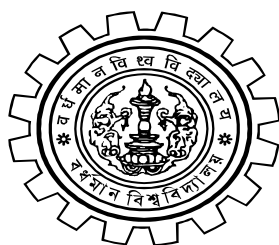


ENVIRONMENTAL SCIENCE
THE UNIVERSITY OF BURDWAN



M. Sc. SYLLABUS
[CHOICE BASED CREDIT SYSTEM]
[w. e. f. 2020- '21]

DEPARTMENT OF ENVIRONMENTAL SCIENCE
THE UNIVERSITY OF BURDWAN
BURDWAN-713104

COURSE STRUCTURE FOR M.Sc. IN ENVIRONMENTAL SCIENCE

SEMESTER- I (TOTAL MARKS: 300)

| Course | | | | Lect. h/week | Dur. of Exam (in h) | Marks | | | Credit |
|----------------|------|-----|------------------------------------|-----------------|------------------------------|-------|--------------|-------|--------|
| Course code | Type | T/P | Name | | | I.A. | E.T. | Total | |
| MSES101 | Core | T | Basic Ideas on Environment | 4 | 2 | 10 | 40 | 50 | 4 |
| MSES102 | Core | T | Physical Environment | 4 | 2 | 10 | 40 | 50 | 4 |
| MSES103 | Core | T | Environmental Biology | 4 | 2 | 10 | 40 | 50 | 4 |
| MSES104 | Core | T | Environmental Microbiology | 4 | 2 | 10 | 40 | 50 | 4 |
| MSES105 | Core | P | Practical on Physical Environment | 8 | 4 | 10 | 40 | 50 | 4 |
| MSES106 | Core | P | Practical on Environmental Biology | 8 | 4 | 10 | 40 | 50 | 4 |
| | | | | | | | Total Credit | 24 | |

Note: T- Theory; P- Practical; I.A.- Internal Assessment; E.T.- End Term

SEMESTER- II (TOTAL MARKS: 300)

| Course | | | | Lect. h/week | Dur. of Exam (in h) | Marks | | | Credit |
|----------------|------|-----|--|-----------------|------------------------------|-------|--------------|-------|--------|
| Course code | Type | T/P | Name | | | I.A. | E.T. | Total | |
| MSES201 | Core | T | Life Processes & Ecotoxicology | 4 | 2 | 10 | 40 | 50 | 4 |
| MSES202 | Core | T | Environmental Geoscience | 4 | 2 | 10 | 40 | 50 | 4 |
| MSES203 | Core | T | Energy Resource & Environmental Statistics | 4 | 2 | 10 | 40 | 50 | 4 |
| MSES204 | Core | T | Environmental Pollution & Degradation | 4 | 2 | 10 | 40 | 50 | 4 |
| MSES205 | Core | P | Practical on Environmental Problems | 8 | 4 | 10 | 40 | 50 | 4 |
| MSES206 | Core | P | Practical on Ecotoxicological Measurements | 8 | 4 | 10 | 40 | 50 | 4 |
| | | | | | | | Total Credit | 24 | |

SEMESTER- III (TOTAL MARKS: 300)

| Course | | | | Lect. h/week | Dur. of Exam (in h) | Marks | | | Credit |
|-------------|------|-----|---|-----------------|------------------------------|-------|--------------|-------|--------|
| Course code | Type | T/P | Name | | | I.A. | E.T. | Total | |
| MSES301 | Core | T | Biodiversity Conservation & Sustainable Development | 4 | 2 | 10 | 40 | 50 | 4 |
| MSES302 | Core | T | Emerging Environmental Problems, Health Hazards & Genetic Engineering | 4 | 2 | 10 | 40 | 50 | 4 |
| MSES303 | Core | T | Remote Sensing & GIS | 4 | 2 | 10 | 40 | 50 | 4 |
| MSES304 | GE | T | Environmental Perspectives | 2 | 2 | 05 | 20 | 25 | 2 |
| MSWM304 | | | or To be opted from SWYAM | -- | -- | -- | -- | -- | 2 |
| MSES305-1 | DE | P | Practical on RS & GIS, EIA & Diseases | 8 | 4 | 10 | 40 | 50 | 4 |
| MSES305-2 | DE | T | Ecological Modelling and GIS for Environmental Applications | 4 | 2 | 10 | 40 | 50 | 4 |
| MSES305-3 | DE | T | Ecotoxicology & Industrial Microbiology | 4 | 2 | 10 | 40 | 50 | 4 |
| MSES306-1 | DE | T | To be opted from SWYAM | -- | -- | -- | -- | -- | 4 |
| MSES306-2 | DE | T | Forest Ecology and Oceanography | 4 | 2 | 10 | 40 | 50 | 4 |
| MSES307 | Core | P | Community Engagement Activities | 4 | 2 | 05 | 20 | 25 | 2 |
| | | | | | | | Total Credit | 24 | |

