Academic Council Meeting No. and Date: 8 / September 04, 2023
Agenda Number: 2 Resolution Number: 34, 35/2.17 & 2.38

Vidya Prasarak Mandal's
B. N. Bandodkar College of Science (Autonomous), Thane

Syllabus for

Programme: Master of Science

Specific Programme: Environmental Science

[M.Sc. (Semester I and II)]

Level 6.0

CHOICE BASED GRADING SYSTEM

Revised under NEP and Autonomy

From academic year 2023-24

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B. N. Bandodkar College of Science, (AUTONOMOUS)-Thane										
Master Program in Environmental Science										
Year (2 Yrs)	**LEVEL**	**SEMESTER**	**Major**			**Research Methodology**	**On Job Training / Field project**	**Research project**	**Cum Credits**	**Degrees**
			Mandatory		**Electives anyone**					
I	**6.0**	SEM-I	**3*4 + 2 = 14**		Credits 4	**Credits 4**	NA	NA	22	PG Diploma in Environmental Science (After 3 Yrs. degree UG)
			Course 1	Credits 4	Course 1= Credits 4					
			Course 2	Credits 4	**OR**					
			Course 3	Credits 4	Course 2 = Credits 4					
			Course 4	Credits 2	**OR**					
		SEM-II	Course 1	Credits 4	Course 1 = Credits 4	NA	**Credits 4**	NA	**22**	
			Course 2	Credits 4	**OR**					
			Course 3	Credits 4	Course 2 = Credits 4					
			Course 4	Credits 2	**OR**					
Cum Cr.for 1 Yr. PG Diploma			**28**		8	4	4		44	
II	**6.5**	SEM- III	Course 1	Credits 4	Course 1 Credits 4	NA	NA	**Credits 4**	22	Master Program in Environmental Science (After 3 Yrs. degree UG)
			Course 2	Credits 4	**OR**					
			Course 3	Credits 4	Course 2 Credits 4					
			Course 4	Credits 2	**OR**					
		SEM IV	Course 1	Credits 4	Course 1 Credits 4	NA	NA	**Credits 6**	**22**	
			Course 2	Credits 4	**OR**					
			Course 3	Credits 4	Course 2 Credits 4					
					OR					
Cum Cr. for integrated 1 Yr. PG Degree				**26**	**8**			**10**	**44**	
Cum Cr. for 2 Yr. PG Degree				**44**	**16**	**4**	**4**	**10**	**88**	

Preamble

The M.Sc. Environmental Science (EVS) Programme is designed to meet the current demands for professional and industrial consulting services. The improvement of administrative, management, and academic skills, and connection with the NET/SET curriculum.

The syllabus includes assignments for field trips, excursions, industrial visits, and specialized in plant training in industries in addition to academic courses. To inculcate analytical ability among the M.Sc. students syllabus included research methodology and various field projects. To develop competence, hands on training interest and communication skill, seminars, laboratory experiments, internship and stalwart's guest lecture will be arranged.

The Department of Environmental Science was established in the year 2011-12 with sufficient infrastructure facilities. The intake capacity is 20 for M.Sc. and 10 for the Ph.D.

Scope

Environmental science is a multidisciplinary science whose basic aspects have a direct relevance to every section of the society. Its main aspects are: Conservation of nature, natural resources and conservation of biological diversity. Being interdisciplinary sciences, it includes ecology, ethnology, biology, chemistry, geology, statistics, geographical information systems (GIS) with social relevance's. Significance of the courses is scope in the across the subjects in employment sectors including the private and government sectors.

The syllabi also include topics such as EIA, Pollution Control Technology, Environmental Policies & Regulations, Green Technology and Nanotechnology which has a bright career scope.

The electives subject can be select by the students as per their desire about their future professional areas. The independent research areas and acquisition of subject-specific skills within an interdisciplinary group of provides a wide range of opportunities in their careers interface with research aptitude, industry, government and society that would be brought by this program.

Dr. Sandhya Pawale
BOS Chairperson

Master of Science
Environmental Science Syllabus
(To be implemented from the academic year 2023-2024)

SEMESTER I and SEMESTER II

SYLLABUS FOR APPROVAL

Sr. No.	Heading	Particulars
1	Title of the Course	M.Sc. (Environmental Science)
2	Eligibility for Admission	Bachelor's Degree in Science (B.Sc.) or EvS and its equivalent
3	Passing Marks	40%
4	No. of Years / Semesters	Sem I and II
5	Level	P.G.
6	Pattern	Semester
7	Status	Revised under Autonomy and NEP 2020
8	To be implemented from Academic Year	2023-24
9	Name & Sign of BOS Chairperson /Coordinator Department of Environmental Science	Dr. Sandhya Pawale

PROGRAMME OUTCOMES (POs) OF MASTERS IN SCIENCE (M.Sc.)

The Postgraduate Programmes of Science are intended to cater quality education and attain holistic development of learners through the following programme outcomes:

PO1 – Domain Knowledge
Comprehend and demonstrate domain knowledge in specialized branch of science. Instil ability to apply it in upgrading professional, social and personal life.

PO2 – Development of Research Competence
Imbibe skills related to identification of research problem, formulating hypothesis, execution of research process, analysing data, interpreting the data, drawing conclusion and presenting research work. Encourage learners for doctoral studies.

PO3 - Digital Literacy
Enhance ability to access, select and use a variety of relevant information e-resources for creating new knowledge resources.

PO4 - Sensitization towards Environment
Build cohesive bond with nature by respecting natural resources, encouraging eco-friendly practices and creating awareness about sustainable development.

PO5 - Individuality and Team work
Encourage learner to work independently or in collaboration for achieving effective results through practical experiments, project work and research activities.

PO6 – Competence for Employment
Promote field work, internships, industrial training, research projects, research paper presentations and publications to develop competence for adapting towards dynamic socio-economic changes and make learner employable.

PROGRAM SPECIFIC OUTCOMES (PSOs)

Program Specific Outcomes (PSOs) for Postgraduate Science Programmes Enhancing Expertise and Skill Development in Environmental Science

PSO1 – Mastery of Environmental Resources and Sustainability
Develop an in-depth understanding of environmental resources, ecology, ecosystems, biodiversity, and conservation strategies. Apply sustainable practices for resource management to ensure alignment with PO1, PO4, and PO6. **Level: 1 and 3 (Understanding and Application)**

PSO2 – Policy Compliance and Advocacy
Understand and interpret environmental policies, regulations, and intellectual property rights. Advocate for environmental protection and ensure compliance with legal and regulatory frameworks, aligning with PO4 and PO6. **Level: 2 (Comprehension)**

PSO3 – Pollution Control, Waste Management, and Safety
Gain knowledge and practical skills in pollution control, waste management, green technologies, environmental nanotechnology, industrial hygiene, and chemical safety. Innovate solutions to address pollution challenges and ensure workplace safety while adhering to environmental standards. Supports PO1, PO4, and PO6. **Level: 3 (Application)**

PSO4 – Sustainable Practices in Agriculture and Technology
Promote organic farming, eco-technology, and environmentally friendly agricultural practices. Equip learners with the knowledge to implement sustainable solutions that support PO4 and PO6. **Level: 3 (Application)**

PSO5 – Environmental Monitoring, Analysis, and Decision-Making
Acquire expertise in environmental monitoring techniques, biostatistics, and instrumentation. Utilize modern tools to analyze data and make informed decisions, linking with PO2, PO3, and PO5. **Level: 4 (Analysis)**

PSO6 – Research, Innovation, and Practical Training
Encourage research initiatives using advanced methodologies, project work, and internships. Promote critical thinking, problem-solving skills, and a practical approach to bridging the gap between theory and application, fulfilling PO2, PO3, PO5, and PO6. **Level: 5 (Synthesis)**

ASSESSMENT: WEIGHTAGE FOR ASSESSMENTS (IN PERCENTAGE) FOR MANDATORY AND ELECTIVE COURSE

Type of Course	**Formative Assessment / Internal Assessment**	**Summative Assessment**
Theory	40%	60%
Practical	-	100%

Assignments/ Tutorials/Class Test	Seminar or any other activities	Ppt/video Presentation or any other activities	Group discussion/Book Review or any other activities	Active Participation & Leadership qualities	Total
10	10	10	05	05	40

VPM's B. N. Bandodkar College of Science (Autonomous), Thane
M.Sc. Environmental Science
Structure of Programme
SEMESTER I

