School of Environmental Sciences, JNU

M. Sc. Programme

The M. Sc. programme is spread over four semesters. It carries 64 credits and comprises of four different components viz: I) Teaching II) Lab Work III) Field Work and IV) Dissertation.

Distribution of credits for M. Sc. Programme is:

Total Credits for M. Sc. Degree Programme = 64 credits

I) Teaching = 50 credits

II) Lab work, Field work and Dissertation = 14 credits

Distribution of credits for teaching (Total 50 credits)

i) Core courses = 26 credits

ii) Optional courses = 24 credits

Distribution of credits for Lab work, Field work and Dissertation (Total 14 credits)

a) Lab work = 6 credits (Lab Work I =3 credits; Lab Work II =3 credits)

b) Field work = 3 credits

c) Dissertation = 5 credits

I) Teaching (50 credits)

Teaching is a major component of the programme. It shares 50 credits out of total 64. The remaining three components i.e. Lab work, field work and dissertation share remaining 14 credits

Various courses offered under M. Sc. programme are categorized as:

A) Core courses

B) Non Credit courses and

C) Optional courses.

Altogether there are 46 courses: 13 as core, 2 non credit courses and 31 optional courses. All core courses are offered in I and II semesters and all optional courses are offered in III and IV semester of the M. Sc programme.

All Core Courses are of 2 credits each and compulsory for all the students. Non credit courses do not carry any credits, however, as per the JNU ordinance, completion of such courses by every student is a mandatory requirement for the award of the degree. Optional courses are of 3 credits each and cover all specialized courses across different sub disciplines of environmental sciences namely; Mathematics, Physics, Statistics, Geology, Chemistry and Biology. There is a running list of 31 optional courses, out of which students will have to choose any 8 optional courses (four in each semester) to obtain 24 credits.

II) Lab work, Field work and Dissertation (14 credits)

a) Lab work (6 credits)

The lab work component is spread over first two semesters and is called as Lab work I and Lab work II to be completed in I and II semesters respectively. Under Lab Work I and II, sets of experiments specially designed for M. Sc. students by faculty members of the school are carried out in M. Sc. lab or in the lab of the concerned faculty member during the period of five working days in the afternoon.

b) Field work (3 credits)

To strengthen the field work component and to have a wider exposure of the field conditions, students will undergo extensive field work which will help them in developing the understanding of different aspects of environmental sciences. Field work is completed in second semester. Each student will submit his/her field work report for evaluation.

c) Dissertation (5 credits)

Each student will work for M. Sc. Project under the supervision of formally assigned supervisor in the school. Assigning of supervisor will be based on academic interest shown by the student in research specialization of the concerned faculty member followed by the consent given by the faculty member to supervise the project work of that particular student. Student shall complete the process of academic interaction to obtain teachers consent to supervise his/her project work by the end of second

semester. The work on research project will start in 3rd semester under the supervision of concerned faculty member in his /her lab and will be completed by 4th semester with writing and submission of dissertation. Dissertation will be evaluated by a 3 member expert committee. Students will have to present their work and defend it in an open viva- voce.

LIST OF COURSES

A) Core Courses (Compulsory for all)
(Total courses 13, Total credits: 13 x 2 =26)

1.	Remedial Mathematics	ES-101
	OR	
2.	Remedial Biology	ES-102
3.	Environmental Chemistry	ES-103
4.	Earth processes	ES-104
5.	Ecology	ES-105
6.	Statistics	ES-106
7.	Environmental Pollution	ES-107
8.	Natural hazards and disaster management	ES-108
9.	Environmental Impact Assessment	ES-109
10.	Energy and Environment	ES-110
11.	Remote sensing and Geoinformatics	ES-111
12.	Environmental Biochemistry and Toxicology	ES-112
13.	Marine environment	ES 113
14.	Soil Science	ES-114

B) Non- Credit Courses (Compulsory for all)

15.	Current Environmental Issues	ES-115
16.	Scientific Writings and Ethics	ES-116

C) Optional Courses – (Total courses- 31 of 3 credits each; Students will have to choose any 8 courses to obtain total 24 credits)

1.	Environmental Modeling	ES-201
2.	Climatology	ES-202
3.	Meteorology	ES-203
4.	Noise Pollution	ES-204
5.	Environmental Physics	ES-205