GE: Generic Elective; DE: Discipline-centric Elective

SEMESTER- IV (TOTAL MARKS: 300)

| Course | | | | Lect. h/week | Dur. of Exam (in h) | Marks | | | Credit |
|--------------------|-------------|------------|---|-------------------------|--|--------------|---------------------|--------------|---------------|
| Course code | Type | T/P | Name | | | I.A. | E.T. | Total | |
| MSES401 | Core | T | Environmental Impact Assessment & Environmental Laws | 4 | 2 | 10 | 40 | 50 | 4 |
| MSES402 | Core | T | Environmental Toxicology & Hazardous Wastes | 4 | 2 | 10 | 40 | 50 | 4 |
| MSES403 | Core | T | Environmental Biotechnology | 4 | 2 | 10 | 40 | 50 | 4 |
| MSES404-1 | DE | T | Environmental Issues, Economics & Environmental Management | 4 | 2 | 10 | 40 | 50 | 4 |
| MSES404-2 | DE | T | Environmental Engineering and Science | 4 | 2 | 10 | 40 | 50 | 4 |
| MSES405-1 | DE | P | Practical of Toxicological Testing | 8 | 4 | 10 | 40 | 50 | 4 |
| MSES405-2 | DE | P | Practical of Spatial Data Analysis and Ecological Modelling | 8 | 4 | 10 | 40 | 50 | 4 |
| MSES406 | Core | P | Dissertation Work | 4 | 4 | 10 | 40 | 50 | 4 |
| | | | | | | | Total Credit | 24 | |

Semester I

MSES101 [Core]

Total lecture hours: 40

Credits: 4 (4T) :: Marks: 50 [I.A.(10) + E.T. (40)]

BASIC IDEAS ON ENVIRONMENT

I. Environmental awareness: Definition, Principles and scope of environmental science; Environmentalism; Environmental ethics and philosophy; Environmental education and awareness; Ecofeminism; Green govt. politics [10]

II. Components of environment: Lithosphere, hydrosphere, atmosphere and biosphere; Physical and biological environments [05]

III. Ecology and Biomes: Concept of ecosystem; Ecological energetics; Food chain & webs; Ecosystem structure and functional aspects; Landscape ecology & ecological interactions; Ecosystem services; Biomes and biome types: forest, grassland, tundra, desert biomes; Concept of Gaia Hypothesis [10]

IV. Population and Human ecology: Population properties and dynamics of population growth, factors controlling population growth, metapopulation; Mechanism of population equilibrium Human population growth, expansion and its causes; Consequences of population growth and affluence; Human demography, promotion and development, demographic transition; Future of human population [10]

V. Man, society and environment: Human civilization processes (Man-Environment relationship), society, class, gender; Human settlements [05]

MSES102 [Core]

Total lecture hours: 40

Credits: 4 (4T) :: Marks: 50 [I.A.(10) + E.T. (40)]

PHYSICAL ENVIRONMENT

I. Fundamentals of Earth processes: Origin and evolution of the Earth; Geological time scale; Continental drift and mountain building with reference to plate tectonics
External geomorphic processes: Weathering and erosion; Soil - origin, nature and classification of parent material for soil formation, classification of soil; Landforms developed due to various geomorphic agents i.e., water, wind and glacier [8]

II. Fundamentals of climatology: Scale of meteorology; Elements of climate – solar radiation, atmospheric temperature, pressure, wind, moisture, fog & dews, clouds and precipitation; Global atmospheric circulation; Weather analysis and forecasting; Climatic classification; Climatic regions of India, Indian monsoon [8]

III. Environmental chemistry: Chemical bonds and chemical reactions; Rate of reaction, rate law, adsorption - physisorption and chemisorption, adsorption-isotherms, organic compounds – hydrocarbons and polymer chemistry; Biological chemistry – chemistry of carbohydrate, nucleic acids, enzymes; Green chemistry – concept, green catalyst; Material life cycle and application of green chemistry [12]

IV. Principles of analytical methods: Design of sampling techniques (air, soil, biological matters); Principles of analytical methods – Chromatography, HPLC, GC-MS; Atomic absorption spectroscopy, Flame photometry; Spectrophotometry, Electrophoresis, TGA, XRF, XRD, NMR, FTIR, SEM & TEM [12]