Course Code	Course Title	No. of Lectures	Credits
MANDATORY PAPERS			
23BPEV1T01	Environment and Natural Resources	**60**	**4**
23BPEV1T02	Ecology and Ecosystem	**60**	**4**
23BPEV1T03	Environmental Pollution	**60**	**4**
23BPEV1P01	Practical based on 23BPEV1T01, 23BPEV1T02 and 23BPEV1T03	**60 Hours**	**2**
ELECTIVE PAPERS			
23BPEV1T04	Biodiversity and Conservation	**30**	**2**
23BPEV1P02	Practical based on 23BPEV1T04	**60 Hours**	**2**
OR			
23BPEV1T05	Pollution and Waste	**30**	**2**
23BPEV1P03	Practical based on 23BPEV1T05	**60 Hours**	**2**
RESEARCH METHODOLOGY (RM)			
23BPRM1T01	Research Methodology	**60**	**4**
	Total Credits		**22**

VPM's B. N. Bandodkar College of Science (Autonomous), Thane
M.Sc. Environmental Science
Structure of Programme
SEMESTER II

Course Code	Course Title	No. of Lectures	Credits
MANDATORY PAPERS			
23BPEV2T01	Environmental Monitoring and Assessment	**60**	**4**
23BPEV2T02	Pollution Control Technology	**60**	**4**
23BPEV2T03	Environmental Policies and Regulations	**60**	**4**
23BPEV2P01	Practical based on 23BPEV2T01, 23BPEV2T02 and 23BPEV2T03	**60 Hours**	**2**
ELECTIVE PAPERS			
23BPEV2T04	Green Technology	**30**	**2**
23BPEV2P02	Practical based on 23BPEV2T04	**60 Hours**	**2**
OR			
23BPEV2T05	Environmental Nanotechnology	**30**	**2**
23BPEV2P03	Practical based on 23BPEV2T05	**60 Hours**	**2**
ON-JOB TRAINING (OJT) / FIELD PROJECT (FP)			
23BPEV2P04	Internship/On-Job Training/Field Project	**120 Hours**	**4**
	Total Credits		**22**
	Total Semester I & Semester II Credits		**44**

Eligibility:

- B.Sc in ANY subject or its equivalent.
- B.Sc. in Environmental Science.

Mode of Conduct: Laboratory practical / Offline lecture / Hybrid lecture

VPM's B.N. Bandodkar College of Science (Autonomous), Thane

Post Graduate Degree Programme M.Sc. Environmental Science

	SEMESTER – I	Course imparts Employability (EM), Entrepreneurship (EN), Skill Development (SD)			Course integrates with Professional Ethics (PE), Gender Equity (GE), Human Value (HV), Environmental Sustainability (ES)			
Course Code	**Mandatory Course Title**	**EM**	**EN**	**SD**	**PE**	**GE**	**HV**	**ES**
23BPEV1T01	Environment and Natural Resources	--	--	--	--	–	✓	✓
23BPEV1T02	Ecology and Ecosystem	--	✓	✓	--	–	--	✓
23BPEV1T03	Environmental Pollution	✓	--	✓	--	–	--	✓
23BPEV1P01	Practical based on 23BPEV1T01, 23BPEV1T02 and 23BPEV1T03	✓	✓	✓	✓	–	--	✓
	Elective Course Title							
23BPEV1T04	Biodiversity and Conservation	--	--	--	✓	–	✓	✓
23BPEV1P02	Practical based on 23BPEV1T04	✓	✓	✓	✓	–	✓	✓
	OR							
23BPEV1T05	Pollution and Waste	✓	--	✓	--	–	--	✓
23BPEV1P03	Practical based on 23BPEV1T05	✓	✓	✓	✓	–	✓	✓
	Research Methodology (RM)							
23BPRM1T01	Research Methodology	✓	--	✓	✓	–	–	✓
	Total	**6**	**4**	**7**	**5**	–	**4**	**9**

VPM's B.N. Bandodkar College of Science (Autonomous), Thane

Post Graduate Degree Programme M.Sc. Environmental Science

	SEMESTER – II	Course imparts Employability (EM), Entrepreneurship (EN), Skill Development (SD)			Course integrates with Professional Ethics (PE), Gender Equity (GE), Human Value (HV), Environmental Sustainability (ES)			
Course Code	**Mandatory Course Title**	**EM**	**EN**	**SD**	**PE**	**GE**	**HV**	**ES**
23BPEV2T01	Environmental Monitoring and Assessment	✓	✓	✓	--	--	--	✓
23BPEV2T02	Pollution Control Technology	✓	✓	✓	--	--	--	✓
23BPEV2T03	Environmental Policies and Regulations	✓	✓	--	✓	✓	✓	✓
23BPEV2P01	Practical based on 23BPEV2T01, 23BPEV2T02 and 23BPEV2T03	✓	✓	✓	✓	--	--	✓
	Elective Course Title							
23BPEV2T04	Green Technology	✓	✓	✓	✓	--	--	✓
23BPEV2P02	Practical based on 23BPEV2T04	✓	✓	✓	✓	--	--	✓
	OR							
23BPEV2T05	Environmental Nanotechnology	✓	--	✓	--	--	--	✓
23BPEV2P03	Practical based on 23BPEV2T05	✓	✓	✓	✓	--	--	✓
	On-Job Training (OJT) / Field Project (FP)							
23BPEV2P04	Internship/Training/Field Project	✓	✓	✓	✓	--	✓	✓
	Total	**9**	**8**	**8**	**6**	**1**	**2**	**9**

Dr. Sandhya Pawale
BOS Chairman & Head Dept. of Environmental Science

SEMESTER I

MANDATORY PAPERS

Course Code 23BPEV1T01	Course Title Environment and Natural Resources	Credits 4	No. of lectures

Course Outcomes:
After completing this course learner will be able to:

CO 1	Explain the concept of environment, structure, composition and its geographical characteristics and classification.	*L2*
CO 2	Demonstrate comprehensive understanding of meteorological and climate aspects, theories of mass and energy.	*L2*
CO 3	Outline the types of natural resources with its characteristics and management	*L2*
CO 4	Classify renewable and non-renewable energy resources, types of alternate energy resources and waste to energy concept	*L3*

CO-PO Mapping Table:

COs (Course Outcomes)	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	2	0	0
CO2	3	2	2	2	0	0
CO3	3	2	2	3	0	3
CO4	3	2	2	3	2	3

Grading will be as:
3: High (>60%);
2: Moderate (40%-60%);
1: Low (<40%);
0: No Mapping

UNIT I Environment	1.1 Definition of Environment, Evolution of environment. 1.2 Physico-chemical and Biological Characteristics of environment. 1.3 Structure and composition of atmosphere, hydrosphere, lithosphere and biosphere. 1.4 Geographical classification, Distribution and zones. 1.5 Minerals and their Classification. 1.6 Characteristics of Soil.	**15**
UNIT II Mass and Energy	2.1 Definition of Mass and Energy. 2.2 Transfer of mass and energy across various interfaces. 2.3 First and second laws of thermodynamics, heat transfer processes. 2.4 Biogeochemical cycles, gaseous and sedimentary turnover rate and turnover item, General relationship between landscape and climate. Climates of India, global climate change. 2.5 Meteorological and Climatic Aspects, Elements of weather and Climate. 2.6 EL NINO and LA NINA Effect.	**15**

UNIT III Natural Resources	3.1 Introduction to natural resources. 3.2 Types of natural resources: 3.2.1 Forest resources: Introduction to forest resources, Types of forest. 3.2.2 Water resources: Surface water resources, River network of India, Ground water resources, Groundwater status of India. Use and utilization of surfaces and ground water. 3.2.3 Mineral resources: Mineral resources in India, Metallic and Non-metallic resources, Major Mineral Producing States in India according to the Mineral Belts. 3.2.4 Food resources: Food sources, Food crops, Live Stock, Aqua culture. 3.2.5 Land resources: Land resources in India, Utilization of land resources in India, Land Cover and Land Use. 3.3 Role of an individual in conservation of natural resources.	**15**
UNIT IV Energy Resources	4.1 Concept and demand of energy, Growing energy needs 4.2 Renewable and non- renewable sources 4.3 Use of alternate energy sources, Wind energy, Solar energy, Tidal energy, Nuclear energy, Water as source of energy 4.4 Biofuels production, use and sustainability, use and over exploitation of energy sources and associated problems. 4.5 Waste to Energy, Clean Energy, Sustainable Energy, Equitable use resources for sustainable lifestyles.	**15**

Texts/References:

