

**DEPARTMENT OF ENVIRONMENTAL STUDIES (Modified Syllabus, 2018)**

**Siksha-Bhavana, Visva-Bharati**

<b>Syllabus for M.Sc. course in Environmental Sciences</b>		<b>(Total 1200 marks)</b>	
<b>Semester I</b>	<b>(5 theory and 1 practical paper)</b>	<b>Total Marks (Internal + Final)</b>	
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)
		<b>Total</b>	<b>300 marks</b>
<b>Semester II</b>	<b>(5 theory and 1 practical paper)</b>		
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)
		<b>Total</b>	<b>300 marks</b>
<b>Semester III</b>	<b>(5 theory and 1 practical paper)</b>	<b>Total Marks (Internal + Final)</b>	
MEE 31	<b>Course selected for the Elective</b> (MEE 311- Environmental Monitoring and Management, MEE 312 Current Issues in Environmental Sciences)	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)
		<b>Total</b>	<b>300 marks</b>
<b>Semester IV</b>	<b>(4 theory and 1 project paper)</b>		
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	
		<b>Total</b>	<b>300 marks</b>

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**Siksha-Bhavana, Visva-Bharati**

**Syllabus for M.Sc. course in Environmental Sciences**

<b>Semester I</b>		<b>Total Credits</b>	<b>Total marks</b>
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
<b>Semester II</b>			
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
<b>Semester III</b>			
MEE 31	<b>Course selected for the Elective</b> (MEE 311- Environmental Monitoring and Management, MEE 312 Current Issues in Environmental Sciences )	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
<b>Semester IV</b>			
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**

**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.

**Unit II:** Introduction to the Earth Systems: Composition, structure and evolution of lithosphere, hydrosphere and atmosphere; Geological time scale and Past records of life.

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

**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.

#### **References:**

1. Botkin, D.B.& Keller, E.A Environmental Science: Earth as a Living Planet, John Wiley, 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**

**Unit I:** Introduction to weather and climate system; Scale of meteorology, Heat budget of the earth; Synoptic Weather (Temperature, Pressure, Precipitation, Humidity, Cloudiness, Visibility, Wind) and their variation patterns.

**Unit II:** Planetary scale motions in the atmosphere and oceans; Monsoon; ENSO, extreme weather events, Tropical Cyclones and Western Disturbances, Classification of climates – Koppen's and Thornthwaite's scheme of classification.

**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, Plume rise, Dispersion of plume.

**Unit IV:** Climate forcing and feedbacks, Past climate record, possible causes of recent climate change, model strategies for predicting climate change, Greenhouse effect, Global warming & Climate change, Consequences of climate change, International treaties and protocol on climate change.

**References:**

1. Barry RG & RJ Chorley, Atmosphere, Weather & Climate, 7th Ed., Routledge
2. D. Lal, Climatology

**MEC 13. PRINCIPLES OF SOIL SCIENCE**

**50 marks**

**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.

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

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

**Unit IV:** Soil quality and fertility- Soil nutrients- Soil Nitrogen, Phosphorus, Potassium and Sulfur and its Environmental Quality and Agriculture.

**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 and 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**

**Unit I:** Need & Scope of Environmental Sampling & Monitoring, Concentration units, Analytical precision, accuracy and recovery, detection limit and quantization limit, standard calibration curve.

**Unit II:** Environmental sampling approaches, Surface water and waste water sampling, ground water sampling, soil and sediment sampling, Biological sampling, ambient air and stack sampling.

**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).

**Unit IV:** Principles of Gravimetry, Titrimetry and Colorimetry; Principles of Spectroscopy (UV-VIS, AAS), Electrophoresis, X-ray fluorescence (XRF), X-ray Diffraction (XRD), Flame photometry, Western blot, Northern blot, Southern blot.

**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**

**Unit I:** Chemistry of water & water pollutants; Importance of water to life forms; Nature and type of water pollutants; Elemental pollution, Heavy metals, Metalloids, Organic Pollutants, Persistent organic pollutants, Pesticides in water, radioactive and thermal pollution.

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

**Unit III:** Waste water treatment and water use, Municipal water treatment, Treatment of water for industrial use, Sewage treatment, Removal of solids, Removal of calcium and other metals, Sludge, Water disinfection.