MSES103 [Core]
Total lecture hours: 40
Credits: 4 (4T) :: Marks: 50 [I.A.(10) + E.T. (40)]
ENVIRONMENTAL BIOLOGY

I. Evolution: Fundamentals of evolutionary processes; Origin of life; Modern synthesis: Role of natural selection, genetic drift, evolutionary divergence, patterns of speciation, population genetics [08]

II. Biological diversity: Brief accounts of microbes, plants and animals and microbes; Principles of taxonomy – nomenclature, an outline of classification and identification [07]

III. Community ecology: Community structure, factors influencing the structure of communities, community dynamics, species diversity in communities, pattern in communities; Ecological succession – causes, trends, of succession, basic types of succession, general process of succession, climax concept, community restoration, chaos and limit cycles, community stability [15]

IV. Systems based modelling techniques: Types of models, Stochastic vs. deterministic, dynamic (Elements and methods of modeling, Competition model, prey-predator models, SIR model) and static models (ENA); Introduction to basic software on modelings; Optimal foraging theory [10]

MSES104 [Core]
Total lecture hours: 40
Credits: 4 (4T) :: Marks: 50 [I.A.(10) + E.T. (40)]
ENVIRONMENTAL MICROBIOLOGY

I. General microbiology: General idea about bacterial morphology -- shape, size, structure; Chemistry and function of capsule, pilus, membrane, cell wall, plasmid and chromosome, replication of bacterial nucleus; fungal morphology; Distinctive properties of virus, nucleic acids, life cycle pattern of bacteriophages; Major waterborne diseases and airborne microbes [15]

II. Food Microbiology: Contamination and microbial spoilage of fresh food and its preservation; Food adulteration; Fermented food; Food poisoning; Bacterial infections and intoxications, viral food borne illness, types of microorganisms used, pasteurization [05]

III. Microbial transformations of pesticides: Fundamental reactions of pesticide metabolism, B-oxidation, oxidative dealkalation, thioether oxidation, decarboxylation, epoxidation, aromatic hydroxylation, aromatic heterocyclic and non-heterocyclic ring cleave; Hydrolysis, halogen reactions, nitro reactions, miscellaneous reactions [10]

IV. Microbial transformations of heavy metals: Microbes in metal containing habitat, metal-microbes interactions, microbial immobilization and transformation of metals, microbial application of metal removal [10]

MSES105 [Core]

Total lecture hours: 40

Credits: 4 (8P) :: Marks: 50 [I.A.(10) + E.T. (40)]

PRACTICAL ON PHYSICAL ENVIRONMENT

1. Measurement and preparation of Oxygen Profile in aquatic ecosystem
2. Macroscopic and microscopic identification of igneous, sedimentary and metamorphic rocks, common minerals; Study of fossils with reference to paleoenvironment
3. Morphometric analysis of drainage system
4. Study of pond biota – phytoplankton, zooplankton and macrophytes; and staining of plankton
5. Physicochemical analysis of water and soil parameters
 - a) Meteorological parameters: Temperature, moisture, humidity, light
 - b) Soil parameters: pH, organic matter, N, P, K; Cation Exchange Capacity (CEC), Available Sulphur
6. Laboratory Note book
7. *Viva-voce*

MSES106 [Core]

Total lecture hours: 40

Credits: 4 (8P) :: Marks: 50 [I.A.(10) + E.T. (40)]

PRACTICAL ON ENVIRONMENTAL BIOLOGY

1. Estimation of abundance: Quadrat counts, line transects and distance method
2. Spatial pattern analysis and indices of dispersion
3. Handling of meteorological data recording equipment; Construction of wind rose
4. Determination of species diversity by diversity indices
5. Lay out of experimental design (RBD; split-plot etc.); Cluster analysis; Sampling techniques and statistical analysis of experimental design
6. Laboratory Note book
7. *Viva-voce*

Semester II
MSES201 [Core]
Total lecture hours: 40
Credits: 4 (4T) :: Marks: 50 [I.A.(10) + E.T. (40)]
LIFE PROCESSES & ECOTOXICOLOGY

I. Toxicology: Principles of toxicology; Elements and areas of toxicology; Acute and chronic toxicology; Dose-response relationship; Statistical concept of LD₅₀ and LC₅₀; Chemical and biological factors and their influences, bioassay methods, routes of entry of toxicants; Interaction of toxicants

[12]

II. Biochemical aspects of heavy metals: Sources, distribution, mechanism of action, effects and remedial measures of some heavy metals like arsenic, cadmium, lead, mercury, aluminium, chromium

[08]

