



# UNIVERSITY OF CALCUTTA

## Notification No. CSR/ 12 /18

It is notified for information of all concerned that the Syndicate in its meeting held on 28.05.2018 (vide Item No.14) approved the Syllabi of different subjects in Undergraduate Honours / General / Major courses of studies (CBCS) under this University, as laid down in the accompanying pamphlet:

### List of the subjects

| <u>Sl. No.</u> | <u>Subject</u>  | <u>Sl. No.</u> | <u>Subject</u>   |
|----------------|---|----------------|--|
| 1              | Anthropology (Honours / General)                      | 29             | Mathematics (Honours / General)                                |
| 2              | Arabic (Honours / General)                            | 30             | Microbiology (Honours / General)                               |
| 3              | Persian (Honours / General)                           | 31             | Mol. Biology (General)   |
| 4              | Bengali (Honours / General /LCC2 /AECC1)              | 32             | Philosophy (Honours / General)                                 |
| 5              | Bio-Chemistry (Honours / General)                     | 33             | Physical Education (General)                                   |
| 6              | Botany (Honours / General)                            | 34             | Physics (Honours / General)                                    |
| 7              | Chemistry (Honours / General)                         | 35             | Physiology (Honours / General)                                 |
| 8              | Computer Science (Honours / General)                  | 36             | Political Science (Honours / General)                          |
| 9              | Defence Studies (General)                             | 37             | Psychology (Honours / General)                                 |
| 10             | Economics (Honours / General)                         | 38             | Sanskrit (Honours / General)                                   |
| 11             | Education (Honours / General)                         | 39             | Social Science (General)                                       |
| 12             | Electronics (Honours / General)                       | 40             | Sociology (Honours / General)                                  |
| 13             | English ((Honours / General/ LCC1/ LCC2/AECC1)        | 41             | Statistics (Honours / General)                                 |
| 14             | Environmental Science (Honours / General)             | 42             | Urdu (Honours / General /LCC2 /AECC1)                          |
| 15             | Environmental Studies (AECC2)                         | 43             | Women Studies (General)  |
| 16             | Film Studies ( General)                               | 44             | Zoology (Honours / General)                                    |
| 17             | Food Nutrition (Honours / General)                    | 45             | Industrial Fish and Fisheries – IFFV (Major)                   |
| 18             | French (General)                                      | 46             | Sericulture – SRTV (Major)                                     |
| 19             | Geography (Honours / General)                         | 47             | Computer Applications – CMAV (Major)                           |
| 20             | Geology (Honours / General)                           | 48             | Tourism and Travel Management – TTMV (Major)                   |
| 21             | Hindi (Honours / General /LCC2 /AECC1)                | 49             | Advertising Sales Promotion and Sales Management –ASPV (Major) |
| 22             | History (Honours / General)                           | 50             | Communicative English –CMEV (Major)                            |
| 23             | Islamic History Culture (Honours / General)           | 51             | Clinical Nutrition and Dietetics CNDV (Major)                  |
| 24             | Home Science Extension Education (General)            | 52             | Bachelor of Business Administration (BBA) (Honours)            |
| 25             | House Hold Art (General)                              | 53             | Bachelor of Fashion and Apparel Design – (B.F.A.D.) (Honours)  |
| 26             | Human Development (Honours / General)                 | 54             | Bachelor of Fine Art (B.F.A.) (Honours)                        |
| 27             | Human Rights (General)                                | 55             | B. Music (Honours / General) and Music (General)               |
| 28             | Journalism and Mass Communication (Honours / General) |                |  |

The above shall be effective from the academic session 2018-2019.

SENATE HOUSE  
KOLKATA-700073  
The 4<sup>th</sup> June, 2018

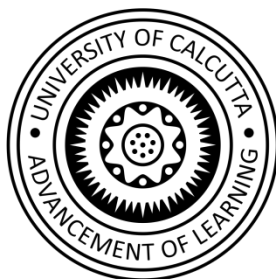
*Paul*  
4/6/18  
(Dr. Santanu Paul)  
Deputy Registrar

**MODEL COURSE CURRICULUM FOR UNDERGRADUATE  
COURSES UNDER CHOICE BASED CREDIT SYSTEM**

**FINAL SYLLABUS**

**FOR**

**BACHELOR IN ENVIRONMENTAL  
SCIENCE (HONOURS)**



**UNIVERSITY OF CALCUTTA**

## Details of course under B.Sc. in Environmental Science (Hons.)

| Course   | Credits*           |
|--|--------------------|
|  | Theory + Practical |
| <b>I Core Courses (14 Papers)</b>  |                    |
| Core Courses - Theory (14 Papers) (4 Credits each)                                     | 14x4=56            |
| Core Course - Practical (2 Credits Each)   | 14x2=28            |
|  |                    |
| <b>II. Discipline Specific Electives (4 Papers)</b>                                    |                    |
| Discipline Specific Electives - Theory (4 Papers) (4 Credits)                          | 4x4=16             |
| Discipline Specific Electives - Practical (4 Papers) (2 Credits Each)                  | 4x2=8              |
|  |                    |
| <b>III Generic Electives (4 Papers)</b>  |                    |
| Generic Electives- Theory (4 Papers) (4 Credits)                                       | 4x4=16             |
| Generic Electives - Practical (4 Papers) (2 Credits Each)                              | 4x2=8              |
|  |                    |
| <b>III. Ability Enhancement Courses (2 Papers)</b>                                     |                    |
| 1. Ability Enhancement Compulsory Courses (AECC 1) English Communications. (2 credits) | 2x2=4              |
| 2. Ability Enhancement Compulsory Courses (AECC 2) Environmental Studies (2 C credits) |                    |
|  |                    |
| <b>IV. Skill Enhancement Courses (SEC)</b>   |                    |
| Skill Enhancement Courses (SEC) (Theory) (2 Papers of 2 Credits each)                  | 2x2=4              |
| <b>Total Credits</b>   | <b>140</b>         |

