Academic Council Meeting No. and Date: 9 / July 02, 2024
Agenda Number: 3 Resolution Number: 41,42/3.16 and 3.36

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 III and IV)]

Level 6.5

CHOICE BASED GRADING SYSTEM

Revised under NEP 2020 and Autonomy

From academic year 2024-25

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 involve conservation of nature, natural resources and conservation of biological diversity. Being interdisciplinary sciences, it includes advanced pollution control technologies, instrumentation, biostatistics, organic farming, industrial safety, IPR, sustainable management, environmental management with social relevance. Significance of this courses leads to opportunities in employment sectors including the private and government sectors which have a bright career scope.

The elective subject can be selected 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 provides a wide range of opportunities in their careers that interface with research aptitude, industry, government and society that would be brought by this program.

Dr. Urmila Kumavat
BOS Chairperson

Master of Science
Environmental Science Syllabus
(To be implemented from the academic year 2024-2025)

SEMESTER III and SEMESTER IV

SYLLABUS FOR APPROVAL

Sr. No.	Heading	Particulars
1	Title of the Course	M.Sc. (Environmental Science)
2	Eligibility for Admission	Four Year Integrated B.Sc. Course in EVS/ PG Diploma in EVS
3	Passing Marks	40%
4	No. of Years / Semesters	Sem III and IV
5	Level	P.G.
6	Pattern	Semester
7	Status	Revised under Autonomy and NEP 2020
8	To be implemented from Academic Year	2024-25
9	Name & Sign of BOS Chairperson /Coordinator Department of Environmental Science	Dr. Urmila Kumavat

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: Pollution Control and Sustainable Environmental Management:
Develop expertise in advanced pollution control technologies and sustainable management practices. Apply scientific and technical principles to design, implement, and evaluate strategies for pollution mitigation and environmental conservation, aligned with PO1, PO4, and PO6. **Level: 3 and 5** ***(Application and Evaluation)***

PSO2: Environmental Monitoring and Analytical Skills
Gain practical skills in environmental monitoring using modern instrumentation, biostatistics, and eco-technologies. Analyze and interpret environmental data to support research and informed decision-making, correlating with PO2, PO3, and PO5. **Level 3 and 4** ***(Application and Analysis)***

PSO3: Environmental Toxicology and Biotechnological Applications
Understand the effects of environmental toxins on ecosystems and human health. Apply biotechnological tools for environmental remediation and risk assessment to support ecosystem sustainability, aligning with PO1, PO2, and PO5. **Level: 2 and 3** ***(Understanding and Application)***

PSO4: Safety and Risk Management in Environmental Systems
Demonstrate knowledge of occupational, industrial, and chemical safety. Assess and manage environmental and workplace hazards by adhering to safety regulations and best practices, supporting PO1, PO4, and PO6. **Level: 3 and 4** ***(Application and Analysis)***

PSO5: Sustainable Agriculture and Eco-Friendly Practices
Promote sustainable agricultural systems through organic farming and eco-technology. Equip students to implement environmentally responsible agricultural practices, in alignment with PO4 and PO6. **Level: 3 and 5** ***(Application and Evaluation)***

PSO6: Research, Innovation, and Policy in Environmental Science
Engage in research and innovation through scientific inquiry, hypothesis formulation, and presentation of findings. Understand environmental regulations and policy frameworks to contribute effectively to sustainable development, fulfilling PO2, PO3, PO4, and PO5. **Level: 4 and 5** ***(Analysis and Evaluation)***

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 III

Course Code	Course Title	No. of Lectures	Credits
MANDATORY COURSES			
24BPEV3T01	Advanced Pollution Control Technology	**60**	**4**
24BPEV3T02	Instrumentation and Biostatistics	**60**	**4**
24BPEV3T03	Industrial Hygiene and Chemical Safety	**60**	**4**
24BPEV3P01	Practical based on 24BPEV3T01, 24BPEV3T02 and 24BPEV3T03	**60 Hours**	**2**
ELECTIVE COURSES			
24BPEV3T04	Environmental Toxicology	**30**	**2**
24BPEV3P02	Practical based on 24BPEV3T04	**60 Hours**	**2**
OR			
24BPEV3T05	Organic Farming	**30**	**2**
24BPEV3P03	Practical based on 24BPEV3T05	**60 Hours**	**2**
RESEARCH PROJECT (RP)			
24BPEV3RP4	Research Project - I Based on Environmental Science	**120 Hours**	**4**
	Total Credits		**22**

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

SEMESTER IV

Course Code	Course Title	No. of Lectures	Credits
MANDATORY COURSES			
24BPEV4T01	Eco Technology	**60**	**4**
24BPEV4T02	Sustainable Management	**60**	**4**
24BPEV4T03	Environmental Management	**60**	**4**
ELECTIVE COURSES			
24BPEV4T04	Intellectual Property Rights for Environmental Science	**30**	**2**
24BPEV4P01	Practical based on 24BPEV4T04	**60 Hours**	**2**
OR			
24BPEV4T05	Environmental Biotechnology- PG EVS	**30**	**2**
24BPEV4P02	Practical based on 24BPEV4T05	**60 Hours**	**2**
RESEARCH PROJECT (RP)			
24BPEV4RP4	Research Project-II Based on Environmental Science	**180 Hours**	**6**
	Total Credits		**22**
	Total Semester III & Semester IV Credits		**44**

Eligibility:

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

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

Post Graduate Degree Programme M.Sc. Environmental Science

	SEMESTER – III	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**
24BPEV3T01	Advanced Pollution Control Technology	✓	✓	✓	✓	--	--	✓
24BPEV3T02	Instrumentation and Biostatistics	✓	✓	✓	--	--	--	✓
24BPEV3T03	Industrial Hygiene and Chemical Safety	✓	✓	✓	✓	--	✓	✓
24BPEV3P01	Practical based on 24BPEV3T01, 24BPEV3T02 and 24BPEV3T03	✓	✓	✓	✓	--	--	✓
	Elective Course Title							
24BPEV3T04	Environmental Toxicology	✓	✓	✓	✓	--	✓	✓
24BPEV3P02	Practical based on 24BPEV3T04	✓	✓	✓	✓	--	--	✓
	OR							
24BPEV3T05	Organic Farming	✓	✓	✓	✓	--	--	✓
24BPEV3P03	Practical based on 24BPEV3T05	✓	✓	✓	✓	--	--	✓
	Research Project (RP)							
24BPEV3RP4	Research Project -I Based on Environmental Science	✓	✓	✓	✓	--	✓	✓
	Total	**9**	**9**	**9**	**8**	**--**	**3**	**9**

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

Post Graduate Degree Programme M.Sc. Environmental Science

	SEMESTER – IV	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**
24BPEV4T01	Eco Technology	✓	✓	✓	✓	--	✓	✓
24BPEV4T02	Sustainable Management	✓	✓	✓	✓	--	✓	✓
24BPEV4T03	Environmental Management	✓	✓	✓	✓	--	✓	✓
	Elective Course Title							
24BPEV4T04	Intellectual Property Rights for Environmental Science	✓	✓	✓	✓	--	✓	✓
24BPEV4P01	Practical based on 24BPEV4T04	✓	✓	✓	✓	--	✓	✓
	OR							
24BPEV4T05	Environmental Biotechnology	✓	✓	✓	✓	--	--	✓
24BPEV4P02	Practical based on 24BPEV4T05	✓	✓	✓	✓	--	--	✓
	Research Project (RP)							
24BPEV4RP4	Research Project – II Based on Environmental Science	✓	✓	✓	✓	--	✓	✓
	Total	**8**	**9**	**9**	**9**	**--**	**6**	**8**

