone I whereas in Thane creek only 25 % enter in zone II and 9 % in zone I (Table 6). Infact zone I of Thane creek has physicochemical characteristics similar to zone II of Ulhas river estuary with which it is connected. However, it harbours very poor fishery as compared to zone II of Ulhas river estuary. Thus the qualitative fishery has got significantly affected by the pollution status of different zones of Thane creek and Ulhas river estuary. Apart from the above, following observations are noteworthy.

1. The *Trypauchen vagina, Katelysia spp., Paphia spp., Meretrix spp., Cardium spp.,* mudskippers and prawns which were once abundant in Thane creek are absent presently in Zone I and Zone II. This is mainly due to (i) severe pollution and (ii) increased siltation which has made the substratum unfavourable for these species. Similar observation is also noted in zone I of Ulhas river estuary.

Infact absence of mudskipper can be used as an indicator of heavy pollution in creeks and estuaries.

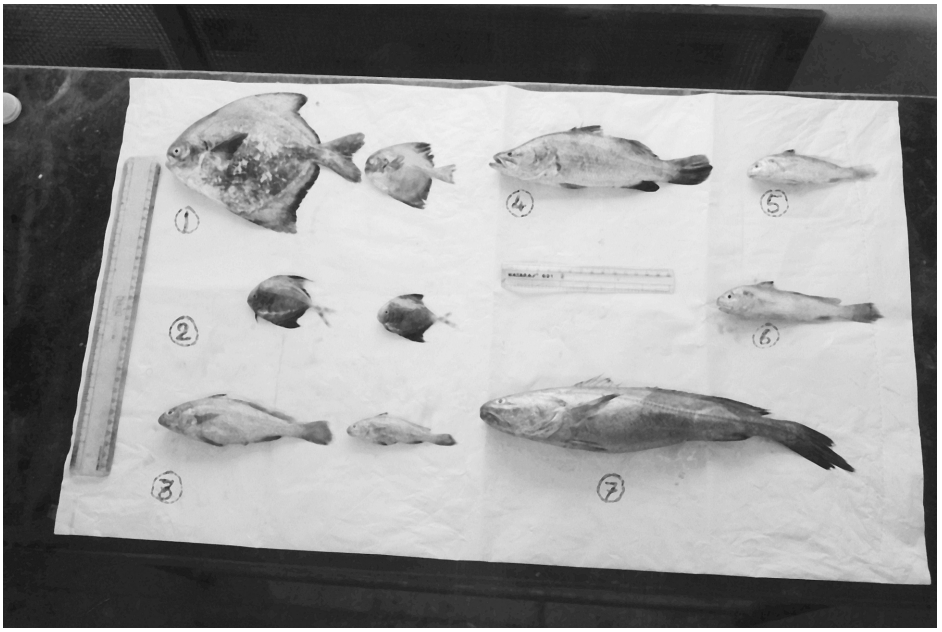
2. Zone I and II of Thane creek have very heavy pollution by plastic bags which clogg the nets and fishing becomes impossible.



Megalops spp.



(1) Mugil Spigleri
(2) Mugil Dussumieri



(1) Pampus sinensis (2) Pampus argenteus (3) Sciaena dussumieri (4) Lates calcarifer
(5) Umbrina spp. (6) Sciaena spp. (7) Otolithus brunneus



Gobius spp.



Macrobrachium rosenbergii

3. A favourable observation to note is significantly good variety of fishery at the mouth of Thane creek. This fishery however is not able to penetrate in the creek. This indicates that if the pollution in the creek is checked, we will be able to revive the fishery of the creek. The same applies to zone I of Ulhas river estuary.

CONCLUSION

The observations in qualitative fishery of Thane creek and Ulhas river estuary have shown the areas and the extent of deterioration in the two ecosystems but at the same time they indicate the possibility of reveiving the systems if mitigation measures are implemented in time.

ACKNOWLEDGEMENT

The authors wish to acknowledge with thanks, the financial support extended by Mumbai Metropolitan Region - Environment Improvement Society. C/o MMRDA, Mumbai.

REFERENCES

APHA, AWWA, WPCF, 1981 International standard methods for the examination of water and waste water. 15th Edition Washington D.C., 874 pp.

Athalye, R.P., 1988. Status of Macrobenthos in detritus food chain of Thane creek near Thane city. Ph.D. Thesis, University of Mumbai, 197.pp.

Athalye, R.P., Vidya Mishra, Goldin Quadros, Vidya Ullal and K.S. Gokhale, 2001 Heavy metals in the abiotic components of Thane creek, Indi, Ecology, Environment and conservation 7 (3) : 105 - 111

Chandramohan, P. B.K. Jena and V. Sanil Kumar. 2001 Littoral dripp sources and sinks along the Indian coast. Current Science 81 (3) : 292 - 296

Day F. 1889. The fishes of India. William Dawson and Sons, London.

Gokhale K.S. and R.P. Athalye 1995 Study of impact of pollution on mangrove fauna of Thane creek near Thane city. Report submitted to the Ministry of Environment and Forests. New Delhi. 40 pp.

Goldin Quadros,2001 Study of intertidal fauna of Thane creek. Ph.D. Thesis. University of Mumbai. 264 pp.

Mutsaddi K.B. 1964 A study of Gobioid, *Boleopthalmus Dussumieri* (Cuv & Val), Ph.D. Thesis, University Of Bombay.

Pejaver, M.K. 1984 Biology of some crustaceans from the creek near Thane city. M.Sc. Thesis University of Bombay.

Qamrul Hassan, 1980 Studies on fishes and fisheries of the Ulhas river, District Thane. Journal of Univ. of Bombay. 85 : XLIX , 25 – 38.

Tandel S.S. 1984 Biology of some fishes of Thane creek near Thane city. M.Sc. Thesis University of Bombay.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 142-147

FOOD AND FEEDING OF *METAPENAEUS MONOCEROS* (FABRICIUS)

Prasad Karnik, V. D. Deshmukh**

**Scientist- in- charge, Mumbai Research Centre of C.M.F.R.I., Mumbai

The paper is based on the Ph. D. thesis work of the first author

ABSTRACT : *Metapenaeus monoceros* is an important species of prawn, common in inshore as well as offshore waters in and around Mumbai coast. The juvenile phase is a dominant constituent in Thane and Bassein creek, more so, in the latter. The species is a prominent candidate for culture practices. It forms about 40% of the estuarine bokshi net catch in Bassein creek. The creek is rich ground for organic matter as dense mangrove swamps are located in the area. Hence, the study of the prawn – its biology in general, and food and feeding habits, in particular – becomes significant. The present paper deals with the feeding of *M. monoceros* in its juvenile phase from the Bassein creek waters as well as nearshore waters from New Ferry wharf fishing harbour, Mumbai. The juveniles from the estuary were found to be moderately fed to well fed, while, those in harbour area, were mostly poorly fed. In general, the prawn was found to be a selective carnivore and a benthic feeder, active mainly during night.

INTRODUCTION

Study of food and feeding of an animal helps us to know about various metabolic activities namely, growth, maturation, reproduction, migration, etc. (Pillay, 1952). In addition, the study also throws light on the organism's general habit, habitat and trophic position in the ecosystem (Nikolsky, 1963). Food and feeding study is necessary for proper management of a fishery. This is true especially in case of prawns in general, and *M. monoceros* in particular, as the species is gaining more and more significance in capture and culture fisheries as well. The species is an important constituent of the valuable seafood in local, domestic and international markets. Locally, in and around Mumbai waters, the prawn is a major constituent, especially, in bokshi net catches from inshore estuarine areas.

In India, food of penaeid prawns was studied by Gopalkrishnan (1952), Panikkar and Menon (1956), Kuttyamma (1974) and Thomas (1980). The food of *M. monoceros* was investigated by George (1974) from Cochin backwaters, Kuttyamma (1974) and Nandakumar and Damodaran (1998) from Cochin waters. The present attempt includes study of food and feeding of *M. monoceros* juveniles from inshore and nearshore waters.

MATERIAL AND METHODS

The samples were collected during January 1998 – December 1998. The dol net catches from New Ferry wharf (NFW) and bokshi net catches from Bassein creek represented nearshore and inshore habitats respectively.

The foreguts were dissected, cleaned and the contents were examined under binocular microscope and identified up to group /generic level. The analysis was undertaken by 'volumetric points form' method by eye estimation. Various grades were assigned to the observed guts according to the extent of fullness. The points allotted to grades were 16 points for full stomach, 12 points for 3/4 full, 8 points for 1/2 full, 4 points for 1/4 full, 2 points for gut with traces of food and 0 point for empty stomach.

Prawns with full and three quarter full stomach were grouped as 'well fed'; those with 1/2 full and 1/4 full guts were termed as 'moderately fed'; while guts with traces of food and empty stomachs were labelled as poorly fed. The preferential order of food items was determined by calculating the index of preponderance (Natarajan and Jhingran, 1961).

From the various food items, three groups of the crustaceans were identified. *Palaemon* could be identified from its stalked eyes and chromatophore spot on the eggs; hence it was grouped separately. From the shells and appendages, prawns other than *Palaemon* were identified and grouped as 'prawns'. The other crustacean parts found among the food items were termed as 'crustaceans'. The other groups were named accordingly and the food items occurring in extremely small amounts were grouped together as 'miscellaneous'. The miscellaneous group included gastropods and foraminiferan shells, fish eggs, etc. Seldom, food material could not be identified correctly and hence termed as 'unidentified'.

RESULTS AND DISCUSSION

Feeding Intensity: During the present investigations 824 specimens of *M. monoceros* caught in bokshi nets and representing inshore, estuarine habitat and 396 juveniles from dol net catches, representing nearshore habitats, were analysed. Sizes of these prawns ranged from 40mm to 100mm in total length. The month wise fullness of gut and feeding intensity is presented in Tables 1and 2 for

the prawns from the inshore (estuarine) and nearshore area respectively.

Prawns from the inshore waters were observed to have very moderate feeding intensity (Table 1). The percentages for various categories of fullness in the same order were 1.58, 26.09, 40.41, 12.99, 8.74 and 10.19. Number of prawns with empty stomachs was found to be minimum in the inshore waters. Juveniles showed higher proportion of well-fed and moderately fed individuals. Out of 824 juveniles examined, 228 (27.67%) were well fed; 440 (53.4%) were moderately fed and only 156 (18.93%) were poorly fed. Significantly high proportion of moderately feeding prawns was observed and their percentage was maximum (75.76%) in September and minimum (20.00%) in August. Since the females were poorly represented in the inshore waters, it is precarious to state that the prevalence of moderately fed females is higher than that of the males.

Table 1 Month wise fullness of gut of *M. monoceros* from inshore habitat (with % in parenthesis)

Month	Full	3/4 full	Well fed	1/2 full	1/4 full	Mod.ly fed	Traces	Empty	Poorly fed	Total
JANUARY	0 (—)	8 (16)	8 (16)	18 (36)	11 (22)	29 (58)	4 (8)	9 (18)	13 (26)	50 (100)
FEBRUARY	11 (10)	46 (41.82)	57 (51.82)	32 (29.09)	12 (10.91)	44 (40)	2 (1.82)	7 (6.36)	9 (8.18)	110 (100)
MARCH	2 (1.92)	49 (47.12)	51 (49.04)	42 (40.38)	5 (4.81)	47 (45.19)	1 (0.96)	5 (4.81)	6 (5.77)	104 (100)
APRIL	0 (—)	21 (26.92)	21 (26.92)	43 (55.13)	4 (5.13)	47 (60.26)	0 (—)	10 (12.89)	10 (12.89)	78 (100)
MAY	0 (—)	34 (32.08)	34 (32.08)	53 (50)	13 (12.26)	66 (62.26)	5 (4.72)	1 (0.94)	6 (5.66)	106 (100)
JUNE	0 (—)	11 (30.56)	11 (30.56)	15 (41.67)	4 (11.11)	19 (52.78)	2 (5.56)	4 (11.11)	6 (16.67)	36 (100)
JULY	0 (—)	16 (20)	16 (20)	37 (46.25)	9 (11.25)	46 (57.50)	6 (7.5)	12 (15)	18 (22.50)	80 (100)
AUGUST	0 (—)	9 (18)	9 (18)	4 (8)	6 (12)	10 (20)	22 (44)	9 (18)	31 (62)	50 (100)
SEPTEMBER	0 (—)	7 (21.21)	7 (21.21)	17 (51.52)	8 (24.24)	25 (75.76)	0 (—)	1 (3.03)	1 (3.03)	33 (100)
OCTOBER	0 (—)	3 (3.9)	3 (3.9)	21 (27.27)	17 (22.08)	38 (49.35)	22 (28.57)	14 (18.18)	36 (46.75)	77 (100)
NOVEMBER	0 (—)	7 (14.89)	7 (14.89)	27 (57.45)	7 (14.89)	34 (72.34)	3 (6.38)	3 (6.38)	6 (12.77)	47 (100)
DECEMBER	0 (—)	4 (7.55)	4 (7.55)	24 (45.28)	11 (20.76)	35 (66.04)	5 (9.43)	9 (16.98)	14 (26.41)	53 (100)
TOTAL	13 (1.58)	215 (26.09)	228 (27.67)	333 (40.41)	107 (12.99)	440 (53.40)	72 (8.74)	84 (10.19)	156 (18.93)	824 (100)

Table 2 Month wise fullness of gut of *M. monoceros* from nearshore habitat

Month	Full	3/4 full	Well fed	1/2 full	1/4 full	Mod.ly fed	Traces	Empty	Poorly fed	Total
JANUARY	1 (2)	7 (14)	8 (16)	8 (16)	14 (28)	22 (44)	8 (16)	12 (24)	20 (40)	50 (100)
FEBRUARY	0 (—)	2 (8)	2 (8)	4 (16)	8 (32)	12 (48)	7 (28)	4 (16)	11 (44)	25 (100)
MARCH	0 (—)	3 (6)	3 (6)	8 (16)	8 (16)	16 (32)	14 (28)	17 (34)	31 (62)	50 (100)
APRIL	0 (—)	5 (10)	5 (10)	15 (30)	10 (20)	25 (50)	7 (14)	13 (26)	20 (40)	50 (100)
MAY	0 (—)	1 (3.13)	1 (3.13)	8 (25)	7 (21.87)	15 (46.87)	8 (25)	8 (25)	16 (50)	32 (100)
JUNE	0 (—)	1 (3.7)	1 (3.7)	7 (25.93)	2 (7.41)	9 (33.34)	6 (22.22)	11 (40.74)	17 (62.96)	27 (100)
JULY	0 (—)	3 (12)	3 (12)	3 (12)	4 (16)	7 (28)	4 (16)	11 (44)	15 (60)	5 (100)
AUGUST	0 (—)	7 (23.33)	7 (23.33)	12 (40)	4 (13.33)	16 (53.33)	2 (6.67)	5 (16.67)	7 (23.34)	30 (100)
SEPTEMBER	0 (—)	1 (4)	1 (4)	4 (16)	1 (4)	5 (20)	9 (36)	10 (40)	19 (76)	25 (100)
OCTOBER	0 (—)	2 (8.33)	2 (8.33)	2 (8.33)	2 (8.33)	4 (16.67)	4 (16.67)	14 (58.33)	18 (75)	24 (100)
NOVEMBER	0 (—)	0 (—)	0 (—)	4 (20)	6 (30)	10 (50)	7 (35)	3 (15)	10 (50)	20 (100)
DECEMBER	0 (—)	1 (2.63)	1 (2.63)	5 (13.16)	9 (23.68)	14 (36.84)	12 (31.58)	11 (28.95)	23 (60.53)	38 (100)
TOTAL	1 (0.25)	33 (8.33)	34 (8.59)	80 (20.20)	75 (18.94)	155 (39.14)	88 (22.22)	119 (30.05)	207 (52.27)	396 (100)

The annual feeding intensity of prawns in nearshore waters (Table 2) showed following results: 0.25% full guts, 8.33% 3/4 full guts, 20.20% 1/2 full guts, 18.94% 1/4 full guts, 22.22% guts with traces of food and 30.05% guts were empty. It is noteworthy that the prawns from the dol nets showed high percentage of empty stomachs almost throughout the year. Out of 396 prawns studied, 34(8.59%) were actively fed; 155 (39.14%) were moderately fed and 207(52.27%) were poorly fed. The proportion of poorly fed prawns was maximum (76%) in September and minimum (23.34%) in August. Monthwise feeding intensity of the two sexes is given in Table 3.5. It is seen that there is no significant difference between the feeding intensity of the males and the females. Thus, the prawns from the nearshore area exhibited poor feeding intensity in contrast to the offshore ones.

From the comparison of the fullness of stomachs of prawns from the two different fishing areas, it is evident that the feeding intensity of the species showed variations. The estuarine samples showed prevalence of moderate feeders, while those from the near shore waters showed very high incidence of poorly fed prawns. The probable reason for such high incidence of empty stomachs in the prawns from the nearshore waters could be as follows: The post larvae of *M. monoceros*, like that of *Penaeus* sp, must be entering inshore waters of low salinity and mangrove vegetations where rich detritus and epifauna is available for feeding as seen from the quantity and quality of food in the guts of prawns from inshore estuarine waters. These post larvae grow rapidly into juveniles and sub-adults and commence their seaward migrations as they reach 70-100 mm size. While migrating, the juveniles probably do not have food intake and therefore, high incidences of empty stomach were observed in nearshore waters of the Mumbai harbour. In addition, the harbour waters are highly polluted on account of large quantities of industrial effluents and domestic sewage generated from Mumbai Metropolitan city; in addition, the shipping traffic in the harbour releases and dumps waste oil and oil products (Anon, 2000). The heavier portion of oil sinks to the bottom and forms a scum over it. The latter could be unsuitable for the growth of benthic organisms. As the availability of benthic organisms, particularly the polychaetes and crustaceans might be poor, the prawn showed more prevalence of empty stomachs or poor feeding.

Table 3 Order of preference of food items of males and females from nearshore waters

	-	Pc.	-	-	C	-	-	Pr.	-	-	D.	-	-	Misc.	-	-	Unid.	-
	Vi	Oi	IP	Vi	Oi	IP	Vi	Oi	IP	Vi	Oi	IP	Vi	Oi	IP	Vi	Oi	IP
JANUARY	37.7	41.67	41.95	0.82	2.78	0.06	47.54	44.44	56.41	7.38	5.56	1.1	3.28	2.78	0.24	3.28	2.78	0.24
	36.45	34.78	52.52	18.69	17.39	13.47	17.76	21.74	16.02	0.93	4.35	0.17	24.3	17.39	17.51	1.87	4.35	0.34
FEBRUARY	35.14	37.93	45.47	39.19	34.48	46.1	13.51	13.79	6.36	5.41	6.9	1.27	4.05	3.45	0.48	2.7	3.45	0.32
	27.27	16.67	13.05	36.36	33.33	34.78	36.36	50	52.17	-	-	-	-	-	-	-	-	-
MARCH	15.31	9.52	4.88	34.69	38.1	44.23	43.88	33.33	48.94	4.08	9.52	1.3	-	-	-	2.04	9.52	0.65
	6.67	15.79	3.32	51.11	42.11	67.89	31.11	26.32	25.83	4.44	5.26	0.74	-	-	-	6.67	10.53	2.22
APRIL	6.83	8.57	1.13	68.32	65.71	86.56	24.84	25.71	12.3	-	-	-	-	-	-	-	-	-
	7.32	16.67	2.3	75.61	66.67	95.02	9.76	8.33	1.53	7.32	8.33	1.15	-	-	-	-	-	-
MAY	11	16.53	4.73	50	51.61	67.15	37	29.03	27.95	2	3.23	0.17	-	-	-	-	-	-
	-	-	-	100	100	100	-	-	-	-	-	-	-	-	-	-	-	-
JUNE	10.26	13.64	3.8	50	50	67.99	37.18	27.27	27.57	-	-	-	-	-	-	2.56	9.09	0.63
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
JULY	2.78	6.67	0.32	77.78	66.67	90.62	19.44	26.67	9.06	-	-	-	-	-	-	-	-	-
	-	-	-	66.37	50	66.57	-	-	-	33.33	50	33.43	-	-	-	-	-	-
AUGUST	73.79	70.83	91.09	19.31	25	8.41	6.9	4.17	0.5	-	-	-	-	-	-	-	-	-
	76.67	66.67	92.93	10	16.67	3.03	13.33	16.67	4.04	-	-	-	-	-	-	-	-	-
SEPTEMBER	12.73	25	8.75	47.27	43.75	56.87	40	31.25	34.38									

Preference of Food Items: The order of preference of food items can be ascertained by considering volume of food material in the gut and occurrence of a particular food item. The volume and occurrence of food items were used in combination to calculate the 'index of preponderance' (Natarajan and Jhingran, 1961). This index indicated the preferential order of food organisms by the animal under study. Table 3 gives an account of indices of volume, occurrence and preponderance and order of preference of major food items in both the fishing grounds.

The inshore prawns showed that polychaetes were the most favourite food (IP 79.94 and 74.56) followed by crustaceans (IP 15.26 and 21.37), miscellaneous (IP 2.64 and 3.58), prawns (IP 1.94 and 0.23), *Palaemon* (IP 0.18 and 0.11) and unidentified material (IP 0.04 and 0.07) in males and females respectively (Table 4). Monthwise analysis of inshore prawns (Table 4) showed that in the case of juveniles, polychaetes were the favourite food and the males preferred them more. For males, maximum IP for polychaetes (99.63) was seen in April and minimum in June (10.67) while in the case of females, IP was cent percent in April and minimum (6.25) in February.

Table 4 Order of preference of food items of males and females from nearshore waters

	-	Pc.	-	-	C	-	-	Pr.	-	-	D.	-	-	Misc.	-	-	Unid.	-
	Vi	Oi	IP	Vi	Oi	IP	Vi	Oi	IP	Vi	Oi	IP	Vi	Oi	IP	Vi	Oi	IP
JANUARY	25.27	23.94	20.23	2.17	2.82	0.2	35.74	38.03	45.45	-	-	-	33.94	29.58	33.57	2.89	5.63	0.54
	15	20	10	25	20	16.67	10	20	6.67	-	-	-	50	40	66.67	-	-	-
FEBRUARY	52.32	44.5	72.78	23.1	26.7	19.28	13.4	12.57	5.27	0.32	0.52	0.005	6.96	7.85	1.71	3.9	7.85	0.96
	12.5	14.29	6.25	37.5	28.57	37.5	-	-	-	-	-	-	31.25	42.86	46.88	18.75	14.29	9.38
MARCH	72.13	62.41	90.8	7.75	9.93	1.55	2.81	3.55	0.2	-	-	-	16.74	21.99	7.42	0.56	2.13	0.024
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
APRIL	93.82	87.84	99.63	3.56	5.41	0.23	1.87	5.41	0.12	-	-	-	0.75	1.35	0.01	-	-	-
	100	100	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MAY	89.34	80.33	98.15	8.19	15.57	1.74	2.21	3.28	0.1	-	-	-	-	-	-	0.26	0.82	0.0029
	100	100	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
JUNE	15.14	19.3	10.67	34.66	36.84	46.62	34.66	28.07	35.52	13.94	14.04	7.15	1.59	1.75	0.04	-	-	-
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
JULY	56.51	53.57	70.66	33.95	35.71	28.3	5.35	5.95	0.74	3.26	3.57	0.27	0.93	1.19	0.03	-	-	-
	34.67	35.71	22.77	65.33	64.29	77.23	-	-	-	-	-	-	-	-	-	-	-	-
AUGUST	36.93	37.25	30.44	56.82	54.9	69.02	3.41	5.88	0.44	2.84	1.96	0.11	-	-	-	-	-	-
	33.33	42.86	37.5	50	42.86	56.25	16.67	14.29	6.25	-	-	-	-	-	-	-	-	-
SEPTEMBER	64.68	59.09	81.34	26.15	29.55	16.45	-	-	-	-	-	-	9.17	11.36	2.22	-	-	-
	50	50	50	50	50	50	-	-	-	-	-	-	-	-	-	-	-	-
OCTOBER	57.21	40.28	68.12	20.19	37.5	22.38	-	-	-	6.25	4.17	0.77	16.35	18.06	8.73	-	-	-
	52.63	40	68.97	21.05	20	13.79	-	-	-	21.05	20	13.79	5.26	20	3.45	-	-	-
NOVEMBER	54.18	45.76	71.95	15.27	23.73	10.52	-	-	-	2.61	3.39	0.21	24.73	23.73	17.03	2.91	3.39	0.29
	63.16	42.86	72	15.79	28.57	12	-	-	-	-	-	-	21.05	28.57	16	-	-	-
DECEMBER	70.87	57.5	82.334	24.441	35	17.26	-	-	-	1.57	2.5	0.08	3.15	5	0.32	-	-	-
	70.97	66.67	83.02	29.03	33.33	16.98	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	688.4	611.77	79.94	256.22	313.66	15.26	99.45	102.74	1.94	31.09	30.15	0.18	114.31	121.86	2.64	10.52	19.82	0.04
	532.26	554.39	74.65	293.7	287.62	21.37	26.67	34.29	0.23	21.05	20	0.11	107.56	131.43	3.58	18.75	14.29	0.07

Table 5 Preferential order of food items for *M. monoceros* males and females (in bold) from different habitats

	Inshore habitat				Nearshore habitat			
	Vi	Oi	IP	Grade	Vi	Oi	IP	Grade
Polychaete	688.4	611.77	79.94	I	290.5	309.36	18.87	II
	532.26	554.39	74.65	I	191.05	183.91	13.15	II
Crustaceans	256.22	313.66	15.26	II	561.68	544.1	64.15	I
	293.7	287.62	21.37	II	448.14	448.4	75.23	I
Miscellaneous	114.31	121.86	2.64	III	7.33	6.23	0.01	V
	107.56	131.43	3.58	III	24.3	17.39	0.16	V
Prawns	99.45	102.74	1.94	IV	297.23	265.66	16.58	III
	26.67	34.29	0.23	IV	168.32	156.3	9.86	III
Palaemon	31.09	30.15	0.18	V	-	-	-	-
	21.05	20	0.11	V	-	-	-	-
Unidentified	10.52	19.82	0.04	VI	10.58	24.84	0.05	VI
	18.75	14.29	0.07	VI	8.54	14.88	0.05	VI
Detritus	-	-	-	-	32.37	50.21	0.34	IV
	-	-	-	-	59.35	69.77	1.55	IV

The prawns in the nearshore waters showed more variations compared to inshore waters (Table 5). The order of preference of major food items (with IP in parenthesis for males and females) was: Crustaceans (64.15 and 75.23), polychaetes (18.87 and 13.15), prawns (16.58 and 9.86), detritus (0.34 and 1.55), miscellaneous (0.01 and 0.16) and unidentified matter (0.05 and 0.05) in males and females respectively. The males showed lesser preference for crustaceans. The polychaetes were the second preference of prawns in the nearshore waters, but they were far less in proportion as compared to those in offshore waters. Monthwise index of preponderance (Table 5) showed that crustaceans were the favourite food in April - July and September - November. In August, the IP for polychaetes was maximum (92.01).

Many workers (Kishinouye, 1900; Menon, 1951; Ikematsu, 1955; Kubo, 1956; Yasuda *et al*, 1957; George, 1959; Hall, 1962; Kuttyamma, 1974; George, 1974 and Rao, 1988) have studied varying feeding habits of prawns. Menon (1951) reported *M. dobsoni* as detritus feeder in younger stage and a herbivore in adulthood. Hall (1962) described prawns as detritus feeders but agreed with the findings of Kishinouye (1900), Ikematsu (1955), Kubo (1956) and Yasuda etal. (1957) that certain species are carnivorous.

George (1959) and Kuttyamma (1973) found *M. monoceros* as an omnivore; while George (1974) reported the same species from Cochin backwaters as a carnivore. Rao (1988) while working on the species along Kakinada coast supported the view of previous workers that *M. monoceros* is an omnivorous prawn. Nandakumar and Damodaran (1998), however, reported that the species is a carnivore. They observed that the specimens studied from the inshore waters preferred polychaetes while those from the backwaters fed mainly on crustaceans. The present study agrees with the findings of Nandakumar and Damodaran (1998) from the inshore waters. The present study also showed that the offshore prawns, too, preferred polychaetes while the prawns from the nearshore waters preferred crustaceans. Nandakumar and Damodaran (1998) reported nocturnal feeding in the case of prawns from Cochin inshore waters. The present study corroborates with the observation, as the bokshi nets are set only during night at Alimghar village in Bassein creek from where the samples were collected for the study, which showed active feeding.

George (1974) and Rao (1988) pointed out that the presence of pelagic polychaetes and copepods suggest 'column feeding' in *M. monoceros.* However, the present study from Mumbai and adjacent waters did not support their views. The study found that *M. monoceros* is a carnivore and a benthic feeder.

ACKNOWLEDGEMENTS

The authors are grateful to the Director, C.M.F.R.I., Cochin for giving kind permission for publishing this work.

REFERENCES

Anon, 2000**.** Environment Status of Brihanmumbai, 1998-99. *Municipal Corporation of Greater Mumbai* .60 pp.

Borradaile, L. A. 1917. On the structure and function of the mouth parts of Palaemonid Prawns. *Proc. Zool. Soc. London.*

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 148-151

IN VITRO EFFECT'S OF CADMIUM CHLORIDE ON BRAIN AND MUSCLE ACETYLCHOLINESTAREASE OF MUD-SKIPPER *BOLEOPTHALMUS*

Ritu Sharma, Jyoti Nair, Anuja Pai and Sharma B.B.*
Dept. of Biological Sciences, V.G. Vaze College, Mulund, Mumbai – 400 081

ABSTRACT : The common mudskipper Boleopthalmus was obtained from mangrove area of Vashi Creek. The fish were kept in aquaria under laboratory conditions for one day for acclimation. The fish were then sacrificed, the brain and muscle were dissected out immediately and washed with 0.9% NaCl containing EDTA. The soluble and membrane bound Acetylcholinesterase was extracted by the method of Varela 1973. The enzyme was assayed by the method of Elimanetal 1961. The data obtained was analysed by the Michaelis Menten plot and Eisenthal and Cornish Bowden plot. The Km, Vmax and Vmax/Km were calculated to find out the effect of Cadmium Chloride (1 ppm) on kinetics and efficiency of the enzyme Acetylcholinesterase.

Keywords : *Cadmium, Acetylcholinesterase, Boleopthalmus, Brain, Muscles.*

INTRODUCTION

Goboid are important members of the mangrove and mudflat fauna. They live in the upper intertidal zone and spend most of the time concealed in burrows. Koumans (1941, 1953) have done pioneering work on taxonomy of gobioid of Indopacific region. Rao (1971) studied the gobioids of the Godavary estuary and Venkateshwarlu (1988) have reported on gobioid of Kakinada bay.

The Thana Creek is one of the major estuarine system near Mumbai. It is lined by extensive mud flats which are exposed at low tides. These mud flats serve as ideal habitat for mudskippers. The Thana Creek-Ulhas estuary yields about 2000-3000 metric tones of fish and shell fish annually which includes mudskippers. These mudskippers are consumed by majority of fishing community and other low income groups.

The review of literature on mudskippers shows and bal. work on various aspects, like biology by Mutsaddi (1969) Clayton and Vaugham (1988); Investigations have been carried out on the genetics (Krishnaja & Rege, 1982), Endocrinology (Patel and Desai 1976); ecological adaptations (Biswas et. al 1979, Chew and IP, 1990). Although Physiological studies on mudskippers are abundant, enzymological studies are relatively fewer. In the present work, the enzyme acetylchlotinesterase was studied in *Boleopthalmus boddaerti.*

Acetylcholinesterase (EC 3.1.1.7) is a hydrolytic enzyme found at the cholinergic synapse and neuromuscular functions..It is responsible for hydrolyzing the neurotransmitter acetylcholine, thus preventing the prolonged stimulation of the nerves. AChE has been studied in various fishes like *Cyprinus carpio* (Szaboet al 1982) *Tilapia* (Pradhan 1982). Major carps (Hande 1990), Frog *Rana tigrina* (Sharma and Pradhan 1990). The study of levels of AChE is of diagnostic value. Levels of AChE was lowered in hepatic tissue of albino rats during experimental plasmodium infection (Saxena *et al* 1981). AChE levels were significantly reduced in RBC of cancer patients. Ramchandran and Iyer (1987) found AChE activity is raised in iron deficiency anemia. Increased AChE levels were found in cerebro-spinal fluid of patients with tuberculosis and meningitis. (Dave *et al* 1990).

Acetylcholinesterase has been reported to be affected by heavy metals. Sastry & Sharma (1981). Activation of the enzyme by lead, was reported in brain of carp (Tishninova & Mouleshkova, 1984).

Hence it was thought to study the effect of Cadmium Chloride on AChE from brain and muscles of *Boleopthalmus boddoerti*.

MATERIAL & METHOD

Fresh specimens of *Boleopthalmus boddaerti* were obtained from Vashi, Thane Creek. The fish were kept in aquaria for one day for acclimation. The fish were then sacrificed, the brain and the muscle were dissected out immediately and washed with chilled 0.9% NaCl (0.15M) containing 0.1% EDTA to remove blood. The tissues were homogenized in electric homogeniser and then the enzyme was extracted by the method of Varela (1973). The cytoplasmic AChE was extracted in 0.9% NaCl at 60,000Xg in refrigerated centrifuge and supernatant was collected. This was considered as cytoplasmic fraction of AChE. The remaining pallet was homogenized in 1% Triton X-100 buffered to pH 7 in 0.1M

tris-HCl buffer and then centrifuged at 60,000g to obtain membrane bound fraction of AChE. The enzyme activity was assayed by spectrophotometric method of Ellmanetal by using DTNB as colouring agent measured at 412nm. Proteins were estimated by method of Lowry*etal (*1951) and the enzyme activity is represented in terms of △A/0.1 mg of protein/min. The data obtained was analysed by Eisenthal Cornish Plot (1974).

RESULTS & DISCUSSION

Initial experiments were performed to establish the basic parameters like pH, time, temperature, protein concentration and DTNB (Chromogen) concentration. The maximum activity for the cytoplasmic as well as membrane bound AChE was recorded at pH 8. The time course was linear upto 5 minutes and protein concentration of 0.06mg of protein for cytoplasmic fraction and 0.047mg of protein showed a linear activity after which it becomes constant. The activity of both the fractions was maximum at about 30°C (± 1). The assay system was saturated at 0.04mM of DTNB. The effects of varying concentration of substrate (0.1-3mμ) on enzyme activity was estimated.

The effect of substrate variation on the cytoplasmic & membrane AChE from the brain and the muscle of *Boleopthalmus boddaerti* control and experimental is depicted in table 1. The specific activity for the different substrate concentration when analysed by Eisenthal and Cornish-Bowden plot for cytoplasmic AChE from brain gave a Vmax of 0.017 △A/0.1mg protein/min and a Km value of 0.595mM ATChI. The corresponding experimental set gave Vmax of 0.12 DA/ 0.1 mg of protein/min and a Km value of 0.490 mM of ATChI. The Vmax by Km ratio was 0.029 and 0.024 for the control and experimental fish respectively.

The membrane bound AChE from brain of normal showed a Km of 0.55mM of ATChI and a Vmax of 0.16 △A/0.1 mg of protein/min. The Km for the AChE from experimental fish was 0.40mM of ATChI and the Vmax was 0.066 △A/0.1mg of protein/min. The Vmax, Km ratio was 0.29 and 0.16 respectively.

The cytoplasmic AChE from muscle showed a Km of 0.936 mM of ATChI and Vmax was 0.046 DA/0.1 mg of protein/min. The enzyme from experimental animal showed a Km of 0.88mM of ATChI and Vmax of 0.013 △A/0.1 mg of protein/min. The Vmax/Km ratio was 0.049 and 0.014 respectively.

The membrane bound AChE from muscles showed a Km of 0.636 mM of ATChI and Vmax of 0.063 △A/0.1 mg of protein/min. The Km and Vmax for membrane bound AChE from muscle for experimental fish was 1.08mM of ATChI and 0.039 △A/0.1 mg of protein/min. The Vmax/Km ratios were 0.10 and 0.036 respectively.

Table 2 shows the percentage change in Km, Vmax and the Vmax/Km ratio for the experimental set of animals.

CONCLUSION

Heavy metals such as copper, mercury, lead, inactivates most enzymes, in high concentrations. Metals are infact general protein precipitants. Few enzymes are extremely sensitive to low concentrations of such metals (Dixon and Webb, 1979). Heavy metals like copper and mercury inhibits sulphydryl-dependent enzymes (Owens 1953). They can directly react at active sites inhibiting –SH enzymes. Nerve cholinesterases and plasma cholinesterases are sulphydryl enzymes (Nachmansohn and Lederer, 1939, Gordon and Quastel 1948).

Table 1

In Vitro effect of Cadmium Chloride on Km and Vmax values of the cytoplasmic and membrane bound AChE from brain and muscles of Boleopthalmus boddaerti as computed from ECB Plots.

	Cytoplasmic AChE		
BRAIN	**Km**	**Vmax**	**Vmax/Km**
Control	0.595 n=8 SE= ± 0.01	0.017 n=8 SE=±0.002	0.029
Experimental	0.490 n=11 SE=±0.002	0.012 n=11 SE=±0.03	0.024
MUSCLE			
Control	0.936 n=11 SE=±0.01	0.046 n=11 SE=±0.02	0.049
Experimental	0.88 n=9 SE=±0.002	0.013 n=9 SE=±0.003	0.014

	Membrane Bound AChE		
BRAIN	**Km**	**Vmax**	**Vmax/Km**
Control	0.55 n=11 SE= ± 0.1	0.16 n=11 SE=±0.002	0.29
Experimental	0.40 n=12 SE=±0.01	0.066 n=8 SE=±0.003	0.16
MUSCLE			
Control	0.636 n=9 SE=±0.01	0.063 n=9 SE=±0.002	0.10
Experimental	1.08 n=14 SE=±0.1	0.039 n=14 SE=±0.01	0.036

Table 2

In Vitro effect of Cadmium Chloride of Km and Vmax values of the cytoplasmic and membrane bound AChE from brain and muscle of *Boleopthalmus boddaerti* represented in percentage in comparison of normal.

	Cytoplasmic AChE		
BRAIN	**Km**	**Vmax**	**Vmax/Km**
Control	100%	100%	100%
Experimental	82%	30%	82%
MUSCLE			
Control	100%	100%	100%
Experimental	94%	28%	28.5%

	Membrane Bound AChE		
BRAIN	Km	Vmax	Vmax/Km
Control	100%	100%	100%
Experimental	72.72%	41.25%	55.17%
MUSCLE			
Control	100%	100%	100%
Experimental	169%	61.90%	36%

Km = mM of ATChI

Vmax = △A/0.1 mg of protein/min.

It can be noted that, in the experimental fish the efficiency of the enzyme is reduced. The cytoplasmic AChE from brain showed an efficiency of 82% as compared to normal. The membrane bound AChE was more affected with efficiency reduced to 55.17%.

The cytoplasmic fraction of AChE from muscle showed only 28.57% efficiency and the membrane bound 36% efficiency as compared to that of normal. Acetylchloinesterase is an important enzyme involved in function of nerve and muscle cells. Acetylcholinesterase is associated with membrane of nerve and muscle (Brzin, 1966). Acetylcholinesterase is involved in cationic permeability of Red blood cells was proposed by Holland and Greig (1950). Varela (1975) proposed a possible role of AChE in utilization of Acetyl groups in excitable cells, and energy metabolism. From the above literature it can be concluded that any reduction or changes in the kinetic parameters of AChE will be affecting the functioning of nervous system, neuromuscular junction and energy metabolism of *Boleopthalmus boddaerti*.

REFERENCES

Biswas N., J Ojha,. and J.S. Datta Munshi, 1979 Bimodal oxygen uptake in relation to body weight of the amphibious mudskipper, *Boleopthalmus boddaerti* (Pall.) Indian J. Exp. Biol., (8): 752-756

Brzin, M. 1966 The localization of AChE in axonal membranes of frog nerve fibres.

Proc. Natl. Acad. Sci USA, 56: 1560.

Chew, S.F. and Y.K Ip,. 1990 Differences in the responses of two mudskippers,

Boleopthalmus boddaerti and *Periopthalmus chrysopilos* to changes in salinity.

J. Exp. Zool., 256 (2): 227-231

Clayton, D.A. and T.C Vaughan. 1988.Ethogram of *Boleopthalmus boddaerti* (Pallas)

(Teleostei, Gobiidae), a mudskipper found on the mudflats of Kuwait.J. Univ. Kuwait (Sci.), 15: 116-138

Dave, K.N., B.N. Dave, F.R. Billimora, M.N. Mehta, and N.K. Hase, 1990 Levels of cerebro spinal fluid acetylcholinesterase in tuberculosis and pyogenic mengitis in hildren.

Indian J. Clin. Biochem., 5: 135-138

Dixon, M. and E.C.Webb, 1979 Enzymes. London, Longmans, Green and Co. Ltd.

Eisenthal, R. and A Cornish-Bowden, 1974 The direct linear plot. A new graphical procedure for estimating kinetic parameters.Biochem. J. 139: 715-720.

Gordon, J.J. and Quastel, J.H. 1948 Biochem J. 42, 337-50 as cited by Goldstein, A. and Doherty, M. 1953 in "Properties and behaviour of purified human plasma holinesterase".Arch. Biochem. Biophys, 83 :35-49.

Hande, R.S. 1990 Physiology of fishes (Studies on acetylcholinesterases from the fingerlings of Indian Major Carps.) Ph. D. Thesis, Univ. Bombay.

Holland, W.C. and M.E. Greig, 1950 Studies on the permeability of erythrocytes. III. The effect of physostigmine and acetylcholine on the permeability of dog, cat and rabbit erthrocytes to sodium and potassium. Amer J. Physiol., 1962 : 610-618

Koumans, F.P. 1953 The Fishes of Indo-Australian Archipelago, 10.

Koumans, F.P. 1941 Gobioid fishes of India Mem. Indian Mus., 13 (3): 205-209.

Krishnaja, A.P. and M.S. Rege, (1982). Induction of chromosomal aberrations in fish

Boleopthalmus dussumieri, after exposure _*in vivo*_ to mitomycin C and heavy metals mercury, selenium and chromium. Mutat. Res., 102 (1): 71-82

Lowry, Q.H., N.J. Rosebrough, A.L. Farr, and R.J. Randall, (1951) Protein measurement with Folin's reagent. *J. Biol. Chem.*_193: 265-275

Michaelis, L. and M.L Menten,. 1913 Biochem. Z, 49: 333-369, ad cited by Cornish-Bowden, A (1976) in "Principles of enzyme kinetics". Butterworths, London, Boston.

Mutsaddi, K.B. and D.V. Bal, 1969 a. Food and feeding of *Bolepothalmus dussumieri* (Cuv. And Val.) Jour. Univ. Bombay, 38 (65): 42-55.

Nachmansohn, D. and E. Lederer, 1939 Sur la biochem de cholinesterase. L. reparation de l' enzyme: Groupements – S.H. Bull. Soc. Chim. Biol. 21: 797 as cited by Rossenberry, T. L. (1976) in "The enzymes of biological membranes", Vol. 4 pp. 331-363 ed. A. Martonosi, Plenum Press, New York and London.

Owens, R G. 1953 Contribs. Boyce Thomson Inst., 17-221 as cited by Hochester, R.M. and Quastel, J.H. in "Metabolic Inhibitors", Academic Press. 1963.

Patel, B. and K. Desai, 1976 Tidal rhythms and cyclic changes in the neuroendocrine complex of *Boleopthalmus dentatus* (Cuv. And Val.) Ann. Zool._(Agra) 12 (3): 69-96

Pradhan, P.V. 1982 Biochemical adaptations in fishes (Studies on acetylcholinesterases from *Tilapia mosambica*, Peters) Ph. D. Thesis – University of Bombay.

Ramachandran, M. and G.Y.N. Iyer, 1987 Red cell creatine and AChE in iron eficiency anemia.Indian J. Biochem. Biophys., 19: 290

Rao, V.V. (1971) New Gobioid fishes from Godavary estuary. J.Zool. Soc. India, 23 (1): 39-54

Sastry, K.V. and K Sharma,. (1981) Effects of $HgCl_2$ on the activities of brain enzymes in *Heteropneustes fossilis* Matsya, 7: 6-69.

Saxena, J.K., A.K. Srivastava, and S.C. Gupta, (1981) AChE in rodents following experimental *Plamodium berghei*_infection. Indian J. Biochem. Biophys., 18: 56

Sharma, B.B. and P.V. Pradhan, (1990) Changes in brain acetylcholinesterase activity in thermal acclimation in Frog, *Rana tigrina*. Curr. Sci., 59(2): 114

Szabo, A., J. Nemsok, , B. Asztalos, , Z. Rakonczay, P. Kasa, and L.H. Hieu, (1992) The effect of pesticides on carp (*Cyprinus carpio*) acetylcholinesterase and its biochemical characterization. Ecotoxicol. Environ. Saf., 23 (1):39-45

Tishinova, N. Vesselina and Mouleshkova, N. (1984) The effect of lead on carp brain acetylcholinesterase activity *in vivo* and *in vitro* God Sof. Univ. Kilment Okhrisdski, Biol. Fak., 76(1): 11-15

Venkateswarlu, T. (1988). Ecology and systematics of Gobioid fishes of Kakinada Bay (Andra Pradesh). Matsya, 14 : 1-26.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 152-155

HISTOPATHOLOGICAL ALTERATIONS INDUCED BY PESTICIDES ON GILL AND LIVER OF THE MUDSKIPPER, *BOLEOPHTHALMUS DUSSUMIERI*

A. M. Rana and S. G. Yeragi
Department of Biology, K. J. Somaiya College of Science and Commerce,
Vidyavihar, Mumbai – 400 077.

ABSTRACT : Mudskippers, *Boleophthalmus dussumieri* were exposed to sub lethal concentration of Cypermethrin and Fenvalerate (25% 96 hr. LC_{50}) for two and four weeks. Histopathological effects of these pesticides were reported on gills and liver of the fish.

Key Words :- Histopathology, Cypermethrin, Fenvalerate, Fish.

INTRODUCTION

Pollutants enter into the body of aquatic organisms mainly through ingestion, general body surface and gills. Gills, because of their location, constantly come in direct intimate contact with the pollutants. Hence, there are more chances of damage to gills by toxicant material whether dissolved or suspended in water.

Liver is one of the largest digestive gland. It is a major site of detoxification. According to Anderson (1977), pollutants enter into the circulatory system of animals and thereby affect the internal organs. Hence, in the present study histopathological effects of pyrethroid pesticides Cypermethrin and Fenvalerate have been investigated.

MATERIALS AND METHODS

For histopathological studies the concentrations of Cypermethrin and Fenvalerate used were 0.138 ppm and 0.299 ppm respectively. At the end of the termination period of two and four weeks, the fish were dissected to obtain gill and liver tissues which were fixed overnight. The fixed tissues were processed through graded series of alcohol. The blocks were prepared using paraffin wax and sections were cut at 4µm. All the sections were stained with hematoxylin and eosin and mounted in DPX.

OBSERVATIONS

Gills : The exposure of fish for two weeks to Cypermethrin resulted in the bulging and fusion of secondary lamellae, lifting of epithelial cells (Fig. 2). Necrosis and destruction of secondary lamellae were noticed after four weeks of exposure (Fig. 3).

The alterations observed in gill of fish exposed to Fenvalerate were epithelial cell separation, necrosis and formation of space after two weeks of exposure (Fig. 4). Sloughing off of secondary lamellae, necrosis and mucus accumulation were observed by the end of four weeks of exposure (Fig. 5).

Liver : The liver cells after exposure to pesticide Cypermethrin for two weeks resulted in damaged blood vessel, clumping of hemocytes and their accumulation and pyknosis (Fig. 7). Necrosis, damaged blood vessels, clumping of hemocytes and extrusion of hemocytes into vacuoles were noticed after exposure period of four weeks to Cypermethrin (Fig. 8).

The histopathological changes observed in liver of fish treated with Fenvalerate for two weeks were clumping of hemocytes in blood sinusoids and accumulation of hemocytes in cellular space and vacuolation of blood vessels (Fig. 9). Degeneration of blood vessels and hepatocytes were after four weeks of exposure to Fenvalerate (Fig. 10).

DISCUSSION

It is clear from the above observations that the gills and liver were greatly affected after exposure of fish for two weeks and four weeks.

Lifting of epithelial cell and their destruction might have resulted in lesser diffusing capacity in the gills. Similar results have also been discussed by Rao and Munshi (1991) in gills of *Cirrhinus mrigala* exposed to malathion.

Fusion of gill filaments indicate an attempt of the fish to reduce the surface area exposed to the pesticide. Similar observations were also reported by Jauch (1979), Dieter (1982) and Padgaonkar and Arundhati (1999).

In the present investigation, the gills of fish gets disorganized leading to respiratory failure. Gopi Leena (1988), Vivitanam *et. al*., (1986) and Bhatnagar *et. al*., (1992) also noticed similar results.

Excessive mucus exudation may lead to respiratory stress in the fish by interfering with oxygen diffusion. Such condition has also been reported by Hawkes (1977), Sing and Sing (1979). Also loss of normal structure of gill may affect normal function of gaseous exchange resulting in hypoxia and anoxia in animal.

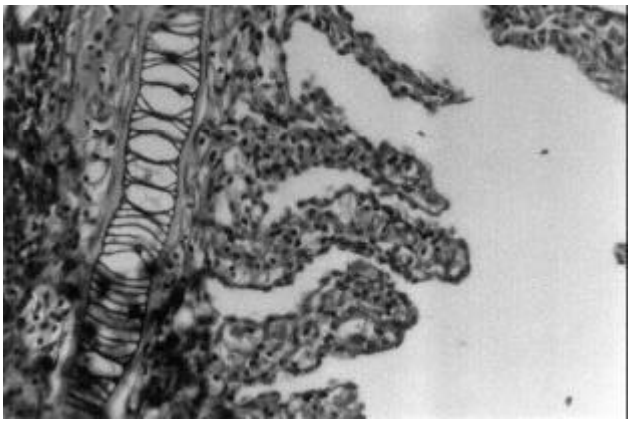


Fig. 1 : Section of control gill (540x)

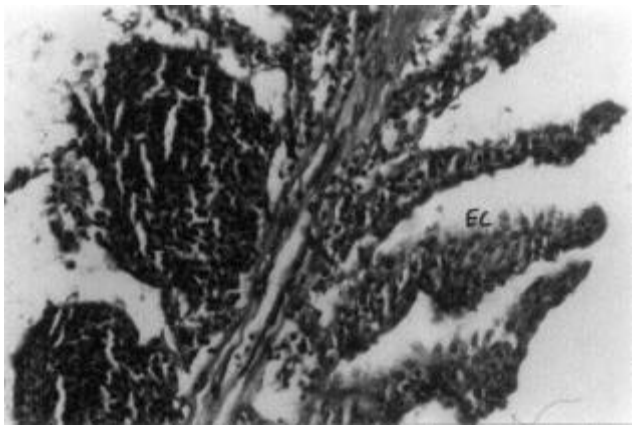


Fig. 2 : Section of gill showing bulging and fusion of secondary lamellac and lifting of epithelial cells (EC) after exposure ot Cypermethrin (540x)

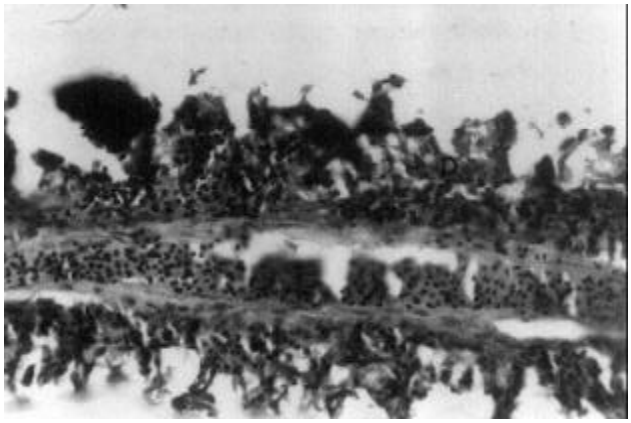


Fig. 3 : Section of gill showing necroses and destruction (D) of secondary lamellac after exposure ot Cypermethrin (540x)

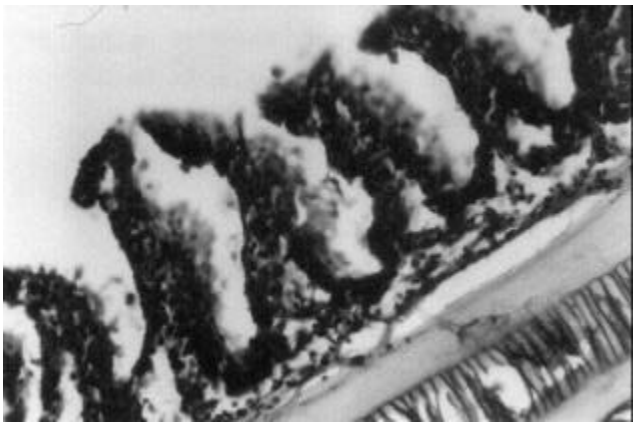


Fig. 4 : Section of gill showing pithelial cells separation , necrosis and formation of spce (540x)

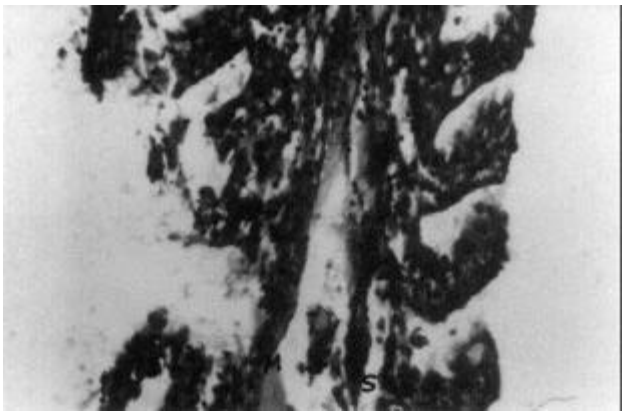


Fig. 5 : Section of gill showing sloughing off of secondary lamellac, necrosis (N), mucus accumulation (M) and space formation (S) after exposure to Fenvalerate (540x)

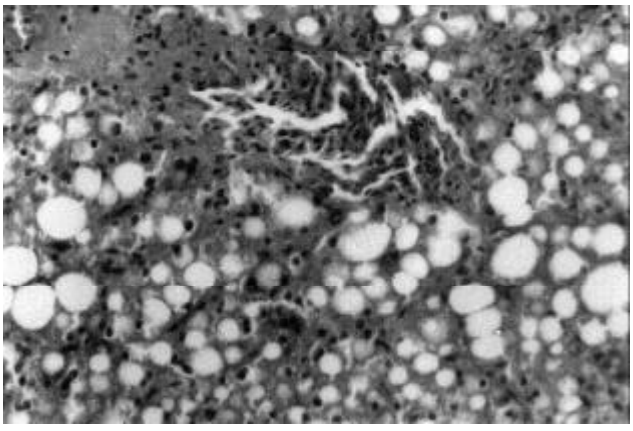


Fig. 6 : Section of the liver of control fish (540x)

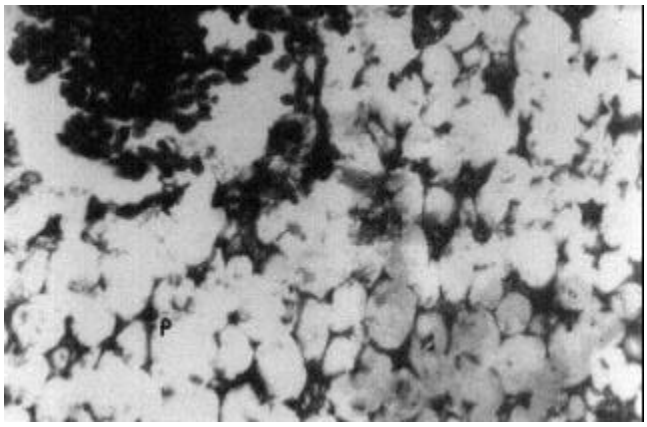


Fig. 7 : Section of liver showing damaged blood vessel, clumping and accumulation of blod cells, Pyknosic (P) after exposure to Cypermethnin (540x)

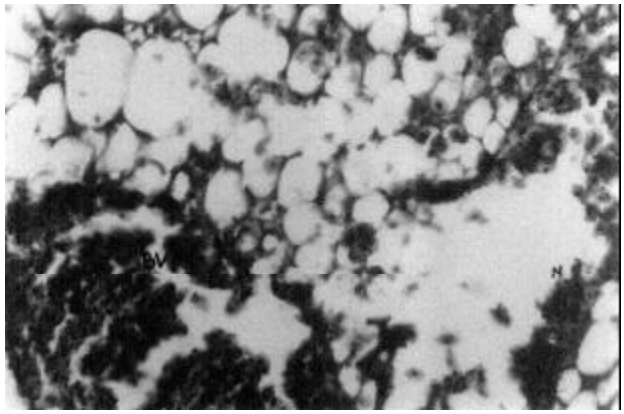


Fig. 8 : Section of liver showing damaged blood vessel (BV), necrosis (N), clumping of hemocytes and extrusion of hemocytes after exposure to Cypermethnin (540x)

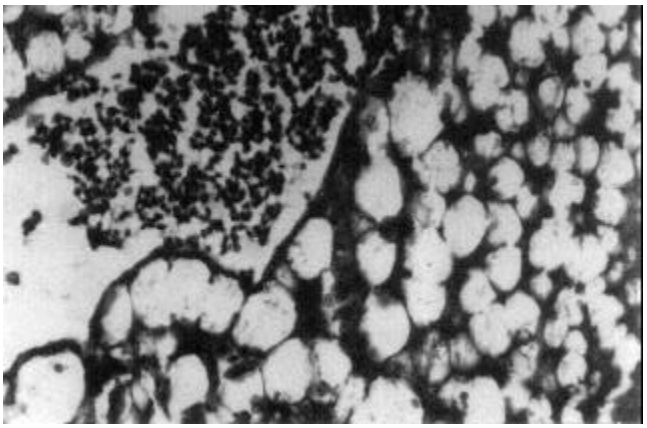


Fig. 9 : Section of liver showing clumping of hemocyte and their accumulation and vacuolation after expousure to Fenvalerate (540x)

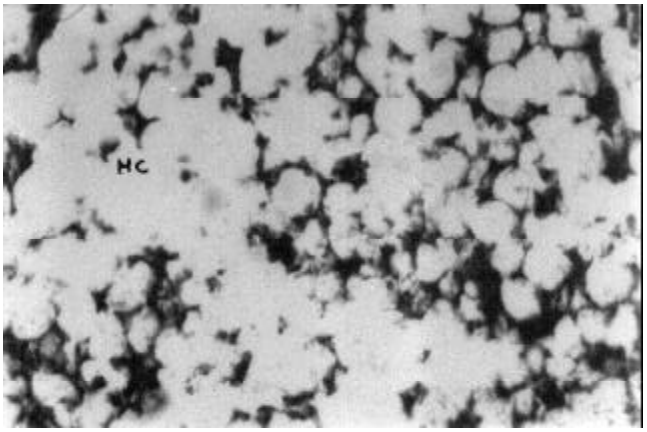


Fig. 10 : Section of liver fish showing degenration of blood vessels and hepatocytes (HC) after exposure to fencalerats (540x)

Liver is the chief metabolic and detoxicating organ and hence concentrates pesticides. This ultimately leads to its damage. Similar changes were noticed by Gaikwad (1981) and Gopi Leena (1988) on exposure of fish *Tilapia mossambica* and *Cyprinus Carpio* to fenthion and thiodan respectively. Bhatnagar *et. al*., (1994) observed necrosis, space formation and blood cell accumulation which is similar to the observations made in the present study.

All the changes in liver are duration dependent. Banerjee and Rajendra (1992) studied the effect of lethal and sub lethal concentration of dichlorvos in liver of *Clarias batrachus* and reported that the extent of damage to the liver depends on duration of exposure. They also found that long term exposure of fish to sub lethal concentration was to found to be more toxic and showed more histopathological changes.

The progressive histopathological changes in gill and liver of cypermethrin and fenvalerate exposed fish were almost similar.

REFERENCES

Anderson J. W. 1977 sublethal effects of petroleum hydrocarbons. In : proceeding of fate and effects of petroleum hydrocarbons in marine ecosystem and organs. Pergamon press, New York.

Benerjee G. Rajendra Nath T. 1992. Histopathological changes in the liver of C*larias batrachus* induced by an organophosphorus insecticide. J. Nature Connserv. 4(2): 75.

Bhatnagar M. C., A. K. Bana and Meenakshi Tyagi 1992 Respiratory distress to C*larias batrachus* exposed to endosulfan – a histopathological approach. J. Environ. Biol. 13(3) : 227.

Bhatnagar M. C., Tyagi Meenakshi, Bana A. K. 1994 Malathion poisoning to C*larias batrachus* a Histopathological study. Proc. Acad. Environ. Bio. 3(1), p. 119.

Dieter J. 1982 Histopathological and hematological studies on the cichlids, *Herotilapia multispinosa* and *Tilapia leucosticte* following organophosphate intoxication with lebaycid. Z. Angeio. Zool. 68(3), p. 257.

Gaikwad S. A. 1981. Toxicity studies with thiodan 35EC and phenyl mercuric acetate on *Tilapia mossambica*. Ph. D. Thesis, Univ. of Bombay.

Gopi Leena 1988. Chronic toxic effect of fenthion. The organophosphorus insecticide to common fresh water carp, *Cyprinus Carpio*. Ph. D. Thesis, Univ. of Bombay.

Hawkes J. W. 1977. The effects of petroleum hydrocarbon exposure on the structure of fish tissue. In : Fate and effects of petroleum hydrocarbons in marine organisms and ecosystems (Ed.) Douglas A. Wolfe Pergamon Press, New York p. 115.

Jauch D. 1979. Gill lesions in cichlid fishes after intoxication with the insecticide fenthion Experientia speciation 35(3), p. 371.

Padgaonkar A. S. and M. Arundhati Parab (1999) Histopathological changes in the fish, *Etroplus maculatus* after exposure to pesticides, rogor and sevin. Trends in Life Sciences. (India). 14(2), p. 85.

Rao P. K. and J. S. Munshi Datta 1991. Malathion induced structural and morphometric changes of gills of a fresh water major carp, *Cirrhinus mrigala*. J. Environ. Biol. 12(1), p. 79.

Sing S. R. and B. R. Sing 1979. Changes in oxygen consumption of siluroid fish, *Mystus vittatus* put to different concentrations of some heavy metal salts. Ind. J. Exp. Biol. 17, p. 270.

Vivitanam Marja T. *et al.*1986. Histopathological and ultrastructural change in gills of *Poecilla reticulates* induced by an organochlorine pesticide. J. Environ. Pathol. Toxicol. Oncol. 7(1/2), p. 73

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 156-158

METABOLISM IN ESTUARINE CLAM – *KATELYSIA OPIMA* UPON HEAVY METAL STRESS

S.N.Kumbhar * , D.V.Muley #, Sameer Terdalkar * and A.S.Kulkarni *
* Department of Zoology, Gogate Jogalekar College, Ratnagiri.
# Department of Zoology, Shivaji University, Kolhapur.

ABSTRACT: The effect of cadmium chloride induced toxicity have been observed in estuarine clam *Katelysia opima* inhabiting Bhatye estuary Ratnagiri Seasonal variation of biochemical constituents under cadmium chloride toxicity was also observed.

Key words : Bhatye estuary, *Katelysia opima*, cadmium chloride toxicity

INTRODUCTION

Cadmium is highly toxic to man and has been implicated as possible causes of hyper tension, kidney ailments, Skeletal deformation etc. In marine organisms cadmium was first detected in the Scallop, *Pectin maximus* by Fox and Ramage [1930]. Some information are available on the cadmium content of marine fish from industrialised countries [Harvey *et. al.* 1973; Penden *et al.,*1973; Windom *et al.,* 1973]

Considering the ecological and economic importance of the estuarine clam *Katelysia opima* inhabiting Bhatye estuary at Ratnagiri, it was considered worthwhile to analyse the toxic stress of cadmium chloride on body metabolism under laboratory conditions during different seasons.

MATERIALS AND METHODS

Clam collection was made at low tide at Bhatye estuary Ratnagiri once in a season, approximately on the same week of season. Clams of medium size were selected (28 to 30 mm, in Shell length). Soon after collection clams were kept in filtered estuarine water for 48 hours for their acclimation. Groups of 10 clams were kept in plastic bucket containing five liter filtered estuarine water. Each group was subjected to different concentrations of $CdCl_2$ for determination of LC_0 and LC_{50} values for that particular season. After determination of toxic doses, clams were treated with particular lethal and sublethal concentrations of $CdCl_2$ for 96 hrs. along with control. After 96 hrs. each group animals were dissected and tissues were blotted by filter paper to remove excess moisture. They were weighed and dried in an oven adjusted to 100^0C ($+5^0$C) until a constant weight was obtained. Tissues were powdered with pestle and mortar. Oven dried tissue powder was used for biochemical analysis. Various tissues (gill, mantle, hepatopancreas, gonad and foot) of live animals from both the species were analysed for total glycogen (De Zwaan and Zandee, 1972), proteins (Gornal *et al*., 1949) and lipids (Barnes and Blackstock, 1973). The data obtained was statistically analysed for confirmation of results.

During different seasons, water parameters like surface water temperature, pH, salinity and dissolved oxygen were determined.

Results : The results are shown in Tables 1 to 4.

Table 1 : Estuarine water parameters of Bhatye Estuary, Ratnagiri during 1998-99.

SEASON	SURFACE WATER TEMPERATURE ^{0}C	RAINFALL (mm)	SALINITY ppt.	pH	O_2/ml/l
MONSOON	Min. 24.5	-	4.3	6.1	4.7
(JULY)	Max. 31.3	146.5	6.2	8.0	6.6
	Avg. 26.1	34.39	5.2	7.29	5.0
WINTER	Min. 19.9	-	26.1	7.0	3.7
(DEC)	Max. 33.1	0.2	31.7	9.9	5.2
	Avg. 25.5	0.006	30.36	8.5	4.3
SUMMER	Min. 24.0	-	33.7	6.8	2.4
(APRIL)	Max 33.2	-	35.9	9.1	4.4
	Avg. 26.9	-	35.2	8.1	3.5

Table 2: CADMIUM CHLORIDE INDUCED ALTERATIONS IN THE TOTAL GLYCOGEN (mg/100mg) CONTENT OF *K. opima* (Result expressed in dry flesh wt basis)

TISSUE	SEASON	CONTROL	LC_0	LC_{50}
GILL	SUMMER	10.412	08.746 (-16.00)	07.913
	MONSOON	09.996	09.163	08.330
	WINTER	09.579	09.524	08.746
MANTLE	SUMMER	24.157	20.406 (-15.52)	17.076 (-26.48)
	MONSOON	25.823	21.658 (-16.12)	17.909 (-30.64)
	WINTER	24.573	25.406	19.159
HEPATOPANCREAS	SUMMER	11.245	12.078	13.328 (18.52)
	MONSOON	09.163	14.161 (54.54)	12.911 (40.90)
	WINTER	12.078	13.744	12.078
GONAD	SUMMER	16.660	12.911 (-22.50)	10.412 (-37,50)
	MONSOON	18.326	13.744 (-25.00)	10.829 (-40.90)
	WINTER	20.406	15.410	12.078
FOOT	SUMMER	23.740	22.491	19.992 (-15.78)
	MONSOON	24.990	23.740	21.658 (13.33)
	WINTER	31.237	24.573 (-21.33)	22.907 (-26.73)

Values in parenthesis are percentage

Table 3 : CADMIUM CHLORIDE INDUCED ALTERATIONS IN THE PROTEIN CONTENT (%) OF *K. opima* (Result expressed in dry flesh wt basis)

TISSUE	SEASON	CONTROL	LC_0	LC_{50}
GILL	SUMMER	20.758	20.982	43.526 (-111.26)
	MONSOON	19.642	19.866	20.535 (4.52)
	WINTER	20.312	20.089	42.410 (108.79
MANTLE	SUMMER	24.330	25.446	24.553
	MONSOON	23.245	24.107	33.482 (44.03)
	WINTER	22.767	23.660	22.321
HEPATOPANCREAS	SUMMER	06.25	06.473	08.258 (32.12)
	MONSOON	06.026	06.696	07.589 (25.93)
	WINTER	05.133	06.026	06.696 (30.45)
GONAD	SUMMER	40.178	36.383 (-9.44)	35.267 (-11.93)
	MONSOON	39.285	37.05 (-04.54)	36.383 (-0.38)
	WINTER	38.612	37.946	36.383
FOOT	SUMMER	51.339	49.107 (-4.34)	42.410 (-17.39)
	MONSOON	47.321	44.642 (-5.66)	42.857 (-09.43)
	WINTER	48.437	44.196 (-08.75)	42.410 (-12.44)

Values in parenthesis are percentage

Table 4 : CADMIUM CHLORIDE INDUCED ALTERATIONS IN THE LIPID CONTENT (%) OF *K. opima*
(Result expressed in dry flesh wt basis)

TISSUE	SEASON	CONTROL	LC_0	LC_{50}
GILL	SUMMER	07.378	09.520 (29.03)	06.168
	MONSOON	09.282	09.758	7.616 (-17.948)
	WINTER	08.092	10.234 (26.470)	06.902 (-14.705)
MANTLE	SUMMER	06.426	04.998 (-22.22)	04.920
	MONSOON	08.568	07.854	06.902 (-19.44)
	WINTER	6.902	07.400	06.426
HEPATOPANCREAS	SUMMER	05.474	09.282 (69.56)	04.760 (-13.04)
	MONSOON	07.854	08.568 (09.90)	05.920 (-24.64)
	WINTER	06.664	08.806 (32.14)	05.474 (-17.85)
GONAD	SUMMER	09.044	08.092	06.426 (-28.94)
	MONSOON	10.234	09.044	07.854 (-23.25)
	WINTER	09.520	08.806	06.902
FOOT	SUMMER	11.662	09.996	10.452 (-10.37)
	MONSOON	07.140	07.040	06.426 (10.00)
	WINTER	09.758	09.282	09.520

Values in parenthesis are percentage

CONCLUSION

Variation in biochemical reserves in control group is related with environmental parameters and spawning period of clam *Katelysia opima* in Bhatye estuary shows two periods of gametogenesis (Oct-Nov, Jan-March) (Nagabhushanam & Mane, 1974). The salinity and temperature data (Table 1) shows that during monsoon when river water enters the estuary, salinity decreases due to influx (July). It has been observed that rate of water filtration and metabolic activity decreases during monsoon because for the majority of period valves remained closed in low salinities. During December and April *Katelysia opima* receives favourable environment. Glycogen and lipid contents are at peak during winter. Protein is abundant during summer.

Experimental clams showed slight decrease in glycogen content at both the concentrations in different seasons in all tissues except hepatopancreas. As campared to control, protein content was increased considerably in gill, mantle and hepatopancreas, while in gonad and foot it decreases in all the seasons. Gonad and foot of treated clams showed decrease in lipid content in LC_0 and LC_{50} group. Gill and hepatopancreas showed slight increase in lipid in LC_0 group and considerable decrease in LC_{50} group.

The present results showed that at the initial stage of cadmium chloride stress the clams tried to overcome the situation by manipulating biochemical composition but due to continuous exposure they can not cope with the surrounding and ultimately die.

REFERENCES –

A O A C. 1990 Official Methods of Analysis. Association of official analytical chemicals, Washington D.C. (U.S.A.)

Barnes H. and J. Black Stock. 1973. Estimation of lipids in marine animals, detail investigation of sulfovanillin method. Jou. of Mar. Biol. Ecol.

De Zwann A & Zandee D.I. 1972 Comp. Biochem, physiol, 43 A : 58

Gornal E.V. 1949. Estimation of proteins in marine animals, Jou. of Mar. Biol. Ecol. 10:88-97

Harve, G N Underdal, B and Christiansen 1973 O I KOS, 24 : 155

Masumoto S and Hibino, M. 1932 J. Sci. Hiroshima Univ. A2 : 158

Peden, J D., J. H. Crothers, and C.E. Waterfall [1973] Mar. Poll. Bull. 4: 7

R. Nagabhushanam and U.H. Mane 1974. Ind. J. of Mar. Sci Vol 4,

R. Nagabhushanam and U.H. Mane 1975June, Ind. J. of Mar. Sci, 88-92

Windom H, Stickney, R, White D and Taylor, F 1973 J Fish Res. Bull. Can 30, 275

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 159-161

ALTERATIONS IN THE Na^+, K^+ CONTENTS OF THE TISSUES OF THE MARINE EDIBLE CLAM, *MARCIA HIANTINA* (LAMARCK) EXPOSED TO FENTHION.

Sathe M.C.* and Shrotri R.V.**
*K.J. Somaiya College of science and Commerce, Vidyavihar, Mumbai 400077.
** Retired Reader, Elphinstone College, Mumbai 400032.

ABSTRACT : Variations in Sodium and potassium ion levels were studied in selected body parts such as gills, mantle, digestive glands, foot and posterior adductor muscles of *Marcia hiantina* (Lamarck) after exposure to sublethal concentrations (0.02,0.12 and 0.22 mg/L) of fenthion for 15 days. Sodium and potassium levels declined in almost all the tissues of the exposed clams. The decrease in these ions was greater in the clams exposed to 0.12mg/L and 0.22mg/L fenthion

Keywords : *Marcia hiantina,* fenthion, Sodium and potassium ion level.

INTRODUCTION

Different species of bivalve molluscs have been used as bioindicators during the "Mussel Watch" programmes of different countries for monitoring the marine pollution caused by organochlorine residues (Matcus and Renfrow, 1990; Ramesh *et al*., 1990). In 1992 Carvalho *et al*. reported that though organophosphorus insecticides are generally considered as non-persistent group of pesticides they remain in the sediment for a long time and thus may be harmful to the animals like clams, which remain buried in the mud-sediment most of the time. Fenthion is an organophosphorus insecticide that gives excellent control of resistant flies, mosquitoes, tick and lice and a variety of crop pests (Matsumura, 1976; Babu, 1992). The present investigation was therefore undertaken to assess the effect of sublethal exposure to fenthion on the Na^+ and K^+ contents in the tissues of the clam *Marcia hiantina*. *Marcia hiantina* (Lamarck) (Mollusca: Pelecypoda) is a very common edible clam inhabiting the backwaters and estuaries on the west coast of India and forms an important part of shellfish fishery.

MATERIALS AND METHODS

Clams (*Marcia hiantina*) of more or less uniform size (3 to 4 cm) and weight (11 to 13 gm with shell) were acclimated to the laboratory conditions for a period of 2 days in sea water with Salinity 29 %o±1, temperature 28° C±2, pH 7.6±0.2 and dissolved oxygen 6.6±0.4mg/ L. These conditions were maintained the same during the experiment. A static bioassay technique was followed. The clams were then exposed to 3 sublethal concentrations of fenthion for 15 days. A control tank was also maintained simultaneously throughout the test period in which fenthion was replaced by acetone. The tests were carried out in glass aquaria of the size 37x22x22 cm. each containing 1 litre of seawater. Aliquots of fenthion stock solution (100mg/100ml) were added to the tanks so as to obtain desired exposure concentrations (0.02, 0.12 and 0.22 mg/L). The aquarium seawater was replaced in the morning and evening with appropriate addition of fenthion dose to maintain the static concentration. Ten clams were maintained in each tank. No special food was given to the animals during the experiment as these animals thrived well under laboratory conditions, perhaps on microfood items present in seawater. Clams were exposed to the three sublethal concentrations of fenthion for 15 days. At the end of the exposure period the clams were sacrificed to obtain gills, mantle, digestive glands (hepatopancreas) and posterior muscles, which were then used to estimate sodium and potassium ion contents. The tissues were digested in 1:1 (v/v) concentrated perchloric acid and nitric acid and evaporated (Dall, 1967). The residues were dissolved in double distilled water and levels of sodium and potassium ions were determined with a flame photometer (Elico Pvt. Ltd. Model CL 22A). Standard graphs were prepared by using sodium and potassium chloride solutions. Data were expressed as mean± standard deviation (SD) and analysed using Student's 't' test.

RESULTS AND DISCUSSION

Results presented in Table 1 and 2 and figures 1 and 2 demonstrate the changes in the sodium and potassium levels in the various tissues of *Marcia hiantina* (L) exposed to the three sublethal concentrations (0.02, 0.12 and 0.22 mg/L) of fenthion for fifteen days.

Sodium and potassium levels declined in almost all the tissues studied. The decrease in these ions was greater in the clams exposed to 0.12 and 0.22 mg/L fenthion than in clams exposed to0.02 mg/L fenthion. A marked decrease (50 %) in Na^+ and K^+ was observed in mantle of clams exposed to 0.12 and 0.22 mg/L fenthion. In all other body parts of clams exposed to 0.12 and 0.22 mg/L the decrease in Na^+ and K^+ was about 20 to 35 % (Table 1, 2 and Figure 1, 2).

Table 1: Changes in Sodium ion (Na^+) content (mg/gm) in different tissues of M. hiantina exposed to sub-lethal concentration of Fenthion for 15 days

Exposure Concentration (mg/L)	Sodium ion (Na^+) content in different tissues of M. hiantina (mg/gm)				
	Gill	Mantle	Digestive gland	Foot	Posterior Adductor muscle
Control (0.00)	4.37 ± 0.31	3.97 ± 0.29	2.95 ± 0.3	3.31 ± 0.35	4.60 ± 0.27
0.02	4.30 ± 0.28 (- 1.67 %)	3.43 ± 0.27 (- 13.52 %)	2.44 ± 0.25 (- 17.24 %)	2.94 ± 0.27 (- 11.16 %)	4.19 ± 0.34 (- 9.00 %)
0.12	4.03 ± 0.20 (- 7.85 %)	1.96 ** ± 0.18 (- 50.64 %)	2.09 ** ± 0.18 (-29.07 %)	2.20 ** ± 0.25 (- 33.46 %)	3.44 ** ± 0.27 (- 25.25 %)
0.22	3.28 ** ± 0.18 (- 25.05 %)	1.97 ** ± 0.15 (- 50.32 %)	2.00 ** ± 0.12 (- 32.42 %)	2.15 ** ± 0.19 (- 35.07 %)	3.63 ** ± 0.14 (- 21.23 %)

Values are mean ± SD of 5 determinations, Values in parenthesis indicate % change over control
* = P < 0.05, ** = P < 0.01

Table 2: Changes in Potassium ion (K^+) content (mg/gm) in different tissues of *M. hiantina* exposed to sub-lethal concentrations of Fenthion for 15 days

Exposure concentration (mg/L)	Potassium ion (K^+) content in different tissues of *M. hiantina* (mg/gm)				
	Gill	Mantle	Digestive gland	Foot	Posterior Adductor muscle
Control (0.00)	3.00 ± 0.25	3.08 ± 0.31	4.51 ± 0.29	4.06 ± 0.28	3.13 ± 0.35
0.02	2.72 ± 0.23 (- 9.34 %)	2.36 * ± 0.25 (- 23.42 %)	3.73 ± 0.28 (- 17.24 %)	3.85 ± 0.25 (- 5.18 %)	2.63 ± 0.29 (- 16.0 %)
0.12	2.52 ± 0.27 (- 15.98 %)	1.52 ** ± 0.14 (- 50.55 %)	3.27 ** ± 0.21 (-27.51 %)	2.87 * ± 0.16 (- 29.37 %)	2.17 ** ± 0.16 (- 30.66 %)
0.22	2.35 * ± 0.16 (- 21.75 %)	1.52 ** ± 0.16 (-50.64 %)	3.20 ** ± 0.12 (-29.07 %)	2.70 ** ± 0.25 (- 33.46 %)	2.34 ** ± 0.13 (-25.25 %)

Values are mean ± SD of 5 determinations, Values in parenthesis indicate % change over control
* = P < 0.05, ** = P < 0.01

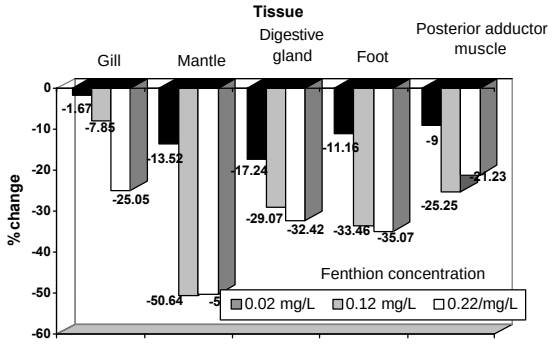


Fig.1: Percent variation over control in Na^+ content of tissues of *M. hiantina* exposed to Fenthion

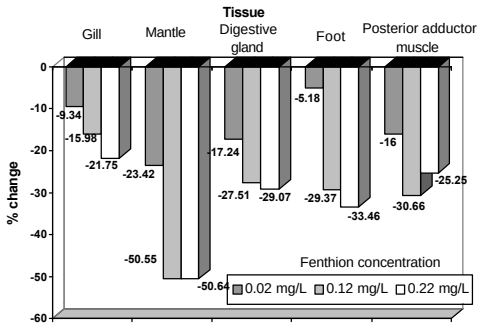


Fig. 2: Percent variation over control in K^+ content of tissues of *M. hiantina* exposed to Fenthion

The major functions of sodium in the animal body appear to be in connection with osmotic- pressure regulation and acid- base balance, although other functions such as catalytic effect on enzyme activity cannot be excluded (Hawk *et al*., 1965).

Potassium is the major base of the body cells and apparently subserves in the cells the same general function relating to osmotic pressure regulation and acid-base balance that have already described for sodium in extracellular fluids of the body. It has been shown that potassium helps in the enzymatic transfer of phosphate from ATP to pyruvic acid, and undoubtedly has a role in a number of basic cellular enzymatic reactions (Hawk *et al*., 1965).

In the present study loss of sodium and potassium ions varied greatly in the different body parts of the clams exposed to fenthion indicating variable response of these body parts. These findings are similar to those reported in the tissues of freshwater mussel, *Lamellidens marginalis* exposed to methyl parathion for 24, 48 and 72 hours (Moorthy *et al*., 1984). They found that changes in ionic content in general were parallel with the changes in oxygen consumption as a function of time during methyl parathion exposure. Gopi (1992) reported decreased oxygen consumption in fish, *Cyprinus carpio* on exposure to fenthion. In lamellibranch molluscs, decrease in oxygen consumption or in tissue respiration on exposure to various pesticides has been reported by Mane *et al*., 1983, Mane *et al*., 1984 and Moorthy *et al*., 1984. Therefore it appears that in *M. hiantina* decrease in these ionic contents could be parallel to the decrease in the oxygen consumption resulting in reduced energy production, which in turn may affect the energy dependent transport of ions and the water permeability system during fenthion exposure.

The changes in the levels of sodium and potassium ions in the gills, mantle, digestive gland, foot and posterior adductor muscles of *M. hiantina* could be correlated to the differential permeability properties of the cell membranes of different cells to maintain electrolyte balance during toxic stress. Changes in the ionic content of the tissues could lead to changes in the activity of enzymes and also decrease in glycogen content of the test animal (Kabeer Ahmad *et al*. 1978, Sreenivasa moorthy *et al*. 1983).

CONCLUSION

On the basis of these observations it appears that fenthion is responsible for the depletion of Na + and K + in the tissues of *M. hiantina*. These changes suggest changes in osmotic regulation, respiration and activity of enzymes in the test animal.

REFERENCES

Babu C. J. (1992): Vector borne diseases of human beings and their management in India; pp. 118-124. In: "Pest Management and Pesticides: Indian Scenario" (Ed.) B. Vasantharaj David, Namratha Publications, 1992, pp-384.

Carvalho F. P., Fowler S. W., Readman J. W. and Mee L. D. (1992): Pesticide residues in tropical coastal lagoons: Use of 14C labeled compounds to study the cycling and fate of agrochemicals. IAEA - SM - 325/106.

Dall W. (1967): Hypo-osmoregulation in Crustacea. Comp. Biochem. Physiol. 21: 653-678.

Gopi L. (1992): Chronic toxic effects of fenthion - the organophosphorus insecticide to common freshwater carp *Cyprinus carpio* (Linn). Ph.D. Thesis, Univ. of Bombay.

Hawk P. B., Oser B. L. and Summerson W. H. (1965): Hawks Practical Physiological Chemistry. 14th Edition, ed. B. L. Oser McGraw - Hill Book Company, Inc. New York, Toronto, London.

Kabeer Ahmad I., Begum Md. R., Sivaiah S. and Rao K. V. R. (1978): Effect of malathion on free amino acids, total proteins, glycogen and some enzymes of pelecypod *Lamellidens marginalis* (Lamarck). Proc. Indian Acad. Sci. 87B (Animal Sciences 4) No. 12, pp. 377-380.

Mane U. H., Akarte S. R. and Muley D. V. (1984): Effect of cythion - malathion on respiration in three fresh water bivalve molluscs from Godavari river near Paithan. J. Environ. Biol. 5 (2): 71-80.

Mane U. H., Muley D. V. and Akarte S. R. (1983): Toxicity of Endosulfan 35EC to freshwater and estuarine bivalve - Acute toxicity and oxygen consumption. Ind. J. Comp. Anim. Physiol. 1 (2): 1-9.

Matcus J. M. and Renfrow R. T. (1990): Pesticides and PCBs in South Carolina estuaries. Mar. Pollut. Bull. 21, 96-99.

Matsumura F. (1976): Absorption accumulation and elimination of pesticides by aquatic organisms. In: Pesticides In The Aquatic Environment Editors M. A. Q. Khan, Plenum Press, New York & London, Pp 77-105.

Moorthy K. S., Reddy B. K., Swami K. S. and Chetty C. S. (1984): Changes in respiration and ionic content in tissues of fresh water mussel exposed to Methyl Parathion toxicity. Toxicol. Letters, 21: 287-291.

Ramesh A., Tanabe S., Subramanian A. N., Mohan D., Venugopalan V. K. and Tatsukawa R. (1990): Persistent organochlorine pesticides in Green Mussels from coastal waters of South India. Mar. Pollut. Bull. 21(12), 587-590.

Sreenivasa Moorthy K., Naidu M. D., Chetty C. S. and Swami K. S. (1983): Changes in Carbohydrate Metabolism in Tissues of freshwater mussel (Lamellidens marginalis) exposed to phosphamidon. Bull. Environ. Contam. Toxicol. 30: 219-222.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 162-166

PHYSIOLOGICAL STUDIES ON AN INTERTIDAL BLOOD CLAM *CARDITA ANTIQUATA* (LAM.) OF MUMBAI COAST

Meenakshi Narayankar Choudhary, B.G.Kulkarni and Ashok Jaiswar.
Department of zoology, The Institute of Science, Madame Cama Road, Mumbai-400032.

ABSTARCT : Mumbai coastal area being highly deteriorated at many sites of it, diversity loss is evident. Girgaon chowpatty coastal area, which is located at south Mumbai, is reeling under anthropogenic pressure. Most of the Girgaon chowpatty area is covered with litter and domestic sewage is heavily released into it. As a result, upper zone of the intertidal area of the chowpatty is unfertile. However, diversity of mollusks like gastropods and pelecypods are seen in this area, especially diversity of pelecypods is quite rich here.

Among pelecypods, the blood clam *Cardita antiquata*, found abundantly at Girgaon chowpatty coastal area. Present investigation reports seasonal variation in oxygen consumption, filtration rates and variation in tissue metabolites like glycogen, proteins and fats in hepatopancreas, adductor muscles and foot of the clam. The results indicate that the clam adjust to polluted environment by showing variation in its physiological mechanisms.

Keywords : *Mumbai, Intertidal area, Clam,* Cardita antiquata*, Oxygen Consumption.*

INTRODUCTION

Mumbai, the economic capital of India is situated at Latitude – 18^0 54¢ North and Longitude – 72^0 49¢ East on the West coast of India. Mumbai, one of the most industrialized and urbanized metropolises in India supports a population of near about 12.5 million. Therefore, 45 km. Coastal line of Mumbai is under heavy anthropogenic disturbance, due to enormous quantity of domestic and industrial effluent released into it. As a result, diversity loss and displacement of species habitat has been reported. However, at some places of Mumbai coastal area, still faunal diversity is reported. (Jaiswar, 2000). Girgaon chowpatty coastal area is one of the beaches in Mumbai, which shows plentiful diversity of mollusks in spite of its degraded conditions. Jaiswar (2000) reported 6 species of gastropods and 16 species of pelecypods at Girgaon chowpatty.

Cardita antiquata is one the bivalve species found substantially at muddy substratum of the middle and lower intertidal area at Girgaon chowpatty. Inspite of its abundance on polluted intertidal zones of Mumbai, attention has been not paid to assess physiological mechanisms present in *C. antiquata* to adjust to polluted surrounding. Moreover, during last millennium, considerable amount of data has been generated on physiological and biochemical aspects in various intertidal clams on east and west coast of India. (Narsimham, 1988). However, a scanty data pertaining to physiology of blood clams in general and on physiology of family Carditidae in particular is available. Therefore, during present investigation an attempt has been made to assess oxygen consumption, filtration rates and biochemical metabolites in the blood clam *C. antiquata* to fill up the major lacunae in ecological studies.

MATERIALS AND METHODS

Clams *C. antiquata* were collected during spring low tide from Girgaon chowpatty coastal area. After cleaning with sea water, *C. antiquata* were brought to the laboratory as a single stock and acclimated for 48 hours. During acclimattion, clams were kept in glass aquaria (20 x 15 x 15 cm), containing 10 clams and 2 liters of sea water. The sea water used for acclimation and experimentation had characteristics like salinity, 31.26 $\%_{0;}$ pH, 8.2; dissolved oxygen, 6.26 ml / l. and temperature, 24-25^0 C. After acclimation, the clams were processed for estimation of respiratory rates and filtration rates. The oxygen consumption of the clams was assessed by using respirometer and oxygen content was estimated by Winkler's method. Whereas the method of Cole and Hepper (1954), was followed for filtration rate measurements. For estimation of tissue metabolites, the clams were dissected out to obtain hepatopancreas, adductor muscles and foot. The Glycogen (Seifter *et al.*, 1980), Protein (Lowry *et al.*, 1951), and Lipid (Barns *et al.*, 1973), were estimated in hepatopancreas, adductor muscles and foot. Similarly, condition index and moisture content were also estimated by standard methods.

RESULTS

The data presented in Table Nos. 1 & 2 clearly indicate seasonal variation in oxygen consumption, filtration rate and tissue metabolites in *C. antiquata.* Table No. 1 shows seasonal variation in oxygen consumption where higher oxygen consumption is noted in post monsoon and in pre monsoon whereas during monsoon, slight depletion in oxygen consumption was noted. However, the variation noted in oxygen consumption in different season is insignificant. (Fig. 1).

Table No. 1:- Seasonal variation in O_2 consumption (ml / hr /gm body wet wt), Filtration rate (ml/lit), Condition Index (gm) & % Moisture in *Cardita antiquata.*

Sr.No.	Parameters		Premonsoon	Monsoon	Postmonsoon
1	Oxygen Consumption		0.0808 ± 0.96	0.0766 ± 1.90	0.0833 ± 1.19
2	Filtration Rates.	1 hr.	4.27 ± 0.18	2.65 ± 0.15	3.30 ± 0.13
		2 hrs.	2.75 ± 0.15	4.48 ± 0.17	4.51 ± 0.15
		3 hrs.	2.97 ± 0.12	4.74 ± 0.18	3.87 ± 0.19
3	Condition Index		29.33 ± 5.85	30.73 ± 5.14	30.28 ± 4.76
4	Moisture Content		60.16 ± 10.36	55.74 ± 11.07	61.46 ± 8.63

Values are mean (± SD) of 5 derivations.

Table 2 :- Seasonal variation in Glycogen (mg/gm), Protein(mg/gm) and Lipid(mg/gm), in *Cardita antiquata.*

Parameters	Tissue	Premonsoon	Monsoon	Postmonsoon
Glycogen	HP	32.32 ± 6.79	77.60 ± 10.54	49.10 ± 5.12
	AM	11.64 ± 3.16	16.75 ± 2.89	17.63 ± 3.86
	FOOT	15.24 ± 4.30	24.14 ± 3.17	10.37 ± 1.33
Protein	HP	21.25 ± 3.01	45.44 ± 3.22	28.18 ± 2.46
	AM	3.90 ± 2.27	23.09 ± 4.19	14.91 ± 2.12
	FOOT	14.74 ± 3.93	25.23 ± 2.55	22.07 ± 2.02
Lipid	HP	27.76 ± 5.35	41.09 ± 6.98	22.52 ± 4.38
	AM	6.05 ± 1.29	8.23 ± 1.33	9.39 ± 2.69
	FOOT	9.55 ± 1.55	6.62 ± 1.64	10.49 ± 1.61

Values are mean (± SD) of five derivations.

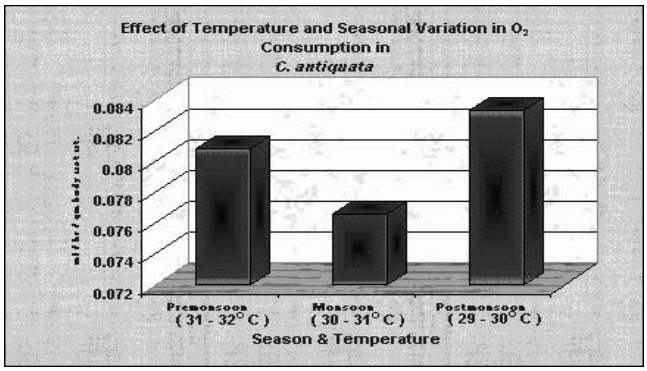
Initially, filtration rate was found more in pre monsoon and post monsoon than that of monsoon. However, after one hour, the higher filtration rate was noted in monsoon and post monsoon. The variation noted in filtration rates during pre monsoon and monsoon was significant. (Fig. 2).

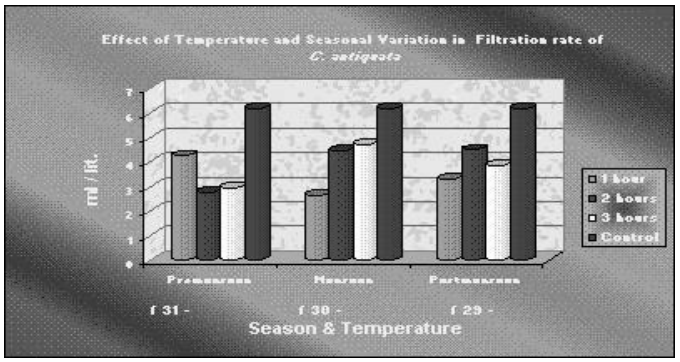
The condition index was found more or less uniform throughout the year in *C. antiquata*. (Fig. 3)

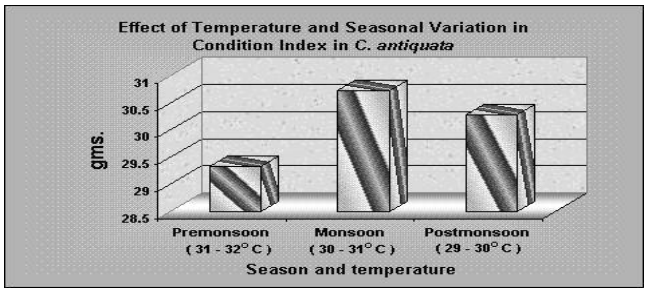
The higher moisture content in *C. antiquata* is noted in postmonsoon, which is followed by pre monsoon whereas significantly lower moisture content in *C. antiquata* was noted in monsoon. (Fig. 4)

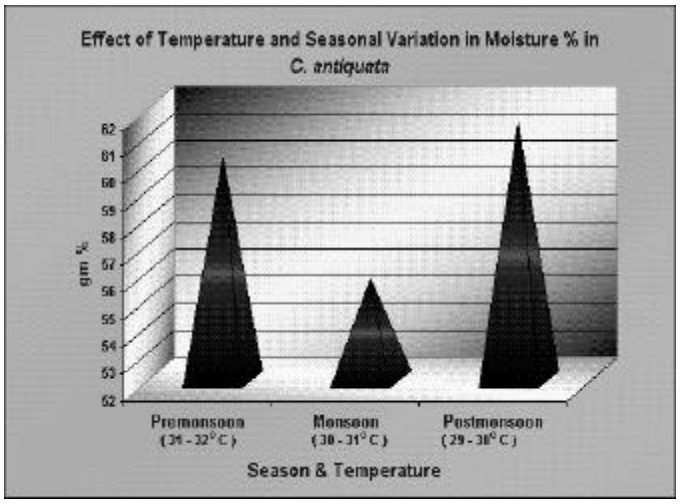
A significant variation was noted in glycogen of hepatopancreas, adductor muscles and foot in different seasons. During monsoon, highest glycogen content was noted in hepatopancreas.

