Department of Ecological Engineering & Environmental Management

Faculty of Engineering, Technology & Management

University of Kalyani, Kalyani- 741235, West Bengal

Syllabus

For

M.Tech. & M. Sc. in Environmental Management

Total Marks – 2300; Semester 1: 600, Semester –2: 600, Semester –3: 600, Semester 4: 500

Total Credit Hours: 110; Semester 1: 30, Semester –2: 30, Semester –3: 30, Semester 4: 20

SEMESTER-1

F.M.- 600

Paper	Course No.	Subject	Credit hours	Full Marks		
				Written	Internal Assessment	Practical
Paper - I	S1- EMI	Fundamentals of Environmental Science and Tools for Environmental Analysis	5	80	20	
Paper-II	S1- EM II	Fundamentals of Environmental Economics and Management	5	80	20	
Paper – III	S1- EM III	Environmental Pollution and Management	5	80	20	
Paper-IV	S1- EM IV	Ecotoxicology and Environmental Health	5	80	20	
Paper – V (Practical)	S1 – EMV-P	Water Quality Analysis and Environmental Statistics	5			100
Paper – VI (Practical)	S1 – EMVI-P	Soil, Air and Food Quality Analysis	5			100

SEMESTER-2

F.M.- 600

Paper	Course No.	Subject	Credit hours	Full Marks		
				Written	Internal Assessment	Practical
Paper - VII	S2 - EMVII	Natural Resource Management	5	80	20	
Paper – VIII	S2 - EMVIII	Bioresource Management and Conservation	5	80	20	
Paper – IX	EM9	Ecological Issues and Interdisciplinary Approaches	5	80	20	
Paper – X	EM10	Sustainable Development	5	80	20	
Paper – XI (Practical)	EMP3	Environmental Bioassessment & Biostatistics	5			100
Paper – XII (Practical)	EMP4	Management of Environmental Health	5			100

SEMESTER-3

F.M.- 600

Paper	Course No.	Subject	Credit hours	Full Marks		
				Written	Internal Assessment	Practical
Paper – XIII	EM13	Waste Management	5	80	20	
Paper – XIV	EM14	Environmental Management Tools: Environmental Impact Assessment, Green Accounting and Reporting	5	80	20	
Paper – XV (Elective)	EM15:M. Tech. / E1 EM15:M. Sc./ E1	Ecological Engineering and Eco-sanitation Water Resource Planning and Management	5	80	20	
Paper- XVI (Elective)	EM16:M. Tech./ E2 EM16:M. Sc./ E2	Environmental Engineering Climate Change and International Developments	5	80	20	
Paper – XVII (Practical)	EMP5	Environmental Toxicology	5			100
Paper – XVIII (Practical)	EMP6	Environmental Microbiology and Geoinformatics	5			100

SEMESTER-4 **F.M. 400**

Paper	Course No.	Subject	Credit hours	Full Marks	
				Written	Internal Assessment
Paper - XIX	EM19:M. Tech./ E3 EM19:M. Sc./E3	Environmental Biotechnology Disaster Management	**5**	80	20
Paper - XX	EM20	Industrial Training/Review Work & Soft Skill Development	**5**	100	
Paper - XXI	EM21	Master's Dissertation	**10**	200	
Paper - XXII	EM22	Comprehensive Viva		100	

INSTRUCTIONS TO THE PAPER SETTERS

1. Each theory paper is of 80 marks. There will be 14 questions in each paper of which 10 questions are to be attempted. Question No. 1 and 2 (objectives/ short answer type) are compulsory and to be answered in separate answer scripts to be submitted within the first 45 minutes from the commencement of examination.

2. Four questions are to be chosen from Question nos. 3 to 8 and the four questions from Question nos. 9 to 14. Questions carrying 10 marks should comprise of a number of parts.

3. Number of questions and division of marks are stated below:

Question No.	**Total Marks**	**No. of questions to be attempted**	**No. of alternative questions to be set**
Question No. 1	8 x 1 = 08	Eight (8)	No Alternative
Question No. 2	6 x 2 = 12	Six (6)	Eight (8)
Question Nos. 3 - 8	4 x 5 = 20	Four (4)	Six (6)
Question No. 9 - 14	4 x 10 = 40	Four (4)	Six (6)

4. The questions in each paper should be fairly distributed over the whole course content (syllabus) of that paper.

SEMESTER – 1

Paper – I (Course No. S1-EMI): Environment and Ecology: Fundamentals and Tools for Analysis

1. **Life and Environment**: Origin of universe, earth, environment and life; biological control of the environment; atmosphere, hydrosphere, lithosphere and biosphere. **(6L)**

2. **Ecosystem**: Structure, principles and processes; kinds of ecosystem; cybernetics and homeostasis; ecosystem services; ecosystem management and optimization. **(5L)**

3. **Biogeochemical Cycles**: Concepts; hydrologic cycle, carbon, nitrogen and phosphorus cycles (C, N, P) and their significance; impact of anthropogenic activities. **(5L)**

4. **Ecosystem Energetics:** Concept, laws of thermodynamics, food chain and food web; energy flow in ecosystem, energy budget, complexity theory; basic concepts of emergy and exergy. **(4L)**

5. **Population Ecology**: Properties, K- and r- selection; carrying capacity and sustainability, population regulation, human population and its implication in environment and development. **(4L)**