III. Biochemical aspects of some specific industrial toxicants: Sources, distribution, mechanism of action, effects and remedial measures of some specific toxicants like MIC, pharmaceutical active compounds (PACs)

[08]

IV. Immunology and immunotoxicity: Properties of immune response; Innate and acquired immunity; Cells and organs of immune system; Concepts of antigens; Concept of antibodies with special reference to structure, function, classification; Antigen antibody interaction, major histocompatibility complex; Cell mediated and humoral immunity

[12]

MSES202 [Core]
Total lecture hours: 40
Credits: 4 (4T) :: Marks: 50 [I.A.(10) + E.T. (40)]
ENVIRONMENTAL GEOSCIENCE

I. Land resources and management: Land resources, land degradation cycle, land-use pattern, land reform, land use plan, soil surveys in relation to land use planning; methods of site selection and evaluation

[06]

II. Water resources management and its environment: World water balance, surface water and groundwater and their interaction; Environmental factors affecting groundwater level fluctuations, water quality, use of water, conservation of water resources, climate change impacts on water resource management

[06]

III. Mineral resources and environment: Geology and mineral resources; Distribution of mineral resources in India; Environmental impact of mineral development; Recycling of mineral resources; Minerals and sustainability

[08]

IV. Geological hazards: Earthquakes, Landslides, Cyclones, Floods and Lightening– origin, effects and minimization and perception of hazards in Indian context

[06]

V. Environmental meteorology: Atmospheric stability, adiabatic character; Turbulence and diffusion, application of meteorology to air pollution study

[06]

VI. Environmental climatology: Climatic change in of recent times; Identification and characteristics of bio-climatic and agro-climatic regions of India; Urban climatology; Climate and human comfort

[08]

MSES203 [Core]

Total lecture hours: 40

Credits: 4 (4T) :: Marks: 50 [I.A.(10) + E.T. (40)]

ENERGY RESOUCES & ENVIRONMENTAL STATISTICS

I. Energy and environment: Energy budget of the earth; Earth's thermal environment and seasons; Sun as a source of energy, solar radiation and its spectral characteristics

Conventional energy sources: Fossil fuels; Nuclear energy - fission and fusion; Non-conventional energy sources: Solar, hydropower wind, geothermal and ocean energy, energy from biofuels, biogas and biomass, energy use patterns in different parts of the world and India and its impact on the environment

[16]

II. Energy management: Energy consumption; Energy conservation, increased efficiency, and cogeneration, energy policy, integrated energy management (energy-audit & green-audit), management of nuclear energy wastes, some conservation factors, research and development on renewable energy

[08]

III. Environmental statistics: Basic elements and tools of statistical data analysis, bivariate and multivariate data; Statistical measures - mean, median, standard error and deviation; Testing of hypothesis: Null and alternative hypothesis, parametric and nonparametric test; Level of significance, degree of freedom, t-test; probability; ANOVA

[16]

MSES204 [Core]

Total lecture hours: 40

Credits: 4 (4T):: Marks: 50 [I.A.(10) + E.T. (40)]

ENVIRONMENTAL POLLUTION & DEGRADATION

I. Air Pollution: Criteria pollutants; National Ambient Air Quality Standard; Motor vehicle emissions; Status of air pollution in Indian cities; Different control measures; Indoor air quality - exposure assessment, infiltration and ventilation; Indoor air quality model

[08]

II. Water pollution: Sources, types and consequences; Inorganic and organic pollutants; Concept of eutrophication, DO, BOD, COD; Sewage and groundwater pollution; Status of water pollution in different water bodies with reference to Indian context; Water purification techniques

[07]

III. Noise pollution: Sources of noise, types of noise; noise and health; Sonic boom; Noise measurement; Measurement of noise indices (Leq, L10, L90, L50, LDN, TNI); Control of noise pollution; Noise mapping and modelling; Impact of noise and vibrations on human health

[08]

IV. Radiation pollution: Radioactivity in the environment; Radiation exposure and radiation standards, radiation protection; Biological effects of radiations; Pollution from electric power generation plant and nuclear plants, thermal pollution

[07]

V. Soil pollution: Sources, effect of soil pollution on biota, surface water and groundwater regimes; Impact of different pesticides (herbicides, insecticides, fungicides, nematicides, rodenticides *etc.*); Synthetic fertilizer (NP&K)

[10]

MSES205 [Core]

Total lecture hours: 40

Credits: 4 (8P)

Marks: 50 [I.A. (10) + E.T. (40)]