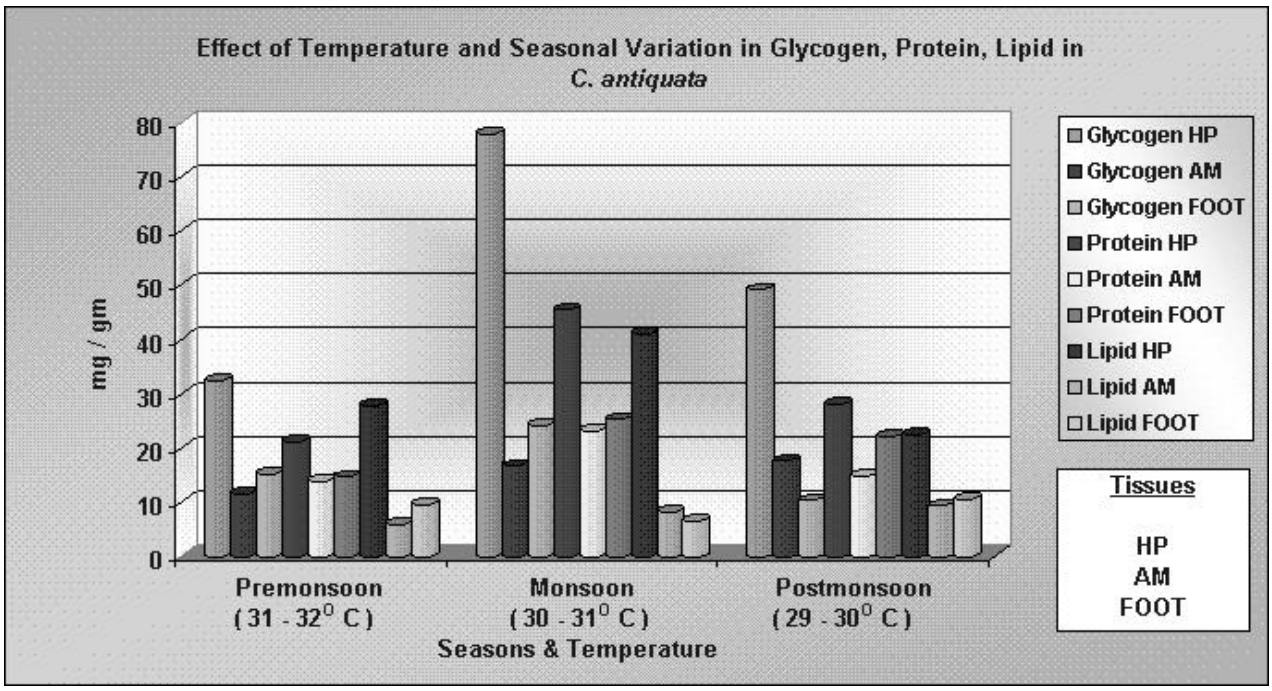
Glycogen in hepatopancreas and adductor muscles found decreased in the order of Pre monsoon < Post monsoon < Monsoon. Whereas, in foot, lowest glycogen content was noted in post monsoon. Similarly, highest


Effect of Temperature and Seasonal Variation in O_2 Consumption in
C. antiquata
0.084
0.082
0.08
0.078
0.076
0.074
0.072
Premonsoon (31 - 32° C)
Monsoon (30 - 31° C)
Postmonsoon (29 - 30° C)
Season & Temperature


Effect of Temperature and Seasonal Variation in Filtration rate of
C. antiquata
ml / hr.
1 hour
2 hours
3 hours
Control
Premonsoon
Monsoon
Postmonsoon
f 31 -
f 30 -
f 29 -
Season & Temperature


Effect of Temperature and Seasonal Variation in Condition Index in C. antiquata
gms.
31
30.5
30
29.5
29
28.5
Premonsoon (31 - 32° C)
Monsoon (30 - 31° C)
Postmonsoon (29 - 30° C)
Season and temperature


Effect of Temperature and Seasonal Variation in Moisture % in
C. antiquata
gm %
Premonsoon (31 - 32° C)
Monsoon (30 - 31° C)
Postmonsoon (29 - 30° C)
Season & Temperature


Effect of Temperature and Seasonal Variation in Glycogen, Protein, Lipid in
C. antiquata
mg / gm
80
70
60
50
40
30
20
10
0
Premonsoon (31 - 32° C)
Monsoon (30 - 31° C)
Postmonsoon (29 - 30° C)
Seasons & Temperature
Glycogen HP
Glycogen AM
Glycogen FOOT
Protein HP
Protein AM
Protein FOOT
Lipid HP
Lipid AM
Lipid FOOT
Tissues
HP
AM
FOOT

protein was noted in hepatopancreas during monsoon. Protein found decreased in hepatopancreas, adductor muscles and foot in the order of Pre monsoon < Post monsoon < Monsoon. A variation noted in lipid content was similar to that of protein variation in tissues of *C. antiquata* in different seasons where maximum lipid found in hepatopancreas during monsoon. (Fig. 5).

DISCUSSION

The variation noted in oxygen consumption, filtration rates and tissue metabolites like glycogen, protein and lipid at different season in *C. antiquata* during present investigation are in agreement with earlier reports. (Nagbhushanam and Mane, 1978; Walne, 1972; Ansell, 1975; Jaibal & Kalyani, 1986; Balsubramaniyan & Natarajan, 1988). These investigatiors have also reported variation in biochemical metabolites in various marine clams in different seasons. It has been shown that abundance of food, spawning cycle, spawning migration and age of shell fish affects the proximate composition in shell fishes. (Narsimham, 1988). An insignificant variation in oxygen consumption different seasons in *C. antiquata* indicates that overall energy demand by *C. antiquata* is uniform. Such insignificant variation in oxygen consumption in different seasons in various marine bivalves has been reported. A significant variation of filtration rates in *C. antiquata* during pre monsoon and monsoon can be correlated to breeding cycle of the clam. During preparatory phase of gametogenesis in monsoon, high water intake could have required for trapping more food, necessary for storage of energy released in the form of carbohydrates, proteins and lipids. Such higher energy reserve in tissues of the clam during monsoon clearly shows that relationship in between higher filtration rates and storage of energy reserve during monsoon. Similar elevated filtration rates observed during post monsoon might be necessary for excretion of matured gametes during spawning period.

Furthermore, an inverse relationship in between the water and other biochemical constituents like glycogen, protein and lipid has been reported in razor-shells and gastropods by Sarvaiya (1977). In *C. antiquata* also, such inverse relationship was observed with respect to water and other biochemical metabolites in different seasons. High levels of water in bivalves help them to survive under stressful conditions. (George and Gopakumar, 1995). Since, *C. antiquata* is present in polluted environment, high water content in the tissues in comparison with other biochemical constituents could be responsible for survival of *C. antiquata* in a polluted environment. Such high moisture content has also been reported in various marine clams. (George and Gopakumar, 1995 and Sarvaiya, 1977). Moreover, breeding cycle in clams is responsible for seasonal variation in its biochemical comparison. During present investigation, a high level of glycogen, protein and lipid in monsoon indicates a stage of gametogenesis that is preparatory phase or spawning. (Mane and Nagbhushanam, 1975; Bayne, 1976). Whereas, depletion in biochemical constituents during post monsoon shows spawning of the *C. antiquata* during this period. Jaibal, (1994) has reported high biochemical composition during maturation period in the estuarine clam *Katelysia opima.* Whereas low level of biochemical constituents was reported in spawning period. Moreover, similar pattern of biochemical composition in different seasons in various marine bivalves has been reported. (Narsimham, 1988; Nagbhushanam and Deshmukh, 1974).

CONCLUSION

The results of present investigation can be concluded as-

1) Insignificant seasonal variation of oxygen could be the result of uniform overall energy demand.

2) Higher rate of filtration rates in monsoon and post monsoon that that of pre monsoon could be necessary for preparatory phase and spawning of gametes.

3) Biochemical constituents like Glycogen, protein and fats in tissues of *C. antiquata* vary as per breeding cycle of the clam.

REFERENCES

Alagarswami, K. and K.A. Narsimhan. 1973. Clam, cockle & oyster resources of the Indian coasts. Proc. Symp. Living Resources Seas around India, C.M.F.R.I. Special Publication, 648-658.

Ansell, A. D. 1975. Seasonal changes in biochemical composition of the bivalve, *Lima hians*, from the Clyde Sea area. Aquatic Sciences and Fisheries Abstracts: 5(4).

Balsubramanyan K. and R. Natarajan. 1988. Seasonal variations in the Biochemical Composition of *Meretrix casta* (Chemnitz) occurring in Vellar Estuary. C.M.F.R.I. Bulletin-42: 184-186.

Bayne, B. L. 1976. Aspects of reproduction in bivalve mollusks. In: Wiley, M. (ed). Estuarine Processes, 1. Academic Press, New York.

George Chinnamma and K. Gopakumar. 1995. Biochemical & Microbiological studies on clam *Villorita cyprinoids*. J. Mar. Biol. Ass. India: 37 (1& 2): 27-30.

Jaiswar, A. 2000. Intertidal biodiversity with reference to Mollusca in and around Mumbai. Ph.D. Thesis. University of Mumbai.

Jayabal R. 1994. Biochemical studies in the estuarine clam *Katelysia opima* from Vellar Estuary. J. Mar. Biol. Ass. India. 36 (1&2): 303-304.

Jayabal, R. and M. Kalyani. 1986. Biochemical studies in the hard clam *Meretrix meretrix* (L) from Vellar estuary, east coast of India. Indian J. Mar. Sci. 15: 63-64.

Joshi, M.C. and D. V. Bal 1965. Obeservations on the chemical composition of the clam *Katelysia marmorata* Lamarck J. Zool. Soc., India, 17: 108-113.

Lowry, O.H., N.J. Rosenbrough, A.L. Farr, and R.J. Randall. 1951. Protein measurement with Folin-Phenol reagent. J. Biol. Chem. 193: 265-275.

Mane, U.H. and R. Nagbhushanam. 1975. Body distribution & seasonal changes in the biochemical composition of the estuarine mussel *Mytilus viridis* at Ratnagiri, Riv. Indrabiol. 14(3): 163-175.

Nagbhushanam, R. and U.H. Mane. 1978. Seasonal variation in the biochemical composition of *Mytilus viridis* at Ratnagiri, on the west coast of India. Hydrobiologia. 57- I: 69.

Nagbhushanam, R. and R. S. Deshmukh 1974. Seasonal changes in body components indices and chemical composition in the estuarine clam *Meretrix meretrix* (L). Indian J. Mar. Biol. Ass. 21: 531- 542.

Narsimham, K. A. 1988. Biology of the blood clam *Anadora granosa* (Linnaeus) in Kakinada Bay. J. Mar. Biol. Assoc. India: 30 (1&2): 137-150.

Sarvaiya, 1977."Saurashtra Molluscs". Physical & chemical studies of mollusks in the intertidal & deeper water of the Gulf of Kutch & the Northern-Western Region of Saurashtra. C.M.F.R.I. P: 18-36.

Seifter, S, S. Dayton, B. Noovic, and Muntwyler, 1950. Estimation of glycogen with anthrone reagent Arch. Biochem. 25: 191-200.

Walne, P.R. 1972. The influence of Current speed, body size & water temperature on filtration rate of 5 species of bivalves. J. Mar. Biol. Assoc. U.K. 52: 545-374.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 167-169

CADMIUM LEVEL IN COASTAL AREAS OF MUMBAI AND ITS TOXICITY TO INTERTIDAL CLAMS

B.G.Kulkarni, Shriprasad Kerkar, Delphine Pereira
Department of Zoology, The Institute of science, Mumbai-400032.

ABSTRACT : Coastal area in and around Mumbai receives enormous quantity of domestic and industrial waste. As a result organic and inorganic pollutants show an increasing trend in it. Among the heavy metals detected in coastal waters of Mumbai, appreciable level of cadmium was recorded.

The present investigation shows $2.08x10^{-3}$ug/ml and 12.9ug/ml cadmium level in water and sediment respectively at Nariman Point coastal area. Therefore acute toxicity of cadmium to intertidal clams *Gafrarium divaricatum, Katleysia opima* and *Meretrix casta,*

Was analyzed by using static bioassay method. These studies revealed that the LC_{50} of Cadmium for 96 hours to the clams varied in-between 0.16-0.80 mg/lit. Furthermore it is found that:

1. *G.divaricatum* and *M.casta* were more sensitive to the cadmium than *K.opima.*
2. 96 Hours LC_{50} of cadmium to the clams indicate that *G.divaricatum* is more sensitive to the cadmium than that of *M casta* and *K. opima.*
3. Comparison of 96 hours LC_{50} to that of 24,48 and 72 hours show that as the period of bioassay test prolonged low concentration of cadmium was found to be more toxic to the clams.

Key words : *Cadmium toxicity, Intertidal clams* Gafrarium divaricatum, Katleysia opima *and* Meretrix casta*, Mumbai Coastal area.*

INTRODUCTION

Hydrosphere holds a prime position in the biosphere, as it is a precious resource, vital for sustenance of human population. However, at present major portion of river, lake and underground water is becoming useless due to pollution. The ocean covering 71% of the earth surface posed a formidable challenge for man exploration and exploitation. With the help of technological advances, man invaded the ocean and explored it mercilessly for its wealth without sparing a though towards the protection of the fragile ecosystem of the ocean. Thus, oceans, which were though to be resilient to any level of human insult, got, damaged so much so that they are now crying out for help and attention. Examples of Baltic, Black, Mediterranean and Caspian Sea illustrate the magnitude of environmental changes taking place in the marine environment. Moreover, degradation of the marine environment has not been limited in the industrialized world but more data on pollution of seas and oceans from developing countries in tropical and subtropical part of the world is also coming to the forefront. The dream of a world fed by the oceans abundance has been replaced by the reality of stagnant oceans, shrinking wetlands, coral reefs and mangroves and falling catches that jeopardize a key source of protein for the worlds poor. Indian coast is also not free from abuse of pollution. The data on Arabian Sea also indicate the deterioration of the coastal region and some parts of the open sea (Qasim 1991). Among the anthropogenic chemicals identified in the marine environment, following pesticides and PCBs, heavy metals rank second as potential hazard to the marine life. Despite that since the beginning of geological time, heavy metals in trace amount have been normal constituent of the oceans, at present additional quantities of metals are being added to the marine environment from various anthropogenic sources.

Sea around Mumbai is one of the major sinks on the western peninsula of the Indian ocean, which receives voluminous amount of partially treated or untreated domestic and industrial effluent. As a result, an increasing trend of heavy metals above their background level has been detected in coastal ecosystem in and around Mumbai. (Borgaonkar and Gokhale 1992, Zingde and Govindan 1997) Cadmium, which is non-essential heavy metal, has been also found in excess at some part of Arabian Sea including Mumbai coast. (Borgaonkar and Gokhale 1992, Padgaonkar et al 1999). Since mussel watch programme, the clams found to be best indicators of heavy metal. (Goldberg 1974). Therefore, during present investigation cadmium level was monitored in Nariman point coastal area of Mumbai and acute toxicities of it were determined for intertidal clams, which are available at Mumbai coast.

MATERIALS AND METHODS

Nariman point coastal area. (NPC) is at extreme south of Colaba point, which encloses a small, shallow bay with mixed substratum of mud, sand, large pebbles and big stones? Cadmium level was monitored every month during 1999 - 2000 in surface water and sediment of this area. Standard methods were followed for collection of water and sediment samples. 200 ml of water sample filtered through 0.44 Millipore membrane filter was treated with ammonium pyrrilidine dithioarbamate and then extracted with mthylisobutyl ketone. The organic phase was processed for cadmium estimation on atomic absorption spectrophotometer (AAS). Whereas dried sediment sample after complete digestion in mixture of nitric and perchloric acid was processed far cadmium measurement on AAS.

The clams *Gafrarium divaricatum, Katelysia opima and Meretrix casta* collected during spring low tide from coastal areas around Mumbai were brought to the laboratory as a single stock. The clams were acclimated in the laboratory in glass aquaria (60x30x30 cm) for 48 hours. The seawater used during acclimation had salinity 30 to 31 ppt, dissolved oxygen 5.5 to 6.5 mg/l ph 7.7 to 8 .2 and temperature 27 to 29°C. The same water characteristics were maintained during acute toxicity experiments. After acclimation, the group of 10 clams size (32x30 mm) selected for bioassay experiments were kept in glass aquaria (20x15x15 cm) containing with three liters of seawater. The bioassay test was carried for 24, 48, 72 and 96 hours. The medium of clams was replaced daily with freshly collected seawater by adding appropriate dose of the cadmium. Stock solution of cadmium chloride was prepared in glass-distilled water and from the stock solution required aliquots were added to get the desired concentration of the metal. Mortality of experimental as well as of control clams was monitored after every 24 hours till 96 hours. The clams keeping valves open even after touching with glass rod were considered as dead. LC^{50} values were determined by graphical interpolation (Litchfield and Wilcoxon 1949)

RESUTLS

Cadmium level of 2.08x103m(µg/ml) and 12.9 (µg/gm) was detected in water and sediment at NPC coastal area during 19992000. (Table 1)

Table 1 Level of Cadmium in water and sediment of Nariman Point coast

Water(µg/ml)	Sediment (µg/g)
2.08 X 10^{-3} ± 3.12 x 10^{-4})	12.9 ± 1.09

Bivalves exposed to higher concentration of cadmium responded immediately by closing their shell valves. Clams remained closed for a period of 2 to 6 hours depending on the concentration of cadmium. Mucus secretion was also seen in the clams exposed to higher concentration of cadmium. The LC^{50} of cadmium for the clams presented in Table No. 2. The data therein shows that 1) *Gafrarium divaricatum* and *Meretrix casta* found more sensitive to the cadmium than that of *Katelysia opima.* 2) 96 hours LC^{50} of cadmium to the clam indicate that *G. divaricatum* is more sensitive to the cadmium than that of *M. casta* and *K opima* 3)Comparasion of 96 hours LC50 to that of 24, 48 and 72 hours shows that as the period of bioassay test was prolonged, low concentration of cadmium found to be more toxic to the clams.

Table 2 LC50 Value of Alue of Cadmium in different Interdial, Bivalbes.

Bivalve	Method	24 hrs.	48 hrs.	72 hrs.	96 hrs.
G. divaricatum	LC50 (mg / L)	1.20	0.80	0.60	0.16
	95% CI	(1.17-0.83)	(1.92-0.33)	(1.32-0.27)	(0.34-0.07)
	Slope F	1.43	2.40	2.20	2.16
K. opima	LC50 (mg / L)	1.80	1.50	1.20	0.80
	95% CI	(1.89-0.58)	(1.87-1.20)	(1.75-0.82)	(1.60-0.44)
	Slope F	1.12	1.56	2.14	4.00
M. casta	LC50 (mg / L)	0.99	0.80	0.60	0.44
	95% CI	(1.38-0.70)	(1.28-0.50)	(1.02-0.35)	(0.83-0.23)
	Slope F	2.16	2.79	3.29	4.50

DISCUSSION

Although NPC area is free from any industrial effluent discharge, a cadmium level of 2.08x10 3 (µg/ml) and 12.9 (µg/gm) was detected respectively in water and sediment. The present level of cadmium in NPC area shows an increasing trend as compared to earlier studies .The presence of cadmium at NPC can be attributed to transport of the metal from coastal area of Mahim, where high industrial effluent discharge is reported (Zingde and Govindan 1997). Moreover, physical and chemical processes of the sea could be one of the factors responsible for transport and settlement of it in the sediment of NPC coast.

Many investigators have shown that intertidal clams initially close their shell valves to avoid contact with the polluted surrounding when exposed to heavy metals. (Widdows and Donkin 1992). The results of the present investigation are also in agreement with the earlier reports. The higher mucus secretion by the clams after cadmium exposure may be providing some kind of protection for removal of accumulated cadmium.

The observed differences between 24 and 96 hours LC^{50} of cadmium to the clams can be explained on the basis of adaptability of the intertidal clams to stressful conditions. Marine bivalves when exposed to the stressful environment close their valves to avoid stressful environment. During present investigation also such behaviour by the clams was observed under cadmium exposure. Therefore, the entry of cadmium into the body through water current was avoided. However, after certain period lapse, clams were seen to open the valves with extended siphon for exchange of gases. Thus the clams came in contact with the surrounding medium for short time, during which accumulation of cadmium could have been possible at higher dose of cadmium. However, at lower dose of cadmium, clams were found to open the valves within short time interval after exposure with the result clams were in contact with polluted medium for a longer duration of 9 hours. Therefore, higher accumulation of cadmium must have taken place in the clams at lower dose of cadmium during 96 hours with the result mortality of clams at lower dose. Similar differences in between 24 and 96h hours LC^{50} have been reported (Akerbali and Trumen, 1984)

REFERENCES

Akerbali H.B. and Trumen E.R 1984. Effect of environmental stress on marine bivalve mollusks In Advances in marine biology (J.H.S.Blaxter *et al* eds) 22:102 - 183

Borgaonkar S.S. and Gokhale K.S. 1992. Distribution of copper, zinc, cadmium and lead in Thane creek and its relation with textural types and organic carbon. J. Environ. Biol. 13 (1) : 39 - 45

Goldberg E.D. 1974. The mussel watch A first step in global marine monitoring. Mar. Poll. Bull. 4: 111

Litchfield, J.T. and Wilcoxon, F. 1949. A simplified method for evaluation dose effect experiment. J. Phar. Exp. Therap. 96: 99-113.

Jaiswar, A.K. 1999. – Intertidal biodiversity with reference to mollusca in and around Mumbai. Ph. D. Thesis University of Mumbai.

Zingde, M.D. and Govindan, K. 1997. Health status of the coastal waters of Mumbai and regions around. Proceedings of seminar on coastal cities in India, responding to environmental and socio-economical issues concerned. July16, 1997, Organized by Indira Gandhi Institute of Developmental Research, Mumbai – 65, India.

Qasim S. Z. 1991. Ocean Pollution, of far reaching implications In The Hindu Survey of Environment 101 - 113

Padgaonkar S.B., Pawar R.B. and Sawant A.D. 1999. Monitoring of marine sediment for lead and cadmium during Ganapati festival A case study, In Proceeding of National symposium on Ecophysiological and conservation of aquatic resources,

Widdows J and Donkin P.L. 1992. Acute toxicity of some heavy metals on the Mytilus edulis community. Bull. Environ. Contam. Toxicol 43: 312 -317

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 170-174

TOXIC EFFECTS OF HEAVY METALS (LEAD, COPPER) ON ACIDPHOSPHATASE AND ALKALINE PHOSPHATASE IN THE INTERTIDAL CRAB *SCYLLA SERRATA*

K. M. Pariya* and B.B. Sharma
*Department of Zoology, B. N. Bandodkar College of Science, Thane: 400601
Department of Zoology, KET'S V.G.Vaze College, Mulund (E), Mumbai: 400081

ABSTRACT : The in vivo effects of lead and copper (heavy metals) on the activity of Acid phosphatase and Alkaline phosphatase from the haemolymph (serum), muscles and hepatopancreas of crab Scylla serrata, the common edible Indian crab were studied. Toxicity was tested individually in laboratory using seawater. One set of crabs was exposed to lead ($PbCH_3COOH$; 370 ppm) and second set of crabs was exposed to copper ($CuSO_4$; 5 ppm) for 7 and 14 days respectively.

After 7 and 14 days the enzyme was extracted from the above-mentioned tissues and was assayed to calculate the specific activity per 0.1 mg of protein.

The study revealed that:

1. The reduction in activity of the enzymes Acid phosphatase and Alkaline phosphatase was seen to be more when the animals are exposed to lead and the reduction was less in the copper treated crabs, showing that lead is more potent than copper.

2. In both the cases, i.e. lead treatment and copper treatment, it is seen the reduction in enzyme activity was more in 14 days treatment as compared to the enzyme extracts from 7 days treated animals.

Key words: *Lead – Copper – ALP – ACP–* Scylla serrata

INTRODUCTION

In recent years the role of metals in causing environmental pollution has been recognized and gaining significance. Many of these metals occur in trace amounts are essential to the normal metabolism of aquatic organisms. However, industrial effluents are discharged into water bodies which contaminate the water systems where they poison or smother the aquatic organisms. Toxic metals are extremely lethal for living beings.

Decapod crustaceans form an important component of aquatic biota and are found in aquatic environment ranging from both fresh to brackish to marine waters. Crustaceans such as crabs, prawns and lobsters form an important group of important seafood items. Humans consume crabs being edible. Crab is an intertidal animal, so it is more likely to be affected by industrial effluents that are released in seawater. Few reports on the effects of metals and their accumulation in adult decapod crustaceans are available. The present study is an attempt to evaluate the effects of heavy metals such as copper, lead on *Scylla serrata,* the common edible Indian crab.

Enzymes are the catalysts virtually controlling all the metabolic activities in the living organisms. They are synthesized within the living cells and act either intracellularly or extracellularly. Some of the enzymes are regarded as marker enzymes as they are localized exclusively in one of the intracellular compartments. The marker enzyme analysis is based on the principle that one enzyme is only associated with one particular morphological constituent of the cell.

Acid phosphatase is a lysosomal enzyme and is used as index for the tissue damage. Serum alkaline phosphatase helps to measure the bone and liver disfunction.

According to Varley (1976) the extent of the rise in serum activity of these enzymes depends not only on the concentration of enzyme on the tissues and the extent to which the organ is damaged but also on the rate at which the enzyme escapes from the damaged tissue, the location of the enzyme in the cells, changes in permeability of cell membranes and the rate at which enzyme is removed from the serum either by metabolism or by renal excretion. In addition, cellular activity changes with variations in environmental parameters such in poikilotherms. (Hochachka and Somero, 1973).
Metal copper is basically non-toxic however, excessive amount is toxic. Copper is an essential element controlled by efficient homeostasis. When introduced into the body is removed only by cell death. Metal lead has numerous commercial applications due to its physical properties and relative chemical inertness. It is highly toxic as the inorganic or organic compounds.

Acid phosphatase and alkaline phosphatase enzyme assays were carried out from the haemolymph, muscles and hepatopancreas of crab for 7 days and 14 days exposure.

Observations were made on the specific activity of the enzymes in the treated *Scylla serrata.*

MATERIALS AND METHODS

MAINTENANCE OF ANIMALS

Crab *Scylla serrata* brought from Mulund market, Mumbai; were maintained in seawater in laboratory for a minimum period of one week prior to sacrificing for experiments. Test containers were holding 1 liter of seawater (temperature 26.5^{0}C – 29.5^{0}C, pH 8.0 to 8.1) and a single animal per tank. Male crabs measuring 30 – 40 mm in carapace length and 50 – 60 mm carapace breadth were used throughout. Crabs were used at intermoult stage. Crabs were fed on chopped prawns daily. The following metal compounds were selected for toxicity studies. Lead acetate ($PbCH_3COOH$) 370 ppm and copper sulphate ($CuSO_4$) 5 ppm. The addition of metal causes no change in pH. All test jars were rinsed with dilute H_2SO_4 and dilute HNO_3 between tests to prevent any possible accumulation of metal residues. Animals were starved one day prior to and during the toxicity exposure. Enzyme assays were carried out for 7 and 14 days exposure.

In Vivo *study*

For toxicity studies Pb and Cu were selected individually for 7 and 14 days exposure. We considered the following points in selecting the sub lethal concentration of metals opposed to levels, which would be considered realistic.

· On continuous low-level exposure of these metals may result in higher body concentration due to bioaccumulation.

ENZYME EXTRACTION

The enzymes, acid phosphatase and alkaline phosphatase were extracted from crab tissues such as; hepatopancreas, muscles and haemolymph. The hepatopancreas and muscles were quickly dissected out and washed with 0.6% NaCl containing 0.1% EDTA in order to remove blood. The haemolymph removed from thoracic legs and chelate legs with aseptic syringe. Anticoagulant used was sodium citrate. The haemolymph diluted to prepare 1:10 w/v 0.9% NaCl.The hepatopancreas and muscles were homogenized in an electrical homogenizer to prepare 1:10 w/v 0.9% NaCl. The enzyme activity assayed by the spectrophotometric 'P' nitro phenyl phosphate method by using the oxidizing agent potassium ferry cyanide forms an orange – red coloured complex which is measured at 510 nm. Protein content and % extraction of enzyme protein were estimated for acid phosphatase and alkaline phosphatase by the method of *Lowry et. al.* represented in terms of $\triangle A$*I* 0.1 mg of protein.

RESULTS AND DISCUSSION :

The results obtained after exposure to different metal compounds are summarized below.

The initial experiments were carried out to establish the basic parameters such as pH, temperature time and protein concentration. The maximum activity for the acid phosphatase and alkaline phosphatase enzymes were at pH 7.5. The activity of both these enzymes were maximum at room temperature.

Further experiments to evaluate the effect of substrate concentration on the activity of two enzymes from the control as well as experimental sets of animals was carried out at the optimum levels of the parameters mentioned above.

The results obtained were analyzed by calculating the specific activity per 0.1 mg of protein.

Table 1(a) reveals that, on 7 days lead exposure

EFFECT OF CU AND PB ON ALKALINE PHOSPHATASE AND ACID PHOSPHATASE (7 Days Exposure)

Table 1(a)

ALKANINE PHOSPHATASE			
TISSUES	Control	7 Days Exposure	
		Cu	Pb
Hepato Pancreas	0.382 100%	0.26 68%	0.18 47%
Muscles	0.099 100%	0.089 90%	0.060 61%
Haemolymph	0.066 100%	0.050 76%	0.031 47%

Table 1 (b)

ACID PHOSPHATASE			
Tissues	Control	7 Days Exposure	
		Cu	Pb
Hepato Pancreas	0.361 100%	0.205 57%	0.177 49%
Muscles	0.096 100%	0.050 52%	0.034 35%
Haemolymph	0.055 100%	0.044 80%	0.029 53%

EFFECT OF Cu AND Pb ON ALKALINE PHOSPHATASE AND ACID PHOSPHATASE (14 Days Exposure)

Table 2 (a)

ALKALINE PHOSPHATASE			
TISSUES	Control	14 Days Exposure	
		Cu	Pb
Hepato	0.382	0.18	0.16
Pancreas	100%	47%	42%
Muscles	0.099	0.080	0.040
	100%	81%	40%
Haemolymph	0.066	0.042	0.030
	100%	64%	45%

Table 2 (b)

ACID PHOSPHATASE			
Tissues	Control	14 Days Exposure	
		Cu	Pb
Hepato	0.361	0.159	0.152
Pancreas	100%	44%	42%
Muscles	0.096	0.042	0.027
	100%	44%	28%
Haemolymph	0.055	0.032	0.024
	100%	58%	44%

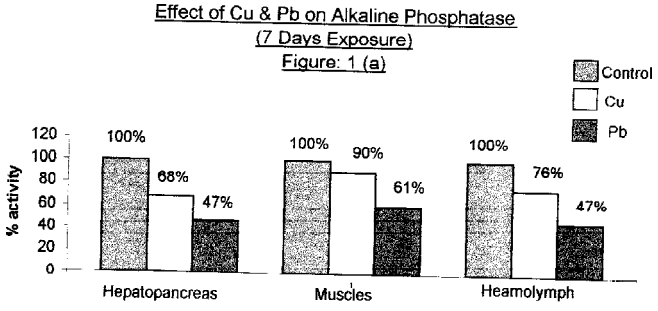
to crab, alkaline phosphatase enzyme activity in hepatopancreas is seen to be 47%, muscles 61% and haemolymph 47%. However, 7 days copper exposure to crab, alkaline phosphatase enzyme activity in hepatopancreas was seen to be 68%, muscles 90% and haemolymph 76%.

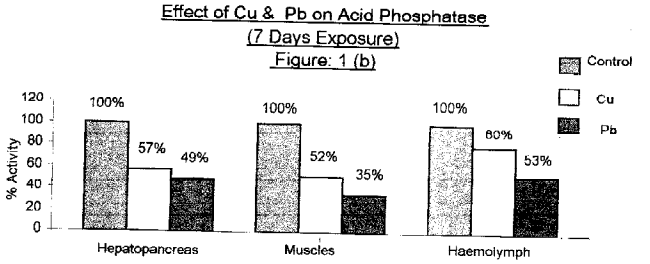
Table 1(b) reveals that, on 7 days lead exposure to crab, acid phosphatase enzyme activity in hepatopancreas seen to be 49%, muscles 35% and haemolymph 53%. However, 7 days copper exposure to crab, acid phosphatase enzyme activity in hepatopancreas seen to be 57%, muscles 52% and haemolymph 80%.

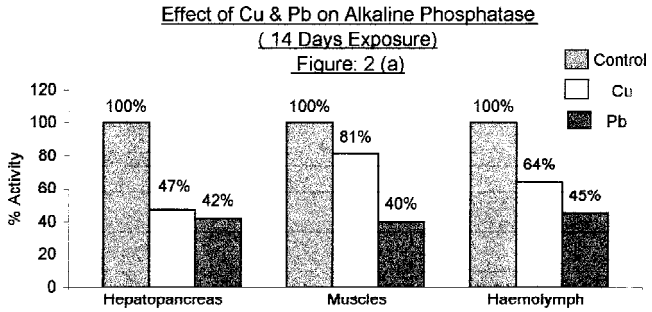
Table 2(a) reveals that, on 14 days lead exposure to crab, alkaline phosphatase enzyme activity in hepatopancreas seen to be 42%, muscles 40% and haemolymph 45%. However, 14 days copper exposure to crab, alkaline phosphatase enzyme activity in hepatopancreas seen to be 47%, muscles 81% and haemolymph 64%.

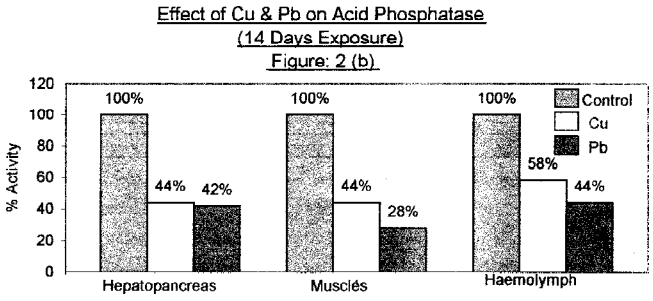
Table 2(b) reveals that, on 14 days lead exposure to crab, acid phosphatase enzyme activity in hepatopancreas seen to be 42%, muscles 28% and haemolymph 44%. However, 14 days copper exposure to crab, acid phosphatase enzyme activity in hepatopancreas seen to be 44%, muscles 44% and haemolymph 58%.

From the scrutiny of the above tables it can be concluded that, 7 and 14 days lead exposure to crab shows more reduction in alkaline phosphatase and acid phosphatase enzymes activities a 7 and 14 days copper exposure to crab in all above mentioned tissues. Hence, lead is more toxic a copper. The results in terms of % enzyme activity are depicted in figures; 1 (a), 1 (b), 2 (a) & 2(b).









EFFECT OF CU ON ALKALINE PHOSPHATASE AND ACID PHOSPHATASE
(7 & 14 Days Exposure)

Table 3 (a)

ALKALINE PHOSPHATASE			
TISSUES	Control	Cu	
		7 days Exposure	14 days Exposure
Hepato	0.382	0.26	0.18
Pancreas	100%	68%	42%
Muscles	0.099	0.089	0.080
	100%	90%	81%
Haemolymph	0.066	0.050	0.042
	100%	76%	64%

Table 3 (b)

ACID PHOSPHATASE			
Tissues	Control	Cu	
		7 days Exposure	14 days Exposure
Hepato	0.361	0.205	0.159
Pancreas	100%	57%	442%
Muscles	0.096	0.050	0.042
	100%	52%	44%
Haemolymph	0.055	0.044	0.032
	100%	80%	58%

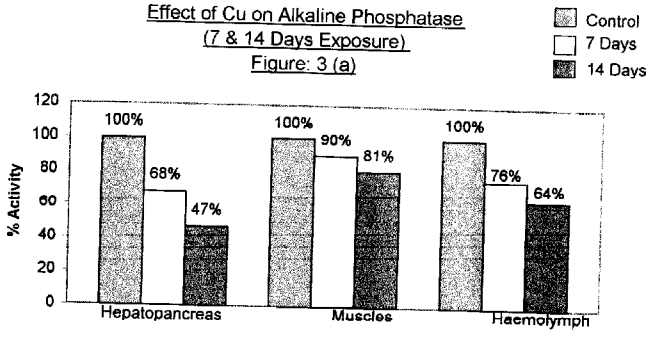
EFFECT OF PB ON ALKALINE PHOSPHATASE AND ACID PHOSPHATASE
(7 & 14 Days Exposure)

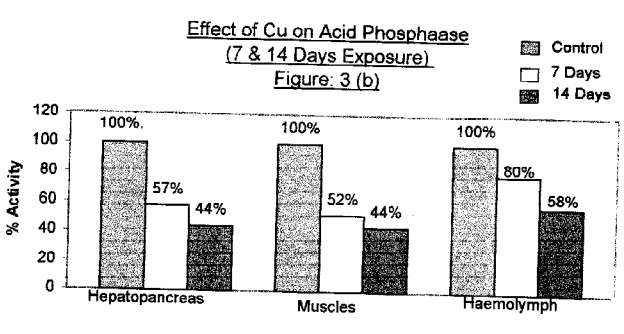
Table 4 (a)

ALKALINE PHOSPHATASE			
TISSUES	Control	Pb	
		7 days Exposure	14 days Exposure
Hepato	0.382	0.18	0.16
Pancreas	100%	47%	42%
Muscles	0.099	0.060	0.040
	100%	61%	40%
Haemolymph	0.066	0.031	0.030
	100%	47%	45%

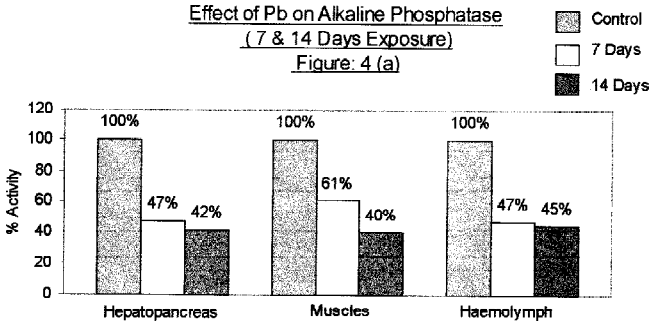
Table 4 (b)

ACID PHOSPHATASE			
Tissues	Control	Pb	
		7 days Exposure	14 days Exposure
Hepato	0.361	0.177	0.152
Pancreas	100%	49%	42%
Muscles	0.096	0.034	0.027
	100%	35%	28%
Haemolymph	0.055	0.029	0.024
	100%	53%	44%

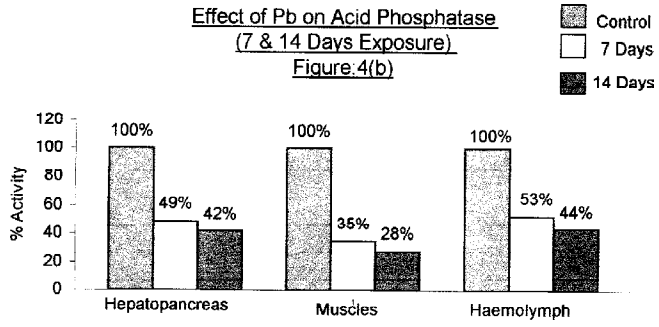




Effect of Pb on Alkaline Phosphatase
(7 & 14 Days Exposure)
Figure: 4 (a)



Effect of Pb on Acid Phosphatase
(7 & 14 Days Exposure)
Figure:4(b)



Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 175-176

EFFECT OF NAPHTHALENE ON LACTATE AND SUCCINATE DEHYDROGENASE OF MALEESTURINE CRAB, *SCYLLA SERRATA.*

K.Durgabhavani, K.Vijayavel and M.P.Balasubramanian
Department of Pharmacology and Environmental Toxicology
Dr. ALM Post Graduate Institute Of Basic Medical Sciences
University of Madras, Taramani, Chennai 600 113.

ABSTRACT : Naphthalene is a polycyclic aromatic hydrocarbon (PAH), which is less sensitive photoxydation. The molecular weight is low when compared to other PAH and therefore more persistent in water. A number of workers have studied the effect of chemical pollutants on the physiology of crustaceans, but no detailed information is available regarding the impact of naphthalene on dehydrogenase enzyme system. The present study deals with the effect of naphthalene on lactate and succinate dehydrogenase enzymes in muscle and testes of intermolt estuarine edible crab *Scylla serrata*.

Keywords *: Naphthalene toxicity,* Scylla serrata, *dehydrogenase, LDH, SDH.*

INTRODUCTION

Xenobiotic compounds into the aquatic ecosystem by various sources viz, direct discharge, use, land runoff, atmospheric deposition, abiotic and biotic movement and food chain transfer etc. In the marine environment PAH are ubiquitous environmental contaminants and derive mainly from anthropogenic activities. Naphthalene is a non polar PAH with two benzene rings and occurs as a component of coal tar and is used as a chemical intermediate for the production of phthalic anhydride. It is found in a wide range of products including petroleum products, mothballs, preservatives, solvents and dyes and can be released to the aquatic environment by means of discharges or spillages from the chemical and petroleum industries, atmospheric fall outs etc

Though a number of workers have studied the effect of chemical pollutants on the physiology of crustaceans, no detailed information is available regarding the impact of xenobiotics on biochemistry of *Scylla serrata*. Therefore it is of interest to study the effect of naphthalene on tissue lactate and succinate dehydrogenase enzymes of male intermolt crab *Scylla serrata.*

MATERIALS AND METHODS

Intermolt male *Scylla serrata* were colleted from the Kovalam, near Chennai. They were maintained in the laboratory in large glass aquaria with seawater. The volume of aquarium water was adjusted so that the individuals were just submerged. They were fed with fresh flesh of prawns. The water was changed daily and the crabs were acclimated to the laboratory conditions and feeding schedule for a period of one week. After the acclimation to the laboratory conditions, the crabs were divided in to two groups of five individuals each. Crabs belonging to group I were reared in naphthalene free-seawater and treated as control. Crabs belonging to group II were exposed to naphthalene at 100 mg l^{-1} concentration for 96 hrs.

The muscle and testis were separated from the control and exposed crabs. The tissues were washed in saline solution and five percent homogenates were prepared with distilled water. The homogenates were centrifuged at 5000 g for 10 minutes and the clear supernatant was used for the enzyme source. The lactate and succinate dehydrogenase enzyme activity was determined following the method of King (1965) and Slater and Bonner (1951) respectively. The protein content of the enzyme samples was determined according to the method of Lowry *et al*. (1951) using bovine serum albumin as standard. The enzyme activity was expressed as µ moles of lactate / succinnate produced / min / mg protein.

Results and Discussion

Lactate dehydrogenase (LDH) is a cytoplasmic enzyme that catalyses the oxidation of lactate to puruvate and *vice versa* and is a marker for membrane integrity and also plays major role for the regulation for many biochemical reactions in the body tissues and fluids. The results of the present investigation are presented in the Table – 1. The LDH activity was significantly elevated in muscle and testis of naphthalene exposed crabs at ($P < 0.01$, $P < 0.5$) respectively. This rise may be attributed to inadequacy of oxygen supply in cells to cope up with complete breakdown of carbohydrates (Seskin and Levin, 1947). Hence the elevated LDH in tissues of crab exposed to naphthalene may also be attributed to hypoxia, decreased oxygen consumptions and elevated lipidperoxidation (Rafiuddin Ahmed *et al*., 1997; Vijayavel *and Balasubramanian* 2002)

Table – 1: Activity of Lactate and Succinate Dehydrogenase activity in muscle and testes of *Scylla serrata* in control and naphthalene exposed crabs.

Tissues		Lactate Deyhdrogenase	Succinate Deyhdrogenase
Muscle	**Control**	42.42 ± 8.52	72.12 ± 7.92
	Exposed	76.39 ± 17 **	46 ± 8.4**
Testes	**Control**	28.39 ± 5.39	64.01 ± 2.52
	Exposed	56.42 ± 3.72*	35.42 ± 8.66*

Results are expressed as Mean ± SD of five individual observations. Asterisks indicate values which are significantly different from controls. NS – Not significant, * P < 0.05. ** P < 0.01, *** P < 0.001

Succinate deyhdrogenase is a gluconeogenic and TCA cycle enzyme. The SDH values were significantly lower when compared to control at the intervals of (P<0.01, P<0.05) respectively (Table – 1). This suggests the impairment of aerobic capacity of the tissues and accumulation of lactic acid in the muscle and testis of *Scylla serrata* may be due to the impairment in the aerobic capacity of tissues due to naphthalene stress. Similar to the present study lower activity of oxidative enzymes by chlorinated compounds (Timothy *et al*. 1974) as well as by organo phosphorous compounds (Ranaganatha and Ramamurthy 1978) has been observed in aquatic animals.

REFERRENCE

King, J 1965 b. The dehydrogenases are oxidoreductase lactate dehydrogenase in colon. Practical clinical enzymology. Van, D.(ed.) Norstand Company Limited London, pp. 83 – 93.

Lowry, O.H., Rosenbruogh, N.J., Tarr, A.I and Randall, 1951**. Protein Measurement with Follin phenol reagent**. J.Biol.chem.., 193 : 265 – 275

Rafiuddin Ahmed. M., Elumalai. M., EzhilarasiBalasubramanian S. and Balasubramanian, M.P. 1997. Individual and combined effect of copper and chromium on oxygen consumption and phosphatases of marine edible crab *Scylla serrata.* Biomedical Letters 55 :147 – 152.

Ranganatha, K.P. and Ramamurthi, R. 1978 **Effect of sumithion (fenitrothion) on some selected** *enzyme system in the fish Tilapia mossambicus.* (Peters); Indian J.Exp. Biol.16 : 809 – 810.

Seskin, S. and Levin, R. 1947 **Carbohydrate metabolism** (Illinios: University Press).

Slater, E.C. and Bonner, W.D. 1951 Succinate Dehydrogenase, Biochem.J., 52 : 182 – 196.

Timothy, P., Leedem, R., Campbell, D. and Jhonson, D.W. 1974. **Osmoregulalatry response of to DDT and varying salinities in** *Salmo gairdneri i.* Gill Na^+ ATP **ase :** Comp.Biochem. Physiol. 49 : 197 – 205.

Vijayavel, K and Balasubramanian, M.P. 2002 **Sublethal effect of naphthalene on antioxidants level during vitellogenesis of** *Scylla serrata.* Proceedings of XX National Symposium on Reproductive Biology and Comparative Endocrinology. pp 60 –61

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 177-

ELECTROPHORETIC STUDIES OF PHOSPHATASES AND NON-SPECIFIC ESTERASES IN THE ESTUARINE EDIBLE CRAB *SCYLLA SERRATA* WITH REFERENCE TO NAPHTHALENE STRESS.

K.Vijayavel, K.Durgabhavani and M.P.Balasubramanian
Department of Pharmacology and Environmental Toxicology
Dr. ALM Post Graduate Institute Of Basic Medical Sciences
University of Madras, Taramani, Chennai 600 113.

ABSRACT : Effect of sublethal concentration of naphthalene on phosphatases and esterases have been studied on estuarine edible crab *Scylla serrata*. Significant changes in these parameters were oberved during the naphthlene stress. Using Polyacrylamid gell electrophoresis (PAGE), the izozyme pattern of phosphatases and nonspecific esterases of different tissues have been studied. There were changes in the number of fractions of phosphatases and nonspecific esterases in the crabs under naphthalene stress when compared to control.

Key words : *estuarine edible crab* Scylla serrata, *naphthalene stress, phosphatases and nonspecific esterases.*

INTRODUCTION

Polycyclic aromatic hydrocarbons (PAH) are formed as a consequence of incomplete combustions of fossil fuels and are also components of crude oil and its refined products. They enter the marine environment via effluent discharges, urban runoff, atmospheric transport and the spillage or disposal of oil and petroleum products. As PAH are hydrophobic they tend to absorb to particulate material and to be deposited to the underlying sediments (Law and Biscaya,1994). They can accumulate in aquatic organisms reaching high levels than the ambient medium and affect normal functions of aquatic life. (Witt, 1995). Among the PAHs naphthalene is extremely toxic to aquatic organisms due to its low molecular weight, less sensitivity to photooxydation and its persistent nature in water (Neff, 1985). In addition naphthalene is considered to be the most toxic component of the water-soluble fraction of the crude and refined oils Elumalai *et al.* (1998)

Although many workers have studied the effects of xenobiotics phophatases and non specific esterases of crustaceans no detailed information is available regarding the electrophoretic studies these enzymes in *Scylla serrata* exposed to petroleum hydrocarbons particularly naphthalene. Hence it is of interest to study the electrophoretic patterns of the phosphatases and nonspecific esterases of estuarine edible crab *Scylla serrata* exposed to naphthalene.

MATERIALS AND METHODS

Intermolt females of *Scylla serrata* were colleted from the Kovalam Brackish water regions near Chennai. They were maintained in the laboratory in large glass aquaria with seawater. The volume of aquarium water was adjusted so that the individuals were just submerged. They were fed with fresh flesh of prawns. The water was changed daily and the crabs were acclimated to the laboratory conditions and feeding schedule for a period of one week. After the acclimation to the laboratory conditions, the crabs were divided in to two groups of five individuals each. Crabs belonging to group I were reared in naphthalene free-seawater and treated as control. Crabs belonging to group II were exposed to naphthalene at 100 mg l^{-1} concentration for 96 hrs.

SAMPLE PREPARATION

Fresh samples of ovary, hepatopancreas and muscle were collected and washed with distilled water to remove the adhering haemolymph and 10 to 20 mg of the tissues were homogenized in 40% sucrose and centrifuged at 1000g for 10 minutes to get the clear supernatant, which served as the enzyme source for electrophoresis. Disc gel electrophoresis was carried out as described by Balasubramanian *et al.* (1982) supplying a current of 3 mA per tube.

The acid phosphate fractions were separated on the PAGE and were detected by the formation of a coloured precipitate produced during the coupling reaction of the substrate with an organic dye. Sodium a naphthyl phosphate served as a substrate and the liberated naphthol by the enzyme couples with fast blue RR to give a coloured red precipitate. The alkaline phosphatase activity was localized with Sodium naphthyl phosphate as substrate (1 mg / ml) and fast blue RR as diazonium dye coupler (1 mg / ml) in 0.1 phosphate buffer at pH 8.0. The esterases were visualized by staining the solution containing 1% 1- naphthyl acetate and 1% fast blue RR in phosphate buffer at pH 7.0 at 37^0 C for 15 minutes. The gels were stained for ½ hr at 37^0 C and subsequently they were stored in 7% acetic acid. (V/V).

Fig I: Zymogram pattern of Acid Phosphatase, Alkaline Phosphatase and Non Specific esterases in Hepataopancreas of Control and naphthalene exposed crabs

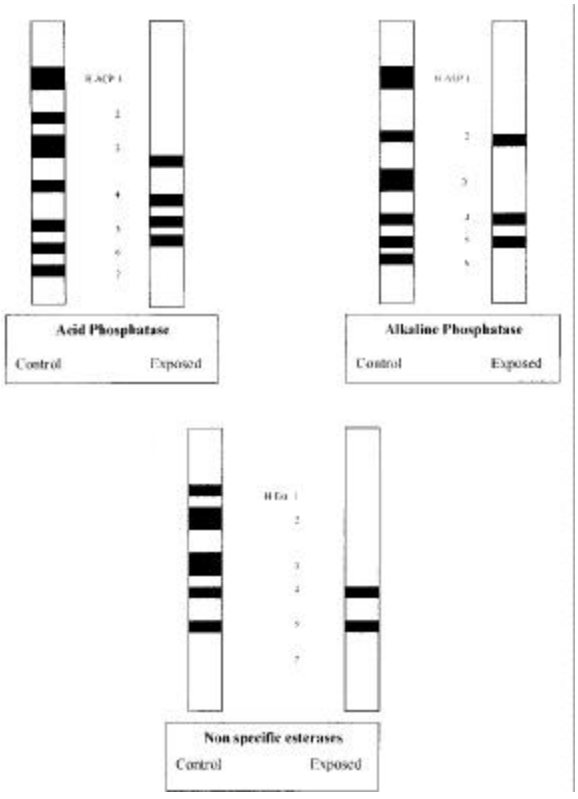


Fig 2 : Zymogram pattern of Acid Phosphatase, Alkaline Phosphatase and Non Specific esterases in Ovary of Control and naphthalene exposed crabs

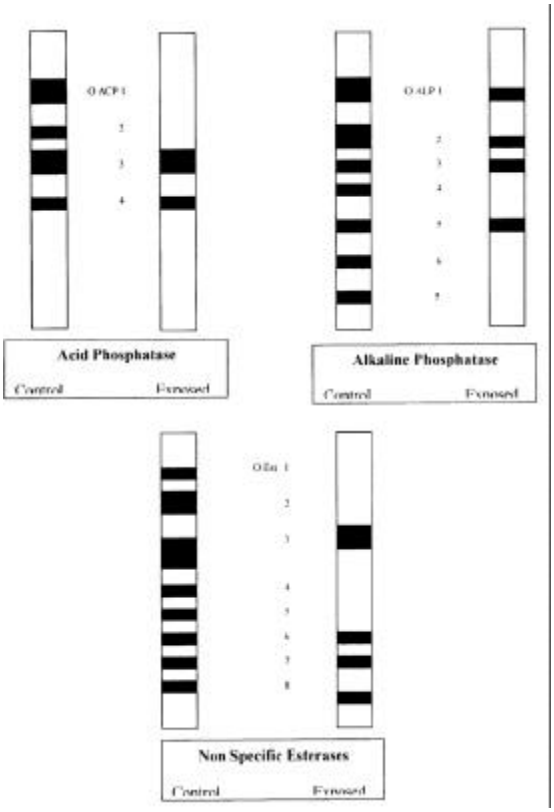
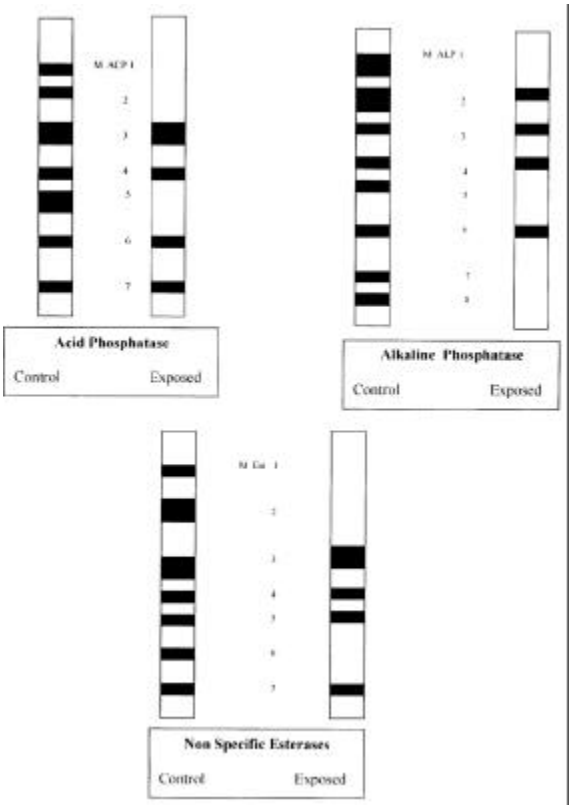


Fig 3 : Zymogram pattern of Acid Phosphatase, Alkaline Phosphatase and Non Specific esterases in Muscle of Control and naphthalene exposed crabs



RESULTS AND DISCUSSION

Phosphatase is a non-specific phosphomonesterase having a pH specificity that hydrolyses various phosphate esters and liberate phosphate. Acid and alkaline phosphatases are known to be distributed in various tissues. Acid phosphatase is a lysosomal enzyme, which hydrolyses the phosphorous esters in the acidic medium and thus is logical that the enzyme is hydrolytic in its function and acts as one of the several acid hydrolyses in the autolysis process of the cell after death. The alkaline phosphatase is a brush border enzyme which splits various phosphorous esters at alkaline pH and it is well known that it is involved in carbohydrate metabolism growth, protein synthesis, synthesis of certain enzymes, secretary activity and transport of phosphorylated intermediates across the cell membranes. The esterases are known to play significant role in the breakdown of lipids into a small chain of fatty acids thereby producing energy for other metabolic process. Administrations of pollutants are shown to alter phosphatases and esterases activity (Omkar 1985, Elumali *et al.* 1998.)

The electrophoretic analysis of ovary, hepatopancreas and muscle of *Scylla serrata* reared in naphthalene free medium revealed presence of four to seven fractions of acid phosphatase and six to eight fractions of alkaline phosphatase based on the mobility of enzyme fractions which were designated as O ACP 1 to O ACP 4, H ACP 1 to H ACP 6 and M ACP 1 to M ACP 7 and O ALP 1 to O ALP 7, H ALP 1 to H ALP 6 and M ALP 1 to M ALP 8,. The esterases showed the presence of at least five to eight fractions, which have been designated as O Est 1 to O Est 8, H Est 1 to H Est 5 and M Est 1 to M Est 7.

It is a known fact that when the crabs are exposed to xenobiotics organs like hepatopancreas, reproductive organs and the muscle are the most affected. The phosphatases and esterases patterns of ovary, hepatopancreas and muscle are shown in the figure 1, 2 and 3. The hepatopancreas showed four fractions of acid phosphatase i.e H ACP 3, 4, 5 and 6. For alkaline phosphatase the fractions were reduced to three viz; H ALP 2, 4 and 5, while the esterases showed only two fractions i.e H Est 4 and 5. The same trend of decline of enzyme fractions was also observed for ovary and muscle. The esterases of hepatopancreas, ovary and muscle of crabs reared in the naphthalene showed a reduction in their fractions. In hepatopancreas only three fractions were visualized i.e H est1, 3 & 4. The fractions O Est 1,2,3,4 and 5 were absent in the ovary, while the muscle showed only four factions viz, M Est 3,4,5 and 7 respectively.

The decrease in the number of fractions for alkaline phosphatase and acid phosphatase in the naphthalene exposed crabs might be due the fall in hydrogen ion concentration following the rupture of lysosomal membranes as suggested by Keshavan and Kamble (1984) which leads to the uncoupling of phosphorylation by the naphthalene toxicity. Similarly the decrease in the fraction number of esterases in the tissues may be due to the alteration in the lipid metabolism as result of naphthalene stress.

REFERRENCE

Balasubramanian, M.P., Nelliappan. K. and Rmamalingam, K. 1982 Characterization of esterase **izozyme of** *Raillietina tetrogona* (Molin 1858) Cestoda: Vet. Parasitol. 10 : 313 – 316.

Elumalai, M. and Balasubramanian, M.P. 1998 **Effect of naphthalene on phosphatases and esterases in muscle and ovary of Intermolt marine edible female crab** *Scylla serrata.* Water, Air and Soil Pollution. (In press)

Keshavan, R. and Kamble, S.M. 1984 Effect of sublethal concentration of Hildan on acid and alkaline phosphatase activity in hepatopancreas and muscle of fresh water cra**b, *P**aratelphusa guerrini.*** J. curr. Biosci. 4 : 145 - 148

Law, R.J. and Biscaya, J.L. 1994 Polycyclic aromatic hydrocarbons (PAH) Progress and process in sampling and interpretation. Marine Pollution Bulletin 29 : 235 – 241.

Neff, J.M. 1985 Fundamentals of Aquatic Toxicology, Ch. 14, pp : 416- 454, 1985. G.M Rand & S.R Petrocelli ed. Hemisphere Publ.Corp.

Omkar. 1985 Changes in acid and alkaline phosphatase activity of fresh water prawn, *Macrobrachium lamarrei* **exposed to aldrin**. Industrial Health. 23 :155 – 157.

Witt, G. 1995. Polycycic aromatic hydrocarbons in water and sediment of the Baltic sea. Marine Pollution Bulletin. 31 : 237 – 248.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 180-181

EFFECTS OF THE PESTICIDE MALATHION ON ACID PHOSPHATASE ENZYMES IN CERTAIN TISSUES OF THE MARINE CRAB UCA MARIONIS (DES) OF MITHBAV CREEK.

V. A. Koli, S. G. Yeragi and S. S. Yeragi
K. J. Somaiya College of Science, Vidyavihar, Mumbai – 400 077.

ABSTRACT :- The influence of organophosphate pesticide Malathion on the respiratory enzyme activity of the marine crab *Uca mariones* (Des) was studied. The important lysosomal enzyme acid phosphate was estimated in relation to pesticide stress. Acid phosphatase showed a significant decrease after the pesticide treatment. In present study the decrease in Acid phosphatase activity was observed in acute and chronic exposure due to decrease in the rate of transphophorylation.

Key Words *: Uca,* Malathion, Acid Phosphatase.

INTRODUCTION

Enzymes are organic cellular catalysts, which control the formation of biochemical components, which are indispensable to all normal physiological process. Pollutant can bring about changes in enzyme activity. Pesticide poisoning may cause physical disorders such as loss of locomotion, changes in feeding habit, abnormal behavior, reproductive disorder, suffocation due to coating of mucus on gills etc. whereas the long term effect could be a result of physiological alteration.

Crabs have shown the ability to adapt themselves in different types of habitats and depend on variety of organic matter as mean of obtaining metabolic energy, pesticides often find their way into the metabolic pathways as direct contaminant or indirectly due to accumulation in smaller organisms.

Pesticides are known for their strong action on the biological tissues. Pesticides once absorbed into the body by metabolic pathway or otherwise are capable of reacting with a variety of active binding sites and disturb the normal physiology of an organism irreversibly and ultimately lead to the death of the organism. Schmidt and Schmidt (1976), stated that the important poisoning effect on enzyme system depends on the capacity of toxicants to react with ligands essential for normal functioning of that system.

The enzyme acid phosphatase is a nonspecific hydrolase. This is an important enzyme widely spread in the animal kingdom. It is a lysosomal enzyme, which hydrolyses the ester linkage of phosphate esters and help in autolysis of the cell. This enzyme is concerned with the presence of transphosphoarylation and has an important role to play in the general energetics of an organism.

MATERIALS AND METHODS

The crabs *Uca mariones* (Des) were collected from the Mithbav Creek (Lat 16° 20' N, Long. 73° 25' E). The crabs were acclimatied to laboratory for seven days. The morphometrically similar crabs were exposed to median lethal concentration and sublethal concentration of pesticide for acute (0.0205 ppm) and chronic (0.008 ppm) treatment. Acid phosphatase activity was measured by the method of Gutman and Gutman (1990).

RESULTS AND DISCUSSION

The values of Acid phosphatase activity for acute treatment in gills, testes, ovaries, larger chelae muscle, smaller chelae muscle, and hepatopancrease of control crab were 42.570, 38.764, 33.976, 40.592, 36.253 and 32.251 µ moles of Formazan / mg protein / hr respectively. There was a reduction in the activity of Acid phosphates after acute exposure of the crab *Uca mariones* (Des) in the above tissues ranging from -3.811% over control in hepatopancrease for 24 hr. exposure, to -26.253% over control in larger chelae muscle for 96 hr. exposure. The decrease in Acid phosphates activity was found to be significant at P<0.5, P<0.01 and P<0.001. The comparative aspects is shown in Fig. 1 and 2.

Fig.1 & 2 : Effect of Malathion on Acid phosphatase activity in GIlls, Testis, Ovaries, Larger chelae muscle, Smaller chelae, Hepatopancrease of *UCA marionis* (Desmarest) in acute exposure

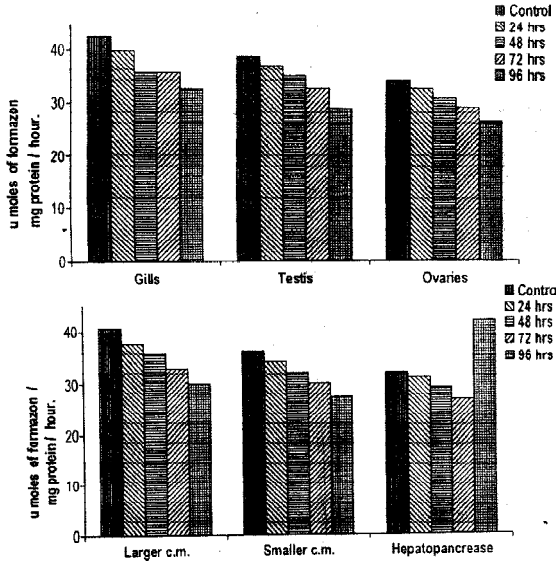
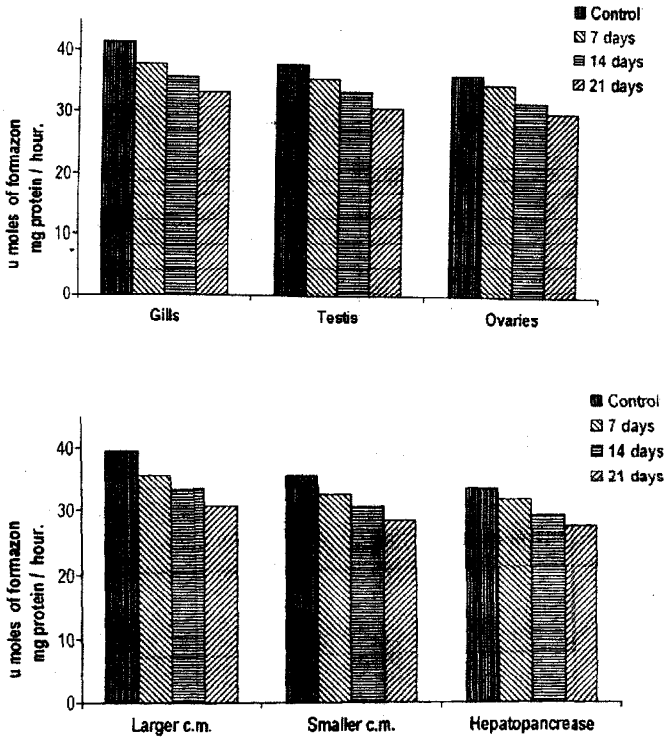


Fig.3 & 4 : Effect of Malathion on Acid phosphatase activity in GIlls, Testis, Ovaries, Larger chelae muscle, Smaller chelae, Hepatopancrease of *UCA marionis* (Desmarest) in chromic exposure



The activity of Acid phosphatase in chronic treatment also showed reduction. The control crab value for gills, testis, ovaries, larger and smaller chelae muscle and hepatopancrease were 41.491, 37.759, 36.176, 39.421, 35.531 and 33.321 µ moles of Formazan / mg protein / hr respectively. The reduction in value of Acid phosphatase ranged from -4.251% over control in ovaries for 7 days treatment to -22.532% over control in larger chelae muscle for 21 days treatment. The decrease was found to be significant at $P<0.5$, $P<0.01$ and $P<0.001$. A comparative aspect is shown in fig. 3 and 4.

The present study the decrease in acid phosphatase activity observed in acute and chronic exposure might be to the necrotic changes occurring in different parts of the body. Dalela *et. al*. (1980) notice similar result. Alam (1984), reported the decrease in Acid phosphates. Acid (1984) reported the decrease in Acid phosphatase in the small *B. bengalenis*, Simon (1953) reported that the concentration to toxicants higher than needed to prevent oxidative phosphorylation damage the mitochondrial network to a degree where the action of enzyme involved in oxidative metabolism is blocked. It is therefore clear that the effect of pesticide is not only limited at physical level but also at biochemical enzymatic level.

REFERENCES

Alam S. M. (1984). Some aspects of physiology of *Bellamiya bengalensis*. Ph. D. Thesis. Marathwada Univ. Aur. M.S. India.

Dalela R. C. et. al., (1980). Physiological stress induced by sublethal concentrations of phenol and pentachlorophenol in *Notopterus notopterus*. Env. Pollut. 213 – 218.

Simon E. W. (1953). Mechanism of cunitrophenol toxicity. Biol. Key Cambridge Phlos. Soc. 28 : 453 – 479.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 182-185

CHANGES IN DIGESTIVE DIVERTICULA OF *GAFRARIUM DIVARICATUM* AFTER EXPOSURE TO WATER SOLUBLE FRACTIONS OF A CRUDE OIL

Donde Snehal S., *Nayak R. R., # Sawant K. B.
Dept. of Zoology, L.U. & M.V.College, Andheri (E), Mumbai - 400 069;
E-mail: dsubhash@roltanet.com
*Dept. of Zoology, K. J. Somaiya College of Science & Commerce,
Vidyavihar, Mumbai – 400077.
Dept. of Zoology, B.N. N. College, Bhiwandi - 421 305.

ABSTRACT : Bivalve molluscs in their natural environment are frequently exposed to single spill or chronic discharges of petroleum oil and are known to accumulate petroleum hydrocarbon in their tissues. Therefore cytotoxic effect of the water-soluble fractions of crude oil was tested in *Gafrarium divaricatum*. In the present study, the digestive gland of *G. divaricatum* has shown decrease in epithelium thickness and increase of the proportion of disintegrating tubules. The hydrocarbons must have been taken up by pinocytosis by special epithelial cells in gut and labial palps. The reduced thickness of epithelium and reduced sizes of digestive tubules in hydrocarbon-contaminated clams indicate low enzyme activities that may disturb the detoxification mechanism. Cytological damages as described here indicate abnormal metabolic rate, as well as abnormal epithelial barriers needed for defense.

Key words *: water-soluble fractions, crude oil,* G. divaricatum*, histopathological changes, digestive diverticula*

INTRODUCTION

Clams living in a polluted environment are subjected to a continuous inflow of its polluted aquatic environment. The bioaccumulation occurs preferentially in the digestive gland and its study is important because it is also the site for the detoxification of xenobiotics (Livingstone, 1991). Intracellular digestion and absorption of food particles entering into the digestive gland takes place within the lysosome of the digestive cell.

The histopathological studies have gained wider acceptance in the field of aquatic toxicology, mainly because the assessment of the impact of xenobiotics on the tissues of animal can be done easily and less expensively. The significance of histological studies as a part of toxicological investigation probably lies in the fact that extremely low level of pollutant may fail to produce obvious external morphological or physiological changes in an animal but still produce subtle damage in its metabolically sensitive tissues. The ability of any tissue to regulate its normal physiological function is extensively related to its structural integrity and any damage to this tissue usually results in abnormal metabolic activities.

Since bivalves constitute an important part of the food of coastal population, there is a need to study the histopathological changes in various organs in bivalve in response to environmental stress factors including chemical pollutants (George *et al*., 1976; Axiak and George, 1987; Sasaki *et al*., 1999; Ibarrola, 2000; Pennec and Pennec, 2001). Thus in the present study, observations were made on the cytological damage caused to digestive diverticula of a clam *Gafrarium divaricatum,* following the exposure to sub lethal concentrations water-soluble-fractions (WSFs) of crude oil.

MATERIAL AND METHODS

Thick-shelled clams *G. divaricatum* were collected from an unpolluted site along the intertidal zone of the North-eastern coastline of Mumbai. The animals were then acclimatized for about a week in laboratory. The average length and weight of G. *divaricatum* with shell was 30 $\pm$ 2.5 mm and 16 $\pm$ 1.1 g respectively. Glass aquaria of size 60x30x30 cm each containing 2.0 liter of seawater were used and 20 clams were introduced in each of the experimental containers. The water-soluble-fractions (WSFs) were prepared by mixing oil and seawater (10%) for 24 hr. The aqueous phase collected after settling down (12 hr) was used as pure WSF stock (undiluted) and various dilution concentrations were prepared by adding seawater. Since the earlier studies indicated a reduction in the toxicity of WSF due to aeration, the seawater used for experiment was aerated vigorously before adding the test pollutant. The static bioassays for 28 days were carried out with 24 hr test water replacement. Clams exposed to sublethal concentrations of 5%, 10%, 25%, 50%, 75% WSF dilution concentrations and 100% (undiluted) WSF stock, were subjected to histological examinations at intervals of every 7th day for 28 days and morphological alterations in the digestive diverticula were studied. After each exposure period the tissues were fixed in Bouin's fixative and were processed as per the routine histological/ microtechnique methods. The sections (8 µm thick) were

stained using eosin and Ehrlich's hematoxylin stains. Criteria for cytotoxicity were evaluated by observing the structural integrity of digestive diverticula and a comparison was done to discriminate between control batches and those treated by WSFs of Bombay High crude oil.

OBSERVATIONS

HISTOLOGY OF NORMAL HEPATOPANCREATIC TUBULE (DIGESTIVE DIVERTICULA)

The digestive diverticula in the clams encircle the stomach. The ducts of the digestive gland show two kinds of tracts, a non-ciliated for receiving the food particles and another ciliated for sending the undigested wastes back into the stomach. The digestive diverticula consist of numerous tubules (acini) in the form of globular, elongated sacs or irregular branched tubes with numerous saccular outgrowths. Plate: 2.1 show each tubule is lined by smooth muscle fibre. The lumen of each tubule has a single layer of ciliated and non-ciliated epithelial cells. The typhlosole (walls of intestine) present in the posterior section of the intestine is formed of tall ciliated cells and there is a gradual decrease in height of the epithelium towards depth of groove. Bubbling in the epithelium also seen. The epithelial cells are arranged in longitudinal bands.

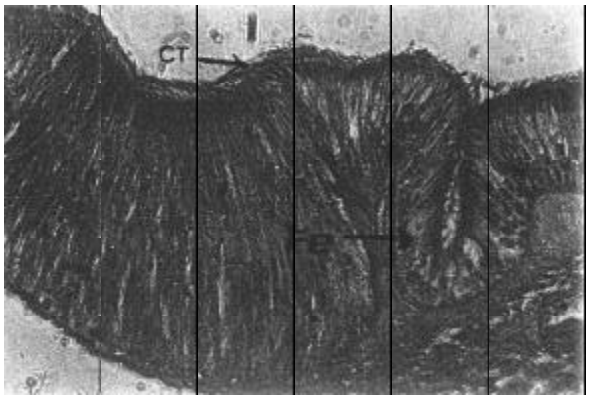


Plate no: 2.1 - (Magnification 400X). Normal digestive diverticula of *G. divaricatum* in control (7th day): showing ciliated border of typhlosole (CT) and folding in epithelial layer (FE).

CHANGES IN DIGESTIVE DIVERTICULA AFTER EXPOSURE

After 7 days of exposure, the hepatopancreas or digestive diverticula did not show any discernible alternations from the normal in 5% (Plate: 2.2), 10% (Plate: 2.3) and 25% (Plate: 2.4) WSF dilution concentrations. Plate: 2.2 show Increase in internal luminary spaces. The histopathological changes in the digestive gland seem to become more pronounced with higher concentrations of toxicant and a longer exposure period. In 25% WSF dilution concentration necrosis and sloughing of epithelial cells is seen (Plate: 2.5) after 14 days of exposure. Loss of typhlosole in 75% WSF dilution is observed (Plate: 2.6). Reduced number and size of acini (Plate: 2.7) in 100% WSF concentration is seen. Detachment of apical cell fragments from digestive cells of disintegrating tubules are evident in 25% WSF dilution (Plate: 2.4). After 28 days of exposure accumulation of haemocytes in between the tubules along with necrosis of tissue is common (Plate: 2.8). In 10% WSF dilution concentration disintegration of the digestive diverticula is more intense along with loss of cytoplasmic organization followed by the necrosis of absorptive cells.

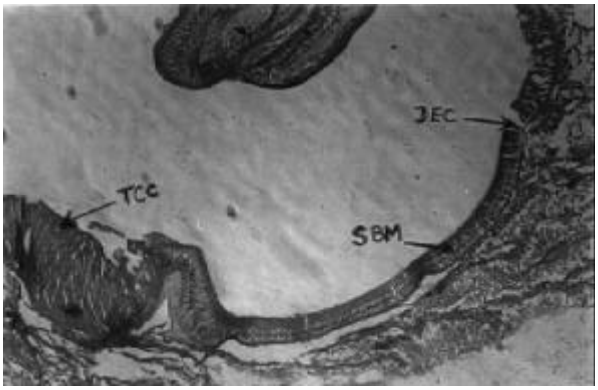


Plate no: 2.2 - (Magnification 100X): **Exposed digestive diverticula of *G. divaricatum* in 5% WSF dilution (7th day):** section of a secondary duct showing disintegration of inner layer of epithelial cells (DEC), broadening of basement membrane (SBM) and tall ciliated cells (TCC).



Plate no: 2.3 - (Magnification 100X) :**Exposed digestive diverticula of *G. divaricatum* in 10% WSF dilution (7th day):** showing loss of ciliated lining of typhlosole (CT), bubbling of epithelium (FE) and thick digestive epithelium (TE).

DISCUSSION

In the present study, the digestive gland of *G. divaricatum* has shown decrease in epithelium thickness and increase of the proportion of disintegrating tubules. A loss of synchronization of intracellular digestion between individual tubules is suggested by Ibarrola *et al.* (2000). In the digestive gland the epithelial cells of

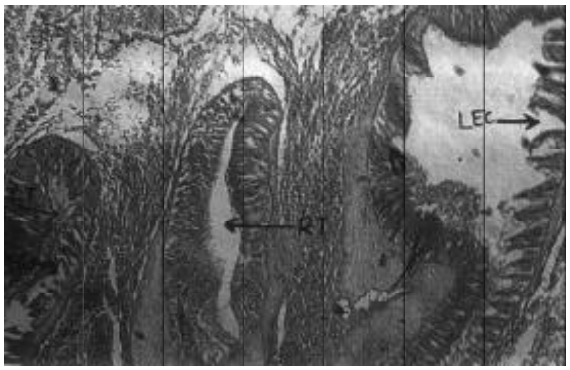


Plate no: 2.4 - (Magnification 100X): **Exposed digestive diverticula of *G. divaricatum* in 25% WSF dilution (7th day):** showing disintegration of epithelial cells (DEC), disintegration of tubule mainly (LT) showing loss of ciliary brush border (LEC) and large gap is created due to reduction in size of acini (LEC). Atrophy of digestive tubules is prominent.

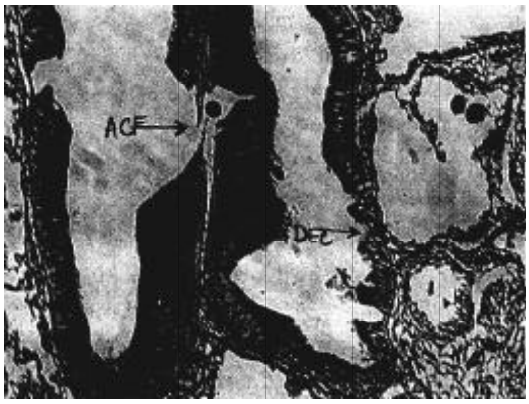


Plate no: 2.5 - (Magnification 100X): Exposed digestive diverticula of *G. divaricatum* in 5% WSF dilution (28th day): **showing loss of ciliary border (DEC) and detached apical cell fragment (ACF). Loss of bubbling of epithelium and few phagocytic cells are seen.**

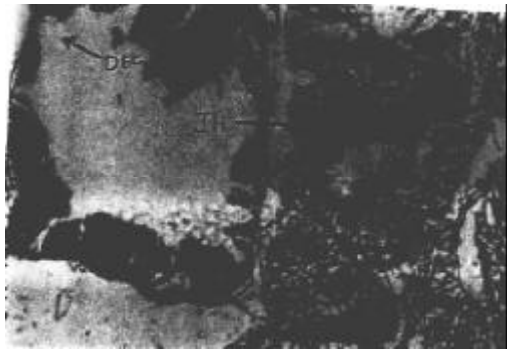


Plate no: 2.6 - (Magnification 100X): Exposed digestive diverticula of *G. divaricatum* in 75% WSF dilution (28th day): **shows reduced infiltration of hemocytes (IH) and disintegration of epithelial cells (DEC). Reduced thickness of digestive diverticula is also seen.**

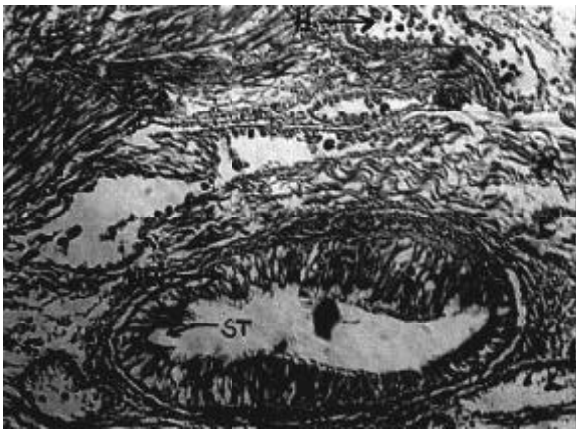


Plate no: 2.7 - (Magnification 100X): Exposed digestive diverticula of *G. divaricatum* in 100% WSF dilution (7th day): **secondary tubule showing mixing of cellular content of different tubules, sunken typhlosole (ST), necrosis of epithelial cell (NEC) and infiltration of hemocytes (H)**



Plate no: 2.8 - (Magnification 100X): Exposed digestive diverticula of *G. divaricatum* in 5% WSF dilution (28th day): **showing disintegration of epithelial cells (DEC), necrotic epithelium with sloughing and vacuolization (NE) and infiltration of hemocytes (IH).**

the tubules and ducts are known to be involved in both absorption and secretion. Therefore any loss of cell membranes may affect both functions. This is observed in 14 days exposure in 25% WSF dilution clams. The phagocytic cells are known to be the sites of intracellular digestion their damage is obvious with tissue damage. George *et al*. (1976) observed that all tissues take up ferric hydroxide by pinocytosis of epithelial cells and held in membrane bound vesicles, with mucus present in digestive diverticulum and midgut cells. Similarly hydrocarbons must have been taken up by pinocytosis by epithelial cells in gut and labial palps in case of *G. divaricatum.* The increase in internal lumen area is also observed at low concentration. Vacuolization of epithelial cells in response to the hydrocarbon stress was followed by the destructive process such as sloughing. With the

loss of epithelial barriers invasion of foreign particles, cell debris and mixing of cellular content of different tubules is possible (Plate: 2.7). Atrophy (reduction in size) of digestive tubules is prominent in higher concentrations (Plate: 2.4, 2.8). In earlier studies also atrophy in digestive tubule is reported in mussel (Lowe *et al.,* 1981; Moore and Clarke, 1982) and oyster (Couch, 1984) exposed to PAHs.

In general, hydrocarbon-induced damages might have reduced metabolism and waste removal in *G. divaricatum,* which lead to adverse effects after prolonged exposure in WSF concentrations. Similarly, Pennec and Pennec (2001) reported that polycyclic aromatic hydrocarbons (PAH) had a negative effect on the survival of digestive acini (in vitro) in bivalve *Pecten maximus* (L.), exposed to WSFs of Arabian crude oil (8.75 g oil added to 1 l seawater). PAH toxicity has also been studied in digestive gland cells in situ (Cajaraville *et al*., 1990). Bivalves rapidly accumulate organic compounds such as petroleum hydrocarbons from their environment and the dynamics of uptake and depuration have been studied (Donde, 2002). The existence and functioning of detoxification enzymes have been considered interesting viz. the use of changes in enzyme activities or biological impact in environmental monitoring (Livingstone *et al*., 1991). The reduced thickness of epithelium and reduced sizes of digestive tubules in hydrocarbon-contaminated clams indicate low enzyme activities, which is also suggested by Ibarrola *et al*. (2000). This might have disturbed the detoxification mechanism.

Cytological damages as described here may indicate abnormal metabolic function (possibly accompanied by lowered resistance) as well as abnormal epithelial barriers needed for defense.

ACKNOWLEDGEMENT

The authors wish to thank Mr. A. Krishna Reddy from Central Institute of Fisheries Education, Mumbai, for his valuable guidance and providing facility for photography.

REFERENCES

Axiak, V.; and J.J. George 1987. Effects of exposure to petroleum hydrocarbons on the gill functions and ciliary activities of a marine bivalve. Mar. Biol. 94 : 241-249.

Cajarville, M.P.; G. Diez, I.A. Marigomez and E. Angulo 1990. Responses of basophilic cells of the digestive gland of mussels to petroleum hydrocarbon exposure. Dis. *Aquat. Org.* 9 : 221-228.

Couch, J.A.; (1984). Atrophy of diverticular epithelium as an indicator of environmental irritants in oyster, Crassostrea virginica. Mar. Environ. Res. 14 : 525-526.

Donde, S.S. (2002). Studies on effects of crude oil on a marine clam**.** Ph. D. Thesis submitted - Mumbai University, Mumbai, India, pp. 125-140.

George, S.G.; B.J.S. Pirie and T.L. Coombs (1976). The kinetics of accumulation and excretion of ferric hydroxide in Mytilus edulis (L) and its distribution in the tissue. J. Exp. Mar. Biol. Ecol. 23 : 71-84.

Ibarrola. I.; E. Navarro and M.B. Urrutia (2000). Acute and acclimated digestive responses of the cockle Cerastoderma edule (L) to changes in food quality and quantity. I. Feeding and absorption of biochemical components. J. Expt. Mar. Biol. Ecol.252 : 181-198.

Le Pennec, G.; and M. Le Pennec (2001). Acinar primary cell culture from the digestive gland of Pecten maximus (L.): an original model for ecotoxicological purposes**.** J. Expt. Mar Biol. Ecol. 259 : 171-187.

Livingstone, D.R.; M.A. Kirchin, and A. Wiseman (1990). Cytochrome P450 and oxidative metabolism in molluscs. Biochem. Soc. Transact. 18, : 15-19.

Livingstone, D.R.; (1991). Organic xenobiotic metabolism in marine invertebrates. In Springer-Verlag (ed.), Advances in comparative and environmental physiology, Vol.7.

Lowe. D.M., M.N. Moore and R.K. Pipe (1981). Effects of oil on digestive cells in mussels: quantitative alterations in cellular and lysosomal structure. Aquat. Toxicol. 1, : 213.

Moore, M.N.; and K.R. Clarke (1982). Use of microstereology and quantitative cytochemistry to determine the effects of crude oil-derived aromatic hydrocarbons on lysosomal structure and function in a marine mollusk, Mytilus edulis. Histochem. J. 14 : 713-718.

Sasaki, K.; K. Makoto, and I. Kinuko (1999). Structure of the siphons of the bivalve Nutallia olivacea (Tellinacea, Psammobiidae) and changes of their states under extended conditions. Jap. Soc. Fish. Sci. Tokyo. Japan. 65:6 : 839-843.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 186-195

BENTHIC MACROFAUNA OF THANE CREEK: SEASONAL VARIATIONS.

Smita Venkatachalam and P.G. Kale
Dept. of Biological Sciences, Ramniranjan Jhunjhunwala College,
Ghatkopar, Mumbai – 400 086.

ABSTRACT : The ecological status of an aquatic ecosystem can be determined by analyzing the benthic community. Thane creek, with its unique historical, geopolitical and biological importance has been chosen for analysis of the benthic community. The benthic macrofauna collected from three sites along the creek, every month for a period of one year has been analysed and the results have been discussed.

Keywords : Thane creek, Benthic community macrofauna,

INTRODUCTION

Estuaries are the nutrients traps providing a fertile habitat to a rich and diverse biota. They are looked upon as an important biodiversity resource. They are the natural ports, also valuable as fishery resource. Thane creek located south of Mumbai harbor along the west coast of India has attracted much attention of environmental biologist due to the acute anthropogenic stress it is subjected to. The creek receives over 180 million litres of wastewater everyday from the Asia's biggest Thane – Belapur Industrial Complex.

Since it harbors sedentary and semi-sedentary forms and is influenced profoundly by the nutrients as well as pollutants received by the system, benthic community is often used as indicator of ecological status of a estuary (Swartz, 1978). Duda *et al.* (1982) has established that the benthic macrofauna provides the most accurate and reproducible information of the fertility of water while Remani *et al*. (1983) and Schafer *et al.*. (1985) have suggested the use of certain benthic macrofauna as bioindicators of change in the environment. The present report is of the survey of benthic macrofauna collected every month, over a period of one year from three stations along Thane creek.

MATERIALS AND METHODS

Three collection sites, one on the west bank, and two on the east bank, approximately one kilometer from one another established along the creek. The sediments samples were collected during the low tide of the eighth day from the full moon day every month from March 1995 to Feburary 1996 from the three collection sites. At these collection sites transects were set up between the high tidemark and the waterfront at the lowest low tide. Random quadrats at these sub-stations were subjected to counting of crab holes to determine the number of crabs per square metre as per the method described by Jones (1984), since they escaped the scoop readily. The sediment samples retrieved from same quadrats using a rectangular metal scoop (10 cms x 10 cms x 5 cms) were watched carefully through a sieve of 0.5 mm mesh size. The macrofauna, thus sieved out, was subjected to sorting and identification. The general procedure followed for the collection and processing of macro benthos was as per the recommendations of Holmes (1971).

It was necessary to narcotize the organisms for the close scrutiny during identification. Drop wise addition of 70 % ethanol achieved optimum extention of bodies and the eversion of proboscis besides narcotisation. The animals from randomly taken scoops from each collection sites were pooled to obtain population density per square metre of sediments. The animals of each variety were gently blotted and weighed to obtain biomass.

Among the species in a community, a few are abundant but many others are rare. This characteristic can be determined by counting all the individuals of each species in a number of sample plots within a community and determining the percentage each contributes to the whole community. This measure is known as relative abundance (Smith and Smith, 1998.). The index of dominance, 'C' (Simpson, 1949), the index of frequency, 'F' or importance value and the Shanon index of general diversity, 'H' (Shanon and Weaver, 1949) were also calculated from the data on the benthic macrofauna of the three collection sites. The index of similarity, 'S' for the collection sites was computed by the method of Sorenson (1948).

OBSERVATIONS AND DISCUSSIONS

The data on population density of benthic macrofauna collected from the three sites is presented in tables 1, 2 and 3; while the data on biomass of the same is included in tables 4, 5 and 6. A critical analysis of this data reveals the following facts:

1. The benthic macrofauna at all three collection sites, included polychaetes of the order Errantia namely *Lycastis indica, Lycastis auanaryensis, Nereis glandicincta* and *Dendronereides sp.*; a decapod crustacean namely *Ilyoplax gangetica*; prosobranchiate gastropod namely *Paludomus sp.*; and an anthozoan *Acontactis gokhalae*, endemic to Thane creek.

2. Site three harboured a maximum population density of benthic macrofauna though the biomass is not proportionately large.

3. Site one had the population density half that of site three though the average biomass of benthic macrofauna of this site was nearly seventy five percent of that of site three.

4. However, at site one the average number of polychaetes was the greatest, in pre and post monsoon months crabs out-numbered them. The average biomass contributed by the crabs was greater than that by polychaetes.

5. Site two had a population density of benthic macrofauna only forty percent as that of site three but the biomass measured roughly fifty-five percent of that of site three.

6. The population density of polychaetes in monsoon was found equal to or more than that in pre monsoon and post monsoon taken together but the biomass is only sixty – eighty percent of that of the total biomass of other two seasons. This is indicative of smaller size of individuals in monsoon agreeing with the observation that the young ones are reared in monsoon months.

7. The polychaetes as well as the mollusc, *Paludomus* being smaller, the number per square metre of these organisms is more, but the biomass contribution is relatively less. These members of macrofauna must therefore be consuming greater detritus compared to that by crabs due to higher cost of maintenance (Odum, 1971). This biological constraint must be naturally limiting the population density of crabs.

Alam (1992) has reported low population density and biomass of polychaetes in the sediments of Malad creek in monsoon while a complete disappearance of benthic macrofauna ,from certain stations along Vellar estuary , in monsoon was observed by Chandran(1987).A substantial decrease in benthic fauna during monsoon has also been reported by Srinivasa Rao and Rama Sarma (1983) and by Jagadeesan and Ayyakannu (1992). Bloom *et al.* (1972) have established that the organic contents in fine sediments can be effectively used by detritic deposit feeders like polychaetes and molluscs while the filter feeders cannot use it for saving their feeding and respiratory apparatus from clogging. Rhoads (1974) has explained the exclusion of the filter feeders due to the bioturbation caused by the deposit feeding species. This explains the seemingly inverse relation between crab and polychaetes as well as molluscan populations.

The abundance of polychaetes in benthos has been reported by Varshney *et al.* (1981) in the Narmada estuary , Govindan (1983) in Ambika and Purna estuaries, Chandran (1987) in Vellar estuary , Vizaket

Table 1.Variations In Population Density (no./sq.meter) of Benthic Macrofauna From I Site

Month	Crab	Polychaetes	Paludomus	Acontiatics	Total
March 95	160	120	120	60	460
April	120	140	80	80	420
May	280	140	130	160	710
June	350	200	80	100	730
July	180	400	0	140	720
August	100	900	70	100	1170
September	120	300	100	0	520
October	260	220	0	0	480
November	160	200	0	100	460
December	200	100	260	0	560
January 96	300	170	250	120	840
February	170	220	0	0	390
Yearly	2400	3110.00	1090.00	860.00	7460.00
Percent	32.17	41.69	14.61	11.53	100.00
Pre-Monsoon	182.5	155	82.5	75	495
Monsoon	187.5	450	62.5	85	785
Post-Monsoon	230	172.5	127.5	50	580
Average	200	259.17	90.83	71.67	621.67

Table 2. Variations In Population Density (no./sq.meter) of Benthic Macrofauna From II Site

Month	Crab	Polychaetes	Paludomus	Acontiatics	Total
March	50	540	120	0	710
April	40	400	100	0	540
May	80	320	160	0	560
June	60	350	180	0	590
July	20	600	160	0	780
August	60	400	220	0	680
September	60	220	280	0	560
October	80	270	300	0	650
November	40	150	280	0	470
December	60	120	240	0	420
January	60	80	160	0	300
February	80	60	180	0	320
Yearly	690.00	3510.00	2380.00	0.00	6580.00
Percent	10.49	53.34	36.17	0.00	100.00
Pre-Monsoon	62.5	330	140	0	532.5
Monsoon	50	392.5	210	0	652.5
Post-Monsoon	60	155	245	0	460
Average	58	293	198	0	548

Table 3 Variations In Population Density (no./sq.meter) of Benthic Macrofauna From III Site

Month	Crab	Polychaetes	Paludomus	Acontiatics	Total
March	20	180	160	0	360
April	20	300	200	0	520
May	60	280	220	0	560
June	140	2200	200	0	2540
July	80	1620	350	0	2050
August	80	2200	300	0	2580
September	80	820	300	0	1200
October	60	800	400	0	1260
November	120	760	200	0	1080
December	100	1760	360	0	2220
January	140	620	400	0	1160
February	40	320	100	0	460
Yearly	940.00	11860.00	3190.00	0.00	15990.00
Percent	5.88	74.17	19.95	0.00	100.00
Pre-Monsoon	35	270	170	0	475
Monsoon	95	1710	287.5	0	2092.5
Post-Monsoon	105	985	340	0	1430
Average	78.33	988.33	265.83	0.00	1332.50

Table 4.Variations In Biomass (g/sq.meter) of Benthic Macrofauna From I Site

Month	Crab	Polychaetes	Paludomus	Acontiatics	Total
March	6.9	4.25	2.59	2	15.74
April	7.4	4.32	1.28	2.4	15.4
May	8.52	4.44	3	4.1	20.06
June	9	5	1.5	2.9	18.4
July	6.25	9.2	0	3.4	18.85
August	4.45	11	1.48	2.89	19.82
September	4.52	3.28	2	0	9.8
October	7.28	8.98	0	0	16.26
November	7.12	7.58	0	2.8	17.5
December	7.89	4.52	6.21	0	18.62
January	10.2	7	6.18	4	27.38
February	7	8	0	0	15
Yearly	86.53	77.57	24.24	24.49	212.83
Percent	40.66	36.45	11.39	11.51	100
Pre-Monsoon	7.455	5.2525	1.7175	2.125	16.55
Monsoon	6.055	7.12	1.245	2.2975	16.7175
Post-Monsoon	8.1225	7.02	3.0975	1.7	19.94
Average	7.21	6.46	2.02	2.04	17.74

Table 5.Variations In Biomass (g/sq.meter) of Benthic Macrofauna From II Site

Month	Crab	Polychaetes	Paludomus	Acontiatics	Total
March	2.5	8.28	3.2	0	13.98
April	2.4	7.29	3	0	12.69
May	4.2	6	4.2	0	14.4
June	2.9	5.4	4	0	12.3
July	1.4	8.4	3.9	0	13.7
August	2.72	6	5.9	0	14.62
September	2.8	3	5.4	0	11.2
October	4	4	7.2	0	15.2
November	2.1	3.24	7	0	12.34
December	3	3.5	6.5	0	13
January	3.1	3.24	4.45	0	10.79
February	4.2	2.8	4.25	0	11.25
Yearly	35.82	61.15	59	0	155.47
Percent	22.72	39.33	37.95	0.00	100.00
Pre-Monsoon	3.325	6.0925	3.6625	0	13.08
Monsoon	2.455	5.7	4.8	0	12.955
Post-Monsoon	3.05	3.495	6.2875	0	12.8325
Average	2.943	5.096	4.917	0.000	12.956

Table 6.Variations In Biomass (g/sq.meter) of Benthic Macrofauna From III Site

Month	Crab	Polychaetes	Paludomus	Acontiatics	Total
March	1.45	3	2.5	0	6.95
April	1.5	3.99	4.94	0	10.43
May	4.2	3.88	5	0	13.08
June	9	20.12	4.62	0	33.74
July	4.5	17	6.65	0	28.15
August	4	23	5.21	0	32.21
September	3.28	10.01	5.32	0	18.61
October	4.5	14.9	7.21	0	26.61
November	9.2	15	4.5	0	28.7
December	9	29.99	7	0	45.99
January	10	12.9	9	0	31.9
February	3.2	4.69	2	0	9.89
Yearly	63.83	158.48	63.95	0	286.26
Percent	22.30	55.36	22.34	0	100
Pre-Monsoon	2.5875	3.89	3.61	0	10.0875
Monsoon	5.195	17.5325	5.45	0	28.1775
Post-Monsoon	8.175	18.1975	6.9275	0	33.3
Average	5.32	13.21	5.33	0	23.855

et al..(1991) in estuaries along Konkan coast, Jagdeesan and Ayyakannu (1992) in Coleroon estuary and Mukherjee (1993) as well as Kotibhaskar (1998) in Thane creek . Crabs as the second largest member of estuarine benthic macrofauna has been established by Untawale and Parulekar (1976) and Kotibhaskar (1998).

