Revised Syllabus for M.Sc. Environmental Science (Approved by the AC on 1st August, 2025 & Implemented from 2025-26 session)

DEPARTMENT OF ENVIRONMENTAL STUDIES

Siksha-Bhavana, Visva-Bharati

Syllabus for M.Sc. course in Environmental Sciences (Total 1200 marks)

Semester I	**(5 theory and 1 practical paper)**	**Total Marks (Internal + Final)**
MEC 11	Fundamentals of Environmental Science	50 (10+40)
MEC 12	Climatology and Climate Change	50 (10+40)
MEC 13	Principles of Soil Science	50 (10+40)
MEC 14	Techniques in Environmental Science	50 (10+40)
MEC 15	Water Pollution	50 (10+40)
MEC 16	Practical-I	50 (10+40)
	Total	**300 marks**

Semester II	**(5 theory and 1 practical paper)**	
MEC 21	Biodiversity and Conservation	50 (10+40)
MEC 22	Air Pollution	50 (10+40)
ME C 23	Environmental Earth Science	50 (10+40)
MEC 24	Energy and Environment	50 (10+40)
MEC 25	Soil Pollution and Solid Waste Management	50 (10+40)
MEC 26	Practical-II	50 (10+40)
	Total	**300 marks**

Semester III (5 theory and 1 practical paper)		**Total Marks (Internal + Final)**
MEE 31	**Course selected for the Elective** (MEE 311- Basics of Natural Resource Management MEE 312 Emerging Environmental Issues)	50 (10+40)
MEC 32	Ecology	50 (10+40)
MEC 33	Environmental Toxicology	50 (10+40)
MEC 34	Remote Sensing and GIS	50 10+40)
MEC 35	Environmental Economics & Sustainable Development	50 (10+40)
MEC 36	Practical-III	50 (10+40)
	Total	**300 marks**

Semester IV (4 theory and 1 project paper)		
MEC 41	Environmental Biotechnology	50 (10+40)
MEC 42	Environmental Management	50 (10+40)
MEC 43	Environmental Education, Policy and Legislation	50 (10+40)
MEO 44	One Optional (to be selected from four) (MEO -441 Ecotoxicology, MEO 442-Air Pollution & Health MEO 443- Hydrology & Water Management, MEO 444- Soil Pollution)	50 (10+40)
MEC 45	Project Work with Presentation	100
	Total	**300 marks**

DEPARTMENT OF ENVIRONMENTAL STUDIES

Siksha-Bhavana, Visva-Bharati

Syllabus for M.Sc. course in Environmental Sciences

Semester I		**Total Credits**	**Total marks**
MEC 11	Fundamentals of Environmental Science	4	50
MEC 12	Climatology and Climate Change	4	50
MEC 13	Principles of Soil Science	4	50
MEC 14	Techniques in Environmental Science	4	50
MEC 15	Water Pollution	4	50
MEC 16	Practical-I	4	50
Semester II			
MEC 21	Biodiversity and Conservation	4	50
MEC 22	Air Pollution	4	50
MEC 23	Environmental Earth Science	4	50
MEC 24	Energy and Environment	4	50
MEC 25	Soil Pollution and Solid Waste Management	4	50
MEC 26	Practical-II	4	50
Semester III			
MEE 31	**Course to be selected for the Elective** (MEE 311 Basics of Natural Resource Management MEE 312 Emerging Environmental Issues)	4	50
MEC 32	Ecology	4	50
MEC 33	Environmental Toxicology	4	50
MEC 34	Remote Sensing & GIS	4	50
MEC 35	Environmental Economics & Sustainable Development	4	50
MEC 36	Practical-III	4	50
Semester IV			
MEC 41	Environmental Biotechnology	4	50
MEC 42	Environmental Management	4	50
MEC 43	Environmental Education, Policy and Legislation	4	50
MEO 44	Optional Paper (One to be selected from four)	4	50
MEC 45	Project Work and Presentation	8	100
		96	1200

SEMESTER I

MEC 11. FUNDAMENTALS OF ENVIRONMENTAL SCIENCE **50 marks**

Objective: To introduce the subject of environmental science (including its concept and Scope to the students, who usually come from various disciplines and let them understand the inter-relationships of different components of the environment and how their previous curriculum is linked to this course.

Expected outcome: The students will be acquainted with the various terms associated with Environmental Science and will understand the intricate relationships that exist among the various components of the environment and what role they can play in maintaining this relationship ever with perfection.

Unit I: Concept and Scope of Environmental Science, Environmental Science as a multidisciplinary subject; Nature, Man & Society; Introduction to natural resources and its depletion, life support system, Historical perspective related to the development of environmental science and studies with respect to India and world, traditional knowledge systems to protect the environment. (6 hours)

Unit II: Introduction to the Earth Systems Science, Composition and structure of geosphere, hydrosphere and atmosphere; Origin of earth, Geological time scale, Origin and evolution of continents and oceans, Geological history of earth's atmosphere, Past record of life. (10 hours)

Unit III Chemical potential, acid-base reaction, the solubility of gases in water, the carbonate system, Classification of elements, Chemical speciation, Redox Potential, Concept of pH, Eh and their variations in water. (10 hours)

Unit IV: Fundamental concept of genetics: Concept of nucleic acids, replication, transcription, translation, operon concept; Fundamental concept of microbes: Microbial growth, kinetics, stress response and control; Fundamental concept of statistical hypothesis testing: Mean, mode, median, concept of p- Value, t-test and chi-square test, ANOVA. (14 hours)

References:

1. Botkin, D.B.& Keller, E. Environmental Science: Earth as a Living Planet, John Weily, NY
2. College Botany, Vol. I, II & III- Gangulee, Kar and Das
3. Cunningham, W.P.& Cunningham, M.A., Environmental Science, Tata McGraw Hill. ND
4. Santra, S.C., Environmental Science
5. Maier, Pepper & Gerba, Environmental Microbiology.
6. Das, N.G., Statistical Methods (Volume 1 and 2)

MEC 12 CLIMATOLOGY AND CLIMATE CHANGE 50 marks

Objective: Introduction to the climate system and meteorological variables, circulation patterns in the atmosphere and oceans, mechanisms and factors influencing Earth's climate, and role of meteorology in air quality. Cause, effect and adaptation measures to climate change.

Expected outcome: The students will appreciate the complexity of the climate system involving the atmosphere, ocean, land and biosphere. They will learn the nature and significance of variation patterns in atmospheric temperature, pressure, wind, humidity, precipitation, etc.; the role of meteorology in the dispersion of air pollutants; the climate forcings and feedback mechanisms to understand the climate changes in the past and present.

Unit I: Introduction to weather and climate; Scale of meteorology, Radiation balance and earth's energy budget; Synoptic Weather elements(Temperature, Pressure, Precipitation, Humidity, Cloudiness, Visibility, Wind) and their variation patterns. Traditional and advanced methods of weather forecasting. (12 hours)

Unit II: Atmospheric circulation; Weather systems; Ocean circulation, Indian Summer Monsoon; Coupled Ocean-Atmosphere system, ENSO; Extreme weather events- Heat waves, Thunderstorms, Tropical Cyclones, Western Disturbances. (8 hours)

Unit III: Meteorological fundamentals and air quality (Radiation, Temperature, Atmospheric stability, inversions and mixing height, Boundary layer meteorology) Primary meteorological parameters (Winds, Laminar flow; Turbulence of winds, Windroses), Secondary meteorological parameters (Temperature, Precipitation, Humidity) Influence of stability on stack effluents, Topography and plume, types of plume, Plume rise, dispersion of plume. (12 hours)

.