6. Environmental instrumentation and techniques	ES-206
7. Geochemistry	ES-207
8. Groundwater Hydrology	ES-208
9. Oceanography	ES-209
10. Natural resource Management	ES-210
11. Glaciology	ES-211
12. Biogeochemistry	ES-212
13. Environmental Geology	ES-213
14. Water Resources	ES-214
15. Air Pollution Chemistry	ES-215
16. Water Pollution Chemistry	ES-216
17. Soil Pollution Chemistry	ES-217
18. Solid and Hazardous Wastes Management	ES-218
19. Metrology	ES-219
20. Pollution Biology	ES-220
21. Biodiversity and conservation	ES-221
22. Forest ecology	ES-222
23. Microbial Ecology	ES-223
24. Ecosystem Dynamics	ES-224
25. Environmental Biophysics	ES-225
26. Ecology and sustainable development	ES-226
27. Environmental Xenobiotics and human health	ES-227
28. Fundamentals of Molecular Biology and Biotechnology	ES-228
29. Applied biotechnology and Bioremediation	ES-229
30. Eco-toxicology	ES-230
31. Environmental and Occupational health	ES-231

D) <u>Lab Work</u>

1. Lab work I	(3 credits)	ES-232
2. Lab work II	(3 credits)	ES-233

E) <u>Field Work</u> (3 credits) ES-234

F) <u>Project Work</u> (5 credits) ES-235

COURSE CONTENT

A) Core Courses

1. Remedial Mathematics ES-101 (for Non- Mathematics students)

Functions- polynomial, logarithmic, exponential, absolute value, trigonometric. Limits, Indeterminate forms, Continuity. Derivability. Differentiation of simple mathematical functions- product rule, quotient rule and chain rule. Integration- by parts, substitution and by partial fractions. Linear differential equations and their solution. Introduction to Matrices and Determinants. Introduction to Vectors- addition, subtraction, multiplication of vectors. Equation of Straight Line and Solving Linear System of Equations.

OR

2. Remedial Biology ES-102 (for Non- Biology students)

History and scope of ecology, Evolution of biosphere, Diversity of life forms.

Biological communities, species interaction, Communities properties, succession. Plant diversity and nomenclature with major classes of plants; Phytogeographical regions; Rare and threatened plants and exploration of plant wealth. Animal diversity and categories of animals; Rare and threatened species of mammals, aves, reptiles, pisces etc.; Exploration and conservation of faunal wealth. Microbial diversity, bacteria, fungi, actinomycetes; Microbial diversity in man-made ecosystems and natural ecosystems. Importance of flora and fauna in nutrient cycling, its effect, degradation and metabolism.

3. Environmental chemistry ES-103

Fundamental Chemistry: Elements, Chemical bonding, chemical reactions and equations, Organic functional groups, classes of organic compounds. Free radical reactions, catalytic processes.

Elemental cycles (C, N, S, O) and their environmental significance.

Fossil fuels: their types, properties, combustion and environmental implications.

Atmospheric constituents, Green house gases and climatic changes. Chlorofluorocarbons and their substitutes. Photochemical smog. Water quality and wastewater treatment. Role of soaps, detergents and phosphorus fertilizers in eutrophication. Persistent organic

pollutants: pesticides usage, toxicity and their environmental degradation. Earth crust and weathering mechanism; Soil formation and chemical characteristics. Chemical classes of Hazardous waste, their effects on the environment. Chemical treatment of hazardous wastes.

4. Earth Processes ES-104

Evolution of various branches of Geology. Origin of the earth. Primary differentiation and formation of core, mantle, crust, atmosphere and hydrosphere. Magma generation and formation of igneous and metamorphic rocks. Concept of Minerals and Rocks. Weathering, erosion, transportation and deposition of earth's materials by running water, wind and glaciers. Formation of land forms and sedimentary rocks. Plate tectonics- sea floor spreading, mountain building, evolution of continents and structural deformation. Thermal, magnetic and gravitational fields of the earth. Concepts of engineering and urban geology.

5. Ecology ES-105

History and scope of ecology, autecoloty, synecology, population, community, biome, tolerance range and limiting factors. Distinguishing characters of forests grasslands, arid lands and wetlands; community organization- concept of habitat, functional role and niche, key stone species, dominant species, ecotone, edge effect. Analytical characters, synthetic characters like forms, species diversity and measurement of diversity. Population dynamics, models for single and interacting population, stable points, stable cycles, chaos competition, prey predation, etc. Ecological succession, primary and secondary processes in successions, models of successions, climax community and types of climax. Vegetation of India. Fundamentals of Microbial ecology. Microbial metabolism and microbial interaction. Biochemistry of biological nitrogen fixation and other microbial Pathways in terms of enzymology.

6. Statistics ES-106

Measures of central tendency. Measures of dispersion. Measures of skewness and kurtosis. Probability- definition, addition and multiplication laws,concept of random variable. Probability distributions- binomial, poisson and normal. Sampling theory-

hypothesis testing and interval estimation for large samples. Chi-square test, t-test and F-test of significance. Correlation and regression. analysis. One way analysis of variance.