Various ecological indices calculated from the data on population density and biomass of benthic macrofauna from the collection sites are displayed in tables 7, 8 and 9. An analysis of these brought out the following facts

1. At site one the frequency values as well as importance values for crabs were higher than those for other sites, considering yearly average and pre monsoon as well as monsoon seasons.

2. However, at site two, the gastropod, *Paludomus* dominated the benthic macrofauna in the post monsoon season.

3. The highest value of Shanon index computed for site one in all seasons clearly indicated it to be the station with maximum diversity of macrobenthos.

4. Low values of Shanon index in monsoon, for all stations confirmed the reduction in diversity of benthic macrofauna in monsoon.

5. Though the values of Shanon index, considering numbers, varied between forty-four and hundred percent of maximum, those computed from biomass of the macrofauna showed variation only from eighty-five to hundred percent of maximum through the seasons. This brings out the facts that there is optimum utilization of available resources in the creek resulting in maintaining a fairly constant biomass over all seasons despite the fluctuations in number and types of organisms constituting it.

6. The faunal similarity indices calculated for the three sites in three seasons suggest a total similarity between sites two and three though the site one differs from them in all seasons. The difference, however, is only marginal.

It may be concluded that the diversity of the benthic macrofauna is poor in Thane creek. *Paludomus*, the sea anemone endemic to the creek has become quite rare and is presently found only at one out of three sites and that too only in certain months during the period of survey. The polychaetes, though predominating by numbers, the biomass of the benthic community is mainly contributed by the crabs. The population density as well as diversity decreases in monsoon. There appears a reciprocative correlation between the population density of the crabs and polychaetes in the macrobenthos of Thane creek. This is a result of differences in their mode of feeding.

BIBLIOGRAPHY

Alam S.K.1992. Ecology of zooplankton and benthos with reference to waste waters of Malad creek along Mumbai coast. Ph.D. Thesis, University of Mumbai.

Table 7.

Frequency Value of Members of Benthic Macrofauna of I Site

Month	Crab	Polychaetes	Paludomus	Acontiatics
March	0.348	0.261	0.261	0.130
April	0.286	0.333	0.190	0.190
May	0.394	0.197	0.183	0.225
June	0.479	0.274	0.110	0.137
July	0.250	0.556	0.000	0.194
August	0.085	0.769	0.060	0.085
September	0.231	0.577	0.192	0.000
October	0.542	0.458	0.000	0.000
November	0.348	0.435	0.000	0.217
December	0.357	0.179	0.464	0.000
January	0.357	0.202	0.298	0.143
February	0.436	0.564	0.000	0.000
				1.323
Pre-Monsoon	0.366	0.339	0.159	0.137
	+/- 0.064	+/- 0.160	+/- 0.111	+/- 0.099
Monsoon	0.261	0.544	0.090	0.104
	+/- 0.163	+/- 0.204	+/- 0.081	+/- 0.083
Post-Monsoon	0.401	0.319	0.190	0.090
	+/- 0.094	+/- 0.148	+/- 0.230	+/- 0.108
Average	0.343	0.400	0.147	0.110
	+/- 0.121	+/- 0.189	+/- 0.147	+/- 0.090

Frequency Value of Members of Benthic Macrofauna of II Site

Month	Crab	Polychaetes	Paludomus	Acontiatics
March	0.070	0.761	0.169	0.000
April	0.074	0.741	0.185	0.000
May	0.143	0.571	0.286	0.000
June	0.102	0.593	0.305	0.000
July	0.026	0.769	0.205	0.000
August	0.088	0.588	0.324	0.000
September	0.107	0.393	0.500	0.000
October	0.123	0.415	0.462	0.000
November	0.085	0.319	0.596	0.000
December	0.143	0.286	0.571	0.000
January	0.200	0.267	0.533	0.000
February	0.250	0.188	0.563	0.000
			0.000	
Pre-Monsoon	0.134	0565	0.301	0.000
	+/- 0.084	+/- 0.266	+/- 0.182	+/- 0.000
Monsoon	0.081	0.586	0.333	0.000
	+/- 0.038	+/- 0.154	+/- 0.123	+/- 0.000
Post-Monsoon	0.138	0.322	0.541	0.000
	+/- 0.048	+/- 0.066	+/- 0.059	+/- 0.000
Average	0.118	0.491	0.392	0.000
	+/- 0.061	+/- 0.206	+/- 0.162	+/- 0.000

Frequency Value of Members of Benthic Macrofauna of III Site

Month	Crab	Polychaetes	Paludomus	Acontiatics
March	0.056	0.500	0.444	0.000
April	0.038	0.577	0.385	0.000
May	0.107	0.500	0.393	0.000
June	0.055	0.866	0.079	0.000
July	0.039	0.790	0.171	0.000
August	0.031	0.853	0.116	0.000
September	0.067	0.683	0.250	0.000
October	0.048	0.635	0.317	0.000
November	0.111	0.704	0.185	0.000
December	0.045	0.793	0.162	0.000
January	0.121	0.534	0.345	0.000
February	0.087	0.696	0.217	0.000
Pre-Monsoon	0.072	0.568	0.360	0.000
	+/- 0.031	+/- 0.092	+/- 0.099	+/- 0.000
Monsoon	0.048	0.798	0.154	0.000
	+/- 0.016	+/- 0.083	+/- 0.074	+/- 0.000
Post-Monsoon	0.081	0.666	0.252	0.000
	+/- 0.040	+/- 0.109	+/- 0.092	+/- 0.000
Average	0.067	78	0.255	0.000
	+/- 0.031	+/- 0.131	+/- 0.119	+/- 0.000

Importance Value of Members of Benthic Macrofauna of I Site

Month	Crab	Polychaetes	Paludomus	Acontiatics
March	0.438	0.270	0.165	0.127
April	0.481	0.281	0.083	0.156
May	0.425	0.221	0.150	0.204
June	0.489	0.272	0.082	0.158
July	0.332	0.488	0.000	0.180
August	0.225	0.555	0.075	0.146
September	0.461	0.335	0.204	0.000
October	0.448	0.552	0.000	0.000
November	0.407	0.433	0.000	0.160
December	0.424	0.243	0.334	0.000
January	0.373	0.256	0.226	0.146
February	0.467	0.533	0.000	0.000
Pre-Monsoon	0.453	0.326	0.099	0.122
	+/- 0.026	+/- 0.140	+/- 0.075	+/- 0.087
Monsoon	0.377	0.412	0.090	0.121
	+/- 0.122	+/- 0.132	+/- 0.085	+/- 0.082
Post-Monsoon	0.413	0.371	0.140	0.077
	+/- 0.032	+/- 0.149	+/- 0.167	+/- 0.089
Average	0.414	0.370	0.110	0.106
	+/- 0.075	+/- 0.132	+/- 0.108	+/- 0.081

Importance Value of Members of Benthic Macrofauna of II Site

Month	Crab	Polychaetes	Paludomus	Acontiatics
March	0.179	0.592	0.229	0.000
April	0.189	0.574	0.236	0.000
May	0.292	0.417	0.292	0.000
June	0.236	0.439	0.325	0.000
July	0.102	0.613	0.285	0.000
August	0.186	0.410	0.404	0.000
September	0.250	0.268	0.482	0.000
October	0.263	0.263	0.474	0.000
November	0.170	0.263	0.567	0.000
December	0.231	0.269	0.500	0.000
January	0.287	0.300	0.412	0.000
February	0.373	0.249	0.378	0.000
Pre-Monsoon	0.258	0.458	0.284	0.000
	+/- 0.092	+/- 0.160	+/- 0.069	+/- 0.000
Monsoon	0.194	0.433	0.374	0.000
	+/- 0.067	+/- 0.142	+/- 0.087	+/- 0.000
Post-Monsoon	0.238	0.274	0.488	0.000
	+/- 0.051	+/- 0.018	+/- 0.064	+/- 0.000
Average	0.230	0.388	0.382	0.000
	+/- 0.071	+/- 0.141	+/- 0.110	+/- 0.000

ImportanceValue of Members of Benthic Macrofauna of III Site

Month	Crab	Polychaetes	Paludomus	Acontiatics
March	0.209	0.432	0.360	0.000
April	0.144	0.383	0.474	0.000
May	0.321	0.297	0.382	0.000
June	0.267	0.596	0.137	0.000
July	0.160	0.604	0.236	0.000
August	0.124	0.714	0.162	0.000
September	0.176	0.538	0.286	0.000
October	0.169	0.560	0.271	0.000
November	0.321	0.523	0.157	0.000
December	0.196	0.652	0.152	0.000
January	0.313	0.404	0.282	0.000
February	0.324	0.474	0.202	0.000
Pre-Monsoon	0.249	0.396	0.354	0.000
	+/- 0.088	+/- 0.076	+/- 0.133	+/- 0.000
Monsoon	0.182	0.613	0.205	0.000
	+/- 0.061	+/- 0.074	+/- 0.068	+/- 0.000
Post-Monsoon	0.250	0.535	0.216	0.000
	+/- 0.079	+/- 0.103	+/- 0.071	+/- 0.000
Average	0.227	0.515	0.258	0.000
	+/- 0.077	+/- 0.121	+/- 0.106	+/- 0.000

Table 8 . Index Of Dominance Of The Benthic Macrofauna Collected From The Three Sites Along Thane Creek

	Considering Numbers			
I				
	CRAB	POLYCHAETES	PALUDOMUS	ACONTIACTIS
Pre Monsoon	0.548147	0.536257	0.137859	0.104078
Monsoon	0.352934	0.308259	0.052572	0.063879
Post Monsoon	0.669488	0.471951	0.304138	0.067667
II				
	CRAB	POLYCHAETES	PALUDOMUS	ACONTIACTIS
Pre Monsoon	0.093354	1.48884	0.460898	0
Monsoon	0.030264	1.443984	0.489826	0
Post Monsoon	0.082799	0.427144	0.178905	0
III				
	CRAB	POLYCHAETES	PALUDOMUS	ACONTIACTIS
Pre Monsoon	0.023607	1.316772	0.547056	0
Monsoon	0.009967	2.568751	0.11137	0
Post Monsoon	0.031208	1.812515	0.280277	0
	Considering Biomass			
I				
	Crab	Polychaetes	Paludomus	Acontiactis
Pre Monsoon	0.82124	0.485032	0.05635	0.082207
Monsson	0.612321	0.732088	0.053871	0.078636
Post Monsoon	0.684326	0.616911	0.162176	0.046943
II				
	Crab	Polychaetes	Paludomus	Acontiactis
Pre Monsoon	0.292195	0.91636	0.336068	0
Monsson	0.163145	0.808854	0.582115	0
Post Monsoon	0.23401	0.300842	0.966251	0
III				
	Crab	Polychaetes	Paludomus	Acontiactis
Pre Monsoon	0.272007	0.645545	0.540742	0
Monsoon	0.143194	0.519513	0.18244	0
Post Monsoon	0.267921	1.175456	0.200764	0

Table 9. Shanon Index Of The Benthic Macrofauna Collected From The Three Sites Along Thane Creek

I			
	Pre-Monsoon	Monsoon	Post- Monsoon
H (PD)	9.38	7.94	8.2
H (BM)	8.88	8.8	8.21
II			
H (PD)	6.068	6.07	6.31
H	8.17	8.09	8.29
III			
H (PD)	6.17	4.14	4.98
H (BM)	8.37	7.32	7.87

Bloom, S.A., J.L. Simon, and V.D. Hunter, 1972. Animal sediment relations and community analysis of Florida estuaries. Marine Biology.13: 43 to 56

Chandran,R. 1987. Hydrological studies in the gradient zone of the Vellar estuary.4.Benthic fauna. Mahasagar .24(2):81-88

Duda,A.M., D.R. Lenat, and D.C. Penrose, 1982. Water quality in Urban streams ,what we expect. J.Water Poll. Control Fed: 1139-1147.

Govindan, K, P.K. Varshney, and B.N. Desai, 1983. Benthic studies in South Gujarat estuaries. Mahasagar. 16(3):349-356.

Holmes, N.A. 1971. Macrofaunal sampling in International Biological Program Handbook No.16, Blackwell, Scientific Publ.Oxford.

Jagdeesan,P and K. Ayyakannu, 1992 Seasonal variation of benthic fauna in marine zone of Coleroon estuary and inshore waters, southeast coast of India. Ind.J.Mar.Sci.21:67-69.

Jones, N.S.1984. Hydrobiology of Mangal estuary Ed. Francis Dov Por and Inka Dor,Dr.W.Junk Publishers

Kotibhaskar V. Y, 1998 Biology and ecology of Thane creek : Habitat analysis of some benthic macrofauna. M.Sc.Thesis, University of Mumbai.

Ludwig, J. A. and J. P. Reynolds. 1988. 'Statistical ecology: a primer on methods and computing' John Wiley and sons, N Y Chicester, Brobane, Toronto, Singapore.

Mukherjee, M 1993 Study of macrobenthic fauna of mangrove ecosystem [Thane region]. Ph.D.Thesis, University of Mumbai.

Odum, E. P. 1971 'Fundamentals of ecology'. W.B. Saunders Co. Philadelphia and London.

Remani, K. N., K. Sarla devi, K. P. Venugopal and R.V. Unnithan 1983. Indicator organisms of pollution in cochin backwaters, Mahasagar.16(2):199-207.

Rhoads, D. C. 1974 Organisms-sediments relations on the muddy sea floor. Oceanogr. Mar. Biol.Ann.Rev.12:263-300.

Schafer D J, W H Ellinger, W J Tucker and H W Kerster 1985. Evaluation of a community based index using benthic indicator organisms for classifying stream quality. J. W. P. C. F.

Shannon C E and W. Weaver 1963. The mathematical theory of communication. Univ. of Ellionis Press, Urbana. Pp.117.

Simpson E H 1949. Measurement of diversity. Nature 163:681-688

Smith R L and T.M. Smith 1988. 'Elements of Ecology'. Wesley Longman Inc. C.A.

Sorenson T 1948. A method of establishing groups of equal amplitude in plant society based on similarity of species content. K.Danske Vidensk. Selsk. 5:1-34.

Srinivasa Rao, D and D.V. Rama Sarma, 1983 Abundance and distribution of intertidal polychaetes in Vasistha-Godavari estuary Mahasagar, 16(3):327-340.

Swartz R C., 1978. Techniques for sampling and analyzing marine macrobenthos. Environmental protection agency, U S. Publ. No. EPA-600/march 1978.

Untawale A G and A H Parulekar 1976 Some observations on the ecosystem of an estuary,mangrooves of Goa. Mahasagar 9:1-4,57-62.

Varshney, P.K., K. Govindan, V.R. Nair and B.N. Desai. 1981. Benthos of the Narmada estuary. Mahasagar 14 (2) : 141 – 148.

Vizakat, L., S.N. Harkantra and A.H. Parulekar. 1991 Population ecology and community structure of subtidal soft sediment dwelling macroinverts of Konkan, West Coast of India. Indian J. Marine Science. 20 : 40 – 42.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 196-200

STUDY OF THE DOMINANT FAUNA OF MANGROVES AT SEVEN BUNGALOWS BEACH, VERSOVA, MUMBAI – A PRELIMINARY STUDY

Contzen Pereira, C. V. Rao and S. Krishnan
Department of Zoology, St. Xavier's College, Mahapalika Marg, Mumbai. 400 001.

ABSTRACT : The mangroves at Seven Bungalows, Versova extend over a large area and form the habitat of diverse groups of intertidal fauna that have still managed to survive, despite the prevailing stressful conditions caused by various human activities.

A survey of the flora and fauna was undertaken and environmental factors likely to affect distribution of dominant fauna were recorded for a period of one year. The study revealed the presence of seven mangrove species, of which *Avicennia marina* (62%) and *Acanthus ilicifolius* (31%) were most dominant and widely distributed. Amongst the fauna since crabs (57%) and molluscs (39%) were predominant, population studies were carried out on these groups. Differences in distribution of crab species showed a correlation with varying soil texture of the area and this could be related to their feeding habits. Within the mangroves the percentage of silt was more as compared to the fringes, which had a higher percentage of sand. Among the crabs *Uca annulipes* was most dominant and uniformly distributed, *Uca vocans* was restricted to areas with fine sand while *Uca dussumieri, Metaplax distincta* and *Sesarma quadrata* were present only within the mangroves, where there is substantial plant cover, percentage of silt is more and coarse sand is minimal. The density of molluscs, *Potamides cingulatus* and *Telescopium telescopium* increased during monsoon when salinity values dropped. Distribution studies showed that *Telescopium telescopium* was uniformly distributed and *Potamides cingulatus* was found along the fringes. Parameters like moisture content and temperature of soil did not show much variation throughout the year.

***Key Words :- M**angroves, crabs, molluscs, density, distribution.*

INTRODUCTION

The mangrove ecosystem serves as a living buffer between landmasses and open seas. Traditionally, this ecosystem has been ignored by both scientists and administrators the world over. Since they were considered to be "wastelands", human beings have decimated these resources, and it was only three decades ago that concern for mangroves began to emerge.

India has a mangrove area of 356,500 ha, comprising more than 60 species belonging to 41 genera and 29 different families as cited by Untawale (1984). The mangroves in Maharashtra are present along the southern region bordering the principal creeks and estuaries. In Mumbai remnants of previously luxuriant mangroves are seen at Vasai creek, Thane creek, Bandra creek, Vashi creek and the Versova – Manori beach strip.

Mangrove vegetation traps sediments and thus creates a congenial habitat for diverse groups of intertidal fauna. As early as 1955 Altevogt studied the ecology and behaviour of two species of fiddler crabs on the beach near Bandra. Distribution studies on fiddler crabs were done by Teal (1958) in Georgia, Macintosh (1984) in Malaysia and Chakraborty and Choudhury (1985) in Sunderbans. Distribution of Molluscan fauna in the Pitchavaram mangroves was examined by Kashinathan and Shanmugam (1985) while Yeragi (1979) studied the ecology of some Bombay molluscs. Listing of the mangrove species for the Salsette Islands (Mahim creek, Versova, Manori, Bassein, Thane, Danda and Juhu) was done by Patil (1957) and later Sreeramamurthy (1980) carried out ecological studies on the intertidal macro-fauna at Versova and Seven Bungalows beach.

The mangroves at Seven Bungalows beach extend over approximately 1.5 km. Encroachment by hutments and large scale dumping of construction debris for reclamation has destroyed a large percent of the area. This prompted the present study, which enumerates the dominant life forms that subsist within the mangroves and are hence extremely vulnerable to man made changes.

MATERIALS AND METHODS

Distribution studies were carried out using random quadrat sampling at low tides (5m x 5m for flora and 1m x 1m for fauna, 10 quadrats/month/site). Physical factors like salinity, soil temperature and moisture content were measured using standard methods Donahue (1977) and Fanson (1989).

Oven dried samples were passed through successive sieves of mesh sizes 2mm, 0.2mm, 0.02mm and 0.002mm in order to grade them into gravel, coarse

sand, fine sand, silt and clay respectively Donahue (1977). For convenience the area was separated into a mangrove (G1 and G2 sites partitioned by a channel) and a non-mangrove or fringe region which was further segregated into four sites A, B, C and D on the basis of the extent of tidal inundation. The year-long study period was divided into a monsoon (June to September) and non-monsoon (October to May) season. The statistical analysis of the data was carried out in Microsoft Excel based on the statistical analysis programme and the significance is given at $P<0.05$.

RESULTS AND DISCUSSIONS

At Seven Bungalows the mangrove species recorded were *Avicennia alba, Acanthus ilicifolius, Rhizophora mucronata, Aegiceras corniculatum, Bruguiera cylindrica, Avicennia officinalis* and *Sonneratia apetala* and the main mangrove associates were *Salvadora persica, Sesuvium portulacastrum* and *Aeluropus viliosus*. Amongst the mangroves *Avicennia marina* (62%) and *Acanthus ilicifolius* (31%) were predominant (Fig. 1(A)).Although there is ambiguity regarding the status of *A. ilicifolius* as a true mangrove, since Tomlinson (1986) and various other taxonomists consider it a mangrove associate, in the current study, the authors have followed the classification of Metcalfe and Chalk (1957), Untawale (1984) and Almeida (1996) wherein *A. ilicifolius* is referred to as a true mangrove, as it shows the presence of epidermal glands on the leaves. The abundance of *A. ilicifolius* at Seven Bungalows may be a reflection of the high sewage pollution in the area, since the plant is an ecological indicator of organic pollution Mullick (1990). Sreeramamurthy (1980) reported two sewage disposal outlets that discharge untreated sewage into the mangrove and presently the hutment population who use the mangroves for their daily ablutions add to the defilement of the area.

The fauna recorded in the mangroves were *Uca vocans, Uca annulipes, Uca dussumieri, Dotilla myctiroides, Scopimera pilula, Sesarma quadrata, Metaplax distincta, Galene bispinosa, Telescopium telescopium, Potamides cingulatus, Nerita crepudilaria*, *Bulla ampula, Cassidula nucleus, Onchidium sp* and *Periopthalamus sp.* The crab *Scylla serrata* was observed in the area though it was never recorded in the quadrats. Predominant faunal groups were crabs (57%) and molluscs (39%) (Fig. 1(B)). The distribution of populations of crabs and molluscs varied at different sites. *Uca annulipes* among crabs and *Telescopium telescopium* among molluscs were present at all sites (Fig. 2(A) & (G)). A soil profile showed that the percentage of silt in the mangroves was more as compared to the fringes, which had a higher percentage of coarse sand (Fig. 1 (D) & (E)).

Fiddler crabs show specialization in the form of their mouthparts, which adapt them to feeding either on muddy or sandy substrates (Miller, 1961; Icely and Jones, 1978). This results in each species of *Uca* being distributed broadly in relation to the occurrence of suitable sediment grades Macintosh (1985). *Uca annulipes* was found on the outskirts of the mangrove where sand content is high and this distribution corroborated with Chakraborty and Choudhury's (1984) findings, which stated that high sand content, played a key role in distribution of *Uca annulipes*. However, at Seven Bungalows *U. annulpies* was also found within the mangroves, where sand content is minimal. Crane (1975) also observed occasional populations of *U. annulipes* in mud without admixture of sand when mangroves are in the vicinity.

Uca vocans was restricted to areas with fine sand (Fig. 3 C) and similar findings were reported by Dye and Lasiak (1986). According to Crane (1975) *U. vocans* has certain modifications for retention of fine particles of sand which have a higher content of organic matter, hence their preference for the region.

Sesarma quadrata, Metaplax distincta and *Uca dussumieri* were present within the mangroves (Fig. 3 (B)), where there is substantial plant cover, the percentage of silt is more and coarse sand is minimal. According to Macintosh (1984) *Sesarma spp* was found among roots of mangrove trees along banks of channels and creeks while *Metaplax spp*. preferred soft, well drained mud banks of seaward mangroves and *U. dussumieri* avoided vegetated regions occurring only in the unshaded area within the mangroves. MacNae (1968) and Berry (1972) worked on mangrove macro-fauna and obtained similar distributions for *Sesarma spp*. and *Metaplax spp*. *Sesarma spp.* feeds on mangrove litter an young mangrove seedling (MacNae 1968), while *Metaplax spp*. has specialized filters to feed on organic deposits (Berry, 1972). The chelae of *U. dussumieri* are adapted for feeding in muddy sediments, hence it is found in muddy area (Icely and Jones 1978). Chakraborty and Choudhury (1985) reported that high amounts of sand restricts distribution of *U.dussumieri*. The argument put forward by Macintosh (1984) that the large size of *U. dussumieri* restricts its distribution within the mangroves (since the mangrove roots hamper its burrowing) does not hold good for the present study site as the mangroves here are not dense and open spaces are present within G1 and G2.

Among the recorded molluscs *Telescopium telescopium* and *Potamides cingulatus* were observed in large numbers. Molluscs usually feed on detritus and micro algae (diatoms and filamentous algae) which are high in sand and mud (Yeragi 1979). MacNae (1968) observed that *T. telescopium* was found in areas where water content in the soil is high. In this study, *T. telescopium* was observed in sizable numbers in all sites except site. A which has the least tidal inundation. During the monsoon both *T. telescopium* and *P. cingulatus*

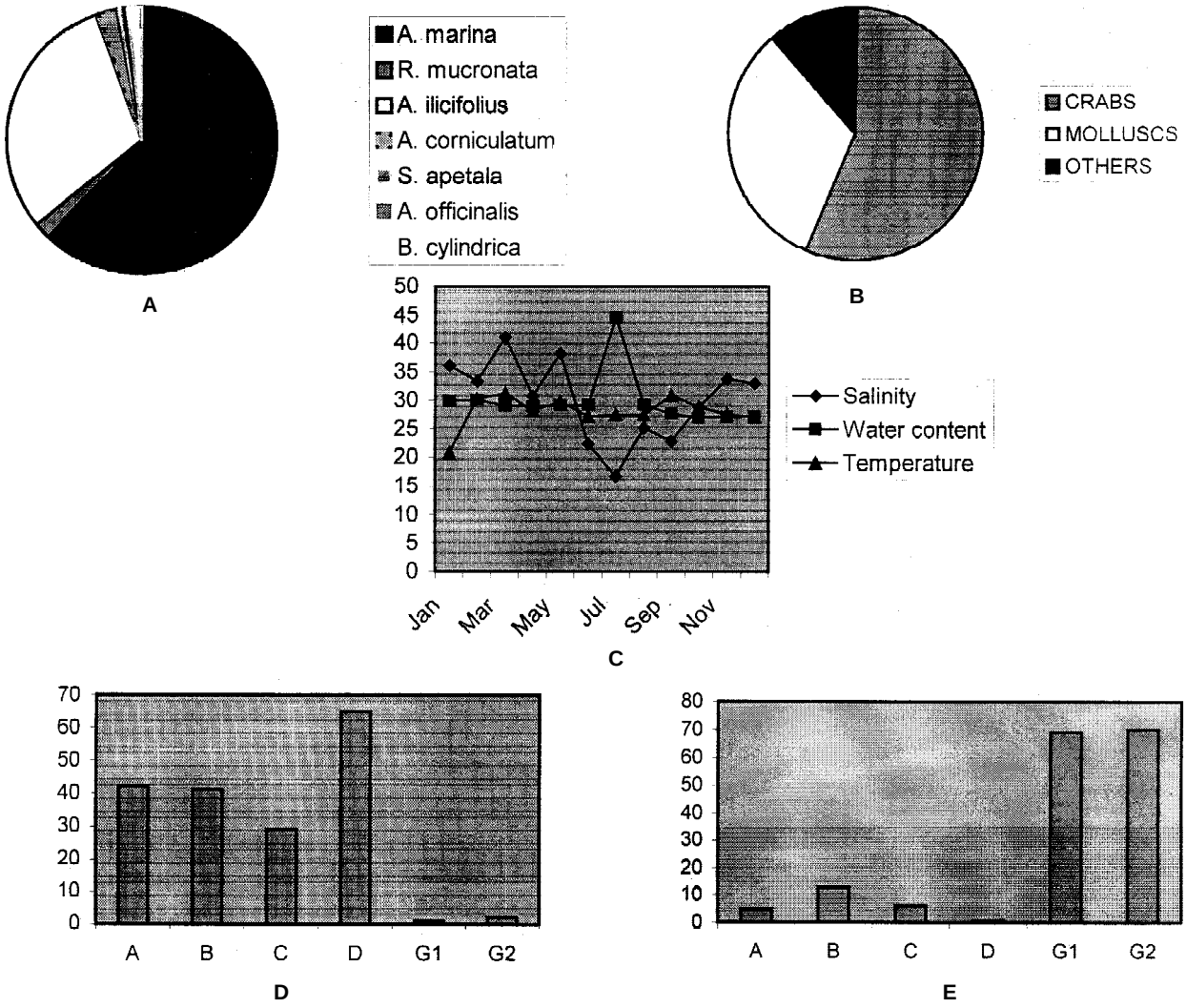


Fig. 1 (A) Percentge of Flora (B)Percentage of fauna (C) Physical parameters recorded. (D) Percentage of course sand & (E) Percentage of silt.

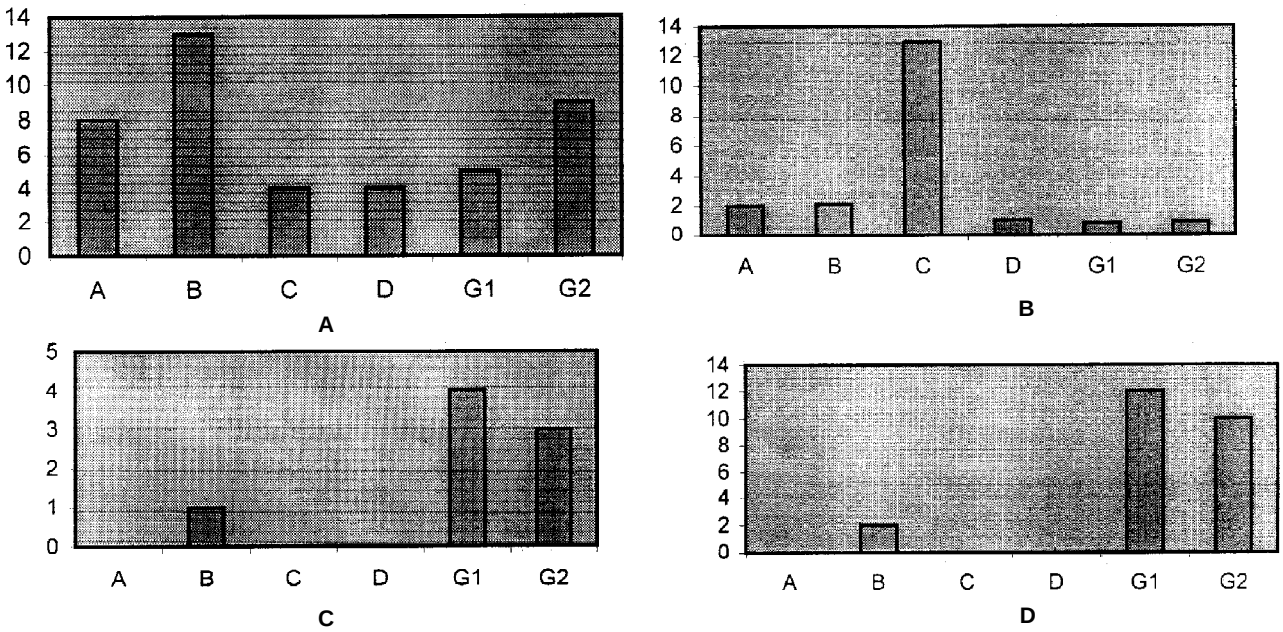


Fig. 2 (A & G) For all graphs X axix = Sites & Y axix = Average densities (m sq) : (A) UCA annulipes (B) Uca vocans (C) Uca dussumieri (D) Metaplax distincta (E) Sesarma quadrata (G) Telescopium telescopium

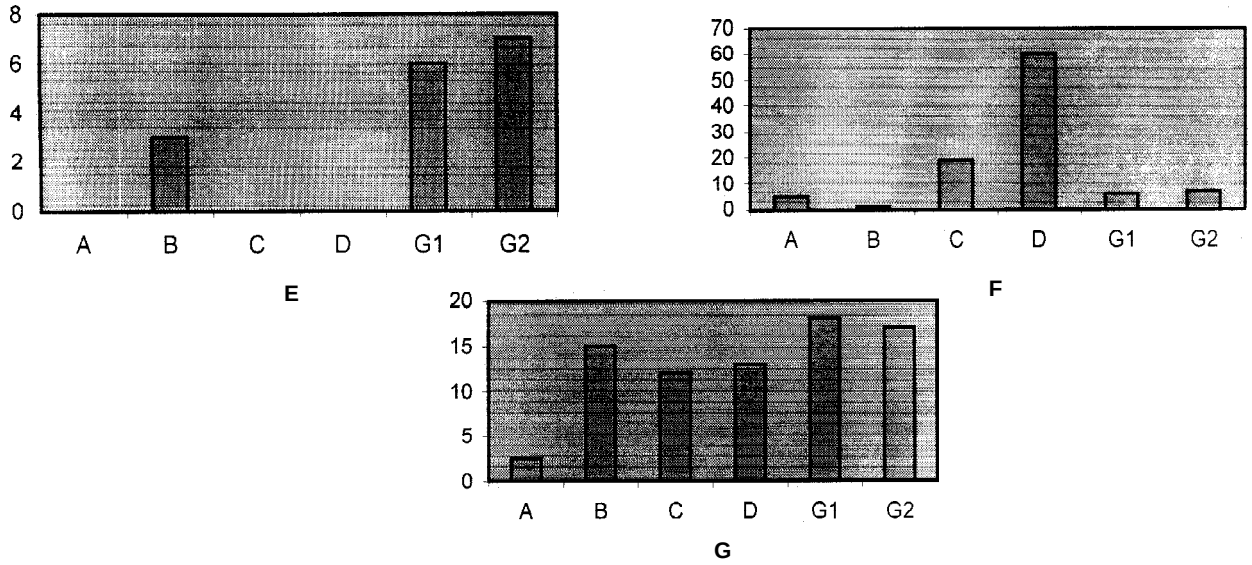


Fig. 2 (A & G) For all graphs X axix = Sites & Y axix = Average densities (m sq) : (E) Sesarma quadrata (F) Potamides cingi;atus & (G) Telescopium telescopium

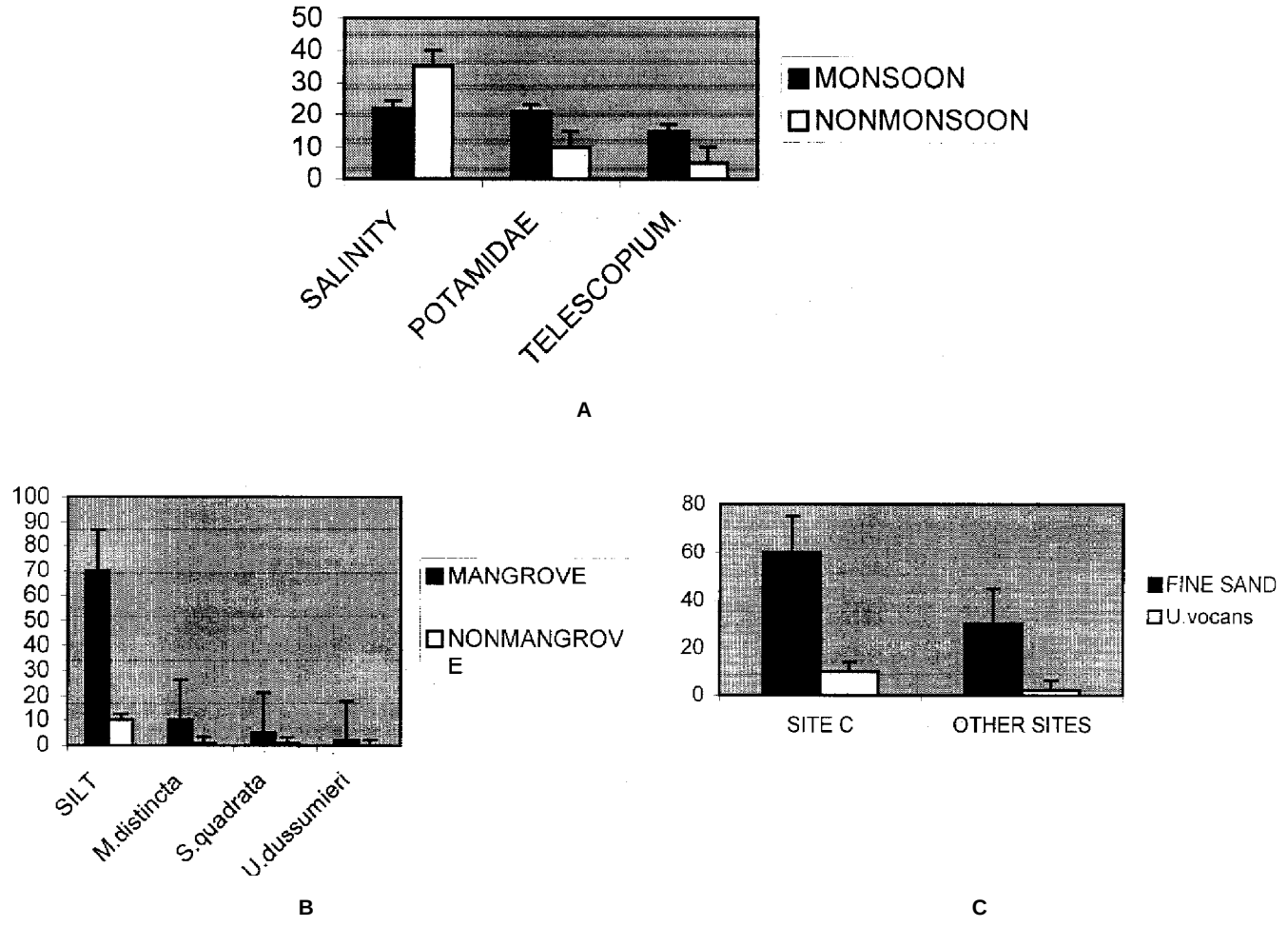


Fig. 3 (A) X axix = Values pf salinity and dessity of molluscs & Y axis = Salinity and molluscs in monsoon & nonmoonsoon (A) X axis = Density of crabs and % of silt & Y axis = Silt and crab in mangroves & nonmangroves (C) X axis = Density of U. vocans and % of fine sand & Y axis = Sites. Sigfificance is given at Mean ± S.D. where p<0.05

increased in number (Fig. 3 (A)). Physical factors like soil temperature and moisture content did not show much variation over the year, though salinity dropped significantly during the monsoon.

CONCLUSION

From the present study it is concluded that the distribution of crabs is largely governed by the feeding preferences of the crab species and soil texture of the area. This in turn decides the water retaining capacity of the soil. Human activities like dumping of construction debris may change the soil profile and alter the faunal scenario. Deposit feeding crabs process the surface soil layer and probably assist in the further breakdown of particulate organic material and their burrows allow sea water penetration which also accelerates soil to water nutrient exchange. Thus they benefit these so called wastelands, which are actually among the most fertile ecosystems in the world.

ACKNOWLEDGEMENT

The authors acknowledge the help rendered by Dr. Chapghar for identification of crabs, Prof. Rajendra Shinde for identification of plants and Prof. Saju George, Mr. Kunal Condillac and Mr. Rohan Arthur for helping in the statistical analysis.

REFERENCES

Almedia M. R. 1996. Flora of Maharashtra. Published by Mr. T. P. Almedia Vol. 1.

Altevogt R. 1955. Some studies on two species of Indian fiddler crabs, *Uca marionis* nitidus (Dana) and Uca annulipes. (Latr). J. Bombay. Nat. Hist. Soc., Vol. 52 pp 702 – 716.

Apte D. 1998. The book of Indian shells. B.N.H.S. Oxford University Press.

Berry A. J. 1972. The natural history of the west Malaysian mangrove faunas. Malay. Nat. J., 25 : 135 – 162.

Chakraborty S. K. and A. Choudhury. 1985. Distribution of fiddler crabs in Sunderbans mangrove estuarine complex, India. The mangroves : Proc. Nat. Symp. Biol. Util. Cons. Mangroves, : 467 – 472.

Chapghar B. F. 1957. Marine crabs of Bombay state. Taraporevala Marine Biological Station, Bombay.

Crane J. 1975. Fiddler crabs of the world (Ocypodidae : Genus Uca). Princeton Univ. Press, New Jersey : 736 pp.

Donahue R. L., Miller W. Raymond. and John C. Shickluna. 1977. Soils : An introduction to soils and plant growth. Prentice – Hall, Inc., Englewood, Cliff's, New Jersey. Pp 50, 83 – 84.

Dye A. H. and T. A. Lasiak 1986. Microbenthos, meiobenthos and fiddler crabs : Trophic interactions in tropical mangrove sediment. Mar. Ecol. Prog. Ser. Vol. 32 : 259 – 264.

Fanson, H. (Editor). 1989. Standard methods for the examination of water and wastewater. 17th ed. American public health association, American water works. Association, Water pollution control federation.

Icely J. D. and D. A Jones. 1978. Factors affecting the distribution of the Genus Uca (crustacea : Ocyodidae) on an East African shore, Est. Coast. Mar. Sci. 6 : 315 – 325.

Kashinathan R. and A. Shanmugam. 1985. Molluscan fauna of Pitchavaram mangroves, Tamil Nadu. The mangroves : Proc. Nat. Symp. Biol. Util. Cons. Mangroves : 438 – 443.

Macintosh D. J. 1977. Some responses of tropical mangrove fiddler crabs (Uca sps.) to high environmental temperature, In : D. S. McLusky & A. J. Berry (Eds). Proc. 12th Europ. Mar. Biol. Symp. Pergamon Press, Oxford. pp 49 – 56.

Macintosh D. J. 1984. Ecology and productivity of Malaysian mangrove crab populations (Decapoda : Brachyura). Proc. As. Symp. Mangr. Env. – Res. & Manag. : 354 – 377.

MacNae W. 1966. Mangroves in Eastern and Southern Australia. Aust. J. Bot., 14 : 67 – 104.

MacNae W. 1968. A general account of the flora and fauna of mangroves swamps and forests in the Indo-West Pacific region. Adv. Mar. Biol., 6 : 73 – 270.

Metcalf C. R. and L. Chalk. 1957. Anatomy of the dicotyledons, Oxrford Press. University.

Miller D. C. 1961. The feeding mechanism of fiddler crabs with ecological Consideration of feeding adaptations. Zoologica, N. Y. 46 : 86 – 100.

Mulik N. C. Possible pollution indicator species from mangroves at Bhagatye estuary. Pro. Indian. Sci. Congr. 77 Sect. Bot. pp 221.

Patil R. P. 1957. The mangroves in Salsette Islands, near Bombay. B.S.I. Lucknow.

Sreeramamurthy K. B. 1980. Ecology of intertidal macrofauna at Versova and Seven Bungalows beaches, Bombay. M.Sc. Thesis C.I.F.E.

Teal J. M. 1958. Distribution of fiddler crabs in Georgia Salt Marshes, Ecology 39 : 185 – 193.

Untawale A. G. 1984. Present status of mangroves among the west coast of India. In Proc. As. Symp. Mangr. Env. – Res. & Manag., pp 57- 74.

Yeragi S. G. 1979. A study of some Bombay mollucsc. Ph. D. Thesis, Institute of Science Bombay.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 201-202

STUDY OF COPPER IN POLYCHAETA *LYCASTIS MERUKENSIS* FROM THANE CREEK.

Mukherji M. N. and Gokhale K. S.*,
RKT College, Ulhasnagar.
*Zoology Department, B.N.Bandodkar College of Science, Thane 400 601.

ABSTRACT : Thane Creek receives industrial and domestic waste which includes heavy metals such as Cu, Zn, Cd, Pb, etc. *Lycastis merukensis* was studied over a period of two years for metal contamination. It exhibited a threshold for copper after which the metal concentration was depleted, even though the sediment contamination was higher indicating a regulatory mechanism after reaching a particular threshold.

Key words: Thane Creek, Copper, *Lycastis merukensis*, Threshold.

INTRODUCTION

Thane Creek lies 19.00 to19.15 N latitudes and 72.55 to 73 E longitudes south of Bombay harbour and moves northward joining the Ulhas river by a connection. This creek is tide dominated and is fringed with mangrove mudflats. Bombay, Thane, Belapur industrial and urban complex are situated along the creek. As a consequence the mangrove sediment is contaminated with heavy metals. These trace metals are non-biodegradable and hence tend to accumulate in marine organism and can create potential hazards for human beings.

Lycastis merukensis is a resident polychaete of this mud flat forming major component of benthos throughout the year. They are detritivorus in habit feeding on sediment- organic matter. This paper attempts to study the bioaccumulation and regulation of copper in this polychaete.

MATERIAL & METHODS

All the sediment samples were collected from the surface of 10 cms. Depth from low level water mark and high level water mark for a period of two years. (July 1988-June 1990). The macrobenthos were sieved from the sediment. The polychaete *Lycastis merukensis* were hand picked and size and weight of each were noted. The sediment and *Lycastis merukensis* were digested with nitric acid and perchloric acid and the extracted metals were read on A.A.S. at B.A.R.C. Mumbai.

The data has been computed into eight groups each of three months which approximately coincides with seasons and named as KI, KII, KIII, KIV,KV, KIV, KVII, KVIII. for 1988-89 and 1989-90 respectively.

KI and KV- July, August and September.

KII and KVI-Oct., Nov. and Dec.

KIII and KVII- Jan., Feb. and March.

KIV and KVIII- April, May and June.

RESULTS & DISCUSSION

Table 1 presents season wise variation in the sediment & the polychaeta. The portal entry of the metal in the polychaeta is through the body surface and food. The organisms try to adopt to the load of pollutants by evolving methods of solubilizing, transporting, regulat-

Table 1 : Concentration of Copper in the sediment and body of *Lycastis merukensis*

1988-89	Conc. Of Sed. Cu µg/g	Body Cu	Body/ Sed ratio
KI	175.22	7.65	0.044
KII	168.3	73.13	0.440
KIII	85.82	12.57	0.150
KIV	122.6	15.36	0.130
1989-90			
KV	150.20	21.45	0.140
KVI	180.07	12.50	0.070
KVII	192.96	9.96	0.050
KVIII	204.09	33.00	0.160

ing, detoxifying and excreting the material. *Lycastis merukensis* exhibited regulation of body copper more evidently than any other metals. The sediment-copper fluctuated in the range of 85.82 – 204.09 µg/g while the body concentration of copper varied to 7.65 – 73.13 µg/g. The ratio of body copper to sediment copper showed variations of 0.044 – 0.44 indicating insignificant bio-accumulation of copper. The significant observation was the sediment copper level did not reflect on the concentration of body – copper level. This suggests efficient regulation of copper in *Lycastis merukensis*. Bryan and Langston (1992) mentions control of metal concentration in the body by three ways 1) Excretion 2) Temporary storage and 3) Regulation; the strategy may vary according to the species with different trace metals.

The correlation between sediment – copper and body – copper shows body concentration of copper changed significantly from 7.65 – 21.45 µg/gm while the sediment copper changed from 85.82 – 150.20 µg/gm. This can be attributed to either excretion or detoxitication mechanism. This mechanism appears to have reached its limitation when the sediment copper increased as a result the body – copper level reached the maxima of 73.13 µg/g which appears to have stimulated the other mechanism. The operation of this mechanism was discernible by a similar abrupt fall of body copper level to 7.65 µg/g, perhaps after reaching the threshold.

A threshold is the maximum limit of metal beyond which organism must expend energy to maintain sub – lethal concentration which may subtly act on physiology (Chernoff and Dooley, 1979). This regulatory mechanism has been well represented by *Lycastis merukensis*.

Rainbow *et al*. (1990) generalized metal accumulation strategies in evolutionary forms. According to them physiologically advanced members of any group appear to be capable of partial or complete metal regulation. Less advanced members seems to adapt as storage accumulation strategy.

Hence it can be concluded that *Lycastis merukensis* are physiologically more advanced as they adapt to the strategy of regulating copper showing the threshold.

REFERENCES

Bryan G W and Langston W J 1992 Bio-availability, accumulation and effect of heavy metals in sediment with special reference to UK estuaries. A review Environmental pollution,76: 89 – 131.

Chernoff B, Dooley J, 1979 Heavy metals in relation to the biology of *Fundulus heteroditus* J.fish bio.14: 309-328.

Rainbow P S, Philips, David J H, Depledge N H, 1990. The significance of trace metals concentration in marine. invertebrates. Mar.Poll.Bull .Vol.21(7):321-324

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 203-212

TEMPORAL AND SPATIAL VARIATIONS IN SEDENTARY MARINE MACROFOULING ORGANISMS

B.S. Swami, M. Udhayakumar and S. N. Gaonkar
Marine Biology & Environmental Sciences, Naval Materials Research Laboratory, DRDO, Anandnagar P.O., Ambernath (E), Dist.- Thane - 421 506, Maharashtra..

ABSTRACT : With growing dependence on the seawater as an industrial fluid by shore based industries several problems of material durability as well as marine biota are presently encountered. It is, therefore, mandatory to generate scientific data that may help in understanding the ecological aspects of macrofouling species which may help in evaluating the impact of hazardous marine environment on the man-made facilities. The tasks of the biologists involved in the field work are i) quantitative and qualitative assessment of biotic life, ii) observations on spatial variability among replicate biofouling test coupons (panels) and iii) the effect of seasons on prevalence of sedentary organisms.

The present studies have been carried out continuously for a period of 16 months at two sites having different status of water quality in Mumbai harbour (lat.18º 55'N; long.72º 50'E). The data pertaining to water quality were also simultaneously collected. It is observed that the species belonging to varied animal phyla are adequately represented. The macrofouling at Near-shore waters and Tidal basin has been characterised with regard to species abundance, species composition and weight of biomass. A total of sixty species have been recorded during the investigation period. These species mainly belong to phylum polychaeta (11 species), bryozoa (22 species), cirripedes (4 species), mollusca (5 species.), coelenterata (6 species), tunicata (10 species) and porifera (2 species.) Out of sixty species, 35 species have been recorded from Tidal basin which is influenced by organic polluntants released through sewage water. Among these macrofoulers, six species of ascidians, six species of polychaetes and five species of bryozoans are new records from the region.

The study revealed that the density, species composition and biomass recorded at two sites, varied from month to month as well as season to season. The species density and biomass recorded at Tidal basin was significantly ($P < 0.00005$) higher than the density recorded at Near-shore waters, indicating the remarkable spatial variations. The influence of sewage water pollution was obvious showing considerable reduction in species diversity. Around 55% deviation in species settlement was noted during monsoon, indicating impact of stressed environmental conditions caused due to rainy season. Seasonal trend appears to be affected at polluted Tidal basin.

Key words *: Macrofouling, species, biomass, season, pollution, diversity.*

INTRODUCTION

The settlement of undesirable marine sedentary organisms on man-made facilities, biofouling as it is called, depends on the environment, the life it supports, the nature of the material and on the scope of marine enterprise where the material is put into use. The choice of control measures adopted to prevent biological growth depends on several factors and before any one measure is recommended, it is obligatory to ascertain the physico-chemical characteristics of the site with respect to water and the life it sustains.

The development of macrofouling on immersed structures or on marine machinery has now been recognised as one of the major problems and is receiving increasing attention all over the world. It is now widely accepted that the problems related to settlement of the marine organisms are not only confined to ship hulls and ship machinery. Installations such as coastal power stations, chemical and desalination plants which use sea water as cooling medium, and many other harbour activities face a constant problem of preventing a build-up of marine fouling organisms. The quality and the quantity of fouling assemblage at a given site or environment depend on its biotic and hydrographical conditions.

This fouling adds to the weight of the immersed structures, generates debris, induces corrosion, impairs functioning of moving parts, increases drag and creates several other problems. Soft fouling includes plant species and certain animal forms like ascidians, coelenterates, polychaetes and bryozoans. These organisms, besides contributing to the weight and volume of the immersed structures can also cause choking of inlet and outlet of conduits on ship and harbour facilities.

The economic loss due to damage caused by fouling organisms in India is stupendous. About 360 million rupees are spent annually to maintain boats and ships free of fouling (Balaji, 1988). Oil and Natural Gas Commission (ONGC) spends about Rs.120 million annually to maintain their platforms free from fouling.

A good amount of information on biofouling has been generated in Indian tropical waters (Swami and Gaonkar ,1998). In near-shore waters of Mumbai a large number of sedentary species indulge in marine fouling. Among these, polychaetes and bryozoans occur in abundance.

The present investigation was mainly confined to major groups of biofouling species like bryozoans, polychaetes, cirripedes and ascidians.. The main objectives were a) to determine community abundance, species composition and weight of biomass of macrofouling, and b) to study the month to month, season to season and spatial variations in density, species composition and biomass.

Materials and methods

1. *Exposure sites* : In order to assess the settlement, distribution, species composition and seasonal variability of macrofoulars, the test coupons were exposed at two study sites in Mumbai harbour (lat. 18° 55' N; long. 72° 50' E) during June1995- September1996 and the qualitative and quantative aspects studied.

i) *Near- shore waters* : Near-shore waters is an open sea having a good tidal flow. It is located at the mouth of Thane-Mumbai Bay. The water is relatively clean and is subject to diurnal tidal flow. The maximum depth at this site is 15 metres. This site is denoted as St.1. ii) *Tidal basin*: It is semi-enclosed water close to the shore and receives untreated sewage through storm water-culvert. During monsoon, a considerable amount of rain water enters the tidal basin, causing wide and frequent fluctuations in salinity. The site supports a good growth of sulfate reducing bacteria, which contribute to severe corrosion (Karande and Srivastava**,** 1984). The depth of water at this site is 7.5 metres. This site is denoted as St. 2.

2. *Exposure of the coupons* : In field exposure studies for collecting data on various biological aspects at selected sites, pre-weighed test panels of perspex, (size 15 x 16 x 0.4 cm) were bolted on mild steel frames. The experimental frames were immersed one metre below the low tide mark. A set of 10-12 test panels was immersed at every calendar month and an equal number was withdrawn for examining the biota under live condition (non-destructively).

3. *Examination of the coupons* : The test panels (coupons) were examined under stereo-microscope (Zeiss). The census of each individual was made using square grid method (Winston and Jackson, 1984; Karande and Swami, 1988). A thin perspex sheet was engraved with squares of 1 cm. and superimposed on the test panel. The biota assessed was characterised as density, species composition and biomass. The coupon area of 15 x 12 cm (180 sq. cm.) was actually screened. After examination of the biota, the panels were preserved in 5% formalin for 6 hours and were kept for air drying for 8-10 days to get constant weight. The weight of biomass was estimated accurately and expressed as g/m^2. The data collected was statistically treated (Trivedy and Goel, 1984).

RESULTS

Near-shore waters (St. 1)

Hydrography

St. 1 and St. 2 differ from each other in respect of water quality. Water quality status at St.1 is stable. Temperature, salinity, dissolved oxygen (DO) and Total suspended solids (TSS) ranged from 26.2°C to 31.9°C, 22.12 to 36.21‰, 3.56 to 6.57 mg/l and 35.6 to 249.2 mg/l respectively. In comparison to St.1, the water quality at Tidal basin (St. 2) is found to be polluted. Dissolved oxygen content was considerably low here. It ranged between 0.55 and 7.49 mg/l. Salinity fluctuation was wide during monsoon. Temperature, salinity and TSS ranged between 26.8 and 32.0°C, 16.26 and 35.81‰ and 6.8 and 37.6 mg/l respectively. The pH ranged from 7.28 to 7.95 . The low value of 7.28 was recorded in April, 1996. The organic sewage released through storm water-culvert resulted in depletion of 0_2 content to an extent of 0.55 mg/l during June, 1996 (see table 1). Swami *et al*. (2000) reported this site as polluted.

Density (Community abundance)

The sedentary organisms settled on test panels comprised heterogeneous groups. The species mainly belong to the phyla Ectoprocta, Annelida, Arthropoda, Mollusca, and Ascidia. In the present study, as many as 60 animal taxa were recorded. The phylum-wise species are listed in table 2.

Table 3 summarises the density (i.e. number of individuals of the species) of macrofoulants during various months. During the early period of immersion, the density of biogrowth was not uniform. The number of individuals settled varied from month to month. Gradual increase in density was observed from July to September, 1995. The species which contributed substantially to increase the density were *Hydroides elegans*, *Hydroides operculatus* , *Dasycone cingulata, Balanus variegatus* and *Apomatus* sp. The polychaete and bryozoan species jointly contributed to an extent of 90 % of the density. The highest growth was recorded during September,1996, whereas low density was recorded in July, 1996. The lowest value can be attributed to low salinity caused due to monsoon.

Month to month variations

The density varied from month to month. The difference between the number of individuals settled in June and July was insignificant whereas in the

Table 1 - Hydrographical parameters monitored at two study sites at Mumbai harbour.

Period	Near shore waters (St.1)					Tidal basin (St.2)				
	Temp. (° C)	pH	Saln. (ppt.)	DO (mg/l)	TSS (°C)	Temp.	pH (ppt.)	Saln. (mg/l)	DO	TSS
June'95	31.5	7.77	30.81	5.84	69.20	31.6	7.70	35.57	1.46	25.6
July	29.2	7.86	27.87	5.89	245.6	29.2	7.71	22.21	4.47	14.4
Aug.	29.5	7.85	27.89	5.66	179.6	29.5	7.61	23.08	4.56	21.2
Sept.	29.5	8.15	30.45	6.3	118.4	29.6	7.95	31.4	4.0	37.6
					Post-monsoon					
Oct.	30.3	7.91	34.92	4.47	73.2	31.2	7.86	33.65	2.74	37.2
Nov.	28.7	7.95	34.92	4.47	37.2	29.6	7.85	34.29	3.83	13.6
Dec.	27.0	7.71	35.87	5.21	35.6	27.5	7.49	34.92	7.49	9.6
Jan'96	26.2	7.84	35.50	6.2	40.0	26.8	7.71	34.92	3.56	9.6
					Pre-monsoon					
Feb.	27.2	7.92	35.57	5.2	46.6	27.1	7.77	35.81	4.29	6.8
March	28.1	7.99	34.92	6.29	56.4	28.0	7.75	35.25	5.39	24.8
April	30.4	7.94	36.21	5.29	202.8	30.5	7.28	35.81	1.83	18.8
May	31.1	7.91	36.21	4.19	144.0	30.8	7.68	35.25	2.09	16.0
					Monsoon					
June	31.9	7.88	35.81	3.56	170.0	32.0	7.61	35.81	0.55	103.6
July	29.3	7.93	23.72	4.47	986.0	29.0	7.66	16.26	5.58	30.8
Aug.	29.1	7.95	22.12	6.57	35.7	28.9	7.78	21.16	3.74	21.2
Sept.	29.3	7.92	31.73	5.82	249.2	29.4	7.83	23.72	4.12	28.6

temp.= temperature, Saln. = salinity, DO = dissolved oxygen, TSS = total suspended solids

Table 2 – The macrofouling species recorded from two study stations at Mumbai harbour

Name of the species	St. 1	St. 2	Name of the species	St. 1	St. 2
Coelenterata			***Bugula stolonifera***	**A**	**P**
Companularia sp	. P	P	*Savignyella sebogi*	P	A
Obelia sp.	P	P	*Scrupocellaria scruposa*	P	A
Clytia sp.	P	A	*Zoobotryon verticellatum*	P	A
Sertularia sp.	P	A	*Victorella pavida*		P
Plumularia sp.	P	P	*Amethia convoluta*	P	A
Tubularia sp	A	P	*Nellia tenella*	P	A
Annelida			***Electra bellula****	**P**	**A**
Hydroides elegans	*P*	*P*	Nolella popuenensis	*A*	*P*
*Hydroides operculatus**	P	A	**Cerripedes**		
Apomatus sp.	P	A	*Balanus variegatus*	P	P
Pomatoleus sp.	A	P	*Balanus reticulatus*	P	P
*Ficopomatus uschakovi**	A	P	*Chirona amaryllis euamaryllis*	P	P
Chaetopterus variopedatus	P	P	*Megabalanus tintinnabulum*	P	A
Dasycone cingulata	*P*	*P*	***Mollusca***		
*Pseudobranchiomma orientalis**	P	P	*Crassostrea graphoides*	P	A
*Branchiomma cingulatum**	A	P	*Crassostrea sp.*	P	A
*Jasmineria sp**	A	P	*Saccostrea cucullata*	P	A
*Demonax leucaspis**	A	P	*Mytilopsis sallei*	A	P
Bryozoa**(encrusting)**			***Oyster sp.***	**A**	**P**
Electra bengalensis	*P*	*P*	***Tunicata***		
Membranipora annae	P	A	*Symplegma reptans*	P	P
Membranipora tenuis	P	A	*Symplegma brakenbielmi*	P	P
Membranipora sp.	P	A	*Symplegma viride**	P	P
Membranipora saverti	P	A	*Botrylloids magnicoecum**	P	P
Acanthodesia sp.	P	P	*Botrylloids chevalense**	P	A
*Alderina arabianensis**	P	P	*Diplosoma macdonaldi**	P	P
Hippoporina americana	P	P	*Ascidia sydneiensis**	P	P
Hippopodina feegeensis	P	A	*Ascidia indica**	P	P
*Electra crustulenta**	P	A	*Styela bicolor*	P	P
Clothrudium sp.*	P	A	*Ecteinascidia sp.*	P	P
Bryozoa **(erect forms)**			Porifera		
Bugula bengalensis	*P*	*P*	Leucosolenia sp.	*P*	*A*
Bugula neritina	P	A	*Sycone sp.*	P	A
			Others	10	-

P = present A = absent * recorded for the first time

Table 3 - Macrofouling characterisation at Near-shore waters (St.1)

Period	Density (no./m^2)		Species comp. (no./panel)		Biomass (g/m^2)	
	Mean	SD	Mean	SD	Mean	SD
June'95	3416	± 1037	14	± 3	84.8	± 28.6
July	2592	± 1152	11	± 3	35.0	± 12.4
Aug.	6896	± 1926	17	± 2	160.8	±58.5
Sept.	9716	± 1668	19	± 3	224.4	±89.25
Oct.	2632	± 883	15	± 2	114.7	±24.4
Nov.	2808	± 794	16	± 2	145.3	±45.7
Dec.	3354	± 386	15	± 2	77.0	± 8.5
Jan.'96	10345	± 1901	22	± 2	53.5	±34.3
Feb.	6078	± 1314	28	± 3	34.4	± 7.99
Mar.	8359	± 1857	25	± 3	42.8	± 11.2
Apr.	3759	± 1334	20	± 2	35.8	± 10.9
May	8635	± 2191	17	± 2	9.1	± 6.9
June	2576	± 984	14	± 2	18.0	± 6.91
July	1877	± 911	11	± 3	20.9	± 7.4
Aug.	4205	± 526	11	± 3	76.0	± 25
Sept.	12069	± 2275	22	± 3	84.8	± 23.5

subsequent months of July to September the difference was highly significant ($p<0.00005$). This was due to heavy and varied settlement of polychaete species namely *H. elegans, H. operculatus* and *D. cingulata*. The month-to-month difference in settlement of fouling organisms was maintained by individuals of only two major groups, viz. polychaetes and bryozoans. Thus it can be inferred that the month-to-month variations in density were quite high.

Seasonal variations

The seasonal difference in population density was high at near-shore waters. The settlement of fouling individuals during pre-monsoon was significantly more than the settlement recorded in monsoon and post-monsoon (table 5). During monsoon, as expected, the density recorded was significantly less than the density in pre-monsoon, indicating the monsoonal effect. However, the density in monsoon was significantly higher than that of post-monsoon.

Table 4 – Statistical estimation of month to month variations among macrofouling organisms settled at St. 1.

Period	Density (no/m^2)			Species composition (no/panel)			Weight of biomass (g/m^2)		
Mon. – Mon.	'n'	't'	'p'	'n'	't'	'p'	'n'	't'	'p'
Monsoon									
June - July	14	1.38	NS	14	1.86	NS	14	4.33	p < 0.001
July – Aug.	14	5.20	p < 0.0002	14	4.25	p< 0.001	14	5.90	p< 0.00005
Aug.- Sept.	15	3.20	p = 0.005	15	1.5	NS	15	1.60	NS
Sept.- Oct.	16	9.77	p< 0.00005	16	3.05	p< 0.01	16	3.16	p< 0.01
Post-monsoon									
Oct. – Nov.	18	0.69	NS	18	1.07	NS	18	1.77	NS
Nov. – Dec.	15	2.59	p< 0.05	15	1.0	NS	15	4.37	p< 0.001
Dec. –Jan.	16	8.88	p<0.00005	16	6.86	p< 0.00005	16	6.71	HS
Jan'96 - Feb.	19	4.36	p< 0.0005	19	5.08	P< 0.0005	19	10.6	HS
Pre-monsoon									
Feb. – Mar.	19	1.39	NS	19	2.18	P< 0.05	19	1.91	NS
Mar.- Apr.	20	5.38	p< 0.00005	20	4.23	P< 0.0005	20	1.41	NS
Apr.- May	19	6.30	p< 0.00005	19	3.29	P< 0.005	19	6.46	HS
May – June	18	6.35	P< 0.00005	18	3.19	P< 0.005	18	2.74	P< 0.02
Monsoon									
June – July	17	1.64	NS	17	3.09	P< 0.01	17	0.82	NS
Jul. – Aug.	18	2.33	p <0.05	18	0.84	NS	18	6.61	HS
Aug. – Sept.	20	13.07	p< 0.00005	20	8.20	p< 0.00005	20	0.81	NS

n = number of samples, 't'= student's 't' test, p=level of significance,
HS = highly significant, NS = not significant

Table 5 – Season to variations and their significant level among macrofoulants settled at St. 1 and St. 2.

Season	Density (no/m^2)		Species comp.(no/panel)		Biomass (g/m2)	
	Mean	SD	Mean	SD	Mean	SD
			Near-shore waters (St. 1)			
Pre – mon.	6708	± 1674	23	± 5	30.52	± 9.20
Monsoon	5655	± 1446	15	± 4	126.05	± 47.20
Post-mon.	4785	± 911	18	± 3	122.65	± 28.22
			Tidal basin (St. 2)			
Pre-mon.	45393	± 9106	16	± 4	164.04	± 37.22
Monsoon	60992	± 13556	12	± 5	132.0	± 22.15
Post-mon.	60062	± 14191	15	± 3	138.92	± 38.03

Seasons	Density			Species composition		Biomass	
	'n'	't'	'p'	't'	'p'	't'	'p'
			Near-shore waters				
Pre-mon. x Mon.	75	2.91	p< 0.005	7.69	p< 0.00005	6.50	p< 0.00005
Mon. x Post-mon.	71	3.09	P< 0.005	3.61	P< 0.001	0.37	NS
Post-mon x Pre-mon	72	6.06	P< 0.00005	5.2	p< 0.00005	18.2	P< 0.00005
			Tidal basin				
Pre-mon. x Mon.	82	6.1	P< 0.00005	3.96	P> 0.0002	5.33	P< 0.00005
Mon. x Post-mon.	76	0.29	N S	3.15	P< 0.005	0.97	NS
Post-mon x Pre-mon	82	5.47	P< 0.00005	1.30	NS	3.2	P< 0.002

Table 6 - Macrofouling characterization of Tidal basin (St.2).

Period	Density (no./m^2)	Species composition (no./panel)	Biomass (g/m^2)
	Monsoon		
	Mean ± SD	Mean ± SD	Mean ± SD
June'95	16299 ± 2332	9 ± 2	167.50 ± 18.3
July	55678 ± 20964	8 ± 2	132.16 ± 43.3
Aug.	28300 ± 9652	10 ± 2	96.54 ± 19.1
Sept.	143691 ± 21342	19 ± 4	421.50 ± 87.7
	Post-monsoon		
Oct	13563 ± 7895	12. ± 2	141.10 ± 79.2
Nov.	137995 ± 19522	15 ± 2	218.20 ± 35.6
Dec.	85082 ± 28500	13 ± 2	102.50 ± 21.24
Jan. 96	3610 ± 845	18 ± 3	93.91 ± 16.1
	Pre-monsoon		
Feb.	6541 ± 2648	20 ± 3	62.50 ± 14.1
Mar.	134526 ± 21312	18 ± 3	274.16 ± 63.77
April	28026 ± 9232	16 ± 2	177.80 ± 25.53
May	12778 ± 3232	10 ± 1	141.70 ± 45.51
	Monsoon		
June	17544 ± 8012	8 ± 2	38.60 ± 6.6
July	29485 ± 7895	7 ± 3	76.60 ± 12.42
Aug.	21891 ± 9260	8 ± 2	93.0 ± 14.6
Sept.	128096 ± 15542	14 ± 3	319.8 ± 63.6

SPECIES COMPOSITION

Monthly variations

Table 3 shows the month-wise species recorded at St. 1. Although the number of species settled at the beginning was not high, substantial increase in species during August, was observed (17 ± 2) and this trend continued till the end of September 1995 in which 19 species were encountered on the panels. Generally, the species settling in each month varied. Only in three months from October-December the species settlement was uniform, showing no significant difference in the settlement. During investigation the period, the species number ranged between 11 and 28. The lowest number recorded was particularly during the monsoon month of July and highest number (28/panel) in the pre-monsoon month of February,1996.

In July and August 1996, species number reduced to 11. This drastic decrease in species was mainly due to monsoon. (table 4).

Seasonal variations

It was observed that the maximum species settled during pre-monsoon period whereas minimum in monsoon season. The average species recorded during pre-monsoon, monsoon and post-monsoon were 23 ± 5, 15 ± 4 and 18 ± 3 respectively. The species settled in pre-monsoon were significantly more than species settled in monsoon and post monsoon (table 5).

BIOMASS

Table 3 shows the month-wise biomass recorded at St. 1. It was observed that the biomass varied from month to month. It ranged from 9.1 to 224.4 g/m^2. The highest value was recorded in the month of September, 1995 and lowest value of 9.1 g/m^2 in May 1996.

Tidal Basin (St. 2)

The site is 500 m off the St. 1, which is subjected to sewage pollution released through storm water culvert. Earlier, this site has been investigated to assess its biological (faunal) and pollution status. Karande and Srivastava (1984) stated that this site is influenced by organic pollution. The study was conducted to understand the faunal composition and density in relation to stressed water quality.

The macrofouling organisms recorded at this site belong to four major groups, viz. polychaetes, bryozoans, ascidians and cirripedes. In the present study, 35 species were recorded (table 2).

Density

Table 6 shows the density recorded during different periods at St. 2. It is observed that this site supports a good growth of polychaetes. Swami (1987) reported that the most dominant group at this site was polychaetes. The present study revealed that at any time of the year, if the panels are exposed, around 85% of the population density is due only to polychaetes. Nine different species were recorded from this site. Bryozoan contribution for density build-up at this site was much less (7.15 ±14.2). The density varied between 3610 and 143691 individuals/m^2. The highest value was recorded during September 1995 whereas lowest was in January, 1996.

Month to month variations

It is observed that the population density significantly varied from month to month. The level of significance estimated between the months were very high (table 7). The species that contributed substantially in enhancing the density at this site were *H. elegans, Ficopomatus uschakovi, Chaetopterus. variopedatus, Branchiomma. cingulatum, Pomatoleus* sp and *Electra. bengalensis.*

Seasonal variations

Species composition:

In all, 35 different species have been recorded from this polluted site. The most dominant group polychaetes (9 species), bryozoans 8 species, (4 encrusting and 4 erect bryozoans), ascidians (9 species), cirripedes (3 species), molluscs (2 species), hydroids (4 species).The study revealed that the species recorded at this site were relatively less than that at St. 1. The number of species settled in each month varied from month to month. The species settled varied from 7 to 20, the lowest in July and highest number recorded in February 1996. The number of species settling during pre-monsoon and post-monsoon were significantly more than the species settled in monsoon. Maximum settlement was recorded during pre-monsoon, whereas minimum number (n = 12) was in monsoon (table 5).

BIOMASS

Table 6 shows month-to-month variations in biomass. The result shows that the biomass developed in all months differed from each other.

Month to month variations

Month-to-month variation pattern was similar to that observed in density. The highest biomass was recorded in September (421.5 g/m^2), and the lowest in June 1996. Season to season variations in biomass were observed at St. 2. The biomass recorded during pre-monsoon was significantly higher than the biomass recorded in monsoon and post-monsoon. However, the difference between biomass recorded during monsoon and post-monsoon was negligible, showing no significant difference between these two seasons (table 5).

Table 7 – Statistical estimation of month to month variations among macrofouling organisms settled at St. 2.

Period	Density (no/m^2)			Species composition (no/panel)			Weight of biomass (g/m^2)		
Mon. – Mon.	' n'	't'	' p'	' n'	' t'	' p'	' n'	' t'	' p'
				Monsoon					
June – July'95	8	5.28	p< 0.00005	18	1.06	NS	18	2.16	P< 0.05
July – Aug.	18	3.14	p< 0. 005	18	2.13	p< 0.05	18	2.16	p< 0.05
Aug.- Sept.	20	15.59	p<0.00005	20	6.38	p< 0.00005	20	11.45	p< 0.00005
Sept.- Oct.	18	17.83	P<0.00005	18	4.82	P< 0.0002	18	7.11	p< 0.00005
				Post-monsoon					
Oct. – Nov.	18	19.95	P< 0.00005	18	3.19	p = 0.005	18	2.51	P< 0.05
Nov. – Dec.	20	4.84	P< 0.0001	20	2.25	p< 0.05	20	8.1	P< 0.00005
Dec. –Jan.	20	9.09	P< 0.00005	20	4.38	P< 0.0005	20	1.02	NS
Jan'96 - Feb.	22	3.25	P< 0.005	22	1.85	NS	22	4.86	P< 0.0001
				Pre-monsoon					
Feb. – Mar.	24	20.69	P< 0.00005	24	1.94	NS	24	11.22	P< 0.00005
Mar.- Apr.	22	15.64	P< 0.00005	22	1.87	NS	22	4.52	P< 0.0002
Apr.- May	20	4.92	P< 0.0001	20	5.08	P< 0.0001	20	2.18	p< 0.05
May – June	20	1.74	NS	20	1.69	NS	20	7.09	P< 0.00005
				Monsoon					
June – July	20	4.03	P< 0.001	20	0.88	NS	20	8.63	P< 0.00005
Jul. – Aug.	19	1.97	NS	19	0.87	NS	19	2.62	P> 0.02
Aug. – sept	19	30.79	P< 0.00005	19	5.08	P< 0.0001	19	11.02	P< 0.00005

HS = Highly significant, NS = Not significant

Table 8 – Site to site variations among the macrofouling organisms settled at St. 1 and St. 2.

Period	Density			Species composition		Biomass	
	no.	' t'	' p' values	' t'	' p'	' t '	' p ' values
				Monsoon			
June'95	15	15.65	p< 0.00005	4.06	p< 0.001	7.09	p< 0.00005
July	14	7.14	p< 0.00005	2.13	NS	6.03	P< 0.00005
Aug.	18	6.84	p< 0.00005	7.44	p< 0.00005	2.98	p< 0.01
Sept.	17	19.79	p< 0.00005	0.00	NS	4.51	p< 0.0005
				Post-monsoon			
Oct. 95	18	3.89	p < 0.002	3.0	p < 0.01	0.9	NS
Nov.	18	21.98	p < 0.00005	1.07	NS	1.49	NS
Dec.	18	9.11	p< 0.00005	2.12	p < 0.05	3.19	P= 0.005
Jan.'96	18	11.62	p< 0.00005	3.39	p< 0.005	4.86	p< 0.0002
				Pre-monsoon			
Feb.	21	1.08	NS	6.06	P< 0.00005	5.78	p< 0.00005
Mar.	22	20.74	P< 0.00005	5.46	P< 0.00005	11.38	p< 0.00005
Apr.	20	9.49	p< 0.00005	4.49	P< 0.0005	6.19	P< 0.00005
May	19	4.02	p< 0.001	5.83	p< 0.00005	9.1	p< 0.00005
				Monsoon			
Jun.	19	5.83	p< 0.00005	6.59	p< 0.00005	6.47	p< 0.00005
Jul.	16	9.82	p< 0.00005	3.38	p< 0.005	10.90	p< 0.00005
Aug.	19	6.33	p< 0.00005	2.58	p< 0.02	1.80	NS
Sept.	20	37.11	p< 0.00005	5.22	p< 0.00005	10.96	p< 0.00005

NS= not significant

Spatial variations

Site to site variations (St. 1 & St. 2) :

The faunal composition at Tidal basin (St. 2) varied from that recorded at St. 1. Tidal basin supported the settlement of 35 species, whereas Near-shore waters (St. 1) supported 60 macrofouling species. The numbers of individuals settling at St. 2 were not comparable to those settled at St. 1.

DENSITY

The density recorded at St. 2 was extremely higher than the density recorded at St. 1. The number of individuals settled at Tidal basin was 10-12 times higher than the individuals settled at St. 1 (tables 3 and 6).

Species composition

The observations on species composition at St. 1 were exactly reverse of that of density recorded at St. 2. The level of significance showed that during the earlier part of the study period, the species settled at St. 1 were significantly higher than the species settled at St. 2 (table 8). However, only in two months of September and November, the number of species occurring at two stations was similar showing no significant difference.

Bryozoans : St. 2 supported the settlement of 4 encrusting bryozoan species, whereas St. 1 supported the growth of 11 species.

Polychaetes: Polychaetes were the most dominant species at this site (St. 2). Nine different species have been recorded.

Ascidians : Stations 1 and 2 supported more or less equal number of ascidian species.

Cirripedes: Three species were recorded at St. 2, viz. *B. variegatus, B. reticulatus* and *C. amaryllis euamaryllis.* Of these, the first two species occurred abundantly during September and November 1995. Four species were recorded at St. 1. In addition to the above three, *M. tintinnabulum* was encountered at this site.

Molluscs: The settlement of molluscan species was very poor at Tidal basin. Only two species viz. O*yster* sp. and *M. sallei* were restricted to St. 2 . Interestingly, these two species did not occur at St. 1. The species *C. gryphoides, Crassostrea* spp. and *S. cucullata* settled at St. 1 .

Hydroids: Four species, settled at St. 2. Five species settled at St. 1. Overall, it can be stated that there was not much difference among the hydroid species settled at St. 1 and St. 2.

Biomass :

The biomass generated at two stations were compared and significant level was estimated

(table 8). The study showed that biomass generated at St. 2 was significantly higher than the biomass generated at St. 1.

DISCUSSION

Temporal variations

In light of different characteristics, the variations (both temporal and spatial) in respect of diversity, species composition and biomass were determined.

Density

The number of individuals settled on test panels immersed at St. 1 and St. 2 showed significant month-to-month variations. Boyd (1972) emphasised that no two panels in the series were exactly similar in respect of fouling settlement. Mook (1976) also observed the variations in species numbers among five replicate panels exposed in estuarine waters. Our earlier studies in Mumbai harbour reported considerable variations among the monthly panels (Karande *et al*, 1986; Swami,1987; Udhayakumar and Karande,1996; Swami and Gaonkar,1998 and Swami and Chhapgar, 2002). The present observations corroborate not only with our earlier observations but also with the observations made in temperate waters.

At St. 1, density varied from 1877 to 20,069/m^2. This wide variation is attributed to local hydrographical conditions. Swami and Karande (1988) observed the influence of monsoon on the recruitment of fouling organisms at Mumbai harbour. The lack of settlement during monsoon at St. 1 was attributed to the turbulence of water. In the present study, low density was due to the low salinity resulting form monsoon, in which not only the number of individuals (density) but also the number of species have been significantly reduced to an extent of 11 (table 3). The oligohaline species of erect and encrusting bryozoans disappeared from the site. Sunilkumar (1995) also reported low density and low species richness during monsoon at Cochin waters.

The seasonal variations in density were obvious. At St. 1, density recorded during pre-monsoon was significantly more than that recorded during monsoon and post-monsoon, whereas at St. 2, a reverse trend in density was observed. Here, density in monsoon was higher than that recorded in pre-monsoon ($p<0.00005$). The reverse trend occurred due to polycheate species.

Species composition

The number of species recorded at St. 1 was significantly higher than the species recorded at St. 2. 60 species have been recorded from St.1; on the other hand, around 42% reduction in species was observed at St. 2. This can be attributed to pollution and wide variations in salinity. February is the period of onset of the pre-monsoon season , where temperature starts increasing and all parameters are within normal level.

The DO and salinity recorded during Feb. were 5.2 mg/l. and 35.7 ‰ respectively (table 1). This period favoured heavy settlement of macrofoulers. Sunilkumar (1995), observed high species number and density during pre-monsoon at Cochin back waters. Rao and his co-workers (1982) reported that the peak period for fouling of bryozoans and polychaetes at Karwar waters, was the pre-monsoon.

The seasonal variations of species composition were observed. Maximum species settled during pre-monsoon and minimum in monsoon. The species settled during pre-monsoon were significantly higher than the monsoon. However, At St. 2, species settled during pre-monsoon and post-monsoon were comparable, showing no significant difference. Venkat *et al*. (1995), observed the higher settlement of ascidian species during pre-monsoon and post-monsoons at Mangalore port located along the west coast of India. Similar observations were made by Khandeparkar *et al*. (1995) at the same port. This indicates that seasonality brings changes not only in species composition but also in population abundance.

Biomass

The biomass recorded at St. 1 ranged between 9.1 and 224.4g/m^2. The highest value was recorded during September,1995 and lowest in May 96. The high value of biomass recorded in September was due to the settlement of shell dwelling organisms like barnacles and calcareous tube-worms. DePalma (1978) commented that shell-dwelling animals from molluscs and cirripedes were responsible for increasing the weight of under-water structures. DePalma (1984) stated that among all the parameters, biomass and abundance are more realistic to represent the fouling intensity of any locality. Maruthamuthu *et al*. (1990) observed high weight of biomass due to profound settlement of *M. tintinnabulum* at Tuticorin harbour.

At St. 2, month-to-month variation pattern was similar to that observed in density. The biomass ranged between 38.62 and 421.5 g/m^2. The lowest value was observed in June 1996, whereas high value was recorded in September1995. During this period maximum number of barnacles and oysters settled, enhancing the weight of biomass at this site.

Spatial variations

The study revealed that the biotic parameters like density, species composition and biomass determined at St. 1 and St. 2 significantly differed from one another, showing distinct spatial variations. Two sites, viz. Near-shore waters (St. 1) and Tidal basin (St. 2) differed in respect of water quality. Dissolved oxygen content was considerably low at St. 2. The organic pollutants released through sewage water caused the depletion in oxygen contents to a critical level (Swami *et al*. 2000). Salinity fluctuations were wide and frequent during monsoon at St. 2. St. 1 was a relatively clean site facing the open sea, and supported a variety of fouling species (n = 60).

The species distribution at St. 1 and St. 2 was not similar. The clean Near-shore waters supported 60 macrofouling species whereas stressed water mass of Tidal basin supported only 35 species. The faunal composition appears to differ. The observations on species composition were dissimilar to those of density. Here, at St. 1, maximum number of species was encountered. For instance, 11 species of encrusting bryozoans settled at St. 1, whereas four species at St. 2; almost 30% reduction in species was evident. Pollution reduced the bryozoans diversity at St. 2. Rao and Balaji (1988), have also attributed the drastic reduction in species settlement at St. 1 at Kakinadda port, to sewage and oil pollutions. Nair (1965) stated pollution and salinity to a larger extent to be the limiting factors of the environment, causing a natural check over the fouling community. Sasikumar *et al*. (1993) observed the influence of stressed conditions at discharge site on low species diversity of foulers. The pollution changes physical and chemical characteristics of the water mass, causing unfavourable conditions for the biota. Hence the reason for reduction in species number at tidal basin was evident.

Like density, the biomass recorded at St. 2 was significantly higher than the biomass recorded at St.1.

It can be concluded from the present investigations, that density, species composition and biomass recorded at two sites varied from month to month as well as season-to- season. Spatial variations were also evident. In the present study, St. 2 being influenced by sewage pollution, affected the species diversity and supported only filter-feeding species from polychaete and ascidians. In this context, it is true to quote the statement of Gray (1981) that 'there are many biotic and abiotic factors responsible for spatio-temporal variations of benthic populations, biomass and community structures'. It is , therefore, necessary to conduct such kind of study. The study not only provides information about changes and variations in local communities but also helps to modify or improve the fouling control methods (Bambar, 1990).

ACKNOWLEDGEMENTS

Authors are thankful to Dr. P. C. Deb, Director, NMRL for his support and interest in the work. Thanks are due to Dr. B. F. Chhapgar, BNHS for his critical evaluation of the manuscript. We are grateful to Dr. H. A. T. Hove, Netherland and Dr. (Mrs) V. K. Meenakshi,

Tuticorin, for identifying the polychaetes and ascidians collected during the study respectively. We also thank Mrs. Madhavi Swami for typing the manuscript and Mr. Ramphular Chouthi, Technician 'C' for rendering assistance in the field work.

REFERENCES

Balaji, M. 1988 **Investigations on biofouling at two ports in Andhra Pradesh, India and some aspects of toxicity of copper to fouling bivalve *Mytilopsis sallei* (Recluz).** Ph.D. thesis, Andhra University, India.

Boyd, M. 1972 **Fouling community structure and development in Bodega harbour , California**. Ph.D. dessertation, University of California, Davis.

Daniel, A. 1954 **Seasonal variation and succession of fouling communities in the Madras harbour**. Jounal of Madras University 24B: 189 –212.

De Palma, J. R. 1978 Proceedings of ocean thermal energy conversion (OTEC), **Biofouling and Corrosion Symposium, Seattle, USA.** pp 185.

DePalma, J. R. 1984 **Fouling production in world ocean**. In Proceeding of 6th International Congress on Marine Corrosion and Fouling, Athens 237-244.

Gray, J. S. 1981 **Ecology of marine sediments**. Cambridge University Press, Cambridge. 185 pp.

Karande, A.A. and Srivastava, R. B. 1984 **Pollution of coastal sea water and sulfate reducing bacteria**. Proceedings of 6th Inernational congress on Marine Corrosion and Fouling , Athens, 347- 354.

Karande ,A.A. , Goankar , S. N. and Swami, B. S. 1986 **Marine biofouling and its assessment in Indian waters.** In Proceeding of 3rd Indian conference on ocean engineering . IIT, Powai, Bombay 2:E21.

Karande ,A.A. and Swami, B. S. 1988 **Importance of test coupons in the assessment of marine biofouling community development in coastal waters of Bombay, India.** Indian Journal of Marine Sciences 17:317-321.

Khandeparker,D. C., Anil, A. C. and Venkat, K. 1995 **Larvae of fouling organisms and macrofouling at New Mangalore Port, west coast of India**. Indian Journal Marine Sciences 24: 37 – 40.

Maruthamuthu, S. Eshawar, M. Manickam, S. T. Ambalavanan, S. Venkatachari and Balakrishnan, K. 1990 **Marine fouling on test panels and in service structural steel in Tuticorin harbour**. Indian Journal of Marine Sciences19:68-70.

Mook, D.. 1976 **Studies on fouling invertebrates in the Indian river. I. Seasonality of settlement.** Bulletin of Marine Sciences 26: 610 – 615..

Nair, N. U. 1965. **Marine fouling in Indian waters**. Journal of Scientific and Industrial Research 24:483-488.

Rao, P. N. Kusuma, M. S. and Neelkantan, B. 1982 **Preliminary account on the intensity of fouling in Karwar waters.** Fishery Technology 19:113-118.

Sasikumar, N., Azariah, J. and Nair, K.V. K.1993 **Changes in the composition of tropical marine fouling community of a power plant discharge**. Biofouling 6:221-234.

Sunilkumar, R. 1995 **Macrobenthos in the mangrove ecosystem of Cochin back waters of Kerala (southwest coast of India)**. Indian Journal of Marine Sciences 24:56-61.

Swami, B. S. 1987 **Biofouling community, its structure and development in Bombay harbour**, M. Sc. Thesis, Bombay University, India, 39pp.

Swami, B. S. and Karande, A. A. 1988 **Recruitment and growth of biofouling invertebrates during monsoon in Bombay waters, West coast of India**. Indian Journal of Marine Sciences 17:143-149.

Swami B. S. and Gaonkar, S. N. 1998 **Studies on the variability amongst macrofouling on test coupons exposed in Bombay harbour.** Indian Journal Marine Sciences 27:333-339.

Swami, B. S., Suryawanshi, U. G. and Karande, A. A. 2000 **Water quality status of Mumbai harbour- an update**. Indian Journal Marine Sciences 29:111-115.

Swami,. B. S. and Chhapgar, B. F. 2002 **Settlement pattern of ascidians in harbour waters of Mumbai, west coast of India**. Indian Journal Marine Sciences 31(3):207-212.

Trivedy, R. K. and Goel, P. K. 1984 **Chemical and biological methods for water pollution studies**. Environmental publications, Karad, India 186 pp.

Venkat, K. Anil, A. C. and Khandeparkar, B. C. and Mokashe , S. S. 1995 **Ecology of ascidians in the macrofouling community of New Mangalore Port.** Indian Journal Marine Sciences 24:41-43.

Winston, J.E. and Jackson, J. B.C. 1984 **Ecology of cryptic coral reef communities IV . Community development and life history of encrusting cheilostome bryozoa**. Journal of Experimental Marine Biology and Ecology 76: 1- 21.

Udhayakumar, M. and Karande, A. A. 1996 **Field notes on a fouling serpulid, *Hydroides elegans* Haswell (Polychaeta: Serpulidae) present in confined waters of Bombay**. Indian Journal of Marine Sciences 25: 133 –136.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 213-215

INCREASED MACROBENTHIC DENSITY AND DIVERSITY: INDICATOR OF RECOVERY OF CHILIKA LAKE FROM ENVIRONMENTAL DEGRADATION

Baban Ingole
Biological Oceanography Division
National Institute of Oceanography,
Dona Paula, Goa –403004.
Email: baban@csnio.ren.nic.in

Key words: *Macrobenthic diversity; Ckilika Lake; environmental degradation; recovery.*

EXTENDED SUMMARY

Chilika Lake is the largest brackish water lagoon in Asia. Ecologically, it is boasted with a wealth of flora and fauna. The rich demersal fishery (especially of prawn, crabs and mollusks) of Chilika supports over 80,000 fishermen from 122 villages. However, Chilika has been facing with some natural and manmade problems, particularly frequent shifting of the mouth region, reduced seawater inflow, siltation and encroachment. The lagoon is shrinking by 2 km^2 per year. To protect the environmental degradation, the Chilika Development Authority (Govt. of Orissa) initiated the ambitious "Chilika Development Plan" with dredging of the feeding channel and deepening the shallower areas. Impacts of the developmental activities, on the lake environment were evaluated by a detailed monitoring study conducted during September 1999 to February 2001. Results of the present investigation are part of the monitoring program and describe the effect of dredging activity on the macrobenthic assemblages.

Data on the abundance of macrobenthic fauna (density and biomass) were collected from 30 different locations from across the entire stretch of Chilika. A spatially replicated before-after design was used. Sampling was conducted during three occasions (before dredging, during dredging and after dredging). The lake sediment was generally muddy and composed of fine sand material. The organic carbon content varied from 0.22% to 2.16% with a yearly mean±SD value of 0.75% ±0.44% (n=85). Generally the higher C_{org} values were observed during August 2000 with the maximum values being recorded in section I where the dredging was confined (Table 1). A total of 105 benthic macro-invertebrate species belonging to 11 phyla were recorded from the Chilika Lake sediments. The fauna was comprised mainly of Mollusca (53%), Crustacea (27%), Polychaeta (16%) and other miscellaneous forms (4%). The most important group in terms of number of species were Polychaeta (46 spp.) followed by Mollusca (34 spp.) and Crustacea (30 spp.) (Table 2). There was two fold increases in macrofaunal abundance during dredging (February 2000) and eight fold increases in post dredging (February 2001) phase, mainly due to the exposure of deep-burrowing organisms to the sediment surface and due to the improved food supply. The diversity of macrobenthos was slightly reduced during the dredging period in contrast to the faunal density. The increased values for faunal abundance (from 1832 to 7075 individuals m^2, Table 3), number of species (from 32 to 46). The values for macrofaunal diversity and species richness showed very high fluctuations between the sampling stations and seasons (Table 4). The faunal density (individuals per m^2) and species diversity (*H'*) were relatively higher at stations located in deeper waters. Maximum *H'* value was observed in section IV through out the study period except August 1999. During August 1999, maximum diversity was recorded in section -I, specially the dredging site and surrounding stations had higher species diversity. As shown in table 3, section IV dominated in terms of species diversity and richness (SR). The values for species diversity (*H'*) varied between 1.1 and 3.83 with a seasonal mean value of 2.27 ± 0.71 SD. The values for species dominance (D) showed greater variation among the sampling stations. The increased values of species diversity in post dredging phase suggest that opening of new lake mouth in November 2000 has not only enhanced the quantity of incoming seawater and facilitated an immediate recovery of macrobenthic communities but also created suitable environment for benthic re-colonization. Substantial increases in the fish production during February 2001 signify the recovery of Lake Environment. This study suggests that one time dredging in selected area was extremely beneficial for the recovery of Ckilika Lake.

Table 1: Organic carbon content (%) in the sediment of Chilika

Lake studied during September 1999 to February 2001 (-; no data).

Sections	Station No.	Sep-99	Feb-00	Aug-00	Feb-01
I	N0 (Dredging)	0.66	0.82	0.74	1.31
	N1 (+500)	-	-	1.08	1.55
	N2 (+1000)	**0.96**	**-**	**0.69**	**-**
	N3 (+2200)	**0.9**	**-**	**1.06**	**1.27**
	26	**0.44**	**1.24**	**0.85**	**1.42**
	27	0.69	0	0.9	0.6
	28	0.414	0.33	0.83	1.07
	29	0.083	-	0.25	-
	30	0.69	-	0.23	-
	Mean	**0.60**	**0.60**	**0.74**	**1.20**
	SD	**0.28**	**0.55**	**0.31**	**0.34**
II	12	0.48	0.52	0.44	2.65
	2	-	-	1.29	0.73
	22	0.63	0.41	-	0.4
	25	0.52	-	0.81	0.47
	Mean	**0.54**	**0.47**	**0.85**	**1.06**
	SD	**0.08**	**0.08**	**0.43**	**1.07**
III	14	-	-	2.16	-
	16	-	-	1.27	-
	19	-	-	1.06	-
	20	0.44	-	-	0.93
	21	-	0.93	-	-
	23	-	-	0.6	-
	24	0.63	0.22	0.32	1.32
	Mean	**0.54**	**0.58**	**1.1**	**1.18**
	SD	**0.13**	**0.50**	**0.71**	**0.25**
IV	3	0.93	0.69	0.69	1.43
	4	1.2	-	-	-
	5	0.55	-	-	-
	6	0.3	-	-	-
	8	1.5	0.55	-	-
	9	0.75	0.3	-	-
	10	0.38	0.74	0.78	-
	11	0.94	0.74	0.83	-
	13	-	-	2.12	-
	Mean	**0.82**	**0.60**	**1.11**	**1.43**
	SD	**0.41**	**0.19**	**0.68**	**0.0**

Table 2: No. of species, mean density mean (no. m^{-2}) and percentage (%) contribution of major faunal groups studied during different sampling seasons.

Phylum	August 1999			February 2000			August 2000			February 2001		
	No. of Species	Mean density	%	No. of Species	Mean density	%	No.of Species	Mean density	%	No.of Species	Mean density	%
Coelenterata	-	177.17	6.7	1	0.3	0.02	-	0	0	-	-	-
Platyhelminthes	-	0	0	-	0	0	I	46	0.4	1	3.68	0.05
Nematoda	-	0	0	-	0	0	1	234.5	1.9	-	-	-
Mollusca	9	781.3	29.3	5	295.5	16.9	28	7746.5	62.3	18	3387.12	47.87
Annelida	30	1089.23	40.9	16	457.5	26.3	17	1223.9	9.8	14	1220.56	17.25
Arthropoda	14	597.26	22.4	9	985.8	56.6	18	2903.7	23.4	12	2406	34.00
Miscellaneous Groups (unidentified)	2	21	0.8	1	1.3	0.08	1	272.8	2.2	4	18.55	0.26

Table, 3: Macrobenthic data collected during the different lake developmental phases.

Parameter	Benthic sampling period		
	Before dredging (May 1998*)	During Dredging (February 2000)	After dredging (February 2001)
Macrobenthic density range and mean (±SD) no. m^{-2}	21 - 3126 (916.7 ± 988.4;n=12)	75 – 5625 (1832.4 ±1687.2;n=24)	959 - 14586 (7074.8 ± 4720;n=16)
Biomass range and (mean values) g m^{-2}	3.71 –201.9	0.40 – 204.5 (23.8±43.5)	3.3 - 352.7 (86.9 ±106.2)
No. of species	38	32	46
Species diversity Range and mean (*H'*)	1.4 – 2.6 (2.11±)	0.80 – 3.27 (2.06±0.73)	1.24 - 4.05 (2.77±)
Dominant Taxon	Crustacea	Crustacea	Mollusca

Table 4: Mean values of diversity, evenness, species richness and Dominance for the macrofauna of Chilika Lake.

Seasons	**Diversity indices**				
Aug-99	Sections	H'	J	SR	D
	I	2	0.64	1.06	0.36
	II	2	0.64	1.06	0.36
	III	1.1	0.69	0.37	0.31
	IV	1.89	0.66	0.96	0.34
Feb-00	I	1.87	0.77	0.77	0.23
	II	1.7	0.59	0.86	0.41
	III	1.77	0.65	0.83	0.35
	IV	3.02	0.84	1.64	0.16
Aug-00	I	2.44	0.64	1.45	0.36
	II	2.15	0.59	1.44	0.41
	III	2.41	0.6	1.63	0.4
	IV	3.04	0.75	1.93	0.25
Feb-2001	I	2.52	0.69	1.45	0.31
	II	3.15	0.71	2.39	0.29
	III	1.47	0.46	0.84	0.53
	IV	3.83	0.78	3.25	0.22
	Mean	2.27	0.67	1.37	0.33
	SD	0.71	0.09	0.71	0.09

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 216-222

INTERTIDAL MACROBENTHOS FROM ULHAS RIVER ESTUARY AND THANE CREEK

Goldin Quadros and R.P. Athalye
Department of Zoology, B.N. Bandodkar College of Science, Thane (W) 400 601.