Dr. Urmila Kumavat
BOS Chairman & Head Dept. of Environmental Science

SEMESTER III

MANDATORY COURSES

Course Code 24BPEV3T01	Course Title Advanced Pollution Control Technology	Credits 4	No. of lectures

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

CO 1	Outline the concept of pollution control, treatment processes and management of water and wastewater.	*L2*
CO 2	Explain different types of treatment processes for air pollution control, indoor air quality of air.	*L2*
CO 3	Classify sources, characterization, treatment, control and management of hazardous and radioactive waste	*L4*
CO 4	Interpret the sources, characterization, treatment, control and management of biomedical waste and electronic waste.	*L5*

CO-PO Mapping Table:

COs (Course Outcomes)	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	3	2	3
CO2	3	2	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 Water and Wastewater Pollution Control	1.1 General scheme for the treatment of water for drinking purposes. Water Treatment: UV, H_2O_2, Ozonization, chemical precipitation, disinfection, adsorption, softening, desalinization / demineralization, membrane processes. 1.2 Biological treatment processes for wastewater- 1.2.1 **Aerobic processes**: Suspended floc type- the activated sludge processes. Extended aeration, Aerated lagoons, Waste stabilization ponds, rotating biological contact system, the trickling filter process. 1.2.2 **Anaerobic processes**: Flow through systems and contact systems. Sludge types, treatment and disposal. Processing of sludges- conditioning, thickening, dewatering, drying, incineration and disposal. 1.3 Concept of common effluent treatment plant (CETP) their importance and advantages, Unit processes involved. Effluent discharge standards, industry specific minimum and national standards. 1.4 Difference between ETP, CETP and STP. 1.5 Case study: Yamuna Water Pollution.	**15**

UNIT II Air Pollution Control	2.1 Treatment Processes for Particulate matter: Absorption in liquids by Scrubbers, adsorption on solids. Combustion: flaring, thermal incineration, catalytic oxidation, gravity settler, venturi scrubber, cyclone separator, bag filters. electrostatic precipitator. 2.2 Treatment Processes for other gaseous pollutants: Odour, VOCs, oxides of sulphur and nitrogen emissions. 2.3 Indoor air quality management, principles and control measures, steps for improving indoor air quality. 2.4 Air quality and emission standards. 2.5 Case study: Delhi Air Pollution.	**15**
UNIT III Hazardous and Radioactive Waste Management	3.1 Hazardous wastes: Sources and characteristics. Classification. Health and environmental effects. 3.2 GHS pictograms for hazards. 3.3 treatment of hazardous waste, Stabilization and disposal-chemical, thermal, physical, biological. 3.4 Safety precautions for transportation for hazardous chemicals. Handling and storage of hazardous chemicals. (Shifted from paper 4 sem III) 3.5 Radioactive waste: classification, health and safety aspects. Control and Management of radioactive wastes 3.6 Case study: Chernobyl Nuclear Disaster	**15**
UNIT IV Biomedical Waste and Electronic (E-Waste Management)	4.1 Biomedical Waste: categories, transportation specifications, storage, safety measures for handling biomedical waste. 4.2 Treatment methods: Shredding, Incineration, Microwave, Plasma Pyrolysis, Hydroclave etc. 4.3 Treatment and disposal of metal sharps in biomedical waste 4.4 Treatment and disposal of Plastic waste, Packaging alternatives to plastic 4.5 E-Waste: transportation and treatment methods- collection, sorting, dismantling, recycling, proper disposal. Challenges in e-waste recycling	**15**

Texts/References:

1. Publishing Company, New Delhi.
2. Water Supply & Sanitary Engineering: G.S. Birdie
3. Textbook of Water Supply & Sanitary Engineering: S.K. Husain
4. Water Supply & Sanitary Engineering: R. C. Rangwala and S. C. Rangwala, Charotal Publishing House, Anand.
5. Wastewater Treatment: M. N. Rao, A. K. Datta, IBH Publishing Company, New Delhi.
6. A Textbook of Sanitary Engineering: Vinayak Gharpure, Engineering Book Publishing Company, Pune.
7. Water Pollution: V. P. Kudesia, Pragati Prakashan, Meerut.
8. Environmental Problems and Solution: D.K. Asthana, S. Chand and Company, New Delhi.
9. A Textbook of Environment: K. M. Agarwal and P.K. Sikdar, Macmillon India Ltd, Nagpur
10. Environmental Chemistry: B.K. Sharma, and H. Kaur.
11. Elements of Environmental Chemistry: H.V. Jadhav.
12. Environmental Chemistry: S. K. Banerjee.
13. A text book of Environmental Chemistry and Pollution Control: S.S. Dara.

Course Code 24BPEV3T02	Course Title Instrumentation and Biostatistics	Credits 4	No. of lectures

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

CO 1	Discuss the concepts of environmental monitoring, types and general steps of sampling for air, water and soil.	*L2*
CO 2	Explain the principle, components and applications of various instruments.	*L2*
CO 3	Interpret the principle, components and applications of various instruments for Environmental Analysis.	*L5*
CO 4	Illustrate and describe various statistical concepts like data collection, tabulation, representation, types of tests, correlation and regression.	*L3*

CO-PO Mapping Table:

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

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

UNIT I Environmental Monitoring and sampling	1.1 Concepts of environmental monitoring and its significance. 1.2 Methods of physical characterization of samples. 1.3 Sampling of air: Purpose of Air Sampling, Types of Air Sampling: Personal Sampling, Area Sampling, Grab Sampling, Integrated Sampling. Air sampling strategies: collection techniques, place of sampling, time of sampling, duration of sampling, types of samples, minimum volume required 1.4 Sampling of water: General Guidelines for Sampling, Surface water Sampling, Groundwater Sampling, Sample Labelling, Sample Preservation and Transport, Importance of the sampling procedures, Sampling devices, Sample Containers 1.5 Sampling of soil**: -** General steps involved in soil sampling, Selection of area and parameters for sampling, Selection of monitoring equipment, sample representativity and its role/importance in monitoring of soil contamination	**15**
UNIT II Instrumentation	2.1 Conductometry, Potentiometry: Theory, instrumentation and applications. 2.2 Colorimetry: Electromagnetic radiation spectrum. Interaction of radiation with matter. Beer- Lambert's law, 2.3 Flame photometry- Principle, components, and application. 2.4 Hyphenated techniques for analysis –GC-MS, HPTLC, GC-AES- Principle and application 2.5 Electrophoresis: Theory, classification, types	**15**