7. Environmental Pollution ES-107

Linkage between energy, environment and development. Human population issues. Definition of pollution. Different types of pollution- Air, Water and soil and their local, regional and global aspects. Air: Sources of air pollutants, their behavior in the atmosphere. Effects of air pollutants on humans, animals, plants and properties. Control approaches. Water: Sources, effects, water pollution treatment. Soil: Sources and nature of soil pollution and its harmful effects. Solid waste: generation, collection, environmental effects and safe disposal practices. Environmental problems associated with noise pollution, oil pollution and radioactive pollution.

8. Natural hazards and disaster management ES-108

Introduction to Hazards- Hazard classification-types of hazards ;Natural Hazards: causes, (continental drift, plate tectonics, sea floor spreading, isostacy, etc.,) distribution pattern, consequences and mitigation: Earthquake, Tsunami, Volcanoes, Cyclone, Flood, Drought, Landslide, cold and heat hazards, forest fire, etc.,- causes, types, distribution adverse effects, etc.,- Disaster introduction- disaster Management Capability- Vulnerability- risk- preparedness and mitigation- Disaster management cycle- community planning education and Engineered structure /structural strengthening techniques- Hazard zonation and mapping- Risk Reduction Measures.

9. Environmental Impact Assessment ES-109

Linkage between development and environment; global commons: carrying capacity: origin and development of EIA: relationship of EIA to sustainable development: EIA in project planning and implementation: EIA process: evaluation of proposed actions, scoping and base line study, identification and prediction of impacts, mitigation measures. Comparison of alternatives, review and decision making, public participation and compensatory actions: green belts: National Environmental Policies and guidelines in

India. Conditions and approach for EIS review. Case studies: river valley projects: thermal power plants: mining projects: oil refineries and petrochemicals.

10. Energy and Environment ES-110

Energy resources and their exploitation, Sun as source of energy- nature of its radiation, Conventional energy sources: coal, oil, biomass and nature gas, non-conventional energy sources: hydroelectric power, tidal, wind, geothermal energy, solar collectors, photovoltaics, solar ponds, nuclear-fission and fusion, magneto-hydrodynamic power (MHD), Energy use pattern in different parts of the world and its impact on the environment. CO_2 emission in atmosphere.

Mechanism of radiation action on living systems- Stochastic and Non-stochastic effects; delayed effects, radioactivity from nuclear reactors, fuel processing and radioactive waste, hazards related to power plants, terrestrial and non terrestrial radiation, dose from environment and nuclear radiations, ultraviolet radiations, pathways analysis and dose assessment, radiologic age dating, radioactivity risk assessment, criterion for safe exposure.

11. Remote sensing and Geo- informatics ES-111

Introduction to Remote sensing & GIS. Principles of remote sensing & GIS. Spectra of Environmental Components. Terrestrial and Extra terrestrial satellites in Remote sensing and GIS. Remote sensing & GIS applications on Ocean, Atmosphere, Land, Geology, Water Resources (Ground water and Surface water). Cryosphere, Disaster, Defence studies. Use of softwares in Remote sensing and GIS to solve Environmental problems including Groundwater Exploration, Rainwater Harvesting, Biomass analysis and its relationship with Georesource evaluation. Use of Remote sensing and GIS in development of Early warning system to monitor Agriculture. Identification of Genetically modified crops in correlation with water quality and soil moisture by using Remote sensing & GIS. Applications of Remote sensing and GIS in early warning of Tsunami, Earthquake, Snowfall, Global warming, Forest fire, Landslide, Landsubsidance. Use of LANDSAT, SPOT, IRS ERS, RADARSAT and Extra terrestrial satellite data by using ERDAS, ARCGIS, ERMAPPER, IDRISI ENVI and S+ software for solving the

Environmental problems. Sun-earth cosmic connection to understand environment of the Earth.

12. Environmental Biochemistry and Toxicology ES-112

Environmental physiology with considerations of intermediary metabolism- approaches for studying energy metabolism and body temperature changes; Thermo regulation and adaptation. Oxygen uptake from the environment, respiration and metabolism. Electron transport system and oxidative phosphorylation. Photosynthesis: C1, C3, C4 pathways and their regulation. Photorespiration. Biochemistry of altered membrane permeability, free radical formation, lipid peroxidation, lysosomal degradation, superoxide dismutase. Environmental pollutants and their effects on living system. Biochemical approaches to the detoxification of xenobiotics through cellular metabolism.

13. Marine Environment ES-113

Introduction-Classification- open ocean- shallow marine and deep sea environment-marine resources- marine ecology- marine organisms-productivity- coastal environment-coastal water movement- beaches- coastal dunes- barrier islands- cliffed coast- deltas-coast line- estuaries-mangroves- lagoons- salt marshes- coral reefs- classification of marine sediments- clay minerals- biogenic silica- evaporites- nutrient in oceans- carbon and global climate change- marine pollution- law of the sea.