Abstract : Macrobenthos from the intertidal mudflats of Ulhas river estuary and Thane creek were studied from September 2001 to August 2002. The diversity, abundance and biomass were observed to be higher in Thane creek (42 faunal types, av. abundance 52123 no/m^2 and av. biomass 195.59 gm/m^2) than Ulhas river estuary (30 faunal types, av. abundance 4697 no/m^2 and av. biomass 23.42 gm/m^2). Further the diversity was low in the highly polluted regions of both the ecosystems. The Abundance – Biomass curves plotted to detect stress revealed Thane creek to be more polluted than the Ulhas river estuary.

Key words *:* Thane Creek, Ulhas river estuary, Macrobenthos, pollution , Abundance -Biomass curves.

INTRODUCTION

The studies of benthic animals and communities have gained importance with the increasing realization of the significant role they play in the trophic cycle (Pillai, 1977). According to Duda *et al*. (1982), macrobenthic fauna prey on all lower forms of life, help to process organic matter and they act as the principal source of food for most fishes i.e. they play an important role in the food chain either at secondary level as feeders of detritus and plant matter or at tertiary level as food for predators like crabs and fishes. Hence their study can act as an indicator of demersal fishery potential (Varsheney *et al.,* 1988). The Benthic macroinvertebrates in the view of Bilyard (1987) are good indicators of environmental condition because most benthic animals are sedentary and respond immediately to organic stress. Benthic fauna have a great potential to indirectly control the fate and subsequent bioavailability of sedimentary contaminants in their immediate environment (Sandens *et al.,* 2000). Hence according to Engle and Summers (1999), the information gained from monitoring Benthic macron invertebrate communities has been used widely to measure the status and trends in the ecological condition of estuaries.

In India study of benthos was initiated in the early 20th century, with significant literature available for the west coast than east coast. However information on the bottom fauna of Mumbai (Bombay) coast is scanty, and mainly restricted to the subtidal region, with limited data available for the intertidal region.

MATERIALS AND METHODS

The present study was conducted from September 2001 to August 2002 in the 40 km. stretch of Ulhas river estuary (Lat. 18°.45' to 19°.16' N and Long. 72°.45' to 73°.20' E) and 26 kms of Thane creek (Lat. 19°.00' to 19°.15' N and Long. 72°.55' to 73°.00' E). Both these ecosystems are in the proximity of the heavily urbanized and industrialized Thane-Mumbai metropolis and receive large amount of domestic sewage and industrial effluents, apart from the runoff from terrestrial and agricultural fields. The sampling was done from 12 stations from each of the ecosystems, however for convenience 3 zones were considered viz. Zone I – Riverine end; Zone II – Middle Zone; Zone III – Seaward end each consisting of 4 stations (Fig.1)

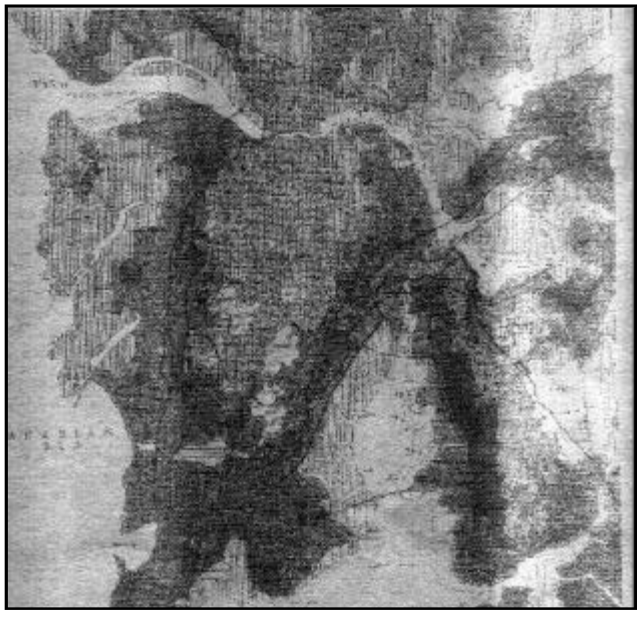


Fig. 1 : Map showing sampling stations in Ulhas river estuary and Thane creek

The water samples were collected during high tide and low tide using standard procedures and analysed employing Standard methods (APHA, AWWA, WPCF, 1981). The soil for sediment parameters and macrobenthos was collected during the low tide and pooled together from 3 different levels namely Low Level Water Mark (LLWM), Mid Level Water Mark (MLWM) and

High Level Water Mark (HLWM). The collection was done from 10 cm depth surface soil with the help of 0.01 m^2 (10 cm x 10 cm) metal scoop (Kiceniuk & Williams, 1987). From each sample 100 gm of soil was oven dried at 70°C and used for analysis of soil texture and organic carbon using Buchnans' (1984) pipette method and Walkley & Black (1934) method respectively. For macrobenthos 5 scoops of soil was randomly collected from each level and pooled together, the animals were narcotized with 10 % $MgCl_2$ to prevent fragmentation, then the sediment was drained through 0.425 mesh sieve and the fauna retained on the sieve was preserved in 10 % formalin made in marine water. The different organism types then separated, counted and weighed to get the abundance (number / meter square) and biomass (gram / meter square). For Molluscs shell free wet weight was obtained by dissolving the shells in dilute (1%) hydrochloric acid.

To detect the pollution stress Warwicks (1986) Abundance Biomass Curves (AB curves) were employed individually on the macrofaunal groups.

RESULTS AND DISCUSSION

Water & Sediment Quality

The zonewise minimum, maximum and average values of the water and sediment parameters recorded from both the ecosystems are given in Table 1. Both the ecosystems showed high suspended solids load, persistent hypoxia and excess nutrients. The sediments were clayey-silt type rich in organic carbon that exceeded the limits of unpolluted sediments. A comparison between the ecosystems on the basis of physicochemical and sediment parameters revealed Thane creek to be more polluted than Ulhas river estuary.

Table 1 : Water and sediment parameters of Ulhas river estuary and Thane Creek

	Ulhas River Estuary										Thane Creek									
	Zone 1			Zone 2			Zone 3			Total	Zone 1			Zone 2			Zone 3			Total
Water Parameters	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Avg
Water Temperature C	21.25	33.13	28.03	21	31.5	28.19	22.75	33.25	28.35	28.18	21.5	33.75	28.75	22.5	33.45	29.37	26.38	34.88	30.28	29.71
Light Penetration	14	50.75	30.5	13.38	57.5	27.44	7.75	27.25	16.11	24.69	22	57.75	33.51	19.75	59.25	39.81	13	42.5	30.56	34.63
Suspended solids gm/l	0.16	0.96	0.555	0.15	2.375	1.249	0.205	6.15	3.865	1.89	0.43	3.385	1.911	0.6	13.5	2.414	0.535	3.17	1.551	1.958
pH	6.93	7.76	7.44	7.22	7.8	7.54	7.4	8.04	7.78	7.59	7.19	8.09	7.67	7.4	8.19	7.74	7.57	8.193	7.78	7.73
Salinity ppt.	0.389	18.51	8.93	0.73	30.28	15.34	1.035	34.92	22.93	15.73	0.803	32.48	19.67	2.85	34.6	23.93	6.825	37.14	27.55	23.73
Dissolved oxygen mg/l	0.75	3.825	2.29	1.425	3.35	2.55	1.983	4.8	3.62	2.82	0.375	2.925	2.015	0.7	8.2	1.998	0.925	4	2.11	2.041
B.O.D. mg/l	5.375	24.43	16.25	2.225	13.48	8.341	0.55	8.45	5.083	9.892	9.75	42.75	24.67	2.125	24.13	13.04	1.9	20.05	10.79	16.17
PO4-P mg/l	0.03	0.094	0.06	0.03	0.092	0.055	0.023	0.061	0.047	0.054	0.061	0.162	0.132	0.033	0.096	0.074	0.027	0.094	0.069	0.092
NO3-N mg/l	0.292	2.521	1.491	0.905	3.533	1.89	0.189	2.275	1.616	1.666	0.471	1.458	1.022	0.145	2.099	0.853	0.145	1.383	0.983	0.953
SiO3-Si mg/l	12.66	77.43	33.67	11.1	72.6	34.07	11.72	61.09	29.07	32.27	12.25	43.02	26.66	8.498	35.15	22.34	5.734	38.98	15.88	21.63
Sediment parameters																				
Organic Carbon %	1.906	4.183	3.102	2.045	3.878	2.926	1.58	3.595	2.611	2.88	2.727	4.512	3.81	2.688	4.568	3.554	2.185	4.003	3.222	3.529
Sand %	3.7	15	8.406	8.528	17.5	12.65	14.13	21.91	18.53	13.19	0.895	10	5.18	2.838	10	6.067	4.975	12.5	8.979	6.742
Silt %	48.75	74.1	59.69	30	55.52	41.52	30	69.68	48.88	49.36	62.5	82.23	76.34	63.36	81.07	69.88	60.57	75	65.53	70.59
Clay %	16.34	40	31.9	33.74	52.5	45.84	10.22	52.71	34.6	37.45	15	27.5	18.48	15.86	32.6	24.05	13.75	32.11	25.81	22.77

MACROBENTHOS OF ULHAS RIVER ESTUARY

The macrobenthos in Ulhas river estuary comprised of 30 faunal types representing 11 groups (Table 2). The overall macrofaunal density and biomass varied from 475 to 38685 no/m^2 (av. 4697 no/m^2) and 3.57 to 224.11 gm/m^2 (av. 23.42 gm/m^2) respectively (Table 3). The groups occurred in the following decreasing order of abundance. Polychaetes (45.84 %) > Oligochaetes (20.55 %) > Nematodes (13.07 %) > Gastropods (6.15 %) > Seaanemones (5.17 %) > Insect larvae (3.11 %) > Crabs (2.95 %) > Bivalves (2.68 %) >

Table 2 : Distribution of macrobenthic fauna in Ulhas river estuary and Thane creek.

Sr. No.		Ulhas river			Thane creek		
		Riverine	Middle	Seaward	Riverine	Middle	Seaward
1	Seaanemones			+	+	+	+
2	Planaria			+		+	
3	Nematode Polychaetes	+	+	+	+	+	
4	Nereis glandicinta	+	+		+	+	+
5	Nereis (Cerateronereis) burmensis				+	+	+
6	Lycastis indica	+	+	+	+	+	+
7	Lycastis ounaryensis				+	+	+
8	Sigambra bassi			+		+	+
9	Polydora tentaculata					+	
10	Dendronereis heteropoda		+	+	+	+	+
11	Unidentified polychaete		+	+		+	
12	tube polychaete Gastropods					+	
13	Assiminea brevicula		+	+	+	+	
14	Turitella spp.	+	+				
15	Haminea crocata	+			+		+
16	Nerita Dostia violaceae	+			+		+
17	Salinater burmana			+	+	+	+
18	Onchidium verruculatum			+	+		+
19	Stenothyra minima	+	+		+	+	+
20	Stenothyra deltae			+	+	+	+
21	Melampus singaporensis		+		+		
22	Cerethidea cingulata				+	+	+
23	Nassarius spp.	+				+	+
24	Nassarius ornatus		+			+	
25	Auricula spp.				+	+	+
26	Neritina spp.		+			+	
27	Mitra amphorell					+	+
28	Thiara spp.			+			
29	Auricula elongata.			+			
30	Calcerous tubes Bivalves		+	+	+	+	
31	Microbivalve				+	+	+
32	Cuspidaria cochinensis		+	+		+	+
33	Glauconome cerea		+		+	+	+
34	Katelyasia spp.					+	+
35	Cardium spp.					+	+
36	Brachyodontes karachienis		+				+
37	undientified bivalve Crabs						+
38	Ilyoplax gangetica	+	+	+	+	+	+
39	Uca spp.	+	+		+		+
40	Shrimp spp.			+			+
41	Cumacea spp.			+		+	+
42	Unidentified crustacean				+		
43	Insect larvae	+	+	+	+	+	
44	Bettle like insect					+	
45	Balanus.				+	+	+
	Total types	11	18	19	26	33	29
	Ecosystem wise total		30			42	

Plannaria (0.38 %) > Barnacle (0.09 %) > Other Crustaceans (0.02 %). A spatial comparison of the macrobenthic abundance and biomass in Ulhas river estuary indicated higher values at the riverine end (Zone I) and lower values at the seaward end (Zone III). Ansari *et al.* (1986) observed in Goa estuaries that the Benthic population and biomass were significantly higher at the site of organic enrichment, which corroborates with the observations made for Ulhas river estuary. Further the species diversity increased towards the sea with decreasing organic enrichment, similar observations were also reported by Annie Mathew (1989) and Mishra (2002) for Ulhas river estuary.

Table 3- Comparison of Abundance (no/m2) and Biomass (gm/m2) in Ulhas river estuary

Months	Zone1	Zone2	zone3	Avg	Zone1	Zone2	zone3	Avg
Sept	4770	3505	550	2942	13.17	16.825	2.617	10.871
Oct.	5705	4185	515	3468	14.95	24.865	3.57	14.462
Nov	5305	4625	995	3642	17.005	24.75	4.285	15.347
Dec	5220	6655	650	4175	16.73	20.285	7.055	14.69
Jan	4895	2170	1005	2690	25.315	7.995	3.94	12.417
Feb	11045	3965	1115	5375	22.645	12.078	2.753	12.492
Mar	10725	4310	1070	5368	49.505	23.815	2.795	25.372
Apr	38685	2900	2155	14580	224.11	30.12	17.455	90.562
May	12395	4900	2380	6558	23.28	24.705	12.38	20.122
Jun	4450	3975	2305	3577	65.32	37.28	9.8	37.467
Jul	3680	2330	1255	2422	20.12	24.355	5.735	16.737
Aug	1995	2225	475	1565	8.925	16.105	6.295	10.442
Total	108870	45745	14470	56362	501.075	263.178	78.68	280.981
Avg.	9072.5	3812.08	1205.83	4696.83	41.76	21.93	6.56	23.42

Table 4- Comparison of Abundance (no/m2) and Biomass (gm/m2) in Thane creek.

Months	Zone1	Zone2	zone3	Avg	Zone1	Zone2	zone3	Avg
Sept	4770	75430	55540	45247	70.95	147.86	225.56	148.123
Oct.	5530	77100	74140	52257	64.29	152.97	223.015	146.758
Nov	6795	74290	66790	49292	70.66	143.895	251.24	155.265
Dec	6155	68130	58215	44167	63.575	129.865	184.785	126.075
Jan	5780	77780	69225	50928	70.89	144.91	251.24	155.68
Feb	9340	542915	30395	194217	221.98	1262.93	652.635	712.515
Mar	12375	118760	23465	51533	52.645	165.215	43.89	87.25
Apr	5130	5140	90710	33660	54.725	153.125	347.418	185.089
May	4305	3970	46765	18347	35.041	34.475	81.62	50.379
Jun	24890	81910	43285	50028	213.325	781.205	274.195	422.908
Jul	10205	24840	8105	14383	44.355	140.58	67.925	84.287
Aug	4045	18275	41915	21412	38.81	97.693	82.093	72.865
Total	99320	1168540	608550	625471	1001.246	3354.723	2685.616	2347.194
Avg	8277	97378	50713	52123	83.44	279.56	223.80	195.60

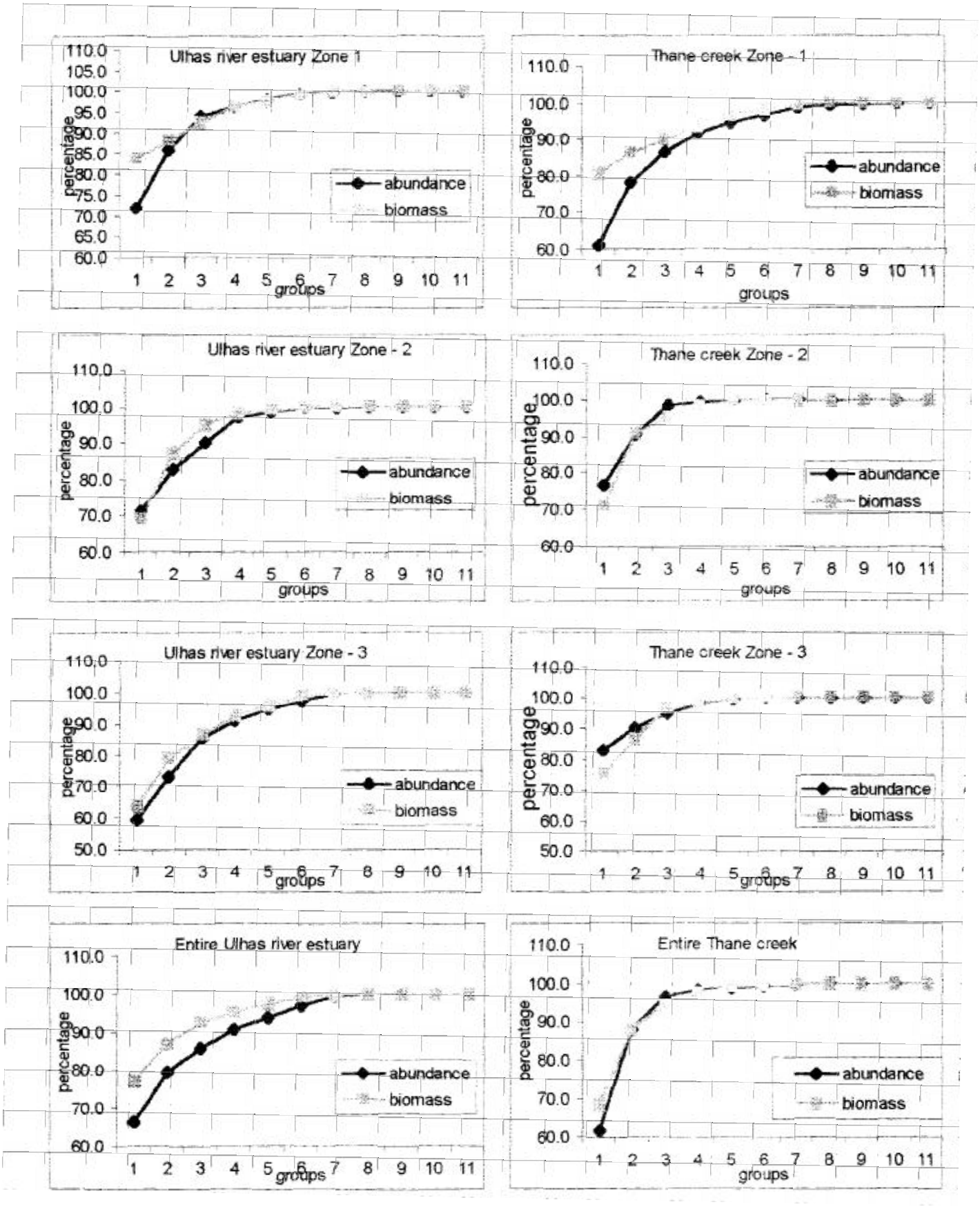


Fig. 2 : Comparison of Abundance and Biomass in Ulhas River estuary and Thane creek.

MACROBENTHOS OF THANE CREEK

In Thane creek 42 faunal types representing 12 major groups were recorded (Table 2), the overall macrobenthic abundance and biomass varied from 3970 to 542915 no/m^2 (av. 52123 no/m^2) and 34.475 to 1262.93 gm/m^2 (av. 195.59 gm/m^2) respectively (Table 4). The groups occurred in the following decreasing order of abundance. Nematodes (32.46 %) > Bivalves (29.28 %) > Gastropods (26.03 %) > Polychaetes (8.76 %) > Seaanemone (3.14 %) > Oligochaetes (0.59 %) > Insect larvae (0.48 %) > Crabs (0.26 %) > Barnacles (0.095 %) > Plannaria (0.04 %) > Other crustaceans (0.023 %) > Unidentified (0.01 %). The spatial variations showed minimum diversity, abundance and biomass at the Riverine end (Zone I) and maximum at zone II which was mainly due to the dominance of mollusks. The proliferation of mollusks in the subtidal sediments of the middle region of the creek was also observed by Annie Mathew (1989) and attributed it to the calm conditions in the region which fascillated their growth. Similar observations wherein the molluscan fauna outnumber other faunal groups has been reported from many tropical ecosystems (Goldin, 2001). When the individual sampling stations in the creek were studied it revealed an increasing trend towards the sea i.e. Zone III. A similar trend has been reported from many Indian estuaries and creeks (Goldin, 2001) and the riverine decline was mainly attributed to the salinity gradient which is also observed to a minor extent in Thane creek.

A comparison between the ecosystems revealed high abundance and biomass in Thane creek than the Ulhas river estuary. Annie Mathew (1989) reported similar observations for the subtidal regions of both the ecosystems and attributed the difference to the narrow and shallow ecosystem of Thane creek and deeper & larger water volume in Ulhas river estuary. Harkantra and Parulekar (1987), attributed the spatial variations in the distribution and abundance of Benthic fauna to the impact of localized environmental factors. Further a comparison with other marine ecosystems revealed both Thane creek and Ulhas river estuary to have high density and biomass (Goldin, 2001; Mishra, 2002) which can be attributed to high nutrient content and organic enrichment in both the ecosystems.

Benthic communities of organically enriched ecosystems according to Tsutsumi (1990) are frequently affected by catastrophic environmental actions and vary seasonally. Bhat & Neelkantan (1988) ascribed the environmental characteristics of an estuary to fluctuate periodically depending on the 3 seasons i.e. pre-monsoon, monsoon and post-monsoon. The post-monsoon season is known for stable environmental conditions and increasing Benthic production. In the present study the seasonal variations in abundance and biomass followed a similar pattern with low values in monsoon and pre-monsoon.

Other than the seasonal variations, sediment type is another factor determining the macrobenthic community (Muniz & Pires, 2000) and different functional groups have been defined in association with different substrate type. During the present study both the ecosystems had clayey-silt substratum but the macrofaunal diversity, density and biomass varied greatly indicating pollution stress.

Macrobenthos are considered a suitable group for detecting the effects of pollution (Warwick, 1993). Hence to detect the level of stress the Abundance – Biomass curves were plotted for both the ecosystems (Fig 2). The plots indicate stressfull conditions in both the ecosystems, with maximum stress in organic enriched zones. The over all comparison of the ecosystems revealed moderate pollution in Ulhas river estuary as both the abundance and biomass curves are close to each other. While in Thane creek they also cross each other at certain points and indicate moderate pollution tending towards gross pollution.

CONCLUSION

The present study revealed high density and biomass in both the ecosystems compared to other ecosystems indicating high organic pollution. The diversity, density and biomass were more in Thane creek than Ulhas river estuary. However the AB curves indicated Ulhas river to be moderately polluted while Thane creek tended towards gross pollution.

ACKNOWLEDGEMENT

Financial assistance provided by Mumbai Metropolitian Region –Environment Improvement Society (C/o MMRDA, Mumbai) is gratefully acknowledged.

REFERENCES

Annie Mathew, 1989 Marine benthos of the creek and coastal environments of Bombay Ph.D. Thesis Univ. of Bombay 138 pp.

Ansari, Z.A., B.S. Ingole, G. Banerjee and A.H. Parulekar 1986 Spatial and temporal changes in benthic macrofauna from Mandovi and Zuari estuaries of Goa, west coast of India. Indian Journal of Marine Sciences. 15 : 223 – 229.

APHA, AWWA, WPCF, 1981 International Standard Methods for the examination of water and waste water. 15th edition, Washington D.C., 874 pp.

Bhat, U.G. and B. Neelkantan 1988 Environmental impact of macrobenthic distribution of Kali estuary, Central west coast of India. Indian Journal of Marine Sciences. 17 : 134 – 142.

Bilyard, G.R., 1987 The value of Benthic infauna in Marine Pollution monitoring studies. Marine Pollution

Bulletin. 18 (11) : 581 – 585.

Buchnan, J.B. 1984 in Methods for study of marine benthos. Edited by N.A. Holmes & A.D. McIntyre (Blackwell Scientific publication). 387 pp.

Duda, A.M., D.R. Lenat and D.C. Penrose. 1982 Water quality in Urban streams – What we can expect. Journal of Water Pollution Controll Federation pp. 1139 – 1147.

Engle, V.D. and J.K. Summers 1999 Refinement, validation and application of a Benthic condition index for Northern Gulf of Mexico estuaries. Estuaries 22 (3A) : 624 – 635.

Goldin Quadros, 2001. Study of intertidal fauna of Thane creek. Ph.D. Thesis Univ. of Mumbai pg. 264.

Harkantra, S.N. and A.H. Parulekar 1987. Benthos off Cochin, south west coast of India. Indian Journal of Marine Sciences. 11 : 75 – 78.

Kiceniuk, J.W. and U.P.Williams 1987. Sediment hydrocarbon contamination at the side of the Baie Verte, NewFoundland, oil spill – resulting a four year study. Marine Pollution Bulletin 18 (6) : 270 – 274.

Mishra Vidya, 2002. Study of macrofauna of mangrove mudflats of Ulhas river estuary Ph.D. Thesis Univ. of Mumbai. pg. 233

Muniz, P. and A.M. Pires 2000. Polychaete associations in a subtropical environment (Sao Sebastiao Channel, Brazil) : A structural analysis. Marine Ecology 21 (2) : 145 – 160.

Pillai, N.G. 1977 Distribution and seasonal abundance of macrobenthos of the Cochin backwaters. Indian Journal of Marine Sciences. 6 : 1 – 5.

Sandens, J., T. Forbes, R. Hansen and B. Sandens 2000. Influence of particle type and faunal activity on mixing of di (2-ethlehexyl) phthalate (DEHP) in natural sediments. Marine Ecology Progress Series. 197 : 151 – 167.

Tsutsumi, H. 1990 Population dynamics of *Capitella capitata* (Polychaeta, Capitellidae) in an organic polluted grove. Marine Ecology Progress Series. 36 : 139 – 149.

Varsheney, P.K., K. Govindan, U.D. Gaikwad and B.N. Desai. 1988. Macrobenthos off Versova (Bombay), west coast of India, in relation to environmental conditions. Indian Journal of Marine Sciences 17 : 222 – 227.

Walkley, A. and J.A. Black 1934 The determination of organic carbon by rapid titration method. Soil Science 37 : 29 – 38.

Warwick, R.M. 1986 A new method for detecting pollution effects on marine macrobenthic communities. Marine Biology 92 : 557 – 562.

Warwick, R.M. 1993 Environmental impact studies on marine communities : Pragmatical considerations. Australian Journal of Ecology 18 : 63 – 80.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 223-225

RESTORATION OF MANGROVES AT JAMNAGAR

Dhiren M Pania,
Hort. Dept.,EO#1,Reliance Greens, Reliance Petroleum Limited,
Motikhavdi, Jamnagar, Gujarat –361 140.
e-mail: Dhiren_M_Pania@ril.com, pania_dhirenm@yahoo.com

ABSTRACT : Gujarat has a long seacoast, Jamnagar, being one of the coastal cities located in the Gulf of Kachchh. Reliance group of Industries has set up a grass-root refinery at Motikhavdi, Jamnagar district of Gujarat. As one of its aims is to improve the Coastal ecology and environment, a project on the restoration of mangroves was undertaken by Reliance Petroleum Ltd., in an area of 100 acres. A total 1.2 million of seeds/ propagules of *Rhizophor*a species & *Avicennia* species of mangroves, collected from the Maharashtra coast, were grown and transplanted in the Marine Tank farm area. The Saurashtra region is semi-arid region with an average 21.5 days of rain in a year. High salinity, high tidal amplitude, strong winds, makes this region tougher for plant to survive. The paper deals with the problems and achievements.

***Key word** : Mangroves, restoration, diversity,* Avicennia *sp.,* Rhizophora *sp.,*

INTRODUCTION

The Mangrove cover of India is estimated to be 4,827sq. Kms.[1] (Table 1), which is only 2.66% of the world mangroves cover. Of the country's total area under the mangrove vegetation, 77% has been recorded on the East Coast and 23% on the west coast (Kathiresan,1998). Mangroves of the east coast has vast existence, due to rich–nutrient that comes along with Ganges, Brahamputra, Mahanadi, Godavari, Krishna and Cauvery and a perennial supply of freshwater along deltaic coast. This has resulted in species richness of mangroves and greater cover compared to the west cost. On the other hand, along the west coast alluvial deposits are almost absent; funnel shaped estuaries of the major rivers such as Narmada, Tapti and Indus or backwaters or creeks or neritic inlets are present. This natural formation restricts mangroves to flourish, as they do on the eastern coast.

GEOGRAPHICAL LOCATION

Gujarat Coast is located along west coast of India between 20^0 2′-24^0 41′ lat. And 68^0 8′-74^0 23′E. This coastline covers over 1650-sq. km., which is longest amongst coastal states in the country. The coastline has numerous creeks, brackish waters, mangroves, coral reefs, mudflats, and rocky and sandy shores. Abound with a rich coastal ecosystem; 62.3% of total coastal wetlands of the country are found in the state (Garg *et al,* 1998). The Gulf of Kachchh, which occupies an area of 7300 km^2 is about 170-km. long and 75 km. wide at mouth. The region has tropical monsoon type of climate with an average rainfall of about 300 mm, during July to September. The post-monsoon lasts, from November to February, when climate is cool and dry, whereas the pre-monsoon from, March to June is dry and hot.

The Gulf differs markedly from other coastal regions of Gujarat. Here, precipitation and evapo-transpiration ratio recorded ranges between 3.0 to 6.0 m, it is very high in the Gulf of Khambhat exceeding 10.0 m. The P^H throughout the Gulf is fairly constant 8.0 to 8.5 and rarely it varies from typical of range of seawater. While salinity normally varies from 37 to 44 ppt. (Singh, 2000) and inner Gulf, maintains high salinity. In summer some creeks, it has been recorded up to 50 ppt. (NIO, 1995). The mangroves in Gujarat are often called open scrubby mangroves and generally considered as a degraded ones.

MATERIALS & METHODS

The seeds of Avicennia sp. were collected locally, whereas propagules of Rhizophoraceae were collected from Maharashtra coast, located on the west coast (about 1000 km. south from the site) during July-August and February-March. After collecting them, they were packed in a gunny bag and transported to Jamnagar by road. On site, they were kept in a well-ventilated room. Total time taken from collection to transporting them to nursery was 3-4 days. In the meantime nursery beds were prepared and kept ready. At a time 1-1.5 lakh propagules were collected and transported. It took a total of 105 days for collecting 1.2 million seedlings/ propagules.

The saplings were kept for six months in the nursery and then planted. The complete process was spread over 21 months between July 1998 to March 2000.

RESULTS AND DISCUSSION

The refinery is located in the Saurashtra region of Gujarat, which is a drought prone region. The average annual rainfall in the region is 450 mm to 600 mm with

Table: 1. Extent of Mangroves in India:

Sr. No.	State	Area km.^{2}	% of Total area
1	**East Coast** : West Bengal	2,123	44.0
2	Orissa	211	4.4
3	Andhra Pradesh	383	7.9
4	Tamil Nadu	21	0.4
5	**Bay Islands** : Andaman & Nicobar	966	20.0
6	West Coast : Gujarat	991	20.5
7	Maharashtra	124	2.6
8	Goa	5	0.1
9	Karnataka	3	0.06
10	Kerala	sparse	
	Total	**4,827**	

Table: 2 Mangrove distribution in Gujarat

District	Taluka	Area Km^2
Jamnagar	Jamnagar	192.88
	Jodiya	105.00
	Kalyanpur	21.50
	Khambahlia	246.35
	Lalpur	20.00
	Dwarka	80.20
	Total	**665.93 ***
Rajkot	Maliya-Miyana	77.70
Sub-total for Saurashtra	**743.63**	
Kutch	Mundra	53.30
	Abdasa-Lakhpat	529.50
Sub-total for Kutch		**582.80**
	Total	**1326.43 $**

Note : 1. ***Out of **665.9 sq. km**. Area of mangroves in Jamnagar, **103.25 sq. km**. Area has been leased out to **21** salt industries.

2. **$** Though 1326.43 sq. km. has been declared as forest in the state under different notification, all of them do not have mangrove cover. There are large blanks or hyper-saline mudflats within the block of notified forest; some of them are not suitable for the mangrove plantation.

Table 3: Species wise distribution of Mangroves in Gujarat

Mangrove Species	Jamnagar (141.5 sq.km..)	Kutch-Mundra, etc.area (15.2 sq.km.) (724.4 sq. kms)	Bhavnagar
Avicennia marina	Y	Y	Y
A. officinalis	Y	Y	Y
A. alba	Y	Y	Y
Rhizophora mucronata*	Y	Y	Y
Ceriops tagal *	Y	Y	Y
C. decandra *	N	N	N
R. apiculata *	Y	N	N
Bruguiera gymnorrhiza *	Y	N	N
B. parviflora *	Y	N	N
Aegiceras corniculatum	Y	N	N

Note * Introduce in Sikka region.

Tidal elevation (m) In Gulf of Kachchh

Stations	MLWS	MLWN	MSL	MHWN	MHWS
Okha	+0.41	+1.20	+2.04	+2.96	+3.47
Sikka	**+0.71**	**+1.73**	**+3.04**	**+4.35**	**+5.35**
Kandla	+0.78	+1.81	+3.88	+5.71	+6.66
Navlakhi	+0.78	+2.14	+4.15	+6.16	+7.21

MLWS -mean low-water spring

MLWN -mean low-water neap

MSL - mean sea-level

MHWN - mean high-water neap

MHWS - mean high-water spring

average 21.5 rainy days in a year. There is no perennial river between Jamnagar & Motikhavdi. During monsoon, seasonal streams are seen, which are flowing up-to November /December. At the end of these streams, check dams are built or due to other obstructions, fresh water is stopped about 5-6 kms before creek area. Hence the streams remain dry most of the time and very little organic matter micronutrients are added to the mangrove forest.

The Refinery is located along state highway no. 25 while Jetty is near Sikka village, a coastal area. It is developed for receiving crude and exporting the refinery products. Around jetty, there are some patches of existing mangroves, with average height of 1 to 1.5 mt. These include *Avicennia marina*, *Avicennia officinalis* and *Avicennia alba,* which were planted by the Gujarat forest department of Marine National Park in the year 1992-93.

The main task was to restore the existing mangroves and bring in diversity of the species. The surrounding areas were surveyed and it was found that in the majority of the areas *Avicennia* sp. were growing, while one or two areas showed *Rhizophora mucronat*a or *Ceriops tagal* with average height of 1.3 to 2 mt. After studying the P^H, salinity, tidal amplitude and other parameters, it was decided to take up a pilot project in a four-acre area. Initially plantation of those species, which were growing around, were collected from the western coast, so as to see their adaptability to the region, before undertaking large scale plantation in inter- tidal region.

In June 1999, propagules were collected from Maharashtra coast, located along West coast of India. These were grown in the nursery for about six months. While they were in the nursery, it showed 80-85% survival. After six months, these were planted in inter-tidal area to see the establishment of species.

In the Gulf of Kachchh, where the sea is very choppy and rough during monsoon (June-July), and continues to be so for some weeks of post monsoon, the loose mud, which is churned, comes in with tidal water and slowly get settled on leaves & bark. This affected the growth of the plants in the initial stage. During post monsoon another change of under currents brings along algae to shore along with the high tide, which get entangled and stick to the young mangroves. Under the weight of algae the saplings bend. Once the algae dry off, it damages the saplings and some of these young plants die. Keeping these problems in mind, most of the plantation was undertaken during the February-March period, which is late winter season, when sea is calm, giving the plants four months to settle before the onset of monsoon.

SUCCESS & FAILURE

At the end of 1st year, *Avicennia sp*. & *Rhizophora sp*. showed 80-88% mortality; growth of plants were 10 cm to 15 cm, while *Ceriops sp*. showed less growth with higher mortality.

At the end of second year *Rhizophora sp.* showed encouraging growth with mortality rate of 70%. The problem faced was that of fishermen walking amongst the mangrove area to catch crabs & fishes.

When it was observed that those mangroves growing with protection of *Aviennia sp*. around, had shown good growth & development, more saplings are planted in the open seaside area.

Direct sowing of propagules of *Rhizophora*, *Ceriops*. and *Bruguiera* were also done. It was found that propagules took one and half time more for sprouting and only 30 - 40% sprouted.

REFERENCE

Garg J.K., *et.al.* 1998, Wetland of India, Space Application Center (ISRO), Ahmedabad, Project Report on Nation Wide Wetland.

Kathiresan K.1998. Distribution And Status of Mangroves in India, Seshaiyana Vol.6 No.2, published by ENVIS Center of Advanced study in Marine Biology, Annamalai University, 8-9.

Singh H.S., 2000. Mangroves in Gujarat, Gujarat Ecological Education and Research Foundation, Gandhinagar, Ahmedabad 128 pp.

Singh H.S., 1984 Status Report on Mangroves in Gujarat State, Marine National park, Gujarat State Forest Department, Jamnagar, 79 pp.

Thivakaran, G.A., *et.al.* 1999. An ecological study of Kachchh mangroves and its associated fauna with reference to its management and conservation. A project report submitted by Gujarat Institute of Desert Ecology, Bhuj-Kachchh, 75 pp.

Marine Environmental Impact Assessment of Proposed Refinery Complex at Motikhavdi, National Institute of Oceanography, Bombay, April 1995.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 226-233

MANGROVE DIVERSITY AND ITS ROLE FOR SUSTAINING PRODUCTIVITY OF THE N.W. COAST IN INDIA

M.J. KOTHARI
Ministry of Environment & Forests
Botanical Survey of India, Western Circle, Pune - 411 001

ABSTRACT : The paper deals with mangrove diversity and its role for sustaining productivity along the coastal region of Gujarat, Maharashtra and Goa. Based on recent literature and survey, the study revealed that there are *c* 22 mangroves and *c* 68 mangrove associates along the above coastal region of India. The study also resulted in publication of 3 new records viz. *Bruguiera cylindrica, Dolichandrone spathacea* and *Porteresia coarctata* at state level and 2 new records for West coast viz., *Halophila ovalis* subsp. *ramamurthiana* and *Roccella belangeriana*. The phytodiversity also includes several hundred species (*c* 1550) including various epiphytic and terrestrial ferns, orchids, parasites, sea-grasses, sea-weeds, soil binders, etc - collected or noted from creeks, wetlands islands and sandy/stony beach areas.

The paper also deals with economic and medicinal value of mangroves, various environmental factors (biotic and abiotic) and its impact on mangroves and other species. Regeneration of mangroves and management plan of government of India especially for conservation of the fragile marine ecosystem are also discussed.

Key Words: Mangrove diversity, Maharashtra, Gujarat, Goa, New records.

INTRODUCTION

The mangroves are the tropical forest formations encircled or spread by the tidal rivers and/ or the sea water, flooded frequently by the tidal water (Naskar & Guha Bakshi, 1987). In other words these are a group of salt tolerant woody plants and characterized by typical morphological, physiological and anatomical adaptations such as evergreen woody habit, vivipary, development of pneumatophores for breathing, knee, stilt or prop roots for anochorage and salt glands, sclerophyllous tissues, sunken stomata in thick coriaceous leaves to restrict transpiration and for resistance against adverse climatic forces (Kothari & Rao, 1991).

India is very rich in plant diversity and is recognised as one of the 12 megadiversity regions of the World (Vavilov, 1951). From about 70% of the total geographical area surveyed so far, 46000 plant species and 81000 animal have been described. India became a party to International Convention on Biological Diversity (CBD) in May 1994. (Annual Report 2000-2001, MOEF, N. Delhi). It is estimated that 'Plant Diversity of India' include Bacteria & Viruses (*c* 850 spp.), Algae (*c* 6,500 spp.), Fungi (*c* 14,500 spp.), Liverworts (*c* 845 spp.), Mosses (*c* 1980 spp.), Pteridophytes (*c* 1200 spp.), Lichens (*c* 2021 spp.), Gymnosperms (*c* 48 spp.) and Angiosperms (*c* 17,500 spp.) [Groombridge, 1992; Sharma *et al*. 1997].

The Floristic diversity in coastal regions of India is studied by a number of workers. To mention a few, Waheed Khan (1959), Rao & Sastry (1972, 1974, 1977), Blasco (1975), Banerjee *et al.* (1989) and Naskar and Mandal (1999) worked out coastal ecology of India in general. While the eastern coast is explored by Rao & Mukherjee (1971), Rao *et al*. (1972), Banerjee (1984, 1987), Naskar & Guha Bakshi (1987), Dagar *et al*. (1991), Thomas & Radhakrishnan (1999) etc. The mangroves of western region is known through the works of Blatter (1905), Navalkar (1951), Shah (1962), Vartak (1966), Dwivedi *et al* (1974), Untawale (1981, 82), Kothari & Rao (1990, 1991, 1994, 1995, 1996, 1998), Karthikeyan (1996), Kothari & Singh (1997, 1998), and Singh & Kothari (1996, 1997).

India has *c* 5,700 km long coast line which can be divided into west coast, east coast and island chains. mangrove area of India is about 6,740 sq km (Banerjee *et al.* 1989). The present satellite based estimate of mangroves is 4460 sq km which indicates loss of about 2,280 sq km (Nayak *et al.* 1996). Out of which Gujarat covers c 260 sq km, Maharashtra covers *c* 300 sq km and Goa of *c* 200 sq km. It is estimated that out of *c* 59 species of mangroves in India, *c* 34 species are present in the east coast and *c* 25 species occur along the west coast of India covering Kerala, Karnataka, Goa, Gujarat and Maharasthra (Banerjee *et al.*, 1989). Based on available literature and critical survey of mangrove areas of Thane (Billore, 1972; Kothari & Rao, 1998), Raigad (Kothari & Moorthy, 1993), Sindhudurg (Kulkarni, 1988), Goa (Untawale, 1981, 82; Rao, 1985; Kothari & Rao, 1990, 95; Kothari & Singh, 1998) it has revealed that in Gujarat there are 18 species of mangroves and 33 species are mangrove associates while in Maharashtra there are *c* 17 speceis of mangroves, 8 species of non-mangrove halophytes and *c* 15 other associated plants

which are not strictly mangroves but are seen along tidal swamps under fresh water conditions along coastal regions. Similarly, in Goa also there are *c* 10 species of mangroves found along the muddy river banks associated with *c* 13 mangrove associates and *c* 14 other coastal or strand plants known from Goa. However, based on recent literature and survey, it is estimated that out of about 1,550 species of North Western coast (cf Karthikeyan 1996), there are c 22 species of mangroves and c 68 mangrove associates available. Among true mangroves about 16 species are recorded viz. *Avicenna alba, A. marina* var. *acuminata, A. marina* var. *marina, A. officinalis, Bruguiera cylindrica, B. gymnorrhiza, B. parviflora, Ceriops decandra, C. tagal, Kandelia candel, Lumnitzera racemosa, Rhizophora apiculata, R. mucronata, Sonneratia alba, S. apetala* and *S. caseolaris* etc. while among 6 semi, obligate/ minor mangroves (Tansely & Fritsch, 1905; Tomlinson, 1986) species recorded are *Acrostichum aureum* (littoral fern), *Aegialitis rotundifolia, Aegiceras corniculatum, Excoecaria agallocha, Heritiera littoralis* and *Xylocarpus granatum.*

There are number of species (*c* 68) which are not strictly mangroves but are usually associated with mangroves or grow as non-mangrove halophytes along the banks of rivers, creeks and in salt marshes a few of them are as mentioned here viz., *Acanthus ilicifolius, Aeluropus lagopoides, Amoora lawii, Ardisia littoralis, Arthrocnemum indicum, Barringtonia acutangula, B. racemosa, Caesalpinia bonduc, C. crista, Calophyllum inophyllum, Cerbera manghas, Clerodendrum inerme, Cryptolepis buchnami, Cynometra ramiflora, Cyperus arenarius, C. compactus, C. malaccensis, C. rotundus, Dendrophthoe falcata, Derris scandens, D. trifoliata, Dolichandrone spathacea, Drynaria quersifolia* (epiphytic fern), *Echinochloa frumentosa, Fimbristylis dichotoma, Flagelaria indica, Hibiscus tiliaceous, Ipomoea turbinata, Myriostachya wightiana, Pandanus tectorius, Phoenix humilus* var. *pedunculata* (Littoral palm), *Premna corymbosa, Porteresia coarctata, Salicornia brachiata, Salvadora persica, Scaevola taccada, Sesuvium portulacastrum, Sporobolus virginicus, Suaeda maritima, Thespesia populnea, Viscum orientale*, etc.

MATERIALS AND METHODS

After Cooke's work (1901-08), some collections were made in the first decades of the century by Gammie, Bhide, Chibber etc. from 1957-61, the northern region i.e. Ratnagiri was explored on a few occasions by Jain, Ahuja, Ansari and Rolla Rao from BSI, WC, Pune. Kulkarni (1988) from BSI also worked out Flora of Sindhudurg based on his explorations in the area during 1964-69. Vartak (1966) published a list of *c* 1512 species based on literature and exploration from Gomantak including *c* 200 species from Goa and rest from N. Kanara, Ratnagiri etc. Thereafter the Goa region was explored from Botanical Survey of India, Western Circle, Pune through Raghavan, Singh, Kanodia and Cherian and Nagar Haveli by Ansari in different seasons beginning with November 1962 and based on which Flora of Goa, Daman Diu, Dadra & Nagar-Haveli was published (Rao, 1985). Under the project on "Mangroves of Goa and Gujarat" Kothari & Rao (1989-90) explored coastal belt of Goa and Gujarat and published a few papers (Kothari & Rao, 1990, 91, 95). Similarly, Thane creeks were explored by Billore (1972) and Kothari & Rao (1994) and creeks of Raigad district during 1976-'80 (Kothari & Moorthy, 1993). All the specimens collected were processed by customary methods and housed in the regional herbarium of Botanical Survey of India, Western Circle, Pune (BSI). Aronda, the only place of mangroves in Savantwadi, the Southern most taluka of Sindhudurg district of Maharahtra was explored by Almeida during 1976-83 (Almeida,1990) and Ratnagiri by Mistry (1983-86). Specimens collected were housed in Blatter herbarium, Bombay (BLAT).

Floristic Diversity

Champion & Seth (1968) classified plant diversity, especially coastal vegetation of India as Littoral and swamp forests. This is further divided into Littoral forests i.e. strand vegetation and Tidal swamp forests i.e. Estuarine vegetation (Rao & Sastry, 1974).

I. ***Tidal Swamp Forests (Estuarine vegetation)***

Along the Gujarat coast, mangrove occur especially in tidal creeks of Arabian sea (Saurashtra and S. Gujarat), Gulf and Cambay and Kutch (Pirotan Island etc.). Salt marshes (Cambay, Jamnagar) and occasionally on muddy river banks. The mangrove vegetation is dominated by *Avicennia marina* and *A. officinalis*, Blasco (1975) and Kothari & Rao (1991) also noted that *c* 250 sq. km in Saurashtra coast was covered by *Avicennia marina* var. *acutissima*. Other members in the area are *Acanthus ilicifolius*. *Aegiceras corniculatum, Bruguiera gymnorhiza, Ceriops tagal, Rhizophora apiculata, R. mucronata* and *Sonneratia apetala.* Stem parasites like *Cassytha filiformis* growing on *Avicennia* spp. was also collected. Some non-mangrove halophytic species like *Atriplex stocksii*, *Cressia cretica, Salicornia brachiata, Salvadora persica, Sesuvium portulacastrum, Suaeda nudiflora, S. fruticosa, S. monoica, Tamarix troupii,* etc. and sea grasses like *Halophila ovalis* ssp. *ovalis* and ssp. *ramamurthiana, Halopyrum mucronatum* and *Urochondra setulosa* were collected. Another sea grass *Enhalus acoroides* was reported by Raghavan *et al* (1981) from Piram beyt, Gujarat.

Srinivasan (1969) recorded 55 marine algae from Okha and Dwaraka coast, of which 10 marine algae viz. *Amphiroa* sp., *Caulerpa* (5 spp.), *Chaetomorpha media, Codium* (2 spp.,) *Rhodymenia palmata, Sargassum* (2 spp.) and *Ulva* sp. were colleted by the

survey parties. Some of them e.g. *Sargassum* sp. and *Ulva* sp. were associated closely with *Avicennia marina*. These epiphytic marine algae are much valued for fish food (Kothari & Rao, 1995).

In Maharashtra, especially in Thana coast, mangroves occur in muddy creeks and saline areas at Dahanu, Mumbra, Vaitarna, Bhainder, Bassein etc. Among them *Avicennia marina var. acutissima* is common and abundant. Other species found are *Avicennia officinalis, Bruguiera cylindrica, Ceriops tagal, Rhizophora mucronata, Sonneratia apetala* etc. The associated species collected alongwith them were *Acanthus ilicifolius, Aegiceras corniculatum, Cyperus arenarius, Derris trifoliata, Excoecaria agallocha, Halopyrum mucronatum, Salvadora persica* etc.

In Raigad district of Maharashtra also, the mangroves occur in muddy sea-shore and saline areas. The dominant species are *Avicennia marina var. acutissima* and *A. officinalis*. Other species found are *Acanthus ilicifolius, Aegiceras corniculatum, Rhizophora mucronata, Sonneratia apetala* etc. Some associated species as occur on muddy soil along with mangroves are *Aeluropus lagopoides, Cressa cretica, Cyperus spp., Salvadora persica, Sesuvium portulacastrum, Suaeda monoica* etc. (Kothari & Moorthy, 1993).

The mangroves recorded from Sindhudurg district are *Aegiceras corniculatum, Avicennia marina, A. officinalis, Bruguiera gymnorrhiza, B. cylindrica, Ceriops tagal, Excoecaria agallocha, Kandelia candel, Lumnitzera racemosa, Rhizophora mucronata, Sonneratia apetala* and *S. caseolaris.* Some associated species found here are *Acanthus ilicifolius, Caesalpinia crista, Clerodendrum inerme* and *Derris trifoliata* etc. (Kulkarni, 1988). While mangroves recorded by Mistry (1983-86) on muddy coast and tidal estuaries of Ratnagiri district are *Aegiceras cornicalatum, Avicennia officinalis, Ceriops tagal, Kandelia candel, Lumnitzera racemosa, Rhizophora mucronata* and *Sonnertia alba* etc. Similarly, on salt marshes at Aronda in Savantwadi area, mangroves recorded are *Aegiceras corniculatum, Avicennia marina, Excoecaria agallocha, Rhizophora mucronata, Sonneratia caseolaris* along with a few associates viz. *Acanthus ilicifolius, Clerodendrum inerme, Salvadora persica, Sesuvium portulacastrum* and *Suaeda maritima* etc. (Almeida, 1990).

In Goa, the mangroves are localised in some estaurine areas like swampy river banks of Chapora, Mandovi, Tiracol and Zuari. They occur in abundance in Chorao island and Cumberjua canal. Occasionally, they occur in muddy creeks near sea coast e.g. Betul. The common and abundant species found in these areas are *Avicennia alba, A. marina, A. officinalis, Excoecaria agallocha, Kandelia candel, Rhizophora apiculata, R. mucronata and Sonneratia caseolaris*, while *Aegiceras corniculatum* and *Bruguiera gymnorrhiza* are found scattered and infrequent.

The critical studies of mangroves of Gujarat and Goa revealed that two species viz. *Bruguiera cylindrica* (Rhizophoraceae) and *Porteresia coarctata* (Poaceae) are known for the first time from Goa and Gujarat coast (Kothari & Rao, 1991 b.), one species viz. *Dolichandrone spathacea* (Bignoniaceae) as a new record for Goa State (Kothari & Rao, 1995) and 2 species viz. *Halophila ovalifolia* subsp. *ramamurthiana* a sea grass in the family (Hydrocharitaceae) and a symbiotic lichen viz. *Roccella belangeriana* (Roccellaceae) were found as new records for western coast (Kothari & Rao, 1994). The lichen species was reported by Awasthy (1981) from Pondicherry on Eastern Coast on stilt roots of *Rhizophora* sp. in 1979. After the lapse of 11 years the same lichen species was recollected on the leafy branch of *Ceriops tagal* from Pirotan island, Jamnagar Gujarat in western coastal region. Similarly, Ravikumar and Ganesan (1990) recorded a new subspecies of *Halophila ovalis* from Eastern coast which was recorded again from Somnath, Veraval, West coast of India (Kothari & Rao, 1994). In estuarine areas of Goa, some plants found as an under growth or growing in close association with mangroves are *Acanthus ilicifolius, Acrostichum aureum* (a littoral fern), *Caesalpinia crista, Cayratia trifoliata, Crotalaria mucronata, Cryptolepis buchnani, Cyperus arenarius, Derris trifoliata, Fimbristylis dichotoma and Sesuvium portulacastrum*, etc. Epiphytic ferns like *Drynaria quercifolia* and orchids like *Vanda tessellata* are also found on *Rhizophora* spp. (Kothari & Rao, 1990).

II. ***Littoral Forests or Strand Vegetation***

This includes vegetation found along sandy and rocky sea-coast.

In Gujarat, it is observed in Kutch (Kandla, Mandvi), Saurashtra (Bhavnagar, Dwarka, Gopnath, Navlakhi, Okha, etc.) and in South Gujarat (Danu, Hajira, Tithal), etc.

Trees species as observed in these areas are *Borassus flabellifer, Delonix elata, Hyphaene dichotoma, Prosopis chilensis, Salvadora oleoides* and man made forests of *Casuarina equisetifolia* and *Cocos nucifera,* etc.

Along with above tree species, some sand binding herbs on sandy sea shore are also found. These are *Cassia italica, Cyperus arenarius* and *Ipomoea pes-caprae, Spinifex littoreus* etc. Some medicinal plants like *Commiphora wightii* growing on rocky habitat were also collected from Diu island.

Along the rocky and sandy coast of Goa, especially Polem, Agonda, Arambel, Betul, Calangute, Gonsua, Hansa (Vasco) and Miramar beach, tree species observed and collected were *Calophyllum*

inophyllum, Hydnocarpus laurifolia, Hyphaene dichotoma (endemic to western coast), *Pandanus tectorius, Pongamia pinnata, Thespesia populnea* and cultivated ones like *Anacardium occidentale, Casuarina equisetifolia, Cocos nucifera* and *Terminalia cattapa* etc.

Other associated plants found as an undergrowth or sand binders are *Boerhavia diffusa, Borreria aritcularis, Celosia argentea, Clerodendrum inerme, Cyanotis cristata, Hyptis suaveolens, Ipomoea pes-caprae, Leucas lavandulaefolia, Lantana camera* var. *aculeata, Rauvolfia terraphylla, Scaveola taccada, Spinifex littoreus* and *Vitex negundo*, etc.

The tree species occuring along the sandy/ rocky sea-shore of Thane coast in Maharashtra are *Borassus flabellifer, Calophyllum inophyllum, Caryota urens, Cocos nucifera, Hyphaene dichotoma, Phoenix sylvestris and Thespesia lampas*, etc.

Sand binding herbs like *Evolvulus alsinoides, Calotropis giagantea, Crotalaria verrucosa, Ipomoea pes-caprae, Pedalium murex, Perotis indica, Spinifex littoreus* and *Tridax procumbens*, etc. were also found.

Some lithophytic marine algae like *Chaetomorpha media, Sargassum sp.,* and *Ulva fasciata* are observed along the creek areas of Thane and Raigad associated with roots of Mangroves .

Similarly, on sandy and rocky coast of Alibag, Nagaon, Murud etc. in Raigad district, Sindhudurg (including Savantwadi) and Ratnagiri districts of Maharashtra floristic composition found was more or less similar to Thane coast.

Infrequent or rare species

Dalgado (1898) recorded *Lumnitzera racemosa* (Combretaceae) along the muddy banks of Siolim and Rarim rivers of Goa with remarks as 'rare'. It is not found in Goa at present. Banerjee *et al.* (1989) also reports this species from Bandra in Bombay, Maharashtra as 'common' in 1934 but not seen now. However, it has been collected from Sindhudurg district (Kulkarni, 1988).

Similarly, Cooke (1901) recorded *Heritiera littoralis* (Sterculiaceae) from Kalanadi river bank near border of Goa and Karnataka. Rao (1985) also mentions the possible occurence of this species along Mandovi and Zuari river bank in Goa. Inspite of intensive search along the above localities, the two species could not be traced out. Similarly, *Cerbera manghas* (Apocynaceae) - an associate species of mangrove, recorded by Rao (1985) from Goa also could not be collected. Similarly, *Bruguiera parviflora* and *Sonneratia alba* recorded by Untawale (1980) from Goa and Banerjee *et al.* (1989) from Maharashtra could not be collected. species of *Rhizophora* and *Bruguiera gymnorrhiza* have also become rare or even disappeared in this area and the vegetation is reduced to stunted strands of *Avicennia spp*. and *Acanthus ilicifolius* particularly in Maharashtra (Banerjee, *et al,* (1989).

Economic and medicinal value of mangroves

Mangroves are useful to mankind in various ways :

i) They provide wood for furniture, boat building, construction and fuel.

ii) Green leaves and fruits of *Avicennia spp*. are used as fodder during scarcity.

iii) Stem-bark is good source of tannin used in leather industries and in medicines for the treatment of diarrhoea (*Bruguiera gymnorrhiza*), heart diseases like angina (*Rhizophora mucronata*), asthma and rheumatism (*Acanthus ilicifolius*), herpes and itches (*Lumnitzera racemosa*) etc.

iv) Indirectly, it protects inland plants against wind and act as a buffer agent along the muddy sea shore. Its peculiar root system (Pneumatophores, knee, prop or stilt roots) holds sand and mud particles and thus help in stabilization of coastal land and conservation of soil.

v) These mangroves also give shelter and breeding ground to fishes, crabs, lobsters, prawns, reptiles and birds (Kothari & Rao, 1991, 1995). Along with mangroves , sea-grasses and salt marshes also play an important role to maintain bay environment eg. in Piram beyt, Pirotan island (Gujarat), Chorao (Goa) and Elephanta island in Raigad, Maharashtra.

vi) Promote eco-tourism.

Environmental impact on mangroves

According to Khoshoo (1991), Biological diversity is a sum total of species including number of plants, animals and micro-organisms living in an ecosystem. This biodiversity is very essential to maintain various ecosystems and their proper functioning, food-chains etc. This biowealth especially above mentioned much valued fragile coastal ecosystem is in danger of extinction. The phytodiversity of N.W. Coast is also affected badly due to various biotic and abiotic factors. The environmental impact on vegetation was studied, especially on N.W. Coast by Kulkarni (1959), Blasco (1975), Kothari & Hajra (1983), Kothari & Rao (1991, 95), Kothari & Moorthy (1993) and Kothari & Singh (1995), etc. Its brief account and possible measures for their conservation is summarised below:

A) **Biotic factors:** Various biotic factors viz. overgrazing, over-exploitation, chemical hazards, industrialization and urbanization in port areas have affected the mangroves as follows.

i) **Overgrazing** : In Saurashtra and Kutch over 2,500 camels of Rabaris are dependent on browsing of mangroves , The cattle grazing is also noticed in Gazibag Sadulsa area, Goa as well as Thane in Maharashtra. This has rendered *Avicennia spp.* with stunted growth.

ii) Over-exploitation of Coastal resources including green leaves, fruits, and wood of mangroves for cattle fodder and fuel purposes affect the growth of mangroves. Over 10,000 persons working on ports of Kutch and Saurashtra are dependent on mangroves for fire-wood (Kulkarni, 1959). During a recent visit of the area, the above facts were also observed at Jambusar (Bharuch), Salaya port in Gujarat and Bassein (Thane) creeks in Maharashtra.

iii) **Chemical hazards :** In Gujarat, Tata Chemical Works Ltd., Mithapore throws constantly, chemically concentrated hot water through grand pipe line in sea near Marine National Park, Dwarka. Similarly, Salaya-Mathura pipeline throws waste oil near Pirotan Island (Kothari & Rao, 1991). In Mahrashtra and Goa also due to proliferation of chemical plants, including fertilizers and Petrochemical units, which sprew poison, affects the growth of coastal vegetation.

iv) **Industrialization and Urbanization** : In port areas of Gujarat e.g. Jafrabad and Alang (Saurashtra) where once upon a time *Avicennia* species were growing profusely but now due to ship breaking and urban developing for commerce and rehabilitation, the growth of mangroves is reduced. The proposed multinational Reliance Refinery Project could also destroy the Gujarat's Marine National Park at Motikhavdi, about 25 km east of Jamnagar in the western region of Gujart at (WWF report October - December 1993). Similarly, mining of Iron Ore for exports through Minerals and Metals Trading Corporation by dumping waste is also affecting riverine system and growth of mangoves of Goa. (Madan Mohan, 1991). Tourists and tourist developments in coastal region have also affected partly the growth and development of mangrove e.g. Goa and Elephanta Islands in Maharashtra are constantly visited by tourists. To accommodate them a number of multistoreyed Hotels, shopping centres etc. are developed in coastal areas. Besides, some of the other major problems faced by the littoral zone in India especially Maharashtra coast are related to coastal erosion, siltation, pollution, quantum of fish catch, destruction of mangrove swamps and salt marshes, sea level rise, land slides and slope failure, population pressure, Industrialization, construction of road and rail links and security of coastline (Dhavalikar, 1996).

v) Habitat destruction such as conversion of mangrove forests and wetland area for agriculture or aqaculture as in Goa and Maharashtra.

B) **Abiotic factors:** Abiotically, high velocity of winds and cyclones bring high tide in sea water which uproots mangroves . Similarly, the adverse arid climate and constant drought in Kutch and Saurashtra during 1971 to 1975 and 1984 to 1987 have also affected the growth of mangroves . Consequently the mangrove species viz. *Bruguiera gymnorrhiza, Rhizophora mucronata* reported by Santapau (1962) from Saurashtra could not be recollected now (Kothari & Rao, 1995).

C) **Regeneration:** To save this important fragile group of plants, multiplication, regeneration and conservation is essential. Nature has created peculiar viviparous germination in mangroves especially in species of *Bruguiera, Rhizophora* and *Ceriops* etc for natural regeneration. The forest department of Goa has done pioneering work in the establishment of mangrove nurseries and plantations in 1985. number of experiments are carried out for growth and development of mangroves (Kothari & Rao, 1991). Since mangrove require muddy, salty habitat and tidal waves of sea water, these hardly survive for long under artificial conditions.

D) **Conservation :** To protect the plant diversity and fragile ecosystem of mangroves from all the above mentioned threats, necessary measures for conservation are essential. For *in situ* conservation, Government of India has declared *c* 12 Biosphere Reserves, 88 National Parks and 490 Wild Life Sanctuaries in the country covering an area of 1.53 Lakh Sq. kms. Financial assistance for development of National Parks and sanctuaries has been provided to 157 National Parks and Sanctuaries in 25 states including North Eastern States) and Union territories in the country during the year (Anon. 2001) to conserve Biodiversity of India. To conserve mangroves in particular, Department of Science & Technology, Government of India constituted a panel of experts and published *State of the Art Report on Mangrove Ecosystems* in 1979. Later, the Ministry of Environment and Forests, New Delhi revised the Status Reports on Mangroves of India in December 1987 and also published Conservation of Mangroves in India in June 1989 with extensive information. At presemt 10 Mangrove Steering Committees in different States and Union Territories are functioning. *c* 15 mangrove areas have been selected and a National Committee is reconstituted in December 1988 with the Secretary of Ministry of Environment & Forests as its Chairman to advise Government to take appropriate measures for conservation and management of mangroves (Banerjee *et al*. 1989). The 15 selected mangrove areas are Andaman & Nicobar Islands, Sundarbans (West Bengal), Bhitar Kanika and Mahanadi delta (Orissa), Koringa, Godavari delta and Krishna Mangrove forests (Andhra Pradesh), Pichavaram and Pvaint Kelimer (Tamil Nadu), Kundapur (Karnataka), Ratnagiri and Achra

(Maharashtra), Bembanad (Kerala), Piroton island and Jakhau-Mundra (Gujarat). In view of significant role played by mangroves during Super Cyclone in Orissa in October, 1999 in protection of life and properties of people along coast line, the development of mangroves has been identified as one of the `Thrust areas'. Fifteen additional areas in the countries have been identified for intensive conservation and management. It has been revealed that there has been a significant incrase of 615 sq km of mangrove areas in the country in last one decade (Annon. 2001). To classify and identify the mangroves of India, Botanical Survey of India has published a book also. (Banerjee *et al.,*1989). Ministry of Environment and Forests have also initiated mapping of mangrove Wealth of India with the help of experts, along with regeneration, plantation and other conservation programmes. Establishment of Marine National Parks in Gujarat at Piroton Island (Jamnagar), Jakhhau and Mudra (Kutch), Pichavaram in Tamil Nadu and Sundarbans, in West Bengal are good examples for action taken by Government of India in this direction for *in situ* conservation of mangroves . Besides, Bird Sanctuaries in mangrove areas at Chorao island (Panaji, Goa), and Cochin are also planned. To create mass awareness, Goa branch of WWF has also designed Environmental Education Centre at Chorao Bird Sanctuary on a plot donated by Goa Government. Under Social Forestry programme *c* 4,00,000 saplings of mangroves have also been introduced in the periphery of mangrove patch in Chorao island to enrich mangrove wealth of Goa. Similarly, for regeneration and multiplication of mangroves, nurseries are also developed at Chorao Island, Cumberjua canal and Banastari areas of Goa as well as various parts of Gujarat and India e.g. Nayachar Island in West Bengal, Piroton island in Gujarat etc. The government of Goa has also declared mangroves as protcted species and their felling is completely banned. Government of India has also classified mangroves in the CRZ-I category. At Sundarbans, Mangrove Interpretation Centre was also opened in 1991 and complete area is declared as Ecological Park for growth and development of Mangroves and to protect tortoise, fishes, Dolfins and Crocodiles etc. (Gupta, 1995).

In India, the Ministry of Environment & Forests is the nodal agency for planning, promoting and co-ordinating environmental programmes. Apart from policy formations, smooth functioning of the developmental efforts is ensured by a system of environmental checks and balances. There is enough legislative, institutional and political support to ensure development without distruction. The legislative measures include -

1. Wildlife (Protection) Act, 1972.
2. Forest (conservation) Act, 1980- amended in 1988.
3. Environment (Protection) Act, 1986.
4. Notification on coastal regulation zone, 1991.
5. Hazardous waste (Management & Handling), Rules, 1989.

Environment Impact Assessment has been made compulsory under the Enmvironment (Protection) Act, 1986 for 29 categories of development activities involving investment of Rs. 50 crores and above. The same act the Government of India has declared the coastal stretches of seas, bays, estuaries, creeks, rivers and back waters which are influenced by tidal action in the landward side upto 500 m from High Tide Line (HTL) and the land between the Low Tide Line (LTL) and HTL as the coastal Regulation Zone (CRZ), *Certain activities prohibited in the CRZ are* -

i) Setting up of new industries or expansion of existing industries except those directly related to water front or directly needing foreshore facilities.

ii) Manufacturing, handling, storage or disposal of hazardous substances.

iii) Setting up and expansion of units/ mechanisms for dsisposal of wastes.

iv) Dumping of city or town waste.

v) Mining of sand rocks and other substrate materials.

vi) Construction activities in ecologically sensitive areas.

In the state of Kerala, the major problems concerning the destruction of Mangroves are lack of awareness among public, injudicial tourism activities and pollution from industrial effluents (Thomas & Radhakrishnan, 1999). Therefore the above instruments are intended to improve global environment. The nature of problems and action taken by government of India are mentioned. Still lot more needs to be done involving Public participation and Non-Governmental Organisations (NGO). Environmental education and awareness are important. It is because of this awareness that has led to judicial activision recently in the country. The developed countries of today have almost exhausted their natural resources during industrial revolution in the past. Now they are looking towards the developing countries for raw material. Hence all our technological development and liberalisation the economy should be made with caution and cosumerism cult must not be encouraged. This can be best done by sensitizing the children at the school level (Atri, 1996). The Ministry also interacted actively with the UGC, NCERT & Min. & Human Research Development for introducing and expanding environmental concepts, themes, issues, etc. in the curricula of schools and colleges. In this direction, Environmental education and mass awareness among

laymen and school children is also started at Chorao Bird Sanctuary, Panaji, Goa.

ACKNOWLEDGEMENTS

Author is grateful to Dr. M. Sanjappa, Director, Botanical Survey of India (BSI), Calcutta for facilities, Dr. P. Lakshminarasimhan, Scientist `C' In-charge, Shri. M.K. Vasudeva Rao, ex-Joint Director, and Dr. P.V. Prasanna, Scientist `C', BSI, Western Circle, Pune for encouragement and useful suggestions.

REFERENCES

Almeida, S.M. 1990. The Flora of Savantwadi Vol.1., Scientific Publishers, Jodhpur.

Anonymous, 2001. Annual Report 2000-2001, Ministry of Environment & Forests, Govt. of India, New Delhi.

Atri, B.S. 1996. Management of Coastal Environment - Key note address in *Maeer's MIT Pune Journal*.

Awasthi, D.D. 1981. Roccella belangeriana. Awas. Bryologist 4(2) : 218.

Banerjee, L.K. 1984. Vegetation of the Bhitarkanika Sanctuary, Orissa State. J. Econ. Tax. Bot. 5: 1065-1079.

——— 1987. Ecological studies on the mangals of Mahanadi estuarine delta, Orissa. Trop. Ecol. 82: 117 - 125.

——— ---, A.R.K. Sastry & M.P. Nayar 1989. Mangroves in India: Identification Manual. Botanical Survey of India, Calcutta.

Billore, K.V. 1972. Studies on the vegetation and Flora of Thana District, Maharashtra State. Ph.D. Thesis, Botanical Survey of India, Pune.

Blasco, F. 1975, The Mangroves of India. Inst. Francais, Pondicherry, Trav. Sect. Sci. Tech. 14: 1-175.

Blatter, E. 1905. The Mangroves of Bombay Presidency and its biology. J. Bombay Nat. Hist. Soc. 16: 644-656.

Champion, H.G. & S.K. Seth, 1968. A revised survey of the Forest types of India, Manager of Publications, Delhi, India.

Cooke, T. 1901-08. The Flora of the Presidency of Bombay 3 Vols., London.

Dagar, J.C., A.D.Mongia & A.K. Bandopadhyay, 1991. Mangroves of Andaman & Nicobar Islands, Oxford and IBH Publishing Co., New Delhi.

Dalgado, D.G. 1898. Flora de Goa and Sawantwadi, Lisbon.

Dhavalikar, L.N. 1996. Problem, Perspective and Survey of Konkan Coast (Maharashtra in Maeer's MIT. J.4 (15-16): Pune 23-30.

Dwivedi, S.N., A.H. Parulkar & S.C. Goswami, 1974. Ecology of Mangrove swamps of the Mandovi estuary, Goa, India. Proc. Inter. Symp. Manag. Mangroves , Hawaii. 1: 115 - 194.

Groombridge, B. (ed.) 1992. Global Biodiversity. Status of the Earth's Living Resources. Report compiled by World Conservation Monitoring Centre, Chapman & Hall, London.

Gupta, S.L. 1995. Vayushif (Mangroves) in Bharat ki Vanaspati Vividhta (Plant Diversity of India, Eds. Mudgal V. & P.K. Hajra), Botanical Survey of India, Calcutta, pp. 147-155.

_____ & A.R.K. Sastry, 1991. Kachha Vanaspati (Mangroves) Lupt Hota Strot (becoming rare) in Vanaspati Vani (Hindi) 2: 19-22.

Karthikeyan, S. 1996. Northern Western ghats and Northern western coast in Flora of India (Eds. Hajra *et al.*) Botanical Suvey of India, pp. 375-390.

Khosoo, T.N. 1991. Biological diversity - a case for conservation. Hindu, Survey of the Environment, p. 125.

Kothari, M.J. & P.K. Hajra, 1983. Gujarat & Rajasthan region in Materials for a Catalogue of threatened plants of India (Eds. Jain, S.K. & A.R. K. Sastry), Botanical Survey of India, Howrah. pp. 43 - 49.

_____ & S. Moorthy, 1993. Flora of Raigad District, Maharashtra State, Botanical Survey of India, Calcutta.

_____ & K.M. Rao, 1990. Studies on the Mangroves of Goa,. Indian Bot. Contactor 7: 185-188.

_____ & _____ 1991 a. Environmental impacts on Mangroves of Gujarat. Ibid. 8: 51-57.

_____ & _____ 1991 b. Two new records for Goa and Gujarat Ibid. 8: 58-61.

_____ & _____ 1994 a. Halophilla ovalis (R.Br.) Hook.f. subsp. ramamurthiana Ravik. & Ganes. - a new record for West Coast of India. Rheedea 4(1) : 63-64.

_____ & _____ 1994 b. Roccella belangeriana Awas. A new record for western coast of India, J. Econ. Tax. Bot. 18 (3) : 610 - 612.

_____ & _____ 1995 a. Dolichandrone spathacea (L.f.) K. Schum. (Bignoniaceae). A Little known plant for Goa Ibid. 19(2) - 323 - 324.

_____ & _____ 1995 b. Interesting ecosystem of Mangroves along west coast of India (Goa and Gujarat State) in Taxonomy and Biodiversity (Ed. A.K. Pandey). CBS Publishers & Distributors, Delhi pp. 52-58.

_____ & _____ 1998. Plant diversity in Surya river catchment area in Jawahar Taluka and creek area of Thane, Bombay. J. Econ. Tax. Bot. 22 (2): 415-418.

_____ & N.P. Singh, 1997. Mangrove diversity along the Maharashtra coast. WWF Magazine (in press).

_____ & _____ 1998. Mangrove diversity along North-West Coast of India, J. Econ. Tax. Bot. 22 (3): 571-585.

Kulkarni, B.G. 1988. Flora of Sindhudurg Botanical Survey of India. Calcutta.

Kulkarni, D.H. 1959. Utilization of Mangrove forest in Saurashtra and Kutch. Proc. Mangrove Symposium. Calcutta. 1957.

Mistry, M.K. 1983-86. Report of Bot. Surv. India, Ratnagiri Dist. Flora Project. Ph.D. Thesis, 2 Vols. Bombay.

Mohnan, M.M. 1991. Goa : In peril, a fragile environment, Hindu, Survey of the Environment, p. 69.

Naskar, K. & D.N. Guha Bakshi 1987. Mangrove Swamps of the Sunderbans, Naya Prakash, Calcutta.

_____ & R. Mandal, 1999. Ecology and Biodiversity of Indian Mangroves Part-I, Daya Publishing House, Delhi. pp. 140-159.

Navalkar, B.S. 1951. Succession of Mangrove Vegetation in Bombay and Salsette Islands. J. Bombay Nat. Hist. Soc. 50: 157 - 160.

Nayak, S.A. Bahuguna, P. Chawan, H.B. Chauhan & R.S. Rao, 1996. Remote sensing applications for coastal Environmental Management in India in Maeer's MIT Pune **J.** 4(15-16): 113-125.

Rao, R.S. 1985-86. Flora of Goa, Diu, Daman and Nagarhaveli 2 Vols. Botanical Survey of India, Howrah.

Rao T.A. & A.R.K. Sastry, 1972. An ecological approach towards classification of coastal vegetation of India - I, Strand vegetation. Indian Forester 98 : 597-607.

Rao, T.A. & A.R.K. Sastry, 1974. An ecological approach towards classification of coastal vegetation of India -II. Estuarine vegetation Ibid. 100 : 438 - 452.

Rao T.A. & A.R.K. Sastry, 1977. An outline of the coastal vegetation of India Bull. Bot. Surv. India 16: 101-115.

Rao T.A., & A.R.K. Sastry & P.G. Shanware, 1972. Ansalysis of basic patterns of an estuarine shore in the vicinity of Coringa Bay, Andhra Pradesh Proc. Ind. Acad. Sci. 75 (B) :40-50.

_____ & A.K. Mukherjee, 1972. Ecological aspects along shores of Burabalanga tidal estuary, Orissa State. Ibid. 76 (B) : 201-206.

Ravikumar, K. & R. Ganesan, 1990. A new subspecies of Halophila ovalis (R.Br.) J.D. Hook. (Hydrocharitaceae) from the Eastern Coast, Peninsular India. Aquat. Bot. 36: 351-358.

Santapau, H. 1962. The Flora of Saurashtra - I. Saurashtra Research Society, Rajkot.

Shah G.L. 1962. The vegetation along the sea-shore in Salsete Island, Bombay Bull. Bot. Surv. India 4: 239-240.

Sharma, J.R., V. Mudgal & P.K. Hajra, 1997. Floristic diversity, Review, scope and perspectves in Floristic Diversity and Conservation strategies in India (eds. Mudgal & Hajra) Botanical Survey of India, Calcutta 1: 1-45.

Singh, N.P. & M.J. Kothari, 2000. Phytodiversity of India - an overview in Conservation and Management of Biological Diversity Indian Forests and Environment Managers Association (Eds. A. Mehrotra & A. Singh), Bhopal.

_____ & _____ 1997. Floristic diversity of Goa. In Conservation and Management of Biological Diversity (Eds. P.K. Hajra & V. Mudgal), B.S.I. Calcutta 2: 757-774.

Srinivasan, K.S. 1969. Phycologia indica (Incones of Indian Marine Algae) 2 Vols. Botanical Survey of India, Calcutta.

Tansley, A.G. & E.E. Fritsch, 1905. Sketches of Vegetation at home and abroad. I. The flora of Ceylon littoral. New phytol. 4: 17 & 27-55.

Thomas, G. & T. Radhakrishnan, 1999. Man and Mangroves : How far do they go hand in hand? A perspective with respect to the Mangrove Ecosystems of Kerala state Indian Forester 125 (12): 1248-1254.

Tomlinson, P.B. 1986. The Botany of Mangroves Cambridge University Press, Cambridge, London, New York, pp. 1-414.

Untawale, A.G. 1980. Present status of the Mangroves along the West Coast of India, Asian Symp. Mangrove Env. Res. Management, Kaula Lampur. pp. 1-26.

_____,*et al.* 1982. Application of remote sensing techniques to study the distribution of Mangroves along the estuaries of Goa. In Wetlands: Ecol. & Management Proc. 1st Inter. Wetlands conference, New Delhi. pp. 51-57.

Vartak, V.D. 1966. Enumeration of Plants of Gomantak, India. Poona.

Vavilov, N.I. 1951. The origin variation Immunity and Breeding of Cultivated Plants. The Ronald Press Company, New York.

Waheed Khan, M.A. 1959. Ecological studies of the Mangrove forests in India in Proc. Mangs. Symposium Faridabad. pp. 97-113.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 234-236

MANGROVE PLANTATION AT THE RITUCHAKRA BY HOPE

Amol Patwardhan and Madhuri Pejaver
Members of HOPE (Here On Project Environment)
Sahayog Mandir, Ghantali Path,
Thane(w)

ABSTRACT : HOPE is a NGO actively working in the field of environment with the objectives of nature awareness, nature education and nature conservation. HOPE has undertaken a program of mangrove plantation near the nature park Rutuchakra from the year 2000. With the help of HOPE volunteers, successful plantation of different varities of mangroves is done, in which some new varieties of mangroves, which were not present in this area, like *Rhizophora mucronata*, *Agiceras corniculatum* and *Bruguiera cylindrica* are introduced in this area of which only *Rhizophora* is successful.

Key words: *Mangroves, plantation, NGO*

INTRODUCTION:

Mangrove is a group of typical tropical and specialized trees growing on the saline and brackish water system. They show unique biological phenomenon because they survive water logging, poor soil aeration, salinity, high humidity, which are combinations of the conditions not tolerated by other plants. Mangrove swamps are most suitable as feeding, breeding and nursing grounds for many marine organisms. They act as important link in an estuarine food chain, provide protection against storm damage, act as soil binders and prevent erosion of soil. (Patil,1988; Ranade,1988).

Mangroves are seen growing luxuriantly along estuaries, back water islands and in protected areas. Thane city is one through which runs Thane creek and on the banks of it are seen the mangroves from Vikhroli till Vasai, of which some have very good growth with height of about 40'-50'.

PRESENT STATUS:

At present many of these mangroves, particularly in the vicinity of the habitations have been over exploited, neglected, destroyed and degraded for different reasons. Encroachments, urbanization, industrialization have caused serious setback to mangroves habitats. Polluted waters and human interference is causing serious damage to mangroves all over and the picture is no different near Thane city.

We, the members of HOPE, felt that if we take up artificial regeneration of suitable mangrove species best suited locally along with the protection and preservation of existing mangroves, it would be possible to grow the thicket of mangroves which at least partially may regenerate the previous habitat, which is in agreement with Sawant (1994), Untawale (1994) who also suggested the silvicultural practices will help in restocking the degraded mangroves.

Similar suggestion was made by Andrade *et.al.* (2000) for mangroves of Chendiya creek. Keeping this in mind mangrove plantation was initiated by the NGO-HOPE in the in year 2000 as a pilot program which is discussed in the present paper.

AREA OF PLANTATION:

In Thane city near Kalwa bridge the area near a bank of Thane creek was used as a garbage dumping ground. HOPE has taken the initiative and is successful in stopping this garbage dumping. Now with the help of TMC (Thane Municipal Corporation) a nature park, named as Rituchakra, is being created in this area. The area is approximately 1.5 km long, 80m wide and about 17 acres. It is divided in 6 zones according to different seasons or Rutus. The area is protected by a fence wall. The plantation activity in Rutuchakra is taken up by Thane Municipal Corporation (TMC).

In this area towards the waterside the mangroves were damaged and hence HOPE volunteers selected this area for plantation of the mangroves.

METHODS:

Nursery techniques: Different nursery techniques as suggested by Untawale (1986) were used for growing saplings.

- Polythene milk bags were filled by the soil mixed with the bio-fertiliser. Deshmukh (1994) has used farm yard manure.
- The mixture of soil and bio-fertiliser was added in the pots or drums in which many seeds could be planted at a time.

- Nursery beds were prepared in the plantation sites where seeds were sown.
- Some HOPE members grew the saplings at home in the small pots or containers.
- Full-grown mangrove seeds of different varieties were collected from the site, from existing mangroves or from near by areas and were sown in the bags, pots or the nursery beds.
- The collection of propagules or seeds was done mainly from June to September as that is the season for most of the mangroves. (Untawale,1986; Kathiresan,1994)
- The saplings were given fresh water till they grew to size of 25-30cm, were ready for plantation.
- The germination of the seeds started within about 7 to 8 days. About 70-80% seeds of *Avicennia* spp. while only 50% seeds of *Salvadora persica* germinated and the saplings grew to the height of 25-30cm (*Avicennia spp*.) and 12-13cm (*Salvadora persica*) by the end of the rainy season and were ready for plantation.
- 3 to 4 months old naturally grown saplings under the mother plants of different varieties were also collected and planted. This also suggested by Raddy (1987,1994)
- Only healthy, mature, naturally fallen *Rhizophora* propagules found under the mother trees were preferred as suggested by Raddy (1987,1994). While the matured, healthy seeds of *Avicennia* were collected either from plant directly or from the one fallen below the mother plant.

PLANTATION METHODS:

The saplings were planted in mud flats near the creek edge of Rutuchakra. The plastic bags was torn at the base and immersed fully in the mud. The saplings from pots and drums were separated out without hurting the roots and then planted by digging out the mud a little. At certain places the mud was too soft and unreachable, there the saplings were dropped from the height which could easily sink in the mud and remain straight. Whenever possible, care was taken that newly planted saplings would not be directly exposed to force of the tidal waves. However in totally barren patches, this was not possible.

SPECIES OF THE MANGROVES PLANTED:

The efforts were to conserve the original species and also to introduce new species.

Avicennia marina forms the dominant genera of the mangroves in this area, along with few plants of *Sonneratia apetala. Salvadora* spp. the mangrove associate is also seen common in this area. But along with this the new species like *Rhizophora mucronata, Agiceras corniculatum and Bruguiera cylindrica* were also planted in this area. Most of these species are also suggested by Untawale(1986,1994), Raddy (1987,1994) as they are available easily and their propagules or seeds also are available in considerable numbers in mangrove forest.

The mangrove plantation program was as follows:

Mangrove species	Year		
	2000*	**2001***	**2002***
Avicennia marina marina	606	950	—
Avicennia marina officinalis	214	772	48
Salvadora persica	2200	100	—
Rhizophora mucronata	07	86	48
Agiceras corniculatum	70	50	—
Bruguiera cylindrica	59	—	—
Sonneratia apetala	—	35 fruits	—
Ceriops tagal	—	50	—
Excoecaria agallocha	—	15	—

* Figures in column indicate number of seeds, saplings or propagules planted

RESULTS AND DISCUSSIONS:

Each species among the various species planted gave different results.

- *Agiceras corniculatum* and *Bruguiera cylindrica* propagules which were planted in 1st year, were very small. These propagules were planted in polythene bags and then directly in the mud in zone 1. in this zone tidal action is more, water mass is also more and hence all the propagules were either buried in the silt or washed off. Only one propagule of *Agiceras corniculatum* were survived.

  Second year *Agiceras corniculatum* saplings which were one year old, were planted in zone 3. But this zone seems to be more polluted as these saplings did not survive. According to Untawale(1986) sewage pollution or low level non toxic pollutants may not have harmful effects on the mangrove plants but toxic substances increase mortality.
- *Sonneratia apetala,* 35 fruits were sown but not a single germinated.
- *Salvadora persica* seeds were sown in polythene bags, in the nursery beds and also in pots but germination rate is hardly 40% while survival rate is 10%.

- *Ceriops tagal* and *Excoecaria agallocha* saplings were planted in zone 3, where again the survival rate is 0 %.
- *Rhizophora mucronata* was also a new species introduced and it showed good survival rate. *Rhizophora* saplings were 1 year old when planted and showed 50% survival.
- Both the species of *Avicennia* showed good survival rate – about 60-70%. This might be the reason for the dominance of these species in locality. Similar observations were reported by Patil (1988) or it can be preference of soil as *Rhizophora* spp. prefer muddy soil while other species like *Ceriops* and *Bruguiera* prefer more drier soil (Aksornkoae,1985)
- While according to Jagtap (1988) paleo botanical evidences suggest that *Avicennia, Sonneratia* and *Rhizophora* were the first mangrove species to appear, which might be the reason for wide spread dominance.
- Growth rate of the saplings planted in zone 4 and 5 was good and saplings almost doubled in height in one year. *Avicennia marina* saplings were about 30-35cm tall when planted and grew to 70-80cm in height – almost double. This was similar to the observations of Deshmukh (1994). In third year they are about 180 to 200 cm. Tall.

Thus different varieties of mangroves showed different survival as well as growth rates, which was also observed by Maity (1994). But in general growth was seen better in second year than in first year. Similarly it was also observed that mangroves planted in the beginning of September i.e. just at the fag end of the rainy season showed better survival than which were planted in late September or October. Raddy (1987) also stated that 6 months to 1 year old saplings if planted during rainy season showed good survival, but those uprooted and planted after rains survived less.

CONCLUSION

Thus a NGO can take up planned mangrove plantation activity and make it successful but for this to successful public awareness is important, so that many people can participate in the activity.

According to Kokate (1985) such awareness drives create good impact on the age group 20-25 years. In Thane city the mangrove plantation activity can be taken up on either bank of the creek. Similarly protection of existing mangroves also will help in propagation.

ACKNOWLEDGEMENT

The authors are thankful to every member of HOPE who has helped in collection and plantation of mangrove saplings and watering them, which assisted the plantation process. Authors and HOPE also acknowledge Godrej Boyce and Mr. Vivek Kulkarni for providing saplings of some mangrove species and also for the continuous guidance.

REFERENCES

Aksornkoae Sanit 1985, Conservation of Mangroves, The Mangroves: Proc. Nat. Symp. Biol. Util. Cons , Mangroves 99-104

Andrade L.V., V.V.Baadkar and V.N.Nayak 2000 Biodiversity, Distribution, Ecology and Conservation of mangroves of Chendiya creek. Abst. National Seminar on Conservation of Biodiversity and Coastal Aquaculture, University of Karwar.

Deshmukh S. 1994 Ecorestoration of Mangroves- A Case Study. Conservation of Mangrove Forest Genetic resources- A Training Manual , CRSARD

Jagtap T.G. 1988 Ecology of mangroves. Mangrove seminar, Ganpatipule, Maharashtra

Kathiresan K. 1994 Propagation Of Mangroves: Some Considerations, Conservation of Mangrove Forest Genetic resources- A Training Manual , CRSARD

Kokate P.S. 1985 The Mangroves: Proc. Nat. Symp. Biol. Util. Cons , Mangroves 335-337

Maity Subrata 1994 Mangroves and Their Rehabilitation for Conservation. Conservation of Mangrove Forest Genetic resources- A Training Manual , CRSARD

Patil A.V. 1988 Mangrove afforestration, Mangrove seminar, Ganpatipule, Maharashtra

Raddy A.G. 1987 Mangrove Afforestration in Coastal Wetlands. Publ. Jt. Director, Social Forestry Circle, Kolhapur

Raddy A.G. 1994 Rehabilitating Mangroves in Maharashtra, Conservation of Mangrove Forest Genetic resources- A Training Manual, CRSARD

Ranade A. 1988 Significance of Mangroves in Coastal Fishery, Mangrove seminar, Ganpatipule, Maharashtra

Sawant P.V. 1994 Regeneration of Mangroves, Conservation of Mangrove Forest Genetic resources- A Training Manual, CRSARD

Untawale A.G. 1986 How to grow mangroves, NIO, Goa

Untawale A.G. 1994 Development of an intertidal mangroves nursery and afforestation techniques Conservation of Mangrove Forest Genetic resources- A Training Manual , CRSARD

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 237-239

GERMINATION AND GROWTH PERFORMANCE OF *XYLOCARPUS GRANATUM* KOEN.

M. V. Gokhale and N. S. Chavan (Mulik)
Department of Botany, Shivaji University,
Kolhapur – 416 004. (MS) India.

ABSTRACT :- *Xylocarpus granatum* Koen is critically endangered mangrove species growing along the west coast of Maharashtra. The germplasm bank has been established for restoration of the species in its real habitat. Some physical properties of fruits and seeds were studied during collection. Natural seed germination in field was monitored for successive two years. Germination study was carried out. Seeds showed very low viability period. Germination and seedling growth performance was seed weight dependent.

Key Words :- Mangrove, *Xylocarpus granatum,* Seed germination, Reproductive capacity, Viability, Natural Germination in field.

INTRODUCTION

Xylocarpus granatum is one of the mangrove species growing along the west coast of Maharashtra. It is growing luxuriantly in the Achara estuary. It's occurance on the west coast of Maharashtra was first time reported by Bhosale (2000), which was discovered by her in 1999. Bhosale *et al*., (2002) after critical survey of each estuary reported occurance of X. granatum and C. iripa along the coast of Maharashtra. Further, Bhosale (2002) classified it as critically endangered. There is an urgent need for suitable strategies for the conservation of such genotypes. Keeping this view the present work was undertaken.

The reproductive capacity of the species is as much characteristic as any other specific feature of ecological importance (Salisbury, 1942). Fruit and seed weight are also ecologically important because it affects the germination significantly (Mulik and Patil, 1996). It was quite interesting to know above said parameter of very rarely growing mangrove species along the west coast.

Though the mangrove species grow in the estuarine environment they can grow in different zones. The physicochemical parameters of soil and water differ from estuary to estuary and even site wise. The habitat reflect in the morphology and overall growth of the species. There may be the possibility of ecotype development. In case of *Xylocarpus granatum* also it may be possible. For this reason the documentation has been made for some characteristics of fruits and seeds collected from Achara estuary (west coast of Maharashtra, in this region species is critically endangered).

MATERIALS AND METHODS

The matured fruits of *Xylocarpus granatum* were collected from Achara (located in Malvan Tahasil of Sindhudurga district of Maharashtra). The patch of mangrove vegetation dominated by *Xylocarpus granatum* was monitored from April 2000 to April 2002. The matured fruits were collected from selected individuals and analysed for physical properties. One part of this patch was selected for observation on natural seed germination in field. Percent germination in field was determined by counting the fruits on mother plants and by counting the new seedlings on the soil surface of that specified area. Mature fruits were weighed. Seeds were classified on the basis of their weight after natural dehiscence of fruits. Seeds were sown for germination. Growth performance was studied after 100 days of sowing.

Some seeds were stored to know the period of viability. Reproductive capacity was determined by the formula given by Salisbury, (1942)

Reproductive capacity =

$$\frac{\text{Average seed output}}{100} \times \text{Average \% germination}$$

It is to be noted that, as the species is rare the source of seeds was limited. Collection of data by keeping replicates was highly impossible, hence the germination of seeds and survival of the seedlings was carefully monitored.

RESULTS AND DISCUSSION

The fruits of *Xylocarpus granatum* are large. Table – 1 describes the physical characteristics of fruits and seeds. The fresh fruit (Mature) weight was 385.41 gm. (± 121.18), in which the seed weight contributed more than that of fruit wall weight. According to Pandeya *et. al*., (1967), many mangrove seeds belong to the group having heavy seeds. According to them these seeds are usually smooth and without any special appendages. In *Xylocarpus granatum* the seeds are triangular. Testa is

TABLE-1: Physical properties of fruits and seeds of *Xylocarpus granatum*

fruit (g)	Fruit weight (g) weight (g)	Fruit wall weight (g) (cm)	Seed no. per fruit (cm)	Total seed weight per	Average single seed	Fruit height	Fruit Diameter
Average	385.4118	114.9412	6.058	250.47	44.801	7.98	29.88
S.D.	(±121.1822)	(±41.076)	(±2.7)	(±84.78)	(±14.24)	(±1.36)	(±4.01)

Table : 2 : Percent seed germination of *Xylocarpus granatum* field.

Year	2000	2001
Individuals monitored	8	6
Fruit (total of all individuals)	20	17
Portable seed No.	114	103
Seedlings (new) under canopy of the patch.	16	14
% seed germination in field	14.07%	13.50%

thick and corky which is special adaptation particularly notable where the method of dispersal is different between mangrove and terrestrial relatives. (Tomlinson, 1986). They fall on the soil and most of the time germinate under mother plants immediately after the fall. The presence of *Xylocarpus granatum* seedlings far away from mother plants was rarely recorded. This particular observation can be supported by the statement by Tomlinson (1986). According to him seedling of *Xylocarpus* are quite common in *Xylocarpus* community so that maintainance of populations as well as dispersal seems effective.

Seed number differed on the basis of fruit size. Average seed number per fruit was 6 (± 2.7). Average seed weight was 44.809 (± 14.24). But occasionally ranged from 11g to 108 g. Fruit size was also variable (29.88 cm dia (± 4.01)).

Table – 2 describes the percent germination in the field. It was 14.03 and 13.5% for the years 2000 and 2001 respectively i.e. only 13 to 14% seeds could germinate. Others either got washed off by tides or got destroyed by insects. Medicinal use of these seeds has been reported by Bhosale *et. al*., (2002). According to them every house in the village have the collection of seeds. It may possibly contribute in lowering the germination in field. Yamashiro (1961) during working with *Kandelia* has reported only 1.67% propagule collected under mature trees, remaining were lost.

Table – 3 describes the effect of seed weight on germination and growth performance of the seedlings. About 73% seeds showed 11 to 30 g seed weight which is the largest class while only 1.66% seeds were observed in the class having highest weight (i.e. 91 to 110 g).

100% seed germination was observed in the 5th class (having maximum seed weight), while lowest germination percentage was recorded from 1st class (having minimum seed weight).The similar trend has been recorded by Mulik and Patil (1996) in case of *Terminalia arjuna.* The germination percentage was not linear from the lowest to the highest weight class. In 4th class the percentage of germination was lower than previous one. Similar trend was recorded by Mulik and Patil (1986) in *Terminalia arjuna*. In the present investigation shoot length was directly correlated to seed weight but root length was not. Both were the highest in the 5th class but not lowest in 1st class. Shoot to ratio (length) was more in classes 2,3 and 4. It suggest that in low weight seeds the root development is comparatively more than that of shoot at seedling stage. It was also observed during the study that, in *Xylocarpus granatum* the root system get develop primarily and at a very faster rate.

Number of leaves was also directly correlated to the seed weight with few differences (Class 3,4). Number of roots per seedling also increased with seed weight increase (except class 3 and 4). The healthy seeds (with high seed weight) required least days for germination while the light seeds require maximum days.

Over all the percentage of germination and growth performance was better in class 5 where percentage of seeds was very low. The seeds probably tried to overcome the problem of low weight (i.e. low amount of reserved food material) by producing the roots as faster rate than the shoots. The values of shoot length, root length, number of leaves were not significant in the class 4. This might have been due to insect infection to the seeds. This particular problem was unavoidable due to scarcity of plant material. The overall germination of all the classes was 78% after 100 days of sowing. After that no germination was recorded.

Average seed output per individual was 15.5 seeds, which was calculated from the data of 2 successive years. The reproductive capacity (according to Salisbury's formula) was 12.09, which is very low as compared to some other terrestrial tree species, *Boswellia serrata* - 1.985, *Anogeissus latifolia* - 268.9, *Shorea robusta* – 302.7 (Pandeya *et. al.*, 1968).