PRACTICAL ON ENVIRONMENTAL PROBLEMS

1. Collection, isolation and population study of microorganism in air, water and soil
2. Ambient air sampling, monitoring and analysis; Wind rose
3. Measurement of noise level by dB meter in different zones (as per CPCB guidelines)
4. Probabilistic analysis of natural hazards (Flood, Cyclone and Earthquake)
5. Laboratory Note book
6. *Viva-voce*:

MSES206 [Core]

Total lecture hours: 40

Credits: 4 (8P)

Marks: 50 [I.A. (10) + E.T. (40)]

PRACTICAL ON ECOTOXICOLOGICAL MEASUREMENTS

1. Impact of agrochemicals on hydrophytes, xerophytes and mesophytes
2. Analysis of Water parameters: Salinity, conductivity, sulfate, phosphate, nitrate-nitrogen, ammoniacal-nitrogen, residual chlorine, sodium and potassium
3. Effect of pesticides on total sugar content of different crops
4. Effect of pesticides and heavy metals on total protein content of different crops and aquatic vertebrates
5. Laboratory Note book
6. *Viva-voce*

Semester III

MSES301 [Core]

Total lecture hours: 40

Credits: 4 (4T) :: Marks: 50 [I.A.(10) + E.T. (40)]

BIODIVERSITY CONSERVATION & SUSTAINABLE DEVELOPMENT

I. Biodiversity: α , β , γ biodiversity; Genetic species and ecosystem diversity; Biological diversity and biogeography; Productivity of various ecosystems; 'Hotspots' of biodiversity; Strategies for biodiversity conservation and Agenda-21; Biodiversity Acts of India; National Biodiversity Authority; Indian board on Wildlife; Convention on biodiversity; Values of biodiversity; Principles and strategies of protected area network, sanctuary, national park, biosphere reserve, zoological and botanical gardens, wild life tourism and wildlife refuges; Ecotourism, Wildlife Protection Act, 1772 amended 1993; IPR and IPP in biodiversity; Climate change and biodiversity [20]

II. Sustainable development: Overview, sustainable management practices in agriculture, forestry, aquaculture, industrial development, urban development; Sustainable development goals [05]

III. Bioremediation: Concept, practices and applications; Factors influencing bioremediation; Microbial process of bioremediation; Phyco- and Phytoremediation; Microbial removal of nitrogen and phosphorus; Bioremediation of contaminated water: Case studies on Water hyacinth pond, Algae fish pond, the duckweed pond and the reed beds [15]

MSES302 [Core]

Total lecture hours: 40

Credits: 4 (4T) :: Marks: 50 [I.A.(10) + E.T. (40)]

EMERGING ENVIRONMENTAL PROBLEMS, HEALTH HAZARDS & GENETIC ENGINEERING

I. Emerging Environmental Problems: Environmental problems in developing countries – High-rise buildings, urban slum; Rural and urban sanitation problems
Greenhouse gases and global warming, carbon trading and sequestration; ODS and its impact on global climate; Nuclear winter - Concept and prediction; Chemistry of nanoparticles- synthesis, characterization, application and environmental health impacts [10]

II. Environmental health and health hazards: Concept of health and disease; Principles of epidemiology; Epidemiology of communicable and non-communicable diseases – Brief notes; occupational health; Communication for health education; Health planning and management [10]

III. Principle of genetic engineering: Concept, cell cycles, gene cloning; genetics responses of microorganisms with reference to pollutants; GMO and its merits and demerits; Conservation of gene resources; Recombinant DNA technology and its applications and limitations; Nif gene and biological nitrogen fixation [10]

IV. Environmental mutagenic and genetic disorders: Mutagenesis mechanism: UV-induced (cyclobutane type pyrimidine dimmers), single strand DNA breaks, chemical induced DNA alkylation, adduct formation, intra- and inter-strand cross-linking; Enzyme mediated photorepair and excision repair [10]

MSES303 [Core]
Total lecture hours: 40
Credits: 4 (4T) :: Marks: 50 [I.A.(10) + E.T. (40)]
REMOTE SENSING & GIS

I. Concept of map, coordinate and projection: Classification of map; map scale; Spatial referencing system; Map projections; Commonly used map projections; grid systems [10]

II. Basic principles of remote sensing-: Electromagnetic remote sensing process; Physics of radiant energy; Energy source sources and radiation principles; Energy interactions in the atmosphere; Energy interaction with earth surface materials; An ideal remote sensing system [10]

III. Remote sensing platforms and sensors: Satellite system parameters; Resolutions; Imaging sensor systems - Active and passive; Different types of satellite with special emphasis on Indian remote sensing satellites; Drone based remote sensing [08]