14. Soil Science ES-114

Soil forming rocks and minerals- Classification- Weathering of rocks and minerals-Processes of weathering and factors affecting them. Soil formation- Factors of soil formation- Soil forming processes- Profile development- Definition of soil- Soil composition.

Soil physical properties- Soil separates and particle size distribution- Soil texture and structure- Bulk density, particle density, pore space, soil air, soil temperature, soil water, soil consistence - Significance of physical properties to plant growth.

Soil chemical properties- Soil colloids- Inorganic colloids- Clay minerals- amorphous-Ion exchange reactions- Organic colloids- Soil organic matter- Decomposition- Humus

formation- Significance on soil fertility, Soil reaction- Biological properties of soil-nutrient availability.

B) <u>Non Credit Courses</u> (Compulsory for all)

1. **Current Environmental Issues ES-115**

Contemporary and emerging environmental issues of local, regional and global significance. Broadly the topics will be pertaining to: i) Linkage between population, development and environment ii) climate change ii) stratospheric Ozone depletion iii) water resources iv) environmental toxicants and human health v) biodiversity conservation and vi) environmental episodic events, etc.

2. **Scientific Writings and Ethics ES-116**

Overview of Moral and Ethical questions in Scientific writing. Overall outline and structure of the article/manuscript. Description, value, and development of points/outlines before writing. Screening of Material for inclusion within the structure of the manuscript. Importance of Authors and their sequence, importance of clear title, abstract or summary. Introduction, Methods, Results, and Discussion. Numbers and statistics, Tables and Figures, Discussion. Writing Style: Active or passive, Punctuation, use of commas, apostrophe, semicolon and colon. Avoiding duplication and repetition. Importance of revisions and references.

Plagiarism, paraphrasing and copy write violation. Consequences of plagiarism. Why not to fudge, tinker, fabricate or falsify data. Examples.

C) <u>Optional Courses</u>

1. **Environmental Modeling ES - 201**

Role of Modeling in Environmental Science. Model Classification- Deterministic Models, Stochastic Models, Dynamic Models, Steady State Models. General Steps Involved in Modeling, Mass Balancing, Energy Balancing, Microbial Growth Kinetics- Exponential Growth Model, Logistic Growth Model, Monod Equation, Two Species

Population Growth Model of Competition. Lotka-Volterra Prey-Predator Model, Oxygen Sag Model, Gaussian Plume Model.

2. Climatology ES - 202

Elements of climate, climate controls, Earth's radiation balance, latitudinal and seasonal variation of insolation, temperature, pressure, wind belts, humidity, cloud formation and precipitation, water balance, spatial and temporal patterns of climate parameters, Air masses and fronts, SW and NE monsoon, jet stream, tropical and extratropical cyclone, ENSO, QBO. Classification of climate- Koppen's and Thornthwaite' scheme. Climate change

3. Meteorology ES - 203

Meteorology fundamentals- Thermal structure of the atmosphere and its composition, Pressure, temperature, wind, humidity, moisture variables, virtual temperature, radiation, radiation from sun, solar constant, surface and planetary albedo, emission and absorption of terrestrial radiation, radiation windows, greenhouse effect, net radiation budget, atmospheric stability diagrams, turbulence, diffusion, dry and moist air parcel, thermodynamic diagrams, T-phigram and mixing height, thermodynamics of dry and moist air, specific gas constant, adiabatic and isoentropic processes, entropy and enthalpy, adiabatic processes of moist air

4. Noise Pollution ES - 204

Basic properties of sound waves, sound propagation, Definition of Noise, Health Effects of Noise, Concept of sound pressure level (SPL), decibel scale, addition of decibels, Frequency Response of Human Ear, Equal Loudness Contours, Weighting Networks, Octave Bands, Measurement and analysis of sound. Percentile Indices of Noise, Equivalent sound pressure level (Leq), Noise pollution level (NPL), Sound exposure level (SEL), Traffic noise index (TNI), Day-Night level (DNL), noise criteria curves; Noise sources; Industrial Noise and Traffic Noise, Noise control and abatement

measures; absorbing materials, barrier materials and damping materials. Acoustic silencers and mufflers.

5. Environmental Physics ES - 205

Concept and scope of environmental Physics with respect to human environment; built environment; urban environment; global environment. Laws of thermodynamics, irreversible thermodynamics and entropy. Wind chill, Hypothermia. Heat balance (steady and transient), Electromagnetic Radiation, Thermal regulation in buildings- Thermal insulation, Thermal conduction effects, Convection effects, Radiation effects, U-values, Energy use and efficiency in buildings. Energy losses, calculation of energy losses, energy gains.Air regulation in buildings, heat pumps, condensation. Buildings of the future. Nano materials: their properties and influence on human health, environment, communication sector and energy. Method of preparation and Applications of nano materials.