1) Renewable Energy – Environment and Development: M. Dayal; Konark Pub. Pvt. Ltd. Alternative Energy: S. Vandana; APH Publishing Corporation
2) Nuclear Energy – Principles, practice and prospects: S. K. Agarwal; APH Publishing Corporation
3) S. Glass stone, D. Van Nastrand, Source book on atomic energy, 3rd Edition, Germany, 1967
4) M. Eisendbud, Environmental radioactivity, Academic Press
5) E.D.Enger, B.E. Smith, Environmental Sciences- A study of Inter relationships, WCB Publication
6) Bio-Energy Resources: Chaturvedi; Concept Pub.
7) National Energy – policy, crisis and growth: V S. Mahajan; Ashis Publishing House
8) Geography and Energy – Commercial energy systems and national policies: J. D. Chapman

Course Code 23BPEV1T02	Course Title Ecology and Ecosystem	Credits 4	No. of lectures

Course Outcomes:
After completing this course learner will be able to:

CO 1	Classify aquatic, terrestrial ecology and biotic prey-predator interactions.	*L3*
CO 2	Explain types of biomes, ecosystems and dynamic biogeography.	*L2*
CO 3	List the ecosystem components, dynamics and energy flow through ecosystems.	*L1*
CO 4	Categorize phases of biogeochemical cycles and ecological succession, energy models and transfer in trophic levels.	*L3*

CO-PO Mapping Table:

COs (Course Outcomes)	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	3	2	2
CO2	3	2	2	3	0	2
CO3	3	2	2	3	2	2
CO4	3	3	2	3	2	2

Grading will be as:
3: High (>60%);
2: Moderate (40%-60%);
1: Low (<40%);
0: No Mapping

UNIT I Ecology	1.1 Definition, principle and scope of ecology. 1.2 Aquatic and terrestrial ecology, freshwater ecology, marine ecology, estuarine ecology Community concept, types of community, competition and coexistence. 1.3 Types of interactions: predation, parasitism, antibiosis, commensalism, cooperation and mutualism, predator and prey relationship.	**15**
UNIT II Concept of Biosphere and Ecosystem	2.1 Definition of environment, Abiotic and Biotic environment, limiting factors, adaptation, Habitat and niche. 2.2 Biomes, Population parameters, structure, Growth Regulation. 2.3 Types of ecosystems, eco system of India, Characteristics of eco system, structure of ecosystem and function of an ecosystem. 2.4 Marine Environment: Indian marine territory, Biota in different types of zones, its diversity-plankton, nekton, benthos, their adaptations and productivity, Exclusive Economic Zones (EEZ), distribution of mangrove areas in India, ecological importance of mangrove vegetation. 2.5 Dynamic biogeography: routes of migration of plants and animals, their impact on local ecosystems, trade routes, shipping, accidental import, weeds, ballast water.	**15**
UNIT III Organization of Ecological Systems	3.1 Components of Ecosystem: Biotic and abiotic components 3.2 Producers, consumers and decomposer. 3.3 Food chains, food web, and ecological pyramids, population Dynamics, Carrying capacity, construction of ecological pyramids. 3.4 Bioaccumulation and biomagnifications. 3.5 Ecosystem Services, Ecological Footprint, Bio capacity, Quantification of Ecological Footprint.	**15**

UNIT IV Energy and Ecological Succession	4.1 Models of Flow and energy fixation, mass and energy transfer in successive trophic level. 4.2 Biogeochemical cycles: Sources, Phases of biogeochemical cycles, biotic phase (organic phase) and the abiotic phase, fluxes, sedimentation. 4.3 Anthropological activities on biogeochemical cycles. 4.4 Theories of ecological climax, Ecological succession, Types of ecological succession: primary succession, secondary succession, examples of ecological succession. 4.5 Impacts of development on ecosystem.	**15**

Texts/References:

1) E. P. Odum (1996) Fundamentals of Ecology, Nataraj Publisher, Dehra Dun.
2) K.M.M. Dakshini (1999) Principle and Practices in Plant Ecology, CRC, Boston.
3) M.C. Dash (1994) Fundamentals of Ecology, Tata McGraw Hill, New Delhi.
4) M.C. Molles Jr. (1999) Ecology- Concepts and Application, McGraw Hill, New Delhi.
5) V. Ingegnoli (2002) Landscape Ecology: a widening foundation, Springer, Bonn.
6) E.J. Kormondi (1999) Concepts of Ecology, Prentice Hall of India, New Delhi.
7) Chapman, J.L. and Reiss M.J. (2005) Ecology Principles and Applications, Cambridge University Press, London.
8) E.P. Odum and G. W. Barrett (2005) Fundamentals of Ecology, Thomson Asia Pvt. Ltd., Singapore.
9) S.V.S. Rana (2005) Essentials of Ecology and Environmental Sciences, Prentice Hall of India, New Delhi.
10) Environment And Ecology-EAS105/EAS 205-R. Rajagopalan
11) Environmental Studies from Crisis to Cure-2nd Edition-R. Rajagopalan
12) Fundamentals of Environmental Science and Ecology (Zigma Publication)

Course Code 23BPEV1T03	Course Title Environmental Pollution	Credits 4	No. of lectures

Course Outcomes:
After completing this course learner will be able to:

CO 1	Explain overview of pollution; causes, properties, examples, laws and mitigation of air pollution.	*L2*
CO 2	Discuss sources, effects, examples control measures and laws and mitigation of water pollution.	*L2*
CO 3	Outline the types, sources, causes and interaction of soil pollution.	*L2*
CO 4	Elaborate on sources, causes, effects and management of thermal and oil pollution.	*L2*

CO-PO Mapping Table:

COs (Course Outcomes)	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	3	0	3
CO2	3	2	2	3	0	3
CO3	3	2	2	3	0	2
CO4	3	2	2	3	0	2

Grading will be as:
3: High (>60%);
2: Moderate (40%-60%);
1: Low (<40%);
0: No Mapping

UNIT I Air Pollution	1.1 Pollution: Definition and sources of pollution; 1.2 Air pollution: Types and sources of air pollutants, Properties of air pollutants Impact of air pollution on global, regional and local aspects. 1.3 Reaction of pollutants in air forming smog, Ozone Formation and Depletion, PAN, Acid rain, greenhouse gases and greenhouse effect. 1.4 Atmospheric diffusion and stack performance; Transport of pollutants 1.5 Air Quality Index. 1.6 Effects of air pollutants on flora and fauna, human health; Sinks of atmospheric gases. 1.7 Air (Prevention and Control of Pollution) Act 1981	**15**
UNIT II Water Pollution	2.1 Sources of water and their contamination: domestic water pollution, industrial water pollution, agricultural water pollution, thermal water pollution, oil water pollution, toxic water pollutants and their effects 2.2 Types of pollutants, various industrial effluents such as pulp and paper mills, oil exploration and refinery, petrochemicals, iron and steel industries, Domestic wastes, organic debris, agricultural wastes, pesticides. 2.3 Eutrophication – causes, effects and control measures 2.4.1 Water (Prevention and Control of Pollution) Act, 1974 2.4.2 Water (Prevention and Control of Pollution) Cess (Amendment) Act, 2003.	**15**

UNIT III Soil Pollution	3.1 Sources, types and causes of soil pollution; 3.2 Effects of fungicides and weedicides on soil components, residual toxicity. 3.3 Different kinds of synthetic fertilizer (N, P, K), and their interactions with different components of soil, their toxicity. 3.4 Industrial effluents and their interactions with soil components, Contamination by radio nuclides.	**15**
UNIT IV Thermal and Oil Pollution	4.1 Definition and sources of thermal pollution 4.2 Chemical and biological effects of thermal pollution, 4.3 Effect on marine life, bacteria and water quality and other aquatic biota; 4.4 Thermal pollution from power plants and their control. 4.5 Sources of oil pollution, Oil pollution and marine ecology, factors effecting fate of oil after spillage 4.6 Water quality monitoring: movement, spreading, evaporation, emulsification, dispersion, remote sensing	**15**

Texts/References:

1) J.N.B. Bell (2002) Air Pollution and Plant Life, 2nd Edition, John Wiley and Sons, New Delhi.

2) Christon J. Hurst, Ronald L. Crawford, Guy R. Knudsen, Michael J. McInerney, Manual of Environmental Microbiology, 2nd edition, ASM Press. 2001.

3) Bruce Rittman, Perry L. McCarty. Environmental Biotechnology: Principles and Applications,2nd Edition, McGraw-Hill, 2000.