6. **Forest Ecology**: Concept, structure and dynamics; ecological and economic importance; consequences of deforestation. **(4L)**

7. **Aquatic Ecosystems**: Concept, structure and functional attributes, diversity, differences between lentic and lotic habitats, economic importance. **(4L)**

8. **Productivity of Different Ecosystems**: Concept; measurement; productivity and climate change; energy subsidy. **(4L)**

9. **Ecological Footprint**: Concept, measurement and implications in global perspectiv**es.** **(4L)**

10. **Tools for Environmental Analysis:**

    I. **Biostatistics:** Population and sampling, Frequency distribution, Central tendency - mean, median and mode; Dispersion - range, standard deviation, mean deviation; Normal distribution; Elementary probability theory; Standard error; Hypothesis testing - two-sample t-test, paired t-test; Analysis of variance (ANOVA). **(10L)**

II. **Basic instrumentation and tools for analysis of air, water and soil:** **(10L)**
X-ray diffraction in mineral/particulate identification; Spectrophotometry; Chromatography; Remote sensing and GIS, Biosensors.

Paper – II (Course No. S1-EM II): Fundamentals of Environmental Economics and Management

1. **Environmental Management**: Concept; importance; perspectives of environmental management in India; The Environment (Protection) Act, 1986; National Environmental Policy, 2006; environmental priorities in India. **(6L)**

2. **Principles of Management**: Design and structure of an organization; managerial functions, roles and skills; planning processes; problem solving and decision making; control mechanisms; management of conflict and coping with stress**.** **(8L)**

3. **Environmental Economics**: Concept of environmental and ecological economics; Fundamentals of the economics of environmental resources and common property resources; external costs; environmental externalities and externality theory; economic efficiency; trade/markets for the environment – competition, demand-supply basics, accounting, valuation; cost-benefit analysis (CBA**);** environmental risks, eco-balance and its integration in decision making process; economics of environmental quality; precautionary principle and compensation principle; merits of various environmental economic techniques**.** **(14L)**

4. **Environmental Economics and Market Mechanisms:** Resource scarcity, economic efficiency and markets; Economics of sustainable development: Concept, Hartwick-Solow approach, ecological economical approach and safe minimum standard (SMS) approach to sustainability. **(8L)**

5. **Environmental Management Systems**: Environmental system principles, tools and management strategies; different environmental management systems; ISO systems and certification procedure; environmental management and accounting. **(8L)**

6. **Corporate Sustainability and Ethics:** Leadership, good practice/governance and accountability associated with the growing prominence of ethical dimensions of management; concepts of stakeholder capitalism, corporate citizenship and corporate social responsibility (CSR); ethical, social and wider global responsibilities of corporations and their managers/CEOs. **(8L)**

7. **Environmental Taxes and Polices**: Concept of green tax and green subsidy; polluter pays principles; carbon trading; assessing worthiness of environmental project: Legal, fiscal and market policies. **(8L)**

Paper – III (Course No. S1-EM III): Environmental Pollution and Management

1. **Air Pollution**: Source, nature and impacts; effects of acid rain; vehicular air pollution; status of air pollution in major Indian cities; air quality monitoring and air quality standard; control techniques and management issues; The Air (Prevention and Control of Pollution) Act, 1981; green belts; case studies. **(12L)**

2. **Indoor Pollution**: Pollutants at homes and work places; allergens; environmental hazards in science labs; lifestyle hazards; control and management strategies. **(6L)**

3. **Water Pollution**: Sources, nature and impacts; eutrophication- concept, cause and effects; ocean pollution; ground water pollution; river pollution; Ganga Action Plan (GAP), Yamuna Action Plan (YAP); water pollution control; water pollution monitoring; water quality standards; The Water (Prevention and Control of Pollution) Act, 1974; case studies. **(12L)**

4. **Soil Pollution**: Sources and effects; soil quality and soil degradation; impacts of agricultural chemicals and pesticides; interactions between industrial effluents and soil quality; management and control of soil pollution in India. **(8L)**

5. **Noise Pollution**: Sources, measurement and impacts; status of noise pollution in major cities in India; regulation and control of noise pollution; noise mapping; case studies. **(8L)**

6. **Radiation Pollution**: Sources and types of radiation; impacts of radioactive wastes and radiation on environment and biological systems; radioactive hazards; management strategies of radiation pollution; case studies. **(8L)**

7. **Bio-pollution**: Concepts, processes and impacts; microbial pollution; bio-invasion, bioallergy and bioterrorism. **(6L)**

Paper – IV (Course No. S1-EM IV): Ecotoxicology and Environmental Health

1. **Environmental Toxicology:** Concepts, toxicants and xenobiotics; factors modifying the activity of toxicants; effects of toxicants in living systems; antidotes, treatment and detoxification of toxicants; toxicity bioassay methods. **(8L)**

2. **Toxicity of Heavy Metals**: Sources, distribution, toxic effects of heavy metals (Lead, Cadmium, Chromium, Mercury); antidotal measures; case **(8L)**

studies.