Unit IV: Possible causes of recent climate change, model strategies for predicting climate change, Greenhouse effect, Global warming & Climate change, Consequences of climate change on health, agriculture, soil, etc. International treaties and protocol on climate change; Integrating Traditional knowledge system with Modern Climatology. Paleoclimatology, Climate proxies, Notable climate events in geological time, Natural climate forcings and Milankovitch cycles. (8 hours)

References:

1. Barry RG & RJ Chorley, Atmosphere, Weather & Climate, 7th Ed., Routledge
2. D. Lal, Climatology
3. Patra, P.K., Textbook of Climatology, Kalyani Publishers

MEC 13. PRINCIPLES OF SOIL SCIENCE 50 marks

Objective: Basic introduction to soil science like Genesis, Nature, Classification and composition of Soil. They will also introduced to various Physical chemical biochemical properties of Soil, microbial composition of soils—moreover the environmental impacts of soil erosion and impact on agriculture.

Expected outcome: Develop basic knowledge of soil formation, Classification and their various physic-chemical biological properties.

Unit I: Genesis, Nature and classification of Soil; Inorganic constituents of Soil -Soil composition; Primary minerals- weathering of primary minerals; Secondary Minerals; Organic constituents - Soil Organic matter; Humus; Soil Biomass; Biochemical reactions of soil microorganism; Nonhumified organic matter; humified organic matter. (14 hours)

Unit II: Physical properties of Soil - Soil texture; soil structure; soil density and porosity; soil consistency; Soil air- soil water- soil temperature. Chemical properties of Soil - electrical charges, clay – colloidal properties; CEC, AEC, Soil reaction- acidity and alkalinity. (10 hours)

Unit III: Soil classification; Types of Soil, Saline & alkaline Soil, Soils of India; Environmental impacts of soil erosion, land degradation, desertification. (8 hours)

Unit IV: Soil quality and fertility- Soil nutrients- Soil Nitrogen, Phosphorus, Potassium and Sulfur and its Environmental Quality and Agriculture, Traditional knowledge system- Vrikshayurveda. (8 hours)

References:

1. Arora, Environmental Management of toxic & hazardous chemicals, IVY Publ.
2. McBride - Environmental Chemistry of Soils
3. N.C Brady -The Nature and Properties of Soil
4. Dutta -Principles and Practice of Soil Science
5. G.M. Pierzynski, J. Thomas Sims & George F. Vance - Soils and Environmental Quality-
6. Ibrahim A Mirsal – Soil Pollution: Origin, Monitoring and Remediation
7. Yaron. B, Calvet R, and R. Prost.- Soil Pollution: Process and Dynamics
8. Maier, Pepper & Gerba, - Environmental Microbiology
9. Subba Rao N.S., Soil Microbiology

MEC 14. TECHNIQUES IN ENVIRONMENTAL SCIENCE : 50 marks

Objective: To orient and let the students understand the theoretical parts related to Sampling (collection, preparation, storage and analyses) and instruments, which are key to environmental analyses and subsequent exposure and handling of sophisticated instruments

Expected outcome: The students will be trained to collect any environmental samples and analyze them using sophisticated instruments for assessing the environmental health (air, water, Soil or other sample quality).

Unit I: Need & Scope of Environmental Sampling & Monitoring, Types of samples and monitoring, Concentration units, Analytical precision, accuracy and recovery, detection limit and quantization limit, standard calibration curve. (8 hours)

Unit II: Environmental sampling approaches, Surface water and wastewater sampling, groundwater sampling, Soil and sediment sampling, Biological Sampling, ambient air and stack Sampling. (8 hours)

Unit III: Fundamental of sample preparation for environmental analysis; purpose and types of sample preparation, sample preparation for metal analysis, SVOCs, VOCs, from atmosphere, solid or liquid media, clean up of Organic compounds, Chromatography (TLC, GC, IC, HPLC). 10 hours)

Unit IV: Principles of Gravimetry, Titrimetry and Colorimetry; Principles of Spectroscopy (UV-VIS, AAS, ICP-OES and MS),Data quality and interferences in spectroscopic analysis, Electrophoresis, X-ray fluorescence (XRF), X-ray Diffraction (XRD), Flame photometry, Western blot, Northern blot, Southern blot. (14 hours)

Reference Books:

1. Maiti, S.K., Handbook of Methods in Environmental Studies, Vol. I & II, ABD Publ
2. Chunlong Zhang., Fundamentals of Environmental Sampling and Analysis, Wiley Interscience

MEC 15. WATER POLLUTION 50 marks

Objective: The students will be introduced to Chemistry, the health effects and remediation and control of water & water pollutants. Moreover, the river Action Plans and pollution of marine and groundwater and its control.

Expected outcome: Able to understand the chemistry, health effects and strategy to control water pollutants.

Unit I: Chemistry of water & water pollutants; Importance of water to life forms; Types and Sources of Water Pollutants- Organic pollutants: Persistent organic pollutants (POPs) sewage, industrial effluents, agricultural runoff (pesticides); Inorganic pollutants: heavy metals, salts, acids, alkalis; Microbial pollution: pathogens and waterborne diseases; Nutrient pollution: eutrophication and algal blooms; Emerging contaminants: pharmaceuticals, personal care products, microplastics; Thermal and radioactive pollution. (14 hours)

Unit II: Water quality parameters and its standards (DO, BOD, COD, Acidity, Alkalinity, Hardness, Residual chlorine and Chlorine demand, coliform); Water Quality Index (WQI), Deoxygenating substances, Biochemical aspects of water pollutants; Eutrophication; Soaps and Detergent. (10 hours)

Unit III: Control and Treatment Technologies: Primary Treatment**:** screening, sedimentation; Secondary Treatment**:** activated sludge, trickling filters, oxidation ponds; Tertiary/advanced Treatment**:** disinfection, membrane filtration, ion exchange, adsorption, advanced oxidation; Constructed wetlands and nature-based solutions; Wastewater reuse and recycling Natural Water Purification Kit (Based on Traditional Ingredients). (10 hours)

Unit IV: Monitoring (chemical & microbiological methods) and control of water pollution. Standards for drinking and surface water (BIS, WHO, CPCB norms), River Action Plan; Source of marine pollution and control, Groundwater pollution with special reference to West Bengal (Fluoride and Arsenic). (6 hours)

Reference

1. Environmental Chemistry, (1994) Stanley. E. Manahan, Lewis Publication.
2. Basic concepts of Environmental chemistry, (1997) Des W Connel, Lewis publication
3. Environmental Science and Technology, (1997) Stanley. E. Manahan, Lewis Publication.
4. Chemistry of the Environment, Spiro, 2nd Ed., EEE
5. Biology of Freshwater Pollution Mason, C.F., 3rd Ed, Longman
6. Environmental Problems & Solutions, Asthana & Asthana, S. Chand
7. Water Environment & Pollution, Kumar & Kakrari, Agrobios
8. Environmental Chemistry, De, AK.,

MEC 16. PRACTICAL-I — 50 marks

Objective: Study of microorganisms from water and Soil; Study of pond biota (phytoplanktons, zooplanktons); Study of physicochemical parameters of water and Soil; Plotting and interpretation of weather parameters

Expected outcome: Have a working hand analytical knowledge of various water quality parameters and also interpreting weather parameters.