**Unit IV:** Monitoring (chemical & microbiological methods) and control of water pollution. River Action Plan; Source of marine pollution and control, Ground water pollution with special reference to West Bengal (Fluoride and Arsenic).

**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**

- Study of microorganisms from water and soil,
- Study of pond biota (phytoplanktons, zooplanktons)
- Study of physicochemical parameters of water and soil (temperature, pH, DO, dissolved CO<sub>2</sub>, 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**

**Unit I:** Biodiversity and its significance; Species diversity & its measurement; Flora, Fauna and Biodiversity hotspots of India and world; Endangered, threatened, endemic & invasive species, Keystone species, Red Data book.

**Unit II:** Biosphere Reserves, National Parks, Sanctuaries & Wetlands; Concept of wildlife, importance of wild life, Strategies for biodiversity conservation and Agenda -21, Convention on biodiversity.

**Unit III:** Deforestation and its consequences, Conservation and preservation, Afforestation, Social and farm forestry.

**Unit IV:** Ecological Degradation Due to Exploitation of Natural Resources and Development, Eco-restoration, Health and conservation, Bioprospecting, Man-animal conflict, Forest and wild-life conservation, Sacred grooves, Traditional Resource Management Systems, Traditional Wisdom, Eco-tourism.

**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**

**Unit I:** Chemistry of Atmosphere; Thermochemical & photochemical reactions in the atmosphere. 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.

**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.

**Unit III:** Ozone layer depletion, Ground level ozone and oxidants, Effects of oxidants on living systems, Role of international community in protecting ozone layer.

**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.

**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**

**Unit I:** Surface features and Internal structure of earth; Weathering and Erosion; Mass wasting; Erosion, transportation and deposition by running water, wind and glaciers; Fluvial processes and landforms; Drainage patterns; Coastal landforms and Processes; Plate tectonics as a unifying theory, Earthquake, volcanism.

**Unit II:** Mineral Resources and Environment : Types of minerals and their use, Concept of reserve and resources; Genesis and distribution of mineral deposits; Exploration and Extraction (mining) methods for mineral resources, Environmental problems associated with mining industries, Oceans and new areas for exploration of mineral resources. National Mineral Policy, Best management Practices in mining.

**Unit III** Water Resource: Use of water (domestic, agricultural and industrial non-consumptive use); Availability of water, global water balance and hydrological cycle, Water resource development projects, Flood and drought, Ground water storage and flow, National Water Policy, Rain water harvesting, Integrated watershed management.

**Unit IV:** Environmental Geochemistry: Geochemical Classification; Crustal abundance of elements; Concepts of residence time and rate of natural cycles; Geology and environmental health

**Reference Books**

1. Botkin & Keller, Environmental Science: Earth as a Living Planet, John Wiley
2. Monroe, I.S., The Changing Earth,
3. Edward, A, Environmental Geology, Prentice Hall



4. Raymond Seiver, Understanding Earth
5. Watson, I., Geology and Man: An Introduction to Earth Science, George Allen & Unwin
6. G.B.Mahapatra , Textbook of Physical Geology
7. K.S. Valdiya, Geology Environmental & Society

### **MEC 24 ENERGY AND ENVIRONMENT**

**50 marks**

**Unit I:** Basic concepts and forms of energy; Principles of energy conversion; Global energy use and supply; Energy use pattern in different parts of the world, Electrical energy- generation, transmission and storage; energy in transportation

**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 their environmental impacts, Radioactivity and nuclear fueled power plants, Nuclear fuel cycle and radioactive waste, nuclear-fission and fusion

**Unit III** Sun as source of energy, Passive Solar energy, Solar thermal energy, solar collectors, solar ponds; Solar photovoltaic cells, Wind energy Energy from ocean wave and tides, geothermal energy

**Unit IV** Biomass as source of energy; biomass composition and types; biomass conversion; gasification etc; energy plantation; Petro crops, bio-energy (algae, aquatic weeds etc.), biogas

#### **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**

**Unit I:** Sources, behavior and fate of soil pollutants; Effects of soil pollutants on biota, crops, vegetation; Interaction of fertilizers, pesticides, industrial waste effluents and heavy metals with different components of soil.

**Unit-II:** Soil micro-organisms and their functions; Role of microorganisms in the biochemical cycles; N -fixation & P- solubilization; degradation of different insecticides, fungicides and weedicides in soil, residual toxicity. Losses of these substances due to volatilization, leaching and microbial immobilization, their toxicity and pollution.