6. Environmental Instrumentation and Techniques ES - 206

Physics of Dielectrophoresis and its environmental applications, Basics of NMR instrumentations, significance of relaxation time, Raman effect and experimental measurement, Raman Spectroscopy, LASER based techniques, LIDAR based methods and techniques, SODAR Radiofrequency measurement and techniques.

7. Geochemistry ES - 207

Atomic properties of elements, the periodic, table and geochemical classification of elements; abundance of elements in the bulk earth, crust, hydrosphere, atmosphere and biosphere; introduction to mineral structures and compositions; thermodynamic classification of elements into essential, structural, major and trace elements and their partitioning during mineral formation; chemical reactions involving proton and electron transfers, mineral stability diagrams and controls on the chemistry of natural waters; geochemical cycling-concepts with an example; radioactivity, decay of parent and growth of daughter nuclides and methods of radiometric dating; stable isotopes, their

fractionation and application to geothermometry and paleoclimates. Interpretation of XRD and XRF data for Environmental components. Geochemical sample preparation. X-Ray Fluorescence. X-Ray Diffraction. Ion Chromatography, AAS and its interpretation.

8. Groundwater Hydrology ES - 208

Definition and concept of hydrology and hydrogeology. Distribution of water in the earth's crust. Hydrological cycle. Genetic types of groundwater and residence time of groundwater, Geological control of groundwater, Vertical distribution of groundwater, Types of aquifers, springs and their classification, Classification of rocks with reference to their water bearing properties. Mode of occurrence of groundwater in different geological terrains of India. Darcy's law and its validity, Determination of hydraulic conductivity, groundwater tracers. Environmental factors on Groundwater level fluctuations and Land subsidence due to changes in subsurface moisture. Effects of excessive use of groundwater resources. Sources of salinity, Chemical analysis of groundwater, Quality criteria for different uses, Groundwater quality in different provinces of India, pollution of groundwater resources. Ghyben-Herzberg relationship between fresh-saline water. Groundwater exploration. Construction and design of different types of wells. Well completion and development. Groundwater development and management: Groundwater development in urban areas and rainwater harvesting, artificial recharge methods. Management of groundwater and groundwater legislation.

9. Oceanography ES - 209

Introduction- historical, current and future- Earths structure- Physiography of oceans- origin and evolution of ocean basins (Continental and oceanic basins)- Continental drift, sea floor spreading, plate tectonics- shelf and deep sea sedimentation- physical, chemical and biological aspects of sea water- Ocean current (circulation)- Waves properties and motion- tidal currents and characteristics- air-water interface/ exchange, gas solubility and circulation models.

10. Natural resource Management ES - 210

Definition- land, water, soil, plants and animals: quality of life: renewable and non-renewable resources: Mineral occurrences, prospects: Mineral resources: Mineral reserves, ore minerals, coal, petroleum, oil and natural gas: water- hydropower, including tidal power; ocean surface waves used for wave power, wind- wind power, geothermal heat- geothermal power and radiant energy- solar power: sustainable development, Urban planning Environmental management, Understanding the resource ecology and life-supporting capacity of resources-Economic models: Green building concept- green technology concept.

11. Glaciology ES - 211

Glacier systems- Structure and morphology of glaciers- Glacial erosion; Landscape evolution under glaciers, glacial landforms- Mass balance- Glacier dynamics, Englacial and subglacial process and fluctuations- Glacier hydrology- Snow and melt water chemistry of- Approaches to Glaciology- Glacier modeling- Glacier and climate change impact- Glaciers- Glacier and water resources- Recent advances in Glaciology- Spatial Data Acquisition Glacier Hazards- Glaciers as tool for palaeo climate studies.

12. Biogeochemistry ES - 212

Introduction- Biogeochemical provinces- Atmosphere- Lithosphere: weathering process, soil biogeochemistry- Terrestrial systems: photosynthesis respiration- Wetlands: vegetation adaptations- Freshwater and Marine Biogeochemistry: Lakes, ponds, rivers, mangroves, salt marsh and estuaries- Oceans: productivity and limiting nutrient role, carbon chemistry- Global biogeochemical cycles: Nutrient cycles- Advances in biogeochemistry- Sediment biogeochemistry, stable Isotopes in Biogeochemistry and their application to various environmental problems. Nutrient dynamic in the atmosphere, hydrosphere, and Lithosphere. Nutrient budgeting and modeling

13. Environmental Geology ES - 213

Interior of the earth- minerals and rocks- earth processes- plate tectonics- sea floor spreading, mountain building, rock deformation- evolution of continents and earth quakes, volcanoes, landslides, subsidence, rivers and floods and coastal process-

interactions between humans and the geological processes, Environmental Hazards- Pollution of the Environment- Waste Disposal, Natural Resources, and Energy Sources and their exploitation. Past, present and future environmental issues and their affect on the earth and our society.