3. **Arsenic and Fluoride Pollution:** Present status of arsenic and fluoride pollution in India; impacts on human life; remedial measures. **(8L)**

4. **Pesticide Toxicity:** Classification, nature, routes of exposure, modes of action, biological and health effects; pesticide residues in the environment: adsorption, retention, transport and degradation; concept of pesticide resistance. **(5L)**

5. **Emerging Contaminants:** Concept, types and modes of action; pharmaceuticals, PCPs, PPCPs; environmental threats and health hazards; Endocrine disruptors: types, characteristics, modes of action and toxic effects; Environmental carcinogens: categories, actions and toxic effects. **(5L)**

6. **Genetic Toxicology:** Concept, types, classes, effects of genotoxic agents; genotoxicity testing. **(4L)**

7. **Industrial Toxicology:** Concept; industry specific health risks and diseases; case studies; safety of industrial workers; health insurance, policy issues and welfare programs. **(6L)**

8. **Occupational Health:** Concept; emerging issues of health concerns for industrial workers: coal mines, dye, fire cracker, battery, tannery, smelting, fertilizers and bidi. **(8L)**

9. **Food Toxicity and Food Poisoning**: Concept, causes, factors; food adulteration and contamination; preservation of foods and beverages; food hygiene; methods of detection; quality assurance and safety issues. **(8L)**

Paper – V(Practical): Water Quality Analysis

1. Analysis of different water quality parameters (temperature, pH, turbidity, free carbon dioxide, alkalinity, dissolved oxygen) in different water systems.
2. Assessment of nutrient levels (nitrate, orthophosphate) of water bodies for management
3. Assessment of organic load [chemical oxygen demand (COD), biochemical oxygen demand (BOD)] in different water bodies for management
4. Assessment of primary productivity in different water bodies.

Paper – VI (Practical): Soil Quality Analysis and Environmental Statistics

1. Physicochemical characteristics of soil (grain size, porosity, organic carbon, organic matter,)
2. Assessment of nutrient levels (Total & available nitrogen, Total & available phosphate) of pond/agricultural soil for management

3. Statistical analysis: Mean, median, mode, standard error, standard deviation
4. Preparation and submission of Green files

SEMESTER - 2

Paper – VII (Course No. S2-EMVII): Natural Resource Management

1. **Basics of Natural Resources:** Concept, kinds and conservation/preservation of natural resources; resources and economic development. **(2L)**

2. **Nonrenewable Resources:** Concept, kinds, distribution and economic potential of minerals, oil and natural gas; mineral and oil reserves and future. **(6L)**

3. **Energy Management**: Conventional and non-conventional energy resources; renewable energy sources: solar photovoltaic and solar thermal, wind energy, tidal energy, ocean energy (OTEC), geo-thermal energy; biomass gasification; energy recovery from wastes; bio-fuel; nuclear energy and management of nuclear wastes; Emerging energy resources; global energy consumption/use patterns; energy conservation and energy management; national energy policy; energy outlook for sustainable future. **(14L**)

4. **Management of water resource**: World water balance, conservation of freshwater resources; integrated water resource management; rainwater harvesting; watershed management; environmental issues of lakes, dams and reservoirs; river linking and its impacts. **(10L)**

5. **Management of Coastal and Marine Resources: C**oastal resources; mangrove and salt marsh ecosystems: species diversity, distribution, present status in India; impact of tourism; integrated coastal zone management (ICZM); Marine resource: fundamentals of physical and chemical oceanography, ocean biodiversity, Threats to marine ecosystem, Marine pollution, marine resource management. **(10L)**

6. **Management of Soil and Land Resources:** Soil types, health and indicators; soil degradation and soil erosion; soil survey; integrated strategies for soil conservation and regeneration; case studies; land resources: concept, land degradation cycle, recent changes in land use pattern, land use planning. **(10L)**

7. **Wetland Management and Conservation:** Wetlands- definition, functions, ecology and biodiversity; wetland loss and degradation; Ramsar sites; strategies for wetland conservation and management; wetland mapping. **(8L)**

Paper – VIII (Course No. S2-EMVIII): Bioresource Management and Conservation

1. **Basics of Bioresources**: Concept, kinds, importance, economy- environment nexus. **(4L)**

2. **Human Resource:** Management, scope and importance of human resource management (HRM) and personnel management; employment and utilization of natural resources; measures of rural poverty and human development; human development index (HDI); sustainable rural development. **(7L)**

3. **Animal Resources Conservation and Management:** Concept on livestock and livestock production management; domestication: history and process; livestock genetic resources biodiversity, population, production and distribution in different ecology, economic importance and role in livelihood and nutritional securities; sustainable livestock production, problems and opportunities; conservation of livestock biodiversity; Adaptation and acclimatization of livestock; process of thermoregulation and defense against climatic stress; Environmental effect on livestock production; Management of livestock under stressful environment; soil-plant-animal relationship; livestock feed resources in different ecology; pasture conservation and management. **(12L)**

4. **Biodiversity Conservation**: Biodiversity – Concept, types, values, levels, indices and significance; assessing, analyzing and documenting biodiversity; peoples biodiversity register (PBR); diversity loss and extinction; methods of biodiversity conservation; concepts of hot spots, mega biodiversity countries, red data book; traditional knowledge and biodiversity conservation; Intellectual Property Rights (IPR) and biodiversity; Bio prospecting and bio piracy issues with particular reference to India's biodiversity; CITES; Conventions on Biodiversity (CBD); The Biodiversity Diversity Act, 2002; The Biological Diversity Rules 2004. **(15L)**

5. **Forest Management**: Classification and distribution of forests; forest degradation; deforestation and desertification and their impact on environment; aforestation; current strategies of conservation and management of forest resource; agro-forestry, social forestry, farm forestry; Joint Forest Management; National Forest Policy; Forest (conservation) Act, 1980. **(12L)**

6. **Wildlife Conservation and management**: Wildlife- concept and values, strategies of wildlife conservation and management; protected area network, sanctuary, national park, biosphere reserve, nature reserves; Conservation Management Areas (CMAs); Wildlife Protection Act, 1972. **(10L)**

Paper – IX (Course No. S2-EMIX): Ecological Issues and Interdisciplinary Approaches

1. **Biotechnology in Human Welfare**: Production of chemicals, enzymes, vaccines, growth hormones, antibiotics, interferon, monoclonal antibodies; **(6L)**

gene therapy; Single Cell Protein (SCP), Single Cell Lipid (SCL); Mycoprotein; transgenic plants and animals; cisgenic crops; animal cloning; stem cells.

2. **Biotechnology in Environmental Applications**: Concepts of bioremediation, bioenergy, biosensor, bioreactor, biological control, biopesticide, biofertilizers, composting, biocomposting, vermicoposting. **(5L)**

3. **Biotechnology in Industrial Applications**: Bioprocessing, biosensors, bioleaching, bioprospecting and metal recovery **(5L)**

4. **Environmental Microbiology:** Microbial aspects of xenobiotics, biodeterioration, agricultural soil, solid wastes and sewage; microbial control of weeds and pests. **(14L)**

5. **Probiotics, Transgenics and Environment:** Brief ideas about production, uses and environmental concerns of probiotics, GMOs, GMMs, GMFs. **(4L)**

6. **Environmental Engineering and Technology**: Concepts; Brief ideas on approaches for pollution control, waste minimization approaches, cleaner production and recycling. **(6L)**

7. **Green Chemistry and Green Technology**: Concept and principles of green chemistry; Atom economy concept; Green reagents, green solvents and green catalysts – properties and applications. Green Technology: Concept, application in agriculture, industry and water resource management; Green method development. **(10L)**

8. **Ecoinformatics and Geoinformatics**: Gene Bank, Protein Bank, Database management system; Applications of bioinformatics, phylogeny and evolution, Population database, genetic diversity, gene pool; spectral bands, thermal imaging, image processing, Fundamentals of remote sensing, Remote Sensing satellites, Satellite imageries, resolution and spectral bands, Thermal image, Image processing, Application of GIS in land use mapping in environmental management. **(10L)**

Paper – X (Course No. S2-EMX): Sustainable Development

1. **Principles and Practices of Sustainable Development:** Concept, theories and principles; approaches; global changes and sustainability issues; Rio Conference, 1992 (UNCED); sustainable urbanization, sustainable resource consumption and lifestyle; eco-friendly products and technologies. **(10L)**

2. **Management of Specialized Habitats:** Concept of restoration ecology; restoration and/or rehabilitation of specialized habitats (rural landscape, **(8L)**

water bodies, mangroves, salt marshes, coral reef ecosystem, mined areas).

3. **Tourism Management for Sustainable Development:** Tourism culture and society, tourism policy, planning and development, services and businesses, destination marketing, ecotourism, wild life tourism; impact of tourism development, sustainable tourism; case studies. **(8L)**

4. **Resource Conservation and Management**: Principles, strategies - ecosystem management, multiple use-, participatory- and adaptive management; utilization of natural products from agricultural, domestic and wild sources. **(8L)**

5. **Management of Agricultural Crops**: Adverse impacts of Green Revolution and energy intensive agriculture; principles and practices of sustainable agriculture; stress management of horticulture crops; dry-land horticulture; soil health management; improvement of crop protection; integrated pest management (IPM); conservation of arable land and crop genome; Organic farming; food safety, bio-safety and food security. **(14L)**

6. **Sustainable Aquaculture and Fisheries:** Principles and practices of aquaculture, selection of species, management practices of carp culture; air breathing fish culture; prawn culture; ornamental fish culture; economic benefits and livelihood; impact of aquaculture and aquaculture effluents on environment; impact of exotic fishes; sustainable aquacultur**e,** lacustrine and reservoir fisheries; pen and cage culture; management practices of Hilsa fisheries; brackish water fish culture; shrimp culture; marine fisheries, decline of fish catch; fish ranching. **(12L)**

Paper – XI (Practical): Environmental Bioassessment & Biostatistics

1. Assessment of biodiversity using Shannon Index and Simpson Index
2. Determination of Importance Value Index (IVI) of floral biodiversity using quadrate method
3. Quantitative and qualitative analysis of planktons
4. Biostatistics: ANOVA, unpaired & paired t-test, X^2 test, correlation and regression analysis)

Paper – XII (Practical): Management of Environmental Health

1. Noise analysis
2. Qualitative and quantitative analysis of air pollutants
3. Qualitative tests for common food adulterants

4. Management of water and soil quality parameters for agriculture & aquaculture
5. Identification of pests
6. Preparation and application of biopesticides and bioinsecticides

SEMESTER - 3

Paper – XIII (Course No. EM13): Waste Management

1. **Introduction to Wastes:** Concept, types, nature, disposal practices, impacts on environment and economy. **(4L)**

2. **Management of Municipal Solid Wastes:** Concept, sources, quality and quantity; economic importance, characterization; conventional methods and design of collection, transport, treatment and disposal, environmental hazards of disposal; Reuse, recycling and recovery of materials and resources; composting and vermi-composting; management of plastic wastes; Integrated management of wastes; Municipal Solid Wastes (Management and Handling) Rules, 2000. **(12L)**

3. **Management of Industrial Wastes:** Emission & effluent quality, national and International standards; brief ideas on design and treatment of effluents from major industries; Concept, sources, kinds, nature; environmental impact of discharge of industrial effluents on water-bodies. Strategies for industrial waste management; fly ash- generation, hazards and sustainable use; concept of industrial symbiosis and industrial ecology; quality assurance and quality control. **(12L)**

4. **Management of Hazardous Wastes:** Concept, sources, kinds; environmental hazards; methods and design of collection, segregation, treatment, transport and disposal; management of e-wastes and radioactive wastes; health risks associated with hazardous wastes; waste destruction; Hazardous Wastes (Management and Handling) Rules, 1989; Basel Convention for trans-boundary movement of hazardous wastes. **(12L)**

5. **Management of Biomedical and Hospital Wastes:** Concept, kinds, nature; methods of design, segregation, handling, transport, treatment and disposal; hospital effluent treatment plant; case studies; guidelines; Bio-medical Wastes (Management and Handling) Rules, 1998. **(10L)**

6. **Management of Wastewater:** Concept, sources, nature; design of treatment systems; Biological treatments; sewage-fed aquaculture – principles, culture practices, ecological and economic benefits, limitations; treatment efficiencies. **(10L)**

Paper – XIV (Course No. EM14)

Environmental Management Tools: Environmental Impact Assessment, Green Accounting and Reporting

1. **Environmental Management Tools:** Fundamentals on pollution prevention and environmental assessment; environmental Impact Assessment (EIA), **(12L)**

environmental risk assessment, environmental management plan (EMP), pollution prevention, green technologies, environmental audits and auditing methods; green accounting and reporting; environmental performance assessment (indicators), life cycle analysis (LCA), benefit cost analysis (BCA); Environmental Management Systems (EMS); Basic ideas on eco labeling, ecological footprint and emission trading.

2. **Environmental Impact Assessment**: Concept, scope and objectives, approaches for developing list of environment factors, environment impacts (pre-project, operational and post-project); Environmental Impact Statement (EIS); procedure of environmental clearance; EIA process - principles, characteristics, steps; methods (adhoc procedures, checklists, matrices, networks); Basic information on different environmental components; Prediction and assessment of impacts on the land**,** air, water, sound, biological, socio-economic and cultural environments; EIA guidelines -1994, notification of the Government of India, 2006; global scale and trans-boundary environmental impact assessment system (SEIAS); Public participation and preparation of environmental decision-making. **(12L)**

3. **Green Accounting and Reporting**: Concept, various methods of accounting and reporting; advantages and disadvantages. **(5L)**

4. **Life Cycle Assessment (LCA)**: Basic concept, guidelines and procedure; cost benefit analysis; case studies. **(5L)**

5. **International Organization for Standardization (ISO)**: ISO 14001, explanation of ISO 14000 series; clause analysis of ISO 14001, explanation of PDCA cycle; environmental auditing; certification process; comparison of ISO 9001 and ISO 14001; comparison of ISO 14001 and OHSAS-18001. **(12L)**

6. **Case Studies:** Urban development, transportation systems, water resources development, river valley projects; thermal and atomic energy projects, mining projects, oil refineries and petrochemical projects, tourism and coastal zone development, projects on chemical hub; solid and liquid waste management. **(14L)**

Paper – XV (M.Tech. Elective-1)

(Course No. EM15:MTechE1): Ecological Engineering and Eco-sanitation

1. **Ecological Engineering**: Concept, principles, design criteria, application areas, differences between environmental engineering and ecological engineering; relevance in developing countries. **(10L)**

2. **Ecological Engineering in Urban Problems**: Green building; LEED certification; GRIHA Certification; renewable materials in building industry; **(12L)**

buffer plantings along high ways; Green transport- Concept and practices; ecological engineering for traffic control and noise reduction.

3. **Ecological Engineering and Constructed wetlands**: Concept, working principle and design criteria of constructed wetland; constructed wetland for water pollution control, flood control, wastewater treatment. **(8L)**

4. **Restoration of Damaged and Degraded Ecosystems**: Phytoremediation, living machines and probiotics for wastewater treatment; use of sludge and other wastes to restore degraded ecosystems. **(8L)**

5. **Ecological Engineering in Animal Resource Management:** Live stock production and odor control; creation of new wild life habitats; road construction in wild habitats. **(8L)**

6. **Ecological Modeling**: Concept, principles, components, modeling and uses; developing models of environmental self-design. **(8L)**

7. **Ecological Sanitation**: Concept, philosophy, eco-toilets, closing the loop, advantages, limitations, prospects. **(6L)**

Paper – XV (M. Sc/Elective-1)

(Course No. EM15: M. Sc/E1): Water Resource Planning and Management

1. **Hydrological Concepts:** Concept of basic hydrology; hydrological cycle; precipitation types rainfall and its distribution, measurement of rainfall, melting of snow hydrometeorology; rainfall and its estimation; evapotranspiration; potential evapotranspiration versus rainfall; application of stable isotopes. **(5L)**

2. **Surface Water Resources:** Surface water hydrology; historical perspective in surface water use, development and management strategies, irrigation and domestic uses, water quality and environment. Impacts of climate change, floods/drought; Water Diversions; drinking water contamination. River basin/Watershed concept; threats, storage concept, big dams/reservoirs, Water Budget and Population of India; river interlinking in Indian context. **(7L)**

3. **Groundwater/Sub-surface water hydrology:** Occurrence of groundwater**;** resource and distribution; hydro-geological/geomorphological factors governing the groundwater **(15L)**

availability. Movement of groundwater; aquifers and its characteristics, effective porosity, transmissibility, storativity, hydraulic conductivity and related parameters; transmission of groundwater and contaminant transport; salt water hydrology; river meandering; dam hydrology.

4. **Water resource evaluation and management:** Water model (hydrological environment) versus response model (anthropogenic influences); water availability and demand relationship. Surface water versus groundwater; conflicts and quality management in space-time-societal context. Physiography based storage practices; micro watershed analysis; system ecology and environmental planning; Rainwater harvesting concepts and structures; Geophysical investigations; Integrated and Participatory Water Resources Management - issues and scope. Source water protection; wetlands; pollution prevention; remote sensing and GIS applications in hydrology/water resources. Problems related to water resources management in India. **(30L)**

5. **National Policies of Water Resource Management:** Policies of water resources in India, legislation and water resource protection, state level policy; water resource as economic resource and it's analysis; Traditional and customary water rights management. Role of PRIs in water management. **(3L)**

Paper – XVI (MTech/ Elective-2)

(Course No. EM16: M. Tech/E2): Environmental Engineering

1. **Water Supply Management:** Characteristics of water. Drinking water quality standard. Standard method of water analysis. Source of water; Different unit operations of water treatment; Disinfection of water. Intake and flow diagram of different water treatment systems. Water demand. Transmission and distribution network of Municipality water systems. Laying of pipes; Types of pipe and their properties; Advanced water treatments. **(12L)**

2. **Waste Water Management**- Terms used in waste water. Characteristics and types of waste water. Collection and disposal of waste water. Municipality waste water treatment; conventional and low cost systems; unit operations and flow sheet. Design of a sewage treatment plant, Disposal of sludge. Septic tank, **(12L)**

Inhoff tank, Rural Sanitation.

3. **Water Resource Engineering and Management:** Water resources distribution in the world; different types of aquifers; deep and shallow wells; steady and unsteady flow, ground water flow, salt water intrusion; dam and reservoir; river training works and flood management; river engineering types and character of river; different sources of pollution and control; types of irrigation and water demand for crops; water conservation policies. **(12L)**

4. **Solid Waste Management:** Different regulatory authorities for controlling hazardous waste; collection and transport of industrial, biomedical and hazardous waste; Municipal solid waste management; design of disposal methods and recycling; sanitary land filling, composting, incineration; legislation and by-laws in solid waste management, advanced technological methods. **(12L)**

5. **Air Pollution Control:** Air pollution meteorology; plume behavior and dispersion modeling; indoor and outdoor air pollution; pollution due to automobiles; control of air pollution- source correction methods and end of pipe treatment; air quality and emission standard. **(12L)**

6. **Noise Control Engineering: Noise attenuation system: ……?????**

Paper – XVI (M. Sc/Elective-2)

(Course No. EM16: M. Sc/E2): Climate Change and International Developments

1. **Global Climate Change Issues**: Earth's climate system: past, present and future; shifts in the global environment (global warming, ozone hole, acid rain, desertification, biodiversity loss, nuclear winter, El Nino); trends of change in temperature and rainfall pattern in different continents with particular reference to Asian countries. **(8L)**

2. **Greenhouse Effect and Global warming**: Stocks and fluxes of Carbon in terrestrial and marine ecosystems and anthropogenic impact; Greenhouse gases and global warming. **(5L)**

3. **Ozone Layer Depletion**: Chemistry of the ozone layer; ozone depleting substances and formation of Antarctic ozone hole; effects on life; International efforts to protect the ozone layer. **(5L)**

4. **Acid Rain**: Cause, nature and effects on soil, water, biota and archaeological and heritage structures; trans-boundary nature; case studies; combating **(4L)**

strategies.

5. **Climate Change and Natural- and Managed Systems**: Impacts of climate change on forests, freshwater - and marine resources, biodiversity, agriculture and human health. **(14L)**

6. **Climate Change Mitigation and Adaptation**: Ways and means, concept of carbon sequestration, carbon footprint, emission trading and emission market; National and International efforts to combat climate change; National Action Plan for Climate Change (NAPCC); adaptability of ecosystem to climate change. **(12L)**

7. **Global Change Politics and Policy Perspectives:** Developing countries and climate change; developed countries and climate change; global politics and decisions on climate change (protocols, conventions, multilateral environmental agreements); UNFCCC, IPCC, Kyoto Protocol, Clean Development Mechanism (CDM), National Communication to the UNFCCC (NATCOM); COP's and Climate Conferences. **(12L)**

Paper – XVII (Practical): Environmental Toxicology

1. Bioassay of toxicants and response curve: Toxicity bioassay: LC_{50} and LD_{50}
2. Quantification of Arsenic, Cadmium, Lead, Zinc pollution.
3. Enzymatic assay: Catalase, Peroxidase, Dehydrogenase.
4. Genotoxicity Assessment: Comet Assay, Chromosomal aberration study

Paper – XVIII (Practical): Environmental Microbiology and Basic Geoinformatics

1. Bacterial plate count (spread plate, pour plate, broath) from water and soil samples.
2. Counting of total and faecal coliforms in water sample
3. Gram staining
4. Estimation of antimicrobial properties.
5. Hands on training on toposheet, FCC and their application.
6. Submission of model on innovative environmental design

SEMESTER – 4

Paper – XIX (M. Tech./Elective-3)

(Course No. EM19: M. Tech./E3)

Environmental Biotechnology

Full Marks - 100

1. **Introduction to Environmental Biotechnology**: Concept and overview of application areas in management of environmental problems; Concept of green technology**.** **(4L)**

2. **Waste Water treatment**: Advanced and space saving approaches to biological waste water treatment; Sewage treatment methods (lagoons or ponds, trickling filters, activated sludge process, modification of existing processes – bio filters, rotating biological contractor, fluidized bed, deep shaft process, oxygen addition, captor process, membrane bioreactors); role of microphyte and macrophytes in waste water treatment; Biotech approach for wastewater treatment. **(6L)**

3. **Biocomposting**: Composting process and techniques, use of composted materials; vermicomposting**.** **(4L)**

4. **Bio-fuels**: Source and mechanism of various biofuel production; biogas, landfill gas, bioethanol, biohydrogen; microbial fuel cells; biomethanation of agro industrial wastes; Potentials and constraints. **(5L)**

5. **Biodegradation and Hazardous Waste Management:** Concept; Biotechnological removal of xenobiotics; Factors affecting biodegradation; microbial degradation of biopolymers, hydrocarbons (alkanes, alkenes, alkynes, aromatic compounds, halogenated and sulfonated compounds, pesticides**).** **(8L)**

6. **Biotechnology for Air Pollution Abatement:** Use of biological techniques in controlling air pollution; Removal of chlorinated hydrocarbons from air; biotechnological application for pollution reduction in Paper and pulp industry tannery industry; Deodorization process bioscrubbers, biobed, biotrickling filters**.** **(7L)**

7. **Integrated Pest Management**: Concept, approaches and technology involved; potentials and constraints; Natural and bio-pesticides. **(4L)**

8. **Bioremediation**: Concept, types, factors, applications, advantages and constraints; Specific bioremediation technologies (prepared beds, biopiles, composting, bioventing, biosparging, pump and treat method, constructed wet lands, use of bioreactors for bioremediation. Phytoremediation – types, **(8L)**

mechanism, case studies); Biotechnological approaches**.**

9. **Recombinant DNA Technology & Environment**: Concepts; environmental applications; GM Crops, GMO and GMMs: creation and application; environmental, ethical and legal issues; risk groups; biosafety standards and measures; environmental approval, National and international status of current researches in recombinant DNA technology, artificial cell and synthetic life. Biotech Approach of Resource Recovery: Concept; Bio mining, bioleaching. **(10L)**

10. **Biotechnology and Intellectual Property Rights:** Intellectual property rights (IPR) and protection (IPP), Types of IP: Patents, Trademarks, Copyright & Related Rights, Industrial Design, Traditional Knowledge, Geographical Indications, Protection of GMOs; Patents and TRIPS, Convention on Biodiversity (CBD). **(4L)**

Paper – XIX (M. Sc/Elective-3)

(Course No. EM19: M. Sc/E3)

Disaster Management

Full Marks - 100

1. **Introduction to Natural Disaster** – Concept kinds – Meteorological/ Exogenous origin (e.g. cyclone, storm surges, Nor'wester, flood, drought, global warming, slope instability / avalanche, Geo – disaster / Endogenous origin (earthquake, Volcanism) – Physiographic consideration and impact of natural hazards on environment. **(8L)**

2. **Earthquakes**; origin – interior of earth – Continental Drift, Sea floor spreading, plate tectonic theories; Seismic waves – magnitude, seismic zones focus, epicenter ; nature and kinds of destruction (e.g. vibration, deformation, liquefaction, slope failure, flooding, fire etc.); preventive measures. **(6L)**

3. **Volcanism**: Mechanism and energy of volcanic eruptions/ activity – types; Lava flows – diversified types – lava outflows, ashes – bombs; mudflows (lahar –hot – cold), glowing clouds, sea waves (tsunami), volcanic chain – geographic distribution; preventive measures. **(7L)**

4. **Slope instability/Mass wasting:** Landslides, avalanche – classification – processes – related landform features – prevention /reduction measures. **(7L)**

5. **Riverine Floods:** Genesis – fluvial processes and land forms – river valleys – flood plain, terraces, alluvial fans; quantitative consideration- flood frequency magnitude – environmental impacts – mitigation strategies in object orientation**.** **(8L)**

6. **Coastal & Marine Hazards:** Coastal configuration, classification and processes active – beach erosion; dune migration, sea level changes and related impacts; Socio- economic impact and preventive measures. **(8L)**

7. **Drought / Desertification:** Causes – physical, anthropogenic; and degradation, impact on agricultural activities and environment; prevention measures. **(6L)**

8. **Natural Disaster Management & preparedness**: IDNDR Viewpoint; Indian Scenario – National policy on Disaster Management – NDM , Act , Institutional framework, Financial arrangements, disaster prevention, mitigation and rehabilitation, capacity development, knowledge management, role of Information and communication Technologies (ICT), Research and development. **(10L)**

Paper - XX (Course No. EM20):

Part-A: Industrial Training

Part-B: Soft Skill Development **Full Marks: 50+50=100**

Paper – XXI (Course No. EM21): Master's Dissertation **Full Marks - 200**

Paper - XXII EM22: Comprehensive Viva **Full Marks - 100**

Suggested Reading

1. Begon, M., Harper, JL & Townsend, CR. (2006). Ecology (Blackwell)
2. Odum, E.P. & Barrett, G.W. (2006). Fundamentals of Ecology (Cengage)
3. Botkin, DB & Keller, EA (2014). Environmental Science (John Wiley & Sons)
4. Chiras, D.D. (2012). Environmental Science (Jones & Barlett)
5. Cunningham et al. (2003). Environmental Science. (McGraw Hill)
6. Santra, S.C. (2010).Environmental Science. (NCBA)
7. Krishnamoorthy, B. (2009). Environmental Management (PHI)
8. Kulkarni, V. & T.V. Ramachandra (2006). Environmental Management (Capital)
9. Agarwal, S.K. (2005). Environmental Management (APH Publishing)
10. Agarwal, S.K (2001). Ecoinformatics (Vol I-IV) (APH Publishing)
11. Saxena, HM (2010).Environmental Management (Rawat).
12. Asolekar & Gopichandran (2005). Preventive Environmental Management (CUP)
13. Welford (2009). Corporate Environmental Management (Universities Press)
14. Shastri, S.C. (2015). Environmental Law (Eastern Book Company)
15. Mitchell, B. and Jacob, J. (2013). Resource and Environmental Management
16. Sengupta, R. (2001). Ecology and Economics (OUP).
17. Sankar, U. (2001). Environmental Economics (OUP).
18. Kolstad, C.D. (2000). Environmental Economics (OUP).
19. Sahu, N.C. & A.K. Choudhury (Eds 2005). Dimensions of Environmental and Ecological Econbomics (Universities Press).
20. Mitsch, W.J. & S. Jorgensen (2004). Ecological Engineering and Ecosystem Restoration (John Wiley & Sons)
21. Valdiya, KS (2004). Coping with Natural Hazards (Orient Longman).
22. Mitsch, W.J. & J.E. Gosselink (2015) Wetlands (John Wiley & Sons)
23. Masters, GM (2008).. Introduction to Environmental Engineering & Science (Prentice Hall).
24. Keddy, PA (2010). Wetland Ecology. (Cambridge University Press)
25. Manahan, SE (2006). Environmental Science and Technology (Taylor & Francis).
26. Manahan, SE (2009). Environmental Chemistry (CRC Press).
27. Dew, A.K. (2000). Environmental Chemistry (New Age International)
28. Banerjee, BP (2005). Handbook of Energy and Environment in India (OUP).
29. Negi, S.S. India's Forests: Forestry & Wild Life (Indus Pub.)
30. Parekh, JK and H. Datye (2003). Sustainable Management of Wetlands (Sage).
31. Klaassen et al. (2007) Casarett & Doull's Toxicology: The Basic Science of Poisons (McGraw Hill).
32. Yu. M.-H. (2011) Environmental Toxicology (CRC Press).
33. Hodgson, E. (2004). A Text Book of Modern Toxicology (Wiley Interscience)
34. Pandey, K., JP Shukla and SP Trivedi (2011) Fundamentals of Toxicology (NCBA).
35. Banerjee, G.C. (1998) Animal Husbandry (Oxford-IBH)
36. Eaton, E. and MAH Franson (2005). Standard Methods for the Examination of Water & Wastewater. American Public Health Association
37. Sawyer, CN, PL McCarty and GF Parkin (2003). Chemistry for Environmental Engineering and Science. (Tata McGraw-Hill)
38. Trivedy, R.K. & P.K. Goel (1987) Practical Methods in Ecology and Environment (EnviroMedia).
39. Pelczar, MJ, ECCS Chan and NR Krieg (1993) Microbiology (McGraw Hill)
40. Atlas, R.M. (1988). Microbiology: Fundamentals and Applications (Macmillan).

41. Scragg, A. (2014). Environmental Biotechnology (OUP)
42. Chatterjee (2007). Introduction to Environmental Biotechnology (PHI).
43. Rittman & McCarty. (2000). Environmental Biotechnology (McGraw Hill)
44. Biswas, A. (1997). Water Resources: Environmental Planning, Management and Development (McGraw Hill)
45. Tchobanoglous et al. (2003). Wastewater Engineering: Treatment and Reuse (McGraw Hill)
46. Jeffries, M. (1997) Biodiversity and Conservation (Routledge)
47. Maity, P. & Maity, P. (2011) Biodiversity. (PHI)
48. Canter, C.L. (1996). Environmental Impact Assessment (McGraw Hill)
49. Brady, N.C. (2008) Nature and Properties of Soils (Pearson)
50. Weiner, RF and R. Matthews (2003). Environmental engineering (Elsevier)