# Department of 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 – 2400; Semester 1: 600, Semester –2: 600, Semester –3: 600, Semester 4: 600**
**Credit Hours – Total: 30; Semester 1: 30, Semester –2: 30, Semester –3: 30, Semester 4: 30**

## SEMESTER-1

Full Marks- 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 Control and Management | 5 | 80 | 20 | |
| Paper-IV | S1- EM IV | Ecotoxicology and Environmental Health | 5 | 80 | 20 | |
| Paper – V (Practical) | S1 – EMV-P | S1- EMI and S1- EM II | 5 | | | 100 |
| Paper – VI (Practical) | S1 – EMVI-P | S1- EM III and S1- EM IV | 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 | S2-EMIX | Ecological Issues and Interdisciplinary Approaches | 5 | 80 | 20 | |
| Paper – X | S2-EMX | Sustainable Development | 5 | 80 | 20 | |
| Paper – XI (Practical) | S2-EMXI-P | S2-EMVII and S2-EMVIII | 5 | | | 100 |
| Paper – XII (Practical) | S2-EMXII-P | S2-EMIX and S2-EMX | 5 | | | 100 |

## SEMESTER-3

F.M.- 600

| Paper | Course No. | Subject | Credit hours | Full Marks | | |
|---|---|---|---|---|---|---|
| | | | | Written | Internal Assessment | Practical |
| Paper – XIII | S3-EMXIII | Waste Management | 5 | 80 | 20 | |
| Paper – XIV | S3-EMXIV | Environmental Management Tools: Environmental Impact Assessment, Green Accounting and Reporting | 5 | 80 | 20 | |
| Paper – XV (Elective) | S3-EMXV:M.Tech/E1 | Ecological Engineering and Eco-sanitation | 5 | 80 | 20 | |
| | S3-EMXV:M.Sc./E1 | Water Resource Planning and Management | 5 | 80 | 20 | |
| Paper-XVI (Elective) | S3-EMXVI:M.Tech./E2 | Environmental Engineering | 5 | 80 | 20 | |
| | S3-EMXVI:M.Sc./E2 | Climate Change and International Developments | 5 | 80 | 20 | |
| Paper – XVII | S3-EM XVII -P | S3-EMXIII and S3-EMXIV | 5 | | | 100 |

| | | | | | | |
|---|---|---|---|---|---|---|
| (Practical) | | | | | | |
| Paper – XVIII (Practical) | S3-EM XVIII: M.Tech. –P | S3-EMXV:M.Tech/E1 & S3-EMXVI:M.Tech./E2 | 5 | | | 100 |
| | S3-EM XVIII: M.Sc.–P | S3-EMXV:M.Sc./E1 & S3-EMXVI:M.Sc./E2 | | | | |

**SEMESTER-4** **F.M. 600**

| **Paper** | **Course No.** | **Subject** | **Credit hours** | **Full Marks** | | |
|---|---|---|---|---|---|---|
| | | | | **Written** | **Internal Assessment** | **Practical** |
| Paper - XIX | S4-EMXIX | Disaster Management | 5 | 80 | 20 | 50 |
| Paper - XX | S4-EMXX | Environmental Governance and Justice | **5** | 80 | 20 | 50 |
| Paper – XXI (Elective) | S4-EMXXI:M.Tech/E3 | Environmental Biotechnology | **5** | 80 | 20 | 50 |
| | S4-EMXXI:M.Sc./E3 | Earth System Science and Geoinformatics | **5** | 80 | 20 | 50 |
| Paper - XXII | S4-EMXXII | Part – A: Review Work & Presentation/Field Survey & Presentation<br>Part – B: Soft Skill Development | **5** | 50<br>50 | | |
| Paper - XXIII | S4-EMXXIII | Dissertation and Seminar | **5** | 100 | | |
| Paper - XXIV | S4-EMXXIV | Comprehensive Viva | **5** | 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) | 8 |
| Question Nos. 3 - 8 | 4 x 5 = 20 | Four (4) | 6 |
| Question No. 9 - 14 | 4 x 10 = 40 | Four (4) | 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): Fundamentals of Environmental Science and Tools for Environmental Analysis