4) Air Pollution – Stern

5) Environmental Pollution Control Engineering: C. S. Rao

6) Environmental Chemistry: B.K. Sharma, and H. Kaur

7) Air pollution – threat and response: D. A. Lynn

8) Air pollution and Environmental Protection – Legislative policies, Judicial trend and Social perceptions: N. Kumar; Mittal Publication

Course Code 23BPEV1P01	Course Title Practical based on 23BPEV1T01, 23BPEV1T02 and 23BPEV1T03	Credits 2

Course Outcomes:
After completing this course learner will be able to:

CO 1	Experiment with diversity indices of plant communities.	*L3*
CO 2	Examine various soil parameters from different types of soil samples.	*L4*
CO 3	Estimate the physico-chemical parameters of water samples.	*L3*
CO 4	Determine the air quality using standard methodologies.	*L4*

CO-PO Mapping Table:

COs (Course Outcomes)	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	3	3	3
CO2	3	3	2	3	2	3
CO3	3	3	2	3	2	3
CO4	3	3	2	3	2	3

Grading will be as:
3: High (>60%);
2: Moderate (40%-60%);
1: Low (<40%);
0: No Mapping

1. Determination of Shannon-Wiener diversity indices in plant communities.
2. Determination of Chlorophyll content from plant species.
3. Determination of primary productivity by light and dark bottle method.
4. To analyze the carbon sequestration of plant species.
5. Determination of total organic matter in soil.
6. Determination of pH value of different types of soil using indicator.
7. Determination of water holding capacity of soil.
8. To study the soil profiles for their height, color, texture and electrical conductivity.
9. Measurement of photo density flux by Luxmeter.
10. To demonstrate total nitrogen value of the soil by Kjeldahl's method
11. Determination of Dissolved Oxygen of water sample by Winkler's method.
12. Determination of Chemical Oxygen Demand value for industrial waste effluent.
13. Determination of CO_2 in the atmosphere by volumetric method.
14. Estimation of Free Lime Analysis
15. Comparative study of Air Quality Index.

Texts/References:

1. Standard methods for examination of water and waste water, American Public Health Association.
2. A comprehensive laboratory manual for Environmental Sciences and Engineering by P.R. Sreemahadevan Pillai. New Age International Publishers.
3. Chemical and biological methods for water pollution studies By R.K. Trivedi
4. Handbook of water and waste water analysis By S.K. Maiti.
5. Soil and air analysis by S.K. Maiti.

ELECTIVE PAPERS

Course Code 23BPEV1T04	Course Title Biodiversity and Conservation	Credits 2	No. of lectures

Course Outcomes:
After completing this course learner will be able to:

CO 1	Demonstrate understanding on types and importance of biodiversity; types of species, terrestrial ecosystem	*L2*
CO 2	Evaluate on wildlife distribution and its challenges, national and global status of biodiversity, IUCN Red list	*L5*
CO 3	Interpret the role of international organizations and status of Biodiversity conservation.	*L3*
CO 4	List types of biodiversity conservation methods and measures to conserve biodiversity.	*L1*

CO-PO Mapping Table:

COs (Course Outcomes)	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	3	0	2
CO2	3	3	2	3	0	2
CO3	3	2	2	3	0	2
CO4	3	2	2	3	0	2

Grading will be as:
3: High (>60%);
2: Moderate (40%-60%);
1: Low (<40%);
0: No Mapping

UNIT I Biodiversity Status	1.1 Introduction to Biodiversity: Types of Biodiversity: α, β, γ diversity, Economic Importance, ecotone, Flagship species, key stone species and umbrella species. 1.2 Biodiversity status: National status and Global status, Biodiversity hotspot; 1.3 IUCN Category, IUCN Red list, endangered species, vulnerable species, rare species, extinct species and endemic species, threatened species 1.4 Common flora and fauna in India-Aquatic: phytoplankton, Zooplankton and macrophytes. 1.5 Terrestrial ecosystem: Forests; Endangered and threatened species. 1.6 wildlife distribution in India, problem in wildlife protection. 1.7 Biodiversity Act 2002	**15**

UNIT II Biodiversity Convention and Conservation	2.1 Importance of Biodiversity conservation, Different approaches for Biodiversity conservation. 2.2 IPRs, national and international programs for biodiversity conservation 2.3 Role of WWF, WCU, CITES, TRAFFIC, Wildlife Protection Act 1972. Joint Forest Management, People's Biodiversity Register, Speciation in PAN India, NAGOA protocol. CBD, AICHI. 2.4 In-situ conservation: sanctuaries, biospheres reserves, national parks, nature re- serves, preservation plots. 2.5 Ex-situ conservation: botanical gardens, zoos, aquaria, homestead garden; herbarium; In-vitro Conservation: germplasm and gene Bank; tissue culture: pollen and spore bank, DNA bank. 2.6 Current status and Case Studies of Biodiversity Conservation Projects (flora and fauna). 2.7 Indian Wildlife (Protection) Act, 1972	**15**
Course Code 23BPEV1P02	**Practical based on 23BPEV1T04**	**2 Credit**

Course Outcomes:
After completing this course learner will be able to:

CO 1	Mark the protected area network on map of India.	*L3*
CO 2	Choose the methods of qualitative and quantitative characteristics for plant community.	*L4*
CO 3	Create herbarium and setup butterfly garden.	*L6*
CO 4	Take part in educational study tours.	*L3*

CO-PO Mapping Table:

COs (Course Outcomes)	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	3	0	2
CO2	3	3	2	3	2	3
CO3	3	2	2	3	3	3
CO4	2	2	2	2	3	2

Grading will be as:
3: High (>60%);
2: Moderate (40%-60%);
1: Low (<40%);
0: No Mapping

1. Prepare a map of India, showing bio-geographical zones and expanse of territorial waters.
2. Identification and description of economically important plant species.
3. To plot biosphere reserve on a map of India.
4. Prepare a document of endemic and exotic species of plants/animals for a selected PAN.
5. Indicate distribution range of a plant and animal species identified as endangered on an Indian map.
6. Prepare a map of. Maharashtra showing Protected Area Network (PAN) in it.
7. To study qualitative and quantitative characters of a plant community by quadrate method.
8. To study a plant community by using line transect method, using line, belt and profile transects.
9. Study of phytoplankton and zooplankton from water sample.
10. Visit to: seed bank, national park.
11. Preparation of herbarium of any 5 plants
12. To set up of a butterfly garden

Texts/References:

1) Sustaining Life: How Human Health Depends on Biodiversity Eric Chivian Aaron Bernstein (2008)
2) Shahid Naeem, Daniel E. Bunker, Andy Hector and Michel Loreau (2009) Biodiversity, ecosystem functioning and human well-being: An ecological and economic perspective
3) S.K. Agarwal et al (1996) Biodiversity and Environment, APH, Dehra Dun.
4) S.S. Negi (1993) Biodiversity and its Conservation in India, Indus Publications, New Delhi.
5) W.W. Collins and C.O. Qualset (1998) Biodiversity in Agro-ecosystem, CRC, Boston.
6) V.K. Krishnamurthy (2003) Text Book of Biodiversity, Science Publisher, Chennai.
7) P.S. Ramakrishnan (2000) Mountain Biodiversity, Land Use Dynamics and Traditional Ecological Knowledge, Oxford and IBH, New Delhi
8) Global Biodiversity strategy: WRI, IUCN & UNEP
9) Ecotourism and Sustainable Development: Singh; Abhijeet Pub

Course Code 23BPEV1T05	Course Title Pollution and Waste	Credits 2	No. of lectures

Course Outcomes:
After completing this course learner will be able to:

CO 1	List the sources and impacts of nuclear pollution and its treatment methods.	*L1*
CO 2	Explain the sources, effects of noise pollution and its control measures.	*L2*
CO 3	Elaborate on sources, types and segregation of solid waste and biomedical waste.	*L2*
CO 4	Classify and study the types of E-waste and Plastic waste and its alternatives.	*L3*

CO-PO Mapping Table:

COs (Course Outcomes)	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	3	0	2
CO2	3	2	2	3	0	2
CO3	3	2	2	3	0	3
CO4	3	2	2	3	0	3

Grading will be as:
3: High (>60%);
2: Moderate (40%-60%);
1: Low (<40%);
0: No Mapping

