

GAUHATI UNIVERSITY
M. Sc. Syllabus in Environmental Science

Admission Criteria:

Students having B.Sc. degree in the 10+2+3 pattern with Major in any subject or Environmental Science as a pass subject and securing a minimum of 45% marks in Major course or 50% in General course are eligible for admission in the M. Sc. course in Environmental Science. The candidates having major in Environmental Science would get a bonus mark of 5%. All the candidates are required to appear in a written admission test based on general environmental awareness (Environmental Studies) and basic sciences. The selection of the candidates will be made on the basis of the performance in the Admission Test as well as in the B.Sc. Examination. The number of seats for the two-year Full Time Course is limited to 10 (ten). There are two additional seats also on self financing basis.

Course Structure

Course Code	Course Title	Total Marks	Credits	Classes		
				L	T	HW
Semester - I						
ES-101	Fundamentals of Environmental Sciences	75	5	4	-	1
ES-102	Environmental Chemistry	75	6	4	1	1
ES-103	Environmental Biology	75	6	4	1	1
ES-104	Environmental Earth Science	75	6	4	1	1
ES-105	Practical - I and Field Study	100				
	Practicals	85	8		13	3
	Field Study (local)	15	1			
Semester – II						
ES-201	Statistical Methods for Environmental Data Analysis	75	5	4	-	1
ES-202	Environmental Pollution	75	6	4	1	1
ES-203	Ecosystem Dynamics	75	6	4	1	1
ES-204	Environmental Hazards	75	6	4	1	1
ES-205	Practical - II and Field Study	100				
	Practicals	85	8		13	3
	Field Study	15	1			
Semester – III						
ES-301	Environmental Remote Sensing and GIS	75	5	4	-	1
ES-302	Analytical Methods for Environmental Monitoring	75	6	4	1	1
ES-303	Environmental Health and Eco-toxicology	75	6	4	1	1
ES-304	Eco-hydrology and Watershed Management	75	6	4	1	1
ES-305	Practical - III and Dissertation Seminar	100				
	Practicals	85	8		13	3
	Dissertation Seminar	15	1			
Semester – IV						
ES-401	Energy and Environment	75	6	4	1	1
ES-402	Environmental Impact Assessment	75	6	4	1	1
ES-403	Environmental Law and Management	75	6	4	1	1
ES-404	Special Paper (any one of the following papers) (a) Environmental Pollution – Control and Mitigation (b) Natural Hazards in Northeast India	75	6	4	1	1
ES-405	Project	100				
	Dissertation	75	8		13	3
	Viva	25				
	Total	1600	128			

L – Lecture, **T** – Tutorial, **HW** – Home Work

FIRST SEMESTER

ES-101: Fundamentals of Environmental Sciences (Credit: 5)

1. **Introduction:** Meaning, scope and interdisciplinary nature of Environmental Science; Environmental factors; The Global environment and its segments; Structure and composition of atmosphere, hydrosphere, lithosphere and biosphere
2. **Weather and climate:** Weather Elements and their variations; Heat balance of the earth-atmosphere system, Earth as a heat engine
Major climatic zones of the world, Climates of India, Climate and vegetation, Climatic extremes - environmental implications, Global climate change and its impact on environment
3. **Energy fundamentals:** Heat transfer processes; Mass and energy transfer across the interfaces of various geospheres, Hydrologic cycle, Biogeochemical cycles — carbon, nitrogen, and phosphorus cycles.
4. **Man and Environment:** Man-environment relationship, General relationship between landscape, biomes and climate. Concept of sustainable development, Environmental ethic
Population growth - biological growth curves and carrying capacity, Human population growth and environmental constraints, Effects of environment on human culture and livelihood; Human impact on ecosystems
5. **Fundamentals of Ecology:** Meaning and scope; Ecosystems - types, structural and functional aspects; Energy flow in ecosystems, food chain, food web, trophic levels, ecological pyramids; Ecotone; Ecological niche
6. **Natural Resources :** Air, Water, Soil, Minerals, Forests and Energy resources; Concept of reserve and resources; Problems with the exploitation of resources
7. **Environmental Risk and Hazards:** Risk and hazards; Chemical hazards, Physical hazards, Biological hazards, Basics of hazard management and mitigation
8. **Major Environmental Issues:** Green House effect, Ozone layer depletion, Acid rain, Deforestation and loss of bio-diversity

Recommended Books

1. Environmental Science – The natural environment and human impact (1998): A. R. W. Jackson and J. M. Jackson, Longman
2. Environmental Science (2001) : S. C. Santra, New Central Book Agency (P) Ltd
3. Introduction to Environmental Science and Engineering (2nd Ed.) (2004): G. M. Masters, Pearson Education Pvt. Ltd.
4. Environmental Science (6th ed) (1997): Jr. G. T. Miller, Wadsworth Pub. Co.
5. Fundamentals of Environmental Science: G. S. Dhaliwal, G. S. Sangha and P. K. Raina, Kalyani Publication
6. General Climatology: Critchfield H. J.
7. Introduction to Weather and Climate : Trewartha
8. Dimensions of Environmental and Ecological Economics (2005): N. C. Sahu & A. K. Choudhury (Ed), Universities Press

ES-102: Environmental Chemistry (Credit: 6)

1. **Environmental Chemistry:** Concept and scope of Environmental Chemistry; acid base reactions, pH and pOH, ionic product of water, common ion effect, buffer solutions, solubility and solubility product, hydrolysis, chemical equilibrium, oxidation and reduction, chemical speciation, Chemistry of Environmental Trace Elements: Pb, As, Hg and Cd, concept of green chemistry
2. **Chemical Kinetics:** Simple reaction mechanisms; Order and molecularity of chemical reactions; First, second and zero order reactions; Catalysis; Adsorption
3. **Atmospheric Chemistry:** Chemical composition of the atmosphere; Chemical and photochemical reactions in the atmosphere - formation of smog, PAN, acid rain, oxygen and ozone chemistry; Catalytic decomposition process of ozone Concept of atmospheric aerosol chemistry, Green house gases
4. **Water Chemistry:** Physical and chemical properties of terrestrial and marine water and their environmental significance; Water quality parameters – physical, chemical and biological; Distribution of chemical species in water; Gases, organic matter and humic matter in water.
5. **Soil Chemistry:** Chemical & mineralogical composition of soil, Physical properties of soil – texture, bulk density, permeability; Chemical properties – cation exchange capacity, pH, macro and micro nutrients
6. **Chemistry of Cleaning Agents:** Soap, detergents and bleaching agents; Chemistry of colloids
7. **Chemistry of Fuels:** Gasoline and additives, antiknock compounds, lubricants and greases, biogas