According to Salisbury's formula the reproductive capacity is highly dependent on average

TABLE-3: Effect of seed weight on germination and growth performance after 100 days of sowing

Class g/seed	% of seed in the class	% germination in the class	Days required for germination	Shoot lenght	Root length	S:R Ratio	No. of Roots/ individuals	No. of leaves/ individuals
11-30	73.33	46	50	33.89	8.80	4.22	4.02	3.84
31-50	3.33	60	40	47.5	6.50	7.81	6.00	7.5
51-70	10.00	82	28	56.33	9.16	6.26	4.66	5.8
71-90	11.66	72	35	45.78	8.1	7.11	4.66	5.5
91-110	1.66	100	10	71.00	12.0	5.91	7.00	8.0

seed output. It may differ site/geographical area wise. So the present value of reproductive capacity of *Xylocarpus granatum* should be considered as representative of only the study area because the average seed output per individual is subject to change.

It was noted almost a century ago, that in mangroves, seeds do not have resting period. (i.e. dormancy) (Karsten, 1981; KippGolar, 1940; Haberlandt 1985). But no information is available about the longevity of *Xylocarpus* seeds. The seeds of *Xylocarpus granatum* can germinate only up to 4 months after dehiscence from mother plants. Later on they cannot germinate even under fresh water conditions.

Seed output and reproductive capacity of *Xylocarpus granatum* is thus very low. It may possibly be due to the impact of various stresses on the mangroves Achara (Mulik *et. al*., 2001). Hence the mangroves need to be protected from several stresses to conserve the endangered germplasm.

REFERENCES

Bhosale L. J. 2000 Annual Progress Report of Project "Categorisation of Mangroves of Maharashtra based on IUCN red list guidelines and germplasm preservation of threatened species". Submitted to Ministry of Environment and Forest, Government of India, New Delhi.

Bhosale L. J. 2002 Categorisation of Mangroves of Maharashtra based on IUCN red list guidelines and germplasm preservation of threatened species. Final report submitted to Ministry of Environment and Forest, Government of India, New Delhi.

Bhosale L. J., S. Banik, M. V. Gokhale and M. A. Jayappa 2002. Occurrence of *Xylocarpus granatum* Koen and *Cynometra iripa* Kostel along the coast of Maharashtra. J. Econ. Taxon. Bot. 26 (1), 82 to 87 pp.

Chavan (Mulik) N. S., M. V. Gokhale and A. B. Telave 2001. Impact of various stresses on Mangroves of Achara. In Abstract of papers presented in International Congress of Chemistry and Environment (under the auspices of research journal of Chemistry and Environment, Indore (M. P.) India.) 30 p.

Haberlandt G. 1985. Uber die die Emahrung der Keiling and die Bedatung des Endosperms beivivigaven Mangove pflanzen. Ann. Javd. Bot. Buitenzora 12 : 91

Karsten G. 1981. Uber die Mangrove vegetation in Malayaschen Archipel. Bibl. Bot., 22, Stuttgart.

Kipp-Gollar T. 1940. Uber Bau and Entoolcklung der viviparen pflanzen Mangrovenkei mLinge Z. Bot. 35 : 1.

Mulik N. G. and S. G. Patil 1996 Seed germination in *Terminalia arjuna*. In : Shiva M. P. and R. B. Mathur (eds) Management of minor forest produce for sustainability Center of minor forest products, Dehra Dun (India) Oxford and IBH publishing Co. Pvt. Ltd. 164 – 166 pp.

Pandeya S. G., G. S. Puri and J. S. Singh 1968. Research methods in plant Ecology; Asia publishing house. 23 p.

Salisbury ; E. J., 1942. The reproductive capacity of plants. In : Pandeya S. C., Puri G. S. and J. S. Singh (1967). Research methods in plant Ecology. Asia publishing house.

Tomlinson P. B. 1986. The Botany of mangroves. Cambridge University Press, 281 p.

Yamashiro M. 1961. Ecological study of *Kandelia candel* (L.) Druce, with special reference to the structure and falling of the seedlings. Nikobia 2(3) : 209 – 214 pp.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 240-242

COMPOSITION AND PRESENT STATUS OF MANGROVES AT ACHARA CREEK

Aarati S. Yeragi, Rajendra Nayak and S. G. Yeragi
K. J. Somaiya College of Science and Commerce
Vidyavihar, Mumbai – 400 077.

ABSTRACT :- The mangrove forest ecosystem is a dynamic one and changes very frequently. This change may be due to various reasons. In this changing mangrove environment the succession of the diverse mangrove species also show unique adaptation. The mangroves like *Avicenia spp.*, *Sonneratia spp.* and *Excoecaria spp*. are the pioneer trees, grow as and when the new land or island come up? Though mangroves are salt tolerant species, their better growth is observed in less saline zone with much height and more density. In A_3 region of Achara Creek, mangroves are taller than A_1 and A_2 regions. The dwarf trees species of the mangroves in the creek are less frequent in species abundance and distribution. Regular silt deposition may be the dominant cause for these various growths of mangroves. In the present investigation 13 genera and 23 species of mangroves are noticed in which Rhizophoraceae is the dominant family.

It is also noted that an urgent and well planned programme, like mass awareness programme on eco-development and campaign for the protection of these species are needed for the conversation and protection of the natural resources for the sustained utilization. Rural people should be educated for these conservation activities.

Key Words - *Mangrove, Status and Achara*

INTRODUCTION

Mangroves are a group of highly evolved halophytes occupying the intertidal zone creeks, lagoons and coastal mud flats. They grow well in poorly oxygenated water logged, saline habitats, a seasonal fluctuation with fresh water is also equally important for their continuous survival. The undisturbed mangrove forests may act as the seaward barrier and check considerably the coastal erosion and minimize the tidal thrust, hit from the sea. The well developed mangrove habitats may also accelerate the siltation process by arresting the water transport silt and clay particles, which ultimately build the coastal zone through accretion.

To meet their demand for fuel, fishing, bread and butter, lakhs of these native people exploit these forest wood from the slow growing mangrove woodlands and harvest or catch fish prawns, crabs with nets. The large scale exploitation of these natural resources give little chance for the replenishment of these natural wealths.

It is now very much necessary to list out the mangrove flora from different mangrove regions of India and need to classify these true mangroves, with their status, distribution, availability and speciation for the National Understanding. It is also noticed that the checklist of the mangrove for last four decades is variable or rather confusing from one worker to the another.

MATERIALS AND METHODS

The present investigation was carried out in Achara Creek (South Konkan). A series of quadrates of 5 x 5 m (Sidhu 1963) were laid at an interval of 1km along 10km long canal. The number of plants in each quadrate was counted and the data was tabulated. Using certain indices the species structure in community, data on the index of dominance, species diversity and richness of species were calculated.

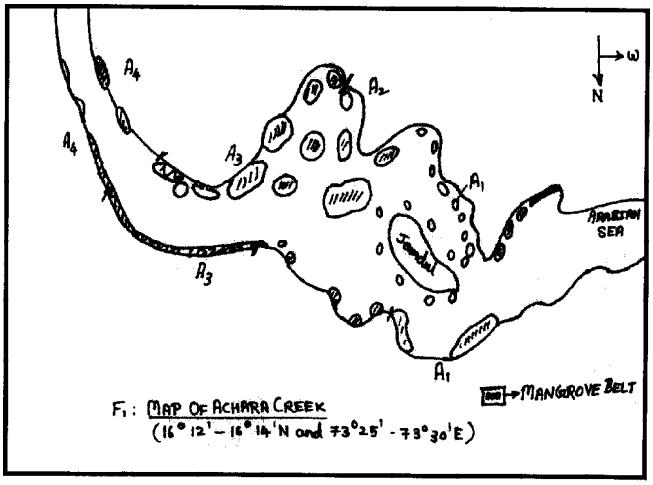
Relative density = (number of individuals of species / total number of individuals) x 100

Relative frequency = (frequency of a species / sum – frequency of all species) x 100

The study was conducted in three zones A_1, A_2 & A_3 (fig. 1).

RESULTS

The percentage composition and status of mangroves in 10 quadrates along the distance of 10 km are given in Table 1. The vegetation in the mangrove swamp consisted of 23 species and 13 genera of mangrove plants. The distributions of these species were varied in a distinct pattern from the mouth of the creek towards the caudal end. Amongst all, six families were dominating like Rhizophoraceae, Avicenniaceae, Sonneratiaceae, Euphorbiaceae, Acanthaceae and Papilionaceae. Under the family Rhiphoraceae, seven species were available out of which the frequency of *Rhizophora apiculata* and *R. mucronata* were 100% and relative density 10% and 8.9% respectively, while relative frequency was 8.4%. Both *Rhizophora spp*. were dominant towards the caudal end of the creek. The middle zone of the creek was lined with thick belt of this species



F1: MAP OF ACHARA CREEK
(16°12'–16°14'N and 73°25'-73°30'E)

Fig.1. Map of Achara Creek

only. The new plantation towards the south side is still in process. Large numbers of seedling are seen on both the sides as well as in A_2 & A_3 regions. The lowest frequency under this family was noticed of *Bruguiera parviflora* (Roxb), *B. gymnorrhiza* (Lamk) and *Ceriops decandra* (Griff). The lowest relative density was observed of *Bruguiera parviflora*.

The family Avicenniaceae supports three species and one genus. The percentage frequency of *Avicennia alba* (Blume) was 100% but the relative density and frequency were 9.0% and 8.4% respectively. *A. officinalis* (L) percentage frequency was 9.0% with 3.9% relative density. The genus is of true mangrove plant available in dwarf condition on both the sides of the creek. They were more abundant in the middle as well as tail end of the creek.

In the south region of the creek there is an island called Jamdul, which is peripherally lined by *Avicennia spp*. as well as *Rhizophora spp*. Several large scale afforestation programmes have been undertaken in this creek. In Achara creek, towards Jamadul areas, large scale plantation of true mangroves is done to protect this island from erosion.

Family sonneratiaceae showed four species and single genus. This is the most dominating family available almost at all the places. *Sonneratia griffithi* (Kurz) and *S. alba* (Smith) were dominant and showed 100% frequency with 10.2% and 9.0% relative density respectively. The flowers of these plants are collected on large scale for medicinal honey. It is the true mangrove, all the species have pneumatophore and salt tolerance characteristics. Dark and dense leaves attract fireflies during night, as such known as the 'fire fly mangrove'.

The family Euphorbiaceae is one of the largest families distributed throughout the creek. Among these diverse habitats, only one genus is available with male and female plants. The genus *Exocoecaria agallocha* has no aerial roots but after soil erosion its horizontal spreading roots come out on the ground and appear as aerial roots. Traditionally, fishermen were making use of these roots as floats for sea operating gillnets. Natives still use the leaves on large scale as mosquito repellant by burning with coconut pericarps. The percentage frequency was 100%, relative density 9.0% and relative frequency 8.4% respectively.

The family Acanthaceae is a large tropical family consisting large number of mesophytic herbs, shrubs and small trees. Amongst, the genus *Acanthus L.* is the typical genus having only one species, *Ilicifolius* was

Sr.	Name of the species	Total number of Indivi-viuals	Fre-que-ncy %	Rela-tive Den-sity %	Rela-tive Fre-ency %
1	Rhizophora apiculata (Blume)	178	100	10	8.4
2	R. mucronta (Lamk)	158	100	8.9	8.4
3	Kandelia candel (L) Druce	51	40	2.9	3.3
4	Ceriops decandra (Griff)	49	30	2.7	2.5
5	Ceriops tugal (Perr) Rab	52	40	2.9	3.3
6	Bruguiera gymnorrhiza (L) Lamk	29	30	1.6	2.5
7	B. parviflora (Raxb)	25	30	1.4	2.5
8	Avicennia alba (Blume)	161	100	9.0	8.4
9	A. marina (Forsk)	85	70	4.8	5.8
10	A. officianalis L.	125	90	3.9	7.5
11	Sonneratia griffthii (Kurz)	182	100	10.2	8.4
12	S. alba (Smith)	161	100	9.0	8.4
13	S. caseolaris (L)	91	70	5.1	5.8
14	S. apetala (Buch)	28	40	1.6	3.3
15	Excoecaria agallocha (L)	162	100	9.0	8.4
16	Acanthus ilicifolius L	85	60	4.7	5.0
17	Derris trifoliate (Lour)	21	20	1.1	1.6
18	D. scandens (Benth)	15	20	0.8	1.6
19	D. indica Bennett	27	30	1.6	2.5
20	Salvadora persica L	37	40	2.2	3.3
21	Lumnitzera racemosa Wild	29	30	1.6	2.5
22	Aegiceras comiculatum Bl	18	30	1.0	2.5
23	Acrostichum aureum L	15	20	0.8	2.5

available in the present investigation. The species contribute 60% frequency, 4.7% relative density and 5.0% relative frequency.

The family Fabaceae is the third largest family. The dominant halophyte genus is Derris sp. It has 80 species but in the present investigation only three were recorded. *Derris indica* contributed the highest percentage frequency of 30% and other two were equal. The relative density highly recorded was 1.6%.

DISCUSSION

Though mangroves are salt tolerant species their better growth was observed in less saline zone with much of heights and thick belts. In A_3 regions mangroves are heightened than A_1 & A_2 regions. No proper or adequate care has been undertaken in south konkan estuaries in connection with the mangroves swamps. The steps and research programmes should be as follows :

1) Phenological studies of mangroves.
2) Pathological investigation.
3) Studies on the deforestation of *S. apetala.*
4) Nursery development technique for the important species of mangroves.
5) Studies on the tissue culture technique and regeneration of the major mangrove species.

In these perspectives, it is also noted that an urgent and well planned programme like the mass awareness programme, on eco-development and campaigns for protection of these mangals are needed for the conservation and protection of the National Resources for sustainable utilization. As such, the interested rural people should be educated for these conservation activities and only by doing this, the world renourished mangrove forests of south konkan may be conserved for the future generation.

REFERENCE

Sidhu. S. S. 1963. Studies on the mangrove of India. East Godavari region. India. Forestar 89 : 337 – 351.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 243-246

STUDIES ON THE ASSOCIATED FLORA IN THE MANGROVE ENVIRONMENT OF MITHBAVCREEK

S. S. Yeragi and S. G. Yeragi
K. J. Somaiya College of Scienc
Vidyavihar,Mumbai – 400 077.

ABSTRACT :- The study of associated flora in the mangrove environment was conducted at Mithbav creek (Lat. 16º 20' N, Long. 73º 25' E) in October 1996 to September 1997 for the first time. The major algae recorded were Chlorophyta, Phaeophyta, Rhodophyta, Cyanophyta and Seagrasses. A total 29 species of marine algae belonging to 24 genera and two species of grasses have been reported from the mangrove swamps of Mithbav.

Key Words :- M*angrove, Algae, Mithbav creek.*

INTRODUCTION

The marine algae, Seagrasses and phytoplankton along with the fauna, form a complex food web in the mangrove ecosystem. This ecosystem is the safest environment, in which varieties of resources organisms enter and settle every moment. It provides highly nutritious organic food materials to the organisms. It is a natural habitat, where the organisms come for spawming and breeding purposes. The primary production of such an ecosystem is always high (Yeragi, 1995) except during monsoon. The pre-monsoon and post-monsoon seasons favour the luxurious growth of algae. The algal growth is directly correlated with the richness of fauna along with high fishery yield potentiality. The algal bloom prevents the predation of larvae of prawns, fishes as well as mollusks. The standing crop of phytoplankton in terms of biomass, Chlorophyll-a and total cells were recorded at high level in mangrove ecosystem. It is also observed that the biomass of zooplankton level was high (Yeragi, 1995) during the algal bloom. The seasonal variability and magnitude of primary production and algae in mangrove environment has been correlated with the potential fishery resources.

MATERIALS AND METHODS

The mangrove ecosystem of Mithbav was studied monthly for marine algae and seagrass distribution at M_1, $M_2$and M_3 regions (fig. 1). The plant samples along with thallus and rhizoids were collected, washed thoroughly to remove epiphytes, adhering mud and derbis and preserved in 4% formalin for further identification. The point method was adapted for calculating percentage contribution of individual algae.

RESULTS AND DISCUSSION :-

Primary production in the mangrove ecosystem is the main part of a mangrove environment. Algae play an important role in the food chain of such ecosystem. In the present investigation 29 species of algae were recorded. The algal growth was either epiterranean or epiphytic on mangrove trunks, pneumatophores, prop roots and plant derbis.

The percentage contribution of individual algae in relation to seasons are recorded in table 1. It is clearly indicated that pre-monsoon was favourable season for luxurious growth of algae both qualitatively and quantitatively. During monsoon, most of algae were directly washed off with quantitively. During monsoon most of the algae were directly washed off with water current. In monsoon season most of the species of algae in the lagoon region creek of remained upto June-July compare to open regions of the creek. The percentage contribution of algae in post and pre-monsoon were high compared with monsoon because of rainfalls. The chlorophyta was the dominant group amongst all.

In Chlorophyta, 11 species were recorded amongst *Ulva* and *Enteromorpha* were dominating while Codium was rare and almost absent in post monsoon and monsoon period. In post-monsoon *Ulva lactuca* and *Enteromorpha clathrata* were the highest contributing 24.28% and 23.35% respectively. In pre-monsoon, the percentage of both decreased and nearly four species were found equally contributing in merit. In Monsoon especially in the month of July the percentage of *Enteromorpha clathrata* was the highest due to protective environmental condition and then reached to zero. The Chlorophyta was dominating only in pre-monsoon period because of high salinity and temperature.

The Phaeophyta showed five species of which *Padina* and *Sargassum* were contributing high level and available in all the seasons. The percentage contribution of *Padina tetrastromatica* and *Sargassum illicifolium* were more or less same. In post-monsoon, *Padina* contributed to 35.17% amongst all.

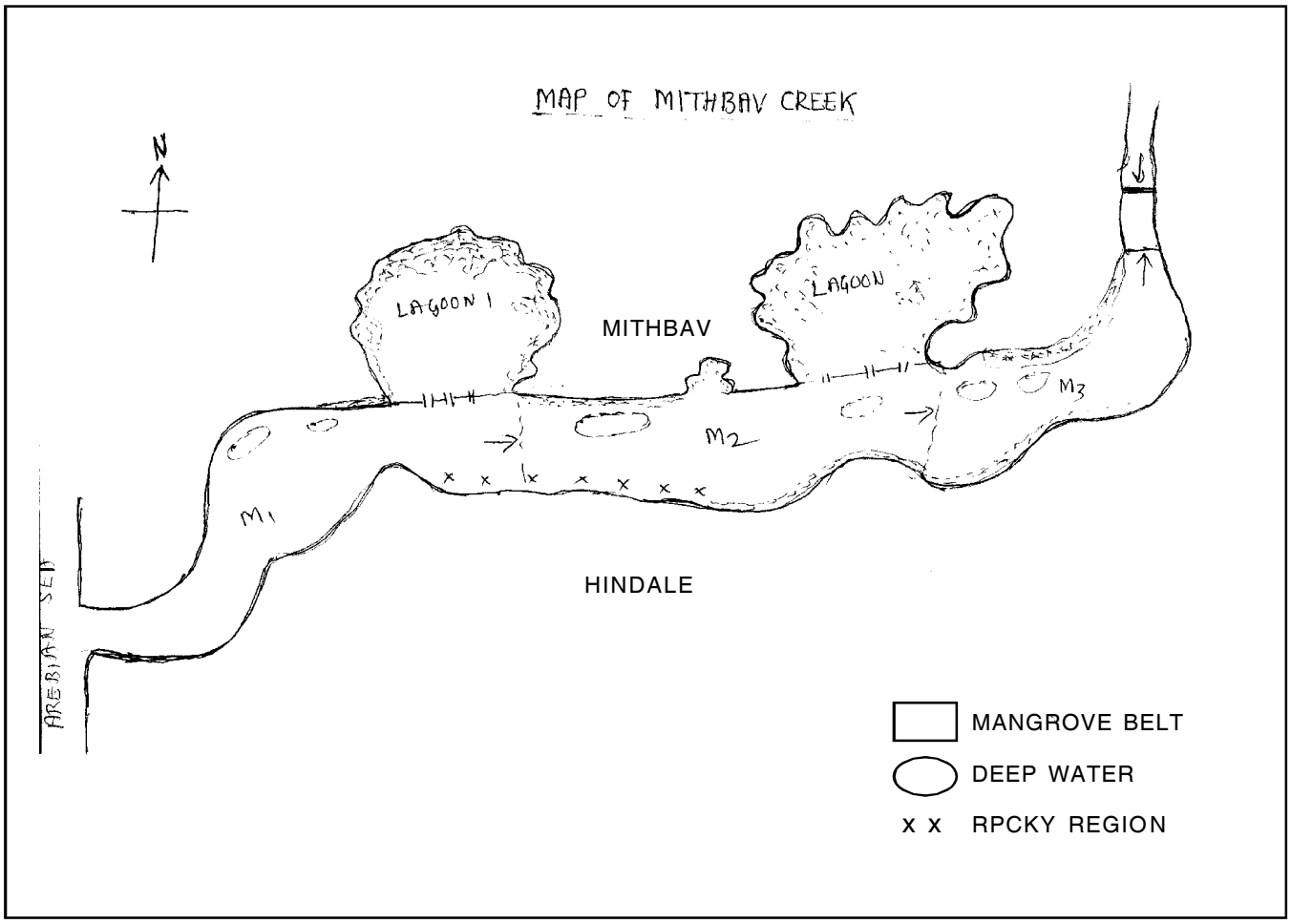


Fig. : Map of Mithbav Creek

In Rhodophyta five species were recorded throughout the studied period. The percentage contribution of *Gracilaria spp.* was high in monsoon because the other two genera were totally absent. In pre-monsoon all the species were recorded with variable percentages in which *Gracilaria* and *Hypnae* contributed the maximum.

In Cyanophyta, totally eight species were recorded throughout the year. It was noticed that pre-monsoon favoured the growth of all the species with equal proportion.

The economically important species such as *Monostroma sp.* appeared during February to May when salinity was high (32.0%) which seemed to favour luxurious growth of *Monostroma sp.* in the mangrove environment. The *Ulva sp.* were observed all over the creek, but abundant towards the mouth and central region of the creek. The coastal people collect such algal mass in the month of March-April for agriculture purpose to be used as biofertilizer for paddy crop.

Chara succinata was observed in the mangrove areas of upstream region only. Another economically important alga, *Gracilaria verrucosa* was also found growing on pebbles and dead oyster shell in mangrove regions.

The seagrass, *Halophila beccarii* was only observed in the mangrove swamps of Mithbav. A patchy growth of *H. beccarii* was noticed, usually in the vicinity of *Avicennia officinalis* and *Sonneratia alba*. It was found to be available throughout the year in the mangrove swamps. This grass is popularly used for feeding cattle.

The growth and survival of sea grass depend on salinity, temperature and light. Mangrove water is turbid, which does not allow much light to penetrate upto the sea grass during high tide. The grass carries maximum photosynthesis during low tide. The sea grass beds in the mangrove ecosystems promote sedimentation by trapping water borne particles and by the retention of organic material derived from sea grass itself.

The drifted seagrass beds of *H. ovalis* were noticed in the deeper and under waters but disappeared in monsoon. This seagrass does not servive at low salinity and low temperature.

Table 1. The percentage of algae

Name of the Species	Post-Monsoon %	Pre-Monsoon %	Monsoon %
CHLOROPHYTA			
1. Ulva lactuca	24.28	19.45	19.16
2. Ulva fasciata	19.38	14.29	23.72
3. Enteromorpha clathrata	23.35	12.17	30.16
4. Enteromorpha intestinalis	15.26	11.12	10.37
5. Monostroma sp.	2.18	4.56	—-
6. Cladophora sp.	1.01	3.12	—-
7. Chaetomorpha linum	4.12	7.32	4.19
8. Rhizoclonium sp.	3.09	5.18	3.25
9. Rhizoclonium kerneri	3.19	5.12	—-
10. Codium fragile	—-	4.36	—-
11. Chara succinata	4.14	13.31	9.17
PHAEOPHYTA			
1. Giffordia mitchellae	15.18	8.25	—-
2. Dictyota indica	21.19	5.29	22.05
3. Padina tetrastromatica	35.17	38.13	45.56
4. Colpomenia sinuosa	8.24	10.21	—-
5. Sargassum iliciflium	20.22	38.12	32.39
RHODOPHYTA			
1. Gracilaria verrucosa	28.38	35.61	48.12
2. Hypnea musciformis	21.12	28.28	39.36
3. Catnella impudica	16.92	18.16	12.52
4. Caloglossa leprievrii	9.38	13.12	—-
5. Polysiphonia macrocarpa	24.02	4.83	—-
CYANOPHYTA			
1. Aphanotheca saxicola	16.72	14.38	28.78
2. Oscillatoria earlei	21.26	18.55	29.17
3. Oscillatoria limosa	18.79	17.28	13.19
4. Oscillatoria annae	11.71	19.81	—-
5. Phormidium sp.	2.18	5.47	—-
6. Spirulina sp.	11.17	9.25	11.17
7. Anabaena sp.	18.17	11.15	17.69
8. Calothrix crustacea	—-	4.11	—-

Thus it is noticed phytoplankton, algae and seagrass beds in the mangroves of Mithbav contribute towards food chain in the mangrove ecosystem. Mithbav creek is associated with number of big lagoons containing thick belt of mangroves in M_2 region look promising for cultivation of economically important seaweed specially *Monostroma spp*. and *Gracilaria spp.*

REFERENCES

Yeragi S. G. (1995) Estimation of Gross primary production of estuary Mithabav of South Konkan J. Aqua Biol. Vol. 10(1) P. 28 – 30.

Yeragi S. G. (1995) Composition and abundance of zooplankton in mangrove regions of Mithbav estuary, South Konkan, Maharashtra J. Aqua. Bio. Vol. 10(1) P. 7 – 9.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 247-248

STUDIES ON COMPOSITION OF STARCH AND AMYLASE ACTIVITY IN THREE *SONNERATIA* SPECIES.

A. B. Telave and N. S. Chavan
Department of Botany, Shivaji University, Kolhapur – 416 004 (MS)

ABSTRACT :- The distribution of starch was studied from three different species of *Sonneratia.* Vegetative and reproductive parts were analysed for determination of starch, amylase and amylopectin. The three species of *Sonneratia* viz. *Sonneratia alba, Sonneratia apetala* and *Sonneratia caseolaris* were collected from west coast of Maharashtra for the present work. The a-amylase activity was also determined. The study reveals that there is change in the distribution of starch, amylase and amylopectin content in different species of *Sonneratia.*

Key Words :- *Mangroves, Sonneratia, Starch, α-amylase activity.*

INTRODUCTION

Starch is major reserve food material, found in woody plant. It plays an important role in growth and development of woody plant. (Zimmarman and Brown, 1971). The distribution pattern of starch is not well documented in *Sonneratia* species. The distribution of starch varies depending upon the parts.

Starch is most important and abundant reserve polysaccharide in the plant world. From the lower algae to higher plants mostly dicotyledons, photosynthetically formed carbohydrates are immediately converted to starch in the chloroplast. Although starch is found in numerous organs of the plant, the starch from seeds, tubers and leaves has been best characterized with respect to structure and biosynthesis. (Akazawa, 1965).

Starch structure is a crucial determinant for many end users of starch. The broadest guage of starch structure is the amylase-amylopectin ratio. While amylase-amylopectin ratio is useful description of starch structure. (Morell *et. al*., 1995). Therefore in the present investigation an attempt has been made to study the levels of amylase and amylopectin from three different species of *Sonneratia.*

MATERIALS AND METHODS :-

The plants of *Sonneratia* species were collected from west coast of Maharashtra from different estuaries. The samples collected were immediately analysed for the activity of a-amylase using Katsumi and Fukuhara (1969) method.

Starch was estimated by Nelson's (1944) method. The method described by Sadasivam and Manickam (1999) was used for amylase determination.

RESULT AND DISCUSSION :-

It is seen from the results that the distribution of starch varies greatly. There is variation in starch content of *Sonneratia* species.

Table – 1 : Starch, amylase and amylopectin from *Sonneratia* species

Species	Plant organ	Starch	Amylase	Amylopectin	a-amylase*
	Leaves	1.50	0.44	1.06	0.442
Sonneratia	Stem	1.41	0.086	1.32	0.25
alba	Fruit	—	—	—	—
	Flower	0.70	0.44	0.26	—
	Leaves	1.9	0.48	1.42	0.051
Sonneratia	Stem	1.41	0.097	1.31	0.078
Apetala	Fruit	—	—	—	—
	Flower	—	—	—	—
	Leaves	1.80	0.37	1.43	0.111
Sonneratia	Stem	1.36	0.06	1.3	0.195
caseolaris	Fruit	2.51	0.73	1.78	0.074
	Flower	0.82	0.37	0.42	—

Values are expressed in g 100^{-1} g dry wt. *Values expressed in OD hr^{-1} mg^{-1} protein.

Table – 1 represents the distribution of starch from the leaves and various parts of *Sonneratia* obtained from different localities. The substratum plays an important role in the distribution of species of mangroves. Kotmire and Bhosale (1979 & 1980) have shown that mangrove species occurring at different estuaries differ in their endogenous salt level and the chlorophyll contents of mangroves species depend upon salinity of leaves. The concentration of starch was found to be more in the leaves of *S. apetala* than *S. alba* and *S. caseolaris*. Manner (1973) observed the starch content which is not exceeded 1 – 2% in some leaf tissues. The starch content of flower of *Sonneratia* species do not differ much.

The fruits of *Sonneratia caseolaris* are rich in starch. The maximum amount of starch (2.51 g/100 g dwt) was found in *Sonneratia caseolaris*. The starch content of plant tissues varies considerably. The tubers, roots, seeds and fruits of some of the plant may contain 20 – 70 % starch (undried bases) which can be characterized with respect to structure and biosynthesis. (Akazawa, 1965).

It was seen from table – 2 that the percentage of amylase and amylopectin also varies in different species of *Sonneratia*. The amylase content ranges between 20 to 29.30% in three *Sonneratia* species.

Table – 2
Percentage of amylase and amylopectin from different Sonneratia species

Species	Plant organ	Amylase	Amylopectin
	Leaves	29.3	70.66
Sonneratia	Stem	6.0	93.9
alba	Fruit	—	—
	Flower	62.85	37.14
	Leaves	25.2	74.13
Sonneratia	Stem	6.87	92.9
Apetala	Fruit	—	—
	Flower	—	—
	Leaves	20.5	79.4
Sonneratia	Stem	4.41	95.5
caseolaris	Fruit	29.0	70.91
	Flower	45.12	54.87

Values are expressed in percentage.

The a-amylase activity was found to be species specific. It may possibly due to different saline habitat. Variation in saline habitat of *Sonneratia* species might be governing the enzyme activity. Sarin and Narayanan (1968) also reported the inhibition of enzyme activity due to salinity. Sheoran (1980) has suggested the response of amylase in different organs of the plants under salinity. Such variations in the isoenzymatic pattern of different enzymes has been observed by various workers (Weimberg, 1970, Sheoran, 1975).

It is suggested from the present work that the low amount of starch content during the study period may possibly due to high energy requiring processes like flowering and fruit setting in respective period. There is variation in the a-amylase activity in different species. This may be again organ specific and related to habitat. Further detailed studies are under progress on this line.

REFERNCES

Akazawa, T. 1965 Starch, Inulin and other reserve polysaccharides. In: Plant Biochemistry. Ed. James Bonner and J. E. Verner. 259- 283 pp.

Katsumi, M. and M. Fukuhara 1969. The activity of a-amylase in the shoot and its relation to gibberellin induced elongation. Physiol. Plant. 22 : 68 – 75 pp.

Kotmire S. Y. and L. J. Bhosale. 1980. Indian J. Marine Sci., 9 : 299 – 301.

Kotmire S. Y. and L.J. Bhosale. 1979. Mahasagar, Bull. of NIO. 12 : 149 – 154.

Manner D. J. 1973. Starch and Inulin. In : Phytochemistry Vol. –I Ed. Lawrence P. Miller. The process and product of photosynthesis. Van Noshand Reinhold Company. 177 – 197 pp.

Morell M. K., S. Rahman, S. L. Abrahams and R. Appels 1995. The Biochemistry and Molecular biology of starch synthesis in cereals. In : Aust. J. of plant physiology. Vol. -22 No. 4. 647 – 660 pp.

Nelson N. 1944. A photometric adaptation of somogyi method for the determination of glucose J. Biol. Chem. 153 : 375 – 380 pp.

Sadasivam S. and A. Manickam 1999. Biochemical Methods for Agricultural sciences. Wiley eastern limited. pp – 12.

Sarin M. N. and A. Narayanan. 1968. Effect of soil salinity and growth regulators on germination and seedling metabolism of wheat Physiol. Plant. 21 : 1201 – 1209.

Sheoran I. S. (1975). Effect of salinity on some important aspects of plant metabolism. Ph. D. Thesis submitted to H. A. V. University. In : Sheoran I. S. (1980). Changes in amylase during germination and early seedling growth of Mung Bean [Vigna radiate (L) Wilczek] under different salts. In : Indian J. of Plant Physiology. Vol. -23 No. 2 169 – 173 pp.

Sheoran I. S. 1980. Changes in amylase during germination and early seedling growth of Mung Bean [Vigna radiate (L) Wilczek] under different salts. In : Indian J. of Plant Physiology. Vol. -23 No. 2 169 – 173 pp.

Weimberg R. 1970. Enzyme levels in Pea seedling grown on highly saline media. Plant Physiol. 46 : 466 – 70 pp.

Zimmarman M. H. and R. I. Brown. (1971). Trees ; Structure and function : (New York U.S.A. Springer-Verlag). In : Phytomorphology Vol. 49. No. 2 209 – 214 pp. (1999)

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 249-255

ARID ZONE MANGROVES OF KACHCHH, GUJARAT: VEGETATION STRUCTURE AND ENVIRONMENTAL CHARACTERISTICS

***G.A. Thivakaran, A. Saravanakumar, Sesh Serebiah and Justus Joshua**
Gujarat Institute of Desert Ecology, Bhuj-370 001, Kachchh district, Gujarat, India.
*E-mail:ga_thiva@rediffmail.com

ABSTRACT : Investigation was carried out in the Kharo creek mangroves of Kachchh district, Gujarat to delineate its structure and governing environmental parameters. All the stands studied were monospecific with only the species of *Avicennia marina*. For delineating mangrove vegetation structure, 100 plots (10 ×10 m size) at 6 stations were studied for characteristics like density, girth at breast height (GBH), canopy index and regeneration and recruitment class density. Station-wise mean density of mature trees ranged from a minimum of 733/ ha to a maximum of 1900/ ha with tree height reaching up to 4.9 m. Height and GBH classes in the range of 1.6 to 3 m and 21 to 40 cm, respectively predominated in all stations. Being an arid zone with very low rainfall and poor terrestrial run-off, the governing environmental parameters were extreme in all the three seasons of the year. The mean creek water salinity ranged from 36 to 45 ppt whereas surface water temperature variation was low (29 to 32.2°C). Contrary to earlier reports mangroves of Kachchh seems to be highly potential with high entry of recruitment class to mature tree category. The governing environmental parameters of mangroves seem to be largely influenced by the high aridity of the hinterland.

***Key words**: Aridity, Vegetation characteristics,* Avicennia marina*, Environmental parameters*

INTRODUCTION

Kachchh mangroves are the only arid zone mangrove formations in India. An arid climate with its extremely low rainfall (av. 346 mm), and poor terrestrial run off, high variability in seasonal temperature and high rate of evapo-transpiration and high water salinity regime subject the mangroves of Kachchh to a harsh environment similar to the one described by Dodd *et al*. (1999) for Arab countries. As a result, mangrove vegetation of Kachchh is dominated by single species stands of *Avicennia marina* (Forsk.) Vierh., which is known for its tolerance for extreme environment. Studies on Kachchh mangroves and the governing environmental parameters are absent except that of Singh (1999) and Thivakaran *et al.* (in press). In the last decades Kachchh mangroves have shown a dramatic increase in extent from 150 to 640 km^2 (Bahuguna *et al.,* 1997). However, recent industrial development in this coast has posed threats to these mangrove formations that covers nearly 88% of Gujarat mangroves and is probably the biggest mangrove stand in the west coast. A major industrial house has developed its jetty and planning to reclaim a dense mangrove patch for its further development in the Kharo creek of northwestern mangrove reserve of Kahchchh. Lack of information on this mangrove stand and the recent developmental activities prompted us to undertake the present study with an aim to create a baseline data on the mangrove vegetation structure and governing environmental parameters of Kharo creek mangroves.

Description of the Study Area

Kharo creek (68° 31' 21"- E; 23° 17' 36.4 – N) is a one of the biggest creek system in the northwestern coastal stretch of Kachchh running parallel to Godia creek (Fig. 1). It tends in NE-SW direction 13-15 km from its mouth at Arabian Sea to the point where it bifurcates into two creek systems namely Padala and Hakti creeks. In its course it ramifies into 4 major and many minor creek systems with intricate meshes of channels forming extensive network of waterways and mudflats. Mangrove formations could be seen towards its tail end where the jetty of an industrial group has become operational recently. Being in a semi-arid region, the mean annual ratio of precipitation to evapo-transpiration ranges from 0.30 to 0.50. Mean annual rainfall during 1989-98 was 315 mm in Abdasa taluka with most of the downpour confined to about 14-20 days of the year. Hence, freshwater input into the coastal zone from the hinterland is quite meager. The winter and summer temperature ranges from 1 to 48° C, resembling subtropical climate. Tides are semi-diurnal in nature. Tidal amplitude is in the range of 1.6 m (MLLW) to 3.5 m (MHHW).

MATERIAL AND METHOD

The present study was carried out during three seasons, i.e. September 2000 (Post monsoon); April (Summer) and August of 2001 (Monsoon). Six patches of mangroves (Stations I-VI) along the Kharo creek were studied which are in the vicinity of the private jetty. (Fig. 1). Totally, 1294 trees from 100 plots (10x10m size) at 6 patches (stations) were studied.

Quantitative analysis of mangroves was done during low tide using line transects and quadrats. In each station, perpendicular to the waterfront, 3 plots of 10 x10 m were laid at every 50 m interval. In each plot, total

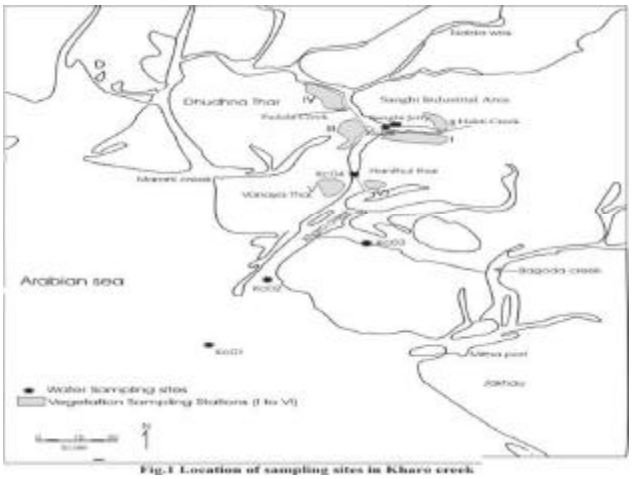


Fig.1 Location of sampling sites in Kharo creek

number of trees was counted. For all trees in the plot, tree height, girth at breast height (GBH), canopy height and width were measured. For each tree canopy height was multiplied with canopy width to calculate canopy index (CI). GBH of all trees larger than 25 cm was measured. Within each larger plot, 2 subplots of 2 x 2 m and 5 x 5 m were laid randomly to enumerate regeneration and recruitment classes. The regeneration class includes seedlings that are germinating saplings which are less than 50 cm tall and the recruitment class includes well established saplings which are more than 50 cm but less than 20 cm GBH. Density of mature trees, regeneration and recruitment class for each station was expressed as number per hectare (No/ ha). Tree height and GBH data were segregated into different size classes to study the frequency of occurrence and to infer their correlation.

Ten parameters in water at five stations (KC 01 – KC 05) along Kharo creek from open sea to station I in three seasons were studied. Water samples were collected during low tide and high tide from surface waters. Surface water temperature was measured using a thermometer (sensitivity 0.1°C). Salinity was estimated using a salinity refractometer (Aatago–Japan). DO was determined by Winkler's method and *p*H was measured using a *p*H meter (Weathertronics, 705). Inorganic phosphate was measured by acidifying the samples with molybdate reagent to get phosphomolybdate compound, which was then reduced with ascorbic acid to get molybdenum blue whose absorption was measured at 882 nm. Nitrate nitrogen was determined after reducing it to nitrite by passing the samples through a column of amalgamated cadmium. Nitrite was estimated by allowing the samples to react with sulphanilamide in acid solution and the absorption was measured at 543 nm. For sulphate, gravimetric method was followed after removing all interfering substance such as silica.

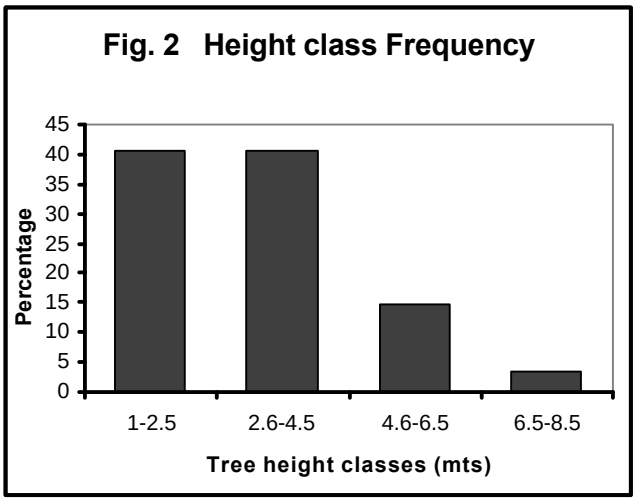
RESULT

Vegetation characteristics

Tree density

Tree density in the six stations ranged between 733/ ha at station III and 1900/ ha at station V with an overall mean density of 1356/ ha (Table 1). Though station V had the maximum density of mature trees, 59.6% of these trees were dead. Station I and VI had a density of 1422/ ha, and 1700/ ha, respectively while at station IV tree density was 1333/ha. Mangrove stands near the jetty (Station II) had a moderate density of 1050/ ha. Though lowest in density (733/ ha), none of the trees at Station III were dead. Density was more near the low water mark, which gradually thinned down towards supratidal zone in all the patches studied.

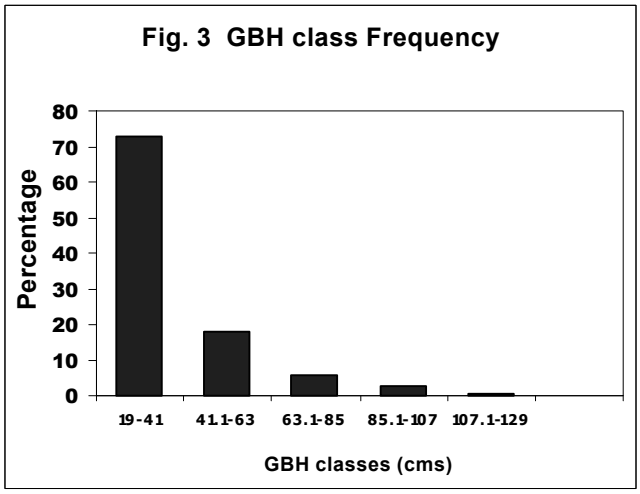
Tree height



Mean tree height in the stations studied varied from 1.69 m (Station V) to 4.92 m (Station IV) (Table 1). Highest variation of 1 to 8 m was recorded at station II and lowest variation of 1 to 3.5 m at stations IV and V. In the rest of the stands, variation in tree height was 1-7.5 m (station I), 1.5-7 m (station III), 2-8.5 m (station IV), and 1 – 3.5 m (station VI). Trees were fairly taller in stations I, II, III and IV while in V and VI, it was comparatively shorter. Segregation of overall tree height into different classes showed that more trees were in the height classes of 1-2.5 m and 2.6-5 m classes constituting 40.8% each (Fig. 2). This was followed by 14.9% of trees in 4.6-6.5 m height class and 3.5% trees in 6.5-8.5 m-height class.

Tree Girth

The mean GBH of trees at different stations ranged between 32.66 and 49.05 cm (Table 1). Minimum and maximum GBH of trees varied from 75-151 cm (station. I), 20-97 cm (station II), 20.5-48 cm (station III), 21-88 cm (station IV), 19-129 cm (station V) and 24-146 cm (station VI). Trees with maximum GBH were recorded



at stations I (151cm) and VI (146 cm) and minimum were at station V (19 cm). Though mangroves at station V were partially dead and damaged due to cyclones of 1998 and 1999 it was the mature and the oldest stand among all the stations studied as they had high mean GBH of 40.03 cm. In contrast, mangrove stands of station II and III appear young and dynamic in view of lower mean GBH recorded. Segregation of GBH in to different classes indicated that majority of the trees (72.74%) occurred in 19-40 cm category followed by 18.07% of trees in 41.1-63 cm, 5.87% in 63.1-85 cm, and the least of 0.3% in 107.1-129 cm and 0.45% of trees in 129.1-151 cm category (Fig. 3). This evidences that the mangroves at Kharo creek were younger.

CANOPY INDEX

Canopy index value was obtained by multiplying the length and breadth of the tree canopy. The mean canopy index in Kharo creek mangroves ranged between 2.1 and 12.9 m^2 (Table 1). Generally, canopy cover was more at stations I to IV. Stations V and VI recorded lowest canopy index due to high percentage of dead trees. There appears to be a uniform decrease in canopy index from low tide level to high tide level at all the sites studied though this was not statistically attempted.

REGENERATION CLASS

Density of plants in the regeneration class in all the stations ranged between a minimum of 6668/ ha at station V and a maximum of 43,333/ ha at station III (Table 2). The highest density of 43,333/ ha recorded at station III indicated its high regeneration potential. At station VI, regeneration class was totally absent. The ratio between regeneration and recruitment was highest at station I suggesting poor entrance of regeneration category into recruitment class. Similarly, this ratio was lowest at station V implying vigorous entry of this class into recruitment category. Though majority of trees at station V were dead, it showed good potential to recover because of low ratio of regeneration to recruitment class. Similarly, ratio between mature tree and regeneration was lowest (1: 3.5) at station V showing good entrance of generation class into mature category. However, it was highest at station II (1:8) (Table 2).

RECRUITMENT CLASS

The density of recruitment class plants in the study areas ranged between 265 and 4933/ ha (Table 2) at station II and III, respectively. Similar to regeneration class, recruitment class was totally absent at station VI. Recruitment class was fairly good at station V with a density of 1200/ ha. Lower density of mature trees in station III and openness of canopy (CI 3.9) in station V seems to have favoured better recruitment to mature tree category in these stations. Station III, where highest density of recruitment class was recorded is the youngest patch with favorable conditions for seed trapping and regeneration. The ratio between recruitment and regeneration class was highest at Station I (1:35) and II (1:30) showing poor entrance of regeneration class into recruitment class whereas it was lowest at stations III (1:9) and V (1:6) (Table 2). Since station V had highest percentage of dead trees with very poor density of younger classes, it had a good entrance from regeneration into recruitment class. Similarly, entrance of recruitment class into mature tree category was good at this station with a ratio of 1:0.6.

Water Quality

Salinity

Moderate spatial and temporal fluctuation in salinity was recorded among different stations with a range of 36 to 45 ppt (Table 3). Season-wise, average salinity in the 5 stations and two tides was low (38.5 ppt) during the monsoon month of August 2001 and high during September 2001 (39.7 ppt) and April 2001 (39.4 ppt). In September 2000 and April 2001, tide induced salinity fluctuation was highly pronounced whereas during August 2001 it was low.

Temperature

Surface water temperature in the study area varied from 29 (September 2001) to 32.9^{0}C (April 2001) (Table 3). Generally, temperature was found to be higher during high tide than the low tide in all the seasons. The average temperature was low during September 2000 (30.25^{0}C) and August 2001 (30.71^{0}C) and high during April 2001 (30.94^{0}C). Spatial and temporal variation in temperature was not much pronounced in all the stations.

Hydrogen Ion Concentration (*p*H)

Hydrogen ion concentration in the Kharo creek waters was always on the alkaline side with the maximum value of 8.8 during April 2001 and a minimum of 7.52 during September 2001 (Table 3). Seasonal average was maximum (8.46) during April 2001 (summer) and minimum (7.93) during September (post monsoon).

Table 1-Mangrove Characteristics in the Study Sites at Kharo Creek

Stations & GPS Co-ordinates	Density	GBH-cm			Height-M		Canopy index-m^2			% dead trees	
	(No/ ha)	Mini	Maxi	Mean	Min	Max	Mean	Min	Max	Mean	Full	Partial
Station I 68° 34' 18.9"–E; 23° 22' 21.9 – N	1422	75	151	37.18	1	7.5	3.54	2.27	38.5	9.6	21.2	14.8
Station II 68° 34' 51.9"–E; 23° 22' 51.9 – N	1050	20	97	32.66	1	8	3.26	2.19	38.7	9.7	20	3
Station III 68°33'32.2"–E;23°21' 47.5 – N 68° 33' 0.48.0"–E; 23° 22' 14.2 – N 68° 34' 04.7"–E; 23° 22' 30.8 – N 68° 33' 29.8"–E; 23° 21' 33.1 – N	733	20.5	48	33.3	1.5	7	3.15	2.25	39	9.6	Nil	Nil
Station IV 68° 33' 14.0"–E; 23° 23' 27.7 – N	1333	21	88	41.27	2	8.5	4.92	3	45.5	12.9	2	1
Station V 68° 33' 18.4"–E; 23° 20' 27.1 – N	1900	19	129	40.03	1	3.5	1.69	1	16	3.9	59.6	Nil
Staon VI 68° 34' 51.9"–E; 23° 22' 51.9 – N	1700	24	146	49.05	1	3.5	2.01	1	9	2.1	19.6	Nil
Average	**1356**			**38.915**			**3.095**			**7.96**		

Rege. Density-No/ ha; Recruitment Density-No/ ha; Root Density- No/ m^2

Table 2-Density and ratio among mature trees, recruitment and regeneration class

Stations	Mature Trees No/ha-1	Recruitment Class No/ha-2	Regeneration Class-3 Class-3	Ratio 1 & 2	Ratio 1 & 3	Ratio 2 & 3
Station I	1422	289	10200	1:0.20	1:7.1	1:35
Station II	1050	265	8000	1:0.25	1:8	1:30
Station III	733	4933	43333	1:7	1:59	1:9
Station IV	1333	533	8888	1:0.4	1:7	1:17
Station V	1900	1200	6668	1:0.6	1:3.5	1:6
VI Island	1700	0	0	0	0	0
Average	1356	1203	12848			

Generally, *p*H fluctuated widely between tides during September 2000 and April 2001, but during August (monsoon) tide related fluctuation was minimal.

Dissolved Oxygen

Dissolved oxygen varied broadly from 5.46 to 8.4 mg/ l (Table 3). DO values were more in open sea station (KC 01) than the interior creek stations. Similarly, DO level was more in August than in September and April. Creek water was more oxygenated in monsoon season possibly due to increased water agitation. Similarly, decreased DO values during summer might be due to increased rate of decomposition than the other seasons (Vance *et al.,* 1990).

Sulphate

Sulphate level varied from 2530 to 4127 mg/ l (Table 3). Except at the open sea station KC 01, sulphate levels were more during September 2000 and April 2001 and low during monsoon month of August 2001. Tidewise, levels of sulphate did not vary much.

Nitrate

Nitrate concentration showed wide variation from 75 to < 1.0 mg/ l (Table 3). Higher levels were recorded in monsoon and post monsoon months of August 2001 and September 2000 which was probably due to the terrestrial run-off. But in summer, low level of nitrate was measured due to reduced input of nitrate from terrestrial source. Decrease in the amount on nitrate during summer (April 2001) might be due to the increased uptake of nitrate by phytoplankton.

Nitrite

The amount of nitrite ranged between 1-9 mg/ l (Table 3). Average value was high during August 2001 (4.1mg/ l) followed by September (3.9 mg/ l) and April (2.3 mg/ l). Generally, an increasing trend of nitrite concentration could be observed from creek stations towards open sea station (KC 01) probably due to great turbulence and shallowness of the open sea waters. Tide-wise, changes in nitrite concentration were well pronounced.

Phosphate

Phosphate levels fluctuated from 11 to 101 mg/ l across seasons and stations (Table 3). Season-wise average was higher (67 mg/ l) in monsoon (August 2001) followed by summer (April 2001; 54.8 mg/ l) and post monsoon (September 2000; 50.8mg/ l). Increasing trend of phosphate level from open sea towards creek stations could be observed in September 2000 but this trend was reversed during April and August 2001.

DISCUSSION

Mangrove vegetation characteristics studied presently showed that mangroves of Kharo creek in general are healthy and dynamic despite high salinity regime and aridity. The overall stand density of 1356/ ha recorded in the present study is rather low compared with the mangroves of Pichavaram (Kathiresan *et al*, 1994) and Sunderbans (Matilal and Mukherjee, 1989; Saha and Choudhury, 1995). The highest density of *A. marina* (36,600/ ha) and *A. officinalis* (2200/ ha) in Pichavaram and Sunderbans (*A. marina* 1783/ ha) might be due to the favorable climatic conditions prevailing there. However, the average tree height of *A. marina* in Kharo creek (3.1 m) is comparable to Pichavaram stands (3.18 m). Mangrove tree density in general is influenced by many natural factors such as salinity regime, tidal inundation, fresh water inflow, micro-level topography, soil texture, nutrient availability, community structure, competitors, and anthropogenic stress like cutting, lopping and grazing. These factors, either singly or in combination, determine vegetation structure and composition. Extremities of weather and natural calamities such as temperature, cyclones, earthquakes and irregular rainfall also affect mangroves of Kachchh. Among these factors, high salinity regime seems to be the reason for the single species prevalence in Kachchh mangroves along with non-availability of seeds of other species. No other eco-tonal community or herbaceous under growths are seen in these mangroves. *A. marina* has been shown to be flourishing well in high salinity of 90 ppt (Macnae 1986). Ubiquitous distribution of this species was earlier reported by Jhonston, (1983), Macnae (1986) and Oswin (1997).

Major abiotic factors in water and sediment showed moderate variation among stations (Tables 3). Abiotic variation is likely to be low in the study area given the stable climatic regime prevailing in Kachchh coast. However, ambient seasonal temperature variation is considerable ranging 1 to 48 ^{o} C. The annual mean temperature of the study area is far above the conducive temperature range of 26-28^{o} C in which mangrove grows best. Winter temperature in the study area often reaches as low as 1 ^{o} C, which is lethal to mangrove flora though *A. marina* has been shown to withstand very low temperature (McMillan 1987). For most of the mangrove species low temperature is harmful (Mall, 1994). Survival and high regeneration rates of *A. marina* stands in the study area possibly indicate that this population is genotypically adapted to this temperature of ambient milieu.

Salinity values recorded in the present study at all the sites are quite high for better growth of other mangrove species except *A. marina.* This high salinity regime (36 to 45 ppt) in the study area is obviously linked to reduced rainfall and increased aridity (aridity index 3-4). Generally, an increasing trend in salinity was observed from open sea stations (KC 01) towards interior creek stations which might be due to the increased evaporation due to shallowness of water. Surface dissolved oxygen levels recorded in all the sites were fairly high.

Nutrient levels such as nitrate, nitrite and phosphate recorded in the present study were comparable with other mangrove stands. Selvam *et al.,* (1990) recorded 0.790 and 0.325 mu g at/ l, 7.10 and 1.60 mu g at/ l and 0.278 and 0.060 mu g at/ l, respectively of phosphate phosphorus, nitrite and nitrate in Kakinada mangrove waters. These values are comparatively higher than the values recorded in the present study. Lower level of nutrients recorded was obviously related with the poor terrestrial run-off in the study area. While phosphate phosphorus and nitrite nitrogen showed an increasing trend from creek interior towards open sea, variation in nitrate nitrogen between open sea and creek interior is not clear. However, all the nutrients studied recorded tide related fluctuation with high values recorded during high tide predominantly. Generally, growth characteristics of mangroves are controlled by nutrient availability along with salinity gradients (Saintilan 1998). It appears that along with

Table 3 - Water Quality in Kharo creek

Stations	KC 01		KC 02		KC 03		KC 04		KC 05	
Tides	**Lt**	**Ht**	**Lt**	**Ht**	**Lt**	**Ht**	**Lt**	**Ht**	**Lt**	**Ht**
Seasons	**Salinity**									
Sep-00	38	38	40	38	44	36	45	38	44	36
Apr-01	38	38	39	38	43	38	43	39	40	38
Aug-01	37	37	38	37	39	39	38	37	42	41
	Temperature- ^{0}C									
Sep-00	30	31	30	31	29	31.5	31	29	30.5	29.5
Apr-01	30	31.3	30	31.2	30.5	31.5	31	32.9	30.5	30.5
Aug-01	31.3	31	31.2	30.3	30.1	30.7	32.9	29.3	30.2	30.1
	DO - mg/l									
Sep-00	6.3	Nil	6.1	Nil	6	Nil	6.3	Nil	5.8	6.1
Apr-01	8.4	6.1	Nil	7.28	Nil	5.85	Nil	5.85	5.6	6.3
Aug-01	6.58	6.9	5.78	5.62	6.58	6.26	5.46	5.78		5.62
	Hydrogen Ion Conc. (pH)									
Sep-00	**7.7**	**8.1**	**8.22**	**8.09**	**8.22**	**8.15**	**7.54**	**8.14**	**7.52**	**7.7**
Apr-01	**8.7**	**8.6**	**8.5**	**8.7**	**8.2**	**8.6**	**8.8**	**7.99**	**8.1**	**8.1**
Aug-01	**8.19**	**8.2**	**8.19**	**8.15**	**8.05**	**8.2**	**8**	**8.15**	**8.1**	**8.15**
	TSS- mg/l									
Sep-00	24.8	55	24.8	87	21.8	82	28.3	87	21.8	86
Apr-01	111	113	109	113	98	119	115	135	125	165
Aug-01	31.6	27.8	17.4	19.4	14	20.4	18.8	17.8	11.3	13.2
	Sulphate - mg/l									
Sep-00	3160	3487	3897	3847	3590	3934	3980	4127	3880	3539
Apr-01	3325	3610	3250	3175	3325	3225	3525	3325	3325	3400
Aug-01	3025	2738	2663	2750	2650	2650	2530	2650	2813	2675
	Nitrate Nitrogen - NO3 - N- µg/l									
Sep-00	75	72	67	58	51.5	59.3	58	72	68	71
Apr-01	4	3	1	40	4	7	5	1	2	2
Aug-01	20	19	34	16	11	49	7	12	4	10
	Nitrite Nitragen NO2-N - µg/l									
Sep-00	4	9	2	3	5	2	2	4	1	7
Apr-01	4	2	4	2	3	2	2	2	1	1
Aug-01	6	5	7	5	4	4	2	3	2	3
	Amm.Nitrogen NH4 N,µg/l									
Sep-00	16	18	29	17	2	14	2	21	1	14
Apr-01	16	16	2	17	17	19	18	18	15	21
Aug-01	8	8	19	18	13	22	6	20	11	19
	Phosphate phosphorous PO4 P- mg/l									
Sep-00	**12**	**11**	**59**	**13**	**59**	**66**	**58**	**98**	**57**	**75**
Apr-01	**75**	**75**	**50**	**59**	**15**	**66**	**48**	**61**	**48**	**50**
Aug-01	**101**	**98**	**84**	**69**	**76**	**32**	**58**	**64**	**45**	**43**

Lt- Low tide; Ht-High tide

prevailing salinity, nutrient availability in the creek system also plays a major role in determining the vegetation characteristics. Less number of taller height classes in the study area might be due to this nutrient limitation.

ACKNOWLEDGEMENT

Authors are thankful to the Director, Gujarat Institute of Desert Ecology (GUIDE), Bhuj for facilities and encouragement. Statistical assistance of Dr. (Miss) Oswin Deiva is gratefully acknowledged. This study was a part of EIA carried out for National Institute of Ocean Technology (NIOT), Chennai.

REFERENCE

Bahuguna, A. 1997. **Coral Reefs and mangrove ecosystems of marine national park, Gulf of Kachchh: A Review of Ecological Study using Satellite Data**. in Sinha, M.P. ed **Recent Advances in Ecobiological Research. Vol. I.** APH Publishing Corporation, New Delhi. 197-207.

Dodd, R., Blasco S., Zara A and Torquebian R.E. 1999. **Mangroves of the United Arab Emirates: Ecotypic diversity in cuticular waxes at the bioclimatic extreme.** *Aq Bot,* 63: 291-304.

Jhonston, I. M. 1983**. Succession in zoned mangrove communities: where is climax ?** in Teas, H.J. ed, **Biology and ecology of mangroves, tasks for vegetation Science**, Dr. W. Junk publishers, The Hague, 131 – 139.

Kathiresan, K., Moorthy, P. and Rajendran, N. 1994. **Seedling performance of mangrove *Rhizophora apiculata* (Rhisophorales: Rhizophoraceae) in different Environs**. Indian J. mar. Sci. 23 (3): 168 -169.

Macnae, W. 1986. **A general account of the fauna and flora of mangrove swamps and forests in the Indo Western Pacific Region**, Adv. Mar. Biol. 6: 74.

Mall, L.P. 1994. **Mangroves: ecology and special features**. in Deshmukh, S.V. Balaji. V. eds. **Conservation of Mangrove Forest genetic Resources: A Training Manual**. CRSARD. Chennai. 1994. 117.

Matilal, S. and Mukherjee, B.B. 1989. **Studies on soil and vegetation of mangroves forests of Sunderbans**. Indian J. Mar. Sci. 15: 181-184.

McMillan, C. 1987. **Adaptive differentiation to chilling in mangrove populations**. Ph.D thesis submitted to University of Texas at Austin. USA. 256

Oswin, S. D. 1997. **Survey, utilization and conservation of natural resources of Muthupet mangroves, southeast coast of India**, Ph. D. thesis submitted to Bharathidasn University, Tiruchirapalli, India. 167.

Saha, S. and Choudhury, A. 1995. **Vegetation analysis of restored and natural mangrove forest in Sagar island, sunderbans, east coast of India.** Indian J. Mar. Sci. 24, 133-136.

Saintilan, N. 1998. **Relationships between height and girth of mangroves and soil-water conditions in the Mary and Hawkesbury river estuaries, eastern Australia.** Australian Journal of Ecology. 23: 4, 322-328

Selvam, V., Azariah, J. and Azariah, H. 1990 **Diurnal variation in physical-chemical properties and primary production in the interconnected marine, mangrove and freshwater biotopes of Kakinada coast, Andhra Pradesh, India**. in Jaccarini, V. and Martens, E. eds **The Ecology of Mangrove and Related Ecosystems, Mombasa (Kenya),** 24-30 Sep 1990 Source: Hydrobiologia. The Hague; 1-3, 181-186.

Singh, H S. 1999. **Mangroves in Gujarat: Current status and strategy for conservation, Gujarat Ecological Education and Research (GEER) Foundation, Gandhinagar**. 127.

Thivakaran, G.A., Saravanakumar, A, Serebiah, S, and Joshua, J. 2002. **Vegetation structure of Kachchh mangroves, Gujarat, northwest coast of India**. Indian J. Mar. Sci. (in press).

Vance, D. J., Haywood, M.D.E. and Staples, D. J. 1990. **Use of mangrove estuary as nursery area by post larval and juvenile banana prawns, *Penaeus merguiensis* de Man, in Northern Australia.** Est. Cost. Shelf Sci. 31:689-701.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 256-259

NUTRIENT ENRICHMENT BY WASTEWATER DISCHARGE - MANGROVES OF PONDICHERRY, SOUTH INDIA.

Saravanan, K.R. and Anisa B.Khan*.
Salim Ali School of Ecology & Environmental Sciences,
Pondicherry University, R.V. Nagar, Pondicherry – 605 014 India.
* Corresponding author ; E mail: anisabasheer@rediffmail.com, krsarav@hotmail.com

ABSTRACT : The present investigation deals with the nutrient enrichment due to agricultural domestic and municipal wastewater discharge runoff at the emerging mangrove ecosystem in Pondicherry. Five sampling sites were selected depending on the point of entry of discharge. The characteristics of chemical composition at all sampling sites was discussed. A high content of NO_3 (12.16 mg/l) at site III, Cl (19.505 ppt.), Ca (220.5mg/l), Mg (1139.5 mg/l), Na (10500 mg/l), SO_4 (1314.8 mg/l) at site IV and K (1326 mg/l) at site V were recorded. PO_4 was highest at site II (410mg/l) where wastewater source is mainly of domestic origin. A high significance of correlation between salinity and magnesium (r = 0.9981, at p = 0.001) is observed. The study discusses the pollution status and concludes with peremptory factors for growth and development of this emerging mangrove.

Keywords : nutrient enrichment, wastewater, pollution, mangrove, Pondicherry.

INTRODUCTION

Mangroves, typical coastal wetlands, are highly productive ecosystems occurring throughout the tropical coasts (MacGill, 1958; Clough, 1998). These ecosystems play an important role in the biogeochemistry of contaminants in tropical coastal areas (Ditmar and Lara, 2001), and posses a remarkable capacity to retain nutrients (Dwivedi and Padmakumar, 1983). Mangrove ecosystem in addition to resisting wastewater pollution, can decrease the concentrations of waterborne suspended solids, nutrients and other contaminants (Clough *et al*., 1983). Water quality is an indicator of the status of the wetland. Analysis of water samples provide the impact of the wastewater entering into the system. Present work is aimed to project the nutrient composition of the emerging mangroves of Pondicherry as it receives the wastewater discharge.

Study sites: In Pondicherry, the mangrove creek is located at 11°54'N x 79°48'E, south of town on the Coramandal coast of South India. The mouth opens into Bay of Bengal on the eastern part of Thengaithittu village, which it encircles and then extends upto Murungapakkam village, 3km away from the mouth. The entire waterway is tide dominated and fringed with 5 exclusive mangrove species. The entire waterway receives wastewater discharge from all the villages around.

MATERIALS AND METHODS

Four major input sites and another near the mouth were selected for sampling. Site-I is opposite to the mouth opening, site III is immediate to *Avicennia* cover and sites II, IV& V are adjacent to sewage discharge at Thengaithittu south, Ariankuppam north and Murungapakkam south respectively. The samples were collected using Mayer's water sampler to the depth of 10cm below the water surface and processed immediately. The physical parameters pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS) and Chemical parameters such as Chlorides (Cl), Salinity, Calcium (Ca) and Magnesium (Mg) Hardness, Nitrates (NO_3), Sulphates (SO_3) and Phosphates (PO_4) were determined using standard methods described in APHA (1998) and the methods recommended by Pannier (1984) for mangrove environment. The data was subjected to regression analysis and the significance of correlation was determined by applying paired t – test. Only the positively correlated r values are expressed and discussed.

RESULTS AND DISCUSSION

All the parameters analysed were found to be in minimum concentration at site-I indicating the buffering activity of sea water by constant dilution and the retention of the nutrients in the mangrove sediments. At site-II high concentration of PO_4 (410*m*g/l) was recorded (Fig.1d); but the concentration is gradually reduced upstream with further dilution near the mouth. Bandela *et al* (1999) report high concentration of phosphates to be due to sewage and wastewater discharge and the same was evident at site-II with the density of households in that region being comparatively higher and hence higher discharge of wastewater.

At site-III the high pH (7.9, Fig.1a) and high Nitrate (NO_3) concentration (12.16mg/l) recorded indicates the Nitrates-pH relationship with a significant correlation (0.9637 at p=0.01, Fig.2). Since Nitrate is partly utilized by the plants its concentration gradually

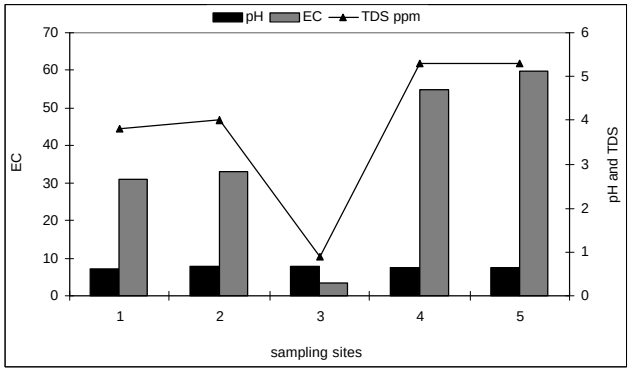


Fig.1a. Comparison of changes between pH, EC and TDS of mangrove water receivingwaste water discharge at different sites.

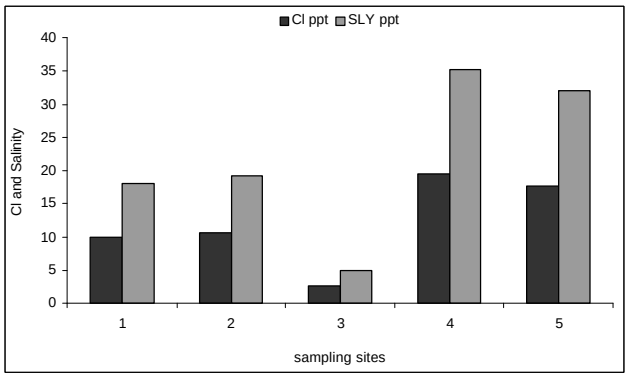


Fig.1b. Comparison of changes between Cl and Salinity of mangrove water receivingwaste water discharge at different sites.

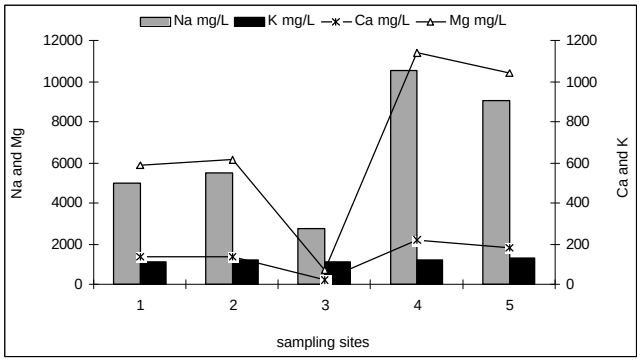


Fig.1c. Comparison of changes between Na, K, Ca and Mg of Mangrove water receiving waste water discharge at different sites.

decreases downstream. That NO_3 Nitrogen range in sewage is upto 20mg/l is reported in Dwivedi & Padmakumar, (1983) and APHA, (1998). The utilization of Nitrates by phytoplankton is evidenced by its relatively lower concentration. Hence, phytoplankton assimilation could be taken as major factor controlling the concentration of nitrates. Since, anoxic conditions of estuarine and coastal marine sediments lack nitrates, the vegetation present removes nitrate from the tidal waters (Rivera-Monroy and Twilley, 1996) and this is evident downstream in the present study. Alongi *et al.* (1992) report dissolved inorganic nitrogen (NO_3) and

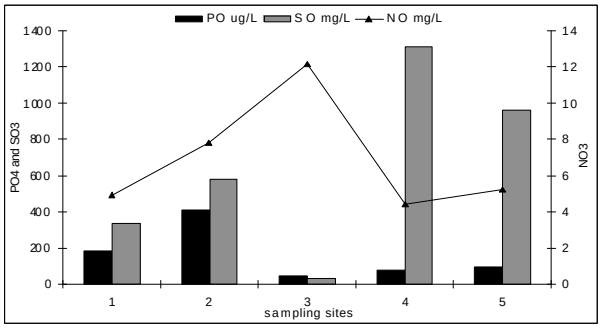


Fig.1d. Comparison of changes between PO_4, SO_3 and NO_3 of mangrove water receiving waste water discharge at different sites.

phosphorus (PO_4) concentrations to be low. In the present study at site III and II respectively NO_3 and PO_4 are found higher. In comparison, at site-III, the Cl, Ca, Mg, Na, PO_4 and SO_3 are lower. The dense growth of *Avecinnia* is responsible for the uptake of these nutrients. However the dense cover of water hyacinth (*Eichhornia crassipes)* at the channel may also absorb part of the nutrients.

The high EC & TDS values recorded in the samples collected from site IV & V correlate with higher salinity and nutrients such as Cl, Ca, Mg, Na, K (Fig.1b & Fig.1c) and SO_3. At these sites there is a mixing of domestic discharge, agricultural runoff along with sewage waters. Although the Chlorides and Salinity are interrelated in the inter-tidal waters, a significant positive correlation was observed between Chlorides-Magnesium and Salinity-Magnesium (0.9981 and 0.9980 at p=0.001 level respectively, Fig.2) which indicates that a large part of Magnesium ion is from the flood-tide and not from the wastewater discharge. Muniyandi (1985) and MSSRF (1994) reported surface water salinity at 20-33‰ and 19.8‰ in Pichavaram mangroves of Tamil Nadu, Mahapatro and Panday (2002) estimated the salinity range to be 18.34-27.9‰ at Rushikulya estuary in Orissa. Due to constant wastewater flushing the obtained salinity range is between 4.885-35.236‰ (Fig.1b).

A significant positive correlation at p=0.01 level was observed between EC-TDS (0.9775), EC-Cl (0.9832), EC-Salinity (0.9831), EC-Mg (0.9878), TDS-Cl (0.9599), TDS-Salinity (0.9596), TDS-Ca (0.9781), TDS-Mg (0.9746), Cl-Ca (0.9596), Cl-SO_3 (0.9727), Salinity-Ca (0.9693), Salinity-SO_3 (0.9728), Ca-Mg (0.9794) and between Mg-SO_3 (0.9607) (Fig.2). The significant interrelationship bet SO_4, Cl & Mg bears a higher correlation after the waste water discharge into the ecosystem. The higher concentration of nutrients (NO_3, SO_3, PO_4 and K) at all the sampling sites is associated with agricultural run-off or domestic and other wastewater discharges. Carlson *et al*.(1983) interrelates the availability of sulphate, nitrate and phosphate to seasonal and short-term tidal flooding and flow-through

rates. He reports that nutrients are mostly sustained due to regular tidal changes and that nutrient limitations in mangroves are related to infrequent inundation.

Although the plants need about twenty chemicals for growth (Moss *et al*., 1996), the level of nutrients is critical. In the present study their level is higher compared to the actual amount needed. Thus, the increased levels of nutrients, particularly PO_4 and NO_3 (Fig.1d) are contributed by agricultural runoff. Site-V being shallow, experiences low tidal current and as a result at this site mixing of tidal water with the sewage input is less, added to the high rate of evaporation.

Scientific reports are available on the ability of mangroves to absorb nutrients and their adverse impacts on mangrove growth. The nutrients are generally absorbed by mangrove vegetation itself besides, algae and microbes. Soil and some other physical processes are also responsible for large amounts of these nutrients (Wong *et al*., 1995, 1997b). Tam and Wong (1995, 1996a; 1996b) reported the efficiency of mangrove soil to trap the waste water-borne nutrients and experimentally described the ability of mangrove soils to absorb nutrients when treated with synthetic wastewater. Similarly, a long-term study with sewage discharge have no adverse effects on growth of mangroves (Wong et al. 1995, 1997a).

CONCLUSION

Compared to the water qualities of Rushikulya estuary of Arabian Sea (Mahapatro and Panday, 2002), Pichavaram (Perumal, 1989) and Sundarbans (Naskar and Mandal, 1999) of Bay of Bengal, the nutrient load in this mangrove is higher. This points to additional inputs from various other sources leading to pollution of the coastal wetland. It was evident that these coastal wetlands retain the nutrients which get flushed to the ecosystem from various sources resulting in highly productive system. Similar to other wetland-wastewater treatment facilities, the mechanism of a mangrove ecosystem to remove pollutants from wastewater involves various ecological processes such as plant uptake, litter decomposition, retention in sediment and microbial activities. As Krishnamurthy *et al* (1987) described, these nutrient enriched water increases the fertility and hence productivity of the coastal waters of Bay of Bengal when mixed by tidal ebb and flow.

Hence, assessing the health of this emerging ecosystem became imperative, monitoring is essential to understand initial fundamental characteristics of the ecosystem such as diversity, structure or productivity, working towards the evaluation of the environmental impacts due to specific anthropogenic activities. The present site-specific study, throws light on the buffering activities by the different functions of the ecosystem.

However more detailed ecological understanding is needed for efficient development plans in the management of this emerging ecosystem.

REFERENCES

Alongi, D.M., K.G. Boto, and A.I. Robertson, 1992 Nitrogen and Phosphorus cycles. In: Tropical Mangrove Ecosystems (eds: A.I. Robertson and D.M. Alongi). American Geophysical Union, Washington D.C. p 251-292

APHA. 1998 Standard methods for the examination of water and wastewater 20th ed. Washington D.C.

Bandela, N.N., D.P. Vidya, V.S. Lomte, and S.V. Shivanikar, 1999 The distribution pattern of phosphate and nitrogen forms and their interrelationships in Barul Dam water. Poll. Res. 18 : 411-414.

Carlson, P.R., L.A.Yarbro, C.F. Zimmermann, and J.R. Montfomery, 1983 Pore water chemistry of an overwash mangrove island. Florida Scientist, 46 : 239-249.

Clough, B. 1998 Mangrove forest productivity and biomass accumulation in Hinchinbrook Channel, Australia. Mangroves and Salt Marshes, 2 : 191-198.

Clough, B.F., K.G. Boto, and P.M. Attiwill, 1983 Mangroves and sewage : a re-valuation. In : Biology and Ecology of mangroves. ed. Teas, H.J. Dr. W. Junk Publishers, The Hague. Vol.8, 188.pp.

Ditmar, T. and R.J. Lara, 2001. Do mangroves rather than rivers provide nutrients to coastal environments south of the Amazon River? Evidence from long-term flux measurements. Marine Ecology Progress Series, Vol. 213 : 67-77.

Dwivedi, S.N. and K.G. Padmakumar, 1983 Ecology of a mangrove swamp near Juhu Beach, Bombay with reference to sewage pollution. In: Biology and Ecology of Mangrove. ed. Teas, H.J. Vol.8, Junk Publishers, Lancaster, pp.163-170.

FAO, 1994 Mangrove forest management guidelines. FAO Forestry Paper 117.

Krishnamurthy, K., A. Choudhury, and A.G. Untawale, 1987 Status report: Mangroves in India. Ministry of Environment & Forests. Govet. of India. New Delhi. 150pp.

MacGill, J.T. 1958 Map of coastal landforms of the world. Geogr. Rev. 48, 402-405.

Mahapatro, T.R. and Panday, S.N. 2002 Seasonal variation of micronutrients in Rushikulya estuary (Bay of Bengal). Poll. Res. 21(1) : 1-5.

Moss, B., J. Madgewick and G. Phillips, 1996 A guide to the restoration of nutrient enriched shallow lakes. Norwich Boards Authority.

MSSRF. 1994 Nutrient dynamics and restoration ecology of Pichavaram mangroves. Report to Ministry of

Environment & Forests, Govt. of India. Centre for Research on Sustainable Agricultural and Rural Development, Madras.

Muniyandi, K. 1985 Studies on Mangroves of Pichavaram (South-east Asia), India. Ph.D. thesis, CASMB, Annamalai University, Port Novo.

Naskar, K. and Mandal, R. 1999 Ecology and Biodiversity of Indian Mangroves. Daya Publishing House, New Delhi p245.

Pannier, F. 1984 Analyses of soil, plant and water components. In: The Mangrove ecosystem: research methods. eds. Snedaker, S.C. and Snedaker, J.G. UNESCO p131-144.

Perumal, P. 1989 Heterogeneity of coastal ecosystems with special reference to mangroves. Ph.D. Thesis, Annamalai University, Parangipettai, India. 155 pp.

Rivera-Monroy, V.A. and R.R. Twilley, 1996 The relative role of denitrification and immobilization in the fate of inorganic nitrogen in mangrove sediments. Limnol. Oceanograf. 41:284-296.

Tam, N.Y.F. and Y.S. Wong, 1995 Mangrove soils as sinks for wastewater-borne pollutants. Hydrobiologia 295(1-3), 231-241.

Tam, N.Y.F. and Y.S. Wong, 1996b. Retention of wastewater-borne nitrogen and phosphorus in mangrove soils. Environmental Technology, 17(8), 851-859.

Tam, N.Y.F. and Y.S.Wong, 1996a Retention and distribution of heavy metals in mangrove soils receiving wastewater. Environmental Pollution 94(3), 283-291.

Wong, Y.S., C.Y. Lam, S.H. Che, X.R. Li, and N.F.Y. Tam, 1995 Effect of wastewater discharge on nutrient contamination of mangrove soil and plants. Hydrobiologia 295: 243-254.

Wong, Y.S., N.F.Y. Tam, and C.Y. Lan, 1997a. Mangrove wetlands as wastewater treatment facility: A field trial. Hydrobiologia 352(1-2), 49-59.

Wong, Y.S., N.F.Y.Tam, G.Z. Chen, and H. Ma, 1997b Response of Aegiceras corniculatum to synthetic sewage under simulated tidal conditions. Hydrobiologia, 352 (1-3) : 89-96.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 260-265

MANGROVES OF ULHAS RIVER ESTUARY AND THANE CREEK

Mangal U. Borkar, Goldin Quadros and R.P.Athalye
Zoology Department, B.N.Bandodkar College of Science, Thane (W) 400 601.

ABSTRACT : The study on the distribution of mangroves and associate plants along Ulhas river estuary and Thane creek during the period September 2001 to August 2002 showed presence of 7 genera and 12 species of mangroves, 12 genera and 13 species of mangrove associate plants and 5 types of non mangrove halophytes. *Avicennia marina var marina, Avicennia marina var acutissima, Avicennia officinallis, Sonneratia apetala, Acanthus ilicifolius, Derris trifoliata, Salvadora persica, Aeluropus lagopoides., Sesuvium portulacastrum* were the most commonly occurring plant types whereas *Rhizophora spp.* and *Bruguiera spp.* were sporadically observed. Inspite of higher influence of fresh water, Ulhas river estuary had less mangrove cover (approx 1.55 sq.km.) than Thane creek (approx 2.3 sq.km.). The mangroves along both the ecosystems are under serious threat of anthropogenic activities. The damaging factors varied from place to place, along Ulhas river estuary the damage was mainly caused due to cutting for fuel, reclamation for agriculture and sand ports (retibunder). Whereas, along Thane creek the damage was chiefly due to soild waste dumping, reclamation for aquaculture ponds or saltpans and to some extent cutting for fuel. There is an urgent need to conserve the mangroves of this region, which can be achieved through education, motivation of local people and strict supervision by administrative bodies and non government organization.

Key words : Thane creek, Ulhas river estuary, Mangroves, Mangrove associate, damaging factors

INTRODUCTION

Mangroves are defined as characteristic littoral plant formations of tropical and subtropical protected coastline extending over 15.5 million ha. worldwide. The most extensive and luxuriant mangroves extend across the Indo-pacific regions where they are best developed in the delta system of major rivers.

The earliest reference to the uses of mangroves dates back to the year 1280 (Bandarnayake, 2000). Reference is made to the use of *Rhizophora* seedlings as food in times of famine, to cure sore mouth, to produce fuel, tannin and dye and wine having an aphrodisiac effect when ingested. The ecology of Mangroves have been studied by a number of workers Blasco (1975), Blatter (1905), Navalkar (1951), Untawale(1980), Deshmukh(1990), Gokhale and Athalye (1995).Presently importance of mangroves has become well known. Inspite of this they are declining due to over exploitation and pollution. This paper describes the distribution of mangroves along the Ulhas river Estuary and the Thane creek.

MATERIALS & METHODS

The present study was carried out to assess the distribution of mangroves in a 40 km stretch of Ulhas river estuary (Long.73 ^{0} 20' E to 72 ^{0} 45' E ;Lat.18^{0}.45' N to 19^{0}.16' N) from Kalyan to Bhayander and 26 km stretch of Thane creek from Balkum to Trombay (Long.72^{0} 55' to 73^{0} .00' E; Lat.19^{0}.00' 19^{0}.15' N). The study was done seasonally during monsoon (June to Sept.); post monsoon (Oct. to Feb.); and pre monsoon (March to May) during period September 2001 to August 2002. Though the full stretch was observed carefully, for the convenience, detailed study was done at stations 1 to 12 in the Ulhas River Estuary and station 13 to 24 in the Thane creek (Fig 1). The stations were chosen on both the banks (North and South bank for Ulhas river estuary and East and West bank for Thane creek). The stations were approached by mechanized boat. Distribution of mangroves was assessed in five quadrats of 10m x 10m at each station . For this presentation, the data for both

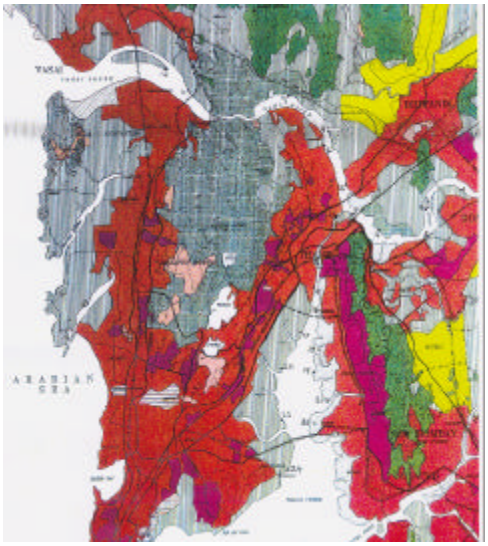


Fig. 1 : Map showing sampling stations in Ulhas river estuary and Thane creek

the ecosystems were consolidated zonewise, considering 3 zones namely 1) Riverine zone having more influence of freshwater (Stations 1 to 4 and 13 to 16). 2) Middle zone having a mixture of river water and sea water (Stations 5 to 8 and 17 to 20). 3) Seaward zone having higher salinity due to proximity to the Arabian sea (Stations 9 to 12 and 21 to 24).

Important parameters of water and sediment were analysed using standard methods (APHA, AWWA& WPCF, 1981 ; Trivedy and Goel 1984)

RESULTS AND DISCUSSION

Zonewise variations of the water and the sediment parameters are given in Table - 1. Comparing the total average values, Ulhas river estuary as compared to Thane creek, had lower salinity (due to more quantum of freshwater), low light penetration, relatively better dissolved oxygen, high silicates, lower sediment organic carbon, higher amount of clay & sand and low sediment total phosphorus.

Table 1 : Water and sediment parameters of Ulhas river estuary and Thane Creek.

	Ulhas River Estuary										Thane Creek									
	Zone 1			Zone 2			Zone 3			Total	Zone 1			Zone 2			Zone 3			Total
Water Parameters	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Avg
Water Temperature C	21.25	33.13	28.03	21	31.5	28.19	22.75	33.25	28.35	28.18	21.5	33.75	28.75	22.5	33.45	29.37	26.38	34.88	30.28	29.71
Light Penetration	14	50.75	30.5	13.38	57.5	27.44	7.75	27.25	16.11	24.69	22	57.75	33.51	19.75	59.25	39.81	13	42.5	30.56	34.63
Suspended solids gm/l	0.16	0.96	0.555	0.15	2.375	1.249	0.205	6.15	3.865	1.89	0.43	3.385	1.911	0.6	13.5	2.414	0.535	3.17	1.551	1.958
pH	6.93	7.76	7.44	7.22	7.8	7.54	7.4	8.04	7.78	7.59	7.19	8.09	7.67	7.4	8.19	7.74	7.57	8.193	7.78	7.73
Salinity ppt.	0.389	18.51	8.93	0.73	30.28	15.34	1.035	34.92	22.93	15.73	0.803	32.48	19.67	2.85	34.6	23.93	6.825	37.14	27.55	23.73
Dissolved oxygen mg/l	0.75	3.825	2.29	1.425	3.35	2.55	1.983	4.8	3.62	2.82	0.375	2.925	2.015	0.7	8.2	1.998	0.925	4	2.11	2.041
B.O.D. mg/l	5.375	24.43	16.25	2.225	13.48	8.341	0.55	8.45	5.083	9.892	9.75	42.75	24.67	2.125	24.13	13.04	1.9	20.05	10.79	16.17
PO4-P mg/l	0.03	0.094	0.06	0.03	0.092	0.055	0.023	0.061	0.047	0.054	0.061	0.162	0.132	0.033	0.096	0.074	0.027	0.094	0.069	0.092
NO3-N mg/l	0.292	2.521	1.491	0.905	3.533	1.89	0.189	2.275	1.616	1.666	0.471	1.458	1.022	0.145	2.099	0.853	0.145	1.383	0.983	0.953
SiO3-Si mg/l	12.66	77.43	33.67	11.1	72.6	34.07	11.72	61.09	29.07	32.27	12.25	43.02	26.66	8.498	35.15	22.34	5.734	38.98	15.88	21.63
Sediment parameters																				
Organic Carbon %	1.906	4.183	3.102	2.045	3.878	2.926	1.58	3.595	2.611	2.88	2.727	4.512	3.81	2.688	4.568	3.554	2.185	4.003	3.222	3.529
Sand %	3.7	15	8.406	8.528	17.5	12.65	14.13	21.91	18.53	13.19	0.895	10	5.18	2.838	10	6.067	4.975	12.5	8.979	6.742
Silt %	48.75	74.1	59.69	30	55.52	41.52	30	69.68	48.88	49.36	62.5	82.23	76.34	63.36	81.07	69.88	60.57	75	65.53	70.59
Clay %	16.34	40	31.9	33.74	52.5	45.84	10.22	52.71	34.6	37.45	15	27.5	18.48	15.86	32.6	24.05	13.75	32.11	25.81	22.77

Table no.2 List of True Mangroves in the present study.

Genera	Family	Ulhas			Thane		
		zone1	zone2	zone3	zone1	zone2	zone3
1) *Avicennia marina* var. *marina* (Forsk) Vierh	Avicenniaceae	+	+++	+++	+++	+++	
2) *A. marina*(Forsk.) Vierh. Var. *acutissima* Stapf &Mold		—	—	+++	+++	+++	+++
3) *A. officinallis* L.		—	+++	++	++	++	++
4) *Aegiceras corniculatum*(L) Blanco (semi mangrove)	Myrsinaceae	—	++	++	++	++	++
5) *Bruguiera. gymnorrhiza*(L) Lamk.		—	+	+	—	+	—
6) *B.caryophylloides* BL		—	—	+	—	—	—
7) *Ceriops tagal* (Perr.) Robin		—	—	—	—	+	—
8) *Rhizophora apiculata* BL.	Rhizophoraceae	—	++	—	—	+	—
9) *R. mucronata* Lamk		—	++	—	—	+	—
10) *Sonneratia .apetala* Buch. Ham	Sonneratiaceae	++	+++	+++	+++	+++	+++
11) *Sonneratia .griffithi*.		+	++	—	++	++	—
12) *Excoecaria agallocha* L.	Euphorbiaceae	—	—	++	++	++	++
Total number of species		3	8	8	7	11	6

– – Absent; + Few; ++ Moderate; +++ Abundant.

Along the Ulhas river estuary and Thane creek total 7 genera and 12 species of true mangroves were recorded which included *Rhizophora apiculata R.mcucronata Avicnnia officinalis, Avicennia marina var. marina. Avicennia marina var. acutissima, Sonneretia apetala, Sonneretia griffithi, Bruguiera gymnorrhiza B.caryophylloides, Aegiceras corinculatum* Their zonewise distribution in both the ecosystems is shown in Table - 2.

Table 3 : List of Mangrove associates

Genera	Family	Ulhas			Thane		
		zone1	zone2	zone3	zone1	zone2	zone3
1) *Acanthus ilicifolius* L.	Acanthaceae	+++	+++	+++	+++	+++	+++
2) *Calatropis gigantea*	Asclepiadaceae	++	++	++	++	++	++
3) *Clerodendrum inerme* Gaer.	Verbnaceae	++	++	++	++	++	++
4) *Cressa critica*	Scvophulariaceae	—	—	++	++	—	—
5) *Derris trifoliata* Lour.	Fabaceae	+++	+++	+++	+++	+++	+++
6) *Derris sps*		+++	+++	+++	+++	+++	+++
7) *Fimbristylis ferruginea* (L) Vahl.	Cyperaceae	+++	+++	++	+++	+++	++
8) *Ipomoea sps*	Convolvulaceae	++	++	++	++	++	++
9) *Pandanus odoratissimus* L.f.	Pandanaceae	++	—	++	—	++	++
10) *Porteresia coarctata* (Roxh). Tatcoca	Poaceae	++	++	++	++	++	++
11) *Salvadora persica* L.	Salvadoraceae	+++	+++	+++	+++	+++	+++
12) *Thespesia populnia*	Malvaceae	++	++	++	++	++	++
13) *Urochondra setulosa* (Trim) Hubb.	Poaceae	++	++	++	++	++	++
Total		12	11	13	12	12	12

– – Absent; + Few; ++ Moderate; +++ Abundant.

Table-4 LIST OF NON MANGROVE HALOPHYTES

Genera	Family	Ulhas			Thane		
		zone1	zone2	zone3	zone1	zone2	zone3
1) *Aeluropus lagopoides* (L.) Trim	Poaceae	—	+++	+++	+++	+++	+++
2) *Sesuvium portulacastrum* L.	Aizoaceae	—	++	++	++	++	++
3) *Suaeda Maritime*(L.) Dumort	Chenopodeaeceae	—	—	++	—	++	—
4) *Scirpus littoralis* Schrad.	Chenopodeaeceae	++	++	++	++	++	++
5) *Tarmarix troupii*	Tamaricaceae	—	+	—	+	+	—
Total		1	4	4	4	5	3

– – Absent; + Few; ++ Moderate; +++ Abundant.

The mangrove associate included 12 genera and 13 species their distribution is presented in Table - 3. Non mangrove halophytes of 5 types also occurred in both the ecosystems (Table - 4)

The distribution and status of mangroves in each zone of Ulhas river estuary and Thane creek are discussed below.

ULHAS RIVER ESTUARY

ZONE 1 (Riverine zone)

This zone from Kalyan to Mumbra is of 15 km stretch and included stations 1 to 4. The salinity ranged between 0.389 to 18.51 ppt. (Av. 15.7 ppt.) showing higher influence of freshwater. Mangrove belt in this zone had average width 20 m. including both banks ; thus the total area is estimated to be approximately 0.3 sq.km (15 x 0.02 km.).

At the extreme riverine end, where freshwater was dominant and salinity was low the mangrove species were absent. There were terrestrial trees on the banks like *Pongamia pinnata, Tamarindus indicus ,Ficus religiosa* etc. Down stream, from station two onwards the mangroves species were seen which included *Avicennia officinalis* (ht 30 feet.) and *Sonneretia apetala* (ht 30 feet) in 50:50 proportion . *Avicennia marina* was absent. On the north bank of this zone, there were continuous stands of one type of grass namely *Cyperus spp*.

(ht.2-3 ft), which is used by fishermen to capture mudskippers on the mud flat.

The main factors causing the damage to the mangroves were cutting for road construction, paddy fields or fuel and solid waste dumping. Along the South bank there were patches of extensive destruction and wherever there was extensive cutting the mangrove associate *Acanthus ilicifolius* had got established . It is a prickly gregariously growing herbaceous shrub that does not allow the germination of mangrove saplings as it grows densely on the mudflat. Though a mangrove associate, it also has the adaptation for saline conditions, having salt glands in the leaves that accumulate the excess salt.

In zone 1 though the overall mangrove cover was less, at Alimghar near station 4 there was luxuriant growth of *Sonneratia* (reaching 7 m height) on an island near north bank. The overall proportion of *A. officinalis* : *Sonneretia apetala* : *Acanthus ilicifolius*: Others was 35 : 35 : 20 : 10.

Zone 2 (Middle Zone)

This zone extended 10 Kms from Mumbra to Keonidiva and included stations 5 to 8. The salinity in this zone was higher than zone 1 and ranged from 0.73 to 30.28 ppt. (Av. 15.34 ppt.). In this zone there is confluence of Thane creek and Ulhas river estuary near station 5. The south bank of this zone is used for unloading the dredged sand which has caused extensive destruction of mangroves; the north bank being relatively undisturbed has luxuriant growth of mangroves. Average width of mangrove belt including both the banks was approximately 50 m. Hence the total mangrove cover could be 0.5 sq.km. (10 x 0.05 km).

This zone had dominance of *Avieninia officinalis* (height 30 feet, diameter 1.5 feet). The front mangroves *Bruguiera gymnorhiza* (height 1.5 m) with knee roots occurred occasionally. The proportion of *Avicennia: Sonneratia* was 50: 25. In this zone there was extensive reclamation of land for paddy fields. The mangrove associates of this zone included *Excoecaria agallocha* and *Salvadora persica.* The overall proportion of *A. officinalis* : *Sonneretia apetala* : *Excoecaria agallocha : Salvadora persica : Acanthus ilicifolius* was 50 : 25 : 5 : 10: 15.

ZONE 3 (SEAWARD ZONE)

This zone extended 15 km. in stretch from Keonidiva to Bhayander including stations 9 to 12. Being on the seaward side it experienced higher salinity from 1.035 to 34.92 ppt., (Av. 22.93 ppt.). In this zone average width of mangrove belt, including both banks was 50 m. thus a total cover approximately 0.75 sq.km. (0.05 km x 15 km). However at some places there was observed extensive growth of mangroves, for example near Versova bridge there was a 0.2 km. x 1.5 km. patch of mangroves with the representation of all the types of mangroves seen in the region. In addition a new species *Bruguiera caryophylloides* was also recorded growing up to 3 feet in height. Around stations 9 and 10 of this zone, trees of *Rhizophora apiculata* of height 15 to 20 feet with well developed propagules and columnar roots were spotted for the first time. In general the dominant mangrove type was *Avicennia marina*. But at some places proportion of *A.marina* : *Sonneratia apetala* was 50 : 50. The major damage causing factors in this zone include anthropogenic activity, sand landing at retibunder, cutting for fuel, roads and construction of houses. The damage was more extensive on the south bank.