	Agarose Gel Electrophoresis (AGE) and Sodium Dodecyl Sulphate-Polyacrylamide Gel Electrophoresis (SDS-PAGE)- Principle, components and application.	
UNIT III Instrumentation for Environmental Analysis	3.1 Principle, instrumentation and environmental applications of: Neutron Activation Analysis, X- Ray Fluorescence, X-Ray Diffraction, Thermogravimetry. 3.2 Continuous monitoring analysis – Fluorescent analyzer for SO_2, chemiluminescent analyzer for NOx, NDIR for CO, Flow injection analyzer 3.3 High Volume Sampler- Principle and Application	**15**
UNIT IV Biostatistics	4.1 Collection, classification and tabulation of data. Essentials of good tabular form. Preparation of one-way and two-way frequency tables. 4.2 Diagrammatic and graphical representation of data (data bar, pie, picot and histograms, frequency polygons), frequency curves and cumulative curves. 4.3 Measures of central tendency and dispersion: mean. median, mode, range, standard and relative deviation, coefficient of variation, skewness, kurtosis confidence limits and confidence intervals and normal distribution curve, Analysis of variance one-way and two-way classification, probit analysis 4.4 Accuracy, precision and errors: Classification, Minimisation of errors, Rejection of data. Z, T, F, and chi-square tests 4.5 Correlation and Regression: Pearson's coefficient, Spearman's coefficient, regression lines and their use. Curve fitting.	**15**

Texts/References:

1. Fulekar, M. H. and BhawanaPathak "Bioinstrumentation" I K International Publication, New Delhi, 2013.
2. Willard. H., Merritt, L., Dean, D.A. and Settle F.A., 'Instrumental Methods of Analysis', 7th edition, Wordsworth, New York, 1998.
3. Galen. W. Ewing, 'Instrumental Methods of Chemical Analysis 5th edition, McGraw Hill, New York., 1995.
4. Roger Reeve,Introduction to Environmental Analysis, John Wiley & Sons Ltd,2002
5. Fundamentals of Analytical chemistry, D.A. Skoog, D.M. West and F.J.Holler, Harcourt Asia PTE. Ltd., 7th edition, New Delhi,2001.
6. APHA standard methods for Water and Wastewater Examination, 20th Edition, Washington,1998.
7. https://industrialsafetyguide.com/air-sampling/

Course Code 24BPEV3T03	Course Title Industrial Hygiene and Chemical Safety	Credits 4	No. of lectures

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

CO 1	Illustrate the concept and types of physical and chemical stress, airborne chemicals and national and international agencies of industrial hygiene.	*L3*
CO 2	Discuss the notifiable diseases, work environment control measures, safety measures and housekeeping and	*L2*
CO 3	Explain the types of natural, industrial and technological hazards, disaster management and emergency plans, international regulatory bodies, application and usage of GIS, AI and RS.	*L2*
CO 4	Interpret the safety audit, types of PPE (NRPPE and RPPE) and quality control of protective equipment.	*L5*

CO-PO Mapping Table:

COs (Course Outcomes)	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	3	2	2
CO2	3	2	1	2	2	3
CO3	3	3	3	3	2	3
CO4	3	2	2	2	2	3

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

UNIT I Industrial Hygiene	1.1 Introduction, definition, scope, significance and applications. 1.2 Occupational environmental stresses i.e Physical stresses – Noise, vibration, illumination, ventilation, heat stresses, Chemical stresses: Toxic chemicals, hazardous chemicals, Flammable chemical, explosive chemicals. etc. Inhalation and ingestion risks. 1.3 Airborne Chemicals: Dust or aerosols (respirable and non-respirable, inhalable and total dust), gases, fumes, vapours, mist and smoke. 1.4 Concept of threshold limiting values(concentration), TLVs, time weighted averages (TWAs), short term exposure limits (STELs), minimal national standards (MINAS), International and national regulatory agencies like ACGIH, OSHA and NIOSH.	**15**
UNIT II Industrial Work Environment	2.1 Monitoring of Work Environment: Identification of contaminants. 2.2 Notifiable Diseases- Definition, sign & symptoms, Diagnoses Tests, Treatment, and Exposure Limits: Pneumoconiosis, Silicosis, Asbestosis, Bagassosis, Byssiniosis. 2.3 Work environment control measures: Substitution, isolation, ventilation, local exhaust system and engineering control methods. 2.4 Housekeeping and maintenance. Modification of the processes and operation. Process and product specific control measures. Report	**15**

	writing 2.5 Safety measures to avoid occupational diseases.	
UNIT III Disaster Management and Risk Assessment	3.1 Introduction, definitions, Natural Hazards, causes impacts and occurrences. Earthquakes, volcanic activity, landslides, cyclones, floods, droughts, forest fires; their Mitigation. 3.2 Industrial and technological hazards; types and causes of industrial accidents: fire, explosion, toxic release and dispersion. 3.3 Disaster management: Components of disaster management plan on-site and off-site emergency plans. 3.4 Techniques of hazards assessment: PHA, HAZOP, HAZAN, MCAA 3.5 Application and usage of GIS, AI and Remote sensing in disaster management.	**15**
UNIT IV Industrial Safety	4.1 Precautions in the processes and operations involving explosives, flammables, toxic substances, dusts, vapours, cloud formation and combating. 4.2 Safety in pipelines and colour coding. 4.3 Safety audit in chemical industry. Accidents and unusual occurrences reporting. 4.4 Respiratory personal protective equipment (RPPE) & non respiratory personal protection equipment (NRPPE): head protection, ear protection, face and eye protection, hand protection, foot protection and body protection. 4.5 Quality control of protective equipment: Maintenance, Recycling and Reuse, Disposal.	**15**

Texts/References:

1. Industrial Hygiene & Chemical Safety - M.H. Fulekar: I. K. International Publishing House, New Delhi.
2. Industrial Hygiene Reference And Study Guide- Allan K. Fleeger, Dean Lillquist, AIHA, 01-May-2006
3. Personal Protective Equipment -Guide to Ports/Dock Workers - M.H. Fulekar : Government of India's Publication
4. Fundamentals of Industrial Hygiene-Barbara A. Plog, Patricia J. Quinlan, National Safety Council Press, 2002
5. Occupational safety management and engineering, Willie Hammer, Dennis Price, Prentice Hall, 2001
6. Industrial Safety and Health Management, C. Ray Asfahl, David W. Rieske, Prentice Hall, 31-Jul-2009
7. Fundamentals of Occupational Safety and Health, Mark A. Friend, James P. Kohn, Government Institutes, 16-Aug-2010
8. Handbook of occupational safety and health, Louis J. Di Berardinis, John Wiley, 1999
9. Occupational Hygiene. Blackwell Science, Harrington, J.M. & K. Gardiner. 1995, Oxford.
10. Industrial Hygiene Evaluation Methods. Micheal S. Bisesi. CRC Press, 28-Aug-2

Course Code 24BPEV3P01	Course Title Practical based on 24BPEV3T01, 24BPEV3T02 and 24BPEV3T03	Credits 2

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

CO 1	Analyze environmental samples using standard titrimetric and spectrophotometric methods.	*L4*
CO 2	Apply physical, chemical, and biological methods for water and wastewater treatment.	*L3*
CO 3	Interpret environmental data using statistical tools and demonstrate chemical safety practices.	*L3*
CO 4	Evaluate environmental parameters and prepare industrial disaster management plans.	*L5*

CO-PO Mapping Table:

COs (Course Outcomes)	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	2	2	3
CO2	3	2	2	3	2	3
CO3	3	3	3	2	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 heavy metals (Fe/Cu) by spectrophotometric methods
2. Removal of suspended solids by sand filter method.
3. Estimation of mixed liquor suspended solids (MLSS)and Sludge Volume Index (SVI) in activated sludge.
4. Jar Test (removal of suspended solids by coagulation, e.g. use of alum).
5. Estimation of Chloride in water sample by conductometric titration.
6. Estimation of Fe^{+2} by potentiometric titration.
7. Analysis of a given field data by t- test/ f test/ z test /Anova.
8. Preparation of Material Safety Data Sheet for some common chemicals.
9. Enlisting the characteristics, advantages and disadvantages of PPE and NRPPE of any industry.
10. To neutralize the given sample using NaOH / HCl/ $CaCO_3$

11. Determination of CO_2 from the atmosphere by volumetric method in a workplace Environment.
12. Estimate Noise Levels and Determine L_{10}, L_{50}, L_{90} by histogram method.
13. Air sampling of gases (sulphur dioxide, nitrogen dioxide, carbondisulphide, carbon monoxide etc.) and analysis by UV-Visible spectrophotometer.
14. Preparation of DMP for nuclear power plant, petrochemical industry, fertilizer plant, hydropower station, chemical industry, thermal power plant, textile mill, metallurgical industry
15. Field visit to industry.

ELECTIVE COURSES

Course Code 24BPEV3T04	Course Title Environmental Toxicology	Credits 2	No. of lectures

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

CO 1	Outline the principles, types and relationships of eco-toxicology.	*L2*
CO 2	Discuss the transport of toxicants, major pesticides and its environmental impact.	*L2*
CO 3	Explain the overview of bioassays and dosimetry.	*L2*
CO 4	Summarise the types of organ toxicity and causes of injuries.	*L2*

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	2	2
CO3	3	2	2	2	2	2
CO4	3	2	1	2	1	2

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

UNIT I Eco-toxicology and Toxicants in the Environment	1.1 Introduction to ecotoxicology, Principles of toxicology, scope of toxicology. 1.2 Types of toxic substances - degradable and non-degradable. Factors influencing toxicity. 1.3 acute and chronic toxicity, entry route for toxicity. 1.4 Sigmoid relationships. Influence of ecological actors on the effects of toxicity. 1.5 Transport of toxicants by air and water: Transport through food chain - bioaccumulation and biomagnification of toxic materials in food chain. 1.6 Toxicology of major pesticides- biotransformation, biomonitoring, programs and parameters of biomonitoring, concept of bioindicator, bioindicator groups and examples. 1.7 Environmental impacts of pesticides: Physiological and metabolic effects on flora and fauna.	**15**
UNIT II Evaluation of toxicity and Organ toxicity	2.1 Concepts of Bioassay- types, characteristics. Importance and significance of bioassay, Microbial bioassay for toxicity testing, 2.2 Bioassay test models 2.3 Threshold limit value, LC50 LD50. 2.4 Concept of Dosimetry: lethal, sub-lethal & chronic tests, Dose response curves 2.5 Organ toxicity: 2.5.1 Hepatotoxicity: examples of hepatotoxicants: Carbon tetrachloride, paracetamol, bromobenzene, ethyl alcohol, injuries caused to liver.	**15**

	2.5.2 Nephrotoxicity: examples of Nephrotoxicants: cadmium, lead, mercury, uranium, injuries caused to kidney 2.5.3 Pulmonary toxicity: examples of pulmonary toxicants: monocrotaline, ipomeanol, parquet, injuries caused to lungs. 2.5.4 Neurotoxicity: examples of neuro toxicants arsenic, aluminium, pesticides organochlorine insecticides, injuries caused to nervous tissues.	

Course Code 24BPEV3P02	**Practical based on 24BPEV3T04**	**Credit 2**

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

CO 1	Demonstrate the use of microbiology laboratory instruments and aseptic techniques for sterile media preparation and microbial handling.	*L3*
CO 2	Evaluate the toxic effects of heavy metals on earthworms, plants, and microbial growth.	*L5*
CO 3	Determine the median lethal concentration (LC50) to assess toxicant impact on organisms.	*L4*
CO 4	Estimate toxicant levels using agar diffusion assay and analyze their biological effects.	*L4*

CO-PO Mapping Table:

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

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

1. Study of instruments and equipment used in the Microbiology Laboratory.
2. Study of aseptic techniques - i) Preparation of sterile glassware and other equipment using autoclave
   ii) Preparation of sterile culture medium and aseptic transfer technique.
3. Effect of Heavy Metal toxicants on the behaviour pattern of earthworm
4. Effect of effluents containing heavy metals on germination of groundnut.
5. Determination of LC50.
6. Effect of different concentrations of any 2 heavy metals on growth of microorganisms
7. Estimation of any toxicant by agar diffusion assay.

Texts/References:

1. Principles of Environmental Toxicology: I. C. Shaw and J. Chadwick; Taylor & Francis ltd
2. Basic Environmental Health (2001): Annalee Yassi, Tord Kjellstom, Theo de Kok, Tee Guidotti
3. Environmental Health: Monroe T. Morgan
4. Handbook of Environmental Health and Safety – principle and practices: H. Koren; Lewis Publishers
5. Moore, G.S., 2002, Living with the Earth: concepts in Environmental Health Science Nd (2 Ed.), Lewis's publishers, Michigan

6. Walker, C.H., Hopkin, S.P., Sibly, R.M., and Peakall, D.B. 2001. Principles of Ecotoxicology. 2 Ed. Taylor & Francis, London.
7. Environmental biology and Toxicology, by Sharma P.D. Rastogi and Lamporary., 1994.
8. Environmental pollution and Toxicology by Meera Asthana and Astana D.K., Alka printers, 1990.
9. Toxicology, by A. Sood, Sarup and sons New Delhi, 1999
10. Text book of Preventive and Social Medicine, by Park J.E. and Park K., Banosidas Bharat Publishers, Jabalpur, 1985
11. Environmental Epidemiology, by Anisa Basheer, Rawat Publication Jaipur, New Delhi 1995.