- Study of microorganisms from water and soil,
- Study of pond biota (phytoplanktons, zooplanktons)
- Study of physicochemical parameters of water (temperature, pH, DO, dissolved CO_2, conductivity, turbidity, Chlorine, total hardness, BOD, COD).
- Plotting and interpretation of weather parameters

Reference Books

1. Maiti, S.K., Handbook of Methods in Environmental Studies, Vol. I & II, ABD Publ.
2. American Public Health Association, 12th Ed.
3. Trivedy, R.K., & Goel, P.K., Chemical & Biological Methods for Water Pollution Studies, Environmental Publ.

SEMESTER II

MEC 21 BIODIVERSITY AND CONSERVATION **50 marks**

Objective: To let the students be aware of various biotic resources (biodiversity) and their significance in serving the ecosystems, including human beings, and also how some of our activities pose threats to their existence. Also, the various management practices and international steps taken to safeguard these important resources are explained.

Expected outcome: The students will learn about the various biotic resources (biodiversity) and their significance in serving the ecosystems, including human beings, and also understand the activities that pose threats to their existence. They were also enlightened about the management practices and international steps taken to safeguard these important resources.

Unit I: Biodiversity and its significance; Types of diversity, Species diversity & its measurement; Flora, Fauna and Biodiversity hotspots of India and world; Endangered, threatened, endemic & invasive species, Keystone species, Red Data Book, Modern Tools in Biodiversity Assessment and Conservation. (10 hours)

Unit II: Biosphere Reserves, National Parks, Sanctuaries & Wetlands; Concept of wildlife, importance of wildlife, Strategies for biodiversity conservation and Agenda -21, Convention on biodiversity. Nagoya Protocol, Aichi Biodiversity Targets & Post-2020 Global Biodiversity Framework. (10 hours)

Unit III: Threats to Biodiversity (Causes and Consequences): Habitat loss, fragmentation, and degradation; Overexploitation: deforestation, overfishing, poaching; Invasive alien species; Pollution and climate change; Conservation and preservation, Afforestation, Social and farm forestry; Case studies: Coral bleaching, Amazon rainforest, Western Ghats, Sundarbans. (10 hours)

Unit IV: Biodiversity and Sustainable Development: Biodiversity and ecosystem services, Role of biodiversity in climate resilience, Agro-biodiversity and traditional knowledge, Biodiversity-based livelihoods: ecotourism, NTFPs, Biodiversity and the SDGs– Eco-restoration, Health and conservation, Bioprospecting, Man-animal conflict, Forest and wildlife conservation, Sacred grooves, Traditional Resource Management Systems, Traditional Wisdom, Eco-tourism. (10 hours)

Reference Book:

1. Trivedy, P.R., Global Biodiversity Authors Press
2. Khan, T.I., Global Biodiversity & Environmental Conservation, Pointer Publ, Jaipur.
3. Swaminathan, M.S., Conservation, Pointers
4. Bebarta, Forest Resources & Biodiversity Management, Concept
5. Kumar, U., Asya, M.J., Biodiversity: Principles and Conservation, Agrobias, India
6. Weddell, Conserving Living Natural Resources, Cambridge
7. Singh, Environmental Guidelines for Indian Tourism, Kanishka
8. Weaver D.B., Ecotourism in the Less Developed World, CAB International.

MEC 22 AIR POLLUTION **50 marks**

Objective: To let the students understand the atmosphere, an important component of the environment, and how this component is degraded due to the release of pollutants and noise from various sources, including the chemistry of the atmosphere and its constituents. To explain to the students how these pollutants affect our health and well-being and what provisions are available for monitoring and control of this pollution in India.

Expected outcome: The students will understand the composition of the atmosphere and how this component is degraded due to the release of air pollutants and noise from various sources, including the atmospheric chemistry of the chemical constituents. It will also help the students understand how these pollutants affect our health and well-being and what provisions are available for monitoring and control of air pollution in India.

Unit I: Chemistry of Atmosphere; Reactive, unstable, and excited atoms and molecules of the tropospheric atmosphere, Thermochemical & photochemical reactions in the atmosphere, photophysical processes, Protective mechanisms of the earth & its atmosphere (ozone layer, Van Allen Belts, & magnetic field). Air pollution - its nature and causes; Types of air pollutants (Primary & Secondary) & their sources (natural & anthropogenic); Chemistry of air pollutants; Air quality standards and criteria. (14hours)

Unit II: Photochemical smog; Acid rain, Status of air pollution in India; Air pollution monitoring & control, Effects of air pollutants on plants, crops, animals, human health & monuments; Traditional knowledge and Practices for Air Quality Management. Air pollution control stratigies, working principal of recent device used to control particulate matter and gaseous pollutants, nature-based air pollution control. (10 hours)

Unit III: Formation of Ozone layer, depletion of O_3-layer and the role of the international community in protecting the ozone layer. Ground level ozone and other oxidants, Effects of oxidants on living and non-living systems. (10 hours)

Unit IV: Sources and types of Noise pollution, measurement of noise and indices; Effects of noise on human health; Noise control and abatement measures; Noise exposure levels and standards; Status of noise pollution in India. (6 hours)

Reference Book:

1. Hutchinzer, O., Environmental Chemistry
2. Spiro, Chemistry of the Environment, 2nd Ed., EEE
3. Sawyer, McCarthy & Parkin, Chemistry of Environmental Engineering, Tata McGraw Hill
4. Des Connell, Basic Concept of Environmental Chemistry, EEE
5. Schulze et al., Global biogeochemical cycles in the climate system, AP
6. Raj M, Emerging trends in environmental Pollution, IVY Pub. House
7. Kanan, Fundamentals of Environmental Pollution, S. Chand
8. Asthana & Asthana, Environmental Problems & Solutions, S. Chand
9. Krupa S.Y., Air Pollution, People & Plants: an Introduction, APS Press

10. De, AK., Environmental Chemistry
11. S.E. Manhan., Environmental Chemistry

MEC 23 ENVIRONMENTAL EARTH SCIENCE 50 marks

Objective: To impart to students basic geological knowledge for understanding the earth's processes and management resources (mineral and water) and natural hazards (Earthquakes, volcanism, landslides, floods, drought, etc.)

Expected outcome: The students will know the exo-genetic and endo-genetic geological processes that shape our earth. They will learn the process of erosion, transportation and deposition and the landforms developed by running water, wind glaciers and coastal water and analyze the role of human activity in modifying the natural processes and their consequences. They will also learn the importance of mineral resources, methods of mineral exploitation and the environmental issues associated with it, and different aspects of water resources, including water conservation and management methods, geochemistry and environmental health.