IV. Digital image processing: Basic character of digital image; Importance of image processing; Basic image enhancement techniques; Colour representations and transformations; Geometric and atmospheric corrections; Saptial filtering technique; Image classification - Unsupervised and supervised [08]

V. Fundamentals of Global Navigation Satellite System (GNSS) and Geographic Information System (GIS) [03]

VI. Environmental Application of Remote sensing and GIS: Land use/landcover mapping; Agricultural, water resource, disaster management and forestry application [06]

MSES304 [GE]
Total lecture hours: 40
Credits: 2 (2T) :: Marks: 25 [I.A.(05) + E.T. (20)]

ENVIRONMENTAL PERSPECTIVES

I. Environmental Issues: Basic ideas on ecosystem and community; Environmental issues; Conservation and environmentalism; Environmental ethics and philosophy; Environmental education; Ecofeminism, environmental agenda; Concept on climate change and its Conventions [06]

II. Medical Geology: Perspectives and concepts; Geological sources of nutrients, mineral elements needed for good health; Dietary sources of essential mineral elements; Pathways and exposure with reference to arsenic and fluoride in groundwater [08]

III. Environmental Health and Diseases: Concept on health and diseases; Principle of communicable and non-communicable diseases; Chemicals in food-preservatives, artificial sweetening agents, elementary idea of antioxidants, antibiotics, antacids; Health programmes in India; Hospital waste management [08]

IV. Medical Microbiology: Concept of pathogens; Infection and intoxication; Epidemics & Pandemics; Causative agents, symptoms, mode of transmission, prevention and treatment [08]

V. Environmental regulations: Constitutional provisions and Rules & Regulations; Statutory boards of pollution control, *viz.*, CPCB, SPCB, Green Tribunal [04]

Or

MSWM304[GE]
Credits: 2 (2T) :: Marks: 25 [I.A.(05) + E.T. (20)]

Course to be opted from [SWYAM]

MSES305-1[DE]
Total lecture hours: 40
Credits: 4 (8P)
Marks: 50 [I.A. (10) + E.T. (40)]
PRACTICAL on RS & GIS, EIA & DISEASES

1. Georeferencing and mosaicking of images/Toposheets
2. Digital image processing: Image enhancement technique; FCC, NDVI
3. Classification of image
4. Digitization and Cartographic representation
5. Characterization of wastes and waste water: BOD; COD; MLSS; MLVS
6. Identification (with characters) of some parasitic and other pathogenic diseases
7. Laboratory Note book
8. *Viva-voce*

MSES305-2 [DE]
Total lecture hours: 40
Credits: 4 (4T/8P) :: Marks: 50 [I.A. (10) + E.T. (40)]
ECOLOGICAL MODELLING AND GIS FOR ENVIRONMENTAL APPLICATIONS

I. Spatial analysis: Scope of spatial analysis and modelling; Spatial query and Reclassification; Geometric and distance measurement; Overlay analysis and map algebra; Spatial interpolation [10]

II. Spatial data exploration with statistics: Exploratory spatial data analysis; Spatial sampling; Measures of spatial distributions; Analysis of spatial patterns; Detection of spatial clusters; Modelling of spatial relationships [10]

III. Basics of modelling concept: Limit concept, Application of differential equation (time and space) in models [10]

IV. Types of models: Biogeochemical models, Modified SIR models, Climate models [10]

MSES305-3 [DE]

Total lecture hours: 40

Credits: 4 (4T) :: Marks: 50 [I.A. (10) + E.T. (40)]

ECOTOXICOLOGY & INDUSTRIAL MICROBIOLOGY

I. Ecotoxicology: Historical background, objectives and need of ecotoxicology. Environmental contaminants: Scientific and technological goal of study of environmental contaminants, major classes of contaminants; Emerging contaminants of concern *e.g.*, PBDE or BDE, halogenated and phenols, POPs, PCB, dioxins; Chemical mutagenesis: Base substitutions, insertions and deletions, spontaneous mutations [10]

II. Molecular effects: General cytotoxicity and histopathology; DNA modification; Oxidative stress and antioxidant response; Biochemical mechanism of toxicity; Immuno-toxicology; Behavioural toxicology, pharmaceutical toxicology, phytotoxicology [10]

III. Community ecotoxicology: Definition, historical perspective; biotic and abiotic factors; biomonitoring and the responses of communities to contaminants [10]

IV. Environmental Microbiology: Microbial flora of soil, interactions among soil microorganisms, biogeochemical role of soil microorganisms, microbiology of domestic water and wastewater - determining sanitary quality [05]

V. Industrial microbiology: Microorganisms and industry, industrial uses of bacteria, yeasts, molds; Petroleum microbiology, microbiology and mining, deterioration and materials like paper, textiles and cordage, painted surfaces γ [05]

OR

MSES306-1

Credits: 4 (4T):: Marks: 50 [I.A.(10) + E.T. (40)]

Course to be opted from [SWYAM]

MSES306-2

Credits: 4 (4T) :: Marks: 50 [I.A.(10) + E.T. (40)]

FOREST ECOLOGY AND OCEANOGRAPHY

I. 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 [06]

II. Forest ecosystem function: Primary productivity of forest ecosystems, litter production and decomposition, nutrient cycling and nutrient conservation strategies, plant water relations [08]

III. 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 Conservation Act, 1980, Indian Forest Act, (revised) 1982; Non-timber forest products [10]

IV. Oceanography: Physiography of oceans, origin and evolution of ocean basins; 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 [16]

MSES307

Credits: 2

Marks: 25 [I.A. (05) + E.T. (20)]

COMMUNITY ENGAGEMENT ACTIVITIES

Preparation of report on field visit (Industrial effluent treatment plants/ water treatment plants/ waste disposal systems/ waste disposal systems/ waste water treatment plants/ recycling systems/ power generation plants etc.). Student has to prepare a field report for submission after visit and necessary evaluation at the end of Sem III.

1. Preparation of field work copy [10]

For outreach programme students have go with respective mentor to nearby school/college with proper presentation for creating/generating awareness among the students. Authority of school/college will provide a certificate of performance of each student participated in the programme. [10]

Semester IV

MSES401 [Core]

Total lecture hours: 40

Credits: 4 (4T) :: Marks: 50 [I.A.(10) + E.T. (40)]

ENVIRONMENTAL IMPACT ASSESSMENT & ENVIRONMENTAL LAWS

I. Environmental Impact Assessment: Concept, aims and objectives of EIA; Environmental Impact Statement (EIS) and Environmental Management System (EMS); Environmental audit; EIA guidelines, 1994 & 2006; Notification of GoI; Revised notification, Sept. 2006; Life cycle assessment [10]

II. EIA techniques and methods: Evaluation of methodologies, different methods - Ad Hoc, Checklist, Overlay, Matrix, use of Computers & Expert system; EIA and planning and management; Prediction and assessment of impacts on the air, water, soil, and noise environment; Process of reviewing EIA of developmental projects [15]

III. Environmental protection & Laws – Issues and problems; International and National efforts for Environment Protection; Provisions in constitution of India regarding Environment (Article 48A and 58A); Principles and objectives; Air (Prevention and Control of Pollution) Act, 1981; The Water (Prevention and Control of Pollution) Act, 1974 as amended up to 1988; The Environment (Protection) Act, 1986 and Rules 1986; Public Liability Insurance Act, 1991 and Rules 1991; Role of Supreme Court and Green Bench of High Court on environment protection in India [15]

MSES402 [Core]

Total lecture hours: 40

Credits: 4 (4T) :: Marks: 50 [I.A.(10) + E.T. (40)]

ENVIRONMENTAL TOXICOLOGY & HAZARDOUS WASTES

I. Toxic responses: General toxic responses of cell, organs, nervous system, gastrointestinal tract, liver, kidney; Bioaccumulation and biomagnifications of toxicants in ecosystem [08]

II. Toxic agents: Toxins in nature, phytotoxins; animal toxins; Microbial toxin and xenobiotic and their impact; Food additives; Synthetic dyes; PAHs, PAN, VOC and POP; Genetic toxicology; Chemical carcinogens; Mutagenicity; Teratogenicity [10]

III. Impacts of industrial effluents: General impacts of some effluents discharged from paper and pulp industry, sugar, distillery, tannery, mining, sponge-iron on ecosystem with special reference to occurrence, environmental sources, biochemical effects, and remedial measures [07]

IV. Microplastics & Microbeads: Sources, occurrence & distribution; Types & classification; Environmental effects & toxicity [07]

IV. Hazardous wastes: Waste & waste types - Solid waste, Municipal solid waste, agricultural, industrial & mining; Hazardous waste - nature, categories, & threat; Waste problems & solutions; Sources, reduction, recycling; Methods of disposal; Waste to energy; Waste valorization [08]

MSES403 [Core]
Total lecture hours: 40
Credits: 4 (4T) :: Marks: 50 [I.A.(10) + E.T. (40)]
ENVIRONMENTAL BIOTECHNOLOGY