14. Water Resources ES - 214

Hydrological cycle- Hydrometeorology and climate- hydrometric networks and catchment morphology- precipitation- evaporation and evapotranspiration- soil moisture- river flow- River, Lakes and Ground water- Occurrence of surface water and groundwater. Movement of water on the surface and below the surface. Springs and Hydrothermal phenomena. Ungauged river basin flow- River bank infiltration and recharge-precipitation analysis- evaporation calculation-river flow analysis- Time variation of stream flow levels- rainfall- runoff relationships- Ecohydrology- urban hydrology- Integrated Water Resource Management (IWRM), Urbanization effect on Water resources. Earthquake, Land subsidence and Water resources. Physical, chemical and biological characteristics of Water resources and water quality data processing and interpretation. Sea water intrusion in aquifer system-structural geological approach. Influence of Sun-Earth cosmic connection on Water resources.

15. Air Pollution Chemistry ES - 215

Chemical composition of atmosphere, Sources of air pollution. Types of air pollutants, organic and inorganic pollutants, their behavior and fate on local, regional and global scale, monitoring of criteria and non-criteria pollutants.

Effects of air pollutants on human health, plants, animals and materials. Pollutants and health effects.

Air pollution meteorology: Mixing heights, Wind roses, Inversion conditions, Stability of the atmosphere. Long range transport, plume behavior, Air pollution dispersion.

Land-atmosphere-ocean interactions of air pollutants. Photochemistry of troposphere, Inorganic reaction in the atmosphere. Reactions involving organic pollutants, Gas to particle conversion. Ozone depletion, Acid rain, Greenhouse effect, Formation of

photochemical smog, CFC, their nomenclature, sources and effect, Atmospheric Brown Cloud

Air pollution control technologies: Concept of clean environment, Green technologies, Carbon sequestration, Chemical methods, Electrostatic precipitators.

16. Water Pollution Chemistry ES - 216

Physicochemical properties of water, Water use- classifications and water quality standard. Basic principles of contaminant behavior in the environment. Hydrologic cycle.

Types and sources of water pollution, Major Water Quality (physicochemical and bacteriological) Parameters and their Applications, Basics of water sampling.

Water quality objectives and the major chemical, physical and biological processes necessary for designing and managing modern drinking water and wastewater treatment plants, Principles of coagulation, flocculation, sedimentation, chemical precipitation, porous media filtration, disinfection, ion exchange, adsorption, membrane Processes, advanced oxidation processes, air-stripping and other advanced treatment processes, Major contaminant groups and natural pathways for their removal from water

17. Soil Pollution Chemistry ES - 217

Physical Chemistry of Soil**:** Soil Solution Phase, The Soil/Solution Interface, Surface exchange reactions, Soil acidity, Electrochemistry and the Soil, chemistry of waterlogged soil.

Soil Pollution: Inorganic and Organic-Definition of pollution and contamination, sources of soil pollution, Effects of chemical residues on soil, (pesticides, fertilizers, heavy metals etc., Soil salinity and alkalinity, Soil pollution from nitrogen, phosphorus, sulfur, micronutrients or trace elements and radionuclide, land degradation, soil erosion.

Soil pollution and climate change: Greenhouse gases production, emission, mitigation, carbon sequestration, soil quality.

18. Solid and Hazardous Waste Management ES - 218

Solid wastes: Definition, types, sources, characteristics, and impact on environmental health. Waste generation rates. Concepts of waste reduction, recycling and reuse. Collection, segregation and transport of solid wastes Handling and segregation of wastes at source. Collection and storage of municipal solid wastes. Solid waste processing technologies. Mechanical and thermal volume reduction. Biological and chemical techniques for energy and other resource recovery. Composting, Vermicomposting, Incineration of solid wastes. Disposal in landfills: site selection, design, and operation of sanitary landfills; secure landfills and landfill bioreactors; leachate and landfill gas management; landfill closure and post-closure environmental monitoring; landfill remediation.

Hazardous wastes: Definition, sources and characteristics: Hazardous waste categorization, generation, collection, transport, treatment and disposal. Legislation on management and handling of municipal solid wastes and hazardous wastes.

19. Metrology ES - 219

Fundamentals of metrology, Chemical metrology, Defining uncertainty of measurements, traceability of standards, validation of method, calibration of method, accuracy and precision of results, selectivity, sensitivity, detection limit, limit of determination, specificity, linearity, analytical error, Accreditation systems, Metrology in environment,

QA/QC parameters in environmental studies, use of CRMs (Certified reference materials), inter-laboratory comparison exercise, participation in National and International round Robin tests.

Representativeness of sampling site, selection of analytical method, selection of appropriate analytical technique, proper storage of samples with suitable preservative, sample blank, field blank, solvent blank, efficiency of extraction, efficiency of sampling, determination of uncertainty in flow, sample preparation.