UNIT I Radiation and Noise Pollution	1.1 Sources of Nuclear Energy, Units of radioactivity and radiation dose; 1.2 Radioactive decay; Biological impact and health hazards associated with radiation. 1.3 Half Life Hazards, Protection against ionizing isotopes and their applications in waste water and air pollution analysis and treatment; 1.4 Radioactive waste disposal. 1.5 Basic properties of sound waves – plane and spherical waves, sound pressure, loudness and intensity levels, decibel; 1.6 Sources of Noise Pollution 1.7 Effects of noise pollution on human health 1.8 Measurement and analysis of sound, Measures to control noise pollution. 1.9 Noise Pollution (Regulation and Control) Rules, 2000	**15**
UNIT II Solid Waste Pollution	2.1 Solid waste pollution: sources, nature, classification and environmental effects. Municipal Solid Waste 2.2 Classification of E Waste, Sources and types and constituents of E-wastes and its environmental consequences 2.3 E-waste Management and Handling Rules 2011 2.4 Plastic waste: Types of Plastics and its impacts on environment 2.5 Microplastics; Alternatives to plastic use: bioplastics 2.6 Pollution as an opportunity: Ecobricks. 2.7 Biomedical waste: sources, types and segregation of waste. 2.8 Plastics Manufacture, Sale and Usage Rules, 2011	**15**

Course Code 23BPEV1P03	Practical based on 23BPEV1T05	2 Credit

Course Outcomes:
After completing this course learner will be able to:

CO 1	Estimate the chemical parameters of various water samples.	*L3*
CO 2	Determine the physical parameters of different water/effluent samples.	*L3*
CO 3	Measure noise pollution using specific devices.	*L3*
CO 4	Assess wind velocity by using anemometer.	*L4*

CO-PO Mapping Table:

COs (Course Outcomes)	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	3	2	3
CO2	3	3	2	3	2	3
CO3	3	3	2	3	2	3
CO4	3	3	2	3	2	3

Grading will be as:
3: High (>60%);
2: Moderate (40%-60%);
1: Low (<40%);
0: No Mapping

1.Determination of Total Dissolved Solids from the lake water.
2.Determination of Total Hardness of well water.
3. Determination of physical parameters of given type effluent/water sample a. Well water b. Industrial c. River water d. Sea water e. lake water.
4. Estimation of Silicates
5. Measurement and classification of noise pollution.
6.Determination of quality of stagnant water using Nygaard index (eutrophication technique)
7. Determination of water transparency by Secchi discs
8. Determination of wind velocity by anemometer.

Texts/References:

1) J.N.B. Bell (2002) Air Pollution and Plant Life, 2nd Edition, John Wiley and Sons, New Delhi.
2) Christon J. Hurst, Ronald L. Crawford, Guy R. Knudsen, Michael J. McInerney, Manual of Environmental Microbiology, 2nd edition, ASM Press. 2001.
3) Bruce Rittman, Perry L. McCarty. Environmental Biotechnology: Principles and Applications,2nd Edition, McGraw-Hill, 2000.
4) Air Pollution – Stern
5) Environmental Pollution Control Engineering: C. S. Rao
6) Environmental Chemistry: B.K. Sharma, and H. Kaur
7) Air pollution – threat and response: D. A. Lynn
8) Air pollution and Environmental Protection – Legislative policies, Judicial trend and Social perceptions: N. Kumar; Mittal Publication

SEMESTER II

MANDATORY PAPERS

Course Code 23BPEV2T01	Course Title Environmental Monitoring and Assessment	Credits 4	No. of lectures

Course Outcomes:
After completing this course learner will be able to:

CO 1	Discuss methods for environmental monitoring and assessment	*L6*
CO 2	Explain the types, process, and methodology for Environmental Impact Assessment (EIA)	*L2, L5*
CO 3	Determine the types, methods, and importance of GIS to understand spatial data	*L5*
CO 4	Interpret on basic concept and software of Remote sensing and its applications in Environmental Monitoring	*L2, L5*

CO-PO Mapping Table:

COs (Course Outcomes)	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	3	2	3
CO2	3	3	2	3	2	3
CO3	3	3	3	3	2	3
CO4	3	3	3	3	2	3

Grading will be as:
3: High (>60%);
2: Moderate (40%-60%);
1: Low (<40%);
0: No Mapping

UNIT I Environmental Monitoring	1.1 Concept of environmental quality. 1.2 Deterioration of environmental quality with reference to anthropogenic impact; 1.3 Methods of assessment of environmental quality; Short term studies/surveys; Rapid assessment; Continuous short- and long-term monitoring, Environmental Samplings, Instrumentation and Sampling Equipment. 1.4 Advantages of Environmental Monitoring	**15**
UNIT II Environmental Impact Assessment (EIA)	2.1 Need of EIA; Scope and objectives; Types of environmental impacts; Steps involved in conducting the EIA Studies 2.2 Environmental Impact Assessment Techniques-Ad-hoc method, checklist method. 2.3 Process of EIA 2.4 Form I and I A 2.5 Merits and Demerits of EIA studies. 2.6 EIA Notification 2006	**15**
UNIT III Geographical Information System (GIS)	3.1 GIS: Basic principles, Techniques. 3.2 Types of Geographical Data; Data Structure; Vector and Raster data: their Advantages and Disadvantages; Input, verification, storage and output of geographical data; 3.3 Importance of Geographical Information System in environmental studies. 3.4 Global Positioning System (GPS): basic principles 3.5 Applications to environmental studies -Point source pollution, hazard monitoring and assessment. 3.6 GIS based Model: Invest Model, Traffic Model of Google Maps	**15**

UNIT IV Remote Sensing and its Applications in Environmental Monitoring	4.1 Principles and Basic concepts of Remote sensing; EMR. 4.2 Aerial Photography and image recognition; Sensors & platforms; IRS satellites Types & their sensors 4.3 Software for Remote Sensing: Q-GIS, R-GIS, SAGA, DIVA GIS, US-GIS, BHUVAN 4.4 Application of remote sensing in environmental studies: land use mapping, forest survey, habitat analysis, water management, drought monitoring and flood studies, wetland survey; rainfall estimation, pollution studies, soil conservation, watershed management and vegetation mapping.	**15**

Texts/References:

1.D. P. Lawrence (2003) Environmental Impact Assessment: Practical Solutions to Recurrent Problems, John Wiley and Sons, New Delhi.

2. Environmental Impact Analysis Handbook: J. G. Rau and D. C. Wooten; McGraw-Hill Book Co.

3. Environmental Impact Assessment, L. W. Canter, Mc Graw Hill Publication.

4. P. Morris and R. Therivel (2001), Methods of Environmental Impact Assessment, Spoon Press.

5. J. Weston (1997) Planning and EIA in Practice, Longman.

6. Jos Arts and Angus Morrison-Saunders (2004) Assessing Impact - Handbook of EIA and SEA follow up, Earthscan, London.

7. Website of MoEF, GOI, New Delhi 8. Srivastava, D. C. (2005) Readings in Environmental Ethics: Multidisciplinary perspectives, Rawat Publications, Jaipur.

Course Code 23BPEV2T02	Course Title Pollution Control Technology	Credits 4	No. of lectures

Course Outcomes:
After completing this course learner will be able to:

CO 1	Discuss about various water pollution control strategies for monitoring sewage and waste water treatments systems	*L6*
CO 2	Explain methods to monitor and control air pollution in the environment from industry and vehicles for significant reductions in air pollution	*L2, L5*
CO 3	Determine types and methods for Solid Waste Management to minimize their impact on health and the environment.	*L5*
CO 4	Choose different biotechnological methods to control pollution	*L5, L6*

CO-PO Mapping Table:

COs (Course Outcomes)	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	3	0	3
CO2	3	3	2	3	0	3
CO3	3	3	2	3	0	3
CO4	3	3	2	3	0	3

Grading will be as:
3: High (>60%);
2: Moderate (40%-60%);
1: Low (<40%);
0: No Mapping

UNIT I Water Pollution Control Technologies	1.1 Sewage and waste water treatments systems: 1.2 Stages in wastewater treatment 1.2.1 Primary: Screening, Grit removal, sedimentation 1.2.2 Secondary: Biological treatments - aerobic versus anaerobic treatments; Measurement of treatment efficiencies; Activated sludge. 1.2.3 Tertiary treatments; 1.3 Development and optimization of membrane bioreactor process for use in sanitary and industrial sewage treatment. 1.4 Environmental pollution control- Bioaugmentation and Biostimulation; Biofilms in treatment of waste water; Bioreactors for waste water treatments; 1.5 Reactors types and design;	**15**
UNIT II Air Pollution Control Technologies and Devices	2.1 Air pollution standard Bharat 6 and 7; Polluter pays principle 2.2 Methods to control air pollution in the environment from industry: Limestone injection and fluidized bed combustion, Desulfurization, Centrifugal collectors- cyclone collector and dynamic precipitators. 2.3 Methods to control air pollution in the environment from vehicles: Catalytic converter and control of vehicular emission, Gravity settling chamber, Electrostatic precipitators; Fabric filters 2.4 Case study: CO_2 diamond startups-Aether Diamonds, Breathe Fresh-Vayu Natural Bag, Graviky Labs-Air-Ink; Kalink.	**15**