1. **Life and Environment**: Origin of universe, earth, environment and life; biological control of the environment; man and biosphere. (4L)
2. **Concept of Environment**: Atmosphere, hydrosphere, lithosphere and biosphere. (2L)
3. **Ecosystem**: Structure and functions, principles and processes; kinds of ecosystem; cybernetics and homeostasis; ecosystem services; ecosystem management and optimization. (5L)
4. **Biogeochemical Cycles**: Concepts; hydrologic cycle, carbon, nitrogen and phosphorus cycles (C, N, P) and their significance in ecosystem; impact of anthropogenic activities and environmental concerns. (5L)
5. **Ecosystem Energetics: Concept, l**aws of thermodynamics, food chain and food web; energy flow in ecosystem, eMergy and exergy concepts, energy budget, complexity theory. (4L)
6. **Population Ecology**: Properties, K– and r- selection; carrying capacity and sustainability, population regulation, human population and its implication in environment and development. (4L)

7. **Forest Ecology**: Concept; ecological and economic importance; consequences of deforestation; importance and conservation of wild life. (4L)
8. **Aquatic Ecosystems**: Concept, structure and functional attributes, differences between lentic and lotic habitats, economic importance and development. (4L)
9. **Productivity of Different Ecosystems**: Concept; measurement; productivity and climate change; energy subsidy. (4L)
10. **Environmental Resources**: Kinds, importance and valuation. (2L)
11. **Environmental Pollution**: Concept, sources, classification and nature of pollutants; Impacts of environmental pollution; bioconcentration, bioaccumulation, biomagnification; case studies. **(**4L)
12. **Ecological Footprint**: Concept, measurement and implications in global perspectives. (2L)
13. **Tools for Environmental Analysis**:

**a. 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). (8L)

**b. Basic instrumentation and tools for analysis of air, water and soil:** X-ray diffraction in mineral/particulate identification; Spectrophotometry; Chromatography; Remote sensing and GIS, Biosensors. (7L)

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

1. **Environmental Management**: Concept; importance; Rio declaration on environment and development; environmental priorities in India. (4L)

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, ecotourism, cattle ranching and the economy of Costa Rica. Economics of sustainable development: Concept, Hartwick-Solow approach, ecological economical approach and safe minimum standard (SMS) approach to sustainability. (10L)

6. **Environmental Management Systems**: Environmental system principles, tools and management strategies; different environmental management systems; perspectives of environmental management in India; ISO systems and certification procedure;

environmental management and accounting. (8L)

7. **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; ethical, social and wider global responsibilities of corporations and their managers/CEOs. (8L)

8. **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 Control 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; green belts; case studies. (12L)
2. **Indoor Pollution**: Pollutants at homes and work places; allergens; environmental hazards in science labs; lifestyle hazards – cosmetics, additives, food preservatives, smoking, etc; 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; 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; case studies; management strategies of radiation pollution. (8L)

7. **Bio-pollution**: Concepts, processes and impacts; major bio-invasive plants and animals in India; biological warfare 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. (10L)

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

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

**4. Genetic Toxicology:** Concept, types, classes, effects of genotoxic agents; genotoxicity testing and genetic bio-monitoring (4L)

5**. Industrial Toxicology:** Concept; industry specific health risks and diseases; case studies; safety of industrial workers; health insurance, policy issues and welfare programs. (10L)

6. **Occupational Health:** Concept; emerging issues of health concern in industrial workers: coal mines, dye, fire cracker, battery, tannery, smelting and bidi. (10L)

7. **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. (10L)

**Paper – V (Practical)**

1. Assessment of general water quality (temperature, pH, free carbon dioxide, alkalinity, dissolved oxygen, etc).in different water for management.
2. Assessment of nutrient levels (nitrate, orthophosphate, etc) of water bodies for management
3. Assessment of nutrient status (organic carbon, organic matter, nitrogen, available phosphate and total phosphate, etc) of some agricultural soils for management
4. Assessment of primary productivity in different water bodies.
5. Demonstration of ecosystem stability.
6. Assessment of biodiversity using Shannon Index and Simpson Index
7. Analysis and characterization of domestic and industrial effluents
8. Analysis and characterization of agricultural effluents and surface runoff
9. Statistical analysis (mean, median, mode, standard error, standard deviation, ANOVA, paired t-test, $X^2$ test, correlation and regression analysis, t-test)