20. Pollution Biology ES - 220

Concepts: Pollutants vs. resources; cycling of materials, tolerance ranges, carrying capacity, bioaccumulation. Air Pollution: Responses of plants and animals, monitoring (e.g. lichens) and control of air pollution by plants. Water pollution: Responses of plants

and animals to changes in physico-chemical characteristics; distribution of plants in relation to pollution (microphytes; Phytoplankton, periphyton and moorophytes); Biological monitoring and control of pollution in water. Soil pollution: Responses of plants to soil pollution; changes in soil characteristics by waste disposal, sanitary land fills, mining wastes and human activities, and effects on plants and animals.

21. Biodiversity and Conservation ES - 221

Biodiversity concepts and patterns, Microbial diversity, Plant diversity, Agrobiodiversity, Soil biodiversity, Economic value of biodiversity, biodiversity losses. Biodiversity hotspots and their characteristic flora and fauna, threatened plants and animals of India, ecosystem people and traditional conservation mechanisms, Biodiversity Convention and Biodiversity Act, IPRs, national and international programmes for biodiversity conservation. Wildlife values and eco-tourism, wildlife distribution in India, problem in wildlife protection, role of WWF, WCU, CITES, TRAFFIC, Wildlife Protection Act 1972. In-situ conservation: sanctuaries, biospheres reserves, national parks, nature reserves, preservation plots. Ex-situ conservation: botanical gardens, zoos, aquaria, homestead garden; herbarium; In-vitro Conservation: germplasm and gene Bank; tissue culture: pollen and spore back, DNA bank.

22. Forest Ecology ES - 222

Forest and forest environment: Structure of forest ecosystem, major forest types of the world, forest types and forest cover of India, regeneration ecology of forest trees.

Forest ecosystem function: Primary productivity of forest ecosystems, litter production and decomposition, nutrient cycling and nutrient conservation strategies, plant water relations.

Forest ecosystem management: Forest management systems, joint forest management, forest hydrology, forest fire, application of remote sensing technique in forest ecology, deforestation and sustainable forestry, forest laws, non timber forest products.

Role of Biology in management and habitat management techniques. Wildlife farming: Objectives, management design, wildlife products, disease control, breeding. Behavioral,

ecology and evaluation.

23. Microbial Ecology ES - 223

An overview of microbial life and its importance in the environment, Microbial structure and function with special emphasis on *Bacteria* and *Archaea,* Evolution and microbial phylogenetic diversity, Microbial nutrition and metabolism with emphasis on microbial metabolic diversity, Environmental factors affecting microbial growth and microbial adaptations to extreme environments (like arctic regions and hot springs), Methods in microbial ecology including introduction to microbial genomics, Microbial habitats (air, soil, subsurface, freshwater, marine and the deep sea), Introduction to geomicrobiology, Natural microbial communities with emphasis on biofilms, Microbial biogeochemical processes of nutrient cycling and biodegradation, Microbial interactions: microbe-microbe interactions, plants as microbial habitats, animals as microbial habitats and human microbiome, Applying microbes in wastewater treatment and solid waste management, Industrial applications of microbes including products for health-pharmaceutical, food and beverage industry and biofuels, Molecular biotechnological applications including genetic engineering for the production of vaccines, diagnostics, biopesticides and transgenic plants, Microbial disease ecology and public health, Transmission of microbial diseases through the environment.

24. Ecosystem Dynamics ES - 224

The ecosystem concept, abiotic and biotic components. Energy input in ecosystem, standing crop, biomass, primary and secondary production, gross and net production, concept of food chain food web, ten percent law, net community production, methods of measuring productivity, pattern of primary production and biomass in the major ecosystem of the world, Energy flow, Feed back and control. Biogeochemical cycles, gaseous and sedimentary turnover rate and turnover item. Hydrological cycle, carbon cycle, nitrogen cycle, sulphur cycle, phosphorus cycle, nutrient budget, man's impact on nutrient cycles. Population dynamics.

25. Environmental Biophysics ES - 225

Cellular function of cell, membrane structure and transport origin and conduction of impulses in nerve cell muscles, methods in bioelectric measurements. Radiation and molecular response, elementary aspects of atomic and molecular excitation, biointeractions with environment, fundamental and applied aspects of extremely low frequency, radio and microwave fields, bioacoustics, biomedical aspects of laser. Magnetic environments and geomagnetic fields, behavioural changes, therapeutic and diagnostic possibilities.