Unit I: Scope and importance of earth science in environmental science, Surface features and hypsometry of earth, Internal structure of earth; Rock weathering; Mass –movement and slope dynamics. River systems and fluvial processes; Coastal processes and landforms ; Aeolian processes and landforms, Glacial Processes and landforms; Role of Indigenous local community knowledge in the sustainable development of riparian, coastal, desert, mountain ecosystems. Plate tectonics as a unifying theory, Earthquake, volcanism. (12 hours)

Unit II: Mineral Resources and Environment: Types of minerals and their use, Concept of reserve and resources; Indian distribution of mineral deposits; Extraction Mining of minerals and fossil fuels, Environmental problems associated with mining industries, Oceans and new areas for exploration of mineral resources. Best Management Practices in Mining. (10 hours)

Unit III Water Resource: Consumptive and non-consumptive use of water ; Availability of water, global water balance and hydrological cycle, Flood and drought, Groundwater storage and movement in the aquifer; Rain water harvesting, Integrated watershed management. Traditional water conservation practices. (10 hours)

Unit IV: Environmental Geochemistry: Geochemical Classification; Crustal abundance of elements; Concepts of residence time and rate of natural cycles; Introduction to medical geology. Natural background levels vs. anthropogenic pollution, Geochemical behaviour of trace elements and radionuclides, Geochemical indicators of pollution and monitoring techniques. (8 hours)

Reference Books

1. Botkin & Keller, Environmental Science: Earth as a Living Planet, John Weily
2. Monroe, 1.S., The Changing Earth,
3. Edward, A, Environmental Geology, Prentice Hall
4. Raymond Seiver, Understanding Earth
5. Watson, 1. Geology and Man: An Introduction to Earth Science, George Allen & Unwin

6. G.B.Mahapatra, Textbook of Physical Geology
7. K.S. Valdiya, Geology, Environment & Society

MEC 24 ENERGY AND ENVIRONMENT **50 marks**

Objective: To make the students understand the increasing global energy needs and consumption with its impact; the principles of electricity generation in fossil-fuelled power plants, hydropower and nuclear power plant and their environmental impacts. To introduce renewable energy concepts and techniques – solar, wind, ocean waves, tides and geothermal energy; Biomass as a source of energy with their advantages and limitations.

Expected outcome: The students will learn the sector-wise changing trends in energy use patterns in different parts of the world. They will learn the basic principles and methods, efficiency and environmental impact of conventional energy resources such as thermal, nuclear and hydropower plants. They will also learn the principles and techniques (including recent developments) in renewable energy– solar, wind, ocean wave, tides, geothermal energy and bio-energy

Unit I: Basic concepts and forms of energy; Global energy use ; Energy use pattern in different parts of the world; Energy security. Electrical energy- generation, transmission and storage; Energy in Transportation. (8 hours)

Unit-II Conventional energy sources: Fossil fuels – Classification, composition, physio-chemical characteristics and energy content of coal, petroleum and natural gas; Fossil fueled power plants and their environmental impact. Hydro-power and its environmental impacts, Radioactivity and nuclear-fueled power plants, nuclear fuel cycle and radioactive waste. (10 hours)

Unit III Sun as source of energy, Solar thermal, power and Solar photovoltaic, Wind energy; Energy from ocean waves and tides; Geothermal energy, Indian initiatives in development of renewable energy, Traditional use of passive solar, wind and geothermal energy. (10 hours)

Unit IV Biomass as a source of energy; biomass composition and types; Biomass residues and energy conversion routes, Utilisation of biomass through biochemical and thermo-chemical routes ; energy plantation; Petro crops, bio-energy (algae, aquatic weeds, etc.), Anaerobic digestion; Definition, stages and factors affecting anaerobic digestion, Pretreatment and co-digestion, Conversion mechanism of biomass to biogas and its properties, Types of biogas digesters, Bioconversion of substrates into alcohol. (12 hours)

Reference Books:
1. Elliot, Energy, Society & Environment, Routledge Publ.
2. Clare Smith, Environmental Physics
3. J.A. Fay and D.S. Golomb, Energy and Environment

MEC 25. SOIL POLLUTION AND SOLID WASTE MANAGEMENT **50 marks**

Objective: Sources, behaviour and fate of soil pollutants; Sources and generation of solid wastes; Waste disposal, recycling and power generation, fly ash utilization; Management of solid wastes

Expected outcome: Understand the basic concept impact of various soil pollutants on the environment and also develop the knowledge of the impact and management of various soil wastes.

Unit I: Sources of soil pollution: industrial waste, agrochemicals, mining, urban waste, sewage sludge, Classification of soil pollutants: heavy metals, pesticides, hydrocarbons, PAHs, microplastics, Soil contamination vs degradation, Soil pollution indicators and health impacts. (8 hours)

Unit II: Heavy metals (As, Pb, Cd, Cr, Hg, Ni, Zn): speciation, mobility, bioavailability; Persistent organic pollutants (POPs): PCBs, dioxins, organochlorines; nano and microplastics, Pesticides: Fate, Transport, and degradation in Soil; Leachate and groundwater contamination; Soil-plant transfer and food chain implications. (10 hours)

Unit III: Soil sampling techniques and contamination assessment, Standards and Guidelines (Indian and international), Risk assessment and soil quality indices, Remediation techniques: Physical: soil washing, capping; Chemical: immobilization, stabilization, Biological: bioremediation, phytoremediation, composting, biochar. (8 hours)

Unit IV: Types and sources of solid waste, Sampling and characteristics, Estimation of solid waste quantity, Factors affecting solid waste generation rate. Recycling of waste materials. Waste disposal, recycling and power generation, fly ash utilization Methods of waste disposal & recycling: Composting- Definition and phases of composting, Factors affecting composting process, Types of composting, Compost quality. Vermicomposting, biogas, farmyard manure; Management of solid wastes; Biomedical wastes, Hazardous and toxic wastes, nuclear waste, Nature and source of Hazardous waste- Classification, Generation, Disposal, Reduction and Treatment, Recent governmental initiatives for waste management, Integrated solid waste management (ISWM), Public-Private-Partnership (PPP) in MSWM projects. (14 hours)

Reference Books:

1. G.M. Pierzynski, J. Thomas Sims and George F. Vance - Soils and Environmental Quality-
2. Ibrahim A Mirsal – Soil Pollution: Origin, Monitoring and Remediation
3. Yaron. B, Calvet R, and R. Prost.- Soil Pollution: Process and Dynamics
4. Maier, Pepper & Gerba, - Environmental Microbiology
5. Subba Rao N.S., Soil Microbiology

MEC 26. PRACTICAL-II 50 marks

Objective: Analyse soil and air quality parameters; Measure and analyze noise level, Computational works in Energy resources; Noise pollution; SPM, SO_2, NOx, Ozone; Chlorophyll content; Identification of common rocks and minerals; To get introduced to Toposheets and geological map; Drainage pattern assessment

Expected outcome: Organic carbon, N, P, K content in Soil; Computational works in Energy resources; Noise pollution; SPM, SO_2, NOx, Ozone; Chlorophyll content; Identification of

common rocks and minerals; Interpretation of Toposheet and geological map; Study of Drainage pattern for water resource management

MEC 26.
Environmental Diary
Organic content in Soil
N, P, K content in Soil
Computational works in Energy resources,
Noise pollution,
SPM, SO_2, NOx, Ozone,
Chlorophyll content
Identification of common rocks and minerals;
Interpretation of Toposheet and Geological Map
Drainage pattern assessment

Reference Books:
Soil analysis: Handbook of reference methods,. Soil and Plant Analysis Council Inc.

SEMESTER III

MEE 311 BASICS OF NATURAL RESOURCE MANAGEMENT **50 marks**

Objective: The main objective of this elective course is to orient and let the students of other departments understand the importance of various natural resources (water, land & mineral, Bioresources and Energy) and the problems associated with their over-exploitation and their management strategies.