**Paper – VI (Practical)**

1. Assessment of organic load (chemical oxygen demand (COD), biochemical oxygen demand (BOD) etc) in different water bodies for management
2. Qualitative tests for common food adulterants
3. Bioassay of toxicants and response curve
4. Lethality tests ($LC_{50}$) and determination of critical threshold value
5. Survey and quantification of arsenic/ cadmium/ mercury/ fluoride pollution
6. Reporting on current developments/news on environmental issues published in different media

## SEMESTER - 2

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

1. **Perceptions about Natural Resources:** Concept, kinds and conservation/preservation of natural resources; resources and economic development. (4L)
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; environmental hazards of thermal power plants including coal mining activities; biomass gasification; energy recovery from wastes; bio-fuel; nuclear energy and management of nuclear wastes; global energy consumption/use patterns; energy conservation and energy management; energy outlook for sustainable future. (14L)

**5. Management of Coastal Resources: C**oastal resources; mangrove and salt marsh ecosystems: species diversity, distribution, present status in India; impact of tourism; integrated coastal zone management (ICZM). (8L)

**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, land use pattern, land reform, land use planning. (8L)

**7. Wetland Management and Conservation**: Definition, functions, ecology and biodiversity; wetland loss and degradation; Ramsar sites in India; strategies for wetland conservation and management; wetland mapping. (9L)

## Paper – VIII

## (Course No. S2-EMVIII): Bioresource Management and Conservation

**1. Basics of Bioresource Management**: 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; IPR and biodiversity; Bioprospecting and biopiracy issues with particular reference to India'a biodiversity. (15L)

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

**6. Wildlife Conservation and management**: Concept and value, strategies of wildlife conservation and management; protected area network, sanctuary, national park, biosphere reserve, nature reserves; Conservation Management Areas (CMAs). (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; gene therapy; transgenic plants and animals; golden rice, Flavr Savr tomato; animal cloning; stem cells. (6L)
2. **Biotechnology in Environmental Concerns**: Concepts of bioremediation, waste management, bioenergy, biosensor, bioreactor, biological control, marine oil pollution control. (5L)
3. **Biotechnology in Industrial Applications**: Bioprocessing, biosensors, bioleaching, bioprospecting and recovery of metals. (5L)
4. **Microbial Biomass Production**: single cell protein and lipid, mycoprotein, mushroom production. ( 4L)

5. Microbial aspects of xenobiotics, biodeterioration, agricultural soil, solid wastes, sewage (6L)
6. Microbial control of weeds and pests, biopesticides, biofertilizers, composting and vermicomposting and biocomposting. (8L)
7. Brief ideas of the production, uses and environmental concern of probiotics, GMOs, GMMs, GMFs. (4L)
8. **Environmental Engineering and Technology**: Concepts; Brief ideas on application for pollution control. Waste minimization approaches; cleaner production; recycling (6L)
9. **Green Chemistry and Green technology**: Concept and principles of green chemistry; Atom economy concept and its importance; Green reagents, green solvents and green catalysts – properties and applications. Green Technology: Concept; green technologies in agriculture, industry and water resource management; biocatalysis; bioprocessing; biotreatment technology. (10L)
10. Applications of bioinformatics, GIS and remote sensing in environmental management. (6L)

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

1. **Principlea and Practices of Sustainable Development: C**oncept, theories and principles; approaches; global changes and sustainability issues; strategies for sustainable agriculture, sustainable urbanization, sustainable resource consumption and lifestyle; eco-friendly products and technologies.
   10

2. **Management of Specialized Habitats:** Concept of restoration ecology; rehabilitation of specialized habitats (rural landscape, water bodies, mangroves, salt marshes, coral reef ecosystem, mined areas).
   8