8. **Organic compounds:** Hydrocarbons, PAH, PCBs, phenols, chlorofluorocarbons, pesticides, chemical fertilizers

Recommended Books

1. Environmental Chemistry : A. K. De
2. Environmental Chemistry : B.K. Sharma, and H. Kaur
3. Environmental Chemistry : S. E. Manahan
4. Environmental Chemistry : J. W. Moore and E. A. Moore
5. Environmental Chemistry - A global perspective: G. W. Vantoon & S. J. Duffy; Oxford university Press
6. Handbook of Environmental Health and Safety – principle and practices (Vol. II): H. Koren; Lewis Publishers

ES-103: Environmental Biology (Credit: 6)

1. **Introduction:** Concept of Environmental Biology, Concept of Ecosphere and Biosphere, Ecological factors and variables
2. **Biomes and Habitat:** Classification of biomes – Tundra, Taiga, Grassland, Desert, Evergreen and deciduous forests, Tropical rain forests and their characteristics, flora and fauna; Classification of Aquatic Habitats – Fresh water pond, Wetlands, Beels, Rivers - their characteristics, flora and fauna; Marine Habitats – Pelagic, Benthic, Inter-tidal Estuarine; Mangroves – their characteristics, flora and fauna
3. **Community Ecology:** Definition and concept of community, community diversity, structure, dominance, stratification and periodicity; Community interdependence, Ecotone, Edge effect and Ecological Niche
Ecological succession – characteristics, types of succession, concept of climax, significance of succession
4. **Environmental Microbiology:** Concept and definitions; Microbes in Agriculture - biological nitrogen fixation, bio-fertilizers, Mycorrhiza; Food Microbiology - micro-organisms of food, microbes in food production, Food spoilage – fish and meat, Food poisoning and its prevention
5. **Air Microflora:** Microflora of atmosphere – different sampling techniques, identification of aeroallergens; Airborne diseases and allergies; Microbes and pollution abatement
6. **Environmental Biotechnology:** Introduction, Concept of Genetic Engineering and its applications, Concept of Gene-Bank, Vermi-culture, Tissue culture, Fermentation, Enzyme technology
7. **Environmental Biophysics:** Introduction, Bio-energetics – Principle of thermodynamics, First and Second law of thermodynamics, Living system and entropy changes; ATP Bioenergetics - ATP formation and breakdown in living system;
Photobiology – UV, Visible and IR radiations - biomedical uses; Photosynthesis
Bioluminescence – Bioluminescence in bacteria and fire-flies, Functions of bioluminescence
8. **Environmental Biochemistry:** Proteins – Biological important proteins, biological functions of proteins; Nucleic acids – DNA, RNA, and their types, biological functions of nucleic acids
Biochemical degradation of pollutants, Bioconversion of pollutants

Recommended Books

1. Fundamentals of Ecology : E. P. Odum
2. Botany: A. C. Dutta; Oxford University Press, Calcutta
3. Aquatic Ecosystems : Kumar, A P H Pubh
4. Microbiology 6th ed: Purohit, Agrobios
5. Global environmental Biotechnology : D. L. Wise
6. Methods in Biotechnology : Hans Peter Schmauder

ES-104: Environmental Earth Science (Credit: 6)

1. **Introduction:** Origin and evolution of the earth; Plate tectonics – sea floor spreading and continental drift, mountain building
2. **Atmospheric Processes:** General circulation and wind systems; Cyclones and anticyclones; Air masses - source, modification and classification; Fronts and weather systems; Monsoons, El-Nino, La-Nina, ENSO
3. **Earth's Surface Processes:** Weathering of rocks - physical, chemical and biological; Mass-wasting; Erosion, Transportation and deposition of earth's materials by running water, wind and glaciers; Development of landforms; Soil erosion
4. **Earth's Geodynamic Processes :** Concept of stress and strain; Mechanics and classification of folds and faults; Recognition and genesis of minor structural elements - foliation, lineation, drag folds, cleavage and joints
Earthquakes, Volcanoes and Tsunamis - Environmental changes
5. **Glaciers:** Physical and chemical aspects, Mass balance, Recession of Himalayan glaciers, Glaciers as index of climate change.

6. **Rocks, Soil and Minerals:** Rock types – igneous, metamorphic and sedimentary; Soil - formation, composition, and classification; Soil profile, Mineral deposits – formation and classification; Environmental problems associated with extraction of mineral deposits
7. **Fundamentals of Meteorology:** Atmospheric thermodynamics – equation of state of dry and moist air, specific heats and application of laws of thermodynamics, thermodynamic process; Temperature lapse rate and inversion; Hydrostatic balance and atmospheric stability; Scales in meteorology. Energy budget near the surface; Planetary boundary layer – variation of air temperature, humidity and wind; Diffusion and Turbulence, Mixing length
8. **Climatology:** Elements of weather and climate, Climatic controls, Energy balance in atmosphere; Elementary ideas about weather systems; Climatic variability and climate change; Climatic classifications; Climates of Indian region

Boundary Layer Climates – Effects of topography, Energy and mass exchange, Climates of vegetated surface, Urban climatology

Recommended Books

1. Boundary layer climates (1978): T. R. Oke; Methuen & Co. Ltd
2. Introduction to Micrometeorology (1988): S. Pal Arya; Academic Press
3. General Meteorology (1974): H. R. Byers; McGraw-Hill
4. An Introduction to Climate (1968): G. T. Trewartha; McGraw-Hill
5. Environmental Geology (1987): K. S. Valdiya; Tata McGraw-Hill
6. Atmospheric Science – An introductory survey (1977): J. M. Wallace and P. V. Hobbs; Academic Press
7. Himalayan Snow and Glaciers: Bahadur; Concept Pub
8. Earths Dynamic Systems (8th ed): Hamblin: Prentice Hall

ES 105 PRACTICAL - I AND FIELD STUDY

PRACTICAL S – (Credit: 8)

(a) Environmental Chemistry: The experiments will be related to -

1. Analysis of water and effluent - Physical parameters, Chemical parameters, Nutrient parameters and Bacterial parameters.
2. Volumetric analysis of water and soil samples by EDTA titration.
3. Turbidimetric experiment - Estimation of sulphates
4. Potentiometric experiments - Estimation of halides in water samples
5. Colorimetric experiments - Estimation of Fe^{2+} , Fe^{3+} and Ni^{2+}
6. Estimation of alkali metals in various samples by flame-photometry
7. Analysis of soils for NPK, Na, Ca.