The mangrove associates in this region included *Clerodendron inermae. Ipomoea spp. Excoecaria agallocha. Thespesia populnea and Salvadora persica.*The proportion of *Avicennia* : *Sonneratia apetala : Rhizophora apiculata : Bruguiera : Acanthus ilicifolius:* others was 30 : 30 : 5 : 5 : 15 : 15.

THANE CREEK

The zonewise distribution of mangroves along 26 km. stretch of Thane creek from Balkum to Trombay has been described below.

ZONE 1 (RIVERINE END)

This zone extended 6 km. from Balkum to Airoli including stations 13 to 16. Being on the Riverine side the average salinity was 19.67 ppt. ranging from 0.803 to 32.48 ppt. The mangrove zone was approximately 50 m wide (including both banks) thus making a total cover of 0.3 sq.km. (0.05 km x 6 km). However near stations 14 & 15 there was an isolated island with an area 0.25 sq.km. having tall mangroves (up to 5 m.). In general, there was dominance of *A.marina* var *acutissima* with average height 2.5 to 3 m. The mudflats in this zone were extensive unlike Ulhas river estuary. By end of monsoon they were dotted by the saplings of *A.marina* and *S.apetala* growing to a height of around 1 –2 feet. They however could not establish and disappeared by summer. There were 12 spp. of associate mangroves and 3 spp. of non mangrove halophytes in this region (Tables 3 & 4) The main mangrove damaging factors in this zone were cutting for fuel & fish aquaculture ponds and dumping of solid wastes. Hence, extensive growth of *Acanthus ilicifolius* was observed. The proportion of *Avicennia* : *Sonneratia apetala : Acanthus ilicifolius* : others was 40 : 20 : 30 : 10.

ZONE 2 (MIDDLE REGION)

This zone between stations 17 (Airoli) to 20 (Ghansoli) extended 10 km. Its average salinity was 23.98 ppt. (range 2.85 to 34.6 ppt.), higher than zone 1. The average width of the mangrove belt was 100 m. hence the total cover 1 sq.km. (0.1 km. x 10 km.). The domi-

MANGROVES AND MANGROVE ASSOCIATES



True Mangrove
Avicennia marina var. acutissima
fam. Avicenniaceae



True Mangrove
Sonneretia apetala



Mangrove Asso.
Hygrophila spinasa
fam. Acanthaceae



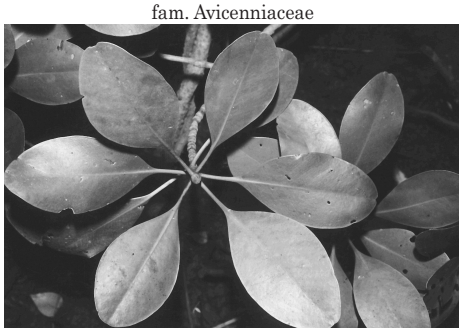
Mangrove Asso.
Salvadora persica
fam. Salvadoraceae



True Mangrove
Avicennia officinalis
fam. Avicenniaceae



True Mangrove
Young propagule of Rhizophora mucronata



True Mangrove
Ceriops decandra



True Mangrove
Bruguiera caryophylloides
fam. Rhizophoraceae



Mangrove Asso.
Sesuvium portulacastrum
fam. Aizoaceae



Non. Mangrove halophyte
Aleuropus logopoides flowering.

nant mangrove type was *A.marina* reaching a height of 3 m. Due to mangrove plantation done near Vikhroli by Godrej, the species diversity in this region was more. Species like *Bruguiera cylindrica*, *Ceriops tagal, Rhizophora mucronata , Aegiceras corniculatum,* were recorded in this region. Most of the associate species were also recorded in this zone along with the mangrove associate *Excoecaria agallocha* (Table 2).

The mangroves suffered damage due to reclamation for saltpans, fish aquaculture ponds and cutting for fuel. A layer of oil & grease was seen on the mangroves probably due to industrial pollutants released in this region. The proportion of *Avicennia* : *Sonneratia apetala : Acanthus ilicifolius* : others was 40 : 10: 30 : 20.

Zone 3 (Seaward zone)

This zone stretched 9 km. between Ghansoli to Trombay (Stations 21 to 24). The salinity ranged between 6.825 to 37.14 ppt. (Av. 27.5 ppt.). The overall width of the mangrove belt in this region was 75 m. thus a total cover approximately 0.675 sq.km. The distribution of mangroves was uneven in this zone. The dominant mangrove type was *A.marina* along with patches of *S.apetala*, whereas the dominant associate plant type was *Acanthus ilicifolius.* The other associates also occurred significantly in this region (Tables 3 & 4). Cutting for fuel and aquaculture ponds were the main factors damaging the mangroves. In certain regions solid waste dumping also damaged the mangroves. The proportion of *Avicennia* : *Sonneratia apetala : Acanthus ilicifolius* : others was 40 : 5 : 30 : 25.

CONCLUSIONS :

In general, the Ulhas river estuary showed low mangrove diversity on the riverine end and more diversity in zones 2 & 3. Thane creek had more diversity in the middle zone due to plantation efforts by Godrej. Cutting for fuel, solid waste dumping, reclamation for road or construction were the damaging factors common to both Thane creek and Ulhas river estuary. However, reclamation for agriculture and sand ports, cutting for fuel were predominant along Ulhas river estuary. While reclamation for fish aquaculture and solid waste dumping were the significant factors for Thane creek. In spite of favourable water conditions for mangrove growth in Ulhas river estuary, it had comparatively less mangrove cover (1.5 sq. km.) than Thane creek (2.3 sq.km.).However it was observed that the mangrove cover in both the ecosystems was rapidly declining.

RECOMMENDATIONS.

Mangrove trees are very important to protect the shoreline , also to provide food for the aquatic fauna. Their destruction by cutting for fuel and reclamation for various purposes should be stopped.

If at all they are cut and utilized for the benefit of local people, plantation should also take place, which should be done and taken care of by the people who have reaped the benefits of these plants. People should not wait for some expert or outside agency to take a project to do the plantation.

If the mudflats are cleared for aquaculture ponds, only the required piece of land should be cleared , and the banks of these ponds should be specially planted by mangrove trees which will also be a source of nutrients to the growing shrimps and fishes in the aquaculture ponds.

If proper plantation is not done and the mudflats are left exposed, the prickly and harmful *Acanthus* will occupy that place. As it is very difficult to destroy *Acanthus illicifolius,* the mangrove cover will be lost.

To achieve conservation, local people need to be educated and motivated.

REFERENCES

APHA, AWWA, WPCF, 1981.International standard methods for examination of water and waste water, 15th Edition, Washington D.C., 874 pp.

Bandarnayake, W. 2000 Australian Institute of Marine Sciences, Queensland Australia (web@aims.gov.an.)

Blasco,F. 1975. The mangroves of India. Inst.Francais, Pondicherry. Trav. Sect. Sci., Tech.14:1-175

Blatter, E.1905 The Mangroves of Bombay Presidency and its biology. J. Bombay Nat. Hist. Soc.16 : 644-656

Cooke, T. 1901-1908. The Flora of the Presidency of Bombay 3 Vols. London.

Deshmukh, S.V. , 1990 Ecological studies of mangroves in Bombay. Ph.D. Thesis University of Bombay, pp153

Gokhale, K.S. and R.P. Athalye. 1995 Study of impact of pollution on mangrove fauna of Thane creek near Thane city. Report submitted to the Ministry of Environment and Forests. New Delhi. 40 pp.

Kothari M.J and N.P.Singh, 1998 Mangrove diversity along the North- West coast of India. J.Econ. Tax. Bot. Vol. 22 No. 3 pp 571-585.

Kothari M J. and. ,Moorthy, 1993. Flora of Raigad District, Maharashtra State. Botanical Survey of India, Calcutta.

Navalkar ,B.S.1951, Succession of Mangrove Vegetation in Bombay and Salsette Islands. *J.Bombay Nat. Hist. Soc*. 50 : 157-160.

Trivedi R.K. and P.K. Goel, 1984. Chemical and biological methods for water pollution studies. Environmental Publications, Karad. 181 pp.

Untawale, A.G.1980. Present status of the Mangroves along the West Coast of India, Asian Symp.Mangrove Env.Res.Management, Kualalampur. pp1-26.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 266-275

AVIAN DIVERSITY IN AND AROUND MANGROVES OF MAHUL CREEK, MUMBAI, INDIA

Ashok Verma*, Naresh Chaturvedi, S. Balachandran and Isaac Kehimkar
Bombay Natural History Society
Hornbill House, Dr. Sálim Ali Chowk,
S.B.S.Road, Mumbai-400023
*Email: vermaasok@rediffmail.com

ABSTRACT : The study carried out during July 2001-May 2002 at Mahul Creek was aimed to examine the avian diversity in and around the mangrove forest. The avian community structure and concomitant population fluctuations were determined by weekly absolute counts of birds along the fixed transect. The area supported a fairly large number of migratory birds during winter. The maximum bird species diversity was recorded during winter (H'=4.06) and minimum during summer (H'=2.97). A total of 134 species of birds, belonging to 14 orders and 37 families were recorded. Of the total bird species, 36% bird species were long distant migrants from as far as Arctic Circle and rest of the avifauna consisted of resident bird species (28%), local migrants (24%) and resident migrants (11%). Shore birds, bulbuls, starlings, shrikes and warblers formed the bulk of the population. Globally threatened birds as Greater Spotted Eagle, Eastern Imperial Eagle, White-backed Vulture, Oriental White Ibis and Lesser Flamingo were also recorded.

The mangrove forest showed the highest bird species richness (D=29.9) but had low species diversity (H'=2.87). Rainfall, tidal water availability, fruiting seasonality, chemical pollution and anthropogenic activities like salt works and woodcutting affected the bird population.

Key words : *Avian diversity, species richness, mangroves, migrants, globally threatened birds, factors affecting bird population.*

INTRODUCTION

Studies are available on the ecology of birds of coastal habitat from within the state (Samant 1985, SPG foundation 2000, Sowrirajan 1994, Nitsure 2002) and the country (Thiyagesan 1996, Jayson 2001); however, a large gap exits in the scientific studies. There are some active NGOs involved in the Bird monitoring of Thane Creek (Pejaver, M.K.; Per. Comm.).

No scientific study is made on the ecology of birds of Mahul Creek, Mumbai so far. The present study is attempted to determine status of birds, species richness, species diversity and population fluctuation. Birds are bio-indicators of habitat quality and are sensitive to any subtle changes take place in the habitat (Diamond and Filion 1987). Monitoring of species diversity is a useful technique for assessing damage to the system, and maintenance of good species diversity is a positive management objective (Mann 2000).

STUDY AREA

All along the coast of Mumbai are found many creeks, in which tidal waters from Arabian Sea flood upstream and inundate much low ground. The present study was carried out during July 2001 to May 2002 in Mahul Creek in an area of around 4 sq km. The Creek is situated at the Northeast corner of the metropolis about 5 km from Sewri Railway Station and 15 km from Victoria Terminus in Chembur suburb and lies to the south west of the Thane Creek. The area extends between 19º 01' North latitude and 72º 53' East longitude (GPS reading). The temperature of the area ranges between 13ºC and 39ºC. Southwest monsoon (June to Mid-October) brings rain to the area which records to be maximum during July (747 mm). The climate is humid and the relative humidity ranges between 29 to 96% (recorded at 0830 hrs).

The whole study area was divided into three broad habitat types; 1) Mangrove forest (2 sq km) 2) Saltpans (1 sq km) and 3) Reclaimed site with mixed habitat types (1sq km)

DESCRIPTION OF STUDY PLOTS

1) Mangrove forest

The creek is lined by mud banks and mangroves. Other micro habitats identified in the mangrove forest of the Mahul creek were tidal lagoon, mudflats, grass patches and reed beds. The tidal water flushes the area regularly but only during spring tide, the water reaches almost the whole area.

The vegetation resembles the vegetation found all along the Thane Creek. The vegetation under daily tidal influence comprise of *Avicennia marina* being the commonest, *Rhizophora mucronata* and *Bruguiera cylindrica. Exoecaria agallocha, Salvadora persica*, *Acanthus ilicifolius, Sesuvium portulacastrum*, *Derris uliginosa*, *Clerodendron inerme*, *Aeluropus lagopoides* (grass) and *Typha angustata* (cat-tail) were other mangrove species and associates present in the study area.

The average height of mangroves falls between 2-6 metres.

2) Saltpans

Till October the saltpans remain inundated with sea and rainwater attracting a large concentration of migratory birds specially seashore birds. The area though is open stretch of shallow water depth ranging between 0-0.5 m, however, harbour few patches of mangroves all *Avicennia marina* and dotted by mangrove associates like *Salvadora persica.* Once the rainwater dries up the salt works start and continue till March.

3) Mixed habitat (Reclaimed site)

Once the mangrove forest is now a reclaimed habitat for fodder grass like *Paspalum* sp., *Penicum* sp. and *Paspaldium* sp. However, few stands of mangroves mainly *Avicennia marina* at periphery and patches of halophytic grass like *Aegilops purpuria* are present. Plantation of *Casuriana equisetifolia* also cover a small patch. The habitat attracts passerines and egrets. The Mumbai Port Trust road (tar road) intersects the connection with the mangrove forest. However, a small canal brings tidal water here. The fresh water is the otherwise main supply to this area and is generally released once in every fortnight during winter for yielding fodder grass crop.

METHODOLOGY

Birds

Data on bird population, species richness and fluctuation was collected by direct count method (Hoves and Blackwell 1989). First quick scanning of each study area was carried out from a vantage point to get an idea of the presence of number of species and then birds were counted species wise starting with the most abundant and finishing with the least abundant. The count was carried out weekly using binoculars in clear weathers about half an hour after sunrise and lasted for about 3 hours covering a transect of 3 km.

The sites were also thoroughly surveyed once in a month so as to avoid missing of any species.

PHYSIO-CHEMICAL PARAMETERS

Data on three variables were obtained from three fixed locations from each study site once in fornight. Dissolved oxygen content was determined by Azide Modification of Winkler Method and salinity was estimated by Argentometric method (Greenberg *et al*. 1981). Measurement of pH value was also determined using indicator paper (Sutherland 1996). Data on rainfall, temperature and relative humidity were obtained from the Metereological Department, Santacruz observatory, Mumbai. The whole study period was divided into three seasons i.e. Monsoon (July-Oct), Winter (Nov-Feb) and Summer (March-May).

ANALYSIS

1) Status of birds

The birds were classified as resident, migrant, local migrant and resident migrant.

Resident: Birds, which were sighted almost all the months, were considered as resident birds. They were breeding birds either of the study area or nearby areas.

Migrant: Long distance birds arriving from as far as the arctic tundra and temperate zones were termed as migrants. After spending over six months in winter quarters they start going back to their breeding ground as early by February at the onset of summer, when the conditions turn to normal in their breeding grounds.

Local migrant: These are the birds, which generally move from colder regions to the warmer plains in the areas of food abundance within the political boundary of the country.

Resident migrant: It includes both resident as well as migratory birds especially local migrants.

The birds were assigned status of rare (1-5), uncommon (6-100), common (101-400) and very common (above 400) based on the number of sightings made during the whole period.

2) Species richness

Margalef Index (Margalef 1968 in Spellerberg 1991) was used to determine species richness of birds in the different habitats.

$D = S-1 / \log N$

Where D is the index, S is the number of species and N is the total number of individuals.

3) Species diversity index

Shannon-Wiener Index (Pileou 1975 in Spellerberg 1991) was calculated to obtain species diversity index, which takes into account proportional abundance of each species.

$H' = - \sum pi \log pi$ (pi is relative abundance of species in a sample)

RESULTS

Greatest abundance (N=8023 sightings) and diversity of birds (H'=4.06) occurred during winter in

November followed by monsoon (N=2767, H'=3.87) and summer (N=2242, H'=2.97). The avifauna of the creek and its surrounding area comprised of 134 species belonging to 14 orders and 17 families (Table.1). Long distant migrants constituted 36% of the total number of bird species followed by resident 28%, local migrants 24% and resident migrants 11%. Redshank, Marsh Sandpiper, Little Stint, Heuglin's Gull, Gullbilled Tern and Rosy Starling were common migrants. White-eared Bulbul, Ashy Prinia, Pied Myna, Common Myna, House Crow, Black Kite and Rufousbacked Shrike are common resident birds.

The number of avian species increased gradually from July (n=31) reaching a first peak in November (n=82) and second peak in February (n=71), thereafter the number decreased gradually leaving mostly resident birds (n=28 species) in May (Fig.1). During November 35% bird species were migratory, 22% local migratory, 15% resident migratory and 28% resident. Few migrants like Redshank, Greenshank, Common Sandpiper and Grey Wagtail were sighted as late as May.

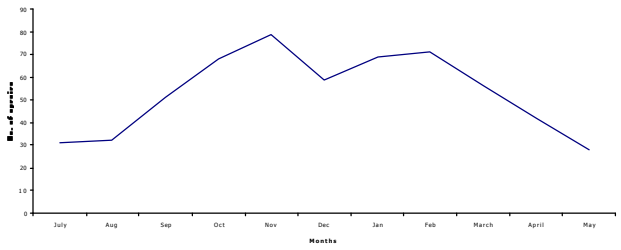


Fig. 1. Monthly variation in the number of bird species recorded in the Mahul Creek and its environs during 2001-2002

PHYSIO-CHEMICAL PARAMETERS

The mean values of the physio-chemical factors are shown in the table 1. The highest dissolved oxygen content was recorded in the mangroves (3.2 ppm) during high tides followed by reclaimed site (1.5 ppm). Salinity was the highest in saltpans followed by mangroves. The pH value obtained in the water samples from three sites showed the quality of water to be alkaline.

Mangrove forest

A total of 112 species of birds, belonging to 13 orders and 36 families were recorded (Table.2). The species richness was 29.93 whereas the diversity was 2.87.

All 5 globally threatened birds recorded from the study area were observed in mangrove forest. They were Oriental White Ibis (n=52), Lesser Flamingo (n=15), Greater Spotted Eagle (n=35), Eastern Imperial Eagle (n=2) and Indian White-backed Vulture (n=3).

Table. 1. Physico-chemical parameters obtained from three study sites

SN	Sampling sites	Dissolved Oxygen (ppm)	Salinity (ppt)	pH	Remark
1	Mangroves Mangroves Mangroves	3.2 0.7 0.0	32.2 31.7 21.6	9 8 8	High tide No tide Effluents
2	Saltpans	1.2	86.0	7.5	
3	Reclaimed site	1.5	2.7	7.3	

Birds like Asian Openbill-Stork, Oriental Honey-Buzzard, Black-shouldered Kite, Indian White-backed Vulture, Long-legged Buzzard, Osprey, Ruddy-breasted Crake, Greater Painted-Snipe, Terek Sandpiper, Curlew Sandpiper, Ruff, Common Iora and Purple-rumped Sunbird were only seen in mangrove forest.

Saltpans

A total of 94 species of birds, belonging to 13 orders and 28 families were recorded (Table.1). The species richness was 25.16 whereas the diversity was 3.31.

Lesser Flamingo (n=56) and Oriental White Ibis (n=2) were globally threatened birds recorded from saltpans.

Birds like Western Reef-Egret, Greater Flamingo, Comb Duck, Northern Pintail, Water Rail, White-breasted Waterhen, Common Coot, Kentish Plover, White-tailed Lapwing, Black-tailed Godwit, Pied Avocet, Brown-headed Gull and Pied Bushchat were only recorded in saltpans.

Mixed habitat (Reclaimed site)

A total of 91 species of birds, belonging to 13 orders and 31 families were recorded. The species richness was 25.23 whereas the diversity was 3.33.

Oriental White Ibis (1), Greater Spotted Eagle (10) and Eastern Imperial Eagle (1) were globally threatened birds recorded from here.

Birds like Glossy Ibis, Coppersmith Barbet, Citrine Wagtail, Bluethroat, Black-headed Munia and Yellow-throated Sparrow were only seen in this habitat.

DISCUSSION

Mangrove forest of the creek show presence of maximum number of bird species but the proportional abundance of the species in comparison to saltpans and mixed habitat is the lowest (H'=2.87). The reason could be mismanagement of the area. The nearby industries

release effluents containing oil, grease, dye and other chemicals. Water samples taken here show dissolved oxygen content to be nil hence supporting no wildlife. The effluents spread in the vast area of mangroves along with tidal water thereby affecting growth of mangroves and threaten life of macro and microorganisms. Mangrove woodcutting, which is prevalent in the area, also affects bird population by depriving them of their resting and roosting habitat. The rainy water stored during monsoon starts drying up by end of November and low availability of tidal water to the area probably force birds to move elsewhere. Birds are known to regulate their time of feeding not by the sun but by the tides (Welty 1964). Secondly chemical effluents released here contain oil, grease, chemicals and hence create tough survival conditions to the avifauna and their prey. The highest avian diversity was recorded from the reclaimed site having mixed habitats. The area is protected by private owners who grow fodder grasses and therefore is less prone to disturbance and regular supply of fresh water to the crop probably create suitable habitat for birds.

The saltpans are private land providing optimal habitat for shore birds and others till water is not pumped out of the area for preparing saltpans. Salt work starts as late as December depending upon the amount of rainy water present and time taken for drying up.

The first peak of bird population in November corresponds with the arrival of migrants in the area and the decline noted in December is due to departure of many bird species as monsoon habitats start depleting, however the second influx of migratory birds is also noted during January resulting in second peak in February. Rosy Starling, Common Myna, White eared bulbul and House Crow increase in number by November when *Salvadora persica* starts fruiting. Rosy Starlings disappear in December and again come back in February in large numbers to utilize berries of remaining *Salvadora* trees.

CONCLUSION

The Mahul Creek and its environs act as wintering, staging and breeding ground for birds. With support of government, private sector and local community the area can serve purpose of both recreational as well as wildlife education centre. Prohibition of mangrove woodcutting, fishing in the saltpans between monsoon and winter and releasing of chemical effluents through the area can be proved beneficial both for man and wildlife. Making water trenches between sea and mangrove forest can help spread tidal water to a larger area providing habitats for birds for longer period.

ACKNOWLEDGEMENTS

The Project was sponsored and funded by the Bharat Petroleum Corporation Limited, (Mahul), Mumbai. We thank Mr. D. M. Reddy, G.M. (P & A), Mr. K. Ravi, Chief Estates Manager, Mr. Balraj S., P. R. Manager for taking keen interest in the study and for providing all logistic supports. Thanks are due to Mr. D. G. Banswal, Deputy Manager Estate (Horti.) and Mr. S. Sunderrajan, Public Relation Officer for being very cooperative throughout the study. Mr. J. C. Daniel, Honorary Secretary, BNHS, Dr. Asad. R. Rahmani, Director, BNHS and Dr. A. M. Bhagwat guided and encouraged us during research work. We thank Mr. Vinod Patil and Mr. Vithal Hegde for assistance in the field.

REFERENCES

Birdlife International (2001): Threatened birds of Asia: The Birdlife International Red Data book. Birdlife International, Cambridge, U.K.

Diamond, A. W. and Filion, F. L. (1987) (Editors): The Value of Birds. International Council for Bird Preservation Technical Publication No. 6. Queens University, Kingston, Ontario, Canada.

Greenberg, A.E., Connors, J.J., and Jenking, D. (1981): Standard Methods for the examination of water and wastewater. American Public health association. Byrd Pre Press, Springfield, USA.

Jayson, E.A.. (2001): Structure, composition and conservation of birds in mangalavalam mangroves, Cochin, Kerala. Zoo. Print J. 16 (5): 471-478.

Joel Carl Welty (1964): The life of Bird. Constable & Co. Ltd. London.

Manakadan, R & Aasheesh Pittie (2002): Newletter for Birdwatchers. Vol. 42, No. 3 (May-June).

Nagarajan, R & Thiyagesan, K. (1996): Waterbirds and substrate quality of the Pichavaram wetlands, southern India. Ibis 138: 710-721.

Nitsure, S.R (2002): Study of Avifauna at Thane Creek near Rituchakkra Nature Park. Master's Thesis submitted to Indian Institute of Ecology and Environment. New Delhi.

Samant, J. S. (1985): Avifauna of the mangroves around Ratnagiri, Maharashtra. Proc. National symposium on biology, utilization and conservation of mangroves 465-466.

Spellerber, I. F. (1991): Monitoring ecological changes. Cambridge University Press, Cambridge.

Sutherland, W.J. (1996): Ecological census techniques. A handbook. Cambridge University Press, Cambridge.

Table. 1. Bird species recorded in and around of Mahul Creek during 2001-2002 (The English and scientif names follow Manakadan & Pittie 2002)

Orders	Families	SN	Species	English	Mangroves name	Saltpans	Rec. site	Status	Bird seen in Nov.
Pelecaniformes	Phalacrocoracidae	1	*Phalacrocorax niger* (Vieillot, 1817)	Little Cormorant	15	65	25	R,LM/C	Y
		2.	*Phalacrocorax carbo* (Linnaeus, 1758)	Great Cormorant	2	1	0	LM/r	-
Ciconiiformes	Ardeidae	3.	*Egretta garzetta* (Linnaeus, 1766)	Little Egret	21	155	47	R,LM/C	Y
		4.	*Egretta gularis* (Bosc, 1792)	Western Reef-Egret	0	8	0	LM/UC	Y
		5.	*Ardea cinerea* Linnaeus, 1758	Grey Heron	8	5	12	LM/UC	Y
		6.	*Casmerodius albus* (Linnaeus, 1758)	Large Egret	15	107	7	LM/C	Y
		7.	*Mesophoyx intermedia* (Wagler, 1829)	Median Egret	25	122	5	R,LM/C	Y
		8.	*Bubulcus ibis* (Linnaeus, 1758)	Cattle Egret	23	11	583	R,LM/VC	Y
		9.	*Ardeola grayii* (Sykes, 1832)	Indian Pond-Heron	75	127	50	R,LM/C	Y
		10.	*Butorides striatus* (Linnaeus, 1758)	Little Green Heron	1	3	0	R/r	Y
		11.	*Nycticorax nycticorax* (Linnaeus, 1758)	Black-crowned Night-Heron	1	4	0	R/r	
		12.	*Dupetor flavicollis* (Latham, 1790)	Black Bittern	3	6	0	LM/UC	
	Ciconiidae	13.	*Anastomus oscitans* (Boddaert, 1783)	Asian Open bill-Stork	2	0	0	LM/r	
	Threskiornithidae	14.	*Plegadis falcinellus* (Linnaeus, 1766)	Glossy Ibis	0	0	1	LM/r	
		15.	*Threskiornis melanocephalus* (Latham, 1790)	Oriental White Ibis	52	2	1	LM/UC	Y
Phoenicopte-riformes	Phoenicopte-ridae	16.	*Phoenicopterus ruber* (Linnaeus, 1758)	Greater Flamingo	0	20	0	LM/UC	Y
		17.	*Phoenicopterus minor* (Geoffroy, 1798)	Lesser Flamingo	15	56	0	LM/UC	Y
Anseriformes	Anatidae	18.	*Sarkidiornis melanotos* (Pennant, 1769)	Comb Duck	0	6	0	LM/UC	
		19.	*Anas poecilorhyncha* (J.R. Forester, 1781)	Spot-billed Duck	6	0	2	LM/UC	
		20.	*Anas acuta* (Linnaeus, 1758)	Northern Pintail	0	15	0	M/UC	Y
		21.	*Anas crecca* (Linnaeus, 1758)	Common Teal	10	22	0	M/UC	Y
Falconiformes	Accipitridae	22.	*Pernis ptilorhynchus* (Temminck, 1821)	Oriental Honey-Buzzard	2	0	0	LM/r	

Orders	Families	SN	Species	English	Mangroves name	Saltpans	Rec. site	Status	Bird seen in Nov.
		23.	*Elanus caeruleus* (Desfontaines, 1789)	Black-shouldered Kite	2	0	0	LM/r	
		24.	*Milvus migrans* (Boddaert, 1783)	Black Kite	58	62	37	R/C	Y
		25.	*Haliastur indus* (Boddaert, 1783)	Brahminy Kite	7	5	2	R/UC	Y
		26.	*Gyps bengalensis* (Gmelin, 1788)	Indian White-backed Vulture	3	0	0	LM/r	
		27.	*Circus aeruginosus* (Linnaeus, 1758)	Western Marsh -Harrier	58	19	25	M/UC	Y
		28.	*Accipiter badius* (Gmelin, 1788)	Shikra	5	3	5	R/UC	Y
		29.	*Butastur teesa* (Franklin, 1832)	White-eyed Buzzard	6	0	3	LM/UC	Y
		30.	*Buteo rufinus* (Cretzschmar, 1827)	Long-legged Buzzard	2	0	0	LM/r	
		31.	*Aquila clanga* Pallas, 1811	Greater Spotted Eagle	35	0	10	M/UC	Y
		32.	*Aquila nipalensis* Hodgson, 1833	Steppe Eagle	6	0	2	M/UC	
		33.	*Aquila heliaca* Savigny, 1809	Eastern Imperial Eagle	2	0	1	M/r	
		34.	*Hieraaetus pennatus* (Gmelin, 1788)	Booted Eagle	3	0	1	M/r	
	Pandionidae	35.	*Pandion haliaetus* (Linnaeus, 1758)	Osprey	2	0	0	M/r	
	Falconidae	36.	*Falco tinnunculus* (Linnaeus, 1758)	Common l Kestre	9	0	2	M/UC	
Gruiformes	Rallidae	37.	*Gallirallus striatus* (Linnaeus, 1766)	Blue-breasted Rail	2	3	1	R/UC	
		38.	*Rallus aquaticus* (Linnaeus, 1758)	Water Rail	0	1	0	M/r	Y
		39.	*Amaurornis phoenicurus* (Pennant, 1769)	White-breasted Waterhen	0	3	0	R/r	
		40.	*Porzana fusca* (Linnaeus, 1766)	Ruddy-breasted Crake	1	0	0	R/r	
		41.	*Fulica atra* (Linnaeus, 1758)	Common Coot	0	5	0	M/r	
Charadriiformes	Rostratulidae	42.	*Rostratula benghalensis* (Linnaeus, 1758)	Greater Painted-Snipe	3	0	0	LM/r	
	Charadriidae	43.	*Charadrius dubius* (Scopoli, 1786)	Little Ringed Plover	20	62	2	M/UC	Y
		44.	*Charadrius alexandrinus* (Linnaeus, 1758)	Kentish Plover	0	1	0	M/r	

Orders	Families	SN	Species	English	Mangroves name	Saltpans	Rec. site	Status	Bird seen in Nov.
		45.	*Charadrius mongolus* (Pallas, 1776)	Lesser Sand Plover	0	11	0	M/UC	Y
		46.	*Vanellus indicus* (Boddaert, 1783)	Red-wattled Lapwing	27	60	7	R/UC	Y
		47.	*Vanellus leucurus* (Lichtenstein, 1823)	White-tailed Lapwing	0	4	0	M/r	
	Scolopacidae	48.	*Gallinago gallinago* (Linnaeus, 1758)	Common Snipe	15	4	0	M/UC	Y
		49.	*Limosa limosa* (Linnaeus, 1758)	Black-tailed Godwit	0	6	0	M/UC	
		50.	*Numenius phaeopus* (Linnaeus, 1758)	Whimbrel	2	4	0	M/UC	Y
		51.	*Numenius arquata* (Linnaeus, 1758)	Eurasian Curlew	4	2	0	M/UC	
		52.	*Tringa erythropus* (Pallas, 1764)	Spotted Redshank	10	14	2	M/UC	
		53.	*Tringa totanus* (Linnaeus, 1758)	Common Redshank	50	130	7	M/C	Y
		54.	*Tringa stagnatilis* (Bechstein, 1803)	Marsh Sandpiper	34	400	0	M/VC	Y
		55.	*Tringa nebularia* (Gunner, 1767)	Common Greenshank	15	27	5	M/UC	Y
		56.	*Tringa ochropus* Linnaeus, 1758	Green Sandpiper	32	13	64	M/C	Y
		57.	*Tringa glareola* Linnaeus, 1758	Wood Sandpiper	53	67	51	M/C	Y
		58.	*Xenus cinereus* (Guldenstadt, 1774)	Terek Sandpiper	3	0	0	M/r	Y
		59.	*Actitis hypoleucos* Linnaeus, 1758	Common Sandpiper	54	146	50	M/C	Y
		60.	*Calidris minuta* (Leisler, 1812)	Little Stint	60	300	30	M/C	Y
		61.	*Calidris temminckii* (Leisler, 1812)	Temminck's Stint	25	250	5	M/C	Y
		62.	*Calidris ferruginea* (Pontoppidan, 1813)	Curlew Sandpiper	4	0	0	M/r	Y
		63.	*Philomachus pugnax* (Linnaeus, 1758)	Ruff	2	0	0	M/r	Y
	Recurvirostridae	64.	*Himantopus himantopus* (Linnaeus, 1758)	Black-winged Stilt	18	425	4	LM/VC	Y
		65.	*Recurvirostra avosetta* (Linnaeus, 1758)	Pied Avocet	0	7	0	M/UC	
	Glareolidae	66.	*Glareola lactea* (Temminck, 1820)	Small Pratincole	12	4	0	LM/UC	
	Laridae	67.	*Larus heuglini* (Bree, 1876)	Heuglin's Gull (Herring Gull)	4	300	0	M/C	Y

Orders	Families	SN	Species	English	Mangroves name	Saltpans	Rec. site	Status	Bird seen in Nov.
		68.	*Larus brunnicephalus* (Jerdon, 1840)	Brown-headed Gull	0	60	0	M/UC	Y
		69.	*Larus ridibundus* (Linnaeus, 1766)	Black-headed Gull	2	55	0	M/UC	Y
		70.	*Gelochelidon nilotica* (Gmelin, 1789)	Gull-billed Tern	10	200	0	M/C	Y
		71.	*Sterna caspia* (Pallas, 1770)	Caspian Tern	3	4	0	M/UC	
		72.	*Sterna albifrons* (Pallas, 1764)	Little Tern	4	55	0	LM/UC	
		73.	*Chlidonias hybridus* (Pallas, 1811)	Whiskered Tern	7	100	1	LM/C	Y
Columbiformes	Columbidae	74.	*Columba livia* (Gmelin, 1789)	Blue Rock Pigeon	14	7	10	R/UC	Y
		75.	*Streptopelia chinensis* (Scopoli, 1786)	Spotted Dove	23	0	6	R/UC	Y
		76.	*Streptopelia decaocto* (Frivaldszky, 1838)	Eurasian Collared-Dove	1	0	2	R/r	
Psittaciformes	Psittacidae	77.	*Psittacula krameri* (Scopoli, 1769)	Rose-ringed Parakeet	25	15	3	R/UC	Y
Cuculiformes	Cuculidae	78.	*Clamator jacobinus* (Boddaert, 1783)	Pied Crested Cuckoo	3	0	1	M/r	
		79.	*Cuculus canorus* (Linnaeus, 1758)	Common Cuckoo	8	0	2	M/UC	
		80.	*Eudynamys scolopacea* (Linnaeus, 1758)	Asian Koel	11	2	30	R/UC	
		81.	*Centropus sinensis* (Stephens, 1815)	Greater Coucal	12	1	5	R/UC	
Apodiformes	Apodidae	82.	*Cypsiurus balasiensis* (J.E. Gray, 1829)	Asian Palm-Swift	150	19	87	R,LM/C	
Coraciiformes	Alcedinidae	83.	*Alcedo atthis* (Linnaeus, 1758)	Small Blue Kingfisher	12	11	5	R/UC	Y
		84.	*Halcyon smyrnensis* (Linnaeus, 1758)	White-breasted Kingfisher	15	30	15	R/UC	Y
	Meropidae	85.	*Merops orientalis* (Latham, 180)	Small Bee-eater	40	0	100	LM/C	Y
	Coraciidae	86.	*Coracias benghalensis* (Linnaeus, 1758)	Indian Roller	6	0	3	R/UC	Y
	Upupidae	87.	*Upupa epops* (Linnaeus, 1758)	Common Hoopoe	4	2	1	LM/UC	
Piciformes	Capitonidae	88.	*Megalaima haemacephala* (Müller, 1776)	Coppersmith Barbet	0	0	7	R/UC	
Passeriformes	Hirundinidae	89.	*Hirundo rustica* (Linnaeus, 1758)	Common Swallow	40	70	200	R,LM/C	

Orders	Families	SN	Species	English name	Mangroves	Saltpans	Rec. site	Status	Bird seen in Nov.
		90.	*Hirundo smithii* (Leach, 1818)	Wire-tailed Swallow	6	0	20	R,LM/UC	Y
	Motacillidae	91.	*Motacilla alba* (Linnaeus, 1758)	White Wagtail	0	3	2	M/r	
		92.	*Motacilla citreola* (Pallas, 1776)	Citrine Wagtail	0	0	90	M/UC	
		93.	*Motacilla flava* (Linnaeus, 1758)	Yellow Wagtail	2	0	200	M/C	
		94.	M*otacilla cinerea* (Tunstall, 1771)	Grey Wagtail	4	1	250	M/C	Y
		95.	*Anthus rufulus* (Vieillot, 1818)	Paddyfield Pipit	9	0	14	LM/UC	Y
	Pycnonotidae	96.	*Pycnonotus jocosus* (Linnaeus, 1758)	Red-whiskered Bulbul	40	11	17	R/UC	Y
		97.	*Pycnonotus leucotis* (Gould, 1836)	White-eared Bulbul	250	126	40	R,LM/VC	Y
		98.	*Pycnonotus cafer* (Linnaeus, 1766)	Red-vented Bulbul	100	38	26	R,LM/C	
	Irenidae	99.	*Aegithina tiphia* (Linnaeus, 1758)	Common Iora	4	0	0	LM/r	Y
	Laniidae	100.	*Lanius cristatus* (Linnaeus, 1758)	Brown Shrike	35	10	12	M/UC	
		101.	*Lanius schach* (Linnaeus, 1758)	Rufous-backed Shrike	100	48	58	R,LM/C	Y
	Muscicapidae	102.	*Luscinia svecica* (Linnaeus, 1758)	Bluethroat	0	0	15	M/UC	
		103.	*Copsychus saularis* (Linnaeus, 1758)	Oriental Magpie-Robin	7	1	3	R/UC	
		104.	S*axicoloides fulicata* (Linnaeus, 1776)	Indian Robin	2	0	1	LM/r	Y
		105.	*Saxicola torquata* (Linnaeus, 1766)	Common Stonechat	20	2	6	M/UC	
		106.	*Saxicola caprata* (Linnaeus, 1766)	Pied Bushchat	0	2	0	LM/r	
		107.	*Turdoides caudatus* (Dumont, 1823)	Common Babbler	90	0	16	R/C	Y
		108.	*Turdoides earlei* (Blyth, 1844)	Striated Babbler	40	0	2	R/UC	Y
		109.	*Cisticola juncidis* (Rafinesque, 1810)	Streaked Fantail -Warbler	5	3	35	R/UC	
		110.	*Prinia socialis* (Sykes, 1832)	Ashy Prinia	210	129	145	R/VC	Y
		111.	*Prinia inornata* (Sykes, 1832)	Plain Prinia	9	29	39	R/C	Y
		112.	*Acrocephalus dumetorum* (Blyth, 1849)	Blyth's Reed-Warbler	48	9	20	LM/C	Y

Orders	Families	SN	Species	English name	Mangroves	Saltpans	Rec. site	Status	Bird seen in Nov.
		113.	*Acrocephalus stentoreus* (Hemprich & Ehrenberg, 1833)	Indian Great Reed-Warbler	30	8	15	LM/C	Y
		114.	*Orthotomus sutorius* (Pennant, 1769)	Common Tailorbird	1	2	2	R/UC	
		115.	*Phylloscopus collybita* (Vieillot, 1817)	Common Chiffchaff	1	1	5	M/UC	Y
		116.	*Sylvia curruca* (Linnaeus, 1758)	Common Lesser Whitethroat	2	0	4	M/UC	Y
		117.	*Rhipidura albicollis* (Vieillot, 1818)	White-throated Fantail- Flycatcher	14	4	3	R/UC	
		118.	*Nectarinia zeylonica* (Linnaeus, 1766)	Purple-rumped Sunbird	4	0	0	R/UC	
	Estrildidae	119.	*Amandava amandava* (Linnaeus, 1758)	Red Munia	35	10	60	R,LM/C	Y
		120.	*Lonchura malabarica* (Linnaeus, 1758)	White-throated Munia	11	5	31	R,LM/C	Y
		121.	*Lonchura punctulata* (Linnaeus, 1758)	Spotted Munia	0	4	127	R,LM/C	Y
		122.	*Lonchura malacca* (Linnaeus, 1766)	Black-headed Munia	0	0	2	R,LM/r	Y
	Passeridae	123.	*Passer domesticus* (Linnaeus, 1758)	House Sparrow	10	18	20	R/UC	
		124.	*Petronia xanthocollis* (Burton, 1838)	Yellow-throated Sparrow	0	0	4	R/r	
		125.	*Ploceus philippinus* (Linnaeus, 1766)	Baya Waereer	210	21	10	R/C	Y
	Sturnidae	126.	*Sturnus malabaricus* (Gmelin, 1789)	Grey-headed Starling	2	14	4	LM/UC	Y
		127.	*Sturnus pagodarum* (Gmelin, 1789)	Brahminy Starling	4	10	4	LM/UC	Y
		128.	*Sturnus roseus* (Linnaeus, 1758)	Rosy Starling	2059	418	328	M/VC	Y
		129.	*Sturnus contra* (Linnaeus, 1758)	Asian Pied Starling	59	20	124	R/C	Y
		130.	*Acridotheres tristis* (Linnaeus, 1766)	Common Myna	229	96	269	R/C	Y
	Oriolidae	131.	*Oriolus oriolus* (Linnaeus, 1758)	Eurasian Golden Oriole	1	0	9	R/UC	
	Dicruridae	132.	*Dicrurus macrocercus* (Vieillot, 1817)	Black Drongo	5	2	28	R/UC	Y
	Corvidae	133.	*Corvus splendens* (Vieillot, 1817)	House Crow	167	213	139	R/VC	Y
		134.	*Corvus macrorhynchos* (Wagler, 1827)	Jungle Crow	12	8	35	R/UC	Y

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 276-282

SPECIES DIVERSITY OF AVIFAUNA AT THANE CREEK NEAR RUTUCHAKKRA NATURE PARK

Shriharsha R. Nitsure and Madhuri Pejaver*
Nicholas Piramal India Limited, Balkum, Thane 400608, Maharashtra, India
* Department of Zoology, B. N. Bandodkar College of Science,
Thane 400 601, Maharashtra, India

ABSTRACT : The species diversity and density of birds of the mangroves, mudflats and near by reclaimed land at Thane creek near Rutuchakkra Nature Park (72^0 55' to 73^0 00 E longitude & 19^0 00 to 19^0 15' latitude) was studied at weekly intervals from September 2000 to March 2002. At low tide, exposed mudflats served ideal feeding grounds for winter visitors, like Little Stint, Common Sandpiper, Red Shanks, Plovers etc. Mudflats were separated by thin water currents and bordered by dense mangroves like *Avicennia marina, Avicennia officinalis* etc. & reclaimed land. At few places mangrove patches were seen as islands. The mudflats and near by area harboured a total of 69 species of birds belonging to 26 families and 12 orders, of which 32 species were wetland inhabitants. Charadriforms formed the largest group inhabiting the estuarine wetland. Maximum species diversity was observed in the month of December 2000 (49 species). Some rare visitors like Avocet (*Recurvirostra avocetta)* was also noted at the site, which is one of the Important Bird Species according to IBA (Important Bird Area) declaration. The present study comprised of a survey of avifauna of Thane creek (Rutuchakkra Park), which will be useful in providing base line data, for planning effective management to study bird diversity with respect to development of Rutuchakkra Nature Park and pollution load on the creek.

Key Words: *Mangrove, Avifauna, Creek*

INTRODUCTION

The variety of distinctive species, ecosystems and habitats, influence the productivity and services provided by the specific ecosystems (Ravan, 1992). The species composition of a specific area or a community is interlinked to the available resources of the area in question, which includes physical structure of the habitat, availability of food and biotic interactions.

The mangroves enrich the creek water with nutrients, act as nursery ground for fish, entrap mud and heavy metals, control salinity of ground water and reduce the impact of tidal currents. This fragile ecosystem is threatened by reclamation, pollution, fire wood exploitation etc.

The area under study was a garbage dumping land of Thane Municipal Corporation. The garbage dumping has been stopped and the area is being developed as "Nature Park" – known as "Rutuchakkra Nature Park". At present there are no plants other than few existing mangroves and shrubs. The new plantation has been started in the area and simultaneously the mangrove plantation is also undertaken. It is expected that within a span of 3 to 4 years, the habitat in the area under study will be restored.

Birds are one of the best indicators of environmental quality of any ecosystem (Ripley, 1978). The Council of Environmental Quality (USA) identified birds as the commonly used indicators of environmental change (Morrison, 1986). Most of the birds have specific habitat requirement from season to season, a loss of which may lead to their extinction.

Thus the conservation value of a habitat could be assessed by the presence of various species of birds in an area. Recently Thane creek area has been declared as IBA (Important Bird Area) and hence the detailed ornithological survey from Rutuchakkra area was undertaken to prepare a base line data.

SELECTION OF STUDY AREA

With its geomorphic head near the city of Thane, the Thane creek is geographically located at 72°55' to 73°00' E longitude and 19°00' to 19°15' latitude. The creek extends about 26km. northwards from the south of Mumbai harbor bay and joins the Ulhas River by a minor connection near Thane city (Map 1). The creek is around 6 km. wide at its mouth and 0.5 km. wide at the confluence with the estuary.

Thane Municipal Corporation previously used the bank of the creek near Kalwa bridge (Map 2) as garbage dumping ground. The total landfill area is about 17 acres with length about 1.5 km. and width about 80 meters. It used to stink and was full of plastic bags and other city wastes.

The Nature Park under development was named as "Rutuchakkra" in which six zones were formed, zone 5, which has landfill area of 3 acres, was selected for observation. It was away from vehicular pollution and close to mud flats, where the expanse of water was less

and shallow. This made the observations clear and easier.

Small bushy mangroves surrounded the selected zone; hence abundance of birds was felt more in this area. The nallas from Thane town entered the creek from both the sides of area under study, bringing fresh water, which formed thin streams during low tide. Due to the compound wall along the boundary with locked gate, overall anthropological activities were less in the area under study.

MATERIAL & METHODS

The aim of the study was to produce detailed report of changes in the number of birds, over a short period and hence weekly census of birds was conducted, for estimating the bird population of the area from September 2000 to March 2002 (i.e. for 19 months). The data was compiled and presented to show monthly fluctuations in population.

The observations were quantitative in nature & were made during the evening, just an hour & half before sunset. The creek area under study is towards East side from the observation ground, hence it was difficult to make visual observations in the morning, as the colour differentiation was not possible due to the rising sun.

The census was made by visual counts of birds, from specific points and also walking on the boundary wall, by direct sighting using binoculars (10 X 50 magnifications). In case number was too large to count approximation was made with the help of binoculars. Advantage of high tide and low tide was considered, to monitor differential occurrence of waders and piscivorous birds.

Standard guides such as Ali (1979), Campbell (1979), Ali & Ripley (1995), Ali (1996), aided identification, classification and nomenclature of birds. During the present study the birds, which might have escaped notice / observation may be some small birds, or are less in number and seen rarely.

The birds observed in the present study were categorised according to their occurrence, throughout the year as per the classification suggested by Dharamkumarsinhji (1973) and Ali (1996)

Resident (R) : birds indigenous & residing in the area through out the year and hence are local.

Resident migrant (RM) : the birds, which migrate locally within the country.

Migrant (M) : birds which arrive in the area under study from other country from September and leave in March or latter.

The birds were also categorised by "modified Buden (!992) method" - Kannan (1998) into three distinct categories as:

Common – Counted daily in relatively large numbers in flocks of ten.

Uncommon – Observed on most of the days in relatively low numbers about 1 – 10 per day.

Rare - Counted 15 times or less in a year.

(Migratory bird species were categorised under common, uncommon or rare for the specific period, based on the observations performed during the migration period).

RESULTS & DISCUSSION

Birds have been considered as useful biological indicators because they are ecologically versatile and live in all kinds of habitats as herbivores or carnivores (Jarvinen & Vaisanen, 1979). The aquatic avifauna is susceptible to the changes in wetlands, similarly they are most conspicuous in an ecosystem & hence can be easily observed for monitoring the changes taking place (Morrison, 1986). Some birds are migratory & hence the population of birds that occurs during the different seasons of the year fluctuates, which may help to know whether the area is normal or getting polluted, as total absence of birds from any area may be considered as pollution indication (Borale *et al*., 1994).

7 species of mangroves and mangrove associates were present at study area, belonging to 5 families, namely *Acanthus ilicifolius, Derris trifoliata, Sonneretia apetala, Salvadora persica, Avecinnia marina var, marina, Avecinnia marina var, accutissima, Avicennia officinalis*. Among the mangroves *Avicennia marina* was the dominant species.

Thane creek is now declared as the Important Bird Area (IBA), which may get an international importance, when it comes under RAMSAR convention. The area under study was a part of Thane creek. Though small, it was equally important because bird like Pied Avocet (*Recurvirostra avocetta*), included in Important Bird Species, visits this area and nearby locality.

According to IBA survey (BNHS 2002), 205 species of birds are reported from the Thane creek region, of which 69 sps. of birds belonging to 25 families and 12 orders were noted at the site of study and few more were sighted from nearby sites. (Table1).

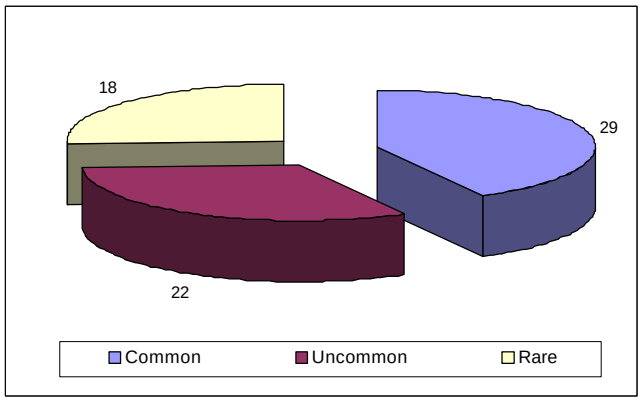
Bhargavi *et al.*(1996) in thir study on wetlands recorded total 45 species of birds belonging to 13 families, while Prashant *et al* (1994) in their study of coastal area of Nellora district recorded 78 sps of birds. Borges & Shanbhag (2001) observed that the mudflats and mangroves of Chorao Island in Mandovi estuary (Goa), harboured a total of 47 bird species belonging to 14 families of which 33 sps. were wetland denizens.

During the present study, 32 sps. of wetland birds were noticed. Quadros (2001) in his study on Thane creek reported 55 sps of birds, while Maharashtra Nature Park Mahim Mumbai, (2000) had published the list of 84 sps of birds sighted in their area.

Compared to the data available, sighting 69 bird sps in such a small area under study supports the idea of the Thane creek to be considered for IBA & also suggests that the ecological conditions in this area and vicinity, if protected and improved, can help to increase the number of birds visiting the area.

The largest order recorded during the present study was Passeriformes (Table1) with 10 families and 26 species of birds. Whereas the second largest order recorded was Charadriiformes with 3 families and 20 species of birds. Order Ciconiiformes though represented by only one family, include 7 species of birds. Other orders were represented by 1 or 2 species.

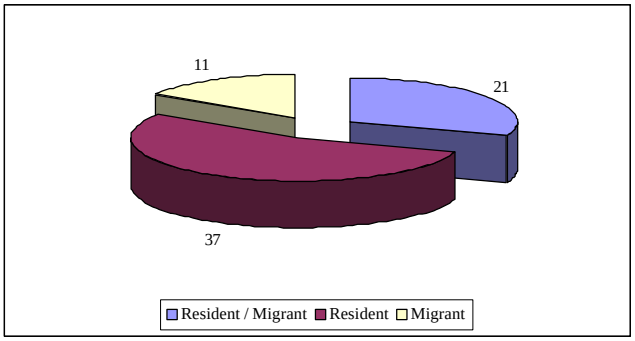
According to the classification based on modified Buden (1992) method & (Kannan, 1998) these birds fall under three categories: common, uncommon and rare, of which 29 species were common, 22 species were uncommon and 18 species were rare. (Graph 1)



Graph 1: Categories of bird species based on observations

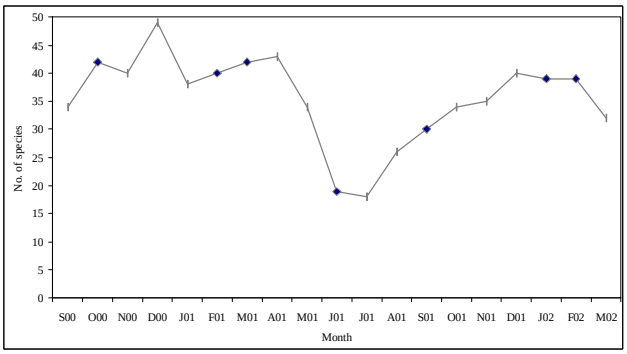
Population study of different species of birds from the area under study elucidated that it serves as a habitat for two main categories of birds a) Resident b) Migrant. The resident birds were further of two categories namely Local or Resident migrant (RM) & Resident (R)

Out of 69 bird species visiting the area under study, 11 species were migratory including Marsh Harrier, Golden Plover, Grey Plover, Blacktailed Godwit, Greenshank, Wood Sandpiper, Marsh Sandpiper, Little stint, Great Blackheaded Gull, Blackheaded Gull and Rosy Pastor. From the remaining, 21 species were of resident - migrants and 37 were resident. The resident migrants include predominantly Cattle Egret, Little Ringed plover, Common Sandpiper, Swallow, Blackwinged Stilt etc. while among resident, dominants



Graph 2: Variation based on habitat preference

were Pond Heron, Common Pariah Kite, Myna (all types) and Munias. The large number of resident species indicates that the area was conducive for them throughout the year. (Graph 2)



Graph 3 Monthly variation of the number of bird species

The total number of species visiting the area under study, increased from September to December 2000 (Graph 3) which include the winter migrants as well as residents. The species number dropped down below twenty in June and July 2001 and then again increased in pre-winter and winter period. During the low tide large mudflats were exposed and since the benthic fauna of the area was very rich, it must have attracted many varieties of birds in non-monsoon seasons. But in the months of June & July, because of large expanse of water due to heavy rains, some resident species might have migrated at nearby areas. While the winter & local migrants had returned to their homelands and only some resident species remained at the site reducing the number.

The total number of birds (Graph 4) were more than 1200 / day during winter months i.e. from December 2000 – March 2001 and November 2001 to February 2002 (for 4 months) in both the years. This can be attributed to winter migrants residing in the area under study during that period. In the month of May 2001 the number of birds again rose high which might be due to the fact that the area under study is on the return route of migratory birds such as Blacktailed Godwit, Common Sandpiper & Little Stint.

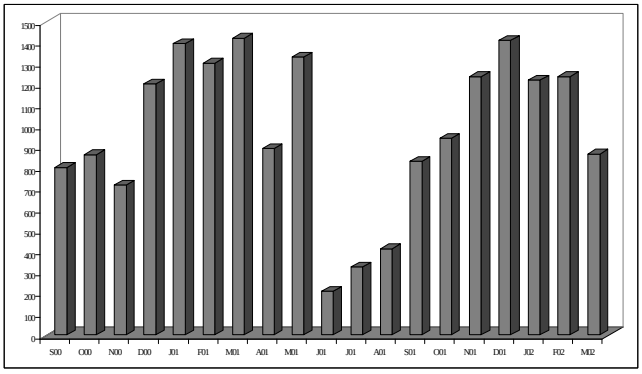
Table 1 : Check - list of Birds at Thane creek near Rutuchakra Nature Park, Thane

Sr. No.	**Serial No.	Order	Family	Common Name	Latin Name *
		PELECANIFORMES			
			Phalacocoracidae		
1	8			Little Cormorant	*Phalacocorax niger*
		CICONIIFORMES			
			Ardeidae		
2	12			Grey Heron	*Ardea cinerea*
3	16			Pond Heron	*Ardeola grayii*
4	18			Cattle Egret	*Bubulcus ibis*
5	14			Large Egret	*Ardeola alba*
6	20			Little Egret	*Egretta garzetta*
7	22			Night Heron	*Nycticorax nycticorax*
8	19			Median Egret	*Egretta intermedia*
		ANSERIFORMES			
			Anatidae		
9	45			Lesser Whistling Teal	*Dendrocygna javanica*
		FALCONIFORMES			
			Accipitridae		
10	75			Common Pariah Kite	*Milvus migrans govinda*
11	76			Brahminy Kite	*Haliastur indus*
12	106			Marsh Harrier	*Circus aeruginosus*
		GRUIFORMES			
			Rallidae		
13	148			Whitebreasted Waterhen	*Amaurornis phoenicurus*
		CHARADRIIFORMES			
			Charadridae		
14	161			Redwattled Lapwing	*Vanellus indicus*
15	165			Golden Plover	*Pluvialis apricaria*
16	164			Grey Plover	*Pluvialis squatarola*
17	166			Little Ringed Plover	*Charadrius dubius*
18	171			Blacktailed Godwit	*Limosa limosa*
19	174			Redshank	*Tringa totanus*
20	176			Greenshank	*Tringa nebularca*
21	177			Wood Sandpiper	*Tringa glareola*
22	175			Marsh Sandpiper	*Tringa stagnatilis*
23	179			Common Sandpiper	*Tringa hypoleucos*
24	186			Little Stint	*Calidris minuta*
			Recurvirostridae		
25	193			Blackwinged Stilt	*Himantopus himantopus*
26	194			Avocet	*Recurvirostra avosetta*
			Laridae		
27	204			Great Blackheaded Gull	*Larus ichthyeatus*
28	205			Brownheaded Gull	*Larus brunnicephalus*
29	206			Blackheaded Gull	*Larus ridibundus*
30	209			Caspian Tern	*Hydroprogne caspia*
31	211			Common Tern	*Sterna hirudo*
32	207			Indian Whiskerd Tern	*Chlidonios hybrida*
33	208			Gullbilled Tern	*Geleochelidon nilotica*
		COLUMBIFORMES			
			Columbidae		
34	226			Blue Rock Pigeon	*Columba livia*
35	233			Spotted Dove	*Streptopelia chineusis*
		PSITTACIFORMES			
			Psittacidae		
36	237			Roseringed Parakeet	*Psittacula krameri*
		CUCULIFORMES			
			Cuculidae		
37	251			Koel	*Eudynamis scolopacea*
		APODIFORMES			
			Apodidae		
38	278			House Swift	*Apus affinis*
39	279			Palm Swift	*Cypsiurus parvus*

Cont.....

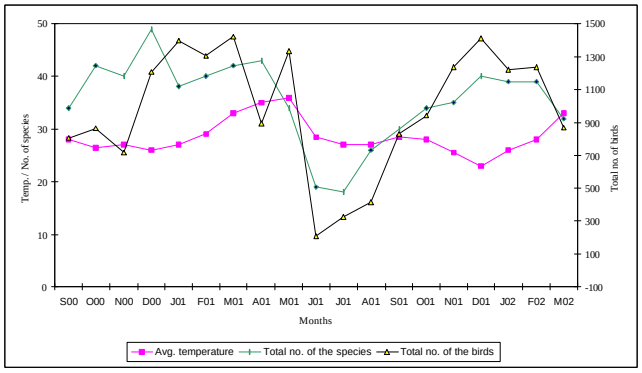
Sr. No.	**Serial No.	Order	Family	Common Name	Latin Name *
		CORACIFORMES			
			Alcedinidae		
40	284			Small Blue Kingfisher	*Alcedo atthis*
41	289			Whitebreasted Kingfisher	*Halcyon smyrnonsis*
			Meropidae		
42	295			Small Green Bee-eater	*Merops orientalis*
			Upupidae		
43	300			Hoopoe	*Upupa epops*
		PASSERIFORMES			
			Alaudidae		
44	332			Bush Lark	*Mirafra assamica*
45	333			Crested Lark	*Galerida cristata*
			Hirundinidae		
46	342			Swallow	*Hirundo rustica*
47	344			Wiretailed Swallow	*Hirundo smithii*
			Lamidae		
48	350			Rufousbacked Skrike	*Lanius schoch*
			Dicruridae		
49		356		Black Drongo	*Dicrurus adsimilis*
			Sturnidae		
50		369		Pied Myna	*Sturnus contra*
51		370		Indian Myna	*Acridotheres tristis*
52		367		Rosy Pastor	*Sturnus roseus*
			Corvidae		
53		380		House Crow	*Corvus splendens*
54		381		Jungle Crow	*Corvus macrorhynchos*
			Pycnonotidae		
55		402		Redwhiskered Bulbul	*Pycnonotus jocosus*
56		404		Redvented Bulbul	*Pycnonotus cafer*
57		403		Whitecheeked Bulbul	*Pycnonotus leucogenys*
			Muscicapidae		
58		448		Whitrbrowed Fantail Flycatcher	*Rhipidura auereola*
		PASSERIFORMES			
			Muscicapidae		
59		458		Streaked Wren Warbler	*Prinia gracilis*
60		456		Ashy Wren Warbler	*Prinia socialis*
61		481		Pied Bushchat	*Saxicola caprata*
62		479		Collared Bushchat	*Saxicola torquata*
			Motacillidae		
63		503		Yellow Wagtail	*Motacilla flava*
64		506		White Wagtail	*Motacilla alba*
65		499		Paddyfield Pipit	*Authus novacseelandiae*
			Ploceidae		
66		521		House Sparrow	*Passer domesticus*
67		532		Spotted Munia	*Lonchura punctulata*
68		527		Red Munia or Avadavat	*Estrilda amandava*
69		533		Blackheaded Munia	*Lonchura malacca*

(* Latin names are as per "Pictorial Guide of Indian Birds" by Salim Ali & Ripley, 1995)
(** Serial numbers are as per "The Book of Indian Birds" by Ali, 1996)



Graph 4: Monthly variation of total number of birds / day

Graph 3 indicates that the total number of species of birds visited in the 1st year of study were more than 2nd year of study. Similarly Graph 4 indicates that total number of birds visited during 1st year of study were also more than 2nd year of study. This can be attributed to slight high temperature in the month of September & October during second year of study (Graph 5) which might have prevented few of the early migrants from residing in the area under study and instead they might have shifted to near by areas.



Graph 5: Monthly variation of average temperature, bird species & total number of birds / day.

From the data it appeared that the earliest arrival period of migrants was early September, while late arrival period may begin in November. When there was an early arrival, population and variety of birds was also more (Vyawahare, 1986). This explained more species and number of birds in the year 2000 – 01 than in 2001 – 02. At the site, early to arrive were Little Stints & Common Sandpiper immediately followed by Blackwinged Stilts, which coincided with the observation, made by Vyawahare (1986).

Among winter migrants Little Stints were predominant, which were seen in congregations of 200-300 birds daily, from September to April 2001. Their number increased in the month of May 2001, which might be due to return migrants. Common Sandpiper, the resident migrant accompanied Little Stints, and form the 2nd dominant species. Blackheaded Gull and Rosy Pastor made their arrival in December and remained till April or May whereas Blacktailed Godwit arrived early i.e. in the month of October – November and remained upto early May.

Among resident birds, Cattle Egret and House Crow were found to be dominating and present more than hundred in number on any given day throughout the year, while Little Cormorant, Pond Heron, Gray Heron, though less in number were found throughout the year. In the landfill area Red Munia were found more in number than House Sparrows, especially during September, October, February & March.

Thus the observations made on total number of migratory and residential species inhabiting the area under study indicate, that it can harbour varieties of birds, which is due to suitable climatic conditions and environmental parameters. Thus though a long list of birds makes reading laborious, it is necessary for knowing the present status. Later a similar list will make it possible to evaluate the nature of extent of changes that have taken place, due to development of Nature Park.

ACKNOWLEDGEMENT

The authors are thankful to Nicholas Piramal India Limited & the Principal and the staff of Zoology Department of B. N. Bandodkar College of Science for their constant encouragement and support. Authors are also thankful to every member of HOPE the NGO actively working in the field of nature consurvation.

REFERENCES

Ali S. 1979. The Book of Indian Birds. Published by B. N. H. S. India

Ali S. & S. D. Ripley 1995. A Pictorial Guide to the Birds of the Indian Subcontinent. B. N. H. S. Oxford University Press.

Ali S. 1996. The Book of Indian Birds. B. N. H. S. Oxford University Press

Bhargavi S., C. Shrinivasulu, V. Nagulu, V. Vasudeva Rao & C. Koteshwarulu 1996. Avifauna of selected water-bodies in Northern Suburb of Secundarabad, Andhra Pradesh. Pavo Vol. 34, (1 & 2) : 87 – 94.

BNHS 2002. 'Mangroves of Thane creek for considering them as RAMSAR site.' Presentation made at Godrej by IBA officer M. Zafar (unpublished)

Borale R. P., J. V. Patil 7 P. M. Vyawahare 1994. Study of population of Local & Migratory (Aquatic) birds observed in and around Dhule City, Maharashtra Pavo Vol. 32, (1& 2) : 81 – 86

Borges S. & A. B. Shanbhag 2001. Seasonal changes in the Diversity profile of the birds on the mudflats of Chorao island in the Mandovi estuary of Goa. Abstract

unpublished.

Buden, D.W. 1992. Birds of the Exumas, Bahama Islands, Wilson Bull. 104: 674 – 698

Campbel B. 1979. Birds in colour, Blandford Press, Poole Dorset

Dharmakumarsinhji R.S. 1973: Migratory & resident Waterfowl, (Anatidae) of Bhavnagar District, Gujarat, India Pavo volume. II (1&2) : 33—60

Jarvinen, O and Vaisanen, R.A.1979. Changes in bird population as criteria of environmental changes. Holarctic Ecology, 2: 72 – 80.

Kannan R. 1998: Avifauna of the Anaimalai Hills (Western Ghats) of South India. Journal of Bombay. Nat. Hist. Soc. Volume. 95 (2) : 193 –214.

Maharashtra Nature Park (Mumbai) Checklist of birds. 2000

Morrison M. L. 1986. Bird populations as indicators of environmental change. In: Current ornithology, Vol. 3 Ed. R. J. Johnston, Plenum Publishing Corporation, London, U. K. pp 492 – 451

Prashant J. J., V. V. Rao & V. Nagulu 1994. Checklist of water-birds in two different habitat in Nellore (Dist.), Andhra Pradesh. Pavo Vol. 32, (1 & 2) : 63 - 73

Quadrus Goldin 2001. Study of Intertidal fauna of Thane creek Ph.D. Thesis. University of Bombay

Ravan P. H. 1992. The Nature and Value of Biodiversity. In: Global biodiversity strategy, Guidelines for Action to save, study and use Earth's Biotic wealth sustainability & equitability Ed. K. Courrier, WRI, IUCN & UNEP pp 1 – 5

Ripley, S.D. 1978. Changes in the bird fauna of a forest area: Simplipal Hills, Mayurbharj District & Dhankanal District, Orissa, J. Bombay Nat. Hist. Society 75 : 570—574.

Vyawahare p. M.1986. Study of migratory waders of Dhule, Maharashtra, Pavo Vol. 24 (1 & 2)

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 283-288

BEHAVIOURAL ECOLOGY AND PHYSICO-CHEMICAL ANALYSIS OF NEST OF CREMATOGASTER ANTS FROM MANGROVE FOREST.

Randive Jayant, Bhalerao A. M. and Modak Manisha
Post Graduate Research Centre, Dept. of Zoology, Modern College, Pune – 411 005.

ABSTRACT : Ethoecological observations are carried out on *Crematogaster* ants, occuring at mangrove forest area of Vikhroli region. These acrobat ants are usually found on the forest trees and construct a very peculiar nest. Soil and decaying vegetation are commonly used for the nest construction. Crematogaster ants protect scale insects on mangrove tree trunks and in turn feed on the honeydew like substance produced by these scale insects. Physico-chemical analysis of nest cartons collected from two different localities viz. Vikhroli and Tamhini forests, showed some interesting similarities as well as differences.

Keywords *: Ethoecology,* Nest of Crematogaster *ants, Mangrove forest, Vikhroli and Tamhini forests.*

INTRODUCTION

The ecosystems of mangrove forests are well known for their role in supporting diverse fauna. Incidentally, when we got the opportunity of visiting mangrove forest of Thane creek near Vikhroli, we were fascinated to see the peculiar type of ant nests on the branches of these trees. Field observations are carried out pertaining to nest construction and feeding habits of these ants. The ants which we observed on mangrove trees belong to genus *Crematogaster*, subfamily Myrmicinae and family formicidae of order Hymenoptera. About 14 genera are present under the subfamily and *Crematogaster* is one of them (Sudd, 1967). These insects are distributed in temperate as well as tropical parts of the world (Holldobler and Wilson, 1990). This group has many interesting features in relation to habitat – selection, polymorphism, food and feeding habits as well as best construction.

Literature survey indicated that *Crematagaster* ants are generally found on the forest trees. Hence, survey of Tamhini forest area (Mulshi, Dist. Pune) was also carried out to understand their occurrence, distribution and behavior pertaining to feeding and nest construction. Along with ethoecological observations on these ants, an attempt is also made regarding the preliminary physico-chemical analysis of their nests.

MATERIALS AND METHODS

For ethoecological observations and collection we have visited Vikhroli mangrove forest in Mumbai and Tamhini forest area near Mulshi Dam in Pune. Following materials were used during field and laboratory maintenance work.

1. Physical – Plastic bags, plastic bottles, pins, wooden cage and forceps.

2. Biological – *Crematogaster* ant colony with nest and plant twigs.

3. Chemical – 70% alcohol, honey, common salt, sucrose and water.

Crematogaster ants were observed on trees at the height ranging from 2.5 feet to a maximum of 20 feet. Small sized ant nest was removed from branches to which it was attached with the help of long forceps and metal rod. The nest along with the ant colony was then brought to the laboratory in perforated plastic bag. Selected individuals of ants were preserved in 70% alcohol at the collection site.

The samples i.e. ants and nests were collected from both the sites. In the laboratory the two nests along with ants and other developing stages were carefully kept in two different wooden insect cages. Twigs of host plant and four Petri dishes, one containing water, second with water and salt, third with water, salt and sugar and fourth containing diluted honey were kept in each wooden cage.

For morphological and morphometrical observations temporary slides were prepared and camera lucida drawings were also made. Photographs were of the nests were also taken in the field as well as in the laboratory.

As the nest cartons were containing decaying organic matter and fibrous tissues of plants, biochemical analysis of the cartons of the nests of *Crematogaster* ants from two different localities were carried out. Different constituents like cellulose, pectic substances, carbohydrates and total proteins were analyzed with the help of following well known and standard methods –

1. Estimation of cellulose by acetic-nitric reagent method (Updegroff D.M, 1969).

2. Estimation of protein by Lowry's method (Lowry O.H. et al, 1951).

3. Estimation of total carbohydrate by phenol-sulphuric acid method

(Dubois M. et al, 1956).

4. Estimation of pectic substances (Ranganna S, 1979).

OBSERVATIONS

MORPHOLOGY OF ADULTS

Two main types of castes were observed in the collected sample of colony, reproductive castes and non-reproductive castes. Reproductive caste consists of queen; drones while non-reproductive caste includes workers and soldiers.Morphometry of different castes is given in table no. 1.

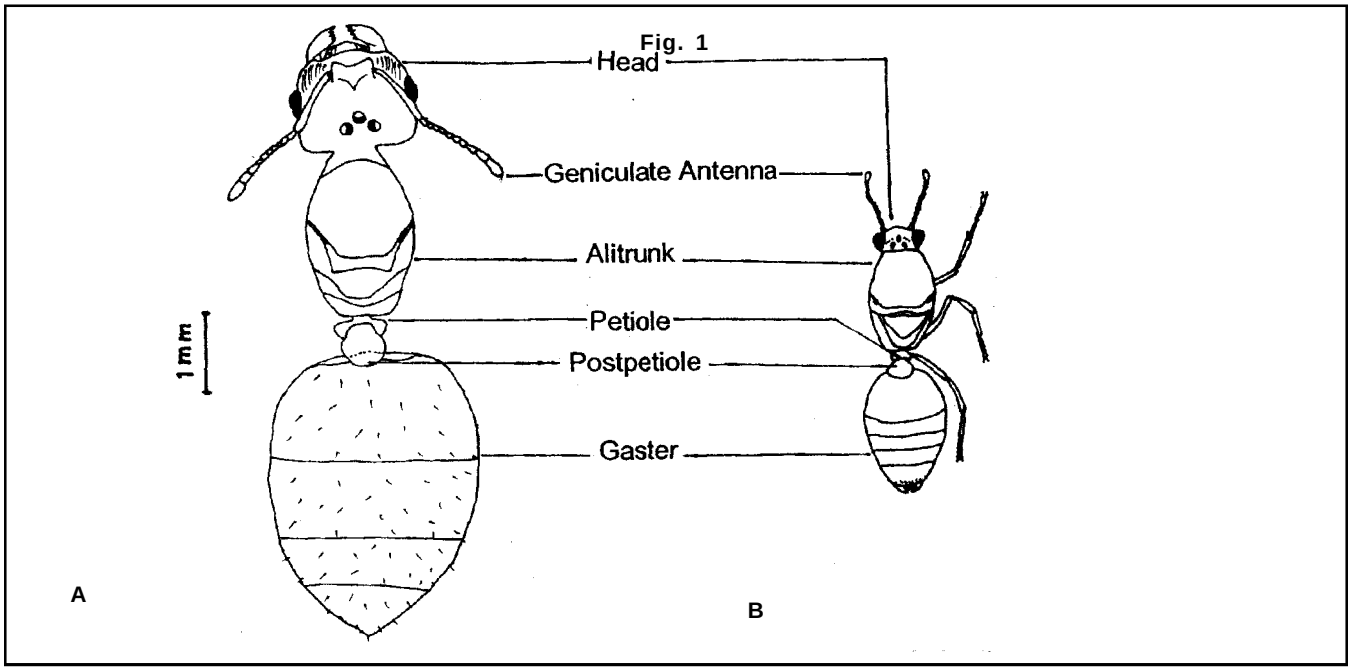
Table No.1

Caste	Head Width mm	Head Length mm	Pronotal width mm	Total length mm
Queen	1.69	1.41	1.12	7.9
Drone	0.58	0.33	0.14	3.48
Soldier	1.18	1.08	0.82	5.9
Media worker	1.02	0.90	0.67	4.9
Minor worker	0.83	0.73	0.53	3.9

Queen is about 7.9 mm in length. Body is divisible into three main regions i.e. head, alitrunk and gaster (Fig.1A). Head is broadly rectangular in shape and bears a pair of compound eyes, a pair of 11-segmented geniculate antenna, three district ocelli and mandibulate type of mouth parts. Alitrunk is the second major division of the body consisting of true thorax; the posterior end of which is fused to the first segment of the abdomen (propodeum). In queen propodeum is not distinguishable from thorax. Mesonotoum and metanotum are marked by presence of a pair of wings. Propodeum is attached to the gaster by the waist consisting of two segments i.e. petiole and post petiole. Gaster is heart shaped or roughly triangular in dorsal view. It consists of 4 segments and tapers towards the posterior end. It is capable of being bent forward over the alitrunk.

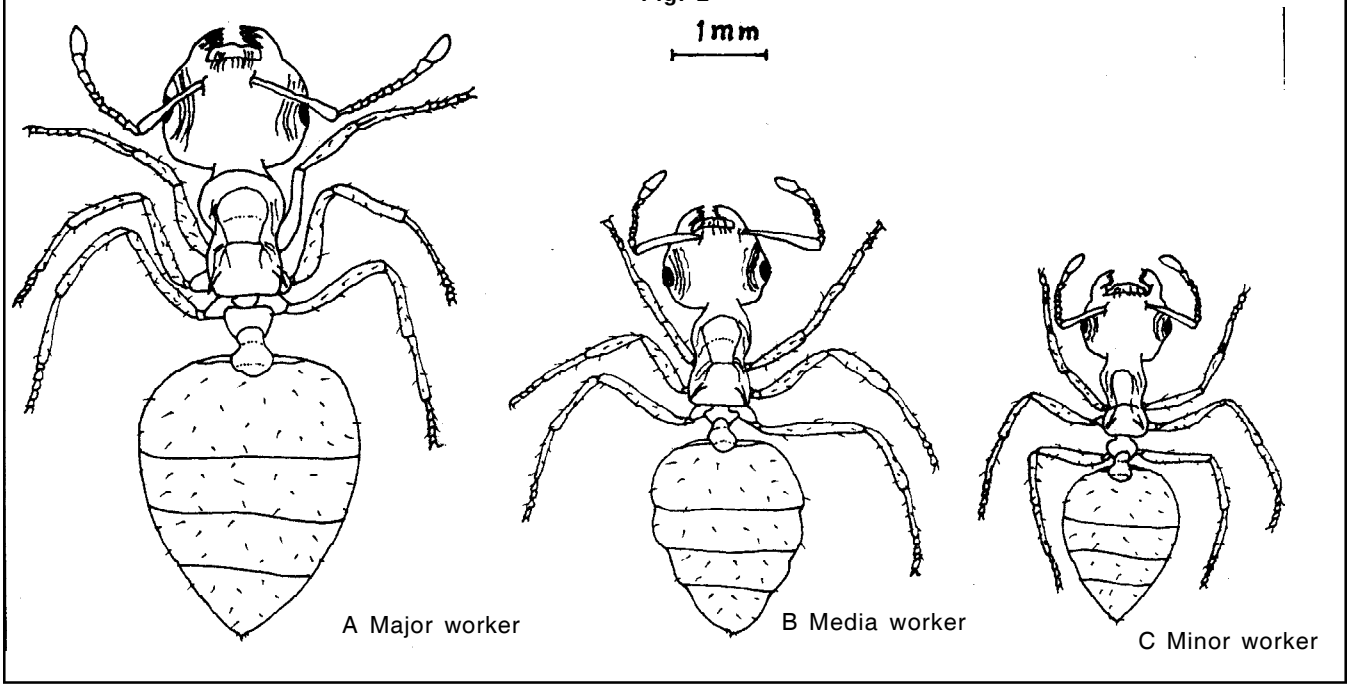
Drone is about 3.4 mm in length. Body is divisible in to three main regions i.e. head, alitrunk and gaster (Fig .1B). Head is roughly triangular in shape and bears a pair of antenna, a pair of compound eyes, 3 ocelli and mandibulate type of mouth parts. Alitrunk of drone resembles alitrunk of queen which bears 3 pairs legs. Gaster is heart shaped and consists of 5 segments.

Non-reproductive caste consists of 3 forms. Major worker (soldier), media worker and minor worker (Fig. 2 A, B, C). Morphology of these 3 forms is almost same, except that major worker is having highly scleortised mandibles. Head is having sculpturation in the form of concentric rings around compound eyes. Pronotum and mesonotum are not distinguishable from each other. These two segments are dome shaped or convex. There is sculpturation of striations on mesonotum and propodeum. Propdeal spines are strong, long, acute and upwardly directed. Propodeum is attached to the dorsal side of the first gastral segment with a waist consisting of two segments i.e. petiole and



Crematogaster Queen (with cut off wings and legs), Crematogaster Drone (with cut off wings)

Fig. 2



postpetiole. Petiole is dorso-ventrally flattened and with out a node. Gaster of workers is similar to that of queen.

ETHO-ECOLOGICAL OBSERVATIONS

Food and feeding habits

In the natural habitat, it has been observed that Crematogaster ants tend scale insects under loosened bark of the trees, which are in the form of small tents or shelters with small entrance holes. On some trees these scale insects are observed on the surface of the twigs exposed to outer environment. Worker ants frequently visit these scales and feed on viscous honeydew like substance excreted by the scales. It has been observed that worker ants feed on the honeydew in the groups of 10-12 individuals. Ants protect scale insects and in turn get sweet sugary substance from these scales. Occasionally some ants do carry these scales to their nests or away to new places, when they are disturbed

Crematogaster ants along with their nest were also maintained in the laboratory in the big insect cages. Ants also learned to visit the water tap of washbasin present near the cage and returned back to their nest. Occasionally, when freshly sacrificed cockroach was kept in the cage, the ants consumed only the body fluid of the cockroach leaving behind the hard, sclerotised body parts.

Co-operative Brood Care

While removing the nest from the branches of mangrove trees during sampling, the ants have been observed running, carrying eggs, larvae and pupae between their mandibles.

Similarly, in the laboratory, when the ants were maintained in the wooden cage (Plate1), occasionally some of them came out of wooden cage through the fine crevices, carrying developing grubs and pupae along with them. These ants were later noticed in the gap present between one side of the cage and the wall present near the cage. Pupal stages and grubs were observed in the central region, amongst the ants, indicating the co-operative brood care especially during the odd situations.

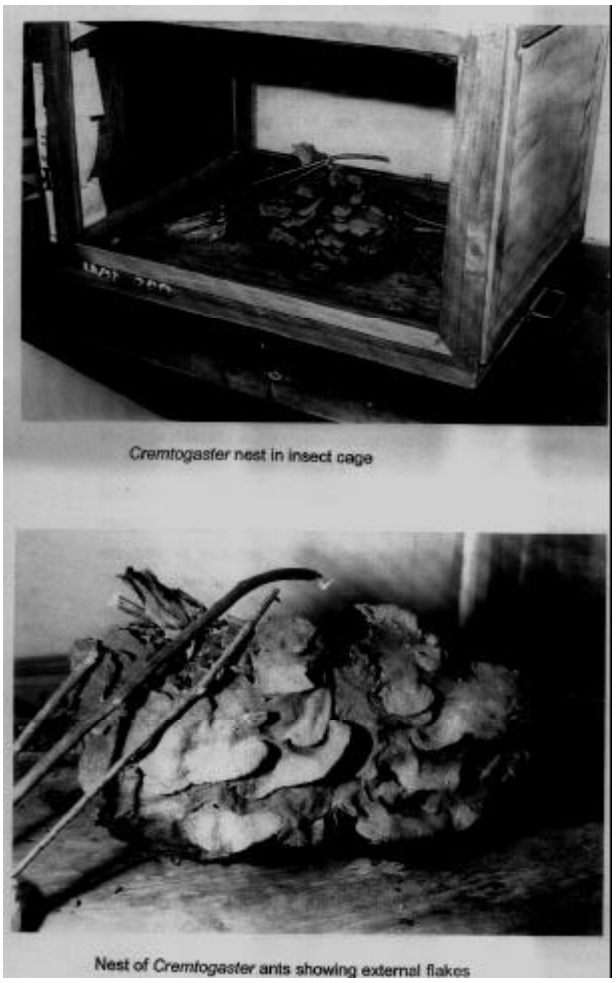
PRELIMINARY PHYSICO -CHEMICAL OBSERVATIONS ON NEST

The physico-chemical analysis of nest cartons collected from two different localities, viz. Vikhroli and Tamhini are carried out.

A. physical characteristics of habitats and nests collected from to different localities:

The two sampling areas or habitats are totally different from each other. The first habitat i.e. Vikhroli is located 25 km away from Mumbai harbour in the north. It has a very old mangrove patch with tall trees and it is one of the polluted areas along the west bank of Thane creek. Sewage water along with biodegradable and non-biodegradable domestic waste, which is released into the seawater, accumulates in this area. Some parts of this area get submerged during spring high tide. Thane creek is one of the biggest creeks in Asia with average rainfall of about 295 mm.

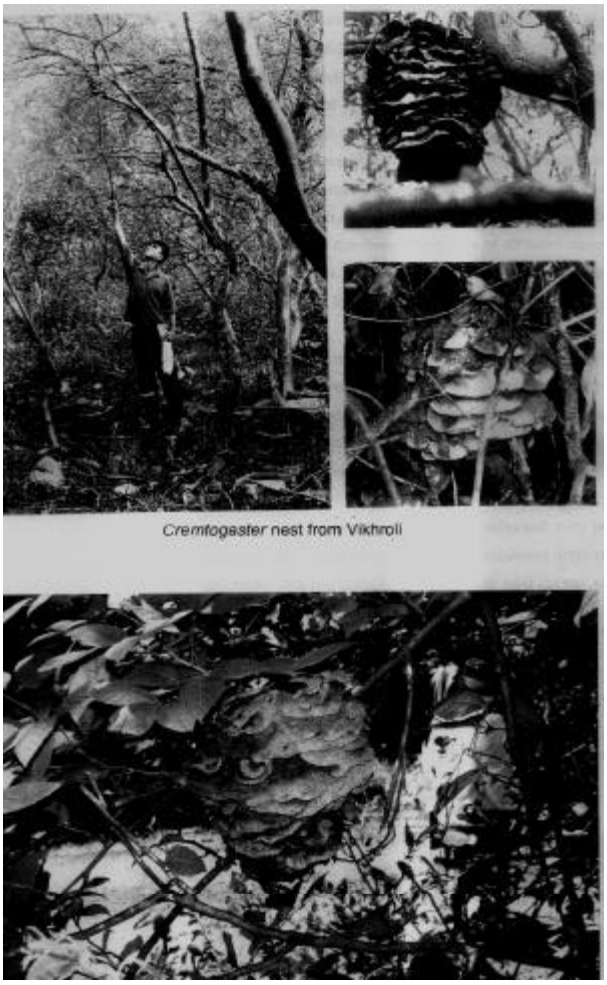
Plate 1



Cremtogaster nest in insect cage

Nest of *Cremtogaster* ants showing external flakes

Plate 2



Cremtogaster nest from Vikhroli

The second habitat or sampling locality i.e. Tamhini is situated about 75 km from Pune city in the west part of the district. It is a moist deciduous forest with rich plant and animal diversity. It is free from any type of pollution. The trees are with good canopy cover and *Crematogaster* nests are observed in the thorny bushes as well as high up on the trees.

Nest-

Crematogaster ant nests found in two different habitats superficially resemble with each other. They are observed in relatively undisturbed areas at a height ranging from 3 to 20 feet (plate 2). The nests were found attached to spiny bushes or trees to a single, wide stem or to 3-4 twigs. The position of the nest between spiny twigs was in such a way that no larger animals or humans can easily reach there.

The nest building starts with a single flake or carton. This first carton may be dried and loosened bark of the tree itself or the humus material carton. The nest grows by adding on flakes over and round the original one so that twigs are enveloped from one side. Cartons are dark brown or black in colour. All the flakes or carton pieces are firmly attached to each other. At the time of high tide, near Vikhroli site some nests remains submerged below the level of water, even then they do not break or the flakes do not separate from each other. The nest is having many entrances covered above by a flake like a roof so that the rainwater will drain properly. All the flakes or pieces of cartons are arranged in roof like manner in such a way that the rainwater will not enter the nest. In cross section, we can see many layers of interconnected cells of different sizes

B. Biochemical estimations of nest samples from two different localities [Vikhroli(sample 1)and Tamhini (sample 2)]

1. Total proteins -

After following the standard methodology, the total protein contents of two samples from Vikhroli and Tamhini respectively were estimated. It has been observed that sample 1 and sample 2 had almost equal amounts of protein i.e. 42 mg/gm of nest carton and 52 mg/gm of nest carton respectively (Graph: 1).

2. Total carbohydrates -

The total carbohydrate contents of nest cartons collected from two different localities were estimated by phenol-sulphuric method. Sample 1 contained 385 mg carbohydrates /gm of nest carton and sample 2 contained 467.5 mg carbohydrates/gm of nest carton (Graph: 1).

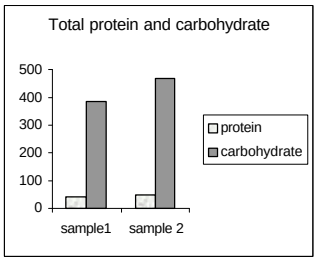
3. Cellulose contents-

The cellulose contents of nest cartons collected from two localities were estimated by acetic/nitric reagent method. Sample 1 contained 25% cellulose and sample 2 contained 35% cellulose (Graph: 2)

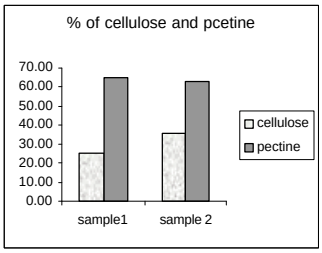
4. Pectic substances -

After following the standard methodology pectic substances present in two different samples are calculated. Sample 1 contained 65% pectic substances and sample 2 contained 63% pectic substances. The percentage of pectic substances present in two different samples in almost equal (Graph: 2).

Morphometrical observations of specific body Segments of different adult castes.



Graph: 1



Graph: 2

DISCUSSION

Crematogaster is an interesting genus under Myrmicinae with peculiar characteristics, which distinguish this genus from other genera. Observations carried out during the present work clearly indicated these distinguishing characters. Ability to bend the gaster over alitrunk is the most interesting peculiarity of this genus, which is not found in other genera. Moreover, the mode of attachment of post petiole to the gaster allows the very characteristics defense posture.

The Myrmicinae is the largest group of ants, most diverse and generally regarded as being very advanced. Diet is varied, ranging from species that are quite carnivorous, with many being omnivorous to some that are more or less completely phytophagus and live either on seeds or nectar or on fungi. *Crematogaster* ants under present investigation observed feeding on honeydew secreted by scale insects. Many *Crematogaster* species collect honeydew avidly.

Some ants encourage aphid and coccoid infestation by guarding the bug and protecting them from predators and parasites in return for receiving the honey dew excreted by the bugs. In extreme cases the ants actually construct small aerial subnests as shelters for scale insects, which are reared inside. Most species of *Crematogaster* belong to this category and many other species practice this husbandry to greater or lesser degree.

The two different localities or habitats viz. Vikhroli and Tamhini, from which *Crematogaster* ants were collected, show different flora and fauna and different environmental conditions. These factors must be having some role to play on life activities of these ants. Vikhroli mangrove forest is marshy, brackish water area polluted with industrial effluents as well as domestic waste of the city, which is released into the seawater. Inspite of polluted water, mangrove trees show good canopy cover.

On the other hand Tamhini forest area is moist deciduous forest with almost no pollution. Trees with good canopy cover and presence of thorny bushes provide relatively undisturbed protective shelter to these ants for the construction of nests. Decaying organic matter provides a very good material for construction of nests. Ants must be using their head glands secretions for compounding the material together.

During the present work, it is observed that some *Crematogaster* ants inhabiting in dead bamboo wood in Mulshi forest area and also inhabiting in tree trunk at Sinhagad forest area.

During the present work it was found that the structure of nests present in two different habitats viz. Vikhroli and Tamhini are more or less same. It was thought there might be some similar amount of substances, macro or micro molecules in the carton of these two nests. Hence biochemical analysis of the cartons of these two nests was carried out. The cellulose contents of the sample 1 (from Vikhroli) is 98 mg/g of sample where as, cellulose content of sample 2 (from Tamhini) is 168mg/g of the sample. The marked differences in the cellulose content of these two samples may be due to the presence of plant diversity in two different localities. In Vikhroli mangrove forest, there is almost monoculture of plants and it is a marshy area with polluted water having acidic industrial effluents. These acidic effluents may be causing more degradation of cellulose. On the other hand in Tamhini forest, there is large diversity of plants and cellulose contents of different plants may be more or less different. Due to

absence of any type of pollution and relatively less water in the soil, there might be less degradation of cellulose. Hence, cellulose contents of the nest found in this area are more as compared to those contents found in the nests of Vikhroli.

The total protein contents and pectic substances of the sample 1 and sample 2 are almost the same. However the total carbohydrate contents showed marked differences.

Salivary and other head gland secretions of the ants might be having some effect on the nest carton material or there might be some environmental effects on this nest material due to which amount of above estimated compounds are showing similarities in some cases and differences in others.

How *Crematogaster* ants under the present study must have been evolved to live in two such diverse habitats is a question of interest. Further biological and etho-ecological observations are necessary to know more about this interesting biotic community.

ACKNOWLEDGMENT

The authors are thankful to Mr. A.G. Gosavi, Principal and Dr. H.V. Ghate Head, Department of Zoology, Post Graduate Research Center, Modern College, Pune – 411005 for providing laboratory facilities.

We are also extremely thankful to Prof. Dr P.V. Joshi research adviser, and Mr. Mahesh Shindikar research fellow and other member of research team of man grow of thane creek for there necessary help and guidance during field work.

Thanks are also due to Mr. Nilesh Rane Lecturer, Department of Zoology, Post Graduate Research Center, Modern College, Pune – 411 005 for excellent photography work and necessary help.

REFERENCES

Dubois, M., K.A. Gilles, J.K. Hamilton, P.A Rebers. and , F Smith (1956), *Anal Chem* 26: 350.

Hill D. S. (1994): Agricultural Entomology, Timber Press, Portland, Oregon, pp. 535-537.

Holldobler B and Wilson E.O. (1990): The ants, Harvard University Press, Cambridge, Mass. 732 p.

Krishnaveni, S. Theymdi Balasubramanian and Sadasivam, S (1984) *Food Chem* 15: 229.

Lowrey, O.H.. N.J. Rosebrough, A.L. Farr and R.J. Randall (1951); *J. Biol. Chem.* 193: 265.

Matoo, R.L. (1970); Indian J.Biochem. 7: 82.

Ranganna, S. (1979) Manual of Analysis of Fruit & Vegetable products Tata MC Grav – Hill Poubl. Co. ltd., New Delhi Pg. 634.

Sadasivam S. and A. Manickam (1992): Biochemical Methods for Agricultural Sciences, Wiley Eastern Ltd., Pg. 10, 13-4 and 17-18.

Sudd J. H. (1967) An introduction to the behavior of ants, Edward Arnold Publishers Ltd., London, Pg. 1,65-72.

Updegroff, D. M. (1969) *Anal. Biochem* 32: 420.

SOME OBSERVATIONS ON TEAK DEFOLIATOR *HYBLAEA PUERA* (LEPIDOPTERA: HYBLAEIDAE) ON SECONDARY HOST PLANT *AVICENNIA MARINA*

Naresh Chaturvedi
Curator, BNHS
Hornbill House, Dr. Salim Ali Chowk (opp. Lion Gate),
Shahed Bhagat Singh Road, Mumbai 400 023.

The *Hyblaea puera* is one of the most important pests of the teak as it attacks the younger leaves of the plants affecting the overall growth of the tree. It is found in the tropical habitat of oriental and Australian region.

Host plants: Though the teak is the principal host plant of the *Hyblaea puera* it is known to feed on 28 other species of the plants of the family Verbenaceae, Bignonacea, Areliaceae, Juglandaceae and Oleaceae (Beeson 1941; Mathur 1960 and Mohandas 1986). Most of them are tree climbers and shrubs. However in 1979 the species was observed to feed on the leaves of *Avicennia marina*, a mangrove species. The subsequent observations were reported in 1995 by the author (Chaturvedi, 1995). The new host plant *A. marina* also indicates a new habitat to the species as most of the host plants reported earlier are land species.

In 1979 it was observed that the mangrove vegetation of the Mahim creek area which usually appears green from the distance had turned brown. On a closer look of the mangrove plants of this area it was observed that the leaves were dried, and curled. On opening some of these leaves they were found to be skeletonised and enrolling a pupa in it. A few pupae were collected for observing the emergence and the moths emerged from them after 3 days were identified as of *Hyblaea puera.*

Subsequent observations on this species showed that the larvae of this moth mainly feed on the green tissues of the leaves thereby skeletonising them. These moths are small in size with a wing span of 3-4 cms. When at rest the greyish brown forewings cover the dark brownish black hind wings having light orangish markings.

Life cycle: The moth is multivoltine and known to have 14 generations in a year, on teak plantation (Beeson, 1941), but very little is known on the number of generation it produces on *A. marina* in a year. However various stages of life cycles have been observed between June to September months and subsequently in January to March. The highest population of the moth was recorded in 1995. When most of the *A. marina* patches along the eastern coast of the Mumbai city were attacked by this moth. Thousand of these moths emerged during the end of September and October were attracted to the powerful lights installed during the Navratri festival of that year.

The mass emergence of *Hyblaea puera* during this period had also affected the working of 5 plants in the Godrej Boyce premises at Vikhroli, which were shut down for a while due to nuisance of these moths. However during this period the mangrove along the western coast of Mumbai were not much affected. In 1995 thousand of the moths were also reported from the mangrove habitats along the western coast of Maharashtra and Goa. It was interesting to note that though teak trees present in the nearby areas like Sanjay Gandhi National Park, Thane, Panvel etc. were not affected by this moth in this period.

Parasites: Nair (1988) had reported 34 species of insects (Diptera and Hymenoptera) as parasites of the teak defoliator but nothing is known on their studies on *A. marina.*

Predator: The predators mainly birds which feed on larvae and pupae of the *H. puera* were observed in the Mahim creek and Vikhroli, mangroves include House Crows, Jungle Crows, Cattle Egrets, Jungle Babbler and Common Mynahs.