- I. Microbes in relation to environment:** Virus, bacteria, fungi, algae, lichen, protozoa microbial groups [05]
- II. Practical utility of viruses:** Bioinsecticides, phase topping [05]
- III. Bacteriology of water and sewage:** Methods for differentiating faecal from Sewage organisms and their characters [05]
- IV. Microbial culture techniques:** Isolation and characterization; Preservation of microorganisms; Microbial growth curves; Gene sequencing and phylogenetic tree analysis [05]
- V. Biotechnological methods:** Pollution detection and abatement [05]
- VI. Biosensor in environmental analysis:** Enzyme electrode, immobilized cell biosensor, optical biosensor, ISFET based devices, H₂O₂ biosensor, microbial biosensor, gas phase biosensor, nanobiosensor, amphoteric biosensor, environmental application of biosensor [10]
- VII. Agricultural biotechnology:** Biofertilizer - Types and application in agriculture; Biopesticides; biocomposting; Integrated pest management - concept, technology involved in agriculture and forestry [05]

MSES404-1 [DE]

Total lecture hours: 40

Credits: 4 (4T) :: Marks: 50 [I.A.(10) + E.T. (40)]

ENVIRONMENTAL ISSUES, ECONOMICS & ENVIRONMENTAL MANAGEMENT

I. Environmental Economics: Concept of ecological economics; Environmental economics and principles; Cost-benefits analysis; Economics of environmental quality; Polluter pays principles; Trade and environment; Externalities, green policies, common resource management systems [10]

II. Environmental Management System: Environmental system principles, tools and management strategies; Environmental management systems & standards (ISO 9001 & 14000 series); Perspectives of environmental management policy in India; Eco-labelling schemes [12]

III. Natural disaster management: Major global disaster framework - IDNDR, HUGO, MDG, SDG, SFDRR, COP 21, PMTPA; HVCR; DM act, plan and policies in India [08]

IV. Waste management: Methods of disposal and management of wastes (Municipal, Bio-medical, hospital wastes, sewage and Hazardous e-waste); Composting, vermicomposting, pyrolysis, biomethanation; Electrical energy generation from solid wastes (Fuel pallets, refuse derived fuels) [10]

MSES404-2 [DE]

Total lecture hours: 40

Credits: 4 (4T) :: Marks: 50 [I.A.(10) + E.T. (40)]

ENVIRONMENTAL ENGINEERING AND SCIENCE

I. Water quality and regulation: Potable water, surface water, waste water, groundwater; Water quality assessment: Physico-chemical and biological surveillance, biological indices, pollution indices, diversity indices, chemical indices [10]

II. Drinking water contamination: Problems derived from resources, water quality problems derived from water treatment, -from distribution, -from home plumbing situations [07]

III. Waste water engineering: Properties of waste water, composition, sewage collection, charging; Waster-water treatment: Requirement of treatment, pre-treatment, design of wastewater treatment plants; Biological aspects of secondary sewage treatment and other biological treatment processes; Anaerobic treatment; Physico-chemical treatment process; Activated sludge and sludge treatment; Household treatment systems [15]

IV. Air Pollution and Control Engineering: Ambient air quality and standards, Climatic and Meteorological effect on air pollution, formation of smog and fumigation, Introduction to air pollution control, Control of gaseous contaminants [08]

MSES405-1 [DE]
Total lecture hour: 40
Credit: 4 (8P) ;; Marks: 50 [I.A.(10) + E.T. (40)]
PRACTICAL ON TOXICOLOGICAL TESTING

1. Measurement of LC₅₀/LD₅₀ and safe concentration of toxicants
2. Quantitative estimation of residual heavy metals in the tissue of aquatic vertebrates with special reference to fish by Atomic Absorption Spectrometer
3. Study on chronic toxicity
4. Study on toxicological biomarkers viz., Histopathological, Morphoanatomical (GaSI, GSI, HIS, RLG, Fecundity)
5. Study on toxicological response through biochemical tests viz., amylase, lipase, protease activity etc.
6. Laboratory Note book
7. *Viva-voce*

MSES405-2 [DE]
Total lecture hours: 40
Credits: 4 (8P):: Marks: 50 [I.A.(10) + E.T. (40)]
PRACTICAL ON SPATIAL DATA ANALYSES AND ECOLOGICAL MODELLING

1. Query build up; Reclassification
2. Buffer; Overlay and Dissolve operation
3. Spatial interpolation
4. Tools in STELLA software
5. Construction of Conceptual diagram
6. Application of models in Environmental processes
7. Laboratory Note book
8. *Viva-voce*

MSES406
[Project/Term
paper] Credits: 4
Marks: 50 [I.A.(10) + Dissertation & *viva-voce* (30+10)]
DISSERTATION WORK

Submission of Dissertation & *Viva voce*