**Unit III:** Sources and generation of solid wastes, Different methods of dispersal and management of solid wastes. Recycling of waste materials. Waste disposal, recycling and power generation, fly ash utilization Methods of waste disposal & recycling: Vermi-composting, biogas, farmyard manure, Management of solid wastes.

**Unit IV:** Biomedical wastes, Hazardous and toxic wastes, nuclear waste, Nature and source of Hazardous waste- Classification, Generation, Disposal, Reduction and treatment.

**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**

Environmental Diary  
Organic content in Soil  
N, P, K content in Soil  
Computational works in Energy resources,  
Noise pollution,  
SPM, SO<sub>2</sub>, NO<sub>x</sub>, 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 ENVIRONMENTAL MONITORING & MANAGEMENT

**50 marks**

**Unit- I:** Need & Scope of Air Sampling & Monitoring, air sampling approaches, Status of air pollution in India, Instrumentation in air monitoring, Air pollution monitoring & control, Noise Pollution monitoring.

**Unit- II:** Water Quality Parameters, Surface and Ground water Sampling, Water pollution monitoring programmes, River action plans.

**Unit- III:** Soil pollution –Source and impact of trace elements, nutrients and organic contaminants; Source of solid waste and its management; Biomedical waste; Cause, impact and remediation of soil erosion, land degradation, desertification.

**Unit-IV:** Bioindicators. Biomonitoring- air, water and soil.

### MEE 312 CURRENT ISSUES IN ENVIRONMENTAL SCIENCE

**50 marks**

**Unit- I:** Pollution Abatement Technology – Biotechnology - Waste management – Green chemistry – Pollution – Case studies – Environmental Hazards – Nanotechnology and the Environment - Analytical Techniques.

**Unit- II:** Wildlife – Conservation of Endangered and Threatened species – Red data book- Bioprospecting - Biopiracy- – Traditional knowledge – Tribal rights - Ecosystems and Human Well Being Current State and Trends.

**Unit III:** Movement- Environmental Rights – Environmental Law – International Environmental treaties- Environmental disputes- Environmental law suits and PIL - Environmental policy - Environmental education.

**Unit IV:** Climate Change - Carbon credit - Rehabilitation - Local waste management - Phase out of toxic chemical – Alternative Energy sources and technology - Understanding and Solving Environmental Problems in the 21st Century.

### MEC 32 ECOLOGY

**50 marks**

**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.

**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, The laws of thermodynamics, Solar radiation and the energy system, Concept of productivity, food chain and food webs, Concept of energy, exergy, ascendancy and ecological footprint.

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

**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.

#### **Reference Books**

1. Odum, E.P., Fundamentals of Ecology, Saunders Publ., Philadelphia
2. Odum, H.T., Basic Ecology
3. Rickfels, R.E. & Miller, G.L. Ecology, Freeman & Comp., N.Y
4. Sharma, P.D., Ecology & Environment, Rastogi Pub., Delhi
5. Kormanday, E.1., Concept of Ecology, Pentis Hall, India
6. Chapman, J.L. & 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**

**Unit I:** Classification of Xenobiotics, Basic principles in environmental toxicology, distribution & fate of toxicants in the environment and organisms.

**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<sub>50</sub>, ED<sub>50</sub>, LC<sub>50</sub>. Toxicity of mixture of toxicants; Interaction of toxicants: synergism, antagonism, additive effect, potentiation; biomagnification, bioaccumulation, Influence of ecological factors on the effects of toxicity.

**Unit III:** Pollution of the Ecosphere by industries, global dispersion of toxic substance, 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.

**Unit IV:** Types of environmental health hazards, Water borne disease, Air-borne diseases and allergies; applied toxicology: forensic toxicology, clinical toxicology, and occupational toxicology.

**Reference Books:**

1. Zakrzewski S, Environmental Toxicology, 3<sup>rd</sup>, Ed., Oxford Univ. Press
2. Wright D.A. & Welbourn, P., Environmental Toxicology, Cambridge Univ. Press
3. Loomis & Hays, Loomis '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**

**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; Indian Scenario of remote sensing, Earth Resource and Meteorological satellites; Orbital characteristics, Characteristic and types of Remote sensors, Remote Sensing Data Products; Spatial, Temporal, Spectral and Radiometric Resolution.