These observations on *H. puera* infesting *A. marina* are limited and there is need for an exhaustive study on the ecology of *H. puera* on *A. marina.*

REFERENCES

Beeson, C.F.C. 1941 The ecology & control of forest insects of India and the neighbouring countries. The Vasant Press, Dehradun (1961 Reprint).

Chaturvedi, Naresh 1995 A New alternate Host Plant of Teak Defoliator *H. puera* (Hyblaeidae: Lepidoptera), *J. Bombay nat Hist Soc* 92(3): 431.

Mathur, R.N. 1960 Pests of teak and their control, *Indian Forest Record* 10: 43-65.

Mohandas, K. 1986 A new host record for the teak defoliator *Hyblaea puera* (Lepidoptera Hyblaeidae), *Current Science* 55 (23): 1207-1208.

Nair, K.S.S. 1988 The Teak Defoliator in Kerala, India (Chapter 14), *Dynamics of Forest Insect Populations*. Plenum Publishing Corporation.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 290-292

OCCURANCE OF SCALE INSECT *ICERYA* SPP. ON MANGROVES OF THANE CREEK &ULHAS RIVER ESTUARY, MAHARASHTRA, INDIA

Hemant V. Karkhanis and R.P.Athalye
Dept. of Zoology, B.N.Bandodkar college of Science, Thane (W.). 400601.

ABSTACT: A survey of insect pests of mangroves of Thane creek & Ulhas river estuary was carried from Oct.2001 to Sept.2002.The study was done in the Riverine, middle & seaward zones of both the ecosystems. During the study heavy infestation to mangroves (*Avicennia marina marina, Avicennia marina acutissima, Avicennia officinalis, Sonneretia apetala)* by scale insect *Icerya* spp. was observed from March to May-June. The scale insect population declined in monsoon season, got re-established in post-monsoon and flourished from March to June. In future the insect pest may cause serious damage to mangroves and near by vegetation. Hence it should be properly studied and attempts should be made to control it.

Key Words : Cottony cushion scale- Icerya spp., Mangroves, Thane creek, Ulhas river estuary

INTRODUCTION

Insect pests cause heavy damage to plants and trees leading to significant economic loss. Mangroves are not exception to this. There are many reports on the insect pests of mangroves. Peter and Sivasothi (2001) have given detailed information on pests of mangroves of Singapore. Ferguson (1993) & Keiru (1993) have reported significant information on pests of Mangroves along the Kenya coast. Chaturvedi (1994) noted occurrence of teak defoliator moth *Hyblaea peura (Lepidoptera)* on mangroves along Thane creek. A detailed study of insect pests of the Mangroves of Thane creek and Ulhas river estuary has not been done so far. Hence a survey of this region was undertaken. Occurrence of scale insect-*Icerya* spp. a common pest of *Citrus* has been reported in this paper.

MATERIALS AND METHODS

Insect collection was done from Oct.2001 to Sep.2002 by insect collection net & by hand picking mainly for the scale insect *Icerya* spp. For collection, 3 zones were imagined in Thane creek (Long 72º. 55" to 73º. 00" E & Lat 19º. 00" to 19º. 15"N & Ulhas river estuary (Long 73º. 20"E & Lat 18º. 45" N to 19º. 16" N)-1] Riverine zone, with more fresh water influence(Stations 1 to 4 and 13 to 16), 2]Middle zone, with intermediate salinity (Stations 5 to 8 and 17 to 20) and 3] Seaward zone, with higher salinity (Stations 9 to 12 and 21 to 24) (Fig.1)

The insects were studied from each zone. Observations on *Icerya* spp. are presented in this paper.

RESULTS AND DISCUSSIONS

Icerya spp. is familiar species of scale insect is commonly known as cottony cushion scale due to the cottony secretion on its body (Fig. 3). In the present study the species of the scale insect *Icerya* (Fig.2) could not be confirmed.

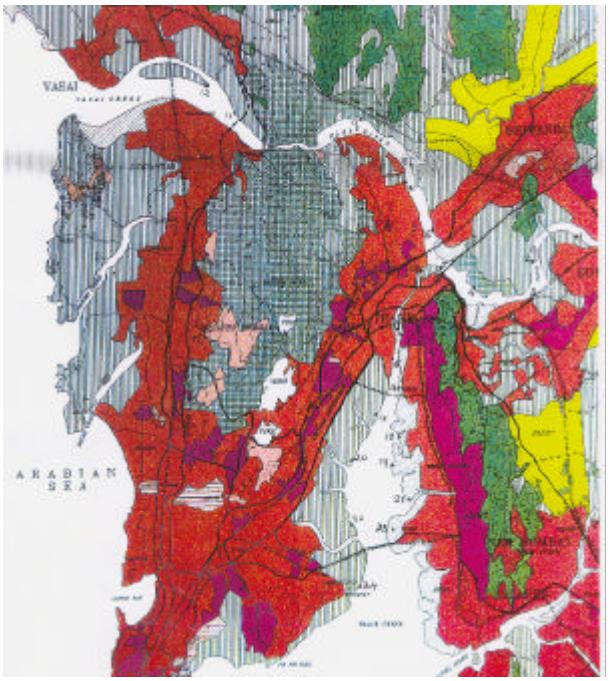


Fig.1-Map of Thane creek & Ulhas river estuary

Cottony cushion scales frequently attack Citrus & Pittosporum in Florida (Gossard, 1901). However, they also attack other host plants (Fasulo and Brooks, 2001). In Australia this insect seriously affects almost 30 plant species, 16 endemic species, c*itrus* plants and other cultivated plants (Gossard, 1901). *Icerya* can severely damage trees, resets and nursery stocks, decrease tree's vitality. Fruit drop and defoliation results from the feeding of this scale. Most damage occurs due to the feeding of early immature stages on the leaves where they settle in rows along midrib veins and smaller twigs. Older nymphs migrate to larger twigs and as adults they settle on larger branches and trunks. Added damage can result from the accumulation of sooty mold due to honeydew secreted by the scale (Maskell, 1878).

Table 1 Zonewise and monthwise occurrenceof Scal Insect- *ICERYA* SPP.

MONTHS ZONE	RIVERINE ZONE	MIDDLE ZONE	SEAWARD ZONE	RIVERINE ZONE	MIDDLE ZONE	SEAWARD	TOTAL POINTS INDICATING DEGREE OF INFESTATION
	Thane creek			Ulhas river estuary			
October 01	++	+	-	+	-	-	4+
November 01	+	+	+	-	+	+	5+
December 01	-	+	++	+	+	+	6+
January 02	-	+	+	-	+	-	3+
February 02	+	+	++	+	-	+	6+
March 02	++	-	++	+++++	++++	+++++	18+
April 02	+++	++	++++	++++	++	+++	18+
May 02	++	+++	++	++	+++	++	14+
June 02	+	++	+	+	+	-	6+
July 02	+	++	+	-	-	+	5+
August 02	+	+	-	+	-	-	3+
September 02	-	-	-	-	+	-	1+
TOTAL POINTS INDICATING DEGREE OF INFESTATION	14+	15+	16+	16+	14+	14+	89+

_ not found + very rare ++ rare +++ moderate ++++ heavy +++++ very heavy

Table 2 MONTHWISE OCCURRENCE (+POINTS) OF ICERYA SPP. ON DIFFERENT MANGROVES

MONTHS	Avicennia marina marina	Avicennia marina acutissima	Avicennia officinalis	Sonneretia apetala	TOTAL INDICATING DEGREE OF INFESTATION
October 01	++	-	-	-	2+
November 01	++	+	-	-	3
December 01	+++		-	-	4+
January 02	++	++	++	-	6+
February 02	++	++	+++	++	9+
March 02	+++	+++	++++	+++++	15+
April 02	++	++++	+++++	+++++	16+
May 02	+++	+++	++++	++++	14+
June 02	+	-	+++	++	6+
July 02	+	+	++	+	5+
August 02	-	+	-	-	1+
September 02	-	-	-	+	1+
TOTAL POINTS INDICATING DEGREE OF INFESTATION	21+	18+	23+	20+	82+

_ not found + very rare ++ rare +++ moderate ++++ heavy +++++ Very heavy



Fig.2- *Icerya* spp



Fig.3 –*Icerya* in its cottony cushion

In the present study the scale insect *Icerya* spp. was found to infest the dominant mangrove species of Thane creek and Ulhas river estuary viz. *Avicennia marina* var. *marina, Avicenniamarina* var. *acutissima, Avicennia officinalis, Sonneratia apetala* (Table 2). The total points indicating degree of infestation show the decreasing order of infestation as *A. officinalis* (23 +) > *A. marina marina* (21 +) > *S.apetala* (20+) > *A. marina acutissima* (18+). The difference however was marginal. The infestation occurred in all the zones but was marginally high in the Riverine zone of Ulhas river estuary and seaward zone of Thane creek (Table 1). Month wise trend showed decrease occurence in monsoon probably due to susceptibility of the scale to the heavy rainfall pattern of this zone (probably it acts as a natural controlling factor). The insect reestablished in the post monsoon months to reach heavy infestation in March to June (Table 1 & 2). During this favorable period they heavily infested *A.officinalis* and *S.apetala* (Table2). During March- April the infestation was so heavy that the scales were dropping from the leaves and the field below became white due to the secretion of the insects. They were also seen carried away with the water current. The insects were found to settle on the undersurface of the leaves so as to get protection from rain and sunlight. When heavily infested, the plant looked dull with curled leaves, but this did not cause death of the larger plants.

The scale so far has not caused significant damage probably as heavy rainfall in this region naturally controls it. However, it is likely that the infestation may become significantly dangerous whenever there is less rainfall in a particular year. In the present year there was low rainfall hence there are more chances of heavy infestation by the scale in March to May 2003. It can also spread to other trees and crops. Hence it is necessary to study the scale & also make attempts to control it using the predatory ladybird beetle *Vadalia* spp. or any other suitable method.

CONCLUSION

1. Cottony cushion scale *Icerya* spp. causes heavy infestation to mangroves (espatially *A.officinalis* & *Sonneretia apetala*) in the months March – June.

2. Though it is found to be naturally controlled by monsoon rainfall, there are chances of its spreading to near by trees, crops & also becoming serious pest in future.

Hence a detailed study of the scale and efforts to control it are essential.

REFERENCES

Chaturvedi H. 1979. A new alternative host plant of teak defoliator *Hyblaea peura,* JBNHS Vol.92, 1995 p. 431.

Fasulo , T.R. and R.F. Brooks 2001. Scale pest of Florida *Citrus*. UF/IFAS ENY 814 (September 2001)

Ferguson and Keiru 1993 Information from Internet about Mangroves of Kenyan cost.

Gossard H.A. 1901 The cottony cushion scale, Florida Agri. Exp.Sta. Bull. 56: 309- 356

Maskell, W.M. 1878 On some Coccidae in NZ, Trans. Proc.NZ Inst. 11: 220-223

Peter K.L. Ng and N. Sivasothi 2001 A guide to Mangroves of Singapore

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 293-295

STUDIES ON WOOD BORERS FROM THE MANGROVES OF MITHBAV CREEK

S. G. Yeragi and S. S. Yeragi
Dept. of Bio Sciences,
K. J. Somaiya College of Science, Vidyavihar, Mumbai – 400 077.

ABSTRACT : Thick belts of mangrove are present on both the sides of Mithbav creek (L. 16°, 20' N, L. 70°, 25' E). Last forty years, hectors of agricultural land is covered by new belts of mangrove swamps. The present paper deals with the marine organisms boring into the wood of the mangroves. Two species of molluscan and one species of crustacean borers were recorded. The comparative observations on size frequency distribution and abundance were made. Molluscan borers appeared to infect M_1 and M_2 regions plants, whereas plants of M_3 areas were attacked by crustacean borers. *Bankia indica* was the most abundant of the live molluscan borer, while *Martesia striata* (Linn) ranked next. The occurrence of the crustacean borer, *Sphaeroma spp*. was through the creek but abundant at M_3 region due to salinity.

Key Words : Mangrove, Borers, *Mithbav*

INTRODUCTION

Deforestation of the mangrove plants is mainly due to aquaculture practice in Mithbav creek, which affects the productivity of the creek heavily. It is an important protective environment for varieties of commercially important organisms for breeding, spawning and fast growth. Now-a-days number of crafts in the creek are limited. The Fishermen are taking maximum cares of their crafts and timbers by using anti-borers, hence, the spats are densely settled in the mangrove regions.

Biofilm is an excellent nutrient broth medium coated around the tree trunks of mangrove. Microbial cells attach firmly to almost any surface submerged in an aquatic environment. The immobilized cells grow, reproduce, and produce extra cellular polymers which extend from the cell forming a matrix of molecular fibres that provide structure to the assemblage termed a biofilm. Microorganisms growing on the wood substrate may improve its overall nutritional quality. Due to heavy escote of pneumatophores the plants do not directly exposed to water current, hence, the rate of formation of 'biofilm' is very fast and they remain for longer time. Biofilms serve beneficial purposes in natural environments especially for parasites, borers etc., It is also observed that, the old plants were heavily infected than the young ones. The population density of borers was more amongst the old trees than the young ones.

The lack of a mangrove management system has led to the beginning of deterioration of this valuable coastal vegetation.

Although the economic damage costs due to molluscan borers are considerably higher than those due to crustacean borers. Borers deserve attention not only because they are detrimental to the national economy but also because of their varied and interesting biological characteristics. They play an important role in the recycling of wood in the oceans.

For the better understanding of preventive measures against borers, knowledge of their ecology, distribution, seasonal variation, physiology and taxonomy is necessary.

MATERIALS AND METHODS

Study area

Wood-borers, collected from three mangrove swamp sites were examined. These sites were M_1 (5.0 Km North-East), M_2 (6.0 Km North-South) and M_3 (8.0 Km East, North-South) of Mithbav creek (fig. 1). Mangrove woods from all the three stations were collected weekly.(fig. 1) General Survey of the wood, biofilm and surface organisms was done and then the woods were dissected to remove individual borers form their burrows. Holes on the surfaces of the wood samples were counted prior to dissection to obtain an estimate of the number of organisms that settled and succeeded in penetrating the wood. The sizes of the holes were noted, these give an indication of the main type of borer that is, either Teredinid or pholadid. The total length of each borer was measured correctly to 0.1 mm.

RESULTS AND DISCUSSION

M_1 region

Mangroves in this location flourish over a vast area, but only at Northern area. There are big lagoons which are densely populated by four species of mangroves in which *Avicennia officinalis* (Linn) and *Rhizophora mucronata* (Lamk) are dominating. Water having a high saline content covers the mangrove that grow. The plants more than one meter high are covered completely by the water at high tide. The leaves of the

plants, when they become submerged at high tides, act as a substratum for the settlement of barnacles. The substratum is hard as well as soft. The salinity ranging between 10-32% during the year, decreasing to 10% in July-September depending upon the monsoon rains.

M_2 region

A moderately wide belt of mangrove swamps on both the sides. Many small and big lagoons as well as an aquaculture plants are associated on both the sides. The soil of this region is of fine sand particles and has a pungent odor due to hydrogen sulfide gas. The substratum varies in character from place to place.

M_3 region

Relatively more mangrove swamps are found at North-South as well as East area. The mangrove tidal flats of M_3 region are characterized by an uneven substratum crossed irregularly with tidal channels.

Instead of forming a continuous belt, the mangroves grow in pockets of various sizes. The vegetation is not dense and therefore, there is less shade which undoubtedly affects the faunal distribution.

Molluscan Wood borers

One species of pholadid and two species of teredinid wood borers were recorded from Mithbav creek mangroves. Intrime notes of their ecology and distribution follow. *Martesia striata* (Linn) is the only representative of the family martesinae. The number and dimension of individuals are given in table 2.

Table 2 : Number and dimensions of *Martesia striata* (Linn) shells from Mithbav Creek (Mean ± ISD)

Month	Location	Number	Shell Lehgth mm	Shell Diameter mm
Feb. 94	M_1M_2	4	2.40	1.5
March	M_2M_3	8	2.42	1.5
April	M_2M_3	21	1.62 ± 0.42	0.8 ± 0.02
May	$M_1M_2M_3$	28	1.83 ± 0.62	0.9 ± 0.03
June	M_2	3	1.21 ± 0.31	1.0
July	—	—	—	—-
August	M_2M_3	2	2.31	1.0
Sept.	$M_1M_2M_3$	6	1.52 ± 0.04	0.8 ± 0.3
Oct.	M_2M_3	3	1.62 ± 0.03	0.8 ± 0.6
Nov.	M_3	2	1.40 ± 0.42	0.7 ± 0.28
Dec.	M_2M_3	4	2.10 ± 0.13	1.4 ± 0.21
Jan. 95	M_3	2	2.14 ± 0.21	1.3

Two teredinids borers were recorded from the mangrove woods namely *Bankia indica* and *Dicyathifer manni*. The seasonal occurrences and size ranges of two species from three localities are given in table No. 3.

Table 3 : Seaspnal Occurance and Morphometry of B. Indica and D. Manni

Month	Bankia Indica	Dicyathifer manni
Feb. 94	1.52 ± 0.34 (12)	4.1 ± 2.12 (3)
March	6.32 ± 2.12 (24)	3.24 ± 0.61 (3)
April	6.41 ± 1.32 (11)	6.14 ± 3.12 (6)
May	5.21 ± 0.25 (4)	5.13 ± 2.1 (8)
June	4.23 ± 0.34 (2)	4.32 ± 1.2 (10)
July	4.36 ± 1.45 (5)	7.12 ± 1.23 (11)
August	2.19 ± 0.34 (3)	3.61 ± 2.1 (7)
Sept.	5.21 ± 0.23 (13)	2.51 ± 0.21 (5)
Oct.	3.24 ± 1.23 (51)	5.23 ± 2.1 (3)
Nov.	4.81 ± 2.12 (32)	2.91 ± 1.3 (4)
Dec.	6.21 ± 1.5 (7)	3.12 ± 1.2 (1)
Jan. 95	2.91 ± 1.21 (1)	4.21 ± 0.31 (4)

Generally mangrove woods are more susceptible to borer attack and are therefore heavily infested. It is noticed that *Rhizophora* is more susceptible than *Avicennia.* It is also observed that coating of Biofilm on *Rhizophora spp*. always was thicker than Avicennia spp. The biofilm is directly related with the population density of wood borers. It is also noticed that, if the surface area is clean by removing the biofilm, then the infestation of borers is less. The spats of the borers get readymade nutrient, protection and easy attachment in the biofilm. It is also seen that the wood of mangrove tree is soft and easy for boring than *Mangifera spp*. and *Calophilum spp*. The crafts of Mithbav creek are made up of such woods only because of less infestation of borers.

Crustacean Wood borers

Sphaeroma spp. is the crustacean wood borer, causing much damage to the wooden crafts. The population density of *Sphaeroma spp*. is more at M_3 region because of low salinities. This species can only withstand at low salinities. In Mithbav, this species has been observed in the mangrove wood of M_2 and M_3 regions only. Their absence in M_1 region mangrove might reflect their incapability to tolerate high salinities. Seasonal variation of *Sphaeroma spp*. abundance is shown in table 1. The specimen were collected from Feb. 1994 to January 1995. The data showed that *Sphaeroma*

Table 1 : Seasonal abundance of Sphaeroma Sp. from M_1, M_2 and M_3 regions of Mangroves swamp (Mean + ISD)

Month	Number	Carapace Length (mm)
Feb. 94	13	9.0 ± 0.005
March	18	9.0 ± 0.13
April	12	8.0 ± 0.16
May	13	9.0 ± 0.14
June	4	9.0 ± 0.11
July	0	—-
August	8	9.0 ± 0.5
Sept.	3	9.0 ± 0.21
Oct.	126	7.6 ± 0.13
Nov.	110	7.0 ± 0.21
Dec.	121	6.0 ± 0.11
Jan. 95	115	8.0 ± 0.13

(pill bugs) is markedly seasonal in occurrence, being most abundant from October to December. The size of individuals ranged between 6.0 to 9.0 mm.

Species composition

The percentage composition of teredinid borers from M_1, M_2, M_3 is shown in table 4? It is evident that *B. indica* is the dominant species. From the table, it can be seen that October, November and January months were peak for *B. indica* compare to *Dicyathifer manni. B. indica* formed the major component of samples obtained from M_2 and M_3 regions.

D. manni percentage composition was low throughout the year except in June, July and August.

Mangroves have become of great economic significance both in terms of their direct resources utilization of forestry and fishery productions and in terms of their indirect potential as protecting coastlines and maintaining estuarine ecological balance. Mangrove forests have been depleted and subjected to various stresses originating from human activities. The borers are further destroying the belts heavily hence proper care should be taken earlier, else disappear soon.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 296-300

BIOGEOTECHNOLOGICAL STUDIES ON MANGROVE ECOSYSTEMS

A. D. Agate
7, Narmada Apts., United Western Society, Pune – 411 052.

ABSTRACT :- Mangrove ecosystems are peculiar formations occurring in sheltered tropical, coastal and estuarine areas. These waters contain a lot of organic matter, which is degraded by bacteria and fungi through a process of mineralization. The aerobic and anaerobic heterotrophic microorganisms grow and exhibit strong hydrolytic activity such as proteolytic and cellulolytic activity and the autotrophs also show oxidation and reduction of compounds of iron and sulfur. Such nutrient cycling is very essential, in keeping the biotic process of mangroves going in continuous cycle in Nature. So far these facts were largely conjectural, based on piece meal data generated from various sources.

To confirm this fact, the microorganisms aerobic as well as anaerobic were studied from two types of mangrove ecosystems :

1. Mining distributed environment of Goa (control)

2. Normal, healthy mangroves of Konkan.

The physico-chemical factors, elemental analysis, total microbial flora-both aerobic and anaerobic, % dominance of aerobic bacterial sp., % incidence of autotrophic bacteria and their activities such as iron oxidation and reduction were studied and monitored over a period of time to prove many of the above conjectures.

The beneficial activities of strong hydrolysis, iron reduction and oxidization could be fruitfully used to take care of certain problems in agriculture and mining disturbed areas, such as phosphate solubilization in soils, ion removal from bauxite and removal of tin using a microbial process. A case study in Thailand on tin removal is presented.

Key words : Microorganisms, Mangrove ecosystems, Tin removal, Mining.

INTRODUCTION

Microorganisms play a very important part in the natural recycling of elements and nutrients in mangrove areas. Although the mangrove ecosystem offers a number of ecological niches having different combinations of ecological factors, all aspects of microbial flora in mangroves are not known. Therefore, it was decided to understand and promote microbiological studies, which would eventually lead to good management practices on a long term sustained yield basis. Efforts in this direction were made in the UNDP/ UNESCO sponsored Mangrove project from 1985 onwards when the first training course on Microbial Aspects of Nutrient Cycling in Mangroves was held at Manila, Philipines. However, the field still remains relatively unexplored. Therefore, it is necessary to understand the role of microorganisms in nutrient cycling of mangrove soils and water. (Agate, 1991)

Broadly, the microbes are divided into 2 groups, the heterotrophs, which thrive on organic matter and are an important part of food chain in mangrove ecosystem and the autotrophs, those that utilize inorganic compounds and are most important in cycling of elements as carbon, nitrogen, phosphorus and sulfur.

Apart from their conventional roles in cycling and mineralization of elements, many important aspects have come to light during recent studies, such as the role of sulfur autotrophs reaching with metals in mining environments. A case in point could be the spin-off generated from such studies where phosphate solubilizing microorganisms and their potential remains to the studied in details. This would have a beneficial role in agricultural practices in the country.

It is well-known that bacteria play an important part in biodegradation of organic matter and nutrient recycling (Alexander, 1961). Out of the microbiological processes occurring in mangrove areas, the role of fungi, algae and other macro-systems is wee-recognized (Fell *etal*., 1975). The role of autotrophic microorganisms is not well-studied (Anonymous, 1958), although role of heterotrophic bacteria in biodegradation has been investigated to a certain extent.

MATERIALS AND METHODS

Area under Study :

Mining-disturbed Mandovi – Zuari of Goa (Experimental) and normal, healthy mangroves of Sindhudurg and Ratnagiri districts of Konkan, Maharashtra (Control) were selected for the studies.

Collection of samples :

In the selected areas, after dividing an area of 10 x 10 m into 4 squares, samples of water-logged soils (WLS), water and sediments from near the roots of *Avicennia* and *Rhizophora* plants were collected from approximately 15 cm below the surface layer, by means of a spatula or a digging instrument and collected in sterilized polythene bags or glass bottles. The samples were collected during May-June (Pre-monsoon season) and November-December (Post-monsoon season) for 2 consecutive years. After collection, the samles were stored at 10 C and were analyzed after noting their physico-chemical characters.

Bacteriological examination :

The samples were diluted in physiological saline and 3 dilutions from 10^{-6} to 10^{-8} were plated out on Standard Plate Count agar in triplicate, in 2 sets. The first set was incubated at room temp. (28c ±2c) for estimating aerobic bacterial count and the second set was incubated in McIntosh-Fielde's Jar for counting the anaerobic bacteria. The colony forming units (cfu) were counted to calculate bacterial numbers in the samples.

Further, the distribution of different groups of bacteria was determined on the basis of cultural characters and microscopic examination, if necessary and the dominant cultures were isolated and identified upto genus level by using standard methods and Bergey's Manual (Buchanan and Gibbons, 1974). The dominant cultures were also tested for their hydrolytic activity viz. amylolytic, cellulolytic and phosphate-solubilizing activity by using standard plate techniques (Starr *et al*., 1981).

Specialized groups of bacteria :

The iron-oxidizers, the iron-reducers and the sulfate reducers were isolated from a wide cross-section of mangrove areas on the west-coast of India from the above region (70 samples), as per the standard methods described in the literature :

a) Iron oxidizers by the method of Silverman and Lundgren (1959);

b) Iron-reducers by Brofield's Method (1954) and

c) Sulfate reducers by Postgate's method (1978).

RESULTS

The total aerobic and anaerobic counts of bacteria from the Experimental and Control areas are expressed as percentage distribution of these bacteria, as shown in Tables 1 and 2 respectively.

The qualitative percent dominance of aerobic bacterial species in experimental (Goa) and Control (Konkan) areas is presented in Tables 3 and 4 respectively.

The percent of dominant species isolated showing hydrolytic activity is given in Tables 5 and 6.

It must be noted that all the observations were made on averages of triplicate and each series of observations were carefully tallied and expressed at statistically significant level with 95% confidence.

The % incidence of specialized groups of bacteria. Viz. the sulfate reducers, iron oxidizers and the iron reducers from Goa and Konkan are shown in Tables 7 and 8.

DISCUSSION

From the above results, it can be summarised that :

a) There was a greater percentage of aerobes associated the control and experimental mangrove areas than

Table : 1

Percentage Distribution of Aerobic / Anaerobic Bacteria in Mangrove Samples of Experimental Area (Goa)

	WLS		SEDIMENT		WATER	
MICROBIAL COUNT*	PRE MONSOON	POST MONSOON	PRE MONSOON	POST MONSOON	PRE MONSOON	POST MONSOON
AEROBIC[1] COUNT	79	84	74	70	81	82
ANAEROBIC[2] COUNT	21	16	26	30	19	18

WLS = WATER-LOGGED SOIL.

* COUNT TAKEN AS CELLS/GM OR ML OF SAMPLE.

[1] AEROBIC BACTERIAL FLORA BY TOTAL VIABLE COUNT TECHNIQUE ON STANDARD PLATE COUNT MEDIUM IN INCUBATOR. (37°C)

[2] ANAEROBIC BACTERIAL FLORA BY TOTAL VIABLE COUNT TECHNIQUE OF STANDARD PLATE COUNT MEDIUM IN McINTOSH FILDE'S JAR.

Table : 2

Percent Distribution of Aerobic / Anaerobic Bacteria in Mangrove Samples of Control Area (Konkan)

	WLS		SEDIMENT		WATER	
MICROBIAL COUNT*	PRE MONSOON	POST MONSOON	PRE MONSOON	POST MONSOON	PRE MONSOON	POST MONSOON
AEROBIC[1] COUNT	85	91	84	78	82	91
ANAEROBIC[2] COUNT	15	9	16	22	18	9

WLS = WATER-LOGGED SOIL.

* COUNT TAKEN AS CELLS/GM OR ML OF SAMPLE.

[1] AEROBIC BACTERIAL FLORA BY TOTAL VIABLE COUNT TECHNIQUE ON STANDARD PLATE COUNT MEDIUM IN INCUBATOR. (37°C)

[2] ANAEROBIC BACTERIAL FLORA BY TOTAL VIABLE COUNT TECHNIQUE OF STANDARD PLATE COUNT MEDIUM IN McINTOSH FILDE'S JAR.

Table : 3

Percent Dominance of Aerobic Bacterial Species in Mangrove Samples of Experimental Area (Goa)

	WLS		SEDIMENT		WATER	
SPECIES	PRE MONSOON	POST MONSOON	PRE MONSOON	POST MONSOON	PRE MONSOON	POST MONSOON
Bacillus Sp.	18	29	19	34	59	26
Pseudomonas sp.	33	18	9	32	12	22
Staphylococus sp.	14	15	4	20	21	15
Micrococus sp.	9	14	9	10	10	17

WLS = WATER-LOGGED SOIL.

Table : 4

Percent Dominance of Aerobic Bacterial Species in Mangrove Samples of Control Area (Konkan)

	WLS		SEDIMENT		WATER	
SPECIES	PRE MONSOON	POST MONSOON	PRE MONSOON	POST MONSOON	PRE MONSOON	POST MONSOON
Bacillus Sp.	19	14	14	21	16	24
Pseudomonas sp.	16	21	10	14	9	19
Staphylococus sp.	11	18	12	14	11	11
Micrococus sp.	13	15	20	14	12	13

WLS = WATER-LOGGED SOIL.

anaerobes and, in general, the aerobic count was higher in post-monsoon season than pre-monsoon season in WLS and water samples, but not in sediments. The anaerobic flora, on the other hand, decreased in post-monsoon season in both the control and experimental area. (Tables 1 & 2).

The reasons attributed to this phenomenon could be the methodology used for counting bacteria and the nature of ecosystem during the season examined, which favours anaerobic (in sediments) aerobic conditions (WLS or water). Hence, the increase or decrease.

b) While examining the % dominance of aerobic species (Tables 3 & 4), it was found that *Bacillus, Pseudomonas, Staphylococcus* and *Micrococcus sp*. dominated both the Experimental (Goa) and Control (Konkan) mangrove areas. In general, *Staphylococcus* and *Micrococcus sp*. were fewer in experimental area (Goa) than in Control area (Konkan). *Pseudomonas* and *Staphylococcus sp.* are considered potentially pathogenic and could occur due to increased human encroachment in experimental (Goa) area. As no mining was practiced in control area (Konkan) at that time, additional human contact was probably minimum and this is probably relected in pattern of occurrence of the aerobic bacterial flora, as was observed here.

From Tables 5 & 6, it was noted that all hydrolytic activities were present at a lower percentage in Control areas (Konkan) than in the experimental area (Goa) in WLS but these were detected at nearly the same level in sediment samples from both areas. Curiously, these

Table : **5** Percent Showing Hydrolytic Activity of Bacteria In Mangrove Ecosystems of Experimental Area (Goa)

	WLS		SEDIMENT		WATER	
ACTIVITY	PRE MONSOON	POST MONSOON	PRE MONSOON	POST MONSOON	PRE MONSOON	POST MONSOON
AMYLOLYTIC ACTIVITY	47	53	13	23	—	—
PHOSPHATE SOLUBILIZING ACTIVITY	29	33	8	13	—	—
CELLULOLYTIC ACTIVITY	19	27	3	9	—	—

WLS = WATER-LOGGED SOIL.

Table : 6

Percent Showing Hydrolytic Activity of Bacteria In Mangrove Ecosystems of Experimental Area (Goa)

	WLS		SEDIMENT		WATER	
ACTIVITY	PRE MONSOON	POST MONSOON	PRE MONSOON	POST MONSOON	PRE MONSOON	POST MONSOON
AMYLOLYTIC ACTIVITY	27	38	16	22	—	—
PHOSPHATE SOLUBILIZING ACTIVITY	13	20	17	24	—	—
CELLULOLYTIC ACTIVITY	6	18	25	30	—	—

WLS = WATER-LOGGED SOIL.

Table : 7

Percent Incidence Of Specialized Groups of Bacteria In Mangrove Ecosystems of Control Area (Goa)

	WLS		SEDIMENT		WATER	
GROUPS	PRE MONSOON	POST MONSOON	PRE MONSOON	POST MONSOON	PRE MONSOON	POST MONSOON
SULPHAT REDUCING MICROORGANISM	13	15	9	11	2	—
IRON OXIDIZING MICROORGANISMS	7	5	—	—	—	—
IRON REDUCING MICROORGANISMS	23	29	8	6	—	—

WLS = WATER-LOGGED SOIL.

Table : 8

Percent Incidence Of Specialized Groups of Bacteria In Mangrove Ecosystems of Experimental Area (Konkan)

	WLS		SEDIMENT		WATER	
GROUPS	PRE MONSOON	POST MONSOON	PRE MONSOON	POST MONSOON	PRE MONSOON	POST MONSOON
SULPHAT REDUCING MICROORGANISM	36	39	12	14	9	14
IRON OXIDIZING MICROORGANISMS	29	30	12	11	—	—
IRON REDUCING MICROORGANISMS	34	39	10	9	4	17

WLS = WATER-LOGGED SOIL.

activities were not detected in water samples from both regions. Remarkably, the cellulolytic activity was significantly more in sediments from control area (Konkan) than experimental area (Goa). (Table 7 and 8)

This is due to undisturbed surrounding present in normal mangroves of Konkan, where the degradation and mineralization processes have proceeded undisturbed for many years, as compared to mining disturbed mangrove areas of Goa. This was later confirmed, when it was noted that all these hydrolytic activities were present at significantly higher levels in bacterial isolates from Konkan area.

c) When the specialized groups of bacteria, viz. the sulfate reducers, iron oxidizers and iron reducers from these 2 areas were compared, it was found that the sulfate-reducing organisms were more in normal mangrove areas of Konkan than in Goa. This was because the primary producers in mangroves use sulfate as sulfur source and reduce it to the oxidation stage (Jacq, 1973). Many decomposing bacteria liberate H_2S from sulfur-containing amino acids and the sulfate reducers are mainly responsible for production of H_2S under anaerobic conditions. The smell of H_2S is a sure sign of healthy, normal mangrove area.

On the other hand, in Goa mangroves, due to mining activity, iron pyrites are brought into the mangrove region, which gives rise to action by iron oxidizers under aerobic conditions and hence, the prevalence of iron-oxidizers in the area and precisely due to this reason, the iron reducers are less prevalent than in healthy mangroves of Konkan. This explains the presence of reddish-brown streams emanating from mining-disturbed regions of Goa due to the activity of iron oxidizers as compared to black streams due to the action of sulfate reducers in normal mangroves of Konkan.

Summing it up, the strong hydrolytic activities of bacteria, iron reduction and oxidation could be fruitfully used in agriculture, such as phosphate solubilization or mining (removal of iron from bauxite or removal of tin using iron oxidizer). A case study on tin removal in Thailand will be presented to illustrate this point.

REFERENCES

Agate A. D. and V.V. Panchnadikar 1992 Microbiological processes in mangrove swamps in Singh K. P. and Singh J. S. eds. Tropical ecosystems : Ecology and management, Wiley Eastern Ltd., New Delhi 301 – 307.

Alexander M. 1961. Introduction to soil microbiology. John Wiley and Sons, New York.

Anonymous 1958. Investigations into tidal mangrove soils : Sulfur oxidation, Reports of W. African Rice Research Station, 26 : 22-24.

Bromfield S. M. 1954. Reduction of ferric compounds by soil bacteria. Journal of General Microbiology, 11 : 1 – 6.

Buchanan R. E. and E. Gibbons 1974. Bergey's Manual of Determinative Bacteriology, 8th Ed. Williams and Wilkins. Baltimore, USA.

Fell J. W., R.C. Cefalu,. I.M. Master and A.G. Tallman 1975. Microbial activities in the mangrove (*Rhizophora mangle*) leaf detrital system, in Wlash G., Snedaker S and Teas H. eds. Proceedings of International Symposum on Biology and management of mangroves, University of Florida, Gainsville.

Jacq V. A. 1973. Biological sulfate reduction in the spermophere and rhizosphere of rice in some acid sulfate soils of Senegal. In Dost H., Ed. Proceeding of International Symposium on acid sulfate soils, Wageningen, Netherlands, 82 – 92.

Postgate J. R. 1978. The sulfate-reducing bacteria, Cambridge University Press, Cambridge, U. K.

Silverman M. P. and D.G. Lundgren 1959. Studies on chemoautotrophic iron bacterium *Ferrobacillus ferroxidans*. I. An improved medium and harvesting procedure for securing high yields, Journal of Bacteriology 77 : 642 – 649.

Starr M. P., H. Stolp, H.G. Truper, A. Balows. and H. G. Schlegel. 1981. The Prokaryotes – A handbook on habitats, isolation and identification of bacteria, Springer-Verlag, New York.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 301-303

QUANTIFICATION OF HALOPHILIC PHOSPHOBACTERIA FROM PICHAVARAM MANGROVES (SOUTH EAST COAST) AND THEIR POTENTIAL APPLICATION TO CROP CULTURE

S. *Ravikumar, G. Ramanathan , M. Babuselvam and S. Prakash
Institute For Coastal Area Studies, Marine Biotechnological Laboratory,
Manonmaniam Sundaranar University, Scott Christian College Campus,
Nagercoil - 629 003, Tamil Nadu, India.
*Email : ravibiotech201320@yahoo.com

ABSTRACT: Phosphobacteria were found higher in root of *Avicennia marina* ($8.9x10^5$) and rhizosphere soil of *Acanthus illicifolius* ($10.2x10^4$). Among 26 bacterial isolates *Bacillus* spp. contributes the maximum of 46.15% than the other genera. The growth of *Bacillus* spp. were found maximum at pH 7.0 and 4% NaCl . However, the phosphate solubilising ability was maximum at 1.5% NaCl and slowed down above 2% NaCl . The percentage seed germination of coastal crop plants increased to 60% in black gram and 35% in rice with the inoculation of *Bacillus* compared with control. The saline tolerant phosphobacteria are recommended as biofertilizers for improving crop yield in coastal agricultural fields.

Keywords *:* Bacillus*, Mangroves, Phosphobacteria, Phosphate solubilising ability*

INTRODUCTION

Mangroves are specially adopted group of woody plants usually grow at the intertidal zone of sheltered shores, tidal creeks, backwaters, lagoons, marshes and mud flats in the tropical and sub tropical latitudes. The physical, chemical and biological factors and their interaction play a significant role in driving the nutrient flow in the mangrove ecosystem. Next only to nitrogen, phosphorous is a vital nutrient for plant and microorganisms(Chandramohan,1988). It is required for proper growth of plants and soil microorganisms. The phosphate in the form of elemental phosphorous is one of the least soluble mineral nutrients in soil. Large quantities of the element phosphorus are immobilized in living organisms and locked up in the sediments as insoluble inorganic and organic phosphorus compounds. This form of phosphorus being held in the sediments for a long time, remains exclude from recycling. Microbes play an important role in the mineralization of these compounds by producing some organic acids lowering the pH and bring about the dissolution of bound form of phosphate. In India , studies have been made on the occurrence and distribution of phosphobacteria in the marine(Ayyakannu and Chandramohan, 1971) terrestrial (Gupta and Biswas,1994) and aquatic (Purushothaman, 1994) environments.

Generally one would not expect the abundance of phosphobacteria in the mangrove sediment, as the tannin rich conditions in that sediment are unfavorable for the growth of bacteria. Therefore a thorough study is necessary on the occurrence, distribution and activity of halophilic phosphobacteria from mangrove environment. In India 7 Mha agriculture crop soil are affected by salinity and alkalinity. Because of the high salt condition, inoculation of crop with non-halophilic microorganisms would not be successful. Marine phosphobacteria is receiving much attention due to its ability to tolerate high salt tolerants phosphate solubilising property, enhancing mineral uptake and production of growth promoting substances.

MATERIALS AND METHODS

The root and rhizosphere soil samples were collected from twelve plant species *viz*., *Acanthus illicifolius L. (*Acanthaceae), *Aegiceras corniculatum* (L.) Blanco (Myrsinaceae), *Avicennia officinalis* L. (Avicenniaceae), *Avicennia marina* (Forsk.) vierh. var marina (Avicenniaceae), *Bruguiera cylindrica* (L.) Bl. (Rhizophoraceae), *Ceriops decandra* (Griff.) *Ding Hou* (Rhizophoraceae), *Exoecaria agallocha* L. (Euphorbiaceae), *Lumnitzera racemosa* wild. (Combretaceae), *Rhizophora apiculata Blume* (Rhizophoraceae), *Rhizophora mucronata Poir*. (Rhizophoraceae) from the Pichavaram mangrove forest situated on the southeastern (Coromandel) Coast of India. (Lat. 11°27' N; Long 79°47'E). All the samples were transferred to clean and previously unused polythene bags and brought to the laboratory. About 5 g of the rhizosphere soil and root samples were inoculated into the Pikovsky"s medium {10.0 g Glucose, 5.0g Tricalcium Phosphate, 0.5g NH_4SO_4, 0.1g $MgSO_4$ $7H_2O$, 0.2g Kcl, $MnSO_4$, $FeSO_4$ trace, 0.5g Yeast extract, Distilled water 1000ml}. The inoculated samples were incubated at 28 ± 2°C for two days.

After attaining visible growth of phosphobacterial colonies with solubilising zone were isolated by repeated streaking in Pikovsky"s agar plates and maintained in the agar slants. Generic level identification of pure culture was done by following Bergey"s manual (Holt *et al.,* 1994) Various parameters *viz*., pH, salinity, nitrogen, phosphorous and potash from the rhizosphere soil were analyzed (Anon,1975; Christopher *et al.,* 1977).

The biofertilizer effect of phosphobacteria on coastal crop plants were studied by soaking 100 seeds each of rice and blackgram in broth culture (10^{8} cells ml^{-1}) for an hour and were spread on to a sterile petriplate containing sterilized filter paper. Ten ml of the autoclaved distilled water was added daily into each petridish. Seed germination was observed daily till maximum number of seed germinated in both treated and untreated (control) sets. The percentage of seed germination in the phosphobacteria treated seeds over the untreated ones in control was calculated.

The effect of pH and NaCl on the growth and phosphate solubilisation was examined in the following manner. The pH regimes of 3,4,5,6,7and 8 and various salinity levels (0,1,1.5,2,2.5,3,3.5,4 and 4.5 ‰) were attained by adjusting the pH and salinity in 50ml Pikovsky"s broth in different flask . Five ml of *Bacillus* cell suspension (10^{8} cells ml^{-1}) was added into each flask and kept on a shaker. After seven days of incubation, the growth was monitored by measuring optical density at 520nm (220S Hitachi, Japan) .

The phosphate solubilisation with different pH and salinity levels was calculated by inoculating one millilitre of the broth culture into 3 ml of basal medium [2.0g yeast extract, 10.0 g Dextrose, 2.5 g Peptone, 1000 ml of Distilled water, pH 8 ± 0.2] . To each treatment, 0.5 ml of 1% suspension of calcium hydroxy apatite was added under constant stirring and incubated the culture for 72 hours at room temperature (28 ± 2^{0}C) and centrifuged at 3000 rpm for 15 minutes and the reactive phosphate was determined calorimetrically Anon(1975). The difference in phosphate level of the treatments and control was taken as the amount of phosphate liberated by the cultures, from the hydroxy apatite. The highest quantity that was released by the culture was taken as 100 and the rest was calculated as the percentage of maximum activity.

RESULTS AND DISCUSSION

Twenty six bacterial isolates belonging to five bacterial genera *viz., Bacillus, Pseudomonas, Flavobacterium, Micrococcus* and *Arthrobacter* were isolated from soil and root samples of 10 mangrove plant species. Among the bacterial species, the *Bacillus* was dominant (46.15%) than the other genera (Table 1). The total counts of phosphobacteria enumerated from the

Table 1 - Generic composition of phosphobacteria isolated from root and soil samples

Bacterial genera	Number of bacterial genera (%)
Bacillus	*12 (46.15)*
Pseudomonas	4 (15.38)
Flavobacterium	5 (19.23)
Micrococus	2 (7.69)
Arthrobacter	3 (11.54)

samples of rhizosphere sediment adjacent and root showed that its abundance was ten fold higher in root than in the sediment samples (Table 2). Similar observations noted in mangrove plants showed root association with *Azotobacter* and *Azospirillum* (Ravikumar,1995; Ravikumar *et al*., 2002). This may be attributed to the quantity and quality of root derived carbon which supports biomass expansion. As the root grows through the soil it releases photosynthetically derived carbon into the soil in a variety of soluble and insoluble forms. The totality of which is referred to a rhizodeposition (Hiltner,1901). Soluble forms, which include both secretions and leakages (Rodrigueze *et al.,* 1971) from the root, may consists of simple monosaccarides, aminoacids and organic acids etc., The biochemical parameters recorded the maximum pH (7.9), electrical conductivity (43.5) and total nitrogen ($7.9 g.kg^{-1}$) in the rhizosphere sediment of *Lumnitzera racemosa*, *Bruguiera cylindrica* and *Acanthus illicifolius* respectively. Maximum total phosphorous ($2.5 g.kg^{-1}$) and total potash ($48.5 g.kg^{-1}$) were recorded in the rhizosphere soils of most of the plants studied.

Table 2 - Counts of phosphobacteria in the rhizosphere and roots of different mangrove plants

Name of the Plant Species	CFU x 10^{5} /g dry wt. of root	CFU x 10^{4} / g wt. of soil
Aegiceras corniculatum	4.2	1.5
Acanthus illicifolius	1.0	10.2
Avicennia marina	8.9	1.2
Avicennia officinalis	5.6	1.0
Avicennia officinalis pneumatophore	1.1	1.0
Bruguiera cylindrica	1.0	1.0
Ceriops decandra	1.0	1.0
Exoecaria agallocha	1.0	1.0
Lumnitzera racemosa	1.0	1.0
Rhizophora apiculata	1.0	1.5
Rhizophora mucronata	1.0	4.9

Higher counts of phosphobacterium ($8.9x10^{5} g^{-1}$ dry weight) were recorded in the root of a *Avicennia*

marina and rhizosphere sediment sample of *Acanthus illicifolius* (10.2 x $10^4 g^{-1}$ dry weight) . This might be attributed to the amount of rhizodeposition in various species of mangrove plants.

The phosphate solubilisation activity was higher at pH 7.0 . This might be due to better growth of *Bacillus* at pH 7.0 (Table 3). It was reported that the nitrogen fixation and IAA production by Azotobacter and Azospirillum were found higher with increasing the density of microorganisms (Ravikumar,1995; Ravikumar *et al.,* 2002).

Table 3 - Growth and phosphate solubilisation of *Bacillus* under different pH regimes

pH	Growth (OD 420)	Concentration of available phosphorus (%)
3	0.7	68
4	1.4	68
5	1.5	73
6	1.6	76
7	1.7	90
8	1.6	85

The effect of NaCl on the growth of *Bacillus* was also investigated (Table 4) The growth was maximum at 4.0% NaCl although there was noticeable growth at 3.0% and 3.5% NaCl. The phosphate solubilising activity was found higher at 1.5% NaCl . But there was no that much of phosphate solubilisation in other concentration of NaCl . Whereas the growth and rate of nitrogen fixation of *Azotobacters* were found maximum at 1% NaCl and it was completely arrested above 1.5% NaCl (Ravikumar,1995; Ravikumar *et al*.,2002).

Table 4 - Growth and phosphate solubilisation of *Bacillus* under different salinity regimes

NaCl (%)	Growth (OD 420)	Concentration of available phosphorus (%)
0	0.10	65
1.0	0.15	83
1.5	0.25	95
2.0	0.60	60
2.5	0.70	60
3.0	0.80	60
3.5	0.90	Nil
4.0	1.0	Nil
4.5	0.75	Nil

The percentage germination of coastal crop plants were found higher in biofertilizer treated seeds than the untreated ones. Higher percentage of germination in rice (35%) 20% in the case of black gram were noticed due to pretreatment with Bacillus Hence the application of halophilic *Bacillus* to coastal crop plants enhanced the biomass production and crop yield . Steps has been undertaken on the combined inoculation of *Azospirillum* with phosphobacteria on the growth of coastal crop plants and preparation of halophilic phosphobacteria for commercial use .

The authors are grateful to the authorities of M. S. University, Tirunelveli and the management of Thiagarajar College, Madurai for providing required facilities.

REFERENCES

Chandramohan, D.1998 Nitrogencycle, in *Mangrove microbiology*, edited by A.D. Agate, C.V. Subramanian & M. Vannucci, (UNDP / UNESCO1988, pp. 61 – 82.

Ayyakkannu, K and D. Chandramohan, D. 1971 Occurrence and distribution of phosphate solubilizing bacteria and phosphatase in marine sediments of portonovo, *Mar. Biol.* 11 : 201 – 205.

Promod, K. C and K.D. Dhevendaran, 1987 Studies on phosphobacteria in Cochin backwaters, *J. Mar. Biol. Assoc. India* 29 : 297 – 305.

Gupta, M, and Biswass, P .P 1994 Inorganic phosphate solubilization by micro – organisms isolated from mango orchards, *J. soil Biol. Ecol.* 14 101 – 106.

Purushothaman, C. S 1994 Studies phosphate solubilizing and phosphatase producing bacteria in velilake, Ph.D. thesis, University of Kerala, India.

Holt, J. G, N.R. Kreig, P.H.A. Sneath, J.T. Staley and T. William, 1994 *Bergey's manual of determinative bacteriology,* Ninth edition, (Williams & Wilkins, Baltimore) 1994, pp. 240 – 241.

Anon, 1975. *Methods for the estimation of water and waste water* (American Public Health Association, Washington) pp. 203 - 208.

Christopher, F., C.F. D'Elia, P.A. Stendler, and N. Corwin, N. 1977 Determination of total nitrogen in aqueous samples using persulfate digestion, *Limnol. oceanogr* 22 : 760 – 762.

Ravikumar, S. 1995 Nitrogen – fixing Azotobacters from the mangrove habitat and their utility as biofertilizer, Ph.D. thesis, Annamalai University, India.

Ravikumar, S., G, Ramanathan, N. Suba, and L. Jeyaseeli 2002 Quantification of halophilic *Azospirillum* from mangroves, *Ind. J. Mar. Sci.* 31 : 157 – 160.

Hiltner, I. 1904 New experience and problems of the role of land bacteria under special considerations of formation and utilization. *J. German Agricultural Research*, 98 : 59 – 63.

Rodriguez – Bazrueco, C., E. Cervanters, N. Subbarao, and E. Rodriguezcacers, 1991. Growth promoting effect on *A. brasilense* on *Casuarina cunnighamiana*, (Kluwer Academic publishers) pp. 121 – 127.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 304-309

CHITIN : A UNIQUE BIOPOLYMER

Varad Ravindra Pradhan* and Atul N. Bedekar
B. N. Bandodkar College of Science, Thane, Maharashtra, India.
408, Teli House, Kharkar Lane, Thane (W) –400601, Maharashtra, India.
e-mail : varadpradhan@yahoo.com

ABSTRACT : It is well known that chitin and chitosan obtained from crustacean shell waste are the most versatile biopolymers known so far. Currently the research on chitin science is mainly focussed on its derivatives like chitosan and glucosamine. In the preparation of chitin, removal of proteins i.e. deproteinization is a very important step. The residual proteins if present in excess quantity can interfere, if specific applications are concerned. The scope of the present study was to optimize the conditions for the deproteinization treatment in the preparation of chitin. Use of 10 % sodium hydroxide at room temperature to deproteinize the shrimp shells is found most suitable. The current paper also covers the information and work on availability, applications and economical aspects associated with chitin.

Key words *: Chitin, Chitosan, Deproteinization, Shrimp, Applications, Economical aspects.*

INTRODUCTION

Chitin is a natural carbohydrate polymer that occurs mainly in the exoskeleton of crustaceans such as shrimps, prawns, crabs, squids, oysters, clams etc. It is a very close relative of cellulose in which each C_2 hydroxyl group of the monomer unit is replaced by acetylamino group (Fig.1). It is a long chain polymer of N – acetyl glucosamine units which are linked via ß, 1 to 4 bonds.

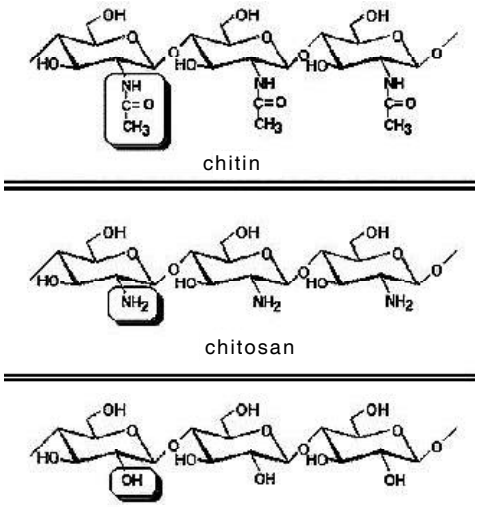


Fig. No.1 : Structure of Chitin, Chitosan and Cellulose

ECONOMIC IMPORTANCE OF CHITIN AND CHITOSAN

Although chitin and its derivatives were in light for many years and its many outstanding properties known, in India its commercial utilization is almost insignificant.

I) Raw Material

Major regions of the world where crustaceans are abundant, are the United States of America, Norway, India, Thailand, Phillipines, South Africa, Mexico, China and Japan. The raw material most abundantly available includes crab shells, shrimp shells, prawn wastes, squids, oysters, clams etc. (Subasinghe, 1994)

i) Shrimps and Prawn wastes - Nearly 35% of raw material shrimp are discarded as wastes when processed into headless shell – on products. Peeling process which involves the removal of the shell from the tail of the shrimp, increases the waste production by 40 – 45%. In many developing countries almost all of the production of frozen shrimp is exported. Thus, in an assessment of shrimp waste availability, the global frozen shrimp export industry can be considered as a prime source of quality waste. The less important sources are the shrimp canning facilities and facilities producing value added shrimp products. On a global basis the shrimp processing industry produces over 700,000 MT of quality waste per annum.

ii) Crab – Over 70% of the chitin rich raw material is discarded by crab processing industries as waste. Most of crab landed is marketed in the shell on form. The waste production mainly occurs during the production of frozen or canned crab meat. The global annual production of crab waste from such facilities can be estimated at around 480,000 MT.

iii) Squid – The most reliable sources of regular supplies of large quantities of quality waste are the facilities which process frozen squids. The global annual production of squid waste from such facilities can easily be estimated around 400,000 MT.

iv) Oysters and clams – The global estimated waste production of oysters and clams can be estimated around 300,000 MT.

In India main sources for chitin production includes shrimp, prawn i.e. *Penaeus monodon* and Squilla i.e. *Oratisquilla nepa* and Crab i.e. *Scylla seratta.* Of all these crustaceans shrimps and prawns are the most important. The state wise annual shrimp landings in India is given in Table No.1.

Table No.1 : State wise annual shrimp landings (Tons) in India (1998 and 1999)

No.	State	Shrimp Landing 1998	Shrimp Landing 1999
1.	Andhra Pradesh	16546	23728
2.	Andaman and Nicobar Islands	601	785
3.	Daman and Diu	527	182
4.	Goa	2651	1622
5.	Gujarat	50625	56443
6.	Karnataka	4699	6929
7.	Kerala	58575	44706
8.	Lakshadweep	——	——-
9.	Maharashtra	118614	102848
10.	Orissa	8534	9897
11.	Pondichery	3736	3923
12.	Tamil Nadu	24168	23168
13.	West Bengal	15625	15337
	Total	304541	289568

Source - Statistics of Marine Products Exports 1999.

From the Table No.1, it seems that annual shrimp landings in India at different coasts is considerable. In the year 1999, frozen shrimps constituted almost 70 % of the total marine products exported to different countries. This valued around 330 crore rupees. From this large amount of shrimp landings at each coast, around 10% is wasted in the form of shells, which contains valuable chitin in it. Total chitin content present in shrimp shells with head on wet basis is around 2.7 % to 4.4 % (Mathew and Nair, 1998). If we calculate the total chitin that can be prepared from the 10 % waste of total shrimp landings, it would be around 1000 to 1200 tons. In India, commercial production of chitin and chitosan has already been started, but is confined to a very less utilization of waste.. The chitin and chitosan production could be coupled with fishery industry. So that the waste generated could be utilized smartly with assurance of additional income. Thus the chitin industry can create a huge job market in India.

Also the little chitin or chitosan which has been prepared by small companies in India, is almost totally exported to different countries such as Australia, Finland, France, Germany, Poland, U.K., U.S.A. etc. In India almost less than 10% of prepared chitin is used for different purposes. So awareness about chitin and chitosan applications should be explored in India in order to save the existing chitin industries.

From a resource angle, the availability of chitin rich species is considerable. But there are practical difficulties in gaining accessability to wastes from such species for commercial production of chitin or chitosan. The seasonal availability of the resources and the geographically distributed nature of the processing industries in many countries are the main factors which can restrict the availability of a regular supply of raw material. The bulky nature of the raw material and its high perishability are the factors which make sourcing raw material difficult. In some countries the seasonal availability of the raw material mostly affects the economics of the chitin production by way of investment on equipment and storage facilities for manufacturing and storing enough product to satisfy the customer requirements for a year.

Applications Of Chitin and chitosan

Chitin and its deacetylated derivative chitosan can be of utmost importance to mankind. Chitosan is a cationic polyelectrolyte with a free amino group and two free hydroxyl groups per glucose unit. Nowadays many derivatives such as, carboxymethyl chitin, hydroxyethyl chitin, ethyl chitin, hydrogels with Poly(ethylene glycol) or gelatin etc. had shown their importance in cosmetics, food applications, medical apllications, water treatment and so on. Table No.2 lists different applications of chitin and chitosan.

PREPARATION OF CHITIN

Many authors worldwide have given the methods of preparation of chitin to suit their specific needs. Out of these many form the basis of chemical processes for industrial production of chitin from crustacean shell waste. In shrimp shells, Chitin is known to appear in complex with minerals and proteins (Muzzarelli, 1977). Pradhan and Bedekar (2002a) studied the chemical composition of shrimp shells and observed species & coastal variations in India. The present work was specifically conducted to determine the optimum conditions required to prepare chitin without any impurities, especially proteins. Since residual proteins if present in excess quantities can interfere in certain applications. The different methods employed so far (No and Meyers, 1997) for deproteinization of shrimp and prawn shells are given in Table No. 3.

Table No. 2 – Applications of Chitin and Chitosan

Properties of chitin and chitosan	Area of application	Reference	Year
High charge density and binding capacity	In ion exchange or chelation chromatography.	Muzzarelli R.A.A. Hauer H.	1977 1978
	Toxic metallic ions removal.	Masri and Randall	1978
		Taba S. *et.al.*	1995
	Industrial process water Purification.	Jais M. J. *et.al.*	1994
Coagulation and flocculation	Coagultion of suspended solids in food processing wastes.	Pinnotti A. et.al.	1997
	Potable water treatment.	Knorr D.	1984
	Clarification and deacidification of fruit juices.	Spagna G. *et. al.* Chen and Li	1996 1996
Film forming capacity	Preservation of fruits and vegetables.	Arul and Chaouth	1995
Antimicrobial effect	Bactericidal.	Sudharshan *et.al.*	1992
	Fungicidal.	Fang *et. al.*	1994
	Measure of mold contamination in agricultural Commodities.	Bishop *et. al.*	1982
Strong binding to negatively charged polymeric products.	Paper strength additive.	Muzzarelli R.A.A. Gopal *et. al.*	1977 1981
	Dye binder for textiles.		
	Binding agent for non-woven fabrics.	Muzzarelli R.A.A.	1977
In Medical or Pharmaceutical field	As a sustained release agent for drug delivery Systems.	Ramanathan S. et.al.	2001
	As bacteriostatic and haemostatic agents.	Kochanska *et. al.*	1994
	In Surgical glove powder	Mathew and Nair	1998
	In treatment of osteoarthritis.		
	As a wound healing material.	Balassa and Frudden	1978
	As surgical sutures.	Mathew and Nair	1998
	In temporary artificial Ligaments.		
	Bioengineering material.		
	Cosmetics.	Wachter and Stenberg	1995
Others	In enzyme immobilization.	Shahidi *et.al.*	1999
	Textile finishes .	Muzzarelli R.A.A.	1977
	Glass fabrics dyeing .		
	Preparation of polymeric dyes .		
	Photography .		

Table No. 3 : Methods employed so far to deproteinize shrimp or prawn shells (No and Meyers, 1997)

Alkali concentration	Temperature (^{0}C)	Time (hr.)	Ratio (weight/ volume)
3 % NaOH	100	1	-
1 % NaOH	65	1	1:10
1 % KOH	90	2	1:20
4 % NaOH	Boiling	1	-
pH 11.5	30	1	1:30
1 N NaOH	100	1	1:6
5 N NaOH	100	1	-
5 % NaOH	Reflux	2	1 :15-20
5 % NaOH	100	0.5	1:1
0.5 % NaOH	Boiling	0.5	2:3
15 % NaOH	65	3	1:10

MATERIALS AND METHODS

Shrimp shells with head from commercial waste were collected from Thane region. The common species obtained were *Penaeus indicus, Metapenaeus affinis, Metapenaeus monoceros, Metapenaeus brevicornis, Parapenaeopsis stylifera, Parapenaeopsis hardwickii, Solenocera indicus, Penaeus monodon* etc. All these species are listed in their decreasing order of abundances. The preparation of chitin from these shrimp wastes include three basic steps viz. 1] calcium carbonate removal – demineralization, 2] protein removal – deproteinization, and 3] removal of pigments – decoloration. The first two steps were conducted in the reverse order also i.e. deproteinization followed by demineralisation to get a clear picture about the protein extractions.

1. Demineralization – It was achieved by dipping the shells in 1 N Hydrochloric acid for 30 minutes. The amount of shells to acid was taken by calculating the stoichiometric requirement of all the minerals peresent in the shells. Then the shells were thoroughly washed with demineralised water till neutral to Phenolphthalein indicator and also checked for negative test to calcium with ammonia and ammonium oxalate solution (Bassett J. *et. al*. 1978).

2. Deproteinization – The demineralised material from (1) was deproteinized using varying Sodium hydroxide concentration and temperature (Table no. 2). The ratio of shells to alkali was taken in 1:6 ratio for all the treatments, since this much amount of sodium hydroxide was sufficient to submerge the shells in it. Then the shells were thouroughly washed with demineralised water till neutral to Phenolphthalein indicator and also checked for negative test to proteins with Copper sulphate (Sadasivam and Manickam, 1994a) solution.

3. Decoloration – Acid and alkali treatments alone can produce chitin with colour. So the chitin obtained was bleached with 0.1 % sodium hypochlorite solution.

Residual proteins from prepared Chitin were analysed by Lowry's (Sadasivam and Manickam, 1994b) and Kjeldahl Nitrogen (Sadasivam and Manickam, 1994c) method. Chitin was then treated with 50 % sodium hydroxide at 100^0 C for two hours to prepare chitosan from it. Infra red spectra of chitin and chitosan were noted after mixing the samples well with KBr in powder form (Roberts, 1997). For recording Infra red spectra of chitin, the sample prepared as such was used without giving any further purification treatments.

RESULTS AND DISCUSSIONS

From Table No.4 it seems clearly that 10 % Sodium hydroxide is better in removing almost all the proteins from shrimp shell waste. It removes proteins from shrimp shell waste at 70^0 C in two hours and the same results were obtained, when shells were kept with 10 % Sodium hydroxide solution for 6 hours at room temperature. As reported by many authors they had to repeat the treatment or the ratio of alkali used was in much excess than required. The removal of proteins was confirmed by Lowry's method and Kjeldahl nitrogen method.

Chitosan, the deacetylated derivative of chitin, which is prepared by the action of 50 % sodium hydroxide on chitin. When we give treatment with so much concentrated alkali, proteins are bound to go. So if we compare the infra red spectra of chitin (Fig. 2) prepared by 10% sodium hydroxide treatment and its derivative chitosan (Fig. 3), there is no considerable change in the two spectra, except the peaks at 1655 cm^{-1} and 1560 cm^{-1} i.e acetamide peaks and also peaks due to C-O stretching, i.e. at 1070 cm^{-1} and 1030 cm^{-1} have got altered due to deacetylation.

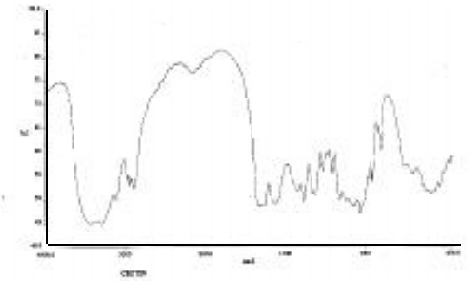


Fig. 2 : Infra-red spectra of Chitin

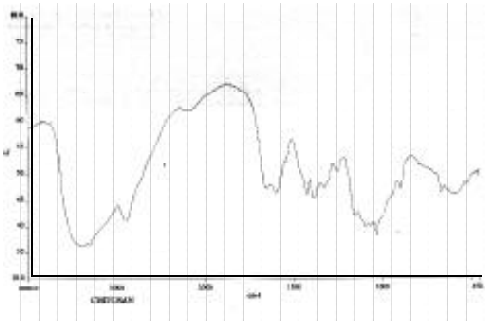


Fig. 3 : Infra-red spectra of Chitosan

Table No.4 : Effect of NaOH concentration in deproteinization

No.	Treatment	Time in Hours	Temp.	Residual proteins remained
1.	0.75 N NaOH	2	70^0 C	7 to 10 %
2.	0.75 N NaOH	2	100^0 C	5 to 6 %
3.	0.75 N NaOH	12	Room Temp.	7 to 10 %
4.	1 N NaOH	2	70^0 C	8 to 9 %
5	1 N NaOH	2	100^0 C	5 to 6 %
6.	1 N NaOH	12	Room Temp.	8 to 10 %
7.	1.5 N NaOH	2	70^0 C	8 to 9 %
8.	1.5 N NaOH	2	100^0 C	5 to 6 %
9.	1.5 N NaOH	12	Room Temp.	8 to 10 %
10.	5 % NaOH	2	70^0 C	6 to 8 %
11.	5 % NaOH	2	100^0 C	4 to 6 %
12.	5 % NaOH	12	Room Temp.	7 to 8 %
13.	10 % NaOH	2	70^0 C	0.5 to 1 %
14.	10 % NaOH	6	Room Temp.	0.5 to 1 %

One thing should be noted here that the treatments with 10 % sodium hydroxide do not deacetylate chitin as it was assumed earlier. This was confirmed by the infra red spectra of chitin (Fig. 2). As can be seen by the spectra the peaks at 1655 cm^{-1}, 1560 cm^{-1}, 1070 cm^{-1} and 1030 cm^{-1} are prominent, indicating that no deacetylation due to alkali treatment has taken place. This was again confirmed by the method reported by Pradhan and Bedekar (2002b) for determining the degree of deacetylation of chitin or chitosan samples, which showed that the prepared chitin samples were highly acetylated.

CONCLUSIONS

From the above results and discussions, it is fairly clear that use of 10% Sodium hydroxide in deproteinization can eliminate proteins to the maximum possible extent, even in single extraction. It also shows that proteins can get extracted in sodium hydroxide solution without applying temperature. Thus as industrial approach is concerned, demineralization as well as deproteinization treatments can be carried out without concerning about the temperature.

Chitin and chitosan are the biopolymers with outstanding properties. Many areas are open with chitin and chitosan which show good prospects for the future. So this biopolymer should be used to get the best out of it.

REFERENCES

Arul J. and Chaouth A. El., 1995, Preservation of fresh fruits and vegetables with chitosan, in Proceedings Of The 1st International Conference Of The European Chitin Society, Jacques Andre Publisher, LYON, France, 372-381.

Balassa L.L. and Prudden J. F., 1978, Applications of chitin and chitosan in wound healing accelerations, in Proceedings of The First International Conference on Chitin/Chitosan, (ed. R. A. A. Muzzarelli & E. R. Pariser), MITSG, Cambridge, 296 – 305.

Bassett J. 1978, in Vogel's textbook of quantitative inorganic analysis : Including elementary instrumental analysis, Fourth edition, ELBS Longman publ., England, 437.

Bishop, R.H., Duncan, C.L., Evancho, G.M. and Young, H., 1982, Estimation of Fungal Contamination on Tomato Products by a Chemical Assay for Chitin, in J. Food Sci., 47, 437 – 439.

Chen, Y. and Li, C., 1996, Studies on the Application of Chitosan to Clarification of Grapefruit Juice, in Food Science, Taiwan 23, 617 – 628.

Fang, S.W., Li, C.F. and Shih, D.Y.C., 1994, Antifungal Activity of Chitosan and its Preservative Effect on Low-Sugar Candied Kumquat, in J. Food Protection, 56, 136 – 140.

Gopal T.K.S., Nair K.G.R., Thankappan T.K., and Govindan T. K., 1981, Improvement in functional properties of fish packaging by chitosan coating, Perfect Pact, 21, 5-8.

Hauer H., 1978, The chelating properties of KYTEX H chitosan, in Proceedings of The First International Conference on Chitin/Chitosan, (ed. R. A. A. Muzzarelli & E. R. Pariser), MITSG, Cambridge, 263 – 277.

Jais Mohd. Jamil, Zakaria Mat, Alimuniar Arisol and Amalina Wan Khairul, 1994, Analysis of the effectiveness of chitosan in the treatment of effluent from rubber coagulation industry, in Proceedings of Asia-Pacific Chitin and Chitosan Symposium, Universiti Kebangsaan, Malaysia, 282 – 290.

Knorr, D., 1984, Use of Chitinous Polymers in Food-A Challenge for Food Research and Development, in Food Technol., 38, 85 – 97.

Kochanska Barbara, Witek Edwerd, and Sramkiewicz Jamina, 1994, Haemostatic properties of Chitosan and its applications in Stomatology, in *Chitin World,* (ed. Zbignew S. Karnicki et.al), Wirtschaftsverlag NW,

Bremerhaven, 520-529.

Masri M. S. and Randall V. G., 1978, Chitosan and chitosan derivatives for removal of toxic metallic ions from manufacturing – plant waste streams, in Proceedings of The First International Conference on Chitin/Chitosan, (ed. R. A. A. Muzzarelli & E. R. Pariser), MITSG, Cambridge, 277 – 287.

Mathew P. T. and Nair K. G. R., 1998, Recent trends in the use of chitin, chitosan and their derivatives, in M.S. Hameed, and B.M. Kurup (ed.), Technological Advancement in Fisheries, Publn. No. 1, Cochin University, Cochin, 310-316.

Muzzarelli R.A.A., 1977, in Chitin, Pergamon press, Oxford.

No Hong Kyoon and Meyers Samuel P., 1997, Preparation of Chitin and Chitosan, in Chitin Handbook, (ed. R. A. A. Muzzarelli and M. G. Peter), European Chitin Society, 475 – 489.

Pinotti, A., Bevilacqua, A. and Zaritzky, N., 1997, Optimization of the Flocculation Stage in a Model System of a Food Emulsion Waste Using Chitosan as Polyelectrolyte, in J. Food Eng., 32, 69 – 81.

Pradhan Varad and Bedekar A. N., 2002a, Study of biopolymer chitin : Coastal and species variation, Ecology environment and conservation, 4 : in press.

Pradhan Varad and Bedekar A. N., 2002b, Degree of deacetylation of chitosan : acetic acid distillation using sulfuric acid, Ecology environment and conservation, 4 : in press.

Ramanathan S. and Block Lawrence H., 2001, The Use of chitin gels as matrices for electrically-modulated drug delivery, Journal of controlled release, 70, 109-123.

Roberts George A. F., 1997, Determination of the degree of N-acetylation of chitin and chitosan, in Chitin Handbook, (ed. R. A. A. Muzzarelli and M. G. Peter), European Chitin Society, 127 – 132.

Sadasivam S. and Manickam A., 1994a, in Biological methods for agricultural Sciences, by Wiley Eastern ltd. and Tamilnadu Agricultural University, Coimbatore, 55.

Sadasivam S. and Manickam A., 1994b, Protein estimation by Lowry's method, in Biological methods for agricultural Sciences, by Wiley Eastern ltd. and Tamilnadu Agricultural University, Coimbatore, 56 - 58.

Sadasivam S. and Manickam A., 1994c, Nitrogen estimation by Micro – Kjeldahl method, in Biological methods for agricultural Sciences, by Wiley Eastern ltd. and Tamilnadu Agricultural University, Coimbatore, 34-37.

Shahidi Fereidoon, Janak Kamil Vidana Arachi and You-Jin Jeon. 1999, Food applications of Chitin and Chitosan; Trends in Food Science & Technology, 10, 37 - 51.

Spagna, G., Pifferi, P.G., Rangoni, C., Mattivi, F., Nicolini, G. and Palmonari, R., 1996, The Stabilization of White Wines by Adsorption of Phenolic Compounds on Chitin and Chitosan, in Food Res. Intern., 29, 241 – 248.

Statistics of Marine Products Exports 1999, published by Marine Products Export Development Authority of India on 31st January 2001.

Subasinghe S., 1994, The Development of Crustacean and Mollusc Industries For Chitin and Chitosan Resources, in the Proceedings of the Asia – Pacific Chitin and Chitosan Symposium, Universiti Kebangsaan, Bangi, Malaysia, 1 – 9.

Sudharshan, N.R., Hoover, D.G. and Knorr, D., 1992, Antibacterial Action of Chitosan, in Food Biotechnol., 6, 257 – 272.

Taba S., Bouvet Ph., Corre G., and Dorange G., 1995, Study and modelisation of some heavy metals removal by ultrafitration in presence of soluble chitosan, in Proceedings Of The 1st International Conference Of The European Chitin Society, Jacques Andre Publisher, LYON, France, 389-399.

Wachter R. and Stenberg E., 1995, Hydagen CMF in cosmetic application. Efficiency in different in-vitro and in-vivo measurements, in Proceedings Of The 1st International Conference Of The European Chitin Society, Jacques Andre Publisher, LYON, France, 381 - 389.

10Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 310-316

ECO-TOURISM POTENTIAL OF MANGROVE SWAMPS OF GOA : AN APPRAISAL

Manoj R. Borkar*, Neelam K. Komarpant*, Padma Kamat and Nirmal Kulkarni
*Biodiversity Research Cell, Department of Zoology,
Carmel College for Women,
Nuvem, Goa- 403 604
Email: carmel@goatelecom.com

ABSTRACT : The state of Goa located along the Midwest coast of India, flanked between continuous range of rugged hills constituting the Western Ghats in the east and vast expanse of Arabian Sea on the west, is a traveler's delight.

Until recently a popular destination for domestic and foreign conventional 'resort tourist', the state is now witnessing an upsurge in Eco-tourism, which is a subset of wildlife or nature tourism. Being a coastal state, Goa enjoys a unique combination of nature's endowment, a significant component of which is the diversity of its coastal habitat characterized by a variety of landforms like beaches, estuaries, islands, lagoons etc. This entire range of coastal environment offers the most amazing array of biodiversity, an important natural resource for 'alternative tourism'.

The excessive beach tourism over the last 3 decades having made substantial contribution to the economic development of Goa, there is no denying the fact that the enterprise has also had its ecological repercussions. Such focused tourism enterprise allowed intensive development of the coastal belt in total exclusion of the hinterland, virtually changing the coastal wilderness of the seventies to haphazardly developed stretches of concrete jungles of today, in less than two decades. In the light of this knowledge, the Government of Goa is facilitating the diversification of tourism product from traditional 'leisure tourism' to 'green tourism'. This paper reviews the potential and prospects of marine Eco-tourism in Goa with a special emphasis on mangrove ecosystem. An attempt has been made here to present the SWOT analysis of the mangrove related eco-tourism enterprise such as Backwater cruises, Bird watching and Crocodile safari of Cumbarjua canal. The paper also takes a look at the role of private enterprise Vis -a -Vis the Government agencies in the existing eco-tourism scenario in the state.

Further an attempt has been made here to verify the anecdotal proposition that eco-tourism is ecologically benign, by presenting a case study of mangroves swamps of Chorao, one of the largest Island at the mouth of river Mandovi and also the site of Goa's only protected Areas for birds, Dr. Salim Ali Bird Sanctuary.

The implicit assumption in the eco-tourism concept that the local communities should benefit has also been examined. The issue of providing opportunities to understand cultural and natural history through eco-tourism is also highlighted by presenting a case study of *"Mannge Thapnee"*(crocodile worship), a unique folk religious response of some eco-tribes settled in this mangrove habitat. The paper further throws light on how these seemingly primitive cultural expressions uphold the conservation of the wilderness. The paper is thus a balance sheet of costs and benefits of 'green consumerism' in the tourism sector.

Key words: *Goa, Eco-tourism, Mangroves, Cumbarjua canal, Crocodile safaris, Crocodile Worship.*

INTRODUCTION

Goa, a tiny State on the Central west coast of India, positioned between Lat. 15^0 48'N & 14^0 53'N and Long. 74^0 20'E & $73^0$40'E is a well publicized tourist destination. The 3,702 Km^2 of its area, showcases diversity of ecosystems, predominately marine and a range of biodiversity therein. The popularity ratings of this place may also be primarily ascribed to the experience of colonial hangover, its secular fabric, and blend of traditional and modern landscapes, and above all the colorful lifestyles of the ever-hospitable Goans. The enviable place that the state has earned for itself in the international tourism sector, can be gauged by examining the graph of tourist influx; that has recorded a steady growth over the years (Keshkamat, 1999). The importance of tourism sector as a revenue earner cannot be denied. As of today, more than 20% of the state's population benefits directly or indirectly from this sector (Dikshit et al., 2001). Nevertheless, this phenomenal growth of tourism has also given rise to multitudes of problem in the realm of Goan environment and culture (D'Souza and Dholey, 2000).

Having been largely focused on the coastal areas, mass tourism has affected the environment and the socio-economics of the coastal population (Alvares, 2002). The fragile coastal environment having reached a threshold of its tourist carrying capacity, the enterprise is showing the early signs of breakdown. Despite a

growing awareness and concern about these undesirable fallouts of coastal tourism, the issue is still viewed with considerable complacence, and the tourism plans for the state continue to be formulated in total indifference to the opinion and sentiments of the locals.

Against this backdrop, the enterprise is attempting to explore the 'greener' pastures, to minimize the impacts, as also to sensitize the tourists to conservation ethics. Eco-tourism, the term in vogue assures to be committed to environmental security, socio-economic upliftment of the natives, and offer an eco-value added alternative to conventional tourism. In addition, the mandate of the National Forestry Action Plan program prepared by the Ministry of Environment and Forests, Govt. of India, eco-tourism in protected areas is strongly recommended as a participatory approach involving native dwellers. Further National Tourism policy 2002, is eager to promote nature and cultural tourism. The paper is an attempt to analyze the tourism enterprise on a retrospective and prospective scale and presents a balance sheet of mass tourism vis- a -vis green tourism, with special reference to contemporary mangrove related eco-tourism in the state.

MATERIALS AND METHODS

The data presented here has been accessed from primary and secondary sources gathered under the MoE&F funded All India Coordinated Mangrove Research Program on "Eco-tourism potential of mangrove swamps of Goa". The primary data was generated through field visits to the mangrove areas of the state, the focus largely being on areas with existing eco-tourism operations. Useful notes were also prepared by interacting with the local people, Directorate of wildlife and eco-tourism and the Research and Utilization Division of the State Forest department, National Institute of Oceanography, Captain of ports, Dept. of River Navigation, Dept. of Tourism, Dept. of Fisheries, the local NGOs and the tourist themselves.

Crucial secondary data on tourist statistics, tourism plan, environmental impacts, and management were obtained through consultations with available literature like, Proceedings of the workshop on Integrated Coastal and Marine area Management Plan for Goa (ICMAM, 1999), study reports of the National Afforestation and Eco-development Board (2001), Goa State Biodiversity Strategy and Action Plan (2001), and all the tourist brochures on wildlife and eco-tourism. Satellite images and toposheets of the mangrove areas were procured from National Institute of Oceanography, Goa and Department of Science and Technology, Govt. of Goa; for assessing the landscape changes, followed by ground truthing. Background literature in form of reports, thesis, and papers was referred.

OBSERVATIONS

Routledge (2000) has indulged in a curious analysis of Goa's reputation as tourist destination particularly focusing on the immediate post liberation times. In essence, a few key points that emerged in his intelligent analysis are as follows:

The state's Portuguese architecture cuisine, dress code, and leisurely lifestyle offer glimpses and feel of its colonial past. Routledge has cited a number of examples of tourist brochures that use colonial references. Interestingly as pointed out, the state has also been marketed in a gendered character.

Commodification of the male gaze was also a means of tourism promotion in Goa. The contemporary cultural debasement as witnessed by rising graph of sexual crimes on Goan coastline is fallout of this gendered commodification. Goa's reputation as a place where one can enjoy a cocktail of timelessness, absolute liberty, heavenly cuisine, and in recent times, as a place where one can have an ero-exotic experience has to be seriously viewed from the cost benefit ratio in tourism sector (Alvares, 2002).

To be able to appreciate the contemporary scenario in the tourism sector particularly with reference to the excessive 'beach Tourism' that this state has witnessed and withstood in the last two or three decades, it is pertinent to look at the history of development of tourism in Goa. As a matter of fact, and supported by narrations and memory of living witnesses there wasn't any organized tourism worth a mention during a pre-liberation years of Portuguese Goa. The oppressive colonial regime stifled all attempts in direction of promoting the place that they ruled as a tourist destination.

The only visitors then, the emigrants who were pulled back to the place of their origin, lured by its unique socio-cultural ethos. Besides this class, the only visitors were the officials of the Portuguese government. Both these groups did not lay any demand in terms of infrastructure and it is only in post-liberation days that the charms of Goa started attracting people from all over the world. Integration of this tiny land with the main stream and the resultant flow of visitors that followed were not compatible with meager facilities. Most often, locals rented out their own residential premises at that time and offered the hospitality.

Within a decade of its liberated status, Goa became the heaven for hippies and it may indeed be right to give credit to the hippies for popularizing Goa as tourist destination within and outside Goa. For within India, the hippies and their lifestyle was an attraction for a domestic tourist. At this time was a rapid increase in the hospitality infrastructure initially by small and medium

establishment, and very soon the first elite luxury hotels appeared on the scene. This laid the foundation of a long-term alteration of coastal landscape that continues until date.

By the mid seventies, the political masters of the state guided by their greed realized the potential of this sector for generating revenue, and supported and vigorously pushed promotion of the state as a tourist destination both within the country and internationally. It was also the perception of the time that the tourism was regarded as 'zero pollution industry' and the global economic scenario favored the development and expansion of tourism sector.

It was during the early eighties that the pressures and repercussions of unplanned, excessive resort tourism were being felt. The environmental costs of this unregulated sector was getting seriously noticeable, to add to which cultural disturbances also became apparent. By the mid eighties, resistance by the locals came to the forefront. Organized protest began building up and the 'think tank' of this land started deliberating on tourism. Cultural debasements, inequitable consumption of resources depriving the locals, were some of the issues that came to the forefront. So intense were the pressure that even the statutory agencies could not refuse cognizance of them. Though by now the hippies backtracked, the rich and the elite patronized the sector.

By the nineties, the tourism sector burgeoned beyond sustainable limits and the sector actually proved to be counter productive. By the last decade of the millennium, the alarm bells were already ringing. (D'souza and Dholey, 2000). It is at this time that the lime light was shifted away from the coastline, and the tourism enterprise launched its search for alternatives that would assure good returns and comply with the consolidated efforts to shift the pressures from our seashores. Some of the earliest examples of the alternative tourism in Goa are the Bird watching trips and the Crocodile safaris in the mangrove swamps of Cumbarjua canal initiated by locals with the minimum of the investments, following the recommendation in the first report on the status of the marsh crocodile in the Cumbarjua canal (Borkar *et. al.*, 1993).

In our unbridled pursuit of development, we have hitherto ignored the environment. As a result, many subtle ecosystems became causality. One of these is mangroves.

Mangroves also called as tidal forests or coastal wetlands are in fact highly specialized ecosystem, in the intertidal areas along sheltered seacoasts and estuaries in the tropical and subtropical regions. Such ecosystem is quite significant in itself, as it is in the confluence of land, seawater, and freshwater; and is therefore an excellent reservoir of plant and animal species of the terrestrial and aquatic realm. The flora and fauna provide the source of livelihood and avenues to gainful employment of the people inhabiting these regions (Borkar, 2001).

Goa's mangroves are extensive, with about 0.5% of the state's area being covered by them. These tidal forests are significant component of the Goan bioregion. Mangroves in Goa are found in the intertidal khazan lands and total area covered by them is about 2000 ha. (D'Souza & Ambasht, 1999). Goa is drained by seven major rivers, of which Mandovi and the Zuari with the Cumbarjua canal form the largest estuarine complex. As per the aerial survey carried out by NIO in the year 1989, Mandovi River constitutes about 7 km^2 of mangroves areas, whereas Zuari constitutes about 9 km^2, and the remaining lie along the Cumbarjua canal. Thus, Mandovi, Zuari and the interconnecting Cumbarjua canal comprises about 75% of the mangrove swamps of Goa.

More than 59 species of mangroves have been recorded all over the world, out of which 45 sps. are found in India. 15 of these species find their home in the saline waters of Goa (Untawale, 1999). The predominant species along the Goa coast are as follows *Rhizophora mucronata, Rhizophora apiculata, Bruguiera gymnorrhiza, Bruguiera cylindrica, Ceriops tagal, Kandelia candel (K.rheedi), Avicennia officinalis, A. alba, A. marina Sonneratia alba, S. caseolaris* and *Aegiceras corniculatus.* The other associates found along with the mangroves are *Derris heterophylla, Acanthus ilicifolius, Excoecaria agallocha Clerodendron inermi, Acrostichum aureum, Cyperus* spp. *Porteresia coaretata and Ceasalpinia crista.*

Mangrove ecosystem houses an impressive diversity of fauna (Parulekar, 1984), and provides a breeding ground for a variety of marine fishes (ZOO/CBSG, 1998). These tidal forests support a variety of gastropods, mollusks represented by number of snail, bivalve mollusks mainly oysters; crustaceans represented by variety of crabs , shrimps mud lobsters and barnacles and fishes of which the commonest form is the mud skipper.

A bare couple of decades ago mangrove forests were considered as wastelands, of little value. However, of late humankind has begun to recognize their importance as major renewable resources to be protected and husbanded carefully. Besides providing free ecological services, the mangroves ecosystem play an important role in economic activities. This fringing swamps also hold a great promise to enthrall the tourists with their extraordinary calm and peaceful settings, far away form the hustle and bustle of overcrowded seashores. Above all the diversity of life forms that these mangroves swamps support offers a great potential for sustainable eco-tourism in Goa.

Mangrove areas of Chorao in Mandovi have been declared as Dr. Salim Ali Bird Sanctuary to protect the flora and fauna of this region. This sanctuary, which is spread over 1.78 sq. km at western end of the Chorao Island along the river Mandovi, is a heaven for a variety of resident as well as migratory avifauna. These fauna along with the lush green surrounding of mangroves and the flowing of waters through the creeks particularly during low tide is a feast to the eyes of nature lovers.

The first mangrove nursery was established at Chorao 1985 and the plantations have been taken up in the same year. A state level steering committee has been set up on mangroves for its management and development. Under this all the 15 species of mangrove found in Goa along with three important associates have been banned for felling by a notification issued by the department under Goa Daman and Diu preservation of Trees Act, 1984. During the last decade, mangrove plantations covering an area of 1018 hectares have been done at some locations in Goa (D'Souza & Ambasht, 1999). Also, as per FSI report 1999, there is an increase of 5 km^2 in forest cover of Goa due to the increase in mangrove forest. The plantation survival is not 100% because of various reasons and one of the main is the biotic interference through fishing and barge movements.

The most significant of mangrove swamps of the Mandovi-Cumbarjua-Zuari complex, is Dr. Salim Ali Bird Sanctuary, the state's smallest WPA with an area of 1.78 km^2 is located at the western end of the Chorao Island. The Sanctuary is an exhibit gallery of Goa's mangrove diversity and is traversed by a network of creeks. The winter visitors; a rich spectrum of avifauna enriches its eco-tourism potential, besides the biggest attraction of the crocodile, this is the nearest WPA from the capital city of Panjim, that offers rustic wilderness without much artificial landscape changes. In fact, the satellite images are showing regeneration of mangroves. The extant eco-tours in these areas are entirely managed by the private enterprise. The only income that this eco-tourism generates for the forest dept is the entry fee levied on the visitors. The stakeholders are mostly locals who are rather handicapped by their lack of training, inadequate infrastructure and resource material. The swamps offer livelihood opportunities to local fishermen who collect fishes, oysters, and mud crabs. Some restaurants from the area, offer authentic Goan cuisine based on the available seafood resources. The place is also significant as it is the first mangrove nursery for Goa.

Cumbarjua Canal, a little further from Chorao is another popular tourist destination. The first field study conducted by Borkar *et. al.,* (1993) revealed a viable wild population of muggers in this stretch, has also highlighted the hot spots in this range.

Barge traffic, fishing activities, development activities effluent discharge points of canning units, poaching and in recent time excessive crocodile safaris have been posing a threat to this area. In the last one decade, the number of crocodile Dundee operators has increased to more than 20. Crocodile safari is a major attraction to visitors in Goa, being advertised at every joint, shack, and booking counters. There has been no attempt to calculate the visitor's carrying capacity for these resources. The mangroves also provide roosting sites for the flying fox, a mega chiropteran bat. However, no authentic data is available on these. Much of these mangrove related eco-tour being managed by private tour operators, lack an angle of education and management. Many a times the tour operators are school dropouts with no background of natural history and only confuse the eco-tourist with their information. Again these eco-tours preferentially target the foreign clients and have their own indigenous marketing strategies in absence of proper organization. Tourists are primarily brought in by taxi drivers for a commission. In absence of proper signage, instruction manual, local field guides, and allied resource material, the visitor is a victim of the whims and fancies of the ill-informed eco-tour operators. The only access to information on these areas is the brochure prepared by the Forest Dept and tourism dept. of the state Govt. that are also not compilations of the factual details of the place.

There is no proper sanitary facility at many of these places. The visitor management has to be reviewed and updated through critical study of visitor response. Periodic check listing of resource species and assessment of their renewal dynamic have to be done. It is also necessary to direct socio-economic research to these protected or "No development zone"

Most of these mangrove areas have connectivity and accessibility. Tourism related infrastructure is rather poor. There is also a complete lack of co-ordination between tour operators and the statutory Govt. agencies, in whose jurisdiction the eco-tourism resources lay. There is a dearth of training facility for eco-tour guides, as also a great scope to develop educational material on these resources. There is an urgent need to collate information related to eco-tourism available with different agencies to streamline the whole enterprise and offer a better service to the tourist. Certain cultural dimension of eco-tourism have not been sufficiently publicized. Cumbarjua canal which links Mandovi and Zuari river is a vibrant mangrove habitat and home for freshwater or marsh crocodile and migratory birds. Crocodile have been found in Goa at least since 1500 A.D. when they were used in the territorial defence of the state **(**Borkar & Mallya, 1995). The local tribe and communities residing along this mangrove habitat worship Marsh crocodile on the new moon day of the 'Paunsh' month of the Hindu calendar, incidentally this worship coincides with the

commencement of the paddy harvest. The role of these unique folk religious response in conserving the crocodile of Goa has been critically analyzed (Borkar & Mallya, 1993; Borkar, 1994).

This unique crocodile worship, locally known as "Mannge Thapnee" could be of great interest to the studious tourists, who would want to interpret the anthropological basis of primitive cultural expression. The event has not been taken a cognizance of in any of the available tourist literature.

An interpretation centre would also ease many of the problems encountered by the eco-tourist. That the big tour operators and the star hospitality sector have almost hijacked mangrove related eco-tourism in Goa, is a matter of serious concern; and defeat the very basis of this enterprise. In his regard, more and local youth need to be encouraged, trained, and supported.

Fortunately, in recent times many of these issues have been infused in curricular framework to increase awareness and sensitize the younger generation (EESS 2002).

DISCUSSION

Eco-tourism as an alternative to beach tourism is a recent phenomenon in Goa (Untawale, 2002). The intense coastal urbanization in absolute defiance of CRZ norms probably mobilized public opinion against the perils of mass tourism. A master plan for tourism development in Goa, prepared by Government in 1987, benchmark of which was exploitation of coastline for charter tourists, invited public wrath as a reflection of an inherent lack of planning. In addition, the 1987 master plan for tourism prepared by state's Town and Country Planning department did not take cognizance of green alternative to mass tourism. A fresh tourism master plan for the state with a 25 years projection was prepared by an "outside" agency in a mood of total indifference to local opinions and expertise (Master Plan for Tourism, 2001). The only element of novelty in this document was analysis of tourist carrying capacity and projection of non-beach areas as tourist destinations. However, the master plan does not address the crucial issue of the environmental impacts of such large-scale diversions of coastal tourists to hinterland destination and lacks ecological sensitivity.

If one has to go by the classical definitions of eco-tourism, hippy tourism could be cited as one of the earliest known environment friendly tourism in Goa. Such an opinion may warrant a debate in the light of certain socio cultural repercussions. The darker side of hippy culture was of course the narco-tourism. Nevertheless, the hippies blended with the local culture more easily, did not place unreasonable demand on the local resources and did support economically the unorganized and economically weaker sector. The cost benefit analysis certainly justifies the impression largely held by the environmentalist in Goa that the hippies were infinitely preferred to the subsequent five star tourists (Alvares, 2002). There is no denying that despite a few undesirable spin-offs this kind of tourism was more environment friendly, involved the local stakeholders, and respected the local cultural sentiments.

With the growing environmental concern, the hospitality industry in the state has begun repackaging of services with a new label of "eco-friendly". In fact, this transformation has been rather smooth as far as the state is concerned. As even prior to the recognition of greener options, tourism was largely centered on natural assets in the coastal ecosystems. Superficial though the changes, the potential of ecotourism to plough back the profits earned into conservation, to acquaint the visitor with local customs and culture, and the involvement of the local communities, equities in profit sharing remains a distant dream. Some preliminary efforts have been made to gauge the prospects and problems of eco-tourism in the state. (D'Souza, 2001)

Howsoever, the sector is yet to be decentralized and opened up to private enterprise. Currently the focus is on wildlife Protected Areas, few heritage sites, and the management is largely over shadowed by the forest department and the tourism department. Nevertheless, many ecotourism destinations lie outside the jurisdiction of statutory agencies and are yet to receive cognizance.

With everything said and done, the 105 km of palm fringed silver sand continues to be the major attraction both for tourists within and outside the country. The coastline, particularly in north Goa is teeming up eateries that offer country specific cuisine. The seashore tourism has steadily graduated from offering a place to laze around and sunbathe, to more sophisticated and contemporary facilities like angling, parasailing, water skiing, wind surfing, diving and snorkeling which are more in the realm of marine adventure tourism.

The year 2002 having been declared as International year of Eco-tourism, intense tourism related activities in many of our fragile eco-system are inevitable. It is prudent to foresee this, and plan and offer this eco-friendly product ensuring a good balance between tourism and ecology. It would also be necessary to create a niche for the local community in this fast growing sector and consolidate the resources and institutional framework with the long-term objective of ensuring sustainable development in compliance with the theme of recently concluded world summit on sustainable development at Johannesburg in South Africa.

In the arena of eco-tourism, the state of Goa is a sleeping giant or perhaps partially awakened and wanting to make strides in the right direction. With its amazing diversity of eco-assets, immeasurable cultural space, and a healthy mindscape receptive to new

concepts and ideas; this new enterprise balancing leisure and recreation with adventure and education can inject order in one of the nation's smallest state; by lessening inequities, empowering citizenry, preserving eco-cultural heritage and promoting dialogue amongst civilization. In a sharp contrast to the existing mass tourism that Goa was hitherto known for, ecotourism is more focused on equitable growth, is less material and energy intensive, and facilitates maintenance of ecological capital; thereby lessening vulnerability to economic crisis.

The advocacy for eco-tourism is also guided by disparities in access to opportunities for economic improvement. Also the concept is underpinned by physical invigoration, mental rejuvenation, cultural enrichment, and spiritual elevation; unlike mass tourism which is singularly focused on pleasure.

Eco-tourism enterprise guided by short-term economic interests in absence of appropriate planning and management are detrimental to the integrity of ecosystem and the local cultural ethos. Thus, a systematic evaluation of socio-cultural and environmental impacts of such promotional and infrastructural development has to be undertaken whereby the positive impacts are facilitated and negative impacts mitigated.

CONCLUSIONS

Mangrove related Eco-tourism is in a nascent stage, in absence of proper guidelines and policies. It would be a farce, if it is totally driven by economic incentives, sidelining the ecological parameters and without ensuring the backflow of profit earned into the conservation of mangroves and the biodiversity it supports. It also needs to be a grass root community based movement. At present, some outsiders and intermediary operate the eco-tours. The locals must be involved if equity and sustainability have to be guaranteed **(**Jagmohan, 2002). In compliance with National Wildlife and Action Plan 2002- 2016, 70% of the eco-tourism receipts must be used for community benefits. The need of the hour is to strengthen partnerships between communities, NGO's, conservationists, Forest department, and the statutory agencies. It would also be interesting to expedite the idea of village tourism, for which Chorao could be an ideal place. More such villages could be financially assisted to offer home stay experience to the tourist at the minimum of infrastructural alterations and investments.