3. **Tourism 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.
   8

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.
   8

5. **Management of Agricultural Crops**: Principles and practices of sustainable agriculture; green revolution; indicators of sustainable agriculture; stress management of horticulture crops; dry-land horticulture; use of pesticides, herbicides and GM crops and their impacts on environment; soil health management; integrated pest management (IPM); improvement of crop protection; conservation of arable land and crop genome; implications of conventional and energy intensive agricultural practices on environment; organic farming; food safety, bio-safety and food security. 14

6. **Sustainable Aquaculture and Fisheries:** Inland and marine fisheries: potentials, pond environment, water, soil and biological conditions; principles 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; monitoring of water and sediment quality; impact of exotic fishes; sustainable aquacultur**e,** lacustrine and reservoir fisheries; pen and cage culture; hilsa fisheries; management practices of brackishwater fish culture; shrimp culture; marine fisheries- types, catch, decline of fish catch; fish ranching. 12

**Paper – XI (Practical)**

1. Ecosystem Approach for pollution remediation
2. Determination of the efficacy of holistic approach
3. Exercise on phytoremediation of pollutants
4. Use of probiotics/weeds/macrophytes in pollution control
5. Management of water and soil quality parameters for agriculture and aquaculture

## Paper – XII (Practical)

1. Biological control of pests: Identification
2. Food chain analysis of pollutants
3. Forest management aspect
4. Aquaculture management aspect
5. Formulation of biopesticides and bioinsecticides
6. Antimicrobial properties

## SEMESTER - 3

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

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

2. **Management of Municipal Solid Wastes:** Concept, sources, quality and quantity; economic importance, characterization; conventional methods 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. (12 L)

3. **Management of Industrial Wastes:** Concept, sources, kinds, nature; brief ideas of treatment of effluents from major industries; effluent quality, national and International standards; 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. (12 L)

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

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

6. **Management of Sewage and Wastewater:** Concept, sources, nature; treatment systems; Biological treatments; wastewater-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:** Environmental Impact Assessment (EIA), environmental risk assessment, environmental management plan, pollution prevention, green technologies, environmental audits and auditing methods; green accounting and reporting; environmental performance assessment (indicators), life cycle analysis (LCA), benefit cost analysis; Environmental Management Systems (EMS); environmental labeling; ecological footprint; emission trading. (12L)

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; Preparation EIA and sustainable development; 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, economics; 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; buffer plantings along high ways; Green transport- Concept; EURO, electric vehicles, mass transport system; ecological engineering for traffic control and noise reduction. (12L)

3. **Ecological Engineering and Constructed wetlands**: Concept, working principle and design criteria of constructed wetland; constructed wetland for water pollution control, floodcontrol,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 – XVI (MTech/ Elective-2)
## (Course No. EM16: MTech/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, Inhoff tank, Rural Sanitation (12L)

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 types of wastes and their characteristics; different regulatory authorities for controlling hazardous waste; collection and transport of industrial, biomedical and hazardous waste; Municipal solid waste management; disposal methods and recycling; sanitary land filling, composting, incineration; legislation and by-laws in solid waste management. (12L)

5. **Air Pollution Control:** Sources (stationary and mobile); types of pollutants and impacts on human health, flora and fauna; economic effects of air pollution; 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)

## Paper – XV (MSc/Elective-1)

## (Course No. EM15: MSc/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. **(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 availability. Movement of groundwater; aquifers and its characteristics, effective porosity, transmissibility, storativity, hydraulic conductivity and related parameters.

**(15L)**

**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; microwatershed 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; Traditional and customary water rights management. Role of PRIs in water management. **(3L)**

## Paper – XVI (MSc/Elective-2)
## (Course No. EM16: MSc/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; Green house 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 strategies. (4L)

5. **Climate Change and Natural- and Managed Systems**: Impacts of climate change on forests, freshwater - and marine resources, biodiversity, agriculture, horticulture, animal husbandry 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); UNFCC, IPCC, Kyoto Protocol, The Clean Development Mechanism (CDM), National Communication to the UNFCCC (NATCOM). (12L)