Expected outcome: The students will learn about various natural resources (particularly water, land & mineral, Bioresources and Energy) and the problems associated with their over-exploitation and how one can manage them properly.

Unit- I: Water Resource: Uses and Availability of water, global water balance, Water resource development projects, basic concepts of groundwater, water conservation strategies.

(10hours)

Unit- II: Types of minerals and their use, Exploration and Extraction (mining), Environmental problems associated with mining industries, National Mineral Policy, Best Management, Practices in mining, land use and degradation. (10hours)

Unit III: Conventional energy sources: Fossil fuels - coal, petroleum and natural gas; Fossil fueled power plants, Hydro-power nuclear-fueled power plants, Solar energy, Wind energy Energy from oceans, geothermal energy (10hours)

Unit IV: Biodiversity and its significance, Strategies for biodiversity conservation, Biosphere Reserves, National Parks, Sanctuaries & Wetlands; Deforestation and its consequences, Bioprospecting. (10hours)

Reference Books:

1. Maiti, S.K., Handbook of Methods in Environmental Studies, Vol. I & II, ABD Publ
2. Chunlong Zhang., Fundamentals of Environmental Sampling and Analysis, Wiley Interscience

MEE 312 EMERGING ENVIRONMENTAL ISSUES **50 marks**

Objective: To familiarize **t**he students with contemporary and emerging environmental issues of local, regional and global significance

Expected outcome: Understand the recent development on various environmental issues related to population, development, disasters, Environmental Movements and Climate Change

Unit- I:. Linkage between population, development & environment (10hours)

Unit- II: Natural and Environmental Disasters: Issues & Management (10hours)

Unit III: Environmental Rights and Movements, Traditional Environmental Management Systems (10hours)

Unit IV: Climate Change and Climate Negotiations (10hours)

Reference Books:

1. Recent articles published in peer-reviewed journals and online materials

MEC 32 ECOLOGY 50 marks

Objective: To let the students be aware of the study of ecology and ecosystems, their types and how various components are intrinsically interconnected and dependent on each other. Also, how different laws are applied as well as nutrients are recycled involving different ecosystems and their continuing change and progression with time

Expected outcome: The students will learn about the various aspects of ecology and will understand the intricate relationships that exist among various components. They will also be enlightened about the various processes of the ecosystems and the services they provide that help us sustain our lives.

Unit I: Definition of ecology, Scope of ecology, Levels of organization hierarchy, Concept of Ecosystems, Producers, Consumers and decomposers, Interconnectedness of ecosystems (The Gaia hypothesis), Classification of ecosystems. Emergence of evolutionary thoughts and its mechanisms: Lamarck and Darwin concept, Mendelism, Hardy-Weinberg law, Species concept. (10 hours)

Unit II: The abiotic environment: Liebig's Law of minimum, Law of limiting factors, Law of tolerance, Soils, nutrients and other factors, Energy in ecological systems. Fundamental concepts related to energy, Solar radiation and the energy system, the Concept of productivity, food chain and food webs, the Concept of eMergy, exergy, ascendency and ecological footprint. (10 hours)

Unit III: Biogeochemcial cycles, Basic types of Biogeochemcial cycles, Hydrological cycle, Carbon cycle, Nitrogen cycle, Sulphur cycle, Phosphorus cycle, Nutrient budget (internal & external), Structural and functional components of ecosystems, Trophic structure of ecosystems, Energy flow in ecosystem; Pyramids of energy, biomass and number. (10 hours)

Unit IV: Population Ecology: Population growth curves, Population regulation, Interspecific (parasitism, predation, concept of niche, competition) and intraspecific relationships; Community Ecology; Structure and function of communities, Ecological succession, Major ecosystems of the world, Problems faced by ecosystems and their possible management. (10 hours)

Reference Books

1. Odum, E.P., Fundamentals of Ecology, Saunders Publ., Philadelphia
2. Odum, H.T., Basic Ecology
3. Rickfels, RE. & Miller, G.L. Ecology, Freeman & Comp., N.Y
4. Sharma, P.D., Ecology & Environment, Rastogi Pub., Delhi
5. Kormanday, E.1., Concept of Ecology, Prentice Hall, India
6. Chapman, lL.& Reiss, M.1., Ecology: Principles & Application, Cambridge Uni. Press.UK
7. Michael Ecological methods for field & Lab. Investigation
8. Hall, B.K., Hallgrimsson, B., Strickberger's Evolution, Jones & Bartlett Student Edition

MEC 33 ENVIRONMENTAL TOXICOLOGY 50 marks

Objective: To introduce the students to the basics of Environmental toxicology, which is a multidisciplinary field of science focusing on the study of the harmful effects of various chemical, biological, and physical agents on living organisms in the ecosystems, including humans. It contributes to the general knowledge of the harmful actions of chemical substances, to study their mechanisms of action, and to estimate their possible risks to humans on the basis of experimental work on biological test systems.

Expected outcome: The students would be able to critically evaluate different advanced exposure assessment methods of chemicals, Design methods for exposure assessment, Understand the advantages and disadvantages of toxicological and epidemiological studies for deriving dose-response relationships, Design methods for study of dose-response relations, Evaluate frequently used methods for health effect measurements; Gather knowledge in the risk assessment process; Will learn how the risk management process works in the practical field; Communicate the results and aware the public of the hazardous effects of the studied chemicals

Unit I: History of Toxicology, Toxicology in ancient Indian context, Classification of Xenobiotics, Basic principles in environmental toxicology, distribution & Fate of toxicants in the environment and organisms. (6 hours)

Unit II: Biotransformation and detoxification mechanisms, types of toxicity: acute, chronic, immediate and delayed; toxicity bioassays: static and continuous bioassay; Quantal dose-response, statistical concepts in environmental toxicology: LD_{50}, ED_{50}, LC_{50}. Toxicity of mixture of toxicants; Interaction of toxicants: synergism, antagonism, additive effect, potentiation; biomagnification, bioaccumulation, Influence of ecological factors on the effects of toxicity. (12 hours)

Unit III: Pollution of the Ecosphere by industries, global dispersion of toxic substances, sources and circulating mechanisms of pollutants, Degradable and non-degradable toxic substances. Toxic chemicals in the environment; Biochemical aspects of arsenic, cadmium, lead, mercury, carbon monoxide, ozone, PAN, Pesticides; Carcinogens in the environment. (12 hours)

Unit IV: Types of environmental health hazards, Waterborne disease, Air-borne diseases and allergies; applied toxicology: forensic toxicology, clinical toxicology, and occupational toxicology. (10 hours)

Reference Books:

1. Zakrzewski S, Environmental Toxicology, 3rd, Ed., Oxford Univ. Press
2. Wright D.A. & Welbourn, P., Environmental Toxicology, Cambridge Univ. Press
3. Loomis & Hays, Loomi 's Essentials of Toxicology, 4th Ed., Academic Press
4. Klaassen, CD., Amdur, M.D., Doull, J. (ed.), Toxicology, Mac MiJJan Pub. Company.

MEC 34 REMOTE SENSING AND GIS 50 marks

Objective: To introduce the principles and techniques of Remote Sensing and GIS in view of their increasing applications in sustainable development.