UNIT III Solid Waste Management	3.1 Types of Solid waste disposal methods – Types of Landfills: Open and secure; Incineration: Energy from waste: pyrolysis, gasification, incineration 3.2 Recycling and reuse. 3.3 Organic pollutants and Hazardous waste disposal and management. 3.4 Formal and Informal sectors for e waste 3.5 Biosorption - Biotechnology and heavy metal pollution; Oil field microbiology; Improved oil recovery; Biotechnology and oil spills; Hydrocarbon degradation, 3.6 Municipal Solid Waste (Management and Handling Rules) 2000	**15**
UNIT IV Biotechnological Methods to Control Pollution	4.1 Concept of Bioremediation, Biotransformation and Biodegradation 4.2 Methods in determining biodegradability; Contaminant availability for biodegradation.; Factors affecting process of biodegradation 4.3 In situ and Ex situ bioremediation; Bioremediation of VOCs. 4.4 Use of microbes (bacteria and fungi) and plants in biodegradation and Biotransformation; 4.5 Phytoremediation: Waste water treatment using aquatic plants; Root zone treatment. 4.6 Phytorid technology	**15**

Texts/References:

1) M.H.Fulekar (2005) Environmental Biotechnology Oxford IBH Publishing cooperation.

2) M.H.Fulekar (2010) Bioremediation technology recent advances, springer.

3) N.P Cheremisinoff (1996) Biotechnology for Waste and Wastewater Treatment, William Andrew Publishing, New York.

4) Bruce Rittman, Perry L. McCarty, Environmental Biotechnology: Principles and Applications,2nd edition, McGraw-Hill, 2000.

5) Christon J. Hurst, Ronald L. Crawford, Guy R. Knudsen, Michael J. McInerney, Manual of Environmental Microbiology, 2nd edition, ASM Press. 2001.

6) Bruce Rittman, Perry L. McCarty. Environmental Biotechnology: Principles and Applications,2nd Edition, McGraw-Hill, 2000.

7) Mizrahi & Wezel, Advances in Biotechnological Process

8) Raina M. Maier, Ian L. Pepper, Charles P. Gerba. Environmental Microbiology, Academic Press, 2000.

9) Gabriel Bitton, Wastewater Microbiology, 2nd Edition. Wiley-Liss; 2nd Edition, 1999.

Course Code 23BPEV2T03	Course Title Environmental Policies and Regulations	Credits 4	No. of lectures

Course Outcomes:
After completing this course learner will be able to:

CO 1	Function and principle of National and International Environmental Policy essential for creating a coordinated approach to environmental protection	*L4*
CO 2	Importance of Environmental Movement in India for addressing environmental concerns	*L5*
CO 3	Summarize International Environmental Treaties and Conventions for addressing global environmental challenges	*L2*
CO 4	Interpret the Objectives and Provisions of Acts and Rules for Environmental Management	*L2, L5*

CO-PO Mapping Table:

COs (Course Outcomes)	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	3	0	3
CO2	3	2	2	3	0	2
CO3	3	3	2	3	0	3
CO4	3	3	2	3	0	3

Grading will be as:
3: High (>60%);
2: Moderate (40%-60%);
1: Low (<40%);
0: No Mapping

UNIT I Evolution of International Environmental Policy	1.1 Fundamental principles of environmental protection - sustainable development Brundtland report 1987. 1.2 Role of International Environmental Agencies -UNEP, GEF, UNFCC and IPCC 1.3 Role of National Environmental Agencies: MoEFCC, MPCB, CPCB 1.4 Intergenerational and intra-generational Equity, precautionary principle, Public Trust Doctrine. 1.5 Constitutional Perspective: Fundamental right to wholesome environment. Directive principles of state policy. Fundamental duty. 1.6 National Environmental Policy. 1.7 Environmental Regulatory Framework in India.	**15**
UNIT II Environmental Movement in India	2.1 Movements related to Environment Sacred groves: Bishnoi movement, Silent Valley, Chipko movement, Tehri Dam Movement, Appiko Movement, Jungle Bachao Andolan, Narmada Bachao Andolan, Sardar Sarovar Dam, Almatti dam. 2.2 Supreme Court Cases – Ratlam Municipality, Ganga Action Plan, Taj Trapezium, Delhi CNG, Tamil Nadu Tanneries, Doon Valley, Span motels private limited case, Oleum gas case, 2.3 Case Studies: Save Aarey Forest, Pollution in Bichhri, Mining in Sariska,Yamuna river water pollution, India Paryavaran Bhavan Case, Swachh Bharat Abhiyan.	**15**

UNIT III International Environmental Treaties and Conventions	3.1 Stockholm Conference on Human Environment,1972 3.2 Ramsar Convention on Wetlands, 1971 3.3 Basel Convention (1989,1992), 3.4 Earth Summit at Rio de Janeiro,1992 3.5 Kyoto Protocol, 1997 3.6 Convention on Desertification 1996 3.7 Convention on Biodiversity & Cartagena Protocol on Bio safety 3.8 Paris Agreement 3.9 CERP	**15**
UNIT IV Objectives and Provisions of Acts and Rules	4.1 Indian Forest Act 1927 4.2 Forest Conservation Act 1980 4.3 Forest Rights Act 4.4 Environment (Protection) Act, 1986 4.5 Bio-Medical Waste (Management & Handling) Rules,1998 4.6 The Hazardous Wastes (Management, Handling and Transboundary Movement) Rules,2008 4.7 Wetland Rules 2009 4.8 National Green Tribunal Act 2010 4.9 Coastal Regulation Zones (CRZ) Rules 2011.	**15**

Texts/References:

1.Shyam Divan and Armin Rosencranz, 2005, Environmental Law and Policy in India, Oxford University Press, New Delhi, 2005

2. Leelakrishnan. P, 2008, Environmental Law Case Book , Lexis Nexis, Butterworths

3. Mohanty. S. K., 2011, Environment and Pollution Law, Universal Law Publishing Co. Pvt. Ltd.

4.Shastri S C, 2008, Environmental Law, (2nd Edn.), Eastern Book Company, Lucknow

5.Singh Gurdip, 2004, Environmental Law in India, Mcmillan & Co.

6.Shantakumar S,2005 Introduction to Environmental Law, (2nd Edn.), Wadhwa& Company, Nagpur

7.Sahasranaman P B, 2008 Handbook of Environmental Law in India, Oxford University Press (India)

8.Environmental Policy by Keith Neil

9.Environmental Impact Assessment and Management by Khitoliya R.K

Course Code 23BPEV2P01	Course Title Practical based on 23BPEV2T01, 23BPEV2T02 and 23BPEV2T03	Credits 2

Course Outcomes:
After completing this course learner will be able to:

CO 1	Determine various parameters of air monitoring that indicate the presence of pollutants and the overall health of the atmosphere.	*L5*
CO 2	Estimate the water quality parameters for analyzing various indicators that reflect the health of a water body.	*L5, L6*
CO 3	Assess soil parameters that indicate soil health, fertility and environmental quality.	*L5*
CO 4	Take part in educational study tour	*L4*

CO-PO Mapping Table:

COs (Course Outcomes)	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	3	2	3
CO2	3	3	2	3	2	3
CO3	3	3	2	3	2	3
CO4	2	2	0	2	3	2

Grading will be as:
3: High (>60%);
2: Moderate (40%-60%);
1: Low (<40%);
0: No Mapping

1. Interpretation of Aerial photographs and preparing weather report based on it.
2. Determination of relative humidity from the atmosphere.
3. Determination of Salinity of water by Volhard's method.
4. Determination of moisture content, alkalinity/acidity of soil sample.
5. To prepare the station-based wind rose for an area.
6. Determination of Residual Chlorine from drinking water using colorimetric method.
7. Study the effect of pH on microbial growth.
8. Study the effect of heavy metals on the growth of bacteria.
9. Determination of K_2O value of soil by flame photometer.
10. Determination of P_2O_5 from soil by Olson's colorimetric method.
11. Determination of SO_2 by spectrophotometry/ NO_2 by Colorimetric method using high volume sampler.
12. Determination of particulate matter from the industrial area by High Volume Sampler/Settling method.
13. Report on Eco-tourism.
14. Reports on various study tours/academic visits.
15. To attend/present research papers in National/International Conferences.