It is safe to invest in the eco-tourism enterprise in the state, as the projected tourist figure of 21.23 lakhs for the year 2011 is well within the WTO recommended carrying capacity limit of 41 lakhs tourist per year. However, a proper institutional mechanism to oversee eco-tourism is necessary. Similarly, marketing strategies have to be reviewed and in tourism promotion should be facilitated through information. In addition, assessment of infrastructure in existing and proposed eco-tourism ventures should be undertaken. Finally, visitor management and environment impact assessment are the two areas that require more attention, as far as mangrove related eco-tourism in Goa is concerned.

ACKNOWLEDGEMENTS

The lead author gratefully acknowledges the funding received from the MoE&F, Govt. of India, New Delhi for the project "Eco-tourism potential of mangroves swamps of Goa" under All India Coordinated Mangrove Research Program.

We gratefully acknowledge the valuable guidance received from Dr. A.G. Untawale, coordinator, AICMRP. MRB and NKK wish to express their gratitude for the encouragement given by Sr. Florence Mary A.C., Principal of Carmel College for Women, Nuvem, Goa.

REFERENCES

Alvares. C. 2002. Fish Curry And Rice A source book on Goa its ecology and lifestyle. The Goa foundation publication 377 pp.

Borkar, M.R. and Mallya M.1992. Eco-theological basis of Crocodile conservation in Goa. Biology Education, 9 (4): 297-298,

Borkar, M.R., Mallya, M., Christopher, S. and Phatak, S. 1993. The status of Marsh Crocodile, (Crocodylus palustris, Lesson) in the Cumbarjua Canal Mugger, of Goa .A consultancy report submitted to World Wide Fund for Nature India (WWF) Goa Division.

Borkar, M.R. and Mallya, M. 1994. Study of Environmental pressures and resource renewal with reference to the Mugger Crocodiles of Goa. Abstract No. 15 National Symposium on Eco-environmental impact and organism response organized by P.G. Department of Zoology and Botany, Govt. Vidharbha Mahavidyalaya, Amaravati, 15-17th October 1994.

Borkar, M.R. and Mallya, M. 1995. Crocodiles in territorial defense in pre- Portuguese Goa. Hornbill, 1: 20-22

Borkar, M.R. 2001. Community knowledge of lesser known Bio-diversity of Goa with special reference to Mormugao and Salcete Talukas A report submitted to National Bio-diversity strategy and Action Plan(NBSAP), A MoE&F initiative. 55pp.

Dixit, A.P., Kukarni, A.R., Mazalkar, R.A. and Singh, R. 2001. Eco-development of tourism spots in and around forests of Goa, Maharashtra (Sindhudurg) and Diu. A report regional centre National Afforestation and Eco-development Board and agricultural Finance Co-operation Limited Mumbai.

D'Souza, and Ambusht. 1999. Status of mangroves in Goa. In: Proceedings of the workshop on Integrated costal and marine Area Management Plan for Goa held at Dept. of Science and Technology and Environment, August 25-26th 1999.

D'Souza, C.A. 2002. Prospects and problems of Eco-tourism in Goa. An evaluation of a novel enterprise. Master's thesis submitted to Indian Institute of Ecology and Environment, New Delhi. 202pp

D'Souza, C.A. and Dholey, N. 2000. Environmental profile of Goa in the last decade of the 2nd Millineum. B.Sc, dissertation submitted to the Goa University 63pp

Directorate of Education Govt. of Goa & Ministry of Environment & Forests, Govt. of India 2002. Teachers training workshop on environmental Education in School System (EESS)

Forest Survey of India 1999. State of forest Report 1999. A report of Ministry of Environment and Forest, Dehradun.

Govt. of Goa, Dept. of Tourism 2001. Tourism Master Plan: 2001-2011. Submitted by Consulting Engineering services (I) Ltd.

Integrated coastal and Marine Area Management Project Directorate, 1999. Proceedings of the workshop on Integrated coastal and Marine Area Management Plan for Goa held at Dept. of Science and Technology and Environment, August 25-26th 1999.

Jagmohan, 2002. Eco-tourism planning In: Yojana, a development monthly. 46: 7-11.

Keshkamat, S.S. 1999. Present status and future Plan for development of tourism Goa. In:Proceedings of the workshop on Integrated Coastal and Marine Area Management Plan for Goa held at Dept. of Science and Technology and Environment, August 25-26th 1999.

Parulekar, A. H. 1984. Fauna of Mangrove ecosystems IN : The report of the training course on mangrove research. 53-62. An N.I.O publication.

Routledge, P. 2000. Golden Goa IN: Economic and Political Weekly. 2651-2652.

State of Forest report 1999. Forest Survey of India. Report by Ministry of Environment and Forest Dehradun.

Untawale A.G. 1999. Status and strategies for marine biodiversity of Goa. In: Proceedings of the workshop on Integrated costal and marine Area Management Plan for Goa held at Dept. of Science and Technology and Environment, August 25-26th 1999.

Untawale, A.G. 2002. Potential and Prospects of marine Eco-tourism along the west coast of India A technical paper presented at workshop on "Development of Eco-tourism in Western Region- Goa held at international Centre Goa on 21st 23rd March 2002

Zoo outreach Organization/ CBSG India 1998. Proceedings of the workshop on Conservation Assessment and Management Plan (C.A.M.P.) for Indian mangrove ecosystems. Held at National Institute of Oceanography, Goa 21st -25th July 1997

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 317-319

NADI TO NALLAH
A STORY OF A RIVER THAT WAS AT DAHISAR

Indira Bhende
Zaveri baug, Y.R.T. Road, Dahisar (W), Mumbai – 400 068

To some of you, who may be visitors to Mumbai, Dahisar is suburb in the North west of Mumbai and the last limits of the city, on the western side of Mumbai.

I am representing the sentiments of a number of my senior colleagues and the people of Dahisar, who could not be here, but are here in spirit to plead for the cause of "save the Dahisar River".

The Dahisar Nadi was the nerve centre of our village. We spent many a summer holidays here, and all my senior colleagues recall the learning to swim, fish here. Ganesh and Navratri diya immersions or washing of Holi colours were enjoyed as community, at the river...

Dahisar River supported potters, brick makers, fisher folks and importantly, the dairy industry.

Dahisar river has its source on the hills of Kanheri, or Krishnagiri or the "Black Mountain" in which are the 1st century B. C. to 9th century Buddhist caves of great Archeological value.

The mountain forest 103 Sq.km., is the "green lung" of the city. A Green-Oasis in the municipal limits, of great ecological and zoological value. These mountain forests cradle the Vihar and Tulsi Lake, which supply water to large part of the suburbs. Many streams from these mountains and the Tulsi Lake join at different parts to flow through National Park. Borivili east, and for the major part, runs through Dahisar, hence called "Dahisar River". **The river finally enters the Mira –Bhyander Mangroves Creek area.**

The river runs through mountain slopes, making large riverbeds which dry up in the month of October / November.

Old dams have been broken, these dams, helped to save the flow of water, and formed small water reservoirs for the animals of the forests.

A well wisher has replaced one. God Bless his soul.

The river passes Sati Baug in National Park, to make a small lake area whose dam has been broken, and the water dries up by March April.

It then flows, to the beginning of it's degradation, as it runs along Krishna Nagar, the quiet bungalow colonies, which began in the Sixties, and today are surrounded by monstrosities of miles of "Apartment Complexes" that contribute to the choking of the river.

Modern Transport Connectivity brought in, in the 70's, the NH8 highway.The bus stand to AHEMDABAD have numerous commuters with their bountiful generosity leave their daily contributions, to the river.

Borivali, Dahisar were the homes of the local dairy business. Cleanliness is our Motto, floor-wash can be chucked out. So also, stable and buffalo washes with the slurry and dry fodder pass into the River, breeding tons of mosquitoes.

The 70's also saw one of the first beautification – drive of South Bombay. We call it, "cleaning my front yard by throwing things in the neighbors back yard", which was North Mumbai. So we received the 'first' present of the big slums on the river bank east of Railway lines of Dahisar.

To add, insult to injury to the river, the famous or infamous, fly over which links Dahisar west to Borivali east and the Highway, is being constructed to solve the traffic problem. Bridges are generally built across the river but here piled pillars run in the middle, all along, vertically in the riverbed. Planners were oblivious of the existence of the river and so, left no semblance to the poor river.

Through the 80's as the land prices in south Bombay skyrocketed, an exodus of the middle class residents were attracted to Dahisar's picturesque banks and low priced apartments. Early builders let out sewage drain in the river.

The next decade colonies of slums were relocated and spread, till now there is no open government land. Year after year, the older slums got regularized by being baptized or "namkaran" with famous names Sanjay, Rajiv, Ambedkar nagars, while the new shanties waited for their turn to be registered by current leaders names. Sanitation is solved by releasing the domestic sewage directly in to river or led it into the nearest storm water drain which empty out in the river.

Major BMC nallahs are released in the river. Toilets are built at intervals on the banks of the river. Micro business of the huts involved in activities like bindi

making, watch straps, plastic bottle caps, repackaging chemical compounds take place in the huts and waste is disposed out in the river.

The greatest hazards to the river are from the rag picker who carry out their sorting at their authorized collection point. The rag picker-king flaunts all laws and warning, as he knows no law can touch him, as he is PROTECTED. Also the sympathetic attitude of the society, elevates his status, as he is doing a noble job for the society. He can chuck it into the riverbed. Or "who to Nallah hai" This discarded plastic gets enmeshed in the dry fodder feed, which is washed out with all stable slurry through the BMC nallahs.

This plastic island slowly floats to choke the riverbed and the old foot-bridge. It appears to have assumed that plastic cannot pass through below the bridge so better break 400 years old foot-bridge. But not prohibit the plastic waste disposable method. Unhygienic conditions from all the collected cess pools, are potent breeding grounds for mosquitoes and infections of all kinds resulting severe medical problems like cerebral malaria, mosquitoes making life miserable, through evening to morning, preventing a good night's sleep.

BMC haphazard cleaning by a contractor who uses dredgers causes more damage to the riverbed and loosens the banks of river. The heavy equipment used is unable to evenly clear debris from the riverbed, leaving pockets of unhygienic cesspools; it also leaves behind thick accumulated sludge. It is learnt that several lakhs of rupees are spent in the process without the desired results, year after year.

The river full of heavy sludge finally enters the creek and chokes the mangroves. Builders have begun their onslaught here, which is injurious to the Mangroves.

1. What is this conservation River and its water that I am speaking of ?

2. And why am I focusing on replenishing of water resource ?

In 1955 availability of water, per head in India was 5300 cu.M

In 1999 availability of water, per head in India was 2200 cu.M

Diminishing water levels places India in the Red List of DRY countries up to 2025 Million of tons of water are lost during the monsoons.

Can we save this water. ????????????

Mumbai has one of the greatest advantages of Vast BIO-Geographic Zones of mountain forestlands, which could be utilized to make several catchment areas to save the colossal loss of rain water every year.

Dr. CharnSingh Sethi, Hon. Min. for Water Resources, in his article in the Times of India Aug 2000 drew our attention to

a. Use methods to prevent the depletion of water tables.

b. Correcting mismanagement of water resources.

c. Rain water harvesting, i.e. saving of colossal loss of the rain water in catchment areas, reservoirs and lakes.

Geographers, scientists, and environmentalists you certainly know all this.

My appeal is to you, with your knowledge, influence to bring a policy change. The danger is our shortsighted VISION.

Some of the methods for correcting water mismanagement and retrieval system.

Several organizations and technological researchers have suggested various methods.

1. Almitra Patel's paper on Sustainable Wastewater Management. She mentions various methods, one of, which is the DECENTRALIZED SEWRAGE TREATMENT, saves enormous cost of underground drainage. This is being used in PUNE Nala Baug at KOREGOAN PARK.

This is a GERMAN TECHNOLOGY exchange. It is a Success Story of the beautiful garden of OSHO ASHRAM designed and maintained on wastewater. This project was collaboration between, 1) State Govt., 2) Pune Muncipal Corp. and the 3) Shunyo Foundation, which funded the project. The Nala Baug, is 900 meters long and 60-70 meters broad and lies downstream of a slum of 5000. It is designed to handle normal flow of 21,000 to 24,000 gallons /hr, as well as, peak monsoon flow of 100 times that volume, without causing any damage to the biological community of flora and fauna that feed on the stream along the length of the park.

The Pune Municipal Corporation has created and planned more cost effective Nalla and Baugs, based on the same principals, 1) Sahakar Nagar, at Kondwa, 2) Bhairoba Nala, 3) at Kotrud. Pimpri-Chinchwad Municipal Corporation has cleaned up 4 nallahs with similar garden treatment. Delhi's Ganda Nala, are some more of the examples.

It is possible that this Low cost, low maintenance technology of decentralized wastewater treatment systems may, with modifications, could it be used in Mumbai as an alternative to Conventional Sewage treatment plants which are cost prohibitive. Would we not empower the slums with a new vision of slum rehabilitation, hygienic and healthy living conditions? This participatory involvement in keeping their surroundings

clean would enhance their well being as beneficiaries rather than keeping them as victims made use of as "vote banks" with false promises.

Other methods are

2. Bio-Towers, a cheap and new treatment to sewerage developed BY EXCEL INDUSTRIES. Jogeshwari, Mumbai.

3. One Nature, offering sustainable technology solutions on wastewater and sanitation by Prof. H. S. Shanker, Professor of Chemical, Bio-chemical and Environmental Engineering, IIT Bombay.

4. CIFR – Project Water – funded by ICEF deals with the community based water resources management with emphasis on scarcity and degradation, depletion, over extraction of ground water, pollution of surface water and its ill effects on Health nutrition, climatic and ecological changes.

5. Rain water harvesting and water shed management. Man made lakes and reservoirs e.g., at Kamshet Project 26 kms off Lonavala has changed the ecology of the areas.

6. In addition to the 2 lakes Tulsi, Vihar and numerous forest streams and the Dahisar river, could provide many other catchment or water sheds, to check the lost millions cubic meters of Rain water.

7. Cascading Dams to check the flow of running water at different intervals, allowing water to flow through out the year, could provide water sources for the rich fauna & flora of the forest.

Water Crisis Management will have to be done on war footing. If there is a WILL there is a WAY.

The Dream Or the Vision, There is A way.

Who all are the beneficiaries?

1) Dahisar River, of course

2) Bio-geographical area of 103.9 sq. kilo meters. As per Udvardy's Bio-geographic classification of National Parks situated in "the Western Ghat Bio-geographic zone No-5, i.e. the Malabar Coast 5 A". It is one of the least protected Bio-geographic zones in India though ; it has a very rich flora and fauna.

(A. R. Bharati, Dy. Conservator of Forest/Sanjay National Park.)

3) The Sanjay Gandhi Parks would be lush green through out the year with variety of seasonal flowers for which the garden was once famous and there could be many a lakes, full of water. Ambiloda garden by Pune Municipal Corporation charges an entry fee of Rs. 1/- for adult, 50 paise per child and Rs. 20 for monthly pass.

The same could be done here. National park annually receives 30 lakhs of visitors, this revenue could make the park self generating, sustaining employment for many unemployed.

4) The Lion SAFARI park, which gets dry, parched and hot by March, would provide fresh drinking water and shade to the animals.

5) The depleting water tables of lands around Borivali and Dahisar could be retrived or corrected.

6) **The large stretches of Mangroves could be saved from the choking sludge and be established as park area for the migratory sea bird to bring about Knowledge and Revenue to Mumbai.**

7) The last but not the least, the Dahisar River could be developed to a DAHISAR NALLA BAUG and fast developing populations of Dahisar would have a place of clean and non-polluted, recreation area and the Senior Citizens will have a place to spend their evening in a pleasant Nalla garden. We are talking of beneficiaries and Well being of thousands of communities.

Ecologists, Conservationists, Geographers, and Scientist, it is you who change the ecology of Northern suburbs with your knowledge influence the planners to change their vision.

ACKNOWLEDGEMENT

I thank Bombay Geographical Association for this opportunity for allowing bringing my cause of Dahisar River to wider platform.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 320-322

NEED OF PUBLIC PARTICIPATION IN PLANTATION, CONSERVATION AND PROTECTION OF MANGROVES IN THANE DISTRICT- MITIGATION AND CONSERVATION ASPECTS

Mahesh M Lahigude
Addresss: Flat No. 402, Vasturajani Apt. Opp. K.O.E.L.
Elphinestone Rd. Bopodi, Pune.

ABSTRACT : Mangroves are the most important natural resource found almost along the entire Indian coast. However the mangroves are being destroyed due to lack of awareness and poor political will. It is necessary to educate common man and convince them about he importance of mangroves. Further replantation of mangroves is necessary which can be achieved through collarabative efforts of Government and Non-government organizations.

Key Words : Combined Role of Govt. and NGO, Environment Education, Public Participation, Rejuvenation, & Sustainable Development

INTRODUCTION

Mangroves are nature's coast guards. Not all tropical coasts are lined with mangroves, but India has been blessed with luxuriant mangroves along almost its entire coastline.

An ecosystem is a natural system in which all forces of nature tend to reach a state of maximum equilibrium and stability. Knowledge of such a system of a particular area should be the basis for stabilizing that particular area for sustainable growth or development. Coastal areas are the most productive and populated areas. Ecological stability of these areas is therefore essential. Unfortunately, throughout the Indian subcontinent, coastal areas have been widely exploited without considering the minimal ecological needs of the area. Mangrove is one such ecosystem, which has been disregarded. This has resulted in gross abuse of this system which has deteriorated immensely. No estimates are available to calculate the cost of restoration of this system. Restoration of mangroves is the need of the hour and every attempt should be made to realize this goal. Now, that the constantly increasing pollution, the continuing destruction of mangroves and the ingressing sea have started showing their ill effects.

A mangrove ecosystem is a peculiar habitat found on the boundary of land and sea. Mangroves are found only in the Tropical and Sub-Tropical regions, i.e. between the 30^0N and 30^0 S latitudes and are the extensions of the tropical rainforests, towards the sea. They usually grow on clay soils, which are flat and sloping gently (Mud – flats) and in regions where tidal action brings in water regularly. Though mangroves are largely found in the estuarine regions, they also inhabit the inter – tidal regions of shallow bays and creeks.

Mangroves are governed by several limiting factors, such as temperature, salinity, substrate, detritus, dissolved oxygen, wave action and wind currents. When these limiting factors are favourable, the mangrove ecosystem flourishes in that area. However if even one or more of the limiting factors are unfavorable, the mangroves do not show healthy growth in that region.

Besides natural conditions, anthropogenic pressures are mainly responsible for deterioration of mangroves. In Thane District, the main reasons for mangrove degradation are reclamation for building, reclamation for civil purposes is mainly occurring in urban areas, mostly around Mumbai and Thane, dumping of solid waste from the urban areas, industrial chemical pollution in most of the creeks, pollution is spreading fast in almost all the major estuarine systems due to increase in number of industrial circles, Cutting for fuel wood, cattle grazing and exploitation for timber.

As mentioned, mangroves are seriously threatened in the Thane District, the main reason for destruction of mangroves is lack of awareness and lack of political will. The political will could develop when people are convinced about the importance of mangroves.

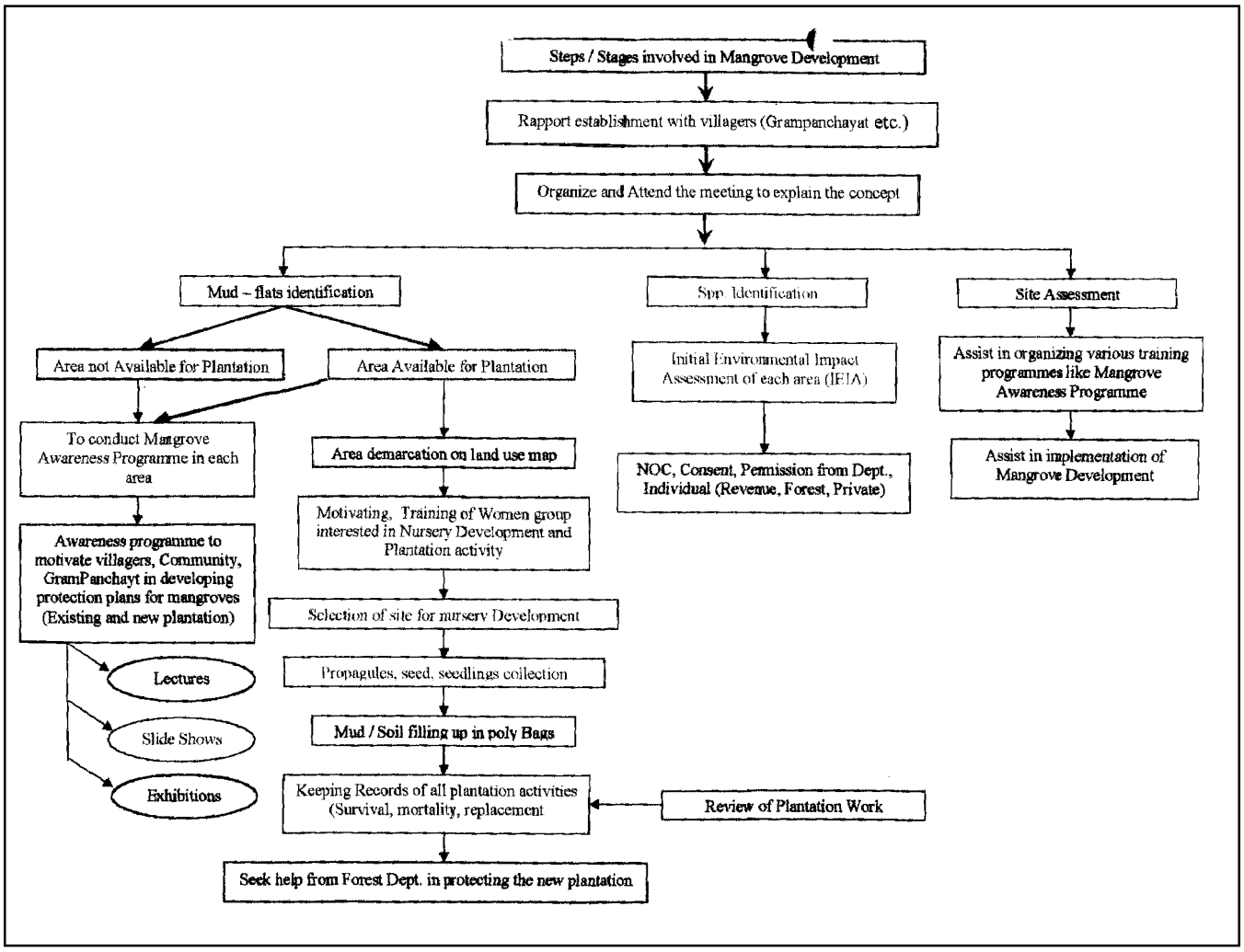
MATERIALS AND METHODS

Materials:-

- Slides:- Showing various components like, Species, Biodiversity of the area, effect of pollution on mangroves, effect of mining, siltation problems, areas available for the plantation
- Posters:- Self explanatory posters showing Environmental as well as Economic importance of Mangroves.
- Charts:- Description and Key – Words related with ecosystem explains Economic & Environmental importance.

Method:-

Various steps / stages involved in Mangrove development is shown in the flow sheet. This involves all aspects of Mangroves rejuvenation, Role of Govt, bodies, Role of NGO's, Environment education and awareness including public participation.



DISCUSSION

Environment Education And Awareness:-

Mangrove Awareness Programme

Since gross ignorance of people towards mangroves is the major factor for the degradation of this ecosystem, any attempts of restoration will fail if the awareness is not brought among the masses. For public participation in protecting new plantations as well as the original mangrove stands, education and training programmes have to be designed. Mangrove awareness programme shall be focused on the following points.

- ✓ What are Mangroves?
- ✓ How do mangroves help us?
- ✓ How do mangroves function?
- ✓ Why should we protect mangroves?
- ✓ How to protect mangroves?
- ✓ What are the different spp. Found in the area?
- ✓ Role of spp. ; Foodweb; Biodiversity?
- ✓ What is the Environmental importance of Man groves?
- ✓ What is the Economical / Commercial impor tance of Mangroves?

Mangroves Management Programme should be based on the following points.

- ✓ Need of Environment Education and Awareness Programmes.
- ✓ Inputs for the Mangrove Awareness Programme.
- ✓ Public participation in such programmes.
- ✓ Areas available for Plantation purpose.

- ✓ Stabilization of such areas with mangrove plantation.
- ✓ Rejuvenation of mangroves in destructed areas.
- ✓ Protection of Existing as well as new Plantation.

Following Facts were revealed during the rapid survey of Thane District Coast line:-

- ❖ Mangroves have been maximum destroyed in Thane for reclamation for building, reclamation for civil purposes, dumping of waste etc.
- ❖ Maximum Chemical, domestic Effluent Pollution and floating waste like empty bottles, poly bags etc. has been observed in creeks nearby Bhiwandi, Thane, Kalyan, Ghodbunder, Vasai region of Thane district.
- ❖ This may reduce the success rate of plantations, even though ideal mudflats are available.
- ❖ Lack of Environment Education and awareness is one of the major factor in destruction of mangroves in the Thane District.

Suggestion and Recommendation

- ➢ Local people's involvement is the most necessary thing which needed to be taken in to consideration.
- ➢ Massive awareness campaigns are required to realize the economic as well as Environmental importance of mangroves for their Livelihood.
- ➢ Development of Awareness campaign material is the prime need.
- ➢ As Thane district is very close to Mumbai, several activities of construction new bridges, roads and road widening nearby creek leads to form new mudflats, which needs to be stabilized by plantation.
- ➢ Development of mangroves in patches wherever technically feasible (presence of suitable tidal lands)
- ➢ Protection of existing mangroves.

REFERENCES

N.D.Chhaya, 1997, Minding our Marine Wealth As appraisal of Gurats Caostal resources. Centre for Environment Educarion, Ahmedabad. Page no 17 - 26.

Saida Wafar And Arvind Untwale, 2000, Marathi handbook on mangrove Pranali Kinaryasathi Vardaan, national institute of Oceanography, Dauna Pola. Goa – 404 004. Page no 8 -19

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 323-324

SUSTAINABILITY EQUATION AND AN INDIVIDUAL'S ROLE

Jyoti Marwah and Manjushri Ganguly
ICLES' MJ College of Science Commerce and Arts Vashi, Navi Mumbai

ABSTRACT : Rio 92 was a watershed but it cannot be denied that it generated enough awareness and need for global commitment towards a greener world. Although it made many key agreements within the framework, to check climatic change and to ensure sustainable use of plants and animal resources (bio-diversity) but there has not been much action. Its declaration was addressed to concerns related to poverty, development, environment and preservation of forests but they have remained unfulfilled. All this and more became clearer at the 10-day world summit on "Sustainable development" held at Johannesburg from 23rd august to 4th September 2002. The struggle now is centered on sustainable development and there is widespread optimism that from Johannesburg will emerge something new that will take the world forward towards the realization of sustainable development goals. These goals are centered on sustainability equation i.e. protection of natural areas and species. Human species has to respect the other creatures with which we share the planet – this means we have to learn to respect the atmosphere, the oceans, soil and forests.

One of the country's largest marine bodies in an enclosed area – the Thane Creek has been polluted throughout its length way beyond the safe limit. The National Environmental Engineering Research Institute (NEERI) reports, after an analysis of the Thane Creek water that the load of domestic and industrial effluents in the area are likely to choke the creek between 2015-25. Samples from the Creek showed that most indicators of pollution like BOD (Bio chemical oxygen demand) and DO (dissolved oxygen) were not of the required sea water standards. NEERI has recommended that all domestic discharge, industrial pollutants should be given secondary treatment.

Key words *: Sustainable development, Thane Creek, Pollution.*

INTRODUCTION

Rio 92 was a watershed but it cannot be denied that it generated enough awareness and need for global commitment towards a greener world. Although it made many key agreements within the framework, to check climatic change and to ensure sustainable use of plants and animal resources (bio-diversity) but there has not been much action. Its declaration was addressed to concerns related to poverty, development, environment and preservation of forests but they have remained unfulfilled. All this and more became clearer at the 10-day world summit on "Sustainable development" held at Johannesburg from 23rd august to 4th September 2002. The struggle now is centered on sustainable development and there is widespread optimism that from Johannesburg will emerge something new that will take the world forward towards the realization of sustainable development goals. These goals are centered on sustainability equation i.e. protection of natural areas and species. Human species has to respect the other creatures with which we share the planet – this means we have to learn to respect the atmosphere, the oceans, soil and forests.

Mahatma Gandhi had rightly said, "earth provides enough every man's needs but not for every man's greed." Indira Gandhi had opined that poverty is the greatest polluter not because the people are poor but because for poor people the immediate need is survival. Those who can meet their daily needs can alone think of their future. So what is required is a change in production and consumption patterns so that the resources are not wasted and re-channeled for every one's needs today as well as for future. Also, what is even more important is the building of balanced ecological practices and waste management so that the environmental concerns are taken care of.

One of the country's largest marine bodies in an enclosed area – the Thane Creek has been polluted throughout its length way beyond the safe limit. The National Environmental Engineering Research Institute (NEERI) reports, after an analysis of the Thane Creek water that the load of domestic and industrial effluents in the area are likely to choke the creek between 2015-25. Samples from the Creek showed that most indicators of pollution like BOD (Bio chemical oxygen demand) and DO (dissolved oxygen) were not of the required sea water standards. NEERI has recommended that all domestic discharge, industrial pollutants should be given secondary treatment.

Persistent organic pollutants such as dioxins and furans are long lasting toxic chemicals and synthetic compounds for aromatic purposes found in cosmetics, perfumes, detergents, soaps and toiletries are a cause for major concern. These chemicals often accumulate in animal bodies and when consumed by human beings are causing long term damage to the immune system

along with changes in the sexual developments of all species from whales to humans.

Detergents, consumers and the environment

The expanding detergent market a major concern for ecologists and therefore it is recommended that

(i) Ingredients, which are, less than 70% biodegradable and which exhibit high toxicity to aquatic organism should be abandoned.

(ii) Required dosages should be lowered and information to the consumer should be clearer.

(iii) Addition of necessary and un-necessary fillers and stabilizers should be limited.

(iv) Detergent producers and washing machine manufacturers should co-operate closely to improve upon the components of washing machine.

(v) Liquid detergent should be developed so as to reduce surfactants and soap levels going into the effluent.

(vi) Environmental data should not be distorted.

(vii) A product should not be promoted as bio0degradable without informing the consumer of the important distinction between the primary and total degradability.

(viii) Unrealistic claims should not be used such as "best for the environment."

(ix) Consumer should be allowed to reach an independent conclusion for an environmentally friendly product by telling him the truth.

It is very clear that the future of the chemical industry will be directly shaped and will be ultimately determined by environmental issues.

SYNTHETIC FRAGRANCES

Synthetic fragrance with chemicals began to be used in the first half of the last century developed parallel to the rapid development of organic chemistry. As plant fragrances – essential oils – are difficult to extract from natural sources chemists successfully produced them synthetically. Total range of synthetic fragrances is very vast, many being made from minerals such as coal tar and petroleum. These synthetic chemicals are predominantly modeled on natural fragrances or they may be entirely new molecules which are not found in nature. These synthetic chemicals are also the cause for major concern as they are found in all consumer goods – edible and non-edible.

Mosquito repellents in form of coils, aerosol sprays, creams, liquid based formulations etc use allethrin and DEET – a synthetic chemical as main active ingredients. These are known to cause health problems and create resistant varieties.

Hence what is required today is to create eco-culture in the use of daily consumer goods specially soaps, cosmetics, disinfectants, insecticides and pesticides.

SOLUTION

1. Insect repellents and slow burning insecticidal incenses containing essential oils, pyrethrum and neem extracts can be used for repelling cockroaches, mosquitoes, ants and even rats.

2. Aromatic plant products like soonth, kapoor, kali mirch, laung, dal-chini, supari, powders can be used for teeth in a formulation with calcium carbonate as ayurvedic tooth powder.

3. For hair wash, an ayurvedic preparation of jaswand, chandan, shikakai, aritha and amla can be used.

4. For a face wash, apreparation made from herbal powders like kachur sugandhi, chandan, aloe, rose can be used in a formulation with roasted dals – pulses.

These products being biodegradable will help to reduce pollutants in water bodies and at the same time make human body healthier by reducing the use of toxic chemicals.

The three great challenges that confront us in India as we contemplate on environment and sustainable development are:

1. Huge industrial and agricultural pollutants, which are still not taken, care of.
2. Societies must live and work with sensitivity but the means to do so are neglected.
3. Governments fail to frame policies to protect public good due to politics.

We hope that the global learning process initiated by the Rio Earth Summit and Johannesburg Earth Summit will offer sound solutions to environmental problems without disrupting domestic production or creating unemployment. But before this can be done, every citizen of the world must become aware of how much pollution, he or she adds.

LITERATURE CITED

CIMAP Lucknow, *Medicinal Plants and Skin care.*

Edgars Woolard, *A Sustainable World,* Chemistry and Industry, 19th Nov 1990.

Eva Kolber, *Detergents: detergents, the consumer and the environment*; Chemistry and Industry, 19th March 1990.

The Hindu, *Survey of Environment 2000*.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 325-330

DYNAMICS OF COASTAL REGIMES

Sudha Srivastava,
Department of Geography,
University of Mumbai,
Mumbai - 400098.

ABSTRACT : Coastal zones are unique in nature as they are located at a transitional interface where the interplay of marine and terrestrial processes creates an array of landforms and microenvironments that harbour complex and varied ecosystems. The precariously balanced ecosystems are vulnerable to even slight alterations in environmental conditions. Coasts are highly favoured sites for occupation by man too. 60% of the human population, that includes two thirds of the world cities with a population exceeding 1.6 million, is located in the coastal domain of the world. Of late anthropogenic influences have caused drastic changes in the morphology, land use/land cover and quality of near-shore water, at times resulting in irreversible damage.

India is endowed with an extensive coastline whose continuity is punctuated by creeks, lagoons, estuaries and deltas. With the impending danger of rise in sea level in response to global warming, protection of coastal areas should be a national priority. Regulations have been framed to arrest further degradation of the ecologically sensitive areas, for instance the CRZ (Coastal Regulation Zone) notification. However due to a wide spectrum of problems ranging from conceptual to implementation, it has met with little success.

The present study focuses on sections of the west coast of Maharashtra, where the influence of metropolitan Mumbai predominates, and rapid transformation is taking place due to the expanding improved transport network.

It is strongly felt that a thorough understanding of factors and underlying processes at work in a coastal system coupled with a meticulously compiled database related to the prevailing physical and socio-economic environments are prerequisites for improvising strategies that ensure stability and sustainability in the development of these areas. Integrated resource development and management for coastal regions is the need of the hour.

Key words: *Coastal landforms and processes, estuaries, creeks, land use/land cover, CRZ.*

INTRODUCTION

A coastal zone extends from the coastal plains to the outer edge of the continental shelves, approximately matching the region that has been alternately flooded and exposed during the sea-level fluctuations of the late Quaternary period.

Coastal zones occupy 18% of the surface of the globe where around a quarter of global primary productivity occurs and supply approximately 90% of world fish catch. 60% of the human population lives here. In fact two thirds of the world cities with population of over 1.6 million people are located here. The coastal waters account for 8% of the ocean surface, less than 0.5% of the ocean volume, around 14% of global ocean production, in addition to a substantial amount of denitrification, organic matter burial, sedimentary mineralisation, suspended river load and its associated elements/pollutants and carbonate deposition.

Terrestrial and marine processes dominate the coastal zones, creating forms produced by erosion like wave cut platforms, sea stacks and sea caves, and those produced by deposition like beaches, deltas, mudflats and spits. Estuaries and creeks, often colonized by mangroves are common along a number of tropical coasts. The geomorphic processes at work are determined by a number of environmental factors - geological, climatological, biotic, tidal and oceanic factors like salinity. There is an input of energy (wind, tides, currents, living organisms) and materials (rock, water, sediment), which interact to generate landforms.

An estuary is a river mouth widening as it enters the sea, where a dynamic and distinctive environment prevails as fresh river water meets and mixes with salt water from the sea. It is linked with deep water offshore, strong marine currents and small sediment load. Strong tidal scour occurs where regional tidal range is great. The nature of the substratum, the extent of tidal influence, the size and frequency of the waves, the strength of the currents, the nature of distribution of salinity, the type of sediments, the oxygen content of the water, pH, temperature, amount of organic matter and its oxidation, presence of hydrogen sulphide, concentration of ions, nature and the extent of pollution among others are important influencing factors. Their fascinating biotypes are highly productive ecosystems. They serve as cradles for several types of finfish, as nurseries of commercially important shrimps, prawns and crab, as highways for

the migration of several varieties of fish and are ideal habitats of mussels, oysters and clams. In addition, these areas have been the focal points of maritime activities culminating in the commercial, social and cultural intercourse between nations.

A creek is an inlet on the seacoast or a short arm of river or tributary. It often comprises mudflats with a network of drainage channels that direct the flow of advancing and receding tidal waters. The significance of such channels is especially realized during storms, exceptional high tides and when torrential rains lash the coastal areas.

Depositional stretches of finer sediments are often colonized by mangroves and marshes along channels. They are extensive in only certain stretches of Thane. These vegetated shelterbelts are of immense value as wind and wave shock absorbers, though aesthetically they may not be all that appealing to the layman. Besides promoting a well-defined detritus food chain, mangrove systems also act as nurseries and spawning grounds for certain organisms. They are believed to absorb excess nitrates and phosphates thus preventing eutrophication of near-shore seawater. Coastal spaces are where nutrients are recycled often (with a positive benefit for fisheries) before sequestering or export.

Due to the advantages in location, ranging from the climatic to commercial, people have concentrated and diversified their economic activities along the coast. Human interventions have constantly disturbed the coastal zone in more ways than one, leading to modifications of coastal landforms, at times subtle and at others drastic. Reclamation and construction, dredging and dumping on the coast and offshore alter the topography and environment. Here species are numerous, numbers are large and there are different metabolic rates, life styles and life expectancies. Decline in fish catch, increasing pollution chiefly by heavy metals and pesticides are local effects produced by anthropogenic influence. Coastal seas undergo cumulative changes which though localized have a global impact.

Attempts to restore coastal environments require a deep understanding of the morphology, factors and processes at work including circulation over the shelf and in estuaries, and effect of human activities, so that through effective modeling pertinent information is available to decision makers on movement of sediments, pollutants and offshore hazards.

Today experts are concerned about the impending climatic change especially rising global temperatures and its impact on coastal areas. It is also likely that there will be an increase in the frequency of heavy rainfall events in South and Southeast Asia. Based on projected emissions of greenhouse gases and sulphate aerosols, predictions reveal a likely increase in annual mean, maximum and minimum surface air temperatures of 0.7° C and 1.0° C over land in the 2040s with respect to the 1980s. Since the warming over land is projected to be lower in magnitude than that over the adjoining ocean, the land-sea thermal contrast that drives the monsoon mechanism could possibly decline.

THE COASTS OF INDIA

India's long coastline, which approximates 7500 sq. kms. if all islands are included, has been inhabited since millennia. Estuaries, deltas, creeks and other landforms are a result of the interplay of processes featuring the waters of the Arabian Sea, Bay of Bengal, and the terrestrial agents chiefly the rivers. The tropical monsoon environment has a profound influence on the seasonal current patterns. Large-scale currents along the outer shelf and beyond reverse seasonally with the monsoon winds. The currents form a continuum from the northern part of Bay of Bengal to the northern Arabian Sea.

Tidal currents have a beneficial effect on the coasts of India. The along shore component that can carry pollutants coastally may never be significantly strong enough to counter the dilution effects during transport. India's coastal waters are clean and well oxygenated with no detectable spread of "hot-spot" influence. (E. de sa, internet). Most pollution in India arises from land-based sources - industrial & domestic wastes and agricultural run-off. As yet our waters are clear as regards metals. Today shipping and associated shipbuilding, breaking and port activities are becoming increasingly significant. The crop of recent industries located on the coast use seawater as a resource and the coastal domain as a sink of altered seawater. This has reference to their temperature and density conditions. They pose newer, more direct threats to ecologically sensitive areas.

The following table enlists the type and quantum of pollutants into the coastal ecosystems of India:

Sr. No.	**Input / pollutant**	**Quantum - Annual**
1.	Sediments	1600 million tonnes
2.	Industrial effluents	50 x 10^6 m^3
3.	Sewage - largely untreated	0.41 x 10^9 m^3
4.	Garbage and other solids	34 x 10^6 tonnes
5.	Fertilizer - residue	5 x 10^6 tonnes
6.	Synthetic detergents - residue	1,30,000 tonnes
7.	Pesticides - residue	65, 000 tonnes
8.	Petroleum hydrocarbons (Tar balls residue)	3,500 tonnes
9.	Mining rejects, dredged spoils & sand extractions	0.2 x 10^6 tonnes

Source: E. de Sa, N.I.O., Present State of the Coastal Environment in India.

Indiscriminate deforestation in the catchment areas, removal of vegetation along riverbanks, improper soil management by farmers and overgrazing have resulted in severe soil erosion and in turn heavy siltation and reshaping of estuaries. In the absence of protection, it is estimated that a one-meter sea level rise on the Indian coastline is likely to affect a total area of 5763 sq. km, and put 7.1 million people at risk.

Indian coasts have a large variety of sensitive eco-systems -- sand dunes, coral reefs, mangroves, sea grass beds and wetlands, and in recent years there has been a movement in the country to protect and conserve all of them. A study of individual elements of coastal configuration at the micro-level is undoubtedly essential to identify the causes of problems, so as to take adequate remedial steps. However each is part of a larger system, with intricately developed feedback relationships, so that a holistic approach is desired.

An extreme case of transformation can be seen with respect to metropolitan Mumbai. Reclamation has played an important role in the enhancement of land resources in the city as population increased and functions multiplied. Pressure on land and demand for space resulted in a change in the basic character of the Island city from an archipelageo to a consolidated extension of the mainland. Coastal areas have been covered by NDZ and CRZ, yet they continue to be highly vulnerable areas. The creeks of the area are becoming increasingly narrow. Reclamation and concretization have both converted the landscape drastically. However the most sensitive areas ecologically are those lying between high and low tidal limits and the greatest changes are actually taking place here! (Srivastava *et al,* 2001)

THE STUDY AREA

A study has been conducted in the northern part of Thane coast. The area comprises the belt that stretches from the high water line to the 20 m contour inland. The depth off shore is limited to 20 m. isobath, as wave action is not of much significance below this level (Bird, 1983). Even this small stretch brings out a great diversity in topography. Between Ulhas and Vaitarna mouths, islands were once formed by the branches of the Bassein (now Vasai) Creek that ran up to Bhiwandi. Today these have been gradually consolidated into one landmass. The coast here suggests considerable submergence.

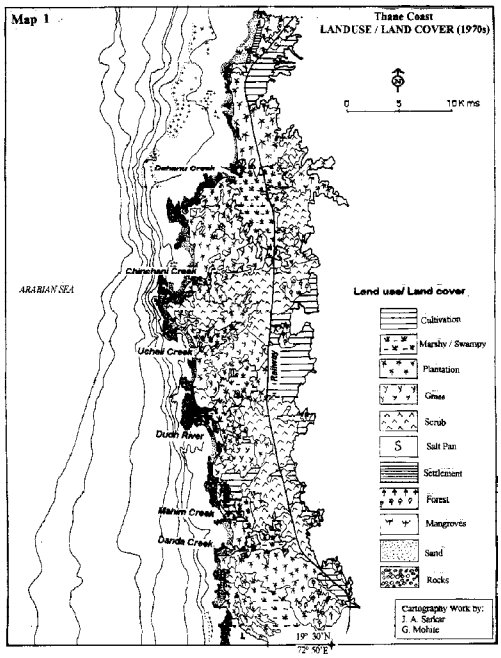
FOCUS OF PRESENT STUDY

The objectives of the present study are:

1. to understand the physical characteristics of the region
2. to determine the changes that have occurred in the area with respect to land use/land cover and population characteristics
3. to put forth suggestions for conservation of coastal habitats.

A cartographic analysis is attempted based on Survey of India topo-sheets (47 A series on scales of 1:50,000 and 1: 250,000), hydrographic charts and satellite imageries. Village level data is based on District Census Handbook data. Field visits have helped to observe changes in the region.

The Physical Setting: ---- a) Onshore features: The tract under study above the mean sea-level is narrow to the north, but widens considerably near Dahanu and further south along the Vaitarna. North of Vaitarna, shores are flat with long sandy beaches. Creeks and streams are at best small inlets divided by wide wastes of salt-marshes and tracts of slightly rising ground in-between, covered by palms, fruit orchards and casuarinas. Salt marshes have been reclaimed as saltpans and rice flats. The entire stretch is dominated by major and minor creeks, in which tidal waters flood upstream and inundate much low ground. Each creek facilitates the penetration of tidal water deep into the interior (Map 1). Rocky promontories protrude at a number of locations alternating with the above creeks. The only major river here is the Vaitarna, which has a number of tributaries that join the mainstream barely 30 kms. from the coast.



b) Offshore features: The width as well as nature of deposits in the littoral zone is not the same everywhere. While sand is found in relatively protected niches, rocky platforms dominate the headlands. The creeks are generally covered by mudflats and in selected sites by mangroves.

The offshore topography shows much variation in width and in gradient. The region can be easily divided into three physiographic divisions:

i) The northern section has a gentle gradient, which is broken by two well-defined steep gradients, one between 5 and 10 m., and another between 17 and 20 m., giving rise to a terraced slope. On an average the width of this belt is 14 kms. Rock ledges and rocks awash present here are dangerous to navigation. This entire stretch is a bay.

ii) The central section shows a gentle followed by a steep slope to the north; and a steep followed by a relatively gentle slope to the south, off projecting rocky headlands. The former is the narrowest part of the off shore study area receding to barely 5 kms., from where it expands to about 7 kms. in the latter part.

iii) The southern section depicts a single terraced feature with a comparatively extensive width of about 20 kms., as seen in the map.

The currents are of monsoon origin, but tend to follow the trend of the coast. In December and January sets are northwesterly with rates of upto 1 knot. In July and August when the southwest monsoon is well-established, southeasterly sets with rates of upto two knots are experienced. Exceptionally on-shore sets of upto 1.5 knots are experienced during the northeast monsoon and upto 3 knots during the southwest monsoon. The tidal information for some of the ports are given below:

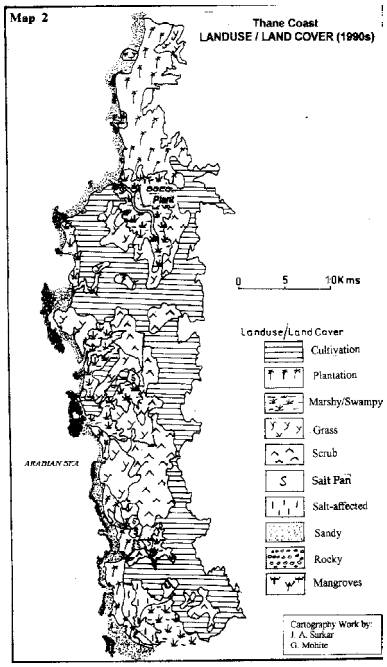
Place	Latitude	Longitude	MHWS	MHWN	MLWS	MLWN	MSL
Tarapur	19º 52'	72º 41'	4.79 m	3.67m	0.89m	2.02m	2.84m
Satpati	19º 43'	72º 42'	4.91m	3.87m	1.25m	2.29m	3.08m
Vasai	19º 18'	72º 48'	4.15m	3.29m	0.91m	1.77m	2.53m

There is a definite decrease in tidal range from north to south. The greater the range, the greater will be the area subject to wave action.

Land Use/ Land Cover: The railway line is the dominating man-made linear feature running all along the belt under study. In the 1970s (Map 1), the region had a predominance of cultivation and scrubs (often considered as indicators of deforestation). Grass, 1 to 2 m. tall, also formed an important component of the vegetal cover. Forests were very limited in extent in the study area. The diversity of features in the coastal region was reflected in the mosaic of diverse land use pattern. The deep creeks were expansive mudflats, with mangroves being restricted to a limited pocket in the north. Settlements were scattered in the region, and well connected by road. Accessibility has been steadily improving over the years.

A zonation of land use/land cover is seen north of the metropolis. Around Vasai, earlier designated as a green belt, was a zone where seasonal green vegetables, betel and bananas have been cultivated for 150 years, depending on the 6000 wells providing fresh-water (Thana Gazetteer, 1982). Seaside and creek-side were areas of fishing and saltpans. Beyond Vaitarna estuary was a zone of fishing and saltpans; around the settlements of Palghar, Vangaon, Chinchani was the region of vegetable and chilly farming that could withstand long distance transport by road and rail. Around Dahanu and Gholvad lay the fruit zone, where chickoos, guavas and pomegranates were grown. Along the northern limits lay the hay and fodder zone. Every railhead had a major hay go-down. So lucrative was this crop that people often gave up rice cultivation in favour of hay farming. Coastal lowlands had a substantial area under tillage. Larger settlements like Dahanu, Chinchani-Tarapur, Kelve-Mahim and Vasai were all ferry points across the creeks, and thus landing points for large quantities of fish. Each was a road terminal linked with a rail-head, 6-8 kms. from it. Dahanu was a huge collection centre for fish, fruits and forest products. The tempo of growth of this region has been hampered by the two wide estuaries and extensive marshes. Previously Dahanu Creek could be entered only at high water.

To the north of Mumbai, reclamation of wetlands due to the urban spillover effect has altered the thriving practice of horticulture along with over-exploitation of ground water, which has led to salinity ingress in the area. A study conducted by NIO revealed an overall reduction in the dissolved oxygen content and a corresponding increase in the biological oxygen demand in the Vasai Creek from 1986 to 1991. A marked increase was also seen in the nitrate and phosphate content of all samples.



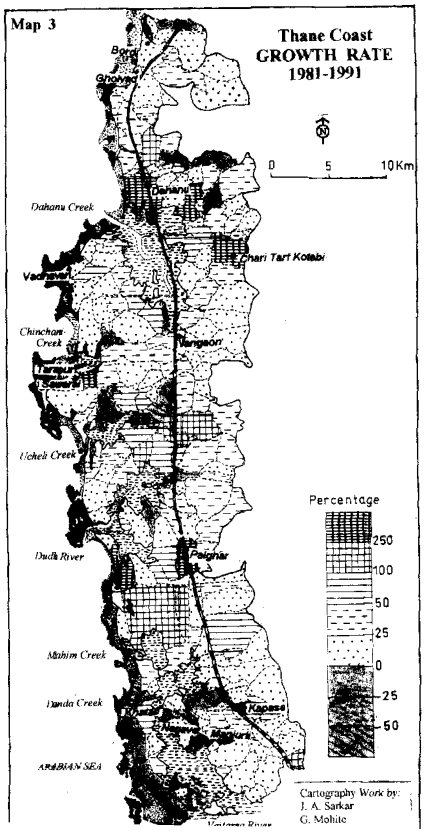
There is a substantial change in the observed land use pattern today (Map 2). Plantations have increased in area esp. in the north. Banana cultivation has given way to cultivation of flowers, esp. jasmine. In many cases scrubs have been converted to cultivated fields. In others grazing land seems to have replaced scrubs and, in some places, cultivation. Salt panning continues to be an important activity in the creeks. Resorts and farmhouses have sprung up along the highway and seacoast, giving an impetus to tourism. Dredging activities along creeks continue to be interventionist in character. An occasional mammoth project like the nuclear power generating centre at Tarapur or the BSES coal-based thermal power plant at Dahanu have had an impact on the environment and lives of the local inhabitants in their vicinity. But often the locals may need to fight for their survival, even though they are pitted against the might of the powerful. A case in point is Vadhavan.

Vadhavan has been in the news for the resentment that has welled up in the region towards the construction of an all-weather port on a Build, Own, Operate, Transfer (BOOT) basis. The site was selected in anticipation of the voluminous post-liberalisation trade and traffic. A draught of not less than 15 meters will be required for large sized cargo ships. Vadhavan is the only port along the west coast where the draught is 20 m. within 5 kms. from the coast, and thus can provide the necessary infrastructure. But this is one of the most fertile fishing grounds of Maharashtra, famous for a wide variety of fish and lobsters. The Coastal Zone Management Plan (CZMP) submitted by Maharashtra Government and conditionally cleared by the MoEF declares the whole coastline of Dahanu as CRZ I (except Bordi which is under CRZ III). The Supreme Court has recognized Dahanu as one of three ecologically fragile zones of the country. In a notification dated June 20, 1991, Dahanu taluka was declared an ecologically fragile zone under EPA. Thus orchards, tribal areas, green areas and environmentally sensitive areas are not to be disturbed. The regional plan for Dahanu made no provision for a port and service industries were allotted only 20 hectares. A port requires a much more extensive area. 80% of the villages are tribal, 60% of the population of Dahanu is tribal and from this area alone 60,000 adivasi men work on boats with no alternative livelihood. People barter wood and grain for fish. They share a symbiotic relationship with the environment, which may not be able to with stand radical disturbances.

Observers feel the point of contention is the location and it is necessary to look for alternatives.

DEMOGRAPHIC AND SOCIO-ECONOMIC CHARACTERISTICS :

Population distribution and density show an interesting pattern over a decade. Villages in the area under study are mainly from the tahsils of Palghar and Dahanu, where urbanisation was slow but is now picking up. Cultivation has always been an important activity though fishing is of significance along the coast. A large part of the population belongs to the category of agricultural labourers. The density of population was mapped for the 186 villages that comprise the study area. Pockets of high density are seen along the railway line as well as near the coast. Around creeks densities are high in urban centres and villages in their fringe. Noteworthy are Dandi, Mawapur, Murabe, Lokmanya Nagar, Umbarpada, Nadade, Saravali, Bandar and Edwan. Site and dominating economic activity are determinants of the density pattern.



It is equally important to observe the trend in growth, which is depicted in Map 3 as percentage growth rate. Most settlements depict an increase in population. A very high growth rate is recorded in Sawarai (+459%), Chari Tarf Kotebi (+431.8%) and Manjurli (+397.3). Cultivation, agricultural labour or fishing/forestry/plantations seem to be prevailing primary activities. However, industry, trade and commerce, transport and other services are gradually gaining importance in specific areas.

Certain villages have recorded negative growth rate. Among them Kapase, Khatali and Nagave Pal are worthy of mention. In most such villages intensive cultivation is not practiced, as there is hardly any irrigation facility. Sometimes forests are primary resources. Often land is not available for cultivation, or patches of culturable waste occur. Further analysis of the socio-

economic conditions of these villages will suggest trends, patterns and underlying processes so as to involve the local inhabitants in utilization, management and above all conservation of the resources.

RECOMMENDATIONS

Problems have arisen mainly due to increasing population pressure and development projects. Change is inevitable and intrinsic to any dynamic system. However it should be within the framework of the principles of sustainability. Nature's resilience and limits of flexibility must be respected to maintain an ecological balance. The coast of a region should be treated holistically for solving problems related to individual micro-features. Being a zone of transition gives rise to immense complexities and diversities in components and relationships. In addition the highly fragile, sensitive and vulnerable systems are in a constant state of flux. This necessitates a thorough understanding of every aspect of functioning in the system and calls for an integrated approach towards planning, utilization and management of resources to ensure sustainability in development of coastal regions. An inventory of the requisite basic information should be compiled and their spatial and temporal characteristics and variations mapped precisely. Thus a complete database is the need of the hour.

Special emphasis should be given to the precariously balanced ecosystems by notifying and enforcing buffer zones in the periphery regions. CRZ I areas must be recognized and regulations strictly adhered to in these areas. The cultivation of mangroves must be encouraged as they play an important role in protection of coasts.

Participatory management only will ensure the success of environmentally friendly policies and plans. The villagers must have a sense of belonging rather than alienation to the land they inhabit

Regular monitoring of such regions should be done using remotely sensed data, e.g. OceanSat and high-resolution PAN data.

Impacts of global phenomena like greenhouse effects and global warming must be understood in the local context too. For this simulations can be modeled using powerful tools like the GIS software package to study, for example, the locations and populations likely to be affected by rising sea level as a consequence to global warming so as to take essential steps to mitigate or at least minimize the intensity of the hazard. Digital terrain modeling can also be attempted to identify microhabitats of the region, to simulate scenarios for varying tide levels.

Perhaps the Brundtland Report sums it up best.

Sustainable development of coastal regions can be described as "the proper use and care of the coastal environment to meet the present needs without compromising the ability of future generations to meet their own needs".

REFERENCES

Bird, E.C.F. 1984 : Coasts – An Introduction to Coastal Geomorphology, Australian National Univ. Press, Canberra.

Hydrographer of the Navy 1975: West Coast of India Pilot, Eleventh Edition.

IPCC. 1998: The Regional Impacts of Climate Change: an assessment of vulnerability, Cambridge, Cambridge University Press.

Menon, M. 1998: Vadhavan Development versus People, Survey of the Environment, The Hindu, Chennai, pp 21-26.

Nair, N.B. (Ed.) 1987: Proceedings of National Seminar on Estuarine Management, Trivandrum.

Srivastava, S. et al 1993: Deployment of Mapping for Coastal Management Regulation: a case study from Maharashtra, Indian Cartographer, Vol. 13, pp.202-205.

Kewalramani, G., & Srivastava, S. 1999: Development Strategies and Environment Issues: a case study, in Resource Management, B.R. Publ.Co., Delhi, pp.271-291.

Srivastava,S. & Kewalramani, G. 1999: Planning for Environmentally Sensitive Natural Habitats in a Metropolis-a case study of Mumbai, in Transactions of Indian Institute of Geographers, Vol. 21, no.1, Jan. pp.1-16.

Srivastava, S. Kewalramani G, Mukherji, D. 2001: Coastal Regulation Zone in and around urban areas: a case study of Mumbai" in Journal of Indian Ocean Studies, Vol. 9, No. 2, August, pp257-273.

TERI. 1999: TERI Energy Data Directory and Yearbook 1999/2000 New Delhi: Tata Energy Research Institute.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 331-333

DEGRADATION OF CREEKS AND MANGROVES AND ITS IMPACT ON URBAN ENVIRONMENT——A CASE STUDY OF MUMBAI

Dipti Mukherji
Department of Geography
University of Mimbai
Mumbai—400098

ABSTRACT : Land is one of our most precious resources. We need land for constructing our houses, industry and infrastructure, to provide soil for our crop to grow in, to provide open spaces for recreation and to allow natural terrestrial ecosystems to thrive and secure genetic resources for the future. Humankinds utilization of land has led to all areas of the earth being modified. Anthropogenic activity like reclamation is creating havoc with natural ecosystems of urban areas. The western part of suburban Salsette is under such danger. Any environmentalist traveling on road or rail from Mahim to Gorai will stand aghast - experience the unwarranted land reclamation and degrading ecosystem.

The present paper with Satellite Imageries and Topographical maps of different time period attempts to study the changing urban environmental ecosystem.

Keywords : *Anthropogenic activity, Changing urban environment.*

INTRODUCTION

Coastal areas are commonly defined as the interface or transition areas between land and sea. These areas are diverse in function and form, dynamic and do not lend themselves well to definition by strict spatial boundaries. There are no exact natural boundaries that unambiguously delineate coastal areas. Coastal areas are characterized by vertical accretion of near-shore land. Sedimentation is the major geomorphic activity that shapes coasts, but anthropogenic activity has the most adverse impact on the coastal morphology.

Management of coastal boundaries, should be need based and should be influenced by the geographic scope of relevant management concerns, including biophysical, economic, social, institutional and organizational aspects.

Many of the world's major cities are located in coastal areas and a large portion of economic activities is concentrated in these cities. The coastal zone is an area of convergence of activities in urban centers. Traditional resource based activities such as coastal fisheries, aquaculture, forestry and agriculture are found side by side with activities such as industry, tourism and housing complexes. The potential for economic opportunities is a strong attractive force fuelling immigration, often from economically depressed areas. These areas are extremely important for the social economic welfare of any urban centre as coastal resources support key economic and subsistence activities.

The present paper attempts to put forward the changing urban coastal ecosystem of Mumbai and analyses the problems which are cropping up and will affect the area in near future. In Mumbai, the creeks and the mangroves are important ecologically as they provide a number of environmental goods and services .The coastal environment of Mumbai is of dynamic nature which results from the transfer of living organism between land and sea systems. Moreover the coast of Mumbai is the storehouse of critical terrestrial and aquatic habitats. The Mumbai coast has the unique location of land/sea interface that has an aesthetic value, which not only provides attractive sites but also is attracted by human settlements. At present these coastal areas of Mumbai are encroached upon mercilessly leading to environmental problems. This paper basically focuses on i) degradation of mangroves, ii) choking of the creeks and iii) disastrous effect of reclamation on the coastal area of the western part of Salsette, through chronological sequence of maps and satellite imageries.

Bombay city till the end of eighteenth century was a group of seven islands. To the north of this group of islands was the larger island group of Salsette. By 1800 this island group was affected by reclamation, especially the western littoral area and to a certain extent, the eastern part. In these parts, land is one of the prime natural resources. For sustainable use of this natural resource, proper planning is the need of the hour. But today most of the natural ecosystems are endangered because of encroachment . This is due to extension of built–up areas which in turn is the result of population pressure. Further the creeks of Mumbai in the western waterfront i.e. Malad

creek, Manori Creek are affected by heavy siltation. This is due to the flushing of the polluted waters from the nearby industrial residential areas and slums.

The mangroves for instance are important natural phenomena in a littoral city like Mumbai. Today it is being illegally destroyed and is being taken over by encroachers and builders for construction purposes. The cost of destroying the mangrove may well have to be borne , not by the persons destroying it, but by the inhabitants themselves.. The widespread destruction of mangroves in Mumbai can lead to siltation of creek mouth or eutrophication of coastal waters. These are the negative externalities of Mumbai. Another example of degradation of creeks is the blockage of Poisar Nadi near Malwani which is causing flooding in the nearby areas. Various storm water channels and creeks in Salsette especially the smaller creeks are today blocked, for instance Irla Nala which is causing flooding during heavy downpour in Juhu Scheme. Another example is the Mahim Bay where in the last 150 years the urban surge has brought about major changes both in the physical and cultural spheres. The wide open initial inland lagoon of 1920's has shrunk into a much narrower channel . The mangrove zone has progressively advanced into the silted banks on either side of the channel. Similarly beach erosion can be attributed to factors like reclamation in the Versova –Juhu area and on both sides of the Malad creek . The littoral drift of sand changing direction alternately with seasons, and the destruction of the mangrove belt and salt marshes, has adversely affected the ecological equilibrium of Versova area.

The changing phase of the western coast of suburban Mumbai:

Fig 1 is the depiction of the western Salsette of Mumbai during 1944.It is observed that during this period up to about 2 kms from the shoreline, Mumbai had a virgin coastline without any encroachment. Only small settlements (gaonthans) existed. Tree plantations were prominent. Mud and marsh was found in the western part of Manori and Madh and Gorai. Towards south, salt pans could be seen near Marve and Malwani. There existed pockets of reserved forests towards west of Malad. Versova, the small fishing gaonthan was surrounded by palm trees and at the fringe of the settlement was mud, marsh and mangroves. In many of these settlements, fishing was the prominent activity.

Fig 2 depicts the scene of the part of western coastline of Mumbai during 1976. What is most striking is that there was a change of the coastal morphology. The areas of mud and marsh are being replaced by mud . There was an extension of tree plantation near Manori and Gorai. Also open scrub and stony wastes were to be found in pockets. The littoral settlements at dry points extended north south and east west in linear fashion. The Malad and Manori creeks have been heavily

Fig: 1

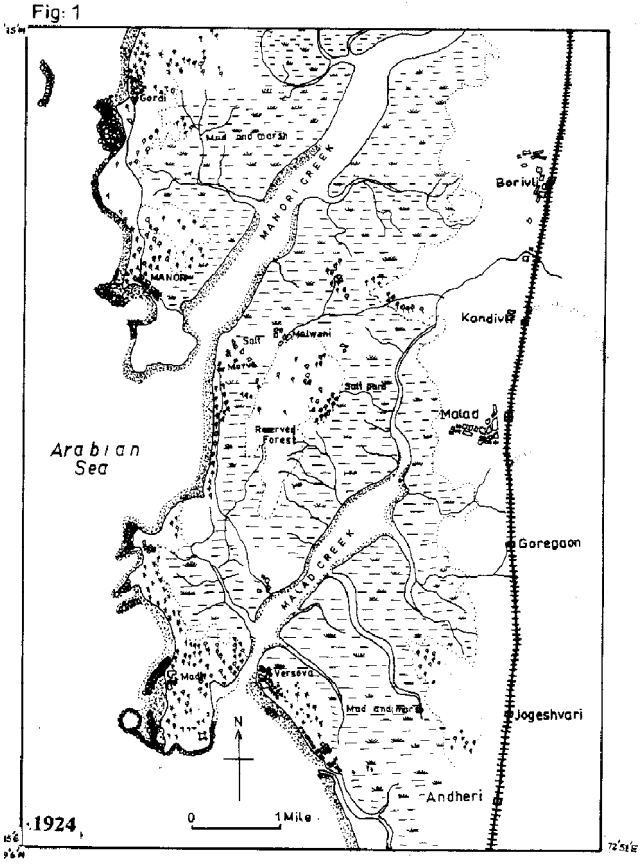
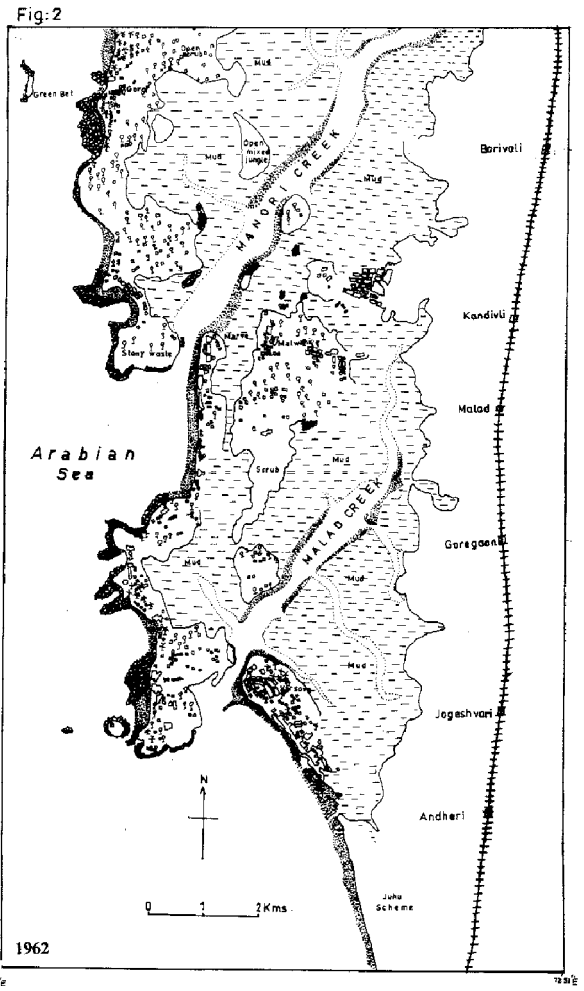


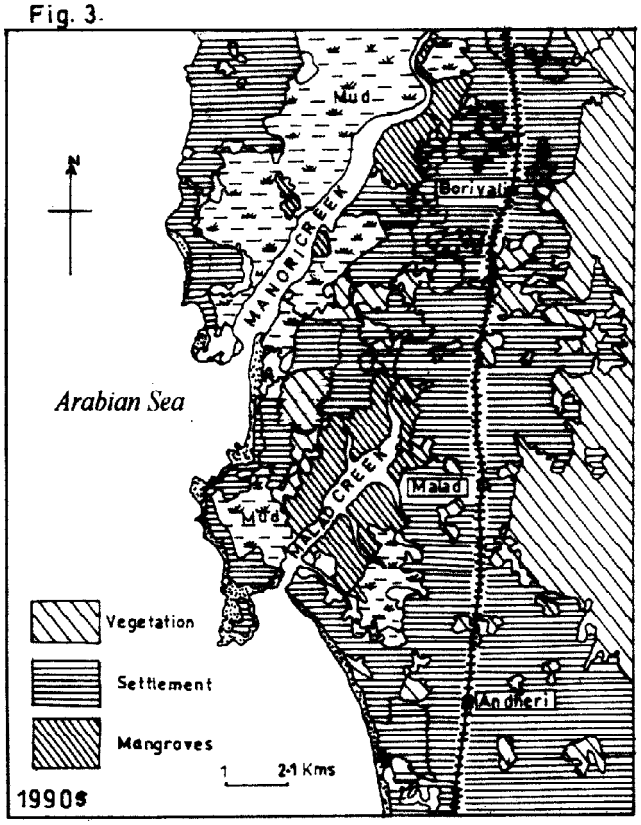
Fig: 2



silted. Madh for instance which was surrounded by tree plantation has been encroached upon by built-up areas. The settlement of Versova extended southward towards Juhu. During this period though anthropogenic activity was infiltrating the coastal environment but it had a limited impact.

Fig.3 reflects the recent scenario of coastal environment of Mumbai which is acquired from satellite imagery of the late 90s. A drastic change can be observed. The most obvious change is the extension of the built–up areas all along the coast. Mud and marsh land has been totally reclaimed. The then small fishing

Fig. 3.



gaonthans though, have their small core but are fringed by the built-up areas. In Versova, Madh, Malwani, Marve , Gorai and Charkop, the scene has been modified totally. The creeks and their mouths have become narrow with heavy siltation which is the impact of reclamation. These creeks are surrounded either by mud or mangroves either live or dead. What is striking is that different stages of mangroves could be detected. Another important feature during this phase is the reclamation of the coast at Bangur Nagar, Lokhandwala, Oshiwara and Charkop. This has basically been caused by population pressure and demand for housing. In Charkop and Malwani, part of the salt and marshy land has been reclaimed for slum rehabilitation. Similarly, change has also been observed in Mahim and Bandra.

CONCLUDING REMARKS

Coastal resources management includes a wide array of management practices. In case of Mumbai land–use planning is very much warranted. Apart from this, administrative and institutional execution is also necessary. For sustainable development of urban environment of Mumbai, a balance should be maintained between the natural and human environment. There should be an interaction between time and space and between economic and ecological, social and natural variability. Only if this is possible in Mumbai, ecosystems and the lifestyle it supports can exist side by side.

REFERENCES

" Coastal Regulation Zone in and around urban areas", G. Kewalramani, S.Srivastava, Dipti Mukherji, Journal of Indian Ocean Studies, Vol.9, No. 2, 2001

" Beach Erosion of Versova", Dipti Mukherji, Indian Cartographer, Vol.19, 1999.

" Mapping of Mahim Bay and Estuart" Proceedings of the seminar on Nautical Cartography—— Past Present and Future, 1998.

" Integrated coastal area management and agriculture, forestry and fisheries"

Food and Agricultural Organisation of the United Nations,Rome, 1998.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 334-337

QUANTIFYING MANGROVE COVER CHANGE IN AND AROUND MUMBAI USING SATELLITE DATA

Hrishikesh P. Samant
Department of Geology, St. Xavier's College, Mumbai, INDIA.
hrishi@geologist.com

ABSTRACT : Today land reclamation has shifted from restoration to the creation of new land to accommodate functions for which there is no land left, that too at the cost of severe damage to the ecosystem. Extensive changes have occurred along the wetlands since these were the only places easily available for exploitation / development in and around the mega polis of Mumbai. The Coastal Regulation Zone Notification from the Ministry of Environment and forest, Government of India has come into effect from 19th February 1991. This has had an impact on the reclamation on the mangroves but rampant illegal (and at times legal) violations of the CRZ regulation are still in evidence. Analysing Survey of India Topographical maps and temporal, remotely sensed satellite data has proved a very effective tool in monitoring and quantifying the mangrove cover. The digital image processing of Indian Remote Sensing Satellite IRS 1C LISS III and PAN data for the year 2000 and LandSat4 TM multispectral data for the year 1989 distinctly brings out the alarming decrease in mangrove cover in the wetlands around Mumbai. The total reclamation on mangrove cover in wetlands around Mithi river, Malad creek, Manori creek, Thane creek, Mankhurd and Mahul creek is approximately 1000 Ha in the last decade. This does not include the areas of naturally degraded mangrove.

Keywords: *Mangrove, reclamation, remote sensing, CRZ, Mumbai.*

INTRODUCTION

With the ever increasing demand for housing in and around the megapolis of Mumbai, the coastal tract has is being extensively exploited. The wetlands which bordered the creeks around Mumbai are fast diminishing. The Coastal Regulation Zone notification issued by the Ministry of Environment and Forests came into effect from the 19th February 1991. Apart from a few amendments to the notification it has remained largely unchanged. This notification has reduced the reclamation activities, which were otherwise rampant in the intertidal lands. A study of Survey of India Topographical maps and digitally enhanced Indian Remote Sensing Satellite data of various dates can be effectively used to quantify the changes in the land use.

METHODOLOGY

To quantify the anthropogenic changes a GIS based approach was used, since these analyses involved the integration of temporal data, which is possible only in a GIS environment. For any GIS based analysis, the primary input is numerical data. Since spatial information is represented on a map, these maps were converted into numerical data by digitising them. The data from Survey of India Topographical maps of the years 1925 and 1967 was classified into land use classes and then digitised. The Land use classes for 1994 were obtained from the Landsat4 digital data.

Land sat 4 data dated December 1989 and IRS 1C LISS III data dated December 2000 were used to generate standard false colour composites (FCC). The Land sat 4 Thematic mapper TM bands 2,3 and 4 were assigned blue, green and red colours respectively to generate the standard FCC. IRS1C LISS III bands 2 (0.52 – 0.59μ), 3 (0.62 – 0.69μ) and 4 (0.77 – 0.89μ), which are the green, red and near Infra red bands were assigned blue, green and red colours respectively.

Due to the high reflectance in the IR wavelengths by green vegetation, areas with high vegetation appear distinctly red in the FCC. A detailed study was carried out along all the creeks around the Mumbai city viz. Thane, Mahim, Malad and Manori creeks. Areas reclaimed after 1989 were digitised and quantified. (Plate 1 and 2).

OBSERVATIONS

Tabulated below is the Landuse/landcover statistics covering the Mumbai and Mumbra-Belapur area.

Year	1925	1967	1994
Land use class	Area in Sq. km		
Forest / Agriculture	521.86	464.35	263.28
Wetlands	235.23	191.12	160.00
Built-up land	102.90	204.51	436.71

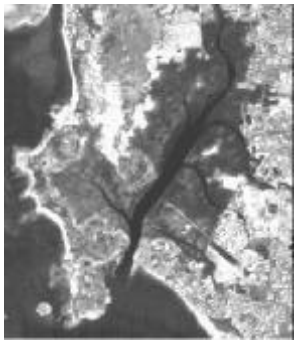
PLATE - 1



1989 : Mahim Nature Park and Surrounding area.



2000 : Mahim Nature Park and Surrounding area.



1989 : Malad Creek and Surrounding area.



2000 : Malad Creek and Surrounding area.



1989 : Manori Creek and Surrounding area.



2000 : Manori Creek and Surrounding area.



1989 : Thane Creek and Surrounding area.



2000 : Thane Creek and Surrounding area.

PLATE - 3



1989 : Mankhurd and Surrounding area.



2000 : Mankhurd and Surrounding area.



1989 : Mahul Creek and Surrounding area.



2000 : Mahul Creek and Surrounding area.



1989 : Bandra Reclamation and Surrounding area.



2000 : Bandra Reclamation and Surrounding area.

Analysis of the December 1989, Landsat4 data and the December 2000, IRS LISS III-Pan merge data, brought out the following facts:

Location	Area reclaimed after 1990 in CRZ, (Ha).
Bandra reclamation, Mahim Nature Park and surrounding.	89.03
Malad Creek and surrounding (Versova, Oshiwara, Madh Island).	171.59
Manori creek and surrounding	132.33
(Charcop, Gorai waste disposal site, Gorai village).	
Thane creek and surrounding (Dighe).	103.20
Mankhurd (Vikhroli, Ghatkopar).	343.18
Mahul Creek and surrounding	68.00

Conclusion

The land use /Land cover changes in the CRZ areas are alarming. The present CRZ regulation (1991) needs to be further strengthened and implemented if our coastal environment is to be preserved. Satellite remote sensing is an efficient, cheap and reliable tool to monitor our CRZ from illegal activities and should be exhaustively used by the governmental and non-governmental monitoring agencies.

Proc. The National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation, Nov. 2002 : 338-340

PRESENT ESTUARINE AND COASTAL FISHERIES IN INDIA

V.S.Somvanshi and A.K.Bhargava
Fishery Survey of India, Mumbai

INTRODUCTION

India by virtue of having 8,129 km long coastline, 0.5 million sq.km of continental shelf area and 2.02 million sq.km of Exclusive Economic Zone (EEZ) supports varied biodiversity. There is about 3.9 million ha of estuarine and 3.5 million ha of brackish water area in the country. Approximately 1.2 million ha of coastal area has been identified suitable for brackish water aquaculture. Through use of sustainable practices these resources can yield optimum quantities of shrimps and other commercially important finfish and shell fish resources.

The present production of marine fishes is estimated to be 2.8 million tonnes (MOA 2000) against the estimated Maximum Sustainable Yield (MSY) of 3.92 million tonnes (Sudarsan *et.al.* 1990). Although the last two decades, the Indian fishery scenario has changed rapidly, there are also concern about depleting stocks and search for new resources for exploitation.

In view of the global conventions on biodiversity and Code of Conduct for Responsible Fisheries (CCRF), the Indian fisheries will have to adopt certain measures for management and conservation of biodiversity in coastal waters for use of these resources by the future generations.

The paper presents present scenario in brackish waters and coastal water fisheries along the Indian coast and future requirements in this area.

ESTUARINE FISHERIES

The important source of estuarine fisheries in India are the extensive estuarine areas of the rivers Ganges, Mahanadi, Godavari, Krishna, Cauvery, Narmada and Tapti, the brackish water lakes of Chilka and Pulicat and the backwaters of Travancore – Cochin in Kerala State.

The fishes constituting the estuarine water in India are mostly marine species that can withstand variations in salinity. Important amongst them are clupeoids – *Hilsa ilisha* (Hamilton), Anchovies – species of *Archoviella, Thrissocles, Nematalosa* and *Setipinn*, Mullets – *Liza corsula* (Hamilton) and *Mugil cephalus* (Linnalus), cat fishes – species of *Tachysurus, Osteogeniosus, Pangasius* and *mystus*, perches – *Lates calcarifer* (Bloch) and pearl spot – *Etroplus suratensis* (Bloch).

HILSA FISHERY

Hilsa is of great economic importance in West Bengal, where it is found in the estuarines throughout the year and ascends the rivers both in the monsoon and winter. Hilsa is caught in appreciable quantities along Saurashtra and Gujarat coast (Anon, 1962). Various types of gears are used to capture of Hilsa such as purse-nets, dip-nets, gill nets, drag net and drift nets.

Present (1998) *Hilsa* production is 51,377 metric tonnes. Majority of catches covers from West Bengal (37,730) tonnes and 94% of catches are from East coast.

Hilsa stocks are shared with Bangladesh, where it forms largest estuarine fishery in the world. Many conflicting theories exist about the precise nature of its life style, movement patterns, reproduction, number of genetic stocks etc. There is an urgent need to take up co-ordinated studies by both the countries for its management and conservation for sustainable use of the resources.

CHILKA LAKE

The Chilka lake, the largest brackish water lagoon (total area 1100 sq.km) in India is situated on the East coast in the State of Orissa on latitude 19°38' and 19°54' and longitudes 85°01' and 85°E. This brackish water lagoon has an opening with the sea on the North-east and is connected with two important rivers on the north i.e. Daya and Bhargabi. The lake has became shallower over the years due to silt deposited by the rivers. The bottom is characterized by loose mud and silt.

A total of 158 species of fishes shrimps and crabs have been known to occur in the lake of which 15 are marine, 24 freshwater and 119 brackish water species. Most important commercial fisheries of the lake are *Mugil cephalus, Liza macrotepis, Eleutheronema tetradactylum, Hilsa ilisha, Nematolosa nasus, Mystus gulio, Pseudosciana coitor, Lates calcarifer, Gerres setifer, Etroplus suratensis, Penaeus indicus, P.monodon*.

Increasing fishing pressure in the lake have caused depletion of stocks and is of great concern. Government of Orissa have already initiated certain conservative measures such as gear restriction mesh-size regulation, banned fishing season and catching of juveniles (Biswas, 1996).

INTRUSION OF ALIEN FISHES

Invasion by alien marine species through ship ballast water, is one of the greatest threat to world's coastal environment and humanity at large. It causes irreversible damages to coastal ecosystem, economy and human health. India having 12 major parts along the coastline, the Indian coasts are fascinating prey to the problem of marine bio-invasion through ballast water. At Mumbai port alone 5000 ships call each year and bring with them approximately 2 million tonnes of ballast water. India indeed faces a potential threat from ballast water.

UNDP, GEF along with IMO have initiated the Global Ballast Water Management Programme to reduce the hazards of marine bio-invasion in six developing countries including India. Under the programme, the Fishery Survey of India has been entrusted with the Mumbai Port Baseline Survey and the main objectives of the project is to prepare the inventory of finfishes, crustaceans and mulluscs occurring in Mumbai Port and to identify invasive species through Ballast water.

The sampling under the Project is done by using beach seine, beam trawl, shrimp and crab trap. During the last two surveys conducted during 2001-2002, 54 species of fin-fishes comprising of 30 families and 42 genus, 22 species of shrimps and lobsters comprising of 7 families and 13 genus and 5 species of crabs belonging to 2 families and 4 genus and 17 species of molluscs belonging to 12 families and 15 genus are identified. During the project attempts are also being made to study the distribution and abundance of these species. So far no invative species has been identified. In future such surveys are proposed in all the major parts of India.

COASTAL FISHERIES IN INDIA

Coastal waters area in India upto 100m depth is 362.8 thousand sq.km of which 196.9 thousand km forming about 54.3% is covered under North-west coast comprising of three maritime States Gujarat, Maharashtra, Goa and Union Territory of Daman and Diu. Potential yield estimates of fishery resources in coastal waters assessed through exploratory surveys and current yield is 1703.5 thousand tonnes for demersal resources and 1401 thousand tonnes of pelagic resources (Sudarsan *et.al.* 1990). Coastal fishery resources forms 79% of the total potential yield estimates in the Indian EEZ.

PRESENT STATUS

During last two decades Indian fisheries has undergone rapid changes. Presently there are 2,80,491 fishing craft including 1,81,284 traditional, 44,578 motorized traditional and 53,684 mechanized boats. Presently, fishing operations of these vessels are confined upto 100m depth mainly targeting shrimps. Marine fish production in India has increased from 1.565 million tonnes in 1980-81 to 2.834 million tonnes in 1999-2000 (MOA, 2000). Gujarat, Kerala, Maharashtra and Tamilnadu contributes significantly to the marine landings. With the increasing craft and efforts in these areas, the catch per unit effort have declined and certain areas along the Indian coast and fin-fish stocks have shown signs of depletion. There has been increasing concern over these issues and Union and State Governments and stake holders have initiated conservative measures and also expanding their fishing operation areas.

In Maharashtra, Greater Mumbai and Thane districts contributes significantly with 2.01 lakh and 1.02 lakh metric tonnes respectively of marine fish catches. Major component of fisheries in Thane district are Elasmobranches, Cat fishes, Anchovies, Bombay duck, Pomfrets and Shrimps. In Thane district the fishing operation are conducted mainly by mechanized boats with small quantity landed by tonny boats. Besides fishing activities, Mumbai and Thane area has a large industrial belt and burgeoning human population which would inspite of necessary monitoring by concern agencies may cause harm to aquatic life and the critical ecosystems through discharge of effluents and sewage. This needs to be assessed, monitored and measures to avoid ill effects to be defined.

Exploratory surveys conducted by Fishery Survey of India during 1972-80 (Joseph 1998), revealed good concentration of elasmobranches, eels, cat fishes, perches, sciaenids, pomfrets, seer fish, ribbon fishes, squids and cuttle fishes and shrimps along Mumbai and Thane district. Elasmobranchs accounted for 23% of the catches in the Mumbai regions with highest catch rate from below 60m depth. Cat fish was found to occur between 26 to 40 kg/hr. from 20-79m depth. In case of sciaenids and pomfrets the highest catch rates were obtained from shallow waters. The catch rate of shrimps was higher from below 20m depth than from deeper waters.

CONCLUSION

The broader objectives of the convention of biodiversity are the sustainable use of its components and the fair and equitable sharing of benefits arising out of the utilization of genetic resources including by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over these resources and to technologists and by appropriate funding (Heywood and Baste, 1995).

Similarly, the Code of Conduct for Responsible Fisheries is voluntary Code and is global in scope, it provides principles guidelines and standards applicable to the conservation, management and development of all fisheries. It also covers the capture, processing and

trade of fish and fishery products, fishing operations, aquaculture, fisheries research and integration of fisheries into coastal area management. It promotes protection of living aquatic resources and their environment and coastal areas.

In India estuarine, brackish and coastal water presents good scope for development of fisheries. These areas are major contributors to the fisheries and also nursing grounds for major fishery stocks of the ecosystem, considering the biological productivity and breeding grounds these areas needs to be conserved and managed according to the convention of biodiversity and Code of Conduct for Responsible Fisheries for sustainable use by the future generation.

REFERENCES

Anon, 1962. *The wealth of India's Raw Material Vol.IV, Fish and Fisheries*. Council of Scientific and Industrial Research, New Delhi : 132p.

Anon, 1998. *Fish Production Report*, Department of Fisheries, Government of Maharashtra : 138p.

Anon, 2000. *Handbook of Fisheries Statistics*, Government of India, Department of Animal Husbandry & Dairying, Ministry of Agriculture : 153p.

Biswas, K.P., 1996. *A textbook of Fish, Fisheries and Technolotgy*, Narendra Publishing House, New Delhi : 201-216.

Heywood, V.H. and I. Baste, 1995. Inducing Biodiversity. *In : Global Biodiversity Assessment* (Eds. : V.H.Haywood and R.P.Watson), Cambridge University Press : 5-19

Joseph, K.M., 1980. Comparative study of demersal fishery resources of the Indian water as assessed by the 17.5m trawlers. *Exploratory Fisheries Project Bulletin* 10 : 40p.

Sudarsan, D., M.E.John and V.S.Somvanshi, 1990. Marine Fishery Resources Potential in the Indian Exclusive Economic Zone – An Update : *Bull. Fish. Sur. India*, 20 : 27p.

AUTHOR INDEX

Achari V.S. 72
Agate A.D. 296
Andrade L.V. 72
Athalye R.P. 1, 58, 66,86, 103, 109, 135, 216, 260, 290
Ayakkannu K. 132
Babu K.N. 84, 93
Babuselvam M. 301
Balachandran S. 266
Balasubramanian M.P. 175, 177
Bedekar Atul N. 304
Bhargava A. K. 338
Bhalerao A.M. 283
Bhende Indira 317
Borkar Mangal U. 58, 86, 260
Borkar Manoj R. 310
Chattopadhyay G.N. 63
Chaturvedi Naresh 266, 289
Chavan (Mulik) N..S. 237, 247
Choudhary M.N. 162
Chouksey M.K. 12
Deshmukh S.V. 125
Deshmukh Sanjay V. 8
Deshmukh V.D. 142
Donde Shenal S. 182
Durgabhavani K. 175, 177
Gajbhiye S.N. 21
Ganguly Manjushri 323
Gaonkar S.N 203
Ghosh (Sarkar) Dolanchamopa .. 63
Goenka Debi 41
Gokhale K.S. 44, 116,201
Gokhale M.V. 237
Govindan K. 28
Hande R.S. 51
Ingole Baban 213
Jaiswar Ashok 162
Jaiswar Jiyalal Ram 19
Joshi P.V. 17
Joshua Justus 249
Kadam A. N. 12
Kale P.G. 186
Kale R.B. 120
Kamat Padma 310
Karkhanis Hemant V. 290
Karnik Prasad 142
Kehimkar Issac 266
Kerkar ShriPrasad 167
Khan Anisa B. 256
Koli V.A. 180
Komarpant Neelam K. 310
Kothari M.J. 226
Krishnan S. 196
Kulkarni A.S. 106, 156
Kulkarni B.G. 162, 167
Kulkarni Nirmal 310
Kulkarni Vivek 37
Kumaran K.P.N. 31
Kumbhar S.N. 106, 156
Kurve P.N. 109
Lahigude Mahesh M. 320
Lokhande R.S. 54
Marwah Jyoti 323
Modak Manisha 283
Mukherjee M. N. 201
Mukherji Dipti 331
Muley D.V. 156
Nair Jyoti 148
Nair V.R. 96
Naskar Kumudranjan 63
Nayak R.R. 182
Nayak Rajendra 240
Nayak V.N. 72
Nitsure Shriharsha R. 276
Pai Anuja 148
Pania Dhiren M. 223
Pariya K.M. 170
Patil N.N. 58, 103, 109, 135
Patil S.M. 51
Patwardhan Amol 234
Pawar B.K. 120
Pejaver M.K. 116, 234, 276
Pereira Contzen 196
Pereira Delphine 167
Pimple Deepali 54
Pradhan Varad Ravindra 304
Prakash S. 301
Quadros Goldin 58, 66, 86, 103, 109,135, 216, 260
Raddi Arvind G. 34
Ramanathan G. 301
Rana A.M. 152
Randive Jayant 283
Rao C.V. 196
Rathod S.D. 135
Ravikumar S. 301
Samant Hrishikesh P. 334
Sanyal Pranabes 47
Saravanakumar A. 249
Saravanan K R. 256
Sathe C.N 54
Sathe M.C. 159
Sawant K.B. 182
Serebiah Sesh 249
Sharma B.B. 148, 170
Sharma Ritu 148
Sharma R.N. 17
Shrotri R.V. 159
Somani Vaishali U. 58, 103, 109
Somavanshi V. S. 338
Srivastava Sudha 325
Stanley Oswin D. 78
Swami B.S. 203
Telave A.B. 247
Terdalkar Sameer 106, 156
Thivakaran G.A. 249
Tiwari L.R. 96
UdayKumar M. 203
Venkatachalam Smita 186
Venmathai Maran B.A 132
Verma Ashok 266
Vijayvel K. 175, 177
Yeragi Arati S. 240
Yeragi S.G. 84, 93, 152, 180, 240, 243, 293
Yeragi S.S. 84, 93, 180, 243, 293
Zingde M.D. 3

The organizers wish to gratefully acknowledge the support from the following

Mumbai Metropolitan Region-Environment Improvement Society

Hindustan Petroleum Corporation Limited, Mumbai

Thane Bharat Sahakari Bank Limited, Thane

Bank of India, Thane

Savita Enterprises

Times of India Group, Mumbai

Vasant J. Sheth Memorial Foundation, Mumbai

Hariyali, Thane

Here on Project Environment (HOPE), Thane

World Wide Fund for Nautre - India, MSO

Mr. M. A. Deuskar

Crown Paper Prodcts

Dipesh Exports

UNI Enterprises

K. D. Writing Instruments

Darshan Distributors.



Are Signages Useful



Sewage Outfall



Thane Creek 1994



Rock Quarry



Thane Creek 1999



Mangrove Cutting For Fuel



Thane Creek 2000



Natural Conservation

Author. **Page no.**

Athalye R.P.

Organisers view 1

Present status of water quality of thane creek and ulhas river estuary. 58

Studies on the intertidal sediments of thane creek and ulhas river estuary. 66

Phytoplankton of ulhas river estuary and thane creek 86

Study of rotifers in thane creek and ulhas river estuary. 103

Study of zooplankton distribution from ulhas river estuary and thane creek 109

Qualitative study of fin fish and shell fish fauna of thane creek and ulhas river estuary 135

Intertidal macrobenthos from ulhas river estuary and thane creek 216

Mangroves of ulhas river estuary and thane creek 260

Occurance of scale insect icerya spp. On mangroves of thane creek & ulhas river estuary, maharashtra, india 290

BACK

Babu K.N.

Seasonal variation of phytoplankton in uran estuary 84

Estimation of gross primary production of uran creek 93

BACK

Balasubramanian M.P.

Effect of naphthalene on lactate and succinate dehydrogenase of maleesturine crab, scylla serrata. 175

Electrophoretic studies of phosphatases and non-specific esterases in the estuarine edible crab scylla serrata with reference to naphthalene stress. 177

BACK

Borkar Mangal U.

Present status of water quality of thane creek and ulhas river estuary. 58

Phytoplankton of ulhas river estuary and thane creek 86

Mangroves of ulhas river estuary and thane creek 260

BACK

Chaturvedi Naresh

Avian diversity in and around mangroves of mahul creek, mumbai, india 266

Some observations on teak defoliator hyblaea puera (lepidoptera: hyblaeidae) on secondary host plant avicennia marina 289

BACK

Chavan (Mulik) N.S.

Germination and growth performance of xylocarpus granatum koen. 237

Studies on composition of starch and amylase activity in three sonneratia species. 247

BACK

Durgabhavani K

Effect of naphthalene on lactate and succinate dehydrogenase of maleesturine crab, scylla serrata. 175

Electrophoretic studies of phosphatases and non-specific esterases in the estuarine edible crab scylla serrata with reference to naphthalene stress. 177

Gokhale K.S

Solid waste management in india 44

Food and feeding habits of metapenaeus monoceros found in thane creek 116

Study of copper in polychaeta lycastis merukensis from thane creek. 201

BACK

Kulkarni A.S.

Living dinoflagellate cysts of gymnodinium catenatum and alexandrium catenella from the recent sediments of bhatye estuary, ratnagiri, maharashtra 106

Metabolism in estuarine clam – katelysia opima upon heavy metal stress 156

BACK

Kulkarni B.G.

Physiological studies on an intertidal blood clam cardita antiquata (lam.) Of mumbai coast 162

Cadmium level in coastal areas of mumbai and its toxicity to intertidal clams 167

BACK

Kumbhar S.N.

Living dinoflagellate cysts of gymnodinium catenatum and alexandrium catenella from the recent sediments of bhatye estuary, ratnagiri, maharashtra 106

Metabolism in estuarine clam – katelysia opima upon heavy metal stress 156

BACK

Patil N.N.

Present status of water quality of thane creek and ulhas river estuary. 58

Study of rotifers in thane creek and ulhas river estuary. 103

Study of zooplankton distribution from ulhas river estuary and thane creek 109

Qualitative study of fin fish and shell fish fauna of thane creek and ulhas river estuary 135

BACK

Pejaver M.K.

Food and feeding habits of metapenaeus monoceros found in thane creek 116

Mangrove plantation at the rituchakra by hope 234

Species diversity of avifauna at thane creek near rutuchakkra nature park 276

BACK

Quadros Goldin

Present status of water quality of thane creek and ulhas river estuary. 58

Studies on the intertidal sediments of thane creek and ulhas river estuary. 66

Phytoplankton of ulhas river estuary and thane creek 86

Study of rotifers in thane creek and ulhas river estuary. 103

Study of zooplankton distribution from ulhas river estuary and thane creek 109

Qualitative study of fin fish and shell fish fauna of thane creek and ulhas river estuary 135

Intertidal macrobenthos from ulhas river estuary and thane creek 216

Mangroves of ulhas river estuary and thane creek 260

Sharma B.B

In vitro effect's of cadmium chloride on brain and muscle acetylcholinestarease of mud-skipper boleopthalmus 148

Toxic effects of heavy metals (lead, copper) on acidphosphatase and alkaline phosphatase in the intertidal crab scylla serrata 170

BACK

Somani Vaishali U.

Present status of water quality of thane creek and ulhas river estuary. 58

Study of rotifers in thane creek and ulhas river estuary. 103

Study of zooplankton distribution from ulhas river estuary and thane creek 109

BACK

Terdalkar Sameer

Living dinoflagellate cysts of gymnodinium catenatum and alexandrium catenella from the recent sediments of bhatye estuary, ratnagiri, maharashtra 106

Metabolism in estuarine clam – katelysia opima upon heavy metal stress 156

BACK

Vijayvel K.

Effect of naphthalene on lactate and succinate dehydrogenase of maleesturine crab, scylla serrata. 175

Electrophoretic studies of phosphatases and non-specific esterases in the estuarine edible crab scylla serrata with reference to naphthalene stress. 177

BACK

Yeragi S.G.

Seasonal variation of phytoplankton in uran estuary 84

Estimation of gross primary production of uran creek 93

Histopathological alterations induced by pesticides on gill and liver of the mudskipper, boleophthalmus dussumieri 152

Effects of the pesticide malathion on acid phosphatase enzymes in certain tissues of the marine crab uca marionis (des) of mithbav creek. 180

Composition and present status of mangroves at achara creek 240

Studies on the associated flora in the mangrove environment of mithbavcreek 243

Studies on wood borers from the mangroves of mithbav creek 293

BACK

Yeragi S.S

Seasonal variation of phytoplankton in uran estuary 84

Estimation of gross primary production of uran creek 93

Effects of the pesticide malathion on acid phosphatase enzymes in certain tissues of the marine crab uca marionis (des) of mithbav creek. 180

Studies on the associated flora in the mangrove environment of mithbavcreek 243

Studies on wood borers from the mangroves of mithbav creek 293

BACK