Expected outcome: Will learn the basic principles such as Electromagnetic radiation (EMR), different types of satellites and sensors and their Orbital characteristics, Remote Sensing Data types and resolutions (Spatial, Temporal, Spectral and Radiometric),
The basic concept of Arial Photography, Optical, Thermal and Microwave remote sensing:
Fundamentals of Digital Image Processing and Geographic Information system, Global Positioning System (GPS) with Introduction to GIS and IP packages;
Case studies related to Remote sensing and GIS applications in pollution monitoring, forest and vegetation mapping rural and urban land, disaster management, etc

Unit-I Principles and Basic concepts of Remote Sensing, The Electromagnetic Spectrum; Interaction of Electromagnetic Radiation with atmosphere and earth surface features; Spectral characteristics of rocks, soils, vegetation and water; Remote sensing satellites and sensors, Remote Sensing Data Products; Spatial, Temporal, Spectral and Radiometric Resolution. (10 hours)

Unit-II:Arial Photography and Drone survey; Optical Remote Sensing- FCC and its visual image Interpretation; Thermal remote sensing: Basic principles, Thermal sensors, characteristics of the image and their use. Microwave remote sensing: Basic definitions and principles, interaction between Microwaves and earth's surface; Interpretation and application of radar images. (10 hours)

Unit-III: Fundamentals of Digital Image Processing, Image Rectification, Image enhancement, Image classification; Geographic Information System:- Definitions and terminology, Spatial Data Models (Raster and vector); GIS Data Management; Data Input and editing; Data Analysis and Modelling; Introduction to GIS and IP packages, Basic principles and utility of Global Positioning System (GPS) and other Global Navigation Satellite Systems (GNSS). (10 hours)

Unit-IV: Remote sensing and GIS applications in pollution monitoring; land use/land cover mapping and Classification; water resource management and disaster management. (10 hours)

Reference Books

1. Lilles & Keifer, Remote Sensing & Image Interpretation, 3rd Ed, John Weily & Sons
2. Jenson, J.R., Remote Sensing of the Environment, Pearson Education, Delhi
3. Guha P.K., Remote Sensing for the Beginners
4. Joseph, Fundamental of Remote Sensing

MEC 35 ENVIRONMENTAL ECONOMICS AND SUSTAINABLE DEVELOPMENT **50 marks**

Objective: To explore the proper role of government, humans, institutions, and NGOs in the regulation of the environment. It will help students develop the tools to estimate the costs and benefits of environmental regulations. These tools will be used to evaluate a series of current policy issues, including the significance of air and water pollution regulations and their effectiveness, the costs of climate change in India and abroad, the importance of "sustainable development", method of proper uses of oil and other natural resources, energy efficiency.

Expected outcome: This course aims to provide students with sound knowledge and understanding of the major results of environmental economics. It helps to apply micro and macro-economic issues in environmental economics. It will probably convey the basics of thorough monetary investigation proceeded with the future learns at a more significant level or investigations of ecological and financial aspects.

Unit I: Concepts, Role, Scope and Significance of Environmental Economics, economics activities and the environment, the market economy, consumer behaviour and demand, producer behaviour and supply, consumer and producer surplus, efficiency and perfect competition, pareto efficiency, imperfect market, market failure and externalities- pecuniary, non-pecuniary or technological, consumption, monopoly and externality, externality and industrial output, approaches to environmental pollution, government policies. (12 hours)

Unit II: Method and Application- utility, benefits and costs analysis, concepts of risk and uncertainty, sensitivity analysis, risk analysis, stakeholder behaviours, existence and Bequest values, instruments for environmental control applications – non-compliance fees, tax emissions, economic and the environmental trends, economic growth and welfare, trade and the environment, policy implications. (10 hours)

Unit III: Issues and environmental problems- poverty, population and the environment, environmental degradation in developing countries, biodiversity losses, resource conservation-economics of conservation, limits to growth, ecological economics, thermodynamics and the environment, waste recycling, India's development in an ecological perspective. (10 hours)

Unit IV: Concept and strategies of sustainable development, SDGs, CSR, CER, Sustainability of resources. (8 hours)

Reference Book:
1. Hussell, A., Principles of Environmental Economics, Routledge
2. Faber, M & Manstelton, R, 1996, Ecological Economics, Edward Elger Pub.
3. Pearce, D.W & Turner, RK, Economics of Natural Resources & Environment, Harvester
4. Dasgupta, P. & Maler, K., 1998, Environmental & Developmental issues, Basil Blackwell.

MEC 36 PRACTICAL-III 50 marks

Objective: Ecology practical; Visual Interpretation of satellite imagery; Digital Image Processing; Bioassay methods in toxicology; Industrial tour; Local biodiversity of Santiniketan (Flora and avifauna)

Expected outcome: Student will be able to do various bioassays with different chemicals on plants, interpret satellite maps and do ecological indices

MEC 36
Ecology practical
Visual interpretation of satellite imagery;
Digital Image Processing;
Bioassay methods in toxicology
Industrial tour
Local biodiversity of Santiniketan (Flora and avifauna)

Reference Books
1. Abbasi & Ramasami, Biotechnological Method of Pollution Control, Univ. Press
2. Sadasivam, S. & Manikam, A., 1992, Biochemical Methods for Agricultural Sciences, Wiley Eastern Ltd.
3. Maiti, S.K., Handbook of Methods in Environmental Studies, Vol. I & II, ABD Publ.

SEMESTER IV

MEC 41 ENVIRONMENTAL BIOTECHNOLOGY 50 marks

Objective: The objective is to introduce the students to basic knowledge of biotechnology like biomonitoring, biomarker responses, Biosensors, Bioelectrodes, bioremediation, Global environmental problems and biotechnology, phytoremediation; Application of IPM technology and Ecoengineering for Sustainable Agriculture, Biofertilizers.

Expected outcome: Students understand the basic concepts of environmental biotechnology and its utilization to combat the various issues of pollution.

Unit I: Objective of Environmental biotechnology; concept of environmental microbiology, Applications of biotechnology in waste and environmental management, Role of biotechnology in maintaining ecological balance & combating various environmental problems, biomonitoring. (10 hours)

Unit II: Interpretation of biomarker responses- biological, statistical and societal interpretations; Conceptual strategy for development and application of biomarker-based biomonitoring; hazard identification and assessment of risk prediction; application potentials of immobilized macromolecules in bioassessments of environmental quality, Biosensors for detoxification of environmental contaminants; Bioelectrodes. (10 hours)

Unit III: Role biotechnology in bioremediation (control of water, air and soil pollution), solid waste management, degradation of Xenobiotics, hazardous waste management, applications to different industrial waste management, Global environmental problems and biotechnology, and phytoremediation. (10 hours)

Unit IV: Traditional versus Modern fuels, Role of biotechnology in cleaner technology, Application of IPM technology and Ecoengineering for Sustainable Agriculture, Biofertilizers, biopesticides, etc. (10 hours)

Reference Books

1. Agarwal, Environmental Biotechnology, APH Pub
2. Jogdand, Environmental Biotechnology, Himalaya Pub!.
3. Maier, Pepper & Gerba, Environmental Microbiology, Academic Press
4. Abbasi & Ramasami, Biotechnological A1ethod of Pollution Control, Univ. Press

MEC 42 ENVIRONMENTAL MANAGEMENT 50 marks

Objective: The course is centrally concerned with understanding deliberate efforts to translate environmental knowledge into action in order to achieve particular outcomes in the way landscapes, societies and/or natural ecosystems are used and managed. It will also consider how the objectives for land and resource use are shaped, fashioned and contested in democratic and

non-democratic settings. The course will critically examine contemporary thinking on these environmental themes, including sustainable use practices, NGO and community-based approaches, social learning, and ISO 14000 systems, EIA practices.