## *Paper – XVII (Practical)*

1. Qualitative and quantitative determination of municipal solid wastes
2. Qualitative and quantitative determination of market wastes
7. Qualitative and quantitative determination of hospital wastes
3. Survey and disposal practices of municipal/bio-medical/domestic wastes
4. Survey for environmental risk assessment of industrial workers/ municipal workers
5. Survey of segregation practices of municipal and hospital wastes

## *Paper – XVIII (Practical)*

1. Environmental monitoring- air, water and soil
2. Surveillance of landscape/wetlands/ forests using GIS and Remote sensing
3. Environmental and Energy audit
4. Environmental impact assessment of road construction and other activities
5. Evaluation of sustainability of developmental activities using sustainability indices.

# Paper – XIX
# (Course No. EM19) : Disaster Management

**1.Introduction to Natural Disaster** – Concept kinds – Meterological / 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. (10L)

**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. (10L)

**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. (5L)

**4. Slope instability/Masswasting:** Landslides, avalanche – classification – processes – related landform features – prevention /reduction measures . (5L)

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. (7L)

7. **Drought / Desertitication:**

Causes – physical, anthropogenic; and degradation , impact on agricultural activities and environment; prevention measures. (5L)

8. **Natural Disaster Management & preparedness** ; I D N D R Viewpoint ; Indian Scenario – National policy on Disaster Management – N D M , 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): Environmental Governance and Justice

1. **International Environmental Policies:** Nature of environmental policies; MAB programme, Stockholm Conference (UNCHE) (1972); Rio Conference (UNCED)(1992); Johannesburg Declarations on Sustainable Development (2002); Conventions on Biodiversity and Climate Change; Agenda 21, Montreal and Kyoto protocols, CoPs Bonn, Copenhagen Conference; Merits and failure of the Conference (12L)

2. **International Agreements and Treaties:** Concept of agreement and treaty; Need of international agreements and treaties; CITES; Role of UNEP (6L)

3. **National Policy on Environment:** National Committee on Environment and Planning (NCEP); Tiwari committee; Establishment of MoEF; National forest policy; national water policy, national energy policy. (10L)

4. **Constitutional Provisions for Environmental Protection:** Indian constitutional provisions Article 14, 19(1), 21, 32, 226, 47, 48(A), 49, 51A(g); Article 246, 248, 253 and other articles related to environment; Public Interest Litigation and Role of SC and HCs in environmental protection. (10L)

5. **National Environmental Legislation:** Environmental laws in India with some case studies, The Water (Prevention and Control of Pollution) Act, 1974 as amended up-to date and rules; The Air (Prevention and Control of Pollution) Act, 1981; The Environment (Protection) Act, 1986; Public liability Insurance Act, 1991 and Rules 1991; The Forest (conservation) Act, 1980, Wildlife Protection Act, 1972 as amended up to date; The Biodiversity Diversity Act, 2002; The Biological Diversity Rules 2004; The National Environment Tribunal Act, 1995. (10L)

6. **Management and Handling Rules:** Hazardous Wastes (Management and Handling) Rules, 1989; Bio-medical Wastes (Management and Handling) Rules, 1998; Recycled Plastics (Manufacture and usage) Rule, 1999; Municipal Solid Wastes (Management and Handling) Rules, 2000. Scheme of labeling of Environmentally Friendly Products (Ecomark); Role of NGOs in environmental protection in India; -CRZ & CMZ notifications as amended and drafted upto 2010 and 2008 respectively; National Environment Policy, 2006. (10L)

## Paper – XXI (M.Tech./Elective-3)
## (Course No. EM21: M.Tech./E3)
## (Course No. EM21): Environmental Biotechnology

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**: Conventional biological treatment; Recent approaches to biological waste water treatment; Sewage treatment methods ( lagoons or ponds, trickling filters, activated sludge process, modification of existing processes – biofilters, 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; computers in water pollution control. (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). (5L)

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. (5L)

7. **Biotechnology for Restoration of Degraded Land:** Reforestation through micropropagation of casurina for tropical reforestation on adverse sites, development of stress tolerant plants; use of mycorrhizae in reforestation, reforestation of soils contaminated with heavy metals. (5L)