**Bachelor in Environment Science (Hons.)**  
**Courses/Papers Sequence**

| <b>Semester 1</b>                                | <b>Semester 2</b>                                     | <b>Semester 3</b>   | <b>Semester 4</b>   | <b>Semester 5</b>                                       | <b>Semester 6</b>   |
|--|---|---|---|---|---|
| CC 1:<br>Earth and Earth<br>Surface<br>Processes | CC3:<br>Water and<br>Water<br>Resources<br>Management | CC5:<br>Ecology and<br>Ecosystems   | CC8:<br>Systematics &<br>Biogeography                                   | CC 11:<br>Biodiversity &<br>Conservation<br>Biology     | CC 13:<br>Environmental<br>Pollution and<br>Human Health          |
| CC2:<br>Physics &<br>Chemistry of<br>Environment | CC4:<br>Land<br>management and<br>soil conservation   | CC6:<br>Environmental<br>Biotechnology  | CC9:<br>Urban<br>Ecosystems   | CC 12:<br>Organismal &<br>Evolutionary<br>Biology       | CC 14:<br>Natural<br>Resources<br>Management &<br>Sustainability  |
| AECC1:<br>English<br>Communication<br>IMIL       | AECC2:<br>Environmental<br>Studies                    | CC7:<br>Atmosphere &<br>Global<br>Climate<br>Change                                 | CC 10:<br>Environmental<br>Legislation &<br>Policy                      | DSE A1:<br>Energy &<br>Environment                      | DSE B1:<br>Natural Hazards<br>& Disaster<br>Management            |
|  |   | SEC A1:<br>Remote<br>Sensing,<br>Geographic<br>Information<br>System &<br>Modelling | SEC B1:<br>Environment<br>Impact & Risk<br>Assessment                   | DSE B2:<br>Solid Waste<br>Management<br><br>OR          | DSE A2:<br>Environmental<br>Economics and<br>Statistics<br><br>OR |
|  |   | SEC A2:<br>Wildlife<br>Management   | SEC B2:<br>Analytical<br>methods,<br>instrumentation<br>and Measurement | DSE B3:<br>Environmental<br>Health<br>and<br>Toxicology | DSE A3:<br>Green<br>Technologies                                  |

## **CC1 (1<sup>ST</sup> SEMESTER) ENV-A-CC-1-1-TH: EARTH AND EARTH SURFACE PROCESSES**

**Theory (50 Lectures)**

### **Unit 1: History of Earth (5 lectures)**

Formation of the Earth: formation and composition of core, mantle, crust, atmosphere and hydrosphere; chemical composition of Earth; geological time scale and major changes on the Earth's surface.

### **Unit 2: Earth system processes (15 lectures)**

Movement of lithosphere plates; mantle convection and plate tectonics, major plates and hotspots, plate boundaries; sea floor spread; earthquakes; volcanic activities; orogeny; isostasy; gravitational and magnetic fields of the earth; origin of the main geomagnetic field; continental drift, Pangaea and present-day continents, paleontological evidences of plate tectonics.

Land surface processes: fluvial and glacial processes, rivers and geomorphology; types of glaciers, glacier dynamics, erosional and depositional processes and glaciated landscapes; coastal processes.

### **Unit 3: Rocks, weathering and minerals (15 lectures)**

Minerals and important rock forming minerals; rock cycle: lithification and metamorphism; Three rock laws; rock structure, igneous, sedimentary and metamorphic rocks; weathering: physical, biogeochemical processes; erosion: physical processes of erosion, factors affecting erosion; agents of erosion: rivers and streams, glacial and aeolian transportation and deposition of sediments by running water, wind and glaciers.

### **Unit 4: Earth atmosphere (6 lectures)**

Atmosphere: evolution of earth's atmosphere, composition of atmosphere, physical and optical properties, circulation; interfaces: atmosphere–ocean interface, atmosphere–land interface, ocean–land interface.

### **Unit 5: Mountain and river systems of India (9 lectures)**

Continental collision and mountain formation; Formation of Peninsular Indian mountain systems - Western and Eastern Ghats, Vindhyas, Aravallis, etc.; Formation of the Himalaya; perennial river systems and evolution of monsoon in Indian subcontinent; formation of Indo-Gangetic Plains, progression of agriculture in the Indian subcontinent in Holocene; withdrawing monsoon and lessons to draw.

**CC1 (1<sup>ST</sup> SEMESTER) ENV-A-CC-1-1-P: EARTH AND EARTH SURFACE PROCESSES**

1. Identification of rocks & minerals (Hand Specimen)
  - a) Rocks- Granite, Basalt, Dolerite, Shale, Sandstone, Limestone, Slate, Marble, Quartzite, Gneiss
  - b) Minerals- Talc, Bauxite, Mica, Quartz, Hematite, Galena (15)
2. Topological sheet interpretation for geomorphology. (10)
3. Viva Voce (5)

## CC2 (1<sup>ST</sup> SEMESTER) ENV-A-CC-1-2-TH: PHYSICS AND CHEMISTRY OF ENVIRONMENT

**Theory (50 Lectures)**

### **Unit 1: Fundamentals of environmental physics (10 lectures)**

**Part A:** Basic concepts of light and matter; spectroscopic concepts: Introduction to the concept of absorption and transmission of light, Beer–Lambert law; scattering of light, Rayleigh and Mie scattering.