Note: Students should undertake field work and survey. The students should visit different places to collect data to make survey and analyze. At least four places may be visited. The Places of visit could be: Lakes, rivers, estuary and marine, nature parks, water/ sewage/ Industrial effluent treatment plant, Solid waste dump, meteorological centre, mangrove vegetation, industries – food, pharmaceutical, petrochemical, fertilizer, paper, sugar, distillery etc. The students should also be encouraged to participate in the public lectures/ seminars/ workshops etc. on environment related issues. Reports on each of visit/ activity undertaken must be included in the journal.

Texts/References:

1. Standard methods for examination of water and waste water, American Public Health Association.
2. A comprehensive laboratory manual for Environmental Sciences and Engineering
By P.R. Sreemahadevan Pillai. New Age International Publishers.
3. Chemical and biological methods for water pollution studies By R.K. Trivedi
4. Handbook of water and waste water analysis By S.K. Maiti.
5. Soil and air analysis by S.K. Maiti.

ELECTIVE PAPERS

Course Code 23BPEV2T04	Course Title Green Technology	Credits 2	No. of lectures

Course Outcomes:
After completing this course learner will be able to:

CO 1	Interpret on green technology and green chemistry principles, enabling to develop sustainable practices in chemical processes and industrial applications.	*L2*
CO 2	Discuss catalytic methods in green synthesis and safer chemicals	*L2*
CO 3	Explain biocatalysis and green chemistry applications in industry, alongside innovative energy technologies and waste control methods.	*L2, L3*
CO 4	Outline eco-friendly methods, minimize waste, and design safer, biodegradable products for a sustainable future.	*L3*

CO-PO Mapping Table:

COs (Course Outcomes)	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	3	2	3
CO2	3	3	2	3	2	3
CO3	3	3	2	3	2	3
CO4	3	3	2	3	2	3

Grading will be as:
3: High (>60%);
2: Moderate (40%-60%);
1: Low (<40%);
0: No Mapping

UNIT I Introduction to Green Technology and Green Chemistry	1.1 Overview, Principle, concepts and Tools of Green technology. 1.2 Overview of green chemistry, Chemistry of the atmosphere, goals of green chemistry, twelve principles of green chemistry. 1.3 Concepts of atom economy and carbon trading, waste minimization and climate change, concept of environmentally balanced industrial complexing and industrial ecology, 1.4 Catalytic methods in green synthesis, safer chemicals - different basic approaches; selection of auxiliary substances (solvents, separation agents), green solvents, solventless processes, immobilized solvents and ionic liquids; energy requirements-use of microwaves, ultrasonic energy; 1.5 Selection of starting materials; use of blocking/protecting groups, catalytic reagents; designing of biodegradable products.	**15**
UNIT II Applications of Green Technology and Green Chemistry	2.1 Biocatalysis, green chemistry in industries 2.2 Energy Technology: fuel cell and electric vehicles, solar energy and hydrogen production, energy from alternate sources; Solar photovoltaic technology, 2.3 Waste Control Technology: Biofuel production (bio-ethanol and biodiesel), Biomass, prevention/minimization of hazardous/toxic products. 2.4 Green Technology in circularity: Industrial ecology, concept of green building 2.5 Agricultural related practices and food processing, Production of biodegradable materials, Pollution free engineering processes.	**15**

Course Code 23BPEV2P02	Practical based on 23BPEV2T04	2 Credits

Course Outcomes:
After completing this course learner will be able to:

CO 1	Determine working principle and application of Atomic Absorption Spectrophotometry, Nephelometry and Turbidimetry.	*L5*
CO 2	Estimate the organic compounds from soil and biological materials with different methods.	*L5, L6*
CO 3	Compare and study different separation techniques using thin layer chromatography and ion exchange chromatography	*L2, L4*
CO 4	Develop different eco-friendly products and study of Biofuel production methods	*L3, L5*

CO-PO Mapping Table:

COs (Course Outcomes)	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	3
CO2	3	3	3	3	2	3
CO3	3	3	3	3	2	3
CO4	3	3	2	3	3	3

Grading will be as:
3: High (>60%);
2: Moderate (40%-60%);
1: Low (<40%);
0: No Mapping

1. To study the principle and application of Atomic Absorption Spectrophotometry for analysis of metal ions from samples.
2. To study the principle and application of Nephelometry and Turbidimetry: General discussion, Instruments for nephelometry and turbidimetry
3. Extraction and separation of organic compounds from soil and biological materials.
   - Ammonium sulphate method (Nichols method),
   - TCA method,
   - Acid digestion method,
   - Steam distillation for volatiles
4. To study different separation Techniques: Principle and process of solvent extraction; Chromatography – principle and application of thin layer and ion exchange chromatography, Gas Chromatography and High-Performance Liquid Chromatography.
5. Biofuel production methods and characterization for biodiesel and bioethanol
6. Preparation of eco-friendly products: color, idol, bag,
7. Case Study: Green Buildings in India, Green Products

Texts/References:

1) Lynn Goldman, Christine Coussens, Implications of nanotechnology for environmental health research, National Academic Press, Washington, 2007
2) Matlack, A. S. Introduction to Green Chemistry. Marcel Dekker: New York, 2001
3) Anastas, P. T.; Warner, J. C. Green Chemistry: Theory and Practice. Oxford Univ. Press: Oxford, 1998.
4) Lynn E. Foster: Nanotechnology: Science, Innovation, and Opportunity, December 21, 2005, Prentice Hall
5) Caye Drapcho, Nhuan Phú Nghiêm, Terry Walker (2008). Biofuels Engineering Process Technology. [McGraw-Hill].
6) Akhlesh Lakhtakia (ed) (2004). The Handbook of Nanotechnology. Nanometer Structures: Theory, Modeling, and Simulation. SPIE Press, Bellingham, WA, USA
7) Green Chemistry: A Textbook by V.K.Ahluwalia
8) Handbook of Green Chemistry by Paul Anastas

Course Code 23BPEV2T05	Course Title Environmental Nanotechnology	Credits 2	No. of lectures

Course Outcomes:
After completing this course learner will be able to:

CO 1	Explain nanotechnology and green nanotechnology focusing on the type, categories, production and characterization of nanoparticles and their applications	*L2, L5*
CO 2	Determine the global trends and function of Nanotechnology Research, Development, and Innovation in India	*L5*
CO 3	Classify nanomedical applications and the use of nanotechnology in agriculture, renewable energy, and environmental remediation	*L2, L4*
CO 4	Outline the role of nanotechnology for health and the environment, exploring innovative methods for waste treatment and water purification	*L2*

CO-PO Mapping Table:

COs (Course Outcomes)	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	3
CO2	3	3	2	3	2	3
CO3	3	3	3	3	2	3
CO4	3	3	3	3	2	3

Grading will be as:
3: High (>60%);
2: Moderate (40%-60%);
1: Low (<40%);
0: No Mapping

UNIT I Nanotechnology	1.1 Introduction to Nanotechnology and green nanotechnology, Nanoparticles; Nanomaterials-Remediation, Nano Membranes, Nano Fibers, Nano Clays Adsorbents, Zeolites, Nano Catalysts, Carbon Nano tubes, Fullerene 1.2 Green nanoparticle production and characterization; Biocompatibility; 1.3 **Nanotechnology Development in India** 1.3.1 Global Trends in Nanotechnology 1.3.2 Importance of Nanotechnology for Developing Countries 1.3.3 Evolution of Nanotechnology in India **1.4 Nanotechnology Research, Development and Innovation in India: Major Actors:** 1.4.1 Department of Science and Technology (DST) 1.4.2 Department of Biotechnology (DBT) 1.4.3Department of Electronics and Information Technology (DeITy) 1.4.4 Department of Industrial Policy and Promotion (DIPP) 1.4.5 Department of Industrial and Scientific Research	**15**

UNIT II Application of Environmental Nanotechnology	2.1 Nanomedical applications of green nanotechnologies; 2.2 Nanotechnology and its Applications in Agriculture and Food Industry, Nanotechnology: Materials and Manufacture, 2.3 Nanotechnology for Renewable Energy, 2.4 Nanotechnology in the Environment 2.5 Nanotechnology- Risks for Health and Environment, Benefits for the Environment. 2.6 Environmental Nano Remediation Technology- Thermal, Physico-Chemical, and Biological Methods, Nano Filtration for the Treatment of Wastes, Removal of Organics, Inorganics and Pathogens, Nanotechnology for Water Purification.	**15**
Course Code 23BPEV2P03	**Practical based on 23BPEV2T05**	**2 Credit**