Course Code 24BPEV3T05	Course Title Organic Farming	Credits 2	No. of lectures

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

CO 1	Outline the overview of organic farming, biological insecticides and applications of biopesticides.	*L2*
CO 2	Summarise the types of nitrogen fixing bacteria, phosphate solubilizing microorganisms and cellulolytic microorganisms.	*L2*
CO 3	Explain types and preparation of Biocomposting methods.	*L2*
CO 4	Interpret preparation and factors affecting vermicomposting.	*L5*

CO-PO Mapping Table:

COs (Course Outcomes)	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	3	2	2
CO2	3	2	1	3	2	2
CO3	3	2	2	3	2	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 Organic Farming, Biopesticides And Biofertilizers	1.1 Introduction and history of organic farming, objective and principles of organic farming, techniques of organic farming, method of organic farming, pros and cons of organic farming, Benefits of organic farming. 1.2 Biological Insecticides, Properties of *Bacillus thuringiensis*, Biochemical Pesticides Plant-Incorporated Protectants (PIPs) like GM plants etc, Applications of Biopesticides. 1.3 Classification, Nitrogen Fixation (Bacterial, with *Blue Green Algae-Cyanobacteria, VAM* etc.), Symbiotic Nitrogen Fixers *Rhizobium sp*., Non-symbiotic, Free Living Nitrogen Fixers *Azotobacter, Azospirillum* etc. BGA Inoculants *Azolla-Anabaena*. 1.4 Phosphate Solubilizing Microorganisms (PSM) *Bacillus Pseudomonas, Penicillium, Aspergillus* etc. *Mycorrhiza*. 1.5 Cellulolytic microorganisms and Organic fertilizers.	**15**
UNIT II Composting	2.1 Biocomposting; Aerobic composting methods such as Windrow, Static pile and In-vessel methods for composting, 2.2 Preparation of Biocompost, Particle size, Carbon to Nitrogen ratio, Temperature, Aeration, pH Control, 2.3 Anaerobic Composting Fermentation/Digestion: Role of Hydrolyzing Microbes, Acetogens and Methanogens, Marketing of Biocompost 2.4 Vermicomposting: Introduction, Biology of Earthworm, Type/ Species of, Preparation of Worm Pit, Bedding Material, Addition of Worms, Sampling, Washing and Sieving Addition of Organic	**15**

	Waste, Harvesting the Final Product (Shifted from Semester IV) 2.5 Factors affecting composting- organisms, use of culture, moisture, temperature, Carbon/Nitrogen (C/N) Ratio, aeration.	
Course Code 24BPEV3P03	**Practical based on 24BPEV3T05**	**Credit 2**

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

CO 1	Develop biofertilizers and compost using organic waste through microbial and vermicomposting techniques.	*L6*
CO 2	Isolate, enrich, and enumerate soil microorganisms, including phosphate-solubilizing and anaerobic bacteria.	*L4*
CO 3	Apply pot culture and vertical gardening methods to promote sustainable agricultural practices.	*L3*
CO 4	Demonstrate practical understanding of eco-friendly farming through field visits to organic farms and nurseries.	*L3*

CO-PO Mapping Table:

COs (Course Outcomes)	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	3	3	3
CO2	3	3	2	3	3	3
CO3	3	2	2	3	3	3
CO4	3	2	1	3	3	3

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

1. Development of Mycorrhizal Soil Using Pot Culture Technique.
2. Development of Compost from Organic Waste.
3. Enrichment and Isolation of anaerobic bacteria
4. Isolation and Enumeration of microorganisms from soil.
5. Preparation of liquid biofertilizer from organic waste.
6. Development of vertical gardening.
7. Development of vermicomposting.
8. Determination of phosphate solubilizing microorganism from soil.
9. Field visit to organic farm/nursery/botanical garden.

Texts/References:

1. Acquaah, G. 2011.Horticulture: Principles and Practices. (4th ed), Pearson Education, London, UK.
2. Chandha K L, 2003. *Handbook of Horticulture.* ICAR. New Delhi
3. Das P.C.,Manures and Fertilizers,Kalyani Publication, 2003
4. George, Acquaah (2008). Horticulture: Principles and Practices, 4th Ed. PHI Learning private Ltd. New Delhi, India.
5. Sathe, T. V. 2004, Vermiculture and Organic Farming, Daya Publishers.
6. Subba Rao, N.S. 1997. Biofertilizers in Agriculture and Forestry. India Book House Limited, Oxford and IBH publishing Co. Pvt. Ltd, New Delhi
7. Vyas, S. C, Vyas, S. and Modi, H. A., 1998, Bio-fertilizers and Organic Farming, Akta Prakashan, Nadiad.
8. Subha Rao, N. S., 2000, Soil Microbiology, Oxford & IBH Publishers, New Delhi.

9. De L. C. (2011). Value addition in flowers and Orchids. New India Publishing Agency, New Delhi.
10. https://mohua.gov.in/upload/uploadfiles/files/chap14(1).pdf

Course Code 24BPEV3RP4	Course Title Research Project I- Based on Environmental Science	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.	*L2*
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.	*L4*

CO-PO Mapping Table:

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

General Guidelines:

- The research project topic may be undertaken from any topic relevant to environmental science with a precise objective.
- Each of the student has to undertake a research project 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 project report and PPT should be submitted to the Department/College.

SEMESTER IV

MANDATORY COURSES

Course Code 24BPEV4T01	Course Title Eco Technology	Credits 4	No. of lectures

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

CO 1	Illustrate the principles and applications of Ecotechnology and appropriate technologies inspired by Gandhian philosophy and analyze various sustainable technological solutions developed for rural development.	*L*
CO 2	Explain Sanitation –Phytosanitation, Ten Commandments of SPS, Green Inhibitors, corrosion problems and corrosion inhibitors.	*L*
CO 3	Discuss knowledge of carbon cycle concepts, international climate change mechanisms like CDM and REDD+, and evaluate India's role and global efforts in carbon sequestration and combating climate change.	*L*
CO 4	Summarise ecological restoration principles and strategies, and evaluate restoration techniques and technologies applied to various degraded habitats and ecosystems.	*L*

CO-PO Mapping Table:

COs (Course Outcomes)	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	3	2	3
CO2	3	2	2	2	2	2
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 Ecotechnology	1.1 Definition, Principles and Concept of Ecotechnology, and Applications of Ecotechnology. 1.2 Appropriate technology for rural environment: Gandhian philosophy: swadeshi movement, concept & definition, characteristic features of appropriate technologies 1.3 An account of various technologies developed for rural people-Biogas schemes for rural development, solar cells, solar cooker, solar heaters, smokeless chulas, Biogas stoves, community Biogas plant.	**15**
UNIT II Sanitation - Phytosanitation and Green Inhibitors	2.1 Meaning, concept and importance of SPS, in reference to WTO-SPS Agreement, important phytosanitation technologies-HBPST, TDC, SPS committee-Who and What they do, 2.2 The ten commandments of the SPS agreement of the WTO. 2.3 Green inhibitors: Factors pertaining to metal samples, Inhibitors in use, Cooling systems, Processing with acid solutions	**15**

	2.4 Corrosion Problems in oil industry, Corrosion inhibition in the mining industry, Atmospheric corrosion inhibition mechanisms, Standardized Environmental testing, Hybrid coating & corrosion inhibitors, Environmental green inhibitors 2.5 Industrial application of corrosion inhibition.	
UNIT III Climate Change Mitigation and Carbon Sequestration	3.1 Carbon related definitions C-pool, C-stock, C-Flux, C-sink, C-source, sequestration/uptake. 3.2 A brief understanding of the Clean Development Mechanism (CDM) to combat CC, Developing C market for combating CC, how India can benefit from CDM projects. 3.3 Development of C-sequestration projects, their modalities & procedures- reducing emissions from degradation and deforestation (REDD and REDD+), International efforts in combating global warming & CC. 3.4 A brief understanding of NATCOM, UNCCD, world heritage conventions, UN forum on forests etc.	**15**
UNIT IV Restoration Ecology& Remediation Technology	4.1 Definitions, aims and objectives, principles, concept & strategies (long tern vs short term) of ecological restoration. physical chemical & biological approaches for restoration, Revegetation and regeneration. 4.2 Habitat Restoration: Lake and Reservoir Restoration, Rangeland Restoration, Restoration of Contaminated Sites: Bioremediation Restoration of Mined out and Disturbed Land, Restoration of Mangrove Wetlands. Case study- Maharashtra Nature Park. 4.3 Greenness improvement & planting technologies, bamboo forest maintenance, biotopes, recycled water technology, soil & ground water contamination survey & cleaning technologies.	**15**