**Unit-II:** Basic concept of Arial Photography and photogrammetry, Visible and NIR Remote Sensing: FCC, Visual image Interpretation . Thermal remote sensing: Basic principles, Thermal sensors, characteristics of image and their use. Microwave remote sensing: Basic definitions and principles, interaction between Microwaves and earth's surface; Interpretation and application of radar images.

**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 advantages of Global Positioning System (GPS).

**Unit-IV:** Remote sensing applications in pollution monitoring; forest and vegetation mapping; Remote sensing and GIS applications in rural and urban land use mapping; water resource monitoring and geologic hazard zonation mapping; Geospatial technology for sustainable development.

**Reference Books**

1. Lilles & Keifer, Remote Sensing & Image Interpretation, 3rd Ed, John Wiley & 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**

**Unit I:** Economics and Environment- concepts, role, scope and significance of environmental economics, natural environment, environmental ecology, economics activities and the environment, the market economy, consumer behavior and demand, producer behavior 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 ad industrial output, approaches to environmental pollution, government policies.

**Unit II:** Method and Application- utility, benefits and costs analysis, concepts of risk and uncertainty, sensitivity analysis, risk analysis, stakeholder behaviors, 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.

**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.

**Unit IV:** Concept and strategies of sustainable development, Sustainability of resources.

### **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**

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**

**Unit I:** Objective of Environmental biotechnology; Role of biotechnology in maintaining ecological balance & combating various environmental problems, Biomonitoring.

**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.

**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, phytoremediation.

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

#### **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**

**Unit-I** Environmental Management: 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.

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

**Unit III:** Tools applied in environmental management; 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.

**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), definition of disaster, types of disaster, manmade and natural, stages of disaster management, role of scientific and local knowledge in NDM.

### **MEC 43 ENVIRONMENTAL EDUCATION, POLICY AND LEGISLATION 50 marks**

**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.

**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.

**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.

**Unit IV:** Environmental education and awareness, Peoples 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.

#### **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 441. ECOTOXICOLOGY**

**Unit I:** Major classes of pollutant, 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.

**Unit II:** The fate of metals and radioactive isotopes in contaminated ecosystems, Terrestrial ecosystems, Aquatic systems The fate of organic pollutants in individuals and in ecosystems, Fate within individual organisms, Organic pollutants in terrestrial ecosystems, Organic pollutants in aquatic ecosystems.

**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.

**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.

#### **Reference Books**

Walker CH et al., Principles of Ecotoxicology

Hoffman, Hand book of Ecotoxicology

Newman & Clement, Ecotoxicology: a comprehensive treatment

### **MEO 442 AIR POLLUTION AND HEALTH**

**Unit I:** Introduction to atmosphere and its interaction with living and non-living systems, Causes and sources of air pollution, Importance of studying Air pollution and Health, Status of air pollution damage in India and world.

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

**Unit III:** Air pollution and forest decline; effect of air pollutant at ecosystem level (direct and indirect), air pollution and biodiversity. Air pollution abatement by green plants and green belts.

**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, Questionnaire and impact study, Effects of noise on human health, Regulatory Authority and air pollution damage control systems in India, Air quality standards and criteria.

#### **Reference Book:**

Bell, J. N. B. and Threshow, M., 2002. Air Pollution and Plant Life. 2<sup>nd</sup> 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**

**Unit- I.** Water: a global perspective, water as a resource, Surface water, precipitation and run off, Principles of hydro-geomorphology, watershed characteristics, runoff and sediment yield, stream flow, lake and wetland hydrology.

**Unit- II.** Groundwater basics, Principles of ground water flow, Well hydraulics, groundwater quality, ground water modelling.

**Unit- III.** Changing patterns in water use and management, Water law, National Water Policy, Impact of climate change on water resources.

**Unit- IV.** Rain water harvesting, Watershed development, Geospatial technology in water management.

#### **References Books :**

D.K. Todd, Groundwater Hydrology

R. Nagarajan , Water

Md. Babar , Hydrogeomorphology

## **MEO 444 SOIL POLLUTION**

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

**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.

**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.

**Unit- IV.** Organic Compounds in Soil – pesticides - POPs – source – behavior 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.

### 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
8. Schwarzenbach R. P., Gschwend P.M., Imboden D.M., *Environmental Organic chemistry*, Second Edition, John Wiley & Sons, 2003.

## **MEC 45 PROJECT WORK**

**100 marks**