Expected outcome: After studying this course, students should be able to understand the usefulness of systems thinking in relation to environmental management in organizations like plan, do, check & act, and describe organizations as systems like ISO 14000, Environmental Impact Assessment (EIA) practices and their role in environmental management; analyze environmental management in relation to the major principles of sustainable development. The student can analyze industry environment relationships by applying Environmental Auditing (EA), EIA, Life Cycle Analysis (LCA), etc.

Unit-I Definition and Scope of Environmental Management (EM) Characteristics and goals of EM; Tools of EM, participants of EM; Environmental Management System (EMS); Definition, need of EMS, Core element of EMS, Benefits of EMS; Concept of Adaptive Management (AM), condition that warrant AM, steps in the process of AM. (10 hours)

Unit II: Environment Management Planning (EMP); Concepts – the need for EMP, the need for Environmental management policy from an Indian perspective; Case studies of EMP; Baseline information system, concept, importance in environmental management, important aspects in building a baseline information system. (10 hours)

Unit III: Environmental assessment, economic assessment, benefit-cost analysis, environmental impact statement (EIS), environmental audit, waste minimization programme and environmental management system, life cycle assessment (LCA), environmental design, ISO 14000 series, concept, basic principles of ISO 14000 series, components of ISO 14001, benefits of implementing ISO 14001 under Indian context, case studies. (10 hours)

Unit IV: Joint Forest Management, concept, Genesis of JFM, National resolution on JFM 1990. JFM vis-a-vis Village Forest Committee (VFC) benefit sharing, Natural Disaster Management (NDM), the definition of disaster, types of disaster, manmade and natural, stages of disaster management, and the role of scientific and local knowledge in NDM. (10 hours)

MEC 43 ENVIRONMENTAL EDUCATION, POLICY AND LEGISLATION 50 marks

Objective: Environmental Law may be the one institution standing between us and planetary exhaustion. It is a substantive understanding of the gradual evolution of pertinent themes in the environment shall be imparted so that the student is not only conversant with the overall framework of environmental Law but also becomes acquainted with fundamental concepts of basic themes. The basic objective is to familiarize the concept and Scope of environmental Law and policy and also of its particular dominant issues so as to become a valuable addition to learning and to ignite academic/research interest, eventually. Students are also enriched by being aware of the social movements related to the environment and the Role of NGOs in this regard.

Expected outcome: Learning about the significance of developments in international environmental Law and the fundamental principles that have emerged, comprehending the statutory and regulatory mechanisms pertaining to the environment in India. Studying the Role of international/ national environmental institutions, NGOs, civil society, and community involvement in promoting the cause of the environment. Understanding the emerging environmental issues like ozone depletion, climate change, energy crisis, nuclear issues, waste accumulation, marine ecology etc. and the viability of posited solutions.

Unit I Legislation and Public Policy Strategies in Pollution control, Legal Provisions for Environmental Protection in India (The Acts and the Rules), Sanction and enforcement bodies of environmental laws (WHO, CPCB, SPCB), Role of Supreme Court in Environmental Matters; Green Benches; International Conventions and Treaties, Eco-mark. (10 hours)

Unit II. Role of tradition and culture in environmental conservation, Environmental ethics, Gandhi & Tagore as Environmentalists, Western Environmental thoughts, Eco-feminism, Man-Nature-Society, Issue and events in the growth of Environmental Sociology in India and the West. (10 hours)

Unit III: Origin and development of Environmental Impact Assessment (EIA), EIA in project planning and implementation, EIA methodologies, evaluation criteria, Risk assessment and management, mitigation measures, Comparison of alternatives, Review and decision making, EIA Case studies. (10 hours)

Unit IV: Environmental education and awareness, people participation and environmental movements (Silent Valley, Chipko, Appiko, Narmada, Tehri & Garwal Dam movements) Environmental groups and community-based planning, Role of NGO in environmental issues. (10 hours)

Reference Books

1. Canter, Environmental Impact Assessment, McGraw-Hill.
2. Saxena, Environmental Management, Rawat Publication
3. Chary & Vyasula, Environmental Management: An Indian Perspective, MacMillan
4. Srivastava, Environmental Impact Assessment, APR Publication.
5. Agrawal, Environmental Laws: Indian Perspective, Nidhi Publication.
6. Kasemir, B., Jager, J., Jaeger, c.c. & Gardner, M.T, Public Participation in Sustainability Science: A Handbook, Cambridge Univ Press, UK

MEO 44. OPTIONAL PAPER (Any one of the following): 50 Marks

MEO -441 Ecotoxicology,

MEO 442-Air Pollution & Health

MEO 443- Hydrology & Water Management,

MEO 444- Soil Pollution

MEO 441. ECOTOXICOLOGY

Objective: The objective is to introduce the students to a multidisciplinary approach to integrate toxicology, ecology, chemistry, and biochemistry. Understand in detail the effects of toxic chemicals on organisms at the population, community, and ecosystem level.

Expected outcome: Students understand the effects of exposure of organisms (plant/animal) and its remediation to potentially hazardous environmental chemicals and biological agents up to ecosystem and community levels.

Unit I: Major classes of pollutants, Inorganic and Organic pollutants, Organometallic compounds, Radioactive isotopes, Gaseous pollutants, Routes by which pollutants enter ecosystems, Entry into surface waters, Contamination of land, Discharge into the atmosphere, Long-range movements and global Transport of pollutants, Factors determining movement and distribution of pollutants, Transport in water, Transport in air. (10 hours)

Unit II: The Fate of Metals and Radioactive Isotopes in Contaminated Ecosystems, Terrestrial Ecosystems, Aquatic systems, The Fate of organic pollutants in individuals and ecosystems, Fate within individual organisms, Organic pollutants in terrestrial ecosystems, and Organic pollutants in aquatic ecosystems. (10 hours)

Unit III: Toxicity testing, Determination of the toxicity of mixtures, Toxicity testing with terrestrial organisms, Toxicity testing with aquatic organisms, Risk assessment, Toxicity testing in the field, Biochemical and Physiological effects of pollutants, Protective biochemical responses, Molecular mechanisms of toxicity, Examples of molecular mechanisms of toxicity Effects of pollutants at the cellular level, Effects at the organ level, Effects at the whole organism level, Effects on plants. (10 hours)

Unit IV: Interactive effects of pollutants, Additive effects, Potentiation of toxicity, Potentiation due to inhibition of detoxication, Potentiation due to increased activation, The detection of Potentiation in the field, Changes in communities and ecosystems, Soil processes: the functional approach, Changes in communities in response to pollution, Global processes Biomarkers in population studies. (10 hours)

Reference Books

1. Walker CH et al., Principles of Ecotoxicology
2. Hoffman, Handbook of Ecotoxicology
3. Newman & Clement, Ecotoxicology: a comprehensive treatment

MEO 442 AIR POLLUTION AND HEALTH

Objective: To let the students understand the atmosphere, an important component of the environment, and how this component is degraded due to the release of pollutants, including recent developments in the field and noise from various sources. To explain to the students how these pollutants affect (at morphological, biochemical and physiological levels) our health and well-being and what provisions are available for monitoring and control of this pollution in India.