26. Ecology and Sustainable Development ES - 226

Ecosystem concept in space and time; Ecosystem level processes and landscape level processes; the concept of sustainable development temporal and spatial dimensions; Currencies for evaluations of sustainable development- Biophysical measurements; Environmental degradations and conservation issues; Global change and sustainability issues: Climate change, biological invasion, bio-diversity concerns; Ecosystem and social processes in: (a) Rehabilitation of degraded rural landscape, (b) Rehabilitation of unbalanced soils, (c) Rehabilitation of specialized habitats, e.g. water bodies, mangroves; (d) Mined area rehabilitation participatory research and education environmental decision making with people initiates.

27. Environmental Xenobiotics and human health ES - 227

Interaction of pollutants with biological systems at different levels, e.g., organism, organs, and cell organelles. Biochemical degradation of pollutants inside the cell as well as cellular interactions with the pollutants. Toxins of plant origin. Stress response in living systems. Toxicogenomics: Human population issues and population genetics. Pharmacogenomics; Epidemiology. Cellular interaction and metabolism of xenobiotics; metabolic disorders. Bioconversion of pollutants: active vs. inactive process; enzymic degradation by monooxygenases; Role of cytochrome P_{450} and its multiple forms. Immunology: Immune cell responses, Immunity and Immunodeficiency. Allergy and hypersensitive reactions and disorders of immune responses. Carcinogens and Carcinogenesis. Metal toxicity: chemical form, metal biomacromolecule interaction, teratogenecity.

28. Fundamentals of Molecular Biology and Biotechnology ES - 228

Basic concepts of molecular biology needed for understanding biotechnology. DNA structure and organization into chromosomes. DNA replication. Repetitive DNA; coding and noncoding sequences in genomes. Gene structure and expression. Mechanics of transcription, translation and their regulation in both prokaryotes and eukaryotes. Key discoveries (restriction enzymes, bacterial plasmids, modifying enzymes) leading to recombinant DNA technology. Overview of basic techniques in genetic engineering: Introduction of cloned genes into new hosts using plasmid and phage vector systems. Expression cloning, affinity purification of expressed proteins. Nucleic acid hybridization and polymerase chain reaction as sensitive detection methods. DNA sequencing. Analysis of genomes and proteomes by bioinformatics tools. Genome-wide analysis using microarrays.

29. Applied Biotechnology and Bioremediations ES - 229

Practical aspects of genetic engineering with microorganisms from extreme environment: Use of extremophilic microorganisms in waste treatment and methane production from agro industrial wastes; Production of enzymes like cellulase, proteases, amylases; alcohol and acetic acid production; Biocomposting: Microbial process involvement, vermin

composting, biofertilizer, biopesticides production. Biomining: Microbial leaching of low grade mineral ores, molecular probes for organisms in mines and mine tailings, Petroleum pollutant biodegradation. Alternate fuels: Source and mechanism of various biofuel production. Bioremediation: Concept, role of bioremediation in controlling various pollution problems e.g. solid water, sewage water, industrial effluents, heavy metals, radioactive substances, oil spillage. Phytoremediation: Abatement of different types of pollution using plants, types of phytoremediation, mechanism involved with case studies. Waste water treatment strategies: Domestic and Industrial waste-water, application of microbiology waste treatment. Metagenomics: Environmental Genomics, ecogenomics or community genomics, the study of genetic material recovered directly from environmental samples and future applications in bioremediation.

30. Eco-Toxicology ES - 230

Principles in toxicology; Definition of Xenobiotics. Animal management in toxicological evaluation; Animal toxicity tests; Statistical concepts of LD_{50}; Dose-effect and dose response relationship; Frequency response and cumulative response; Biological and chemical factors that influence toxicity; Bio-transformation and bio-accumulation. Influence of ecological factors on the effects of toxicity; Concept of green chemistry. Pollution of the ecosphere by industries; Global dispersion of toxic substance; Dispersion and circulating mechanisms of pollutants; degradable and non-degradable toxic substances; food chain. Eco-system influence on the fate and transport of toxicants. Aquatic toxicity tests; Statistical tests; Response of planktons to toxicants; EC_{49}; Photosynthetic bacteria; Bio-absorption of heavy metals. Information management system in eco-toxicology.

31. Environmental and Occupational Health ES - 231

Basic principle of environmental health. Physiological responses of man to relevant stresses in the environment. Cases and effects of pollution. Industrial Toxicology: Study of environmental dose effect relationships. Evaluation of toxicity and threshold limits. Principles and methods of occupational health. The relationship of occupation of hygiene

and safety and disease. Health maintenance: Survey, analysis and recommendations regarding health and safety problems in the working and living environment. Biostatistics, epidemiology: Application of statistical methods to medical records in the study of health problems of human population in a given environment. Treatment of variation, with demographic, vital statistics and epidemiological data. Hazard evaluation in polluted environment with specific emphasis on radiological health. Industrial hygiene technology-laboratory remains illustrating the principles, methods of recognizing evaluating and controlling environmental hazards like air pollution, etc.