8. **Integrated Pest Management**: Concept, approaches and technology involved; potentials and constraints; Natural and biopesticides (4L)

9. **Bioremediation**: Concept, types, factors, applications, advantages and contraints; Specific bioremediation technologies (prepared beds, biopiles, composting, bioventing, biosparging, pump and treat method, constructed wet lands, use of bioreactors for bioremediation. Phytoremediation – types, mechanism, case studies); Biotechnological approaches. (6L)

10. **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. (8L)

11. **Biotech Approach of Resource Recovery**: Concept; Biomining, bioleaching (4L)

12. **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. (4L)

## Paper – XXI (MSc/Elective-3)
## (Course No. EM21: MSc/E3)

**Earth Systems Science and Geoinformatics**
**Full Marks - 100**

**I. Geo – Science and Environment**

a. Earth & its origin , Geological time Scale; terrestrial earth – global tectomics; continental drift, Seafloor Spreading, , Plate tectomic theories , craters – rocks , minerals and Structural elements. (5L)

b. Changing landforms and environment – geomorphological concepts , different types of Landforms; Volcanic , Structural , denudational (Weathering effects ) fluvial, coastal, glaciers – glaciated and Periglacial Zone , krast topography, eoliam. (7L)

c. Ice ages - Pre-cenozoic ice ages; Quaternary Environment and landforms –glacial evidences; Holocene climate and landforms – cycle of erosion- planation – landforms of the cold & temparate zones and tropics and sub-tropics; methods and scale of geomorphic change – man as geomorphic agent ; applied geomorphological studies in environmental management with special reference to natural/anthropogenic hazards. (8L)

**II. Earth and the Atmosphere**

Composition of atmosphere ; horizontal layering of the atmosphere ; analysis of surface, upper air and others derivative charts; formation and movement of Western disturbance , thunderstorms , tropical and extra- tropical cyclones, tropical synoptic meterology, tradewind inversion ; Intertropical Convergence Zone ( ITCZ ); Climatic zones of the world; microclimate modification; Climate change in flucnce on crop production.

Satellite Meteorology – meteorological satellites , polar orbiting & Geo-stationary Satellites; visible and infra-red radiometers, multi-scanner radiometers ; identification of synoptic systems. (20L)

**III. Space technology in environmental management /Remote Sensing Techniques Geographical Information System.**

**A. Remote Sensing Techniques .**

1. Basic and fundamental concept on principles of RS – Electro Magnetic Radiation (EMR) – Spectral Characteristics- Black body concept; Colour concept ; Atmospheric effects ; Interaction of EMR with physical objects on earth – Spectral responses . (5L)

2.Principles and fundamentals of Aerial Photography and photogrametry;

Space borne remote sensing – System overview – platform- Sensors; Recognition of Earth surface features; History of Space imaging with special reference to Indian Scenario. (5L)

3.Interpretation techniques of Aerial photography and satellite imagery – visual interpreation techniques; Digital image processing – Structure of a digital image . Preprocessing- Radiometric and Geometric correction- Image enhancement techniques – Image Classification. (10L)

**B.Geographical information System (GIS)**

Introduction to GIS – definition, components of GIS. Geographical data, representation of topological data-map projection; Comparison of Vector and Raster methods, Data input/output; DEM/DTM (Digital Elevation Model/Digital Terrain Model); application. Geographical positioning System (GPS) Technology and its application in environmental management. (5L)

**C. RS application in Natural Resources Management;**

Environmental application- Natural hazards/disaster- Integrated data analysis of spatial and attribute data for Natural hazard/Disaster mapping

Computer Assisted Mapping; Spatial database structure and desing- database management system. Coordinate Spatial and Georeferrencing- Map projections- Image to image Registration-

Resampling.Interpolution – Deterministic methods- Statistical interpolution methods. Hazard/Disaster mapping. (5L)

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| Paper - XXII EM22 | Part – A Review Work & Presentation/Field Survey & Presentation |
| | Part – B Soft Skill Development |
| Paper – XXIII EM23 | Dissertation and Seminar |
| Paper - XXIV EM24 | Comprehensive Viva |