(b) Environmental Biology: The experiments will be related to -

1. Study of Grassland and Pond productivity by quadrat and plankton study
2. Estimation of Grassland and Forest animal population (seen) by quadrat method
3. Visit to aquatic ecosystem and collection of water and plankton samples for quality and productivity studies
4. Vegetation studies by line and belt transect method and their analysis
5. Preparation of Agar Agar media for microbial culture from soil, water and air and their identification
6. Study of wetland flora and fauna and the status study
7. Plant tissue culture in laboratory

(c) Environmental Earth Science: The experiments will be related to -

1. Familiarization with meteorological instruments and their use
2. Studies related to upper air and surface weather including coding and decoding of meteorological parameters
3. Presentation and interpretation of wind data (wind rose)
4. Studies of thin sections of selective igneous, metamorphic and igneous rocks
5. Study of geological maps and drawing of sections across geological structures
6. Determination of Soil Texture
7. Use of survey instruments - theodolite, dumpy level and plane table

FIELD STUDY (LOCAL) – (Credit: 1)

Field study to a local environmentally important area

SECOND SEMESTER

ES-201: Statistical Methods for Environmental Data Analysis (Credit: 5)

1. **Introduction:** Environmental Variables - Discrete and continuous; Data collection - primary and secondary; Presentation of data - spatial and non-spatial data; Basic Statistics - frequency distribution, Measures of Central Tendency and Dispersion, Moments, Skewness and Kurtosis

2. **Probability Rules and Theoretical Distributions:** Basic probability rules, expectation, conditional probability; Probability distributions – Binomial, Poisson, Normal and Log-normal distributions; Fitting of probability distributions to environmental data.
3. **Design of Sample survey:** Population and sample, Advantages of sampling over complete census and its limitations, Different techniques of sampling –simple random sampling, stratified random sampling, systematic sampling; Relative advantages and disadvantages of different techniques
4. **Analysis of Variance:** Different types of models used in AOV; Basic assumptions and its violation; One and two way classified data; Application of AOV to environmental data
5. **Sampling distribution and Test of Significance:** Parameter and statistics; Sampling distribution, Standard error and its uses; Concept of t- distribution, F-distributions, Chi Square distribution without derivation and their applications; Null hypothesis and uses of t- test, F-test, X^2 -tests; Test of significance of large samples
6. **Correlation and Regression:** Bi-variate data and scatter diagram; Simple (linear) correlation and regression; Coefficient of correlation and regression and their properties; Fitting of regression line; Multiple and partial correlations and regressions
7. **Theory of Attributes:** Definition and classification of Attributes, Contingency Table, Independence of attributes, Yule's coefficient of association and its properties
8. **Time series analysis:** Components of time series, Models, measurement of trend, seasonal movements, cyclical movements

Recommended Books

1. Fundamentals of Mathematical Statistics: S. C. Gupta and V. K. Kapoor; S. Chand & Co.
2. Statistical Methods in Geographical Studies: Aslam Mahmood; Rajesh Publications, New Delhi
3. Statistical Methods : An Introductory Text : J. Medhi: New Age International Ltd. Publishers
4. Practical Statistics (vol 1&2): Singh; Atlantic Publishers

ES-202: Environmental Pollution (Credit: 6)

1. **Introduction:** Definition and sources of pollution; Different types of pollution and their global, regional and local aspects.
2. **Air Pollution:** Types and sources of air pollutants; Reaction of pollutants in air forming smog, PAN, Acid rain; Atmospheric diffusion and stack performance; Transport of pollutants; Effects of air pollutants on flora and fauna; Sinks of atmospheric gases.
3. **Water Pollution :** Sources of water and their contamination; Types of pollutants, various industrial effluents such as pulp and paper mills, oil exploration and refinery, , petrochemicals, iron and steel industries, domestic wastes ,organic debris, agricultural wastes, pesticides; Treatment of water and waste water.
Eutrophication – causes and effects and control measures.
4. **Soil pollution and solid waste pollution:** Causes of soil pollution; Effects of Fungicides and weedicides on soil components, residual toxicity and pollution. Different kinds of synthetic fertilizer (N, P, K), and their interactions with different components of soil, their toxicity and pollution. Industrial effluents and their interactions with soil components, Contamination by radio-nuclides. Solid waste pollution : sources, nature, classification and environmental effects.
5. **Radiation Pollution :** Radioactive decay; Interaction of radiation with matter; Biological impact and health hazards associated with radiation, Units of radioactivity and radiation dose; Protection against ionizing isotopes and their applications in waste water and air pollution analysis and treatment; Radioactive waste disposal.
6. **Noise Pollution :** Basic properties of sound waves – plane and spherical waves, sound pressure, loudness and intensity levels, decibel; Sources of Noise Pollution –Measurement and analysis of sound, Measures to control noise pollution
7. **Thermal pollution:** Definition and sources, Chemical and biological effects of thermal pollution, Effect on marine life, bacteria and water quality and other aquatic biota; Thermal pollution from power plants and their control.
8. **Oil pollution :** Oil pollution and marine ecology, sources of oil pollution, factors effecting fate of oil after spillage movement, spreading, evaporation, emulsification, dispersion, remote sensing in water quality monitoring.