Expected outcome: The students will understand the atmosphere and how this component is degraded due to the release of air pollutants and noise from various sources, including the atmospheric chemistry of the chemical constituents. It will also help the students understand how these pollutants affect our health and well-being (in somewhat great detail) and what provisions are available for monitoring and control of air pollution in India.

Unit I: Introduction to the atmosphere and its interaction with living and non-living systems, Causes and sources of air pollution, Concept of health, Importance of studying Air Pollution and Health, Status of air pollution damage in India and the world. (8 hours)

Unit II: Air pollution threshold levels and injury, concept of critical load, Bioindicators; Effects of air pollutants (particulate & gaseous) on morphological, biochemical and physiological levels in trees and crop plants. (10 hours)

Unit III: Air pollution and forest decline; effect of air pollutants at ecosystem level (direct and indirect), air pollution and biodiversity. Case studies on industrial air pollution (stone crushing, mining etc.) on forest ecosystem services. Concept of air pollution tolerance index (APTI), anticipated performance index (API), importance value index (IVI) etc. Air pollution abatement by green plants and the concept of green belts development. (10 hours)

Unit IV: Air pollution and human, and animal health, study of various lung functions, biochemical and epidemiological parameters for ascertaining air pollution effects on health, COPD, DALY. Questionnaire and impact study, Effects of noise on human health, Regulatory Authority and air pollution damage control systems in India, Development of air quality standards and criteria. (12 hours)

Reference Book:

Bell, J. N. B. and Threshow, M., 2002. Air Pollution and Plant Life. 2nd edition, John Wiley & Sons. Ltd.
Subrahmanyam, G. V., Rao, D. N., Varshney, C. K. and Biswas, D. K., 1985. Air Pollution and Plants: A State-of-the-Art Report. Pub: Ministry of Environment and Forests, Department of Environment, Govt. of India, New Delhi.
Gurjar, Molina, and Ojha, Air Pollution: Health & Environmental Impacts, CRC Press, 2010
Godish, T. Air Quality, Lewis Publisher, 2004.

Raj M, Emerging trends in environmental Pollution, IVY Pub. House
Krupa S.V., Air Pollution, People & Plants: an Introduction, APS Press
Smith, W. Air Pollution and Forests, Academic Press.
S.E. Manhan., Environmental Chemistry
Cheremisinoff, N. P., 2004. Handbook of Air Pollution Prevention and Control. N & P Ltd. Butterworth-Heinemann, Elsevier Print.

MEO 443 HYDROLOGY AND WATER MANAGEMENT

Objective: To teach the basic Nature and characteristics of surface and subsurface water and its movements that are important for the management of water as a resource.

To appreciate the significance of water security and water management strategies.

Expected outcome: Will learn the detailed hydrological cycle and global water balance.
Principles of hydro-geomorphology and its application in watershed characteristics, runoff and sediment yield, and stream flow estimation. Principles of groundwater flow, Well hydraulics, groundwater modelling;
Will be introduced to the conflicts among stakeholders to water use rights and the laws and policies associated with them.
Traditional and modern approaches to water conservation and management

Unit- I. Water: a global perspective, water as a resource, Surface water, precipitation and runoff, Principles of hydro-geomorphology, watershed characteristics, River basins of India. (10 hours)

Unit- II. Groundwater basics, Principles of groundwater movement, Well hydraulics, Groundwater exploration and extraction, Arsenic and fluoride in Groundwater, saltwater intrusion, groundwater tracers; Groundwater modelling. (10 hours)

Unit- III. Changing patterns in water use and management, Water security and water conflicts, National Water Policy, Impact of climate change on water resources. (10 hours)

Unit- IV. Rainwater harvesting, Watershed development, Geospatial technology in water management. Alternative sources of water, Historical and traditional knowledge in water resource management. (10 hours)

References Books :
D.K. Todd, Groundwater Hydrology
R. Nagarajan , Water
Md. Babar, Hydrogeomorphology

MEO 444 SOIL POLLUTION AND CHEMICAL SPECIATION

Objective: Introduce the concept of chemical speciation, Bioavailability and ecotoxicity and various Tools to assess bioavailability, sample preparation- separation techniques, detection, risk assessments/regulations; and Bioremediation.

Expected outcome: Students understand the concept of chemical speciation, its analysis, and the concept of bioavailability of pollutants for both organic and inorganic pollutants.

Unit- I. Trace Elements In Soil- Sources and Origins of Heavy Metals - the interaction of trace elements- Biogeochemical cycles – ecotoxicological effects –individual behaviour of selected elements – analytical procedures; Remediation techniques - physical- chemical – biological techniques. (10 hours)

Unit- II. Speciation of metals in the environment- Chemical speciation – techniques – Sampling- Collection, Storage; Sample Preparation; Separation Techniques; Detection; Risk Assessments/Regulations; Toxic and other adverse biological effects of trace metals. (10 hours)

Unit- III. Bioavailability - new concepts and definitions; the role of chemical speciation in bioavailability; Bioavailability and ecotoxicity of contaminants; Bioavailability of nutrients and agrichemicals; Tools to assess bioavailability; the role of bioavailability in risk assessment and remediation. (10 hours)

Unit- IV. Organic Compounds in Soil – pesticides - POPs – source – behaviour and environmental Fate and Transport; physical and chemical properties that determine environmental Fate- chemical transformation and degradation; chemistry and toxicology of important POPs and pesticides - risk assessment and risk reduction; Pharmaceuticals and Personal Care products - Endocrine Disrupting Chemical; Organic pollutants - sample preparation- separation techniques; detection; risk assessments/regulations; Bioremediation. (10 hours)

Reference Books:

1. Cornelis R. et al. (Ed.). *Handbook of Elemental Speciation: Techniques and Methodology*, John Wiley & Sons Ltd, 2003
2. Ure A.M. and Davidson C.M., (Ed.) *Chemical Speciation in the Environment*, Second Edition, Blackwell Science Ltd, 2002
3. Naidu R. et l. (Ed.) *Chemical Bioavailability In Terrestrial Environments*, Elsevier, 2008
4. Kabata-Pendias A., Mukherjee A. B., *Trace Elements from Soil to Human*, Springer-Verlag Berlin Heidelberg 2007
5. Li A. et al. (Ed.) *Persistent Organic Pollutants in Asia Sources, Distributions, Transport and Fate*, Elsevier, 2007
6. Leo M.L. Nollet and Hamir S. Rathore. , *Handbook of Pesticides - Methods of Pesticide Residues Analysis*, Taylor and Francis Group, 2010
7. Harrison, R. M., *Pollution: Causes, Effects and Control*, The Royal Society of Chemistry, 2001

MEC 45 PROJECT WORK **100 marks**

Objective: Field and Lab-based work on various environmental issues would be done by students in the IV semester (although they start working in III semester). Major areas of their work would be air, Soil, water pollution, biodiversity, microbiology, biogas technology, remote sensing and GIS.

Expected outcome: Students having an interest in a particular area will work and develop practical knowledge in that field and submit a project report which has to be defended. The students will have extensive practical knowledge of Sampling, analyses and handing various sophisticated instruments.