Texts/References:

1. Faegri, K. vanderpifl (1976). The principles of pollination ecology.3rd Edition pergamon press, NY
2. Burroughs (2007). Climate Change: A multi-disciplinary approach, 2nd Edition, Cambridge, New York university press ISBN 9780521690331
3. Cunningham. Principles of Environmental Science.
4. Green Corrosion Inhibitors by V.S. Sastri
5. Sharma. P. D. 1993. Ecology and Environment, Rastogi Pub., New Delhi
6. Odum E. P., Barrett G. W., Principles of Ecology, Brooks and Cole, 2004.
7. Odum, E. P. 1971.Fundamentals of Plant Ecology. W. B. Snderson Co., Philadelphia
8. Jain, S. V. (2021). Applied Ecology and Sustainable Environment. BFC Publications.
9. https://egyankosh.ac.in/bitstream/123456789/85712/1/Unit-13.pdf

Course Code 24BPEV4T02	Course Title Sustainable Management	Credits 4	No. of lectures

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

CO 1	Summarise the multidimensional concept of sustainability, assess global and national strategies for sustainable development, and critically analyze policies, programs, and debates shaping sustainable practices.	*L5*
CO 2	Explain the integration of sustainability into business practices through responsible strategies, reporting frameworks, and global indicators, with emphasis on real-world green business models and the Triple Bottom Line approach.	*L2*
CO 3	Interpret the environmental impacts of urbanization and evaluate sustainable urban planning strategies, green architecture, transportation innovations, and green city initiatives for building eco-friendly urban environments.	*L5*
CO 4	Discuss the watershed management principles and water conservation techniques, and evaluate the role of NGOs in promoting sustainable development and environmental protection.	*L5*

CO-PO Mapping Table:

COs (Course Outcomes)	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	3	2	3
CO2	3	2	2	2	2	3
CO3	3	3	2	3	2	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 Understanding sustainable development	1.1 Definition and dimensions of sustainability Global challenges of sustainable development: Our common future report, Agenda 21 and Millenium Development Goals, Earth Charter, domains of sustainability-Economics, ecology, politics and culture. 1.2 National Action Plan on Climate Change. 1.3 National sustainable development strategies in India: Twenty-point program of Govt. of India, Key programs introduced to increase agricultural productivity and profitability. Policies and programs relevant to sustainable development in India key legislations relative to sustainable development. 1.4 Strategies for promoting sustainable development-International Trade-TRIPS, finance, technology, Science and education. 1.5 Resistances to the concept and some alternative approaches,	**15**

	Important current issues and areas of debate in relation to sustainable development.	
UNIT II Business strategies and sustainability	2.1 Business and sustainability-Concept of responsible business, CERES (coalition for environmentally responsible economics) principles and blended value. 2.2 Principles of sustainable development in business planning and management 2.3 Triple Bottom Line approach in sustainable business planning and development, 2.4 Green Business profiles- The Body Shop, General Electric, Toyota etc. 2.5 Indicators for sustainability: introduction to Nature's Living Planet Index developed by WWF, Happy Planet Index developed by New Economics Foundation, Gross domestic product, Human development index, Dow Jones sustainability index. 2.6 Sustainability reporting: Corporate social responsibility – Global reporting initiatives guidelines for sustainability reporting	**15**
UNIT III Sustainable urban development	3.1 Urbanization and its impact on Environment, Rural and Urban planning for sustainable development, Concept of carbon footprint and its computation using UN carbon footprint calculator. 3.2 Green city challenges- Principles of creating eco cities with two examples. 3.3 Architecture- Eco industrial parks, Urban farming, green roofs, Green Building-LEED certification, with two examples, walkable Urbanism, Xeriscaping, 3.4 Transportation: improved public transport, car free cities, emphasis on proximity, zero emission transport, Diversity in modes of transportation 3.5 Green city solutions - bicycle city, car-free day campaign, green belt, compact development, carpooling, bus rapid transit, parks, greenways and open space, traffic calming.	**15**

UNIT IV Sustainability in practice	4.1 Watershed management: Definition, Concepts, principle and classification in watershed management. 4.2 Rainfall and runoff, water balance approach, water budgeting, topographic surveying, water conservation and harvesting methods – importance and techniques, artificial recharge of groundwater 4.3 NGOs – characteristics and role of NGOs in sustainable development, Principles for NGOs, NGO-Community relations, NGO-Government relations, Some Indian NGOs working for saving environment.	**15**

Texts/References:

1. Our Common Future, Chapter 2: Towards Sustainable Development: Report of the World Commission on Environment and Development.
2. Edwards, Andres R., The Sustainability Revolution: Portrait of a Paradigm Shift. New Society Publishers, 2005.
3. Report of the Department for Policy Coordination and Sustainable Development (DPCSD), United Nations Division for Sustainable Development.
4. Sustainable development in India: Stocktaking in the run up to Rio+20: Report prepared by TERI for MoEF,2011.
5. World Resources Institute (1995) "Environmental Indicators: A Systematic Approach to Measuring & Reporting on Environmental Policy Performance in the Context of Sustainable Development", World Resources Institute, Washington, DC.
6. Adger, W.N., Brown, K., Fairbrass, J., Jordan, A., Paavola, J., Rosendo, S., Seyfang, G. (2003) Governance for sustainability: towards a 'thick' analysis of environmental decision making. Environment and Planning A 35, 1095 –1110.
7. Connelly, J. and Smith, G. (2003). Politics and the Environment: from theory to practice. Routledge, London.
8. Carter, N. (2001) The politics of the environment. Cambridge University Press: Cambridge
9. Leach, M., Scoones, I., Wynne, B. (2005) Science and Citizens: Globalization and the Challenge of Engagement. Zed books, London.
10. Pearce, D.W., Barbier, E. (2000) Blueprint for a sustainable economy. Earthscan, London.
11. https://www.lifestylecalculator.com/unfccc

Course Code 24BPEV4T03	Course Title Environmental Management	Credits 4	No. of lectures

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

CO 1	Summarise the concepts of resources, wealth, and environmental management, and analyze the linkages between development and environment along with key Indian initiatives and management tools for environmental protection.	*L4*
CO 2	Explain understanding of environmental management systems and standards like ISO 14001, and apply Life Cycle Assessment (LCA) principles to evaluate environmental impacts and improve sustainability practices.	*L3*
CO 3	Illustrate the principles and processes of environmental, green, energy, and water audits, and apply economic concepts and valuation techniques to assess environmental impacts and resource use.	*L3*
CO 4	Interpret the principles and applications of Environmental Design and Monitoring, and evaluate modeling techniques and certification programs for sustainable product development and environmental quality management.	*L5*

CO-PO Mapping Table:

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

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

CO4	3	3	3	3	2	3

Unit I Introduction to principles of Environment Management	1.1 Resources and wealth-meaning, types of resources and its exploitation, distinction between wealth and resources, optimum conversion of resources into wealth. 1.2 Definition, Goals of Environment Management, significance of environmental management, scope of environmental management. 1.3 Development and environmental linkages, Environmental concerns in India, Actions for Environmental Protection Indian initiatives- National committee on Environmental Planning and Coordination, The Tiwari committee 1.4 Introduction Environmental Management Tool	**15**
Unit II Environment Management Systems and Life Cycle Assessment	2.1 International Organization for Standardization (ISO), Plan - Do-Check-Act Cycle, EMS Certification 2.2 ISO 14000 series, ISO 14001, Difference between ISO 14000 and ISO 14001 Environmental Policy, Planning, Implementation and Operation, Checking, Management Review, Benefits of ISO 14001 certification, 2.3 Evolution of Life Cycle Assessment (LCA), Cradle to grave approach. Different applications of LCA. Procedure for LCA 2.4 Defining goal and scope, preparation of life cycle inventory, assessment of environmental impact, Areas for Improvement and Interpretation. Methods to assess impact using methods like ecoindicator-95	**15**
Unit III Environmental Audit and Environmental Economics	3.1 Introduction to environmental audit, Types of environmental audits: objectives- based and client- driven types. 3.2 General audit methodology and audit process: Introduction, the basic steps of an environmental audit program. Element of audit process, audit protocols (why, who, what and how). 3.3 Green audit, energy audit and water audit. 3.4 Introduction to macroeconomics, microeconomics, environmental economics, difference between natural resource economics and environmental economics. 3.5 Valuation of environment impacts: types of economic values, approach, valuation techniques, valuing environmental amenities.	**15**

Unit IV Environmental Design (ED) and Modeling	4.1 Environmental Design: Principles of Environmental Design (ED). Benefits of environmental design, ED of manufactured products, ED considerations in products life stages-DfE concepts, tools for ED of products, 4.2 Examples of environmental design: Concept of Ecolabel. Cleaner Production Programmes, Leadership in Energy and Environmental Design certification programmes. 4.3 Introduction to Environmental Monitoring and Modeling, Definition of model, Need of modeling, water quality models-surface and groundwater, Air Quality Models-Dispersion and receptor models	**15**

Texts/References:

1. Vijay Kulkarni and T.V. Ramachandra, 2006. Environment Management, Common wealth of Learning, Canada, Centre for Ecological Sciences, Indian Institute of Science, Karnataka Environment Research Foundation. TERI press.
2. Environmental Economics for Non-Economist, John Asafu-Adjaye, World scientific publishing Co Pvt Ltd, 1999
3. Camborne D F, Environmental Life Cycle Analysis, Lewis Publishers, 1997
4. Cattanach, R.E., Hodrieth J.M., Reinke D.P., Sibik L.K., Environmentally Conscious Manufacturing from Design to Production to Labelling and Recycling, National Centre for Manufacturing Sciences (NCMS), Irwin Publications,1995
5. Fundamental concepts of Environmental chemistry,2009, G.S. Sodhi, Narosa Publishers
6. Environment Management Systems- http://www.iso.org/iso/home/standards/management-standards/iso14000.htm

ELECTIVE PAPERS

Course Code 24BPEV4T04	**Course Title Intellectual Property Rights for Environmental Science**	**Credits 2**	**No. of lectures**
Course Outcomes: After completing this course learner will be able to:			
CO 1	Interpret the definition, origin, and historical evolution of Intellectual Property (IP), and evaluate its role in economic, cultural development, governance, and global innovation.		*L5*
CO 2	Discuss various categories of Intellectual Property Rights (IPR) and understand their significance in protecting creativity and innovation.		*L2*
CO 3	Summarise the concept of patents, conditions for patentability, rights and enforcement associated with patents, and distinguish between patentable and non-patentable inventions.		*L2*
CO 4	Explain knowledge of the patenting process including prior art search, application procedures, opposition stages, commercialization, and roles of national patent authorities.		*L2*

CO-PO Mapping Table:

COs (Course Outcomes)	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	1	2	3
CO2	3	2	2	1	2	3
CO3	3	2	2	1	2	3
CO4	3	2	3	1	2	3

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

UNIT I Introduction to Intellectual Property Rights	1.1 Definition of IP and IPR, Role of IP in the Economic and Cultural Development of the Society, IP Governance, IP as a Global Indicator of Innovation, Origin of IP, History of IP in India 1.2 Categories of Intellectual Property: 1.2.1 Copyrights and Related Rights -Classes of Copyrights, Criteria for Copyright, Ownership of Copyright, Copyright Infringement is a Criminal Offence, Validity of Copyright 1.2.2 Trademarks- Eligibility Criteria, Designation of Trademark Symbols, Classification of Trademark, Acts and Laws, Validity of Trademark 1.2.3 Geographical Indications- Acts, Laws and Rules Pertaining to GI, Rights Granted to the Holders, GI Ecosystem in India 1.2.4 Trade Secrets- Criteria for Trade Secret, Rights Associated with Trade Secrets, Important Information about Trade Secrets 1.2.5 Plant Varieties- Need for Plant Protection as an IP, Indian Context for Protection of Plant Varieties, Duration of Plant Variety Protection in India 1.2.6 Industrial Designs- Eligibility Criteria, Acts and Laws to Govern Industrial Designs, Design Rights, Duration of the Registration of a Design	**15**
UNIT II Patent	2.1 Introduction to patent, Conditions for Obtaining a Patent Protection, To Patent or Not to Patent an Invention, 2.2 Rights Associated with Patents, Enforcement of Patent Rights, Inventions Eligible for Patenting, Non-Patentable Matters, Patent Infringements, Avoid Public Disclosure of an Invention before Patenting 2.3 Process of Patenting: 2.3.1 Prior Art Search, Choice of Application to be Filed 2.3.2 Patent Application Forms, Jurisdiction of Filing Patent Application, Publication, Pre-grant Opposition, Examination, Grant of a Patent, Validity of Patent Protection, 2.3.3 Post-grant Opposition Commercialization of a Patent, Patent Related Forms, 2.3.4 Types of Patent Applications, National Bodies Dealing with Patent Affairs, Utility Models	**15**
Course Code: 24BPEV4P01	**Practical based on 24BPEV4T04**	**Credit 2**

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

CO 1	Demonstrate the procedure for filing a patent using standard forms and	*L3*

	documentation.	
CO 2	Analyze case studies related to copyright, trademark, patent, and geographical indicators.	*L4*
CO 3	Understand the concept and significance of trade secrets in protecting innovations.	*L2*
CO 4	Gain practical exposure to IPR through participation in workshops, seminars, or expert lectures	*L1*

CO-PO Mapping Table:

COs (Course Outcomes)	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	0	2	3
CO2	3	3	2	0	2	3
CO3	2	2	2	0	1	2
CO4	2	2	2	0	3	3

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

1. Filling a Patent:

Form-1 (application for the grant of a patent).
Form-2 (provisional/complete specifications).

2. Study of copyright with suitable examples and case studies.
3. Study of trademark with suitable examples and case studies.
4. Study of geographical indicators with suitable examples and case studies.
5. Study of trade secret with suitable examples and case studies.
6. Study of patent with suitable examples and case studies.
7. Attending a workshop/seminar/Conference/Guest lecture on IPR.

Texts/References:

1. Jyoti Rattan (2024). Intellectual Property Rights. Bharat Law House
2. Sumeet Malik (2013) Intellectual Property Rights Manual. 1st Ed. Eastern Book Company
3. Saurabh Bindal (2023). Intellectual Property Law: An Introduction. 2nd Ed. Eastern Book Company
4. Elizabeth Verkey and Jithin Saji Isaac. (2021). Intellectual Property. 2nd Ed. Eastern Book Company
5. Trade Marks Act, 1999 Bare Act. 19th Ed. 2024. Eastern Book Company
6. M.K. Bhandari (2023). Law Relating to Intellectual Property Rights. 6th Ed. Central Law Publication

Course Code 24BPEV4T05	Course Title Environmental Biotechnology- PG EVS	Credits 2	No. of lectures
Course Outcomes: After completing this course learner will be able to:			
CO 1	Summarize the fundamentals of DNA, RNA, and recombinant DNA technology, and explore the scope and applications of environmental biotechnology in sustainable development.		*L2*
CO 2	Discuss the development and environmental impact of transgenic plants, apply molecular tools for environmental monitoring, and evaluate bioremediation technologies through relevant case studies.		*L5*
CO 3	Explain the principles, mechanisms, and influencing factors of phytoremediation for the treatment of heavy metal-contaminated environments.		*L2*
CO 4	Illustrate microbial approaches for degrading xenobiotics and surfactants, and examine the applications of biosensors, bioleaching, microbial metal recovery, and biopolymers in environmental biotechnology.		*L3*

CO-PO Mapping Table:

COs (Course Outcomes)	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	3	2	2
CO2	3	3	2	3	2	3
CO3	3	2	2	3	2	2
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 Biotechnology	1.1 Basic Concept, Brief account of the structure and functions of DNA and RNA, Recombinant DNA Technology, Tools in rDNA Technology. 1.2 Role of environmental biotechnology; Scope for use, Market for environmental biotechnology 1.3 Transgenic Plants, Insect Tolerant and Herbicide Tolerant Plants, Environmental Impact of Transgenic Plants Impact on the Environment 1.4 Molecular Probes in Environmental Monitoring. 1.5 Bioremediation Technology: Land Treatment, Surface Soil Contaminant Remediation: Case Studies, Slurry Bioreactor, Bioremediation of Metals.	**15**
UNIT II Bioremediation	2.1 Phytoremediation- Approaches, Technical Considerations, Types of Phytoremediation, Factors influencing Phytoremediation, Uptake and Translocation, Enzymatic Transformation, Detoxification and Tolerance for Heavy Metals. 2.2 Degradation of Xenobiotic compounds, Microbial degradation of surfactants, Biological Odorization, Bioleaching- *Thiobacillus ferroxidant* in leaching, 2.3 Metal recovery by Microbial Accumulation, Biosensors in Environmental Monitoring and Analysis, Biopolymers.	**15**

Course Code: 24BPEV4P02	**Practical based on 24BPEV4T05**	**Credit 2**

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

CO 1	Apply bioremediation and phytoremediation techniques using green plants in aquatic and soil environments.	*L3*
CO 2	Extract and quantify DNA from biological samples using standard laboratory protocols.	*L3*
CO 3	Operate electrophoresis equipment to analyze DNA and determine its molecular weight.	*L3*
CO 4	Estimate DNA concentration using spectrophotometric methods and interpret the results.	*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	2	2	3
CO3	3	3	2	1	2	3
CO4	3	3	3	1	2	3

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

1. Bioremediation of Heavy Metals by Green Plants in Aquatic Environment.
2. Bioremediation of Heavy Metals by Green Plants in Soil Environment.
3. Phytoremediation of Heavy Metals by Green Plants in Aquatic Environment.
4. Phytoremediation of Heavy Metals by Green Plants in Soil Environment.
5. Estimation of DNA by spectrophotometer
6. Study of Electrophoresis instrument (Equipment of horizontal unit, Power pack, UV transilluminator).
7. Extraction of DNA using suitable source
8. Determination of molecular weight of DNA by electrophoresis.

Texts/References:

1. M.H. Fulekar (2010) Bioremediation technology recent advances, springer
2. *Environmental Biotechnology - Theory and Application* – M.H. Fulekar: CRC Press and Science Publisher, USA
3. M.H. Fulekar (2005) Environmental Biotechnology Oxford IBH Publishing cooperation
4. Environmental Biotechnology-Alan Scragg, Oxford University Press.
5. Environmental Biotechnology, A Biosystems Approach, *Author(s): Daniel A. Vallero, PhD,* ISBN: 978-0-12-375089-1, Copyright © 2010 Elsevier
6. Bruce Rittman, Perry L. McCarty. Environmental Biotechnology: Principles and Applications, 2nd Edition, McGraw-Hill, 2000.
7. Environmental Biotechnology: Basic Concepts and Applications. 2006, InduShekhar Thakur, I. K. International Pvt Ltd.
8. N.P Cheremisinoff (1996) Biotechnology for Waste and Wastewater Treatment, William Andrew Publishing, New York
9. Raina M. Maier, Ian L. Pepper, Charles P. Gerba. Environmental Microbiology, Academic Press, 200

Course Code 24BPEV4RP4	**Course Title Research Project-II Based on Environmental Science**	**Credits 6**	**No. of Hours: 180**
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.		*L2*
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	2	1	3	2	2
CO2	3	3	2	3	3	3
CO3	3	3	3	2	3	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

General Guidelines:

- The research project topic may be undertaken from any topic relevant to environmental science with a precise objective.
- Each of the student has to undertake a research project 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 project report and PPT should be submitted to the Department/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

24BPEV_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)		
			**********	

<u>Suggested Format for Elective Question paper:</u>

24BPEV_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. II EVS Regular Practical Examination Semester-____Year____

Date: Time: Max. Marks: 50

Paper Course Code:

Paper Course Title:

Distribution of marks

Q.1. Explain/Identification 05

Q.2. Perform the given experiment	20
Q.3. Perform the given experiment	05
Q.4. Certified Field Visit Report	10
Q.5. Viva-Voce	05
Q.6. 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 III / SEM IV	**Internal**	**Min marks for passing**	**Theory Examination**	**Min marks for passing**	**Total**	**Course Code**	**Practical Examination**	**Min marks for passing**
24BPEV3T01/ 4T01	40	16	60	24	100	-	-	-
24BPEV3T02/ 4T02	40	16	60	24	100	-	-	-

24BPEV3T03/ 4T03	40	16	60	24	100	-	-	-
Laboratory 1	-	-	-	-	-	24BPEV3P01/ 4P01	50	20
24BPEV3T04 or 3T05/ 24BPEV4T04 or 4T05	20	08	30	12	50	-	-	-
Laboratory 2	-	-	-	-	-	24BPEV3P02 or 3P03/ 4P01 or 4P02	50	20
Research Project (RP)	-	-	-	-	-	24BPEV3RP4/ 4RP4	100/150	40/60

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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