Recommended Books

1. Environmental Chemistry : A. K. De
2. Environmental Chemistry : B.K. Sharma, and H. Kaur
3. Handbook of Environmental Health and Safety – principle and practices (Vol. II): H. Koren; Lewis Publishers

ES-203: Ecosystem Dynamics (Credit: 6)

1. **Introduction:** Ecosystem - concept, characteristics, kinds and structure; Ecosystem functioning - food chain, food web; Ecological pyramids – pyramids of numbers, pyramids of biomass, pyramids of energy, inverted pyramids; Ecological energetics - energy flow, ecological efficiency
2. **Introduction to Taxonomy:** Taxonomic Principles; Procedure of classification; Linear classification of plants and animals up to generic groups
3. **Population dynamics:** Concept of population, Population growth - density, natality, mortality and growth curves, life curves, age structure, function and equilibrium; Population regulation – biotic potential and environmental resistances; Factors of population regulation – density dependent and density independent; Population crash and carrying capacity; The laws of population growth
4. **Human population:** Human population growth – global and regional human population growth, natality and mortality; Changes in life expectancy; Problems of population growth, Controlling of human population growth
Human food requirements, Food production - Green Revolution and its environmental significance (Food chain losses; effects of pesticides on non-target organisms, effects on predator, pollution)
5. **Limiting Factors of Environment:** Concept of limiting factors, Laws of limiting factors – laws of minimum and tolerance; Combined concept of limiting factors; Earth's carrying capacity
6. **Biological Relationship:** Neutralism, symbiosis, commensalism, mutualism, antagonism, antibiosis, parasitism, predatism; Competition – intra-specific and inter-specific,
7. **Biodiversity:** Organisms-evolution and distribution in space and time; Hotspots of Biodiversity; Gene pool; Climate and its impact on biodiversity; Indian forest and vegetation types and diversity of flora and fauna
Endangered, and Endemic Species; Threatened species; Categories of IUCN, threatened species of plants and animals in Northeast India, Red data books.
8. **Biodiversity Conservation:** Biodiversity conservation; Convergence and divergence in species; Sustainable exploitation and development; Strategies for conservation, Global agreements and national concerns, RAMSAR sites, CBD, Quarantine Regulations, National Forest Policy, Biodiversity Act., Wild-life Protection Act of India. Conservation of National Parks and Sanctuaries

Recommended Books

1. Fundamentals of Ecology : E. P. Odum
2. Demography: Preston; Blackwell
3. Ecotourism and Sustainable Development: Singh; Abhijeet Pub
4. Global Biodiversity strategy: WRI, IUCN & UNEP

ES-204: Environmental Hazards (Credit: 6)

1. **Environmental hazards:** Definition - Hazard, vulnerability and risk; Natural and man-made hazards, Strategies for mitigation – warning system, forecasting, Emergency Preparedness, Education and Training Activities, planning for Rescue and Relief works
2. **Earthquake and Volcanic Hazards:** Origin and severity of earthquakes, effects of earthquakes, risk evaluation, seismic hazards and its zonation in India with special reference to North East India, Coping with seismic hazards Origin and types of volcanic activities; Volcanic belts; Nature of volcanic hazards, mitigation of volcanic hazard vulnerability.
3. **Flood hazard and its management.** Definition - Floods, Floodplains and Flood-Prone Areas; Causes, nature and frequency of flooding; urbanization and flooding; Flood Hazard Assessment - environmental effects of flooding, Flood prone areas of India and associated hazards, flood mitigation and management in Northeast India
4. **Slope instability and Landslide hazard:** Causes - destabilizing forces; mass movement types; human use and landslides; Identification of landslide zones and their control, strength of materials and instability of slopes, subsidence and swelling of ground
5. **Desertification and Drought** – Causes of desertification; Evaluation of desertification hazard – potential and zoning; Drought - causes, types, distribution and management
6. **Cyclones and Tsunami:** Cyclones – their nature and genesis; Nor'westers; Weather associated with cyclones; Tsunami – their origin, nature and impact on coastal areas; Tidal waves
7. **Hazard Mitigation:** Identification of hazard prone belts, Hazard zonation and Risk assessment, Developing warning system, Risk assessment and reduction in vulnerable areas.
8. **Man-made Hazards:** Hazards due to dams and reservoirs, hazards due to nuclear power plant, Industrial hazards, Occupational hazards, Mitigation measures.

Recommended Books

1. Natural Hazards – Local, National, Global: G. F. White (ed), Oxford University Press

- Handbook of Applied Hydrology (1964): V.T. Chow, (New York: McGraw-Hill,
- Environmental Geoscience - Interaction Between Natural Systems and Man (1973): A. N. Strahler and A. H. Strahler; Santa Barbara, California: Hamilton Publishing
- Handbook of Desertification Indicators (1978): P. Reining, (Washington D.C.: American Association for the Advancement of Science.
- Environmental Geology (1987): K. S. Valdiya; Tata McGraw-Hill

ES-205: Practical - II and Field study

Practicals (Credit: 8)

(a) Experiments based on Statistical methods and computer applications

- Use of computer for analysis of environmental data
- Regression analysis, trend analysis, error analysis and application of statistical tests in environmental problems
- Fitting of polynomials to environmental data
- Analysis of time series of environmental variable
- Use of Chi-square, F-test and t- test
- Principle component analysis of environmental variable.

(b) Experiments based on Environmental pollution

- Measurement of noise in silent, industrial, residential and commercial zones.
- Determination of (i) SPM in ambient air by high volume sampler and their analysis
- Analysis of SO₂, NO_x, by wet chemistry method
- Experiments related to physicochemical properties of waste water
- Experiments related to Microbiological analysis of waste water
- Estimations of fluorides and arsenic in ground water
- Experiments related to soil analysis - collection of soil samples for analysis, determination of physical and chemical properties of soil like CEC, P^H, Organic matter content, moisture content, calcium carbonate content

(c) Experiments based on Ecosystem dynamics

- Forest ecosystem studies : vegetation mapping, estimation of primary production
- Aquatic ecosystem : surveying and mapping, determination of some physico-chemical characteristics, studies related to aquatic microphytes, estimation of primary production and respiration of phytoplankton population, studies related to aquatic macrophytes
- Grassland studies : estimation of frequency, density, bio-mass, coverage and important value index (IVI)

(d) Experiments based on Natural hazards

- Calculate of return periods for floods using different methods such as Gumbel's extreme value method, Log Pearson type III method etc.
- Analysis of Seismogram and identification and interpretation of various phases
- Determination of epicentre of an earthquake using P- and S- wave travel time difference
- Landslide studies in Assam region - slope stability analysis and landslide zoning
- Preparation of hazard zoning maps with special reference to Assam region

FIELD STUDY (Credit: 1): Field study will be carried out in an area having environmental significances as decided by the department.