Course Outcomes:
After completing this course learner will be able to:

CO 1	Estimate chemical reactions involved in green nanotechnology.	*L6*
CO 2	Determine working principle, components, and application of SEM, TEM, Spectroscopy, and study of fungi for nanoparticle synthesis.	*L5*
CO 3	Create Ag/Zn nanoparticles and its antimicrobial activity, characterization using spectrophotometer.	*L6*
CO 4	Take part in educational study tour	*L4*

CO-PO Mapping Table:

COs (Course Outcomes)	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	3	2	3
CO2	3	3	3	3	2	3
CO3	3	3	3	3	2	3
CO4	2	2	0	2	3	2

Grading will be as:
3: High (>60%);
2: Moderate (40%-60%);
1: Low (<40%);
0: No Mapping

1. To Study the chemical reactions involved in green nanotechnology: Nanoparticle production
2. Characterization of nanoparticles using:
   - SEM-Working principle, components, and application
   - TEM- Working principle, components, and application
   - Spectroscopy- Working principle, components, and application
3. Synthesis and characterization of Ag nanoparticles using spectrophotometer.
4. Synthesis and characterization of Zn nanoparticles using spectrophotometer.
5. Antimicrobial activity of metals/oxides nanoparticles
6. Study of white rot fungi in nanotechnology with examples
7. Visit to nanotechnology laboratory

Texts/References:

1) M. H. Fulekar (2010) Nanotechnology Importance and applications, I K international publishing house Pvt.Ltd.
2) Lynn Goldman, Christine Coussens, Implications of nanotechnology for environmental health research, National Academic Press, Washington, 2007
3) Matlack, A. S. Introduction to Green Chemistry. Marcel Dekker: New York, 2001

4) Anastas, P. T.; Warner, J. C. Green Chemistry: Theory and Practice. Oxford Univ. Press: Oxford, 1998.
5) Lynn E. Foster: Nanotechnology: Science, Innovation, and Opportunity, December 21, 2005, Prentice Hall
6) Fei Wang & Akhlesh Lakhtakia (eds) (2006). Selected Papers on Nanotechnology—Theory & Modeling (Milestone Volume 182). SPIE Press
7) Caye Drapcho, Nhuan Phú Nghiêm, Terry Walker (2008). Biofuels Engineering Process Technology. [McGraw-Hill].
8) Akhlesh Lakhtakia (ed) (2004). The Handbook of Nanotechnology. Nanometer Structures: Theory, Modeling, and Simulation. SPIE Press, Bellingham, WA, USA.

Course Code 23BPEV2P04	Course Title ON-JOB TRAINING (OJT) / FIELD PROJECT (FP)	Credits 4	No. of Hours: 120

Course Outcomes:
After completing this course learner will be able to:

CO 1	Identify and describe key environmental issues and their implications on ecosystems and human health based on data collected during field observations.	*L3*
CO 2	Apply appropriate field techniques and methodologies to collect, analyze, and interpret environmental data	*L3*
CO 3	Analyze the collected data to identify patterns, trends, and correlations related to environmental conditions, effectively communicating their findings through reports and presentations.	*L4*
CO 4	Discuss the effectiveness of various environmental management strategies based on their field research, proposing sustainable solutions to mitigate identified issues.	*L5*

CO-PO Mapping Table:

COs (Course Outcomes)	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	3
CO2	3	3	3	3	2	3
CO3	3	3	3	3	2	3
CO4	3	3	3	3	2	3

Grading will be as:
3: High (>60%);
2: Moderate (40%-60%);
1: Low (<40%);
0: No Mapping

General Guidelines:

- The OJT/FP topic may be undertaken from any topic relevant to environmental science with a precise objective.
- Each of the student must undertake an OJT/FP individually based on field-work/field-survey/laboratory work.
- Student must remain presented at the time of review meeting scheduled by research guide.
- Structure of report should contain the following chapter: Title; Abstract; Aim, Objectives, and Rationale; Introduction and Review of Literature; Materials and Methodology; Observation and Result; Discussion and Conclusion; References.
- Student should prepare a PowerPoint presentation (PPT) of research project and it should be presented in front of external examiner.
- Duly signed hard copy of report and PPT should be submitted to the Department/College.
- In case of OJT, detail report of attendance, record and acknowledgement /certificate issued from the organization to be submitted in college.

Evaluation and Examination Scheme

Evaluation Scheme 60 (Theory):40 (Internal)
Internals Based on Unit 1 / Unit 2 / Unit 3/ Unit 4

Assignments/ Tutorials/Class Test	Seminar or any other activities	Ppt/video Presentation or any other activities	Group discussion/Book Review or any other activities	Active Participation & Leadership qualities	Total
10	10	10	05	05	40

Theory Examinations: For Paper 1, Paper 2, Paper 3 and Elective

Suggested Format for Mandatory Question paper

23BPEV_T0_/0_/20_

Duration: 2 hr. 30 min **Total Marks: 60**

N.B.

1. **All questions are compulsory**
2. **Draw neat labeled diagram wherever necessary**
3. **All questions carry equal marks**

Q.1.	**(A)**		**Attempt any one**	**8**
		(I)		
		(II)		
Q.1.	**(B)**		**Attempt any one**	**7**
		(I)		
		(II)		
Q.2.	**(A)**		**Attempt any one**	**8**
		(I)		
		(II)		
Q.2.	**(B)**		**Attempt any one**	**7**
		(I)		
		(II)		
Q.3.	**(A)**		**Attempt any one**	**8**
		(I)		
		(II)		
Q.3.	**(B)**		**Attempt any one**	**7**
		(I)		
		(II)		
Q.4.	**(A)**		**Attempt any one**	**8**

		(I)		
		(II)		
Q.4.	**(B)**		**Attempt any one**	**7**
		(I)		
		(II)		
			**********	

Suggested Format for Elective Question paper:

23BPEV_T0_/0_/20_

Duration: 1 hr. 30 min **Total Marks: 30**

N.B.

1. **All questions are compulsory**
2. **Draw neat labeled diagram wherever necessary**
3. **All questions carry equal marks**

Q.1.	**(A)**		**Attempt any one**	**8**
		(I)		
		(II)		
Q.1.	**(B)**		**Attempt any one**	**7**
		(I)		
		(II)		
Q.2.	**(A)**		**Attempt any one**	**8**
		(I)		
		(II)		
Q.2.	**(B)**		**Attempt any one**	**7**
		(I)		
		(II)		

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Semester End Practical Examination:
Practical examination of each paper for 50 marks will be held for 4 hours.

VPM's B. N. BANDODKAR COLLEGE OF SCIENCE (AUTONOMOUS), THANE
DEPARTMENT OF ENVIRONMENTAL SCIENCE
M.Sc. I EVS Regular Practical Examination Semester-I _____Month_____Year

Date: Time: Max. Marks: 50

Paper Course Code:
Paper Course Title:

Distribution of marks

Q.1. Perform the given experiment and interpret the results.	15
Q.2. Perform the given experiment and interpret the results.	15
Q.3. Perform the given experiment and interpret the results/Field Visit Report.	10
Q.4. Viva-Voce	05
Q.5. Certified Journal	05

(This is sample paper pattern for practical. It can be changed by the department/college as per the prescribed practical given in syllabus)

Marks Distribution and Passing Criterion for Each Semester

Theory						Practical		
Course Code SEM I / SEM II	**Internal**	**Min marks for passing**	**Theory Examination**	**Min marks for passing**	**Total**	**Course Code**	**Practical Examination**	**Min marks for passing**
23BPEV1T01/ 2T01	40	16	60	24	100	-	-	-
23BPEV1T02/ 2T02	40	16	60	24	100	-	-	-
23BPEV1T03/ 2T03	40	16	60	24	100	-	-	-
Laboratory 1	-	-	-	-	-	23BPEV1P01/ 2P01	50	20
23BPEV1T04 or 1T05/ 2T04 or 2T05	20	08	30	12	50	-	-	-
Laboratory 2	-	-	-	-	-	23BPEV1P02 or 1P03/ 2P02 or 2P03	50	20
23BPRM1T01 (SEM I)	40	16	60	24	100	-	-	-
OJT/FP (SEM II)	-	-	-	-	-	23BPEV2P04	100	40

Pedagogy for student engagement is predominantly lectures. However, other pedagogies enhancing better student engagement to be recommended for each course. The list includes active learning/ course projects/ problem or project-based learning/case studies/self-study like seminar, term paper or MOOC

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