Deccan Education Society's

Fergusson College (Autonomous) Pune

Learning Outcomes-Based Curriculum

for 3/4 years B.Sc. / B. Sc. (Honours) Programme

as per guidelines of

NEP-2020

for

F. Y. M. Sc. (Environmental Science)

With effect from Academic Year

2023-2024

Program Outcomes (POs) for M. Sc. Programme	
PO1	Disciplinary Knowledge: Demonstrate comprehensive knowledge of the discipline that form a part of a postgraduate programme. Execute strong theoretical and practical understanding generated from the specific programme in the area of work
PO2	Critical Thinking and Problem solving: Exhibit the skill of critical thinking and understand scientific texts and place scientific statements and themes in contexts and also evaluate them in terms of generic conventions. Identify the problem by observing the situation closely, take actions and apply lateral thinking and analytical skills to design the solutions.
PO3	Social competence: Exhibit thoughts and ideas effectively in writing and orally; communicate with others using appropriate media, build effective interactive and presenting skills to meet global competencies. Elicit views of others, present complex information in a clear and concise and help reach conclusion in group settings.
PO4	Research-related skills and Scientific temper: Infer scientific literature, build sense of enquiry and able to formulate, test, analyse, interpret and establish hypothesis and research questions; and to identify and consult relevant sources to find answers. Plan and write a research paper/project while emphasizing on academics and research ethics, scientific conduct and creating awareness about intellectual property rights and issues of plagiarism.
PO5	Trans-disciplinary knowledge: Create new conceptual, theoretical and methodological understanding that integrates and transcends beyond discipline-specific approaches to address a common problem.
PO6	Personal and professional competence: Perform independently and also collaboratively as a part of team to meet defined objectives and carry out work across interdisciplinary fields. Execute interpersonal relationships, self-motivation and adaptability skills and commit to professional ethics.
PO7	Effective Citizenship and Ethics: Demonstrate empathetic social concern and equity centered national development, and ability to act with an informed awareness of moral and ethical issues and commit to professional ethics and responsibility.
PO8	Environment and Sustainability: Understand the impact of the scientific solutions in societal and environmental contexts and demonstrate the knowledge of and need for sustainable development.
PO9	Self-directed and Life-long learning: Acquire the ability to engage in independent and life-long learning in the broadest context of socio-technological changes

PSO No.	Program Specific Outcomes(PSOs) Upon completion of this programme the student will be able to
PSO1	**Academic competence:** (i) Understand fundamental concepts, principles and processes underlying the field of Environmental Science, its interdisciplinary nature and create and disseminate knowledge to the students about environmental problems at local, regional and global scale. (ii) Demonstrate an understanding of a wide range of Environmental techniques (e.g. basic water and soil analysis, microbiological methods, spectrophotometry, GIS based analysis, Ecological data analysis, Bio- assays, statistical data analysis and its applications, mathematical modelling
PSO2	**Personal and Professional Competence:** (i) Carry out laboratory-orientated numerical calculations and be capable in data visualization and interpretation. related to Environmental Science, atmospheric science, Climatology, GIS and Remote sensing (ii) Analyse Environmental data (e.g. in Natural Resource Management, Habitat analysis and biological databases, watershed Management, Environmental pollution and its control. (iii) Formulate ideas, write scientific reports, demonstrate effective presentation, communication skill and standard practices of environmental protection.
PSO3	**Research Competence:** (i) Apply environmental data analysis methodology in order to conduct research and demonstrate appropriate skill to seek innovative solutions to problems that emerge in various fields of Ecology and Environmental Science and interdisciplinary fields like Green Technology, Biotechnology etc. (ii) Integrate (L-6- Create) informatics and statistical skills to explore and authenticate biological data for experimental and research purpose
PSO4	**Entrepreneurial and Social competence**: (i) Employ skills in specific areas related to Environmental Science such as industrial pollution, Green technology development, Ecological, health, agriculture and ensure multilevel commitment to health and well-being of the society at large (ii) Exhibit awareness of environmental and ethical issues: emphasizing on academic and research ethics, scientific misconduct, intellectual property rights and issues of plagiarism. (iii) Demonstrate capability for developing sustainable societies and understand national and international environmental policies and programmes and their implementation strategies.

Semester	Paper Code	Paper Title	Credits
I	**EVS-501**	Environmental Geo and Atmospheric Sciences	4
	EVS-502	Environmental Biology	4
	EVS-503 OR	Elective –I :Environmental Chemistry	4
	EVS-504	Or Elective –II Environmental Health, Toxicology and Safety	
	EVS-510	Research Methodology (Theory)	4
	EVS-520	Practical - I	2
	EVS-521	Practical – II	2
	Total Semester Credits		20
II	**EVS-551**	EIA and Environmental Audit	4
	EVS-552	Water and Wastewater Treatment Technologies	4
	EVS-553 OR	Elective - I: Biodiversity, Forestry and Conservation	4
	EVS-554	Or Elective –II: Ecosystem Restoration and Remediation	
	EVS-560	On Job Training / Field Project	4
	EVS-570	Practical - III	2
	EVS-571	Practical - IV	2
	Total Semester Credits		20
Total PG-I Credits			40

Teaching and Evaluation (Only for FORMAL education courses)

Course Credits	No. of Hours per Semester Theory/Practical	No. of Hours per Week Theory/Practical	Maximum Marks	CE 40 %	ESE 60%
1	**15 / 30**	**1 / 2**	**25**	**10**	**15**
2	**30 / 60**	**2 / 4**	**50**	**20**	**30**
3	**45 / 90**	**3 / 6**	**75**	**30**	**45**
4	**60 / 120**	**4 / 8**	**100**	**40**	**60**

Eligibility: As per the rules and regulations of Savitribai Phule Pune University (SPPU)

M.Sc. Semester I

Title of the Course and Course Code	**EVS -501 : Environmental Geo and Atmospheric Sciences**	**Credits-4**
Course Outcomes (COs) **On completion of the course, the students will be able to**		
CO1	Outline the concepts, key terms of environmental geology and atmospheric sciences.	
CO2	Explain the phenomenon, parameters related to environmental geological and atmospheric processes and discuss their importance.	
CO3	Execute methods to study environmental geological and atmospheric processes.	
CO4	Compare environmental geological and atmospheric processes. Illustrate the role of geo and atmospheric concepts towards specific functions of earth as a system.	
CO5	Determine the environmental geological and atmospheric processes.	
CO6	Specify concepts and write a report on environmental geological and atmospheric processes	

Unit	**Contents**	**Lectures**
I **Earth**	● Origin of earth ● Structure and composition of earth ● Rock cycle and types. ● Minerals ● Geological time scale ● Continental drift ● Sea floor spreading and plate tectonic ● Earthquakes, volcanoes	**10**
II **Earth surface processes and landforms**	● Weathering and erosion ● Devian cycle of erosion ● Landslides ● Geomorphology of fluvial tracts, arid and coastal regions ● Karst landscapes and glaciated region ● Soil genesis and soil profile ● Land use and Land capability classification	**10**
III **Catchment hydrology**	● Hydrological Cycle: ● Precipitation, Infiltration, Condensation ● Evapo-transpiration and surface runoff ● Hydrological budget ● Surface water, Groundwater and Aquifers	**5**
IV **Oceanography**	● Oceanography: ● Concept and scope ● Ocean basins and physical structure of the ocean floor	**5**

	● Ocean Currents, waves and tides ● Thermohaline circulation and the global conveyor belt. ● Current research in oceanography	
V Atmospheric science	● Need of atmospheric studies in environmental sciences ● Evolution of atmosphere ● Composition and structure of the atmosphere ● Elements of weather and climate ● Weather parameters (temperature, wind, pressure, relative ● humidity, rainfall) ● Climatology of weather parameters, long-term and short term ● climatic effects.	**10**
VI Insolation and atmospheric temperature, pressure	● **Insolation:** ● Insolation, Basic laws of radiation, black body radiation ● Factors affecting the distribution of Insolation ● Earth's radiation budget, Net radiation and latitudinal heat balance ● **Atmospheric Temperature and pressure:** ● Horizontal and vertical distribution of temperature, ● Temperature inversion and its types ● Pressure and wind belts ● Factors affecting wind, Geotropic and gradient winds.	**10**
VII Air masses	● Air masses ● Classification and modifications of air masses ● Characteristics and types of fronts ● The jet stream	**5**
VIII Environmental abnormal events	● Thunderstorm and lightning ● Tropical cyclone ● Ozone depletion ● El-Nino, La-Nina phenomena. ● Floods ● Droughts	**5**
References	● Savindra Singh .2002, Geomorphology, Prayag Pustak Bhawan, Allahabad. ● Chamley, H. and Chamley, H. 2003. Geosciences, Environment and Man Elsevier Science & Technology ● D.S Lal: Climatology, Sharda Pustak Bhawan, 2003 ISBN 8186204121, 9788186204122. ● Majid Husain: Fundamentals of Physical Geography. ● Parmodh Alexander. 2009, A Handbook of Minerals, Crystals, Rocks and Ores, By, New India Publishing. ● Tarak Das Biswas, S.K. Mukherjee ,2001Textbook of Soil Sciences, Tata McGraw-Hill Education. ● David Keith Todd, Larry W. Mays. 2005, Groundwater Hydrology, Wiley. ● R. J. Garde. 2006, River Morphology, New Age International, Publication. ● Robert H. Stewart.2009, Introduction to Physical Oceanography, University Press of Florida. Richard Chorley and Roger G. Barry: Atmosphere, Weather and Climate.	

F.Y. M.Sc. Semester I

Title of the Course and Course Code	**EVS -502: Environmental Biology**	**Credits-4**
Course Outcomes (COs) **On completion of the course, the students will be able to**		
CO1	Describe different types of theories of Ecology and its applications. Examine	
CO2	Different measures to remediate ecosystems by natural recovery.	
CO3	Discuss the importance of different biotic, abiotic components of the ecosystem	
CO4	Articulate and relate it to environment protection and conservation issues.	
CO5	Different interactions among the interspecific and intraspecific species.	
CO6	Apply the knowledge to study characters of population and community	

Unit	**Contents**	**Lectures**
Unit I Concepts and Scope	● Biosphere as an ecosystem, its ecological processes and life support systems. ● Anthropogenic impact on the biosphere and its life support systems (Including Flora, Fauna, soil, climate, and atmosphere, terrestrial and aquatic ecosystems). ● Role of biological processes in remedial measures and restoration	**6**
Unit II Fundamental Concepts of Ecology	● Ecology: definition, development and scope. Ecology as an experimental science Basic principles and laws of Ecology ● Ecosystems: concept, components and functioning ● Influence of environmental factors (including temperature, light, moisture, soil, nutrients) on organisms and their adaptations in response to them	**6**
Unit III Population	● Population Ecology· Population Characteristics ● Population Dynamics: Patterns of survival, age	**8**

Ecology	distribution, dispersal and rates of change. ● Attributes of K- selected and r-selected species ● Population Growth	
Unit IV **Community Ecology**	● Community Ecology ● Community Characteristics ● Competition, Exploitation (including herbivore, predation, parasitism), Mutualism (including commensalism, cooperation, symbiosis) ● Food webs and concepts of niche and keystone species. ● Succession, development, climax and stability of Ecosystem	**8**
Unit V **Terrestrial Biomes**	● Climatic and edaphic factors of terrestrial biomes. Heinrich Walter's Biome Climate Diagrams· ● Classification of land biomes with their soil, Climate and vegetation characteristics. Their natural history, wildlife, geography and human influences. ● Mountain Biome: Replication of latitudinal changes in the altitudes of high mountains. ● Terrestrial biomes, ecosystem diversity, forest and vegetation types in India.	**8**
Unit VI Aquatic Biomes	● Challenges and adaptations of life in aquatic biomes (freshwater: still and flowing, marine) ● Freshwater Biomes (Rivers, streams, lakes, ponds) and their natural history ● Marine Biomes (including mangroves, coral islands, kelp Forests, saltwater marshes, seashores, estuaries) and their natural history. ● Wetlands – definitions, types, ecological functions and resources	**8**
Unit VII Microbes and their Importance	● Classification of microbes and their metabolism and ecology ● Micro-organisms and their association with man, animals and plants ● Role of microbes in bio-remedial processes, ecological restoration and other environmental applications. ● Environmental factors affecting microbes, their cultivation and growth	**8**
Unit VIII Ethnobiology	● Definition, Concept, History and Scope Stages of Ethno biology ● Stage 1. Ethno ecology ● Stage 2. TEK: Traditional Ecological Knowledge ● Stage 3. Indigenous Intellectual Property and Rights ● Moving toward more Local Participation ● Ethno biology as Future	**8**

References	● Microbes, Man and Animals: The Natural History of Microbial Interactions: Linton, A. H. and Burns,R.G. (1982) John Wiley and Sons. ● Elements of Microbiology: Pelczar, M.J. and Chan ECS, 1981 McGraw Hill. ● General Microbiology: Stainer, R.Y.., Adelberg, E.A. and Ingraham, J.L. 1977. Macmillan Press. ● Microbial Methods for Environmental Biotechnology: Grainer, J.M. and Lynch, J.M. 1984. Academic Press. ● Microbiological Methods for Environmental Scientists and Engineers: Gaudy, A.F. and Gaudy,E.T. 1980, McGraw Hill. ● Fundamentals of Ecology: E. P. Odum ● Modern concepts in Ecology: H. D. Kumar ● Inorganic Chemistry of Earth: Fergusson J. E. ● Introduction to Geochemistry: Krauskoph K ● Environmental Chemistry: Raiswell ● Environmental Chemistry: S. E. Manaha

F.Y. M.Sc. Semester I

Title of the Course and Course Code	EVS503: Elective –I: Environmental Chemistry	Credits-4
Course Outcomes (COs) **On completion of the course, the students will be able to**		
CO1	Describe concepts, goals, principles, tools used in Green chemistry. Recall concepts of Synthetic polymers, PCBs, Heavy metals and Chemical pesticides. Identify environmental issues associated with these contaminants with reference to their quality and quantity.	
CO2	Classify Soaps, Detergents and discuss consequences, prevention and control of pollution caused by them. Describe concepts of Eutrophication and associated problems.	
CO3	Demonstrate different techniques used for destruction of hazardous substances	
CO4	Compare different instrumentation techniques to estimate environmental parameters and identify the better methods for analysis for environmental contaminants. Differentiate point, nonpoint sources of pollutants and discuss consequences of criteria pollutants.	
CO5	Evaluate the best practices in measurement of environmental pollutants. Appraise different tests to understand the validation of the methods for environmental parameters from air, water and soil.	
CO6	Develop skills to aware the community for importance of soil, water based on scientific knowledge and specify soil quality in the different study areas.	

Unit	Contents	Lectures
Unit I **Environmental Analytical Chemistry Part A**	**Principle, Instrumentation and Environmental Applications:** ● Gravimetric analysis ● Spectrophotometry ● Atomic absorption spectroscopy ● Flame photometry ● Nephelometry and turbidometry ● Polarography	**8**
Unit II **Environmental Analytical**	**Principle, Instrumentation and Environmental** **Applications:**	**8**

Chemistry Part B	• Gas chromatography • High performance liquid chromatography • Ion exchange chromatography • X-ray fluorescence, x-ray diffraction, x-ray absorption • Neutron activation analysis • Isotope dilution analysis	
Unit III **Chemistry of Soil and Water**	**Soil:** • Importance of soil and soil chemistry • Soil composition: minerals, organic matter, moisture, air • Soil pH, Soil acidity • Soil reactions: acid-base and ion exchange reactions • Essential elements: macro and micro elements **Water:** • Chemistry of water • Structure and properties of water, • Importance of water	**8**
Unit IV Contaminants in Air Environment	• **Classification of air pollutants:** Gaseous and particulate pollutants, point and non-point source, Mobile and stationary sources. • **Vehicular pollution:** Meaning, causes, effects and solutions **a) Criteria Air pollutants:** 1. Ground level ozone 2. Particulate matter 3. Carbon Monoxide 4. Lead 5. Sulfur dioxide 6. Nitrogen dioxide **b) Hydrocarbons:** • Classification and sources of hydrocarbons • Environmental effects of hydrocarbons • Environmental degradation and abatement of • Hydrocarbons	**8**
Unit V Contaminants in Water Environment	• **Chemical contamination of water:** From domestic, agriculture, industrial and other sectors. **Major contaminants in water:** • Study of soaps and detergents, chemical pesticides and fertilizers, oil and grease, nutrients etc. on following	**6**

	aspects: 1. Sources, classification, characteristics and composition. 2. Environmental problems and toxicity 3. Abatement processes: Microbial decomposition and other treatment methods, Modified Detergents and alternatives. Eutrophication: Concept, causes, abatement, case studies	
Unit VI Contaminants in Soil Environment	**a) Polychlorinated Biphenyls (PCB's):** ● Need and uses of PCB's. ● Fate of PCB's in the environment. ● Environmental effects and abatement procedures for PCB's pollution. **b) Chemical Pesticides:** ● Classification ● Environmental degradation, ● Pollution due to pesticides and DDT problems **c) Heavy metals:** ● Physical and chemical properties, behavior, human exposure, absorption, influence of Arsenic, lead and mercury on ecosystems. ● Biomagnifications of metals in the environment. **d) Synthetic Polymers** ● Need, classification, characteristics, ● Environmental effects: occupational hazards, health effects, air, land, marine pollution ● Abatement processes: Microbial decomposition, ● Polymer decay, photosensitive additives and alternatives for synthetic polymers.	**10**
Unit VII Destruction of Some Hazardous Substances	● Destruction techniques, safety considerations, ● Mutagenicity assays. ● Destruction of acid halides and anhydrides and alkali metals ● Destruction of cyanides and cyanogens bromides,	**6**

	● Destruction of chromium, aflatoxins	
Unit VIII Green Chemistry	● Introduction: Need and Goals of Green Chemistry ● Principles of Green Chemistry ● Tools of Green Chemistry: Green Starting Materials, Green Reagent, Green Chemical Products etc. ● Green Chemistry and Sustainability ● Zero Waste Technologies	**6**
References	● Instrumental Methods of Analysis by B. Sivasankar, Oxford University Press ● Environmental Chemistry by H. Kaur, Pragati Prakashan ● Textbook of Environmental Chemistry - Balram Pani, IK International Publishing House Delhi ● Fundamental Concepts of Environmental Chemistry, ● G. S. Sodhi, Narosa Publishing House ● Environmental Chemistry - A. K. Dey New Age International publishers	

Title of the Course and Course Code	EVS504: Elective –II :Environmental Health, Toxicology and Safety	Credits-4
Course Outcomes (COs) On completion of the course, the students will be able to		
CO1	Recite the basic concepts in Environmental Health, Toxicology and Safety. List out and recall the scientific principles of these topics.	
CO2	Illustrate the role and responsibilities of an occupational health and safety practitioner. Clarify the policies and legislation on safety in industries and workplace environments. Describe concepts of Biological warfare and protective measures.	
CO3	Determine Toxicity testing methods and interpret the toxicity of Industrial toxicants and hazardous materials. Use epidemiological case studies for real time understanding of different aspects.	
CO4	Estimate Toxicity of different toxicants based on the concept of Toxicokinetics and Toxicodynamics. List and memorize various Parameters of toxicity testing.	
CO5	Evaluate the toxicity level of toxicants depending on the Interaction of toxicants in combination. Describe the concept of Mutagens, Teratogens and Carcinogen and identify the source and effects of these materials.	
CO6	Design an experiment to study the exact dose of toxicity on the selected test organism aspects. Develop protocol for toxicity testing.	

Unit	Contents	Lectures
Unit I Introduction	● Historical developments in EHS, perspectives and concerns in 21st century ● Interrelationship and interactive approaches on EHS ● Strategies for safe and environmentally friendly processes in industries ● Development projects and aspects of health and safety ● Implementation of EHS practices in MNCs ● International agreements on EHS, Case studies	**6**
Unit II Hazards and Safety in	● Occupational Health Hazards ● Physical hazards ● Chemical hazards ● Biological hazards	**8**

Industries	● Radiological hazards ● Personal protective equipment's ● ISO 45001:2018 standard ● Safety policy for the organization ● Leadership and workers participation ● Operation and performance evaluation ● National Policy on Safety, Health and Environment, India	
Unit III **Risk Management and Safety**	● Concept of risk in relation with industries ● Risk management policy for industry ● Authorities and allocation of responsibilities ● Principles of risk management ● Principles of accidents prevention ● Risk planning, assessment and mitigation ● Risk characterization and risk management ● Risk mitigation strategies in industries ● Environmental risks in industries ● Ecological risk assessment ● Public awareness and participation in risk management	**8**
Unit IV **Human Environment and Health Status in Urban and Rural India**	● Historical perspectives ● Water and sanitation status in urban and rural India ● National Health Policy ● National Urban Sanitation Policy ● Eradication programs of diseases and health management ● Mitigation measures on impacts due to developmental pressure ● Public awareness and participation for sanitation and hygiene issues ● Role of NGOs in environmental health ● Role of WHO, UNESCO, FAO, UNEP, and other agencies in public health	**8**
Unit V **Toxic and hazardous waste management**	● Classification of toxic material ● Industrial toxicants and hazardous materials ● Product Stewardship ● Methods used for toxic and hazardous waste management ● Disaster management	**7**
Unit VI **Toxicology**	● Basic principles of toxicology: Concept of toxicants and xenobiotics ● Route of exposure ● Environmental Toxicology ● Classification of toxic materials. Industrial toxicants and hazardous materials	**8**

	● Physiological and metabolic effects of toxicants, e.g.1) VOC and organic solvents, used in industry 2) Heavy metals such as Hg, Pb, AS, Cd etc.	
Unit VII Evaluation of toxicity	● Concept of Toxicokinetics and Toxicodynamics ● Bioconcentration, Bioaccumulation, Biomagnification and Bioavailability ● Factors determining adverse effects of toxicants: Intrinsic toxicity, dose, exposure conditions, response of host ● Parameters of toxicity testing: Acute toxicity, Chronic toxicity TU, ICp TER, NOEC, LOEC, LC 50, LD50, TLm ● Toxicity testing methods: Using test animals Non animal toxicity test methods: In vitro cell and tissue-based method, In silico method and integrated testing method ● Toxicity test: Range finding, Screening, Definitive toxicity test ● Interaction of toxicants in combination: Additive, synergistic and antagonistic effects ● Mutagens, Teratogens and Carcinogen: Definition, sources, effects	**8**
Unit VIII Water and airborne Diseases	● Potential and widespread effects of Water and airborne bacteria and viruses: Endemic, Epidemic and pandemic diseases ● Waterborne bacterial and viral Diseases: causative agent, Spread of disease, symptoms, preventive and curative measures. Case Studies ● Airborne bacterial and viral Diseases: causative agent, Spread of disease symptoms preventive and curative measures. Case Studies ● Human immune-system and its vulnerability to these bacteria and viruses, Concept of Hurd immunity ● Biological warfare and protective measures ● Case studies: Swine flu, Cholera, Covid -19 ● Safeguarding water sources and ambient air quality	**7**
References	● Principles of Environmental Toxicology,I.C.Shaw and J. Chadwick; Taylor& Francis Ltd. ● Basic Environmental Health (2001): AnnaleeYassi, TordKjellstom, Theo de Kok, Tee Guidotti. Oxford University Press. ● Environmental Health (2005): Dade W. Moeller, Harvard University Press. USA ● Handbook of Environmental Health and Safety: Principle and practices. Herman Koren and Michael S. Bisesi. Lewis Publishers.	

	● Essentials of Environmental Health (2006): Robert Friis. Jones & Bartlett Publishers ● Walker, C.H., Hopkin, S.P., Sibly, R.M., and Peakall, D.B. (2001): ● Principles of Ecotoxicology. 2ndEd. Taylor & Francis, London. ● Environmental Biology and Toxicology (2014): P. D. Sharma, Rastogi Publications. ● Environmental Pollution and Toxicology: M.K. Rao. Manglam Publishers & Distributors. ● Environmental Pollution: Health and Toxicology: S.V.S. Rana. Narosa Publishing House. ● Toxicology (1999): A.Sood, Sarup and sons New Delhi. ● Environmental Epidemiology: Anisa Basheer, Rawat Publication Jaipur, New Delhi ● Industrial Hygiene & Chemical Safety: M.H.Fulekar, I. K.International Publishing House, ● Principles of Fire Safety Engineering: Understanding Fire and Fire Protection (2014): Akhil Kumar Das. Prentice Hall India Learning Private Limited. ● Industrial Safety and Environment (2013): AnupamaPrashar. S.K. Kataria& Sons. ● Occupational Safety Management and Engineering (2001): Willie Hammer, Prentice Hall. ● Fundamentals of Occupational Safety and Health, Mark A. Friend, James P. Kohn ● Industrial Safety, Health Environment and Security, Basudev Panda.Laxmi Publications ● Occupational Hygiene (1995): Blackwell Science,Harrington, J.M. & K. Gardiner. Oxford. ● Industrial Safety, Health and Environment Management Systems: R..Jain and S. Rao. ● Industrial Safety -National Safety Council of India. Reports and Survey Papers. The Factories Act with amendments. Govt. of India Publications DGFASLI, Mumbai. ● Risk Characterization handbook, US-EPA,2000 ● Links: https://www.epa.gov/risk ● https://www.epa.gov/risk/conducting-human-health-risk-assessment#tab

F.Y. M.Sc. Semester I

Title of the Course and Course Code	**EVS510: Research Methodology**	**Credits-4**
Course Outcomes (COs) On completion of the course, the students will be able to		
CO1	Learn the various aspects of the research process, framing useful research questions, research design, data collection, analysis, writing and presentation	
CO2	Understand the research problem, methods/techniques to be adopted	
CO3	Apply statistical tools for analyzing the data while performing their research	
CO4	Develop skills in qualitative and quantitative data analysis and presentation	
CO5	Analyse for fitting, errors in the measurements and able to withdraw conclusions from the analysed data	
CO6	Execute a quality research paper and patents in science and technology	

Unit	**Contents**	**Lectures**
Unit I	History of research. Indian, Egyptian, Greek ideas methodologies and research in agriculture, chemistry, metallurgy, medical. Ancient Indian research methodology application Research: Meaning, Types, and Characteristics; Methods of Research: Experimental, Descriptive. Steps of Research. Planning and designing of experiments.	**15**
Unit II	Statistical analyses and its significance, Exploratory and confirmatory research, Planned and ad-hoc methods of data collection, Non-response and methods of recovering the missing response, Various software for statistical analysis. Basic principles of designs-randomization, replication and local control. Concept and types of variable. Uniformity trials, size and shape of plots and blocks; Factorial experiments, degrees of freedom, etc. The module will consist of case studies of the research performed in various subjects using statistical methods, Error and noise analysis, curve fitting.	**15**
Unit III	Literature search, selection of research topic (case study based),	**15**

	maintaining laboratory records (case study based). Types of scientific writings- thesis, technical papers, reviews, manuals, etc; Commonly used abbreviations in the theses and research communications; illustrations, photographs and drawings with suitable captions; pagination, numbering of tables and illustrations; Effective verbal and non-verbal communication, field data collection, safety in field. Writing of abstracts, summaries, précis, citations etc.	
Unit IV	Writing research paper and/or thesis, making a presentation, writing a research proposal, and patents in Science, technology. Communication: Meaning, types and characteristics of communication. Communication skills, Participation in group discussion' Facing an interview, Presentation of scientific papers	**15**
References	● History of the Scientific Methods' by Martin Shuttleworth, https://explorable.com/history-of-thescientific-method ● Research methodology: methods and techniques by C R Kothari New Delhi New Age International (P) Limited Publishers 2011Research methodology: vol.I / by Suresh C Sinha and Anil K Dhiman . by Sinha, Suresh C [Author.]. Ess Ess., 2002 New Delhi:Research methods, design, and analysis / Larry B. Christensen, R. Burke Johnson, Lisa Turner by Johnson, Burke Allyn & Bacon, Boston : 2010 ● The Statistical Analysis of Experimental Data' by, John Mandel, ISBN: 0486646661, ISBN13: 9780486646664 ● Science and ethics / Bernard E. Rollin. by Rollin, Bernard E. Cambridge University Press, Cambridge; New York : 2006 ● Writing and presenting research / Angela Thody. by Thody, Angela. London; Thousand Oaks, Calif.: Sage Publications, 2006 ● Research methods: the basics / Nicholas Walliman. by Walliman, Nicholas. London; New York: Routledge, 2011 ● Research methodology: by Saravanavel,P.: New Delhi: Kitab mahal, 2009 ● Methodology of scientific research programmes: Philosophical papers vol.i by Imre Lakato; Worrall, John, Currie, Gregory. Delhi Cambridge University Press 2001	

F.Y. M.Sc. Semester I

Title of the Course and Course Code	**EVS520: Practical I : Practicals based on Environmental Geo and atmospheric sciences and Environmental Biology**	**Credits-2**
Course Outcomes (COs) **On completion of the course, the students will be able to**		
CO1	Describe the basic concepts of processes and experiments related to geological, atmospheric processes and environmental chemistry.	
CO2	Illustrate different geological, atmospheric processes and environmental chemistry.	
CO3	Apply the knowledge to study watershed characteristics and weather processes. Carry out experiments to analyze the characteristic water, air and soil.	
CO4	Analyze different types of rocks and minerals on the basis of their physical properties. Analyze data to prepare Wind rose.	
CO5	Determine important geological and atmospheric processes used in environmental laboratories and conclude the results obtained by using different methods. Measure different parameters of geological and atmospheric processes based on toposheets and climographs.	
CO6	Prepare maps of hazard zones. Generate a report on different field visits.	

Practicals based on Environmental Geo and atmospheric science:

1. Identification of Rocks.
2. Identification of Minerals
3. Mapping of Hazard zones in India – Earthquake mapping
4. Mapping of Hazard zones in India – Floods/ Landslides mapping
5. Visit to Geological Survey of India
6. Visit to IITM
7. Visit to Indian Meteorological Department, Shimala Office, Pune.
8. Introduction to Toposheet and its interpretation
9. To find out the bifurcation ratio of a given watershed.
10. To measure, length, perimeter and area of watershed from given Toposheet
11. To measure slope and aspect of river / water body from given Toposheet
12. To find out slope angle of watershed from given Toposheet.
13. To draw longitudinal profile of stream/ river or water body
14. To find out slope angle of watershed from given Toposheet.
15. Estimation of distribution of solar radiation / Insolation over Earth's surface
16. Exercises based on incoming and outgoing solar radiations
17. Plume dispersion model (case studies) (optional)

18. Diagrammatic representation of Climograph
19. Diagrammatic representation Wind roses Simple
20. Diagrammatic representation Wind roses Compound Station Model - Coding decoding and plotting of synoptic data
21. Exercises based on adiabatic lapse rates (Graphical / Calculation)
22. Visit to national oceanographic research institutes

Practicals based on Environmental Biology

1. To conduct Mapping of water bodies using Bhuvan web portal.
2. To prepare Ecology and Biodiversity survey report for environmental clearance.
3. To conduct Geo-tagging of Plants by using GPS and link data to google maps/google earth.
4. Calculation of Shannon and Simpson's Index for community comparison.
5. Visit to a Sacred grove/Forest / Grassland / Marine ecosystem to assess its biodiversity.
6. Vegetation studies by line and belt transects and quadrates.
7. Estimating frequency, Density and Abundance of species from Forest/Grassland area.
8. To visit Forest/Costal area and to conduct SWOT analysis.

F.Y. M.Sc. Semester I

Title of the Course and Course Code	**EVS521: Practical II** **Practicals based on Environmental Biology, Environmental Chemistry and Environmental Health, Toxicology and Safety**	**Credits-2**
Course Outcomes (COs) **On completion of the course, the students will be able to**		
CO1	Identify different associations and interactions among the species. Describe basic concepts of environmental biology and chemistry	
CO2	Explain the interactions among the species loss, anthropogenic issues and articulate environmental chemistry	
CO3	Demonstrate methods used for sterilization, media preparation and staining of bacteria. Calculate different indices used in vegetation studies and apply them for data analysis.	
CO4	Organize data obtained through field work, online portals and secondary data and relate it with spatio-temporal aspects.	

CO5	Evaluate different water quality parameters and compare with different water quality standards
CO6	Develop skills to assess biological aspects of the environment in laboratory and on field. Design a field survey with objectives to study environmental biology and environmental chemistry of the region

Practicals based on Environmental Biology

1.Study of Wetland or Riverine ecosystem (source region visit) and rapid assessment its vegetation.
2. Calculation of Palmer Index from a given data.
3. To study association between species in a Forest area.
4. Collect matured leaves (minimum hundred for a class) from two different plants e.g. Shishoo tree & Monkey biscuit tree.
5. Methods used for sterilization and media preparation for microbial practicals.
6. Classification of Bacteria by Gram Staining method.
7. Study of motility of bacteria by hanging drop technique.
8. Isolation microbes from soil / water samples.

Practicals based on Environmental Chemistry

1. Estimation of Turbidity by nephelometric method
2. Estimation of Na/K (alkali metals) from water/soil by Flame-photometry.
3. Estimation of Alkalinity from the given water sample.
4. Estimation of phosphate from a given water sample by Colorimetry and Spectrophotometry.
5. Estimation of Total hardness and Ca, Mg hardness from given water sample.
6. Determine pH and Conductivity of water sample.
7. Visit to the instrumentation laboratory.
8. Estimation of chlorides from water samples.
9. Estimation of acidity of the given water samples
10. Estimation of sulfates by Turbidimetry from a given water sample.
11. Visit to polluted aquatic systems to study impact of pollution like eutrophication
12. Preparation of acid digest for heavy metal analysis.
13. Estimation of chromium form given water sample
14. Estimation of SPM and PM from atmosphere
15. Determination of SOx from ambient air sample.
16. Determination of NOx Determination of SOx from ambient air sample.
17. Estimation of Carbon dioxide and hydrocarbon from air sample
18. Estimation of organic carbon and organic matter from soil.
19. Estimation of N/ P/ K from soil (3P)
20. Estimation of water holding capacity / bulk density and textural classification of soil.
21. To conduct market survey to study status of plastic utility and create awareness about

treats and alternatives for plastic.

Practicals based on Environmental Toxicology

1. Conducting ecological risk assessment
2. Conducting Human risk assessment
3. Effect of toxicant on chick embryo
4. Effect of toxicant on seed germination
5. Fish bioassay for toxicity testing
6. Probit Analysis for toxicity studies
7. Finding the LC50 / LD50 dose of toxicant/ pollutant
8. Survey for identification of effect of pollution on human health
9. Monitoring effect of pollution on aquatic ecosystem
10. Monitoring effect of pollution on plants
11.Safety audit in industries
12.Epidemiological studies: Ecological Study/Cross sectional study/ Case control study
13. Study of risk management software
14. Study of risk assessment in selected industries
14. Study of standard/comparative safety practices in industries
15. Preparation of safety policy for industries
16. Surveys, documentaries and mitigation strategies for risk reduction
17. Identification of environmental and health and risks due industrial operations

F.Y. M.Sc. Semester II

Title of the Course and Course Code	**EVS 551: EIA and Environmental Audit**	**Credits-4**
Course Outcomes (COs) **On completion of the course, the students will be able to**		
CO1	Describe basic concepts in the field of environmental conservation	
CO2	Discuss the scope, importance, opportunities in Environmental Impact Assessment (EIA) practices in relation with sustainable development aspects to connect the global, national and regional issues and interpret the reports. Outline Administrative requirements and policies as per government guidelines	
CO3	Calculate details about environmental impact assessment studies along with case studies for different developmental activities. Categorize methods for accurate prediction and interpretation of the future impacts due to ongoing developmental projects	
CO4	Compare practices followed in different countries about EIA for better understanding of the environmental processes. Identify the best practices, guidelines followed in view of sustainable development	
CO5	Evaluate formats, techniques required to assess impacts and perform audits for protection of environment	
CO6	Prepare a report on the industry specific requirements for environmental management system and environmental audit	

Unit	**Contents**	**Lectures**

Unit I **Introduction**	• Need for EIA: Scope and Objectives • History and evolution of EIA • EIA and sustainable development. • Indian Policies Requiring EIA • Components of EIA • Baseline Data • Identification of Key Issues • Risks to Environment and Human Health • Socioeconomic Impacts • National Environmental Policy Act (NEPA) 1969, USA	**6**
Unit II **A Step Forward in EIA**	• EIA Notification 1994 • QCI/NABET Criteria for EIA consultant Organizations • National Plan of Action for Preventing Pollution of Coastal Waters from Land Based Activities • List of Ecologically Sensitive Areas • Project Technology and Associated Impacts • International Agreements and Commitments to Conventions • Importance of Coastal Management Zone Notification • Guidance Notes on Pre-Appraisal and Appraisal • Model Letters According to Environmental Clearance	**8**
Unit III **Methods Used in EIA**	• The Role of Expert Judgment • Appropriateness of Methods for Developing Countries • Ad Hoc Method • Checklists • Matrices • Sectoral Guidelines • The Systematic Sequential Approach • Networks • Simulation Modelling Workshops • Overlays and Geographic Information Systems • Rapid Assessment of Pollution Sources • Role of WTO, WB, UNEP and other Funding Agencies	**8**
Unit IV **Guidelines by MoEFCC on Methodology**	• Overview of Methods of Monitoring and Analysis • Key Activities and Likely Associated Air Pollutants • Models for Impact Predictions • Checklist for Ecological Impact Assessment • Guidance for Relevant Issues for Different Project Types • Good Practices of Prediction	**8**

	● Risk Assessment ● Impact Mitigation Measures ● Studies on Carrying Capacity ● Project and Process Alternatives ● Criteria for Environmental Grading of Large construction Projects	
Unit V **EIA Notification 2006**	● Requirements of Prior Environmental Clearance (EC) ● Committees and Authorities under Notification ● Stages in Prior Environmental Clearance Process for New Projects ● Grant or Rejection of Prior Environmental Clearance ● Validity, Transferability of EC ● List of Projects/Activities Requiring Prior Environmental Clearance ● Structure of Form 1 ● Form 1 A: Check List of Environmental Impacts ● Generic Structure of Environmental Impact Assessment Document ● Procedure for Conduct of Public Hearing ● Procedure Prescribed for Appraisal	**8**
Unit VI **Case Studies of EIA**	● Infrastructure ● Industrial Development ● Energy Sector ● Construction ● Mining	**6**
Unit VII **Environmental Management Plan**	● Significant or Unacceptable Impacts Requiring Mitigation ● Mitigation Plans, Relief & Rehabilitation ● Physical Planning, Financial Planning ● Appropriate Resource Management ● Environmental Health and Occupational Safety ● Risk Assessment and Disaster Management Plan ● Maintenance and Performance of Environment Control Systems ● Functions of Environment Cell ● Review of Environmental Management Plan	**8**
Unit VIII **Environmental Audit**	● Types of Audit: Compliance Audit and Performance Audit ● Importance of ISO 14000 Series: EMS ● Criteria under ISO 14001 for Environmental Audit	**8**

	● ISO 45001: OH&S Audit and Applications ● Environmental Audit under EPA (Rule 14, Form V) ● Eco-Management and Audit Scheme ● Importance of PDCA in Audit ● Requirement of Documents under Environmental Audit ● Audit Tools and Technology ● Responsibilities of Auditor ● Role of INTOSAI, International Training Organizations and Government Agencies in Audit	
References	● Environmental Impact Assessment: A Guide to Best Professional Practices. 2011, Charles H. and Eccleston.CRC Press. ● Environmental Impact Assessment: A Comparative Review. 2014, Chris Wood. Routledge. ● Peter Wathern. 2015, Taylor & Francis. Environmental Impact Assessment: Theory and Practice. ● Introduction to Environmental Impact Assessment .2005, John Glasson. Spon Press. ● Environmental Impact Assessment .2004, P. R. Trivedi. Laurier Books. ● Environmental Impact Assessment. 2014, N. S. Raman, A.R. Gajbhiye and S.R. Khandeshwar. I K International Publishing House Pvt. Ltd. ● Environmental Impact Assessment Methodologies.2010, Y. Anjaneyulu.B.S. Publications.	

F.Y. M.Sc. Semester II

Title of the Course and Course Code	**EVS 552: Water and Wastewater Treatment Technologies**	**Credits-4**
Course Outcomes (COs) **On completion of the course, the students will be able to**		
CO1	Define the key terms in water and wastewater engineering. Tell physical, chemical, biological impurities in water.	
CO2	Explain different water quality standards for effluent discharge, irrigation and drinking purposes. Predict the role of each unit operation in a water treatment plant.	
CO3	Integrate the role of coagulants and flocculants in wastewater treatment. Use different population forecasting methods.	

CO4	Compare water treatment methods for removal of impurities and differentiate between working principles of unit operations of water treatment plants.
CO5	Select the appropriate unit operations for water treatment and evaluate the performance of each unit operation.
CO6	Design Sewage/Effluent Treatment Plan (STP/ETP) based on characteristics of wastewater.

Unit	Contents	Lectures
I Water Requirements	**Population forecasting methods:** ● Arithmetical progression method, Geometrical progression method, Logistic methods, Graphical projection method **Quality of water required for:** A. Domestic B. Institutional (Schools, Hostels, Hospitals) C. Fire fighting D. Commercial (Hotels, Restaurant) E. Industrial (Dairy, Sugar, Pulp and Paper, etc.	**8**
II Impurities in Water and Water Quality Standards	● Physical, chemical and biological impurities in water. ● Need of water quality standards for domestic & industrial purposes. ● General effluent standards ● Specifications for drinking water by Bureau of Indian Standards (IS 10500) & World Health Organization. ● Packaged drinking water	**8**
III Designing of Wastewater Treatment Plant and Advanced Water Treatments.	**Principle, Applications and Designing of following Unit Operation in water treatment** ● Collection & pumping ● Screen chamber ● Grit chamber ● Oil and grease removal ● Dissolved air floatation. ● Aeration ● Coagulation and Flocculation ● Settling tank (primary and secondary) ● Filtration ● Disinfection methods (Chlorination, UV, Ozonization) ● Demineralization, Ultrafiltration, Reverse osmosis. ● Color & odor removal by activated carbon, Iron removal. ● Selection of appropriate unit operations for the treatment and flow chart of water treatment plants. ● Operation and Maintenance of treatment plant.	**12**

IV Wastewater Engineering for Biological Treatment	● Principle, role of microorganisms, ecosystem and designing of following biological unit operations in wastewater treatment. **Types:** ● **Aerobic and anaerobic treatments** ● Suspended and attached growth treatment processes. **1. Aerobic treatment processes:** ● Activated sludge process ● Stabilization pond, ● Aerated lagoon, ● Trickling filters ● Sequence batch reactor ● Rotating Biological contactor. **2. Anaerobic treatment processes:** ● Anaerobic packed Bed reactors ● Anaerobic Fluidized and Expanded Bed Reactors ● UASB reactor etc.	**10**
V Industrial Wastewater Treatment	Selection of appropriate unit operations for the treatment and flow chart of wastewater treatment plant for: ● Dairy industry ● Pulp and Paper industry ● Textile industry ● Pharmaceutical industry ● Fertilizer industry ● Oil refineries	**12**
VI Biotechnology & Waste Management	**Application of biotechnology for the treatment of:** ● High strength waste: e.g. whey (Dairy industry) and spent wash (Distillery ● Sewage treatment: Impact of Future growth and development and change in quality of life on sewage quality & quantity. Unit operations for the treatment and flow chart of sewage treatment plant. ● Sludge treatment processes	**6**
VII Overview of water audit in industries	● Water audit in industries: case studies ● Industrial etiquettes	**4**
References	● Water pollution – A. K. Tripathi and S. N. Pande ● Water pollution – V.P. Kudesai ● Pollution control in process industry – S. P. Mahajan ● Introduction to wastewater treatment process – Ramalho RS ● Rao C. S.1994, Environmental Pollution Control and Environmental Engineering:Tata McGraw Hill; New Delhi. ● Pollution Management; Agarwal S.K. ● Water pollution: Causes, Effects and Control, P.K.Goel	

	● Environmental Biotechnology: Basic concepts and applications- Indu Shekhar Thakur, I.K. International Pvt. Ltd. New Delhi. ● Environmental Biotechnology: M.H.Fulekar, Oxford and IBH publishing C..Pvt. Ltd. ● Environmental Biotechnology, Alan Scragg, Oxford university press. ● Environmental Science; Daniel Chiras. ● Waste Water Engineering, Treatment, Disposal & Reuse; Metcalf & Eddy. ● Handbook of Methods in Environmental Studies Vol-I &II; Maiti S.K.; ABD Publishers; Jaipur. ● Manivasakam N.1984, Physico-Chemical Examination of Water, Sewage & Industrial Effluents; Pragati Prakashan; Meerut. ● Trivedi R.K. & Goel P.K. 1986, Chemical & Biological Methods for Water Pollution Studies; Environmental Publications; Karad. Manual of Microbiology : Tools and techniques , Ane Books Pvt. Ltd. - Kanika Sharma

F.Y. M.Sc. Semester II

Title of the Course and Course Code	**EVS 553: Elective –I: Biodiversity, Forestry and Conservation**	**Credits-4**
Course Outcomes (COs) **On completion of the course, the students will be able to**		
CO1	Define and state the concepts of Biodiversity at different levels.	
CO2	Discuss concepts and working in forestry and agrobiodiversity. Explain the values of Biodiversity and its importance.	
CO3	Demonstrate Inventory of Global and National Bio resources.	
CO4	Analyse conservations actions at International, National and Local levels. Compare in-situ and ex-situ conservation practices. Relate the importance of people participation in protected area management.	
CO5	Select sampling methods for data collection and review the field data using different statistical techniques.	
CO6	Planand conduct independent field surveys.	

Unit	**Contents**	**Lectures**

Unit I **Biodiversity : Concept and Scope**	● **Biodiversity** ● Types of Biodiversity ● Climatic Zones and Biodiversity ● Biodiversity as a natural resource ● **Indian Biodiversity** ● Vegetation Zones ● Zones of Faunal distribution ● Major protected areas & their importance ● **Global Biodiversity** ● Major Biodiversity areas of the world ● Biodiversity Hot Spots ● **Basic Taxonomy**	**15**
Unit II **Inventory of Bio – Resources: Global and National**	● An inventory of Global and Indian biological resources and their present and potential uses. ● Magnitude and distribution of Biodiversity (global and Indian) and its characterization. ● Rapid assessment of biodiversity and its valuation; skills, trained personnel and resources needed for the task. ● Evaluating nature, scale and intensity of the threats to biodiversity. ● Developing measures for conservation of biodiversity and approaches to its sustainable utilization.	**15**
Unit III	● Management of Protected areas ● Management of Protected areas ● Principles of wildlife management ● Habitat management, Improving carrying capacity ● Dealing with Human –Wildlife conflicts ● Approaches to conservation of plants (in situ and ex situ) ● Regulating forest usage (e.g. grazing at Keoladeo / Gir, ● Fishing in Sundarbans, Mahua collection in Kanha)	
Unit IV **Conservation Actions at International, National and Local Levels**	● Important conventions and treaties on conservation (including WCS, CBD, CITES, IPCC, Ramsar Convention, UNCLOS, Montreal Convention and others) ● People and conservation Traditional knowledge and Traditions & cultures Tribal communities/Locals in conservation Women in conservation Youth in Conservation ● Role of NGOs in conservation International NGOs; UNEP, GEF, WCS, Bird Life International Important NGOs in India & their contributions WWF, ATREE, BNHS, WTI, Kalpavriksha etc. Important NGO movements Chipko movement, Narmada BachavoAandholan, Pani Panchayats, Seed Movement etc.	

Unit V **Planning and Execution of Field Surveys**	● Field surveys &observations ● Sampling methods and identifying study sites ● Different methods of transacts& quadrates ● Techniques of field observation ● Recording & Evaluation of Data Field note book and its records Field kit and its usage ● Different methods of recording field observations Ethics in Field Studies	
Unit VI **Advanced Field techniques**	● Analysis of Animal tracks & signs Tracking Large Mammals, Studying & analyzing Animal Tracks & signs, Scat analysis and evaluation of food, feeding and health Enumeration using tracks & signs, Nest census ● Camera trapping: technique, applications and limitations ● Information Technology in Field Biology Radio-telemetry: technique, devises, applications of telemetry, limitations and ethics Audio recording techniques and applications of Remote Sensing and GIS	
Unit VII **Forestry**	● Forests and Forestry: Forest types of the world. Champion and Seth's Forest Types of India. Forest diversity of Oriental Region. ● Forest Management: Working plans in forestry. Forests Departments and their structure. Conservation and protection of natural forests. Nursery, seed stock and forest plantation. ● Community participation in forestry: Joint forest management. Social forestry. Eco-development. Habitat management in wastelands for forestry and national resources conservation. ● Traditional knowledge and management practices: Medicinal plants in forestry. Rare and endangered forest species. Future sciences in forestry applications.	
Unit VIII **Agrobiodiversity and Cultivated Taxa**	● Introduction, Origin and Evolution of Cultivated Species Diversity ● Diversity in Domesticated species, Land Races, Advanced Cultivars, Wild relatives of Cultivated plants, Wild Plants ● Importance of Agrobiodiversity in changing climate patterns	
References	● Medicinal Plants of India's Hotspots. Daya Publishing House, New	

	Delhi. ● Gary K Meffe and Ronald Carroll C .1994, Principles of Conservation Biology. Sinauer Associates Inc., Massachusetts. Groombridge B (Ed.) 1992. Global Biodiversity Status of the Earths Living Resources. Chapman & Hall, London. ● IUCN. 1992.Global Biodiversity and Strategy. ● Sharma PD .2000. Ecology and Environment. Rastogi Publications, Meerut, India. ● Singh MP, Singh BS and Soma S. Dey .2004. Conservation of Biodiversity and Natural Resources. Daya Publishing House, New Delhi. ● Virchow D .1998. Conservation and Genetic Resources, Springer-Verlag, Berlin. ● Singh B, 1992.Social Forestry for Rural Development, Anmol Publishers, New Delhi. ● Murthy J.V.S., 1994, Watershed Management in India. ● John Wiley ,1984, Raymond F Dasmann, Environmental Conservation. ● Kato, M. The Biology of Biodiversity, 1999, Springer Verlag, Tokyo. ● Kotwal, P.C. and S. Banerjee. Biodiversity Conservation – In Managed forest and Protected areas, 2002. Agrobios, India. Krishnamurthy, K.V. An Advanced Textbook on Biodiversity – Principles and Practice, 2003. Oxford and IBH Publishing, New Delhi. ● Negi, S.S., 1993. Biodiversity and its conservation in India. Indus Publishing Co., New Delhi Singh and Vijaykumar, 2001. Economics of PA's and its effect on biodiversity. APH Publishing Corporation, New Delhi.

F.Y. M.Sc. Semester II

Title of the Course and Course Code	**EVS 554: Elective –II : Ecosystem Restoration and Remediation**	**Credits-4**
Course Outcomes (COs) On completion of the course, the students will be able to		
CO1	State key ecological principles used for restoration of terrestrial and aquatic ecosystems.	
CO2	Discuss about the role of conservation and restoration play within the larger context of natural resource management.	

CO3	Apply their skills for ecosystem restoration for Research and social awareness.
CO4	Explain about restoration approaches that require careful assessment of alternatives constrained by complex ecological, sociological and political realities
CO5	Evaluate the principles of Restoration Ecology.
CO6	Specify the value of various ecosystems which have been improved after restoration practices.

Unit	Contents	Lectures
Unit I **Concept of Restoration**	● Restoration Ecology Eco Restoration, Definition and principles, Significances, Guidelines, Principles of Restoration, Applications of Restoration Ecology	**6**
Unit II **Theory of Restoration**	● . Theoretical basis for understanding restoration potential ● Concepts of resilience and ecosystem change as they relate to aquatic and terrestrial systems, ● Social, economic and political realities of restoration	**8**
Unit III **Urban Restoration**	● Restoration of Urban Ecosystem Ponds, lakes, river banks, avenue tree, ● Biodiversity restoration through gardens, park, restoration of dumping ground, ● Restoration of ecosystem on hills, Restoration of soil in urban areas, ● Ground water resource – replenishment, Sewage or wastewater - recycling for supporting ecosystems Case studies	**8**
Unit IV **Industrial Restoration**	● Eco-restoration and Industrial Environment ● Eco-restoration of mines (Open-cast), restoration of solid waste dumping sites, Improving aesthetics by partial restoration at industrial sites, Case studies	**8**

Unit V Restoration of Natural Habitats	● Restoration of other Natural Habitats / Ecosystems ● Mangroves, Grasslands, Wetlands, Restoration of streams ● Degraded forest patches, Coastal ecosystems, Case Studies	**8**
Unit VI **Restoration Toolbox**	● Terrestrial techniques ● fire, ● mechanical ● chemical and rest) ● Aquatic techniques ● geomorphic structures ● hydrologic regimes ● riparian structures and processes	**8**
Unit VII	● Analysis of trajectories of past and future change ● Landscape level issues associated with endangered species	**8**
Unit VIII	● Re-colonization of animal, Prevention of habitat loss, ● Species-area relationships ● Species reintroduction	**8**
References	● Restoration of Nature by Prakash Gole. ● Restoration Ecology the New Frontier - Edited by Jelte Van Andel and James Aronso Wiley-Blackwell Publication, ISBN9781444336368. ● A Source Book for Ecological Restoration by Foundation for Ecological Security, 2008. ● Foundations of Restoration Ecology (The Science and Practice of Ecological Restoration Series) - Donald A. Falk, Margaret Palmer, Joy Zedler, Richard J. Hobbs. ● Watershed Manual by B. K. Kakade (BAIF and LEAD India Publication). ● Water Harvesting and Sustainable Supply in India by R. N. Athavale Centre for Environment Education, ISBN: 8170337526. ● Watershed Hydrology by Peter Black, Lewis Publishers, ISBN1575040271. ● Soil and Water Conservation Engineering by R. Suresh - Standard Publishers and Distributors, ISBN8180140008	

Title of the Course and Course Code	EVS 570: Practical III Practicals based on EIA & Environmental Audit and Water and Wastewater Treatment Technologies	Credits-2
Course Outcomes (COs) On completion of the course, the students will be able to		
CO1	Identify physical, chemical properties of sewage.	
CO2	Illustrate primary, secondary impacts due to developmental activities and nature, structure of formats required by Government agencies.	
CO3	Calculate and examine performance of water, wastewater treatment plants.	
CO4	Explain the working of unit operations of water and wastewater treatment plants.	
CO5	Determine the environmental aspects, impacts of the industry with the help of tools of Environmental Management System (EMS).	
CO6	Prepare flowcharts, network diagrams, Leopold matrix, checklist as a part of impact assessment techniques, video documentaries, collect field data for environmental impacts with use of online softwares and advanced techniques to write the reports. Design water treatment plants.	

EVS 570: Practical III

Practicals based on EIA & Environmental Audit

1. Preparation of flowcharts and network diagrams to carry out impact analysis.
2. Identification of primary and secondary impacts of nearby ongoing developmental activity.
3. Preparation of checklist of the activities and the impacts associated with it.
4. Study of Environmental Audit of selected industrial unit with reference to environment protection act (Form V)
5. Evaluation of EIA by using Leopold matrix technique: A case study of mining/dam site.
6. Environmental survey based on questionnaire: A case study of construction site
7. To understand structure of 'Form 1' for obtaining prior environmental clearance
8. Preparation of outline of EIA report: A case study of dam/mining/construction/industrial site.
9. Preparation of environmental management plan for a selected industry.

10. Study of physical, chemical and biological analysis of the impact area based on soil and water parameters.
11. Field visit to affected areas due to developmental activities and study EIA aspects in relation with EIA notification 2006.
12. Collection of secondary data based on impacts and analysis by using online software's.
13. Online questionnaire survey of the on-going developmental activity.
14. Submission of video documentary of affected areas due to developmental activities.
15. Use of RS-GIS techniques for mapping of impacts.
16. Use of online softwares for impact identification and analysis.
17. Problems based on impact assessment and prediction methodologies.
18. Identification of impacts and reason associated with on nearby selected ecosystem due to urban growth.

Practicals based on Water and Wastewater Treatment Technologies

1. Designing of ETP/STP: Piping and instrumentation diagram.
2. Efficiency estimation of waste water treatment plants for various industries (Based on given data).
3. Designing of Screen chamber and oil and grease removal tank (based on given data).
4. Designing an equalization tank.
5. Designing of Primary and secondary settling tanks (based on given data).
6. Designing of the Aeration tank.
7. Designing of Chlorine contact tank.
8. Estimation of MLSS, MLVSS and Sludge volume index.
9. Study of physical properties (color, odor, temperature, turbidity) of sewage.
10. Study of types of solids in wastewater (TS, TSS, TDS).
11. Study of chemical properties of sewage (Nitrate / phosphate)
12. Study of Electrocoagulation for wastewater treatment.
13. Study of Models of anaerobic digestion.
14. Visit to the water pumping station.
15. Visit to PMC STP
16. Visit to Industry for study of Effluent Treatment.

Title of the Course and Course Code	**EVS 571: Practical IV** **Practicals based Water and Wastewater Treatment Technologies and Biodiversity, Forestry and Conservation and Ecosystem Restoration and Remediation**	**Credits -2**
Course Outcomes (COs) **On completion of the course, the students will be able to**		
CO1	Describe potability of water based on data obtained by evaluation of water quality parameters.	

CO2	Compare water quality data obtained from laboratory analysis with water quality standards.
CO3	Carry out biodiversity assessment of the area.
CO4	Analyse level of environmental pollutants and investigate a dose of coagulants, disinfectants for the treatment of wastewater.
CO5	Select the field survey techniques to monitor different taxa.
CO6	Write a report on field visits. Compile Community Biodiversity Register. Develop an ecotourism plan for the protected area and Joint forest Management for a local area.

EVS 571: Practical IV

Practicals based on Water and Wastewater Treatment Technologies

1.Study of coagulation and flocculation treatment by using a jar test apparatus.
2.Visit to industrial Effluent Treatment Plant
3.Visit to Sewage Treatment Plant.
4.Determination of Dissolved oxygen (DO) from a given water/ wastewater sample.
5.Determination of Biochemical Oxygen Demand(BOD)from a given water/wastewater sample.
6.Determination of Chemical Oxygen Demand (COD) from a given water/wastewater sample.
7.Estimation of oil and grease from a given water / wastewater sample.
8.Estimation of MPN from a given water sample.
9.Estimation of Residual chlorine from a given water/ wastewater sample.
10.Study of Photocatalytic treatment of wastewater: i) Solar photocatalysis ii) Advanced oxidation processes. (2P)

Practicals based on Biodiversity, Forestry and Conservation

1. To find out Carrying Capacity of protected area.

2. Plant species diversity in a sacred grove or forest area (one season data only).

3. Species wise population count of birds in a wetland.

4. List of minor forest produce used by a community living inside or in the proximity of a protected area.

5. Establish micro-plan and action programme for village-level joint forest management committee and local communities.

6. Develop a biodiversity register at village level near or within Protected Areas

7. Do flora species counts with local forest guards / forest officials in development areas of Pune, Nashik and Ahmadnagar Districts.

8. Verification of forest working plan.

9. Develop and maintain a herbarium of flora species along a water stream in the hills.

10. Develop or verify or monitor and evaluate the conservation action plan for a protected area in collaboration with the forest department and the local village-level community.

11. Develop or verify or monitor and evaluate the eco-tourism action plan near a protected area in collaboration with the forest department and the local village-level community.

12. Identification and documentation of birds using e-bird resource.

13. Identification and study of venomous snakes, action of their venom and first aid for Cobra (spectacled & monocled), Common krait, Banded krait, Russell's Viper, Saw scaled Viper, Pit vipers (Bamboo, Green, Malabar).

14. On a phytogeograhic map of India locate & demarcate major sanctuaries / national parks.

15. Identify and describe land use patterns from false colour images (satellite image); City, reservoir, forest, agricultural land, sea-shore.

16. Compare and interpret given sonograms of bird calls (any two e.g. Courtship calls, Alarm calls).

17. Identify and study specifications & applications of various ringing & tagging devices

18. Study of animal Tracks & signs Field or using photographs or drawings. e.g. pugmarks, foot prints, tracks, claw marks, browse lines, dung mounts, regurgitates (e.g. owls), hair, scats, burrows, dens, nests etc.

19. Identify and study specifications & applications of various telemetric devices: (Photographs or Models or working models and diagrams); Antennae, transmitters (ingestible, implantable, strap) Digitized tags (e.g. implantable micro chips) Dart Gun & Tranquilizing agents & there action.

20. Using a Simulated data perform the following: - Classify the data and calculate ecological indices; Dominance index, Shannon-Wiener Index, Similarity Index, Diversity index. Evaluate and interpret each of the index values.

21. Prepare an audio-visual presentation to communicate conservation to the youth & general public on some environmental issues (e.g.: Destruction of local biodiversity site like mangrove or sea shore or a forest patch.

Practicals based on Ecosystem Restoration and Remediation

1.Visit to restoration Site.
2.Comparison of water quality parameters from a phytoremediation unit.
3.Comparison of biophysical factors from degraded and restored area.