THIRD SEMESTER

ES-301: Environmental Remote Sensing and GIS (Credit: 5)

- Principles of Remote Sensing:** Concepts of Remote Sensing, Physics of remote sensing, effects of atmosphere, Principle of scanner and CCD array, Spectral reflectance of earth's surface features in different wavelength region of electromagnetic spectrum: spectral characteristics of surface features (rocks, soils, vegetations, water).
- Space Imaging:** Landsat, SPOT, IRS, NOAA, Seasat, ERS, RADARSAT, INSAT satellites and their sensors, geometry and radiometry, Orbital characteristics, Data products. Applications of Remote Sensing in environmental monitoring: Land use mapping, forest survey in environment.
- Thermal remote sensing:** Basic principles, Radiation laws, Sensing radiant energy, Thermal sensors, characteristics of image and their uses.
- Microwave remote sensing:** Basic definitions and principles, RADAR, SLAR, SAR; General characteristics, spectral resolution and interpretation.
- Digital Image Processing:** Principles, Image Rectification, Image enhancement and Mosaicing. Image classification, - Supervised, Unsupervised, Ground truth data and training set manipulation, Classification accuracy assessment.
- Areal Photography:** Fundamentals of photogrammetry, areal cameras, planning of areal photography, principle of stereophotography, parallax and measurement of height & slope

Elements of image interpretation, convergence and evidence, interpretation keys; Interpretation of photographs and images for environmental analysis

7. **Geographical Information System (GIS):** Basic principles, Raster and vector data, Map projection, Topology creation, Overlay analysis, Data structure and Digital cartography
8. **Global Positioning System (GPS):** Basic principles, Applications to environmental studies

Recommended Books

1. Remote Sensing of the Environment – An earth resource perspective: J. R. Jensen; Pearson Education
2. Geographic Information Systems: Martin, Routledge
3. An Introduction to GIS: Heywood, Pearson
4. Remote S sensing in Land Evaluation: Yadav; Rajesh Pub
5. Essentials of GPS (2004): N. K. Agarwal; Spatial Networks Pvt. Ltd., Hyderabad

ES-302: Analytical Methods for Environmental Monitoring (Credit: 6)

1. **Physicochemical methods for water and soil analysis:** Physiochemical parameters – Definition and determination of Conductivity, pH, DO, BOD,COD, Measuring instruments
2. **Sampling and Sample preparation:** Sampling of Air, Water and Soil; Sampling equipments; Preparation of sample for trace metal analysis in water air and soil: Dissolution techniques and microwave digestion;
3. **Measurement and analysis of Weather elements:** Weather elements; Measuring equipments, Data analysis, presentation and interpretation.
4. **Analysis of Metal Ions:** Colorimetry and Spectrophotometry – theory and instrumentation; Theory, instrumentation and application of Atomic Absorption Spectrometry, Flame Emission Spectrometry and Inductively Coupled Plasma Mass Emission Spectrometry;
5. **Separation Techniques:** Principle and process of solvent extraction, Extraction reagents and Practical applications; Chromatography – principle and application of thin layer and ion exchange chromatography
6. **Gas Chromatography and High Performance Liquid Chromatography** - Principle, instrumentation and applications
7. **Nephelometry and Turbidimetry:** General discussion, Instruments for nephelometry and turbidimetry and their applications
8. **Principle and application** of Ion-chromatography, GC-MS, Anode Stripping Voltametry and Neutron activation analysis;

Recommended Books

1. Standard Methods for Examination of water and waste water : A. E. Greenberg, A. D. Eaton; APHA, AWWA, WEF
2. Chemistry for Environmental Engineering and Science : C. N. Sawyer, P. L. McCarty and G. F. Parkin
3. Laboratory Manual for the Examination of Water, Waste water and soil : H. H. Rupa and H. Krist; V C H Publication

ES-303: Environmental Health and Eco-toxicology (Credit: 6)

1. **Overview of Environmental Health:** Concept and scope; Global and regional perspectives; Basic requirements for healthy environment; Environmental quality, human exposure and health impact – impact of environmental factors on human health.
2. **Industrial Pollution and Chemical Safety:** Extent of industrial pollution, Public exposure from industrial sources, Hazards by industry, Major chemical contaminants at workplace, Industrial environmental accidents
3. **Environmental Diseases** : Asbastosis, Silicosis, Synosis, Asthma, Fluorosis and Allergies; Epidemiological issues - Malaria and Kalaazar
4. **Occupational Safety and Health:** The relationship of occupational hygiene/ safety and disease; Principles and methods of occupational health, Health problem due to industrial dust, heat, chemicals, noise, toxic gases and metals, Health hazard in agriculture - Pesticides and environment, Pesticides and human health.
5. **Environmental Health Hazard and Risk Assessment:** Hazard and risk, Biological, chemical, physical and psychological health hazard; Health risk assessment and management
6. **Eco-toxicology:** Introduction to ecotoxicology, Principles of toxicology, Types of toxic substances - degradable and non-degradable; Influence of ecological factors on the effects of toxicity; Sigmoid relationships, Corollary of toxicology
7. **Toxicants in the Environment:** Toxic substances in the environment, their sources and entry roots, Eco-system influence on the fate and transport of toxicants; Transport of toxicants by air and water; Transport through food chain - bio-transformation and bio-magnification

8. **Man and Environmental Toxins:** Routes of toxicants to human body – entry through inhalation, skin absorption, indigestion and injection; Response to toxin exposures – Dose response, Frequency response and cumulative response; Lethal and sub-lethal doses; Dose-Response relationships between chemical and biological reactions. Analysis of NOEL, LD 50, LC 50 and MLD; Detoxification in human body - detoxification mechanisms, organs of detoxification

Recommended Books

1. Principles of Environmental Toxicology: I. C. Shaw and J. Chadwick; Taylor & Francis Ltd
2. Basic Environmental Health (2001): Annalee Yassi, Tord Kjellström, Theo de Kok, Tee Guidotti
3. Environmental Health : Monroe T. Morgan
4. Handbook of Environmental Health and Safety – principle and practices : H. Koren; Lewis Publishers

ES-304: Eco-hydrology and Watershed Management (Credit: 6)

1. **Introduction:** Hydrologic cycle and hydrologic budget, Inventory of Earth's water, Global Water Balance; Drainage basin – characteristics, Surface and subsurface environment; Stream classification and ordering
2. **Precipitation:** Mechanism, forms and types of precipitation; measurement of precipitation - rain gauge, radar, satellite; analysis, presentation and interpretation of precipitation data – areal distribution, temporal variation, estimation of areal average; Precipitation characteristics in India – seasonality, areal distribution and trend; precipitation characteristics of Northeast India
3. **Water Abstractions:** Different process of water abstraction in a basin; Evaporation and evapotranspiration - Mechanism, Factors affecting evaporation and transpiration, Measurement of evaporation and evapotranspiration; estimation of evapotranspiration; Infiltration and percolation - Infiltration capacity of soil, Factors influencing infiltration capacity, methods of determining infiltration capacity
4. **Runoff and Stream flow :** Factors affecting runoff – climatic & physiographic; stream flow measurement – stage and discharge, measuring instruments; Stage-discharge relationship - rating curves and their determination; Stream flow hydrograph – elements, analysis, flow separation; Unit hydrograph – concept, assumption, construction, limitations and uses
Water erosion - mechanism, type, estimation; Sediment yield of a basin
5. **Ground water:** Definition – soil moisture, Water table, Aquifers; Geology of aquifers; Ground water flow; Abstraction of ground water; Environmental influences on ground water - fluctuations due to evapotranspiration, fluctuations due to meteorological phenomena, urbanization: Ground water recharging and rain water harvesting
6. **Hydrological forecasting:** Frequency analysis, Probability of the N-year event, Probability plotting, cyclical nature of hydrological phenomena
7. **Wetland and Forest hydrology:** Wetlands – definition and classification, Hydrologic regimes – reduction of flash flood, storage of water, role in ground water recharge; Role of forests in ground water recharge, soil conservation and flood moderation
8. **Watershed Management:** Concept, objectives, planning and measures; Land use planning for watershed management; Water harvesting and recycling; flood control and watershed management; Socioeconomic aspects of watershed management

Recommended Books

1. Elementary hydrology (1994): V. P. Singh, Prentice-Hall of India
2. Hydrology – Principles, analysis and design (1996): H. M. Raghunath, New Age International Publisher
3. Elements of water resource engineering (1996): K. N. Duggal and J. P. Soni, New Age International Publisher
4. Applied Hydrology : Chow
5. An introduction to the environmental physics of soil, water and watersheds (2004): C. Rose, Cambridge University Press
6. Soil erosion and conservation (1993): R. P. Tripathi and H. P. Singh, Wiley Eastern Limited
7. Integrated watershed management: Rajora
8. Principles and Practices of Water Management: Panda; Agrobios
9. River Basin Morphology: Devi; Rajesh Pub
10. Applied Hydrology-Murtreja.

ES-305: Practical – III and Dissertation Seminar

Practicals (Credit: 8)

(a) Experiments related to remote sensing and GIS

1. The experiments will be related to measurements on aerial photograph, use of simple instruments like stereoscope, stereo-meter, digital planimeter; interpretation of aerial photographs for preparation of land use and vegetation maps

2. Interpretation of satellite imagery for environmental mapping and pollution monitoring
3. Identification, delineation and mapping of environmental hazards on satellite imagery
4. Digital analysis of satellite data and their interpretation
5. GIS and GPS applications in environmental survey and monitoring

(b) Experiments related to Analytical Methods for Environmental Monitoring

The experiment will be related to the use of various analytical equipments used in environmental monitoring

1. Determination of turbidity of water of different sources
2. Experiments based on Colorimeter and Flame Photometer
3. Experiments based on the use of Noise Level meter and weather equipments
4. Determination of Cd and Al by fluorimetric method
5. Determination of Cu (II), Fe, Hg and Pb by Spectrophotometric Method
6. Experiments based on microbiological analysis of waste water

(c) Experiments related to Environmental Health and Eco-toxicology

The experiments will be related to -

1. Extraction and separation of organic compounds from biological materials Ammonium sulphate method (Nichols method), TCA method, Acid digestion method, Wet washing for metals, Steam distillation for volatiles
2. Experiments related to dose-response relationships for different pesticides
3. Experiments related to aerobiology

(d) Experiments related to Eco-hydrology and Watershed Management

The experiments will be related to:

1. Measurement and analysis of meteorological data
2. Estimation of evaporation and evapo-transpiration
3. Estimation of areal average precipitation/ volume of precipitation
4. Measurement of infiltration capacity of soil
5. Water balance study
6. Measurement and estimation of flow using current meters
7. Flow separation from discharge hydrograph of given data sample
8. Frequency analysis of flow

Dissertation Seminar Presentation (Credit: 1): Seminar will correspond to the project in ES 405

FOURTH SEMESTER

ES-401: Energy and Environment (Credit: 6)

1. **Introduction:** Human energy requirement, Energy use pattern in different parts of the world and its impact on the environment; Energy use pattern in India; Sources of energy and their classification; Energy forms and transformation
 Sun as source of energy: Source of sun's energy, Solar spectrum, solar radiation – absorption, reflection, scattering and diffusion in the atmosphere, Albedo, Global energy balance
2. **Fossil Fuels:** Fossil fuels – classification, composition, physiochemical characteristics; Energy content of coal, petroleum and natural gas; Formation, reserves, exploration/ mining and uses of Coal, Oil and Natural gas; Environmental problems associated with exploration/mining, processing, transportation and uses
3. **Bio-energy:** Biomass composition and types; Conversion processes – pyrolysis, charcoal production, compression, gasification and liquefaction; Energy plantation; Biogas – production and uses, anaerobic digestion; Environmental constraints; Energy from solid Wastes - Sources, types, energy production
4. **Nuclear energy:** Fission and fusion, Nuclear fuels, – Mining and processing of Uranium – concentration, refining, enrichment, fuel fabrication and fuel cycle; Nuclear reactors and radioactive waste; Environmental implications
5. **Solar Energy:** Harnessing of solar energy, Solar collectors and concentrators, Solar thermal energy, Solar electricity generation, Solar heaters, dryers, and cookers; Photovoltaics
6. **Wind energy:** Wind power, Harnessing of wind energy, Power generation – wind mills, concentrators, wind characteristics and siting, environmental considerations; Wind energy potential in India with special reference to Northeast India
7. **Hydroelectricity:** Principles of generation of hydroelectric power, hazard related to hydropower generation and distribution, environmental impact
8. **Geothermal and Hydrothermal energy:** Sources – crust, high temperature aquifers, low temperature aquifers, reserves; Harnessing of geothermal energy – problems and prospect; Geothermal energy prospect in India

Recommended Books

1. Renewable Energy – Environment and Development: M. Dayal; Konark Pub. Pvt. Ltd.
2. Alternative Energy: S. Vandana; APH Publishing Corporation
3. Nuclear Energy – Principles, practice and prospects: S. K. Agarwal; APH Publishing Corporation
4. Bio-Energy Resources: Chaturvedi; Concept Pub.
5. National Energy – policy, crisis and growth: V S. Mahajan; Ashis Publishing House
6. Geography and Energy – Commercial energy systems and national policies: J. D. Chapman

ES-402: Environmental Impact Assessment (Credit: 6)

1. **Introduction:** Concept of environment and environmental Impact, Nexus between development and environment, origin and development of EIA, Measurement of impact – physical, social - economical, natural; Concept of significant effect; Short term versus long term effect; relationship of EIA to sustainable development
2. **Framework of Environmental Assessment:** Description of environmental setting; Environmental impact factors and area consideration, Prediction and assessment of impact on air, water, noise and biological environment; Prediction and assessment of impact on the cultural and socio-economic environment; Methods of impact analysis; Public participation in environmental decision making, Integration and Optimization criteria for Multipurpose Development Projects, Environmental auditing.
3. **Impact Assessment Methodologies:** Evaluation of proposed actions and determination of impact importance, Development of value functions and scoping EIA methodologies; Comparison of alternatives and decision making; Compensatory actions - green belts; Preparation and writing of EIA/EIS; Review of procedures, practices and guidelines for EIA in India; Examples of total impact evaluation.
Role of GIS in EIA - Base line study; risk assessment, risk management, mitigation measures, comparison of alternatives.
4. **Air quality impact analysis (AQIA):** Typical considerations and factors; Pollution sources, atmosphere interactions; Air pollution effects; Air quality modeling; Legal aspects; Assessment methodology; Mitigation procedures; Case studies – Highway and Power Plants.
5. **Water Quality Impact Analysis (WQIA):** Water quality criteria and standards, Environmental setting; Water quality impact by project type; Water quality modeling.
6. **(a) Noise Impact Analysis (NIA):** Nature of sound, Environmental noise problem, sound power and sound intensity; Decibels and levels, sound propagation and attenuation; Effect of noise on people; Noise scale and rating methods, estimating transportation noise impact, examples of impact assessment.
(b) Energy Impact Analysis (EnIA): Types of energy and distribution; Energy sources; Importance of energy impact analysis; Energy inventory, supply demand scenario; Energy conservation; Energy alternatives; Energy inventory data; energy conservation.
7. **Vegetation and Wild Life Impact Analysis (VWLIA):** Biological concepts and terms; Assessment topics, mitigation measures, alternatives, assessment methodologies; Example of biotic assessment.
8. **Socioeconomic Impact Analysis (SIA):** Types of socioeconomic impact, basic steps in SIA, Analysis of public services and facilities impacts; Fiscal impact analysis; Analysis of social impacts; Impacts of economic profile of the community.

Recommended Books

1. Environmental Impact Analysis Handbook: J. G. Rau and D. C. Wooten; McGraw-Hill Book Co.
2. Environmental Impact Assessment, L. W. Canter, Mc Graw Hill Publication,
3. Methods of Environmental Impact Assessment: P. Morris & R. Therivel; UCL Press
4. Environmental Impact Assessment (2003): A. K. Srivastav; A P H Publishing Corporation
5. Introduction to Environmental Impact Assessment: Glasston; Research Press

ES-403: Environmental Law and Management (Credit: 6)

1. **Environmental Management:** Concept and scope, Systems and approaches, Standards - international and national; Ecomark; Environmental accounts and auditing , Green funding and taxes, Trade and environmental management,
2. **Ecosystem Management:** Ecosystem analysis, modeling, monitoring and planning; Ecotourism and heritage management; Eco-restoration
Environmental management of water, forest and biological resource
3. **Environmental management of industrial pollution:** Management of pollution due to chemical, mining and manufacturing industries (petroleum, coal, cement, paper, fertilizer).

4. **Management of Solid Wastes:** Different types of solid wastes, Methods of disposal and management of Municipal solid wastes, Bio-medical wastes and Hazardous wastes; Recycling of wastes and waste minimization techniques.
5. **International Environmental Laws:** Evolution and development of International Environmental laws with reference to Stockholm Conference, Nairobi Declaration, Rio Conference, Rio+5 and the Rio+10, etc
Global environmental issues and International laws: to control Global warming, Ozone depletion, Acid rains, hazardous waste; Role of UN authorities in protection of Global Environment
6. **Environmental laws in India:** Legal, administrative and constitutional provisions for environmental protection in India; Statutory protection of the Human Environment - Factories Act, Motor Vehicle Act, Hazardous Waste legislation for pollution abatement; Anti Pollution Acts - The water Act. 1974. The Air Act 1981. The Environment Protection Act, 1986
7. **Sustainable development:** Concept and growth of the idea, indicators of sustainability, models of sustainable development. Sustainable Development Scenario – global, national.
8. **Major environmental movements in India:** Chipko Movement, Narmada Dam, Tehri Dam, Almetti Dam, Reclamation of alkaline and saline soil

Recommended Books

1. Sustainable development (Vol. I & II): N. L. Gupta and K. K. Gurjar (ed); Rawat Publications
2. Environmental management: G. N. Pandey; Vikash Publishing House
3. Environmental management: H. M. Saxena; Rawat Publications
4. Environmental Law and Policy in India: S. Divan & A. Rosencranz; Oxford University Press
5. Environmental Management – Physio-ecological facets (Vol. I & II): Rai, Mohapatra & Goel (ed); Rawat Publications
6. Environmental Management in India Vol. I & II): R. K. Sapru; Ashish Publishing House

ES-404: Optional Paper (any one of the following papers)

(a) Environmental Pollution – Control and Management (Credit: 6)

1. **Introduction:** Global, regional and local perspectives of Environmental pollution; Causes of Environmental pollution and remedial measures; Concept of pollution control and management, Environmental quality standards.
2. **Air Pollution:** Sources of air pollutants and mechanism of transport, gas laws governing the behaviour of the pollutants in the atmosphere; Sampling and analysis of air pollutants; Biological indicators of air pollution – bio-monitoring, Air pollution Indices, Air quality modeling, National and international laws, Air quality standards.
Air pollution control methods and equipments, Control of particulate and gaseous emission, Control of SO₂, NO_x, CO and HC
3. **Air Pollution Meteorology and Modeling:** Vertical profile of wind and air temperature, Atmospheric stability, Presentation of wind data – wind rose; Plume behaviour, Dispersion of pollutants, Dispersion models and computation of ground level concentration; Effect of meteorological and topographical factors on transport and dispersion of pollutants
4. **Indoor and Vehicular Air pollution:** Indoor air pollutants, standards, measurements and remedial measures; Vehicular pollution - Emissions from gasoline and diesel powered vehicles; Exhaust emission - air fuel ratio spark timing, combustion chamber surface volume ratio. Control of exhaust emissions: catalytic converters. Emission inventory
5. **Radiation Pollution:** Radiation sources in the environment - natural and man-made, Disposal of radiation waste; Radioactive - sampling methods and detection; units of measurements of radiation energy and radiation absorption
Biological effects of ionizing radiation's - the interactions of radiation's with cells; maximum permissible dose - ICRP recommendations
6. **Noise Pollution :** Basic properties of noise - sound pressure, loudness and intensity levels, decibel, Noise propagation - effect of meteorological parameters; Noise survey – equipment and sampling: Methods of noise abatement; National and International standards.
7. **Water Pollution:** Types, sources and consequences of water pollution - ecological and biochemical aspects; Effects of domestic, industrial and agricultural wastes on water bodies; Chemical and bacteriological sampling and analysis; Water pollutants and their control - Bio-absorption of heavy metals, Water pollution laws and standards for different kinds of uses; Eutrophication - Light penetration, Law of minimum detergents, Thermal stratification and reversible eutrophication. Water treatment processes.
8. **Soil and Solid Waste pollution:** Physical and chemical properties of soil, composition of soil organic matter, soil micro-organisms and their functions, degradation of different insecticides, fungicides, weedicides and fertilizers in soil and their effects on soil components. Toxic heavy metals in soil, Soil degradation due to mining, Reclamation of polluted and degraded soil.

Sources, nature and chemical composition of solid wastes; Different methods of disposal and management of solid wastes; Municipal solid wastes; Alternative methods of disposal, recycling, conversion of solid waste into energy / Manure.

Recommended Books

7. Air Pollution – Stern
8. Environmental Pollution Control Engineering: C. S. Rao
9. Environmental Chemistry : B.K. Sharma, and H. Kaur
10. Air pollution – threat and response: D. A. Lynn
11. Air pollution and Environmental Protection – Legislative policies, Judicial trend and Social perceptions: N. Kumar; Mittal Publication

(b) Natural Hazards in Northeast India (Credit: 6)

1. **Introduction:** Concept of risk, vulnerability, hazard, and disaster; Types of Natural Hazards and their Global and National perspectives; Hazard mitigation – historical perspectives, common practices and alternative approaches; Human perturbation and natural hazards – impact of deforestation, land use and developmental activities on natural hazards, Role of climate change
2. **Geo-environmental Settings and Natural Hazards in Northeast India:** Concept of geo-environmental settings, Relation between geo-environmental settings and natural hazards; Physiographic settings, Land use pattern, Climate and human population distribution in Northeast India; Tectonics and geology of Northeast India; Major Natural Hazards in Northeast India.
3. **Basics of Flood Hydrology:** Concept of Floods, Floodplains, Flood prone areas and Flood hazard; Causes and Types of flooding – Intensive precipitation, snowmelt, dam failure, Estuarine floods, Coastal floods – storm surges and tsunamis; human influence – deforestation, obstruction of free flow due to developmental activities; Causative factors of floods in Northeast India
4. **Flood measurement and Analysis:** Stream flow measurement and hydrograph separation, Unit hydrographs – construction and uses, Flood frequency analysis – Probabilistic treatment of hydrologic data, fitting of models and estimation of return periods
5. **Flood Hazard Assessment and Management:** Frequency of Flooding, Length of Inundation, Flood prone areas and zonation, Flood damage assessment – socioeconomic and environmental, Flood management and mitigation measures – structural and non-structural with special reference to Northeast India
6. **Seismicity and Seismic Hazard:** Earthquake basics: Causative factors and types of earthquakes; Seismic waves and their propagation; Earthquake intensity and isoseismals. Concept of seismicity and seismic hazards, plate tectonics; Effects of earthquakes; Major earthquakes of India and their effects; Seismic zones of India; Seismotectonics of northeast India, Earthquake prediction.
7. **Monitoring and mitigation of seismic hazard:** Measurement of earthquakes – Principle of seismometers and seismograms, Determination of epicenter and their presentation, Earthquake magnitude scales, Frequency–Magnitude relationship, Magnitude–Energy relationship
Earthquake risk and protective measures
8. **Landslides:** Causes and types with special reference to Northeast India – natural, human induced; Landslide prone areas in Northeast India – distribution, rock/soil type, protective measures taken and suggestions

Recommended Books

1. Floods – A geographical perspective (1978): Roy Ward; The Macmillan Press Ltd
2. Natural Hazards – Local, National, Global (1974): G. F. White (ed), Oxford University Press
3. Handbook of Applied Hydrology (1964): V.T. Chow, (New York: McGraw-Hill,
4. Satellite Remote Sensing Technology for Natural Hazards Preparedness and Emergency Response Planning (1989): G. Morgan, World Bank, Environment Operation and Strategy Division, World Bank
5. Elementary seismology (1969): C. F. Richter; Eurasia Publishing house Pvt. Ltd.
6. Geodynamics of Northeastern India and the adjoining region (2001): D. R. Nandy; acb Publications, Kolkata
7. Introduction to Seismology (1999): P. M. Shearer; Cambridge University Press
8. Principles of Seismology (1999): A. Udias; Cambridge University Press
9. Fundamentals of Geophysics: William Lowrie

ES-405: Dissertation (Credit: 8)

Work on the Dissertation topic initiated in Semester III (ES 305) with seminar presentation is to be completed with report submission by the end of semester IV

Time allotted for each theory paper is 3 hours and for practical 6 hours.