**Part B:** Basic concepts of pressure, force, work and energy; types of forces and their relation (pressure gradient, viscous, Coriolis, gravitational, centripetal, and centrifugal force); concept of heat transfer, conduction, convection; concept of temperature, lapse rate (dry and moist adiabatic); laws of thermodynamics; concept of heat and work, Carnot engine.

### **Unit 2: Fundamentals of environmental chemistry (15 lectures)**

**Part A:** Atomic structure, electronic configuration, periodic properties of elements (ionization potential, electron affinity and electronegativity), types of chemical bonds (ionic, covalent, coordinate and hydrogen bonds); mole concept, molarity and normality, quantitative volumetric analysis.

**Part B:** Types of chemical reactions; acids, bases and salts, concept of chemical equilibrium, solubility products; solutes and solvents; redox reactions, concepts of pH and pE, electrochemistry, Nernst equation, electrochemical cells.

**Part C:** Basic concepts of organic chemistry, hydrocarbons, aliphatic and aromatic compounds, organic functional groups, polarity of the functional groups, colloid chemistry. Xenobiotic compounds, chemistry of pesticides and dyes, synthetic polymers.

### **Unit 3: Atmospheric chemistry (9 lectures)**

Composition of atmosphere; photochemical reactions in atmosphere; smog formation, types of smog (sulphur smog and photochemical smog), aerosols; chemistry of acid rain, reactions of  $\text{NO}_x$  and  $\text{SO}_x$ ; free radicals and ozone layer depletion, role of CFCs in ozone depletion.

### **Unit 4: Water chemistry (9 lectures)**

Chemical and physical properties of water; Gases in water, Henry's Law, alkalinity and acidity of water, hardness of water, calculation of total hardness; solubility of metals, complex formation and chelation; heavy metals in water.

**Unit 5: Soil chemistry****(7 lectures)**

Soil composition; relation between organic carbon and organic matter, inorganic and organic components in soil; soil humus; cation and anion exchange reactions in soil; nitrogen, phosphorus and potassium in soil.

**CC2 (1<sup>ST</sup> SEMESTER) ENV-A-CC-1-2-P: PHYSICS AND CHEMISTRY OF ENVIRONMENT**

1. Acidity, Alkalinity (PA & TA), Total Hardness of water, Calcium Hardness of Water (10)
2. Soil moisture, Soil pH, Soil electrical conductivity. (10)
3. Viva Voce (5) Laboratory notebook (5)



**CC3 (2<sup>ND</sup> SEMESTER) ENV-A-CC-2-3-TH: WATER AND WATER RESOURCES MANAGEMENT**

**Theory (50 Lectures)**

**Unit 1: Water resource (5 lectures)**

Sources and types of water; hydrological cycle; precipitation, runoff, infiltration, evaporation, evapotranspiration; classification of water resources (oceans, rivers, lakes and wetlands).

**Unit 2: Properties of water (10 lectures)**

Physical: temperature, colour, odour, total dissolved solids and total suspended solids; Chemical: major inorganic and organic constituents, dissolved gases, DO, COD, BOD, electrical conductivity, sodium adsorption ratio; Biological: phytoplankton, phyto-benthos, zooplankton, macro-invertebrates and microbes.

**Unit 3: Surface and Groundwater (14 lectures)**

Introduction to surface and ground water; water table; vertical distribution of water; formation and properties of aquifers; hydraulic potential, Darcy's equation, types of flow, turbulence, techniques for ground water recharge; watershed and drainage basins; importance of watershed and watershed management.

**Unit 4: Wetlands and their management (6 lectures)**

Definition of a wetland; types of wetlands (fresh water and marine); ecological and hydrological functions of wetlands; threats to wetlands; wetland conservation and management; Ramsar Convention, 1971; major wetlands of India.

**Unit 5: Water resource in India and Water sharing conflicts (15 lectures)**

Demand for water (agriculture, industrial, domestic); overuse and depletion of surface and ground water resources; water quality standards in India; hot spots of surface water; role of state in water resources management. Water resources and sharing problems, case studies on Kaveri and Krishna river water disputes; Multi-purpose river valley projects in India and their environmental and social impacts; case studies of dams - Narmada and Tehri dam - social and ecological losses versus economic benefits.

**CC 3 (2<sup>ND</sup> SEMESTER) ENV-A-CC-2-3-P: WATER AND WATER RESOURCES MANAGEMENT**

1. pH, Electrical conductivity, Salinity (through Chloride Estimation), Dissolved oxygen, TSS, TDS, Iron. (20)
2. Viva Voce (5), Laboratory Notebook (5)

## **CC 4 (2<sup>ND</sup> SEMESTER) ENV-A-CC-2-4-TH: LAND MANAGEMENT AND SOIL CONSERVATION**

**Theory (50 Lectures)**

### **Unit 1: Introduction to Land Resource (5 lectures)**

Land as a resource, types and evaluation, soil health; ecological and economic importance of soil; types and causes of soil degradation; impact of soil loss and soil degradation on agriculture and food security; need for soil conservation and restoration of soil fertility.

### **Unit 2: Fundamentals of soil science (10 lectures)**

Soil formation; classification of soil; soil architecture; physical properties of soil; soil texture; soil profile; soil water holding capacity; soil temperature; soil colloids; soil acidity and alkalinity; soil salinity and sodicity; soil organic matter; micronutrients of soil; nitrogen, sulphur, potassium and phosphorus economy of soil; soil biodiversity; soil taxonomy maps.

### **Unit 3: Soil degradation and conservation (10 lectures)**

Soil resistance and resilience; nature and types of soil erosion; non-erosive and erosive soil degradation; losses of soil moisture and its regulation; nutrient depletion; soil pollution due to mining and mineral extraction, industrial and urban development, toxic organic chemicals, and organic contaminants in soils; fertilizers and fertilizer management; recycling of soil nutrients.

Different techniques of soil conservation (mechanical and biological)

### **Unit 4: Land use changes (5 lectures)**

Land use pattern, drivers of land use and land cover change in major geographic zones and biodiverse regions with particular reference to the Himalaya and the Western Ghats.

### **Unit 5: Land degradation and management (20 lectures)**

Land degradation: biological and physical phenomena; visual indicators of land degradation; drivers of land degradation - deforestation, desertification; habitat loss, loss of biodiversity; range land degradation; land salinization; human population pressure, poverty, socio-economic and institutional factors, Economic valuation of land degradation; onsite and offsite costs of land degradation; loss of ecosystem services; effects on farming communities; effects on food security; effects on nutrient cycles; future effects of soil degradation; emerging threats of land degradation to developing countries.

Sustainable land use planning; role of databases and data analysis in land use planning control and management; land tenure and land policy; legal, institutional and sociological factors; participatory land degradation assessment; integrating land degradation assessment into conservation.

**CC 4 (2<sup>ND</sup> SEMESTER) ENV-A-CC-2-4-P: LAND MANAGEMENT AND SOIL  
CONSERVATION**

1. Soil Organic Carbon, Water Holding Capacity, Determination of Soil carbonate and Bicarbonate , Available NPK of Soil (Demonstration only). (20)
2. Viva voce (5), Laboratory Notebook (5)

## CC 5 (3<sup>RD</sup> SEMESTER) ENV-A-CC-3-5-TH: ECOLOGY AND ECOSYSTEMS

Theory (50 Lectures)

### Unit1: Introduction to Ecology

(12 lectures)

Basic concepts and definitions: ecology, landscape, habitat, ecozones, biosphere, ecosystems, ecosystem stability, resistance and resilience; autecology; synecology; major terrestrial biomes. Ecological amplitude; Liebig's Law of the Minimum; Shelford's Law of Tolerance; phenotypic plasticity; ecotypes; ecoclines; acclimation; ecological niche; types of niche: Eltonian niche, Hutchinsonian niche, fundamental niche, realized niche; niche breadth; niche partitioning; niche differentiation.

### Unit 2: Population Ecology

(8 lectures)

Concept of population; characteristics of population: density, dispersion, natality, mortality, life tables, survivorship curves, age structure; population growth: geometric, exponential, logistic, density-dependent; limits to population growth.

### Unit 3: Community Ecology

(8 lectures)

Discrete versus continuum community view; community structure and organization: physiognomy, sociability, species associations, periodicity, biomass, stability, keystone species, ecotone and edge effect; species interactions: mutualism, symbiotic relationships, commensalism, amensalism, proto-cooperation, predation, competition, parasitism, mimicry, herbivory; ecological succession: primary and secondary successions, models and types of successions, and meta-population; r- and K-selection, climax community concepts, examples of succession, rudreal, competitive and stress-tolerance strategies

### Unit 4: Ecosystem ecology

(15 lectures)

Types of ecosystem: forest, grassland, lentic, lotic, estuarine, marine, desert, wetlands; ecosystem structure and function; abiotic and biotic components of ecosystem; ecosystem boundary; ecosystem function; ecosystem metabolism; primary production and models of energy flow; secondary production and trophic efficiency; ecosystem connections: food chain, food web; detritus pathway of energy flow and decomposition processes; ecological efficiencies; ecological pyramids: pyramids of number, biomass, and energy. Concept of exotics and invasives; natural spread versus man-induced invasions; characteristics of invaders; stages of invasion; mechanisms of invasions; invasive pathways; impacts of invasion on ecosystem and communities; invasive ecogenomics – role of polyploidy and genome size in determining invasiveness; economic costs of biological invasions.

### Unit 5: Biogeochemical cycles and nutrient cycling

(7 lectures)

Carbon cycle; nitrogen cycle; phosphorus cycle; sulphur cycle; hydrological cycle; nutrient cycle models; ecosystem input of nutrients; biotic accumulation; ecosystem losses; nutrient supply and uptake; role of mycorrhizae; decomposition and nutrient release; nutrient use efficiency; nutrient budget; nutrient conservation strategies.

**CC 5 (3<sup>RD</sup> SEMESTER) ENV-A-CC-3-5-TH: ECOLOGY AND ECOSYSTEMS**

1. Field study in ecology using both qualitative and quantitative studies (Checklist/Quadrat /Transect) from any one of the following bio-geographical area (coastal/ forest/ Hills) with report submission. (20)
2. Viva-voce (10)

## CC 6 (3<sup>RD</sup> SEMESTER) ENV-A-CC-3-6-TH: ENVIRONMENTAL BIOTECHNOLOGY

**Theory (50 Lectures)**

### **Unit 1: Basic Concepts of Microbiology**

**(6 lectures)**

Classification of microorganisms, different factors for microbial growth, staining techniques

### **Unit 2: The Structure and Function of DNA, RNA and Protein**

**(10 lectures)**

DNA: structural forms and their characteristics (B, A, C, D, T, Z); physical properties: UV absorption spectra, denaturation and renaturation kinetics; biological significance of different forms; Synthesis.

RNA: structural forms and their characteristics (rRNA, mRNA, tRNA; SnRNA, Si RNA, miRNA, hnRNA); biological significance of different types of RNA; synthesis.

Protein: hierarchical structure (primary, secondary, tertiary, quaternary), types of amino acids; post-translational modifications and their significance; synthesis; types and their role: structural, functional (enzymes).

Central dogma of biology; genetic material prokaryotes, viruses, eukaryotes and organelles; mobile DNA; chromosomal organization (euchromatin, heterochromatin - constitutive and facultative heterochromatin).

### **Unit 3: Recombinant DNA Technology**

**(10 lectures)**

Recombinant DNA: origin and current status; steps of preparation; toolkit of enzymes for manipulation of DNA: restriction enzymes, polymerases (DNA/RNA polymerases, transferase, reverse transcriptase), other DNA modifying enzymes (nucleases, ligase, phosphatases, polynucleotide kinase); genomic and cDNA libraries: construction, screening and uses; cloning and expression vectors (plasmids, bacteriophage, phagmids, cosmids, artificial chromosomes)

### **Unit 4: Biotechnology of Solid waste and solid waste treatment**

**(15 lectures)**

Wastewater treatment: anaerobic, aerobic process, methanogenesis, bioreactors, cell and protein (enzyme) immobilization techniques; solid waste treatment: sources and management (composting, vermiculture and methane production, landfill. hazardous waste treatment); specific bioremediation technologies: land farming, prepared beds, biopiles, composting, bioventing, biosparging, pump and treat method, use of bioreactors for bioremediation; phytoremediation; remediation of degraded ecosystems; degradation of xenobiotics in environment

**Unit 4: Ecologically safe products and processes**

**(7 lectures)**

PGPR bacteria: biofertilizers, microbial insecticides and pesticides, bio-control of plant pathogen, Integrated pest management; development of stress tolerant plants, biofuel; mining and metal biotechnology: microbial transformation, accumulation and concentration of metals, metal leaching.

**Unit 5: GMs and GMOs**

**(2 lectures)**

Concept of GM and GMOs, case studies, biosafety protocol

**CC 6 (3<sup>RD</sup> SEMESTER) ENV-A-CC-3-6-P: ENVIRONMENTAL BIOTECHNOLOGY**

1. Gram Staining, Total coliform count (MPN), ABO Blood grouping. (10)
2. Review paper preparation/ presentation on topics related to Environmental Biotechnology. (15)
3. Viva-voce. (5)

**CC 7 (3<sup>RD</sup> SEMESTER) ENV-A-CC-3-7-TH:ATMOSPHERE AND GLOBAL CLIMATE CHANGE**

**Theory (50 Lectures)**

**Unit 1: Global energy balance (4 lectures)**

Earth's energy balance; energy transfers in atmosphere; Earth's radiation budget; green house gases (GHGs); greenhouse effect; global conveyor belt.

**Unit 2: Atmospheric circulation (12 lectures)**

Movement of air masses; atmosphere and climate; air and sea interaction; southern oscillation; western disturbances; *El Nina* and *La Nina*; tropical cyclone; Indian monsoon and its development, effect of urbanization on micro climate; Asian brown clouds.

**Unit 3: Meteorology and atmospheric stability (14 lectures)**

Meteorological parameters (temperature, relative humidity, wind speed and direction, precipitation); atmospheric stability and mixing heights; temperature inversion; plume behavior; Gaussian plume model.

**Unit 4: Global warming and climate change (12 lectures)**

Earth's climate through ages; trends of global warming and climate change; drivers of global warming and the potential of different green house gases (GHGs) causing the climate change; atmospheric windows; impact of climate change on atmosphere, weather patterns, sea level rise, agricultural productivity and biological responses - range shift of species, CO<sub>2</sub> fertilization and agriculture; impact on economy and spread of human diseases.

Environmental policy debate; International agreements; Kyoto protocol 1997; Convention on Climate Change; carbon credit and carbon trading; clean development mechanism.

**Unit 5: Ozone layer depletion (8 lectures)**

Ozone layer or ozone shield; importance of ozone layer; ozone layer depletion and causes; Chapman cycle; process of spring time ozone depletion over Antarctica; ozone depleting substances (ODS); effects of ozone depletion; mitigation measures and international protocols - Montreal protocol 1987.



**CC 7 (3<sup>RD</sup> SEMESTER) ENV-A-CC-3-7-P:ATMOSPHERE AND GLOBAL CLIMATE CHANGE**

1. Estimation of atmospheric pressure, relative humidity, rainfall, insolation, wind speed, light intensity (Lux meter) (20)
2. Viva-voce. (5), Laboratory notebook (5)

## **SKILL ENHANCEMENT COURSE (SEC)**

### **SEC-A (Anyone from SEC A1 OR SEC A2 IN 3<sup>RD</sup> SEMESTER)**

#### **ENV-A-SEC-A-3-X-TH**

### **SEC A 1: REMOTE SENSING, GEOGRAPHIC INFORMATION SYSTEM & MODELLING**

#### **Theory (Lectures: 30)**

**Unit 1:** Remote Sensing: definitions and principles; electromagnetic (EME) spectrum; interaction of EMR with Earth's surface; spectral signature; satellites and sensors; aerial photography and image interpretation.

**Unit 2:** Geographical Information Systems: definitions and components; spatial and non-spatial data; raster and vector data; database generation; database management system; land use/ land cover mapping; overview of GIS software packages; GPS survey, data import, processing, and mapping.

**Unit 3:** Applications and case studies of remote sensing and GIS in geosciences, water resource management, land use planning, forest resources, agriculture, marine and atmospheric studies.

### **SEC A 2: WILDLIFE MANAGEMENT**

#### **Theory (Lectures: 30)**

**Unit 1:** Need of wildlife management; role of stakeholders in managing wildlife. Journey of mankind from predator to conservator; prehistoric association between wildlife and humans: records from Bhimbetka wall paintings; conservation of wildlife in the reign of king Ashoka: excerpts from rock edicts; understanding wildlife management, conservation and policies regarding protected areas in 21<sup>st</sup> century; positive values provided by wildlife conservation (monetary, recreational, scientific and ecological benefits).

**Unit 2:** Principles and practices of wildlife management, Course and fine filter approaches for wildlife Management. Analysis of wild life management problems. Species conservation projects in India (Tiger, Rhino, Lion)

**Unit 3:** Capture and handling techniques, Identification and marking techniques, Measuring animal abundance, radio telemetry,

## CC 8 (4<sup>TH</sup> SEMESTER) ENV-A-CC-4-8-TH: SYSTEMATICS AND BIOGEOGRAPHY

Theory (Lectures: 50)

### **Unit 1: Concept and systematics approaches (12 lectures)**

Definition of systematics; taxonomic identification; keys; field inventory; herbarium; museum; botanical gardens; taxonomic literature; nomenclature; evidence from anatomy, ultrastructure, cytology, phytochemistry, numerical and molecular methods. Concept of taxa (species, genus, family, order, class, phylum, kingdom); concept of species (taxonomic, typological, biological, evolutionary, phylogenetic); categories and taxonomic hierarchy.

### **Unit 2: Nomenclature and systems of classification (6 lectures)**

Principles and rules (International Code of Botanical and Zoological Nomenclature); ranks and names; types and typification; author citation; valid publication; rejection of names; principle of priority and its limitations; names of hybrids.

### **Unit 4: Biogeography (6 lectures)**

Biogeographical rules – Gloger's rule, Bergmann's rule, Allen's rule, Geist rule; biogeographical realms and their fauna; endemic, rare, exotic, and cosmopolitan species.

### **Part-A: Historical Biogeography (6 lectures)**

Earth's history; paleo-records of diversity and diversification; continental drift and plate tectonics and their role in biogeographic patterns – past and present; biogeographical dynamics of climate change and Ice Age.

### **Part-B: Ecological Biogeography (10 lectures)**

Species, habitats; environment and niche concepts; biotic and abiotic determinants of communities; species-area relationships; concept of rarity and commonness; Island Biogeography theory; Equilibrium Theory of Insular Biogeography; geography of diversification and invasion; phylogeography.

### **Part-C: Conservation Biogeography (2 lectures)**

Application of biogeographical rules in design of protected area and biosphere reserves; use of remote sensing in conservational planning.

## Unit 5: Speciation and extinction

(8 lectures)

Types and processes of speciation – allopatric, parapatric, sympatric; ecological diversification; adaptive radiation, convergent and parallel evolution; dispersal and immigration; means of dispersal and barriers to dispersal; extinction.

### CC 8 (4<sup>TH</sup> SEMESTER) ENV-A-CC-4-8-P: SYSTEMATICS AND BIOGEOGRAPHY

1. Identification of suitable flora and fauna (Definite list of specimens of ecological and economic significance). (20)

#### Specimens for Identification

*Agaricus* sp.  
Crustose Lichen  
*Azolla* sp.  
*Pteris* sp.  
*Ceratophyllum* sp.  
*Andrographis paniculata*  
*Eichhornia crassipes*  
*Lemna minor*  
*Parthenium hysterophorus*  
*Lantana camara*  
*Jatropha* sp.  
*Rauwolfia serpentina/canescens*  
*Acanthus ilicifolius*  
*Pisum sativum*  
*Opuntia dillenii*  
*Solanum lycopersicum*  
*Ficus benghalensis*  
*Datura metel*  
*Vanda roxburghii*  
*Aloe vera*

#### Specimens for Identification

*Hirudinea* sp.  
*Physalia* sp.  
*Taenia solium*  
*Ascaris lumbricoides*  
*Entamoeba histolytica*  
*Coccinella septempunctata*  
*Tryporyza incertulas*  
Spider  
*Lamellidens marginalis*  
*Octopus* sp.  
*Pila* sp.  
*Asterias* sp.  
*Carcharodon carcharias*  
*Tilapia* sp.  
*Exocetus* sp.  
*Rhacophorus* sp.  
*Naja* sp.  
*Chamaeleo* sp.  
*Columba livia*  
*Culex* sp.

2. Identification Key Preparation. (5)
3. Laboratory notebook and Viva voce (5)

## CC 9 (4<sup>TH</sup> SEMESTER) ENV-A-CC-4-9-TH: URBAN ECOSYSTEMS

**Theory (50 Lectures)**

### **Unit 1: Environment in an urban setting (8 lectures)**

Man as the driver of urban ecosystem; commodification of nature; metros, cities and towns as sources and sinks of resources; resource consumption and its social, cultural, economic and ecological perspectives; urban transformation; increasing challenges posed by modernity for the environment.

### **Unit 2: Urban dwelling (12 lectures)**

Urban Sprawl; Housing scenario across a range of large-medium-small cities; poverty and slums in an urban context; Town planning Acts and their environmental aspects; energy consumption and waste disposal as well as accumulation; environmental costs of urban infrastructure.

### **Unit 3: Urban interface with the environment (10 lectures)**

Definition and concepts: green technology, green energy, green infrastructure, green economy, and, green chemistry; sustainable consumption of resources; individual and community level participation such as small-scale composting pits for biodegradable waste, energy conservation; Green technologies in historical and contemporary perspectives; successful green technologies: wind turbines, solar panels; 3R's of green technology: recycle, renew and reduce.

### **Unit 4: Natural spaces in a city (8 lectures)**

Concept of 'controlled nature'; scope, importance and threats to nature in the city; organization and planning of green spaces such as parks, gardens and public spaces; concept of green belts; urban natural forest ecosystem as green lungs.

### **Unit 5: Planning and environmental management (12 lectures)**

Green buildings; history of green buildings, need and relevance of green buildings over conventional buildings, construction of green buildings; associated costs and benefits; outlined examples of green buildings; LEED certified building; Eco-mark certification, establishment of Eco-mark in India, its importance and implementation; Green planning: role of governmental bodies, land use planning, concept of green cities, waste reduction and recycling in cities, role of informal sector in waste management, public transportation for sustainable development, green belts.; rainwater harvesting (Corporation and Municipal areas)

**CC 9 (4<sup>TH</sup> SEMESTER) ENV-A-CC-4-9-P: URBAN ECOSYSTEMS**

1. Urban survey in group of maximum five students (Corporations and Municipal areas) with field report submission and field viva (20)
2. Viva-voce (10)

## **CC 10 (4<sup>TH</sup> SEMESTER) ENV-A-CC-4-10-TH: ENVIRONMENTAL LEGISLATION AND POLICY**

**Theory (50 lectures)**

### **Unit 1: Introduction**

**(4 lectures)**

Constitution of India; fundamental rights; fundamental duties; Union of India; union list, state list, concurrent list; legislature; state assemblies; judiciary; panchayats and municipal bodies.

### **Unit 2: History of environmental legislation and policy**

**(8 lectures)**

Provision of Environmental Conservation - British India: Indian Penal Code 1860, Forest Act 1865, Fisheries Act 1897; Independent India: Van Mahotsava 1950, National Forest Policy 1952, National Forest Policy 1988.

### **Unit 3: Environmental legislation**

**(25 lectures)**

Legal definitions (environmental pollution, natural resource, biodiversity, forest, sustainable development); Article 48A (The protection and improvement of environment and safeguarding of forests and wildlife); Article 51 A (Fundamental duties).

The Indian Forest Act 1927; The Wildlife (Protection) Act 1972; The Water (Prevention and Control of Pollution) Act 1974; The Water (Prevention and Control of Pollution) Cess Act 1977; The Forests (Conservation) Act 1980; The Air (Prevention and Control of Pollution) Act 1981; The Environment (Protection) Act 1986; Motor Vehicle Act 1988; The Public Liability Insurance Act 1991; Noise Pollution (Regulation and Control) Rules 2000; The Biological Diversity Act 2002; The Schedule Tribes and other Traditional Dwellers (Recognition of Forests Rights) Act 2006; The National Green Tribunal Act 2010; scheme and labeling of environment friendly products, Ecomarks.

### **Unit 4: Role of Government institutions and National Policies**

**(5 lectures)**

Role of Ministry of Environment, Forests & Climate Change in environmental law and policy making; role of central and state pollution control boards in environmental law and policy making; National Green Tribunal; National Environment Policy, 2006.

### **Unit 5: International laws and policy**

**(8 lectures)**

Stockholm Conference 1972; United Nations Conference on Environment and Development 1992; Rio de Janeiro (Rio Declaration, Agenda 21); Montreal Protocol 1987; Kyoto Protocol 1997; Copenhagen and Paris summits; Ramsar convention.

## **CC 10 (4<sup>TH</sup> SEMESTER) ENV-A-CC-4-10-P : ENVIRONMENTAL LEGISLATION AND POLICY**

1. Review of different Case studies on Environmental Issues and power point presentation. (30)

## **SKILL ENHANCEMENT COURSE (SEC)**

### **SEC-B (Anyone from SEC B1 OR SEC B2 IN 4<sup>TH</sup> SEMESTER)**

#### **ENV-A-SEC-A-4-X-TH**

### **SEC B1 : ENVIRONMENTAL IMPACT AND RISK ASSESSMENT**

#### **Theory (30 Lectures)**

**Unit 1:** Environmental impact assessment (EIA): definitions, introduction and concepts; rationale and historical development of EIA; scope and methodologies of EIA; role of project proponents, project developers and consultants; Terms of Reference; impact identification and prediction; baseline data collection; Environmental Impact Statement (EIS), Environmental Management Plan (EMP)

**Unit 2:** Rapid EIA; Strategic Environmental Assessment; Social Impact Assessment; Cost-Benefit analysis; Life cycle assessment; environmental appraisal; environmental management - principles, problems and strategies; environmental planning; environmental audit; introduction to ISO and ISO 14000; sustainable development.

**Unit 3:** EIA regulations in India; status of EIA in India; current issues in EIA; case study of hydropower projects! thermal projects.

**Unit 4:** Risk assessment: introduction and scope; project planning; exposure assessment; toxicity assessment; hazard identification and assessment; risk characterization; risk communication; environmental monitoring; community involvement; legal and regulatory framework; human and ecological risk assessment.

### **SEC B 2: ANALYTICAL METHODS, INSTRUMENTATION AND MEASUREMENT**

#### **Theory (30 Lectures)**

**Unit 1:** Sampling, preservation, storage techniques; Principles and applications of titrimetry (Acidimetry, Alkalimetry, Complexometry, Argentometry, Iodometry) gravimetry, potentiometry, conductimetry.

**Unit 2:** Principles and application of UV-VIS Spectrophotometry, Atomic absorption spectrophotometry flame photometry, electrophoresis Chromatography, X-Ray fluorescence and Microscopy- Properties, Types



and applications.

**Unit 3:** Data Information Knowledge Wisdom Loop, data analysis, errors in data representation.

## **CC 11 (5<sup>TH</sup> SEMESTER) ENV-A-CC-5-11-TH: BIODIVERSITY AND CONSERVATION BIOLOGY**

**Theory (50 Lectures)**

### **Unit 1: Biodiversity patterns and estimation (12 lectures)**

Definition; Types; Spatial patterns: latitudinal and elevational trends in biodiversity; temporal patterns: seasonal fluctuations in biodiversity patterns.

Sampling strategies and surveys: floristic, faunal, and aquatic; qualitative and quantitative methods: scoring, habitat assessment, richness, density, frequency, abundance, evenness, diversity, biomass estimation; community diversity estimation: alpha, beta and gamma diversity.

### **Unit 2: Importance of biodiversity (8 lectures)**

Economic values – medicinal plants, drugs, fisheries and livelihoods; ecological services – primary productivity, role in hydrological cycle, biogeochemical cycling; ecosystem services – purification of water and air, nutrient cycling, climate control, pest control, pollination, and formation and protection of soil; social, aesthetic, consumptive, and ethical values of biodiversity.

### **Unit 3: Threats to biodiversity (10 lectures)**

Natural and anthropogenic disturbances; habitat loss, habitat degradation, and habitat fragmentation; climate change; pollution; hunting; over-exploitation; deforestation; hydropower development; invasive species; land use changes; overgrazing; man wildlife conflicts; consequences of biodiversity loss; Intermediate Disturbance Hypothesis.

### **Unit 4: Conservation of biodiversity (10 lectures)**

Importance of biodiversity patterns in conservation; In-situ conservation (Biosphere Reserves, National Parks, Wildlife Sanctuaries); Ex-situ conservation (botanical gardens, zoological gardens, gene banks, seed and seedling banks, pollen culture, tissue culture and DNA banks), role of local communities and traditional knowledge in conservation; biodiversity hotspots; IUCN Red List categorization – guidelines, practice and application; Red Data book; ecological restoration; afforestation; social forestry; agro forestry; joint forest management; role of remote sensing in management of natural resources.

### **Unit 5: Biodiversity in India (10 lectures)**

India as a mega diversity nation; phytogeographic and zoogeographic zones of the country; forest types and forest cover in India; fish and fisheries of India; impact of hydropower development on biological diversity; status of protected areas and biosphere reserves in the country; National Biodiversity Action Plan.

**CC 11 (5<sup>TH</sup> SEMESTER) ENV-A-CC-5-11-P**

1. Biodiversity assessment in local field work (Calculation of parameters (Frequency, density, abundance, relative density) and indices (Shannon wiener diversity index, Simpson's index, Simpson's index of diversity, evenness index) and report submission. (20)
2. Viva voce (10)

## **CC 12 (5<sup>TH</sup> SEMESTER) ENV-A-CC-5-12-TH: ORGANISMAL AND EVOLUTIONARY BIOLOGY**

### **Theory (50 Lectures)**

#### **Unit 1: History of life on Earth**

**(17 lectures)**

Part-A : Paleontology and evolutionary History; evolutionary time scale; eras, periods and epoch; major events in the evolutionary time scale; stages in primate evolution including Homo.

Part B: Lamarck's concept of evolution; Darwin's Evolutionary Theory: variation, adaptation, struggle, fitness and natural selection; Mendelism; spontaneity of mutations; The Evolutionary Synthesis.

#### **Unit 2: Evolution of unicellular life**

**(8 lectures)**

Origin of cells and unicellular evolution and basic biological molecules; abiotic synthesis of organic monomers and polymers; Oparin-Haldane hypothesis; study of Miller; the first cell;

#### **Unit 3: Geography of evolution**

**(5 lectures)**

Biogeographic evidence of evolution; patterns of distribution.

#### **Unit 4: Molecular evolution**

**(7 lectures)**

Introduction to biomolecules: Protein, Lipids, Carbohydrates (General characteristics and classification) Neutral evolution; molecular divergence and molecular clocks; molecular tools in phylogeny, classification and identification; protein and nucleotide sequence analysis.

#### **Unit 5: Fundamentals of population genetics**

**(13 lectures)**

Concepts of populations, gene pool, gene frequency; concepts and rate of change in gene frequency through natural selection, migration and genetic drift; adaptive radiation; isolating mechanisms; speciation (allopatric, sympatric, peripatric and parapatric); convergent evolution; sexual selection; co-evolution; Hardy-Weinberg Law.

## **CC 12 (5<sup>TH</sup> SEMESTER) ENV-A-CC-5-12-P: ORGANISMAL AND EVOLUTIONARY BIOLOGY**

1. Numerical problems on pedigree and population genetics. (10)
2. Estimation of protein using BSA (Lowry method), Glucose (Anthrone Method) (10)
3. Viva-voce (5), Laboratory Notebooks (5)

## DISCIPLINE SPECIFIC ELECTIVE

### 5<sup>TH</sup> SEMESTER

**ENV-A-DSE-A-5-1-TH+P AND ANY ONE FROM ENV-A-DSE-B-5-2-TH+P OR ENV-A-DSE-B-5-3-TH+P**

#### **ENV-A-DSE-A-5-1-TH : ENERGY AND ENVIRONMENT**

**Theory (50 Lectures)**

##### **Unit 1: Energy resources**

**(12 lectures)**

Defining energy; forms and importance; Global energy resources; renewable and non-renewable resources: distribution and availability; sources and sinks of energy; past, present, and future technologies for capturing and integrating these resources into our energy infrastructure.

##### **Unit 2: Energy demand**

**(7 lectures)**

Global energy demand: historical and current perspective; energy demand and use in domestic, industrial, agriculture and transportation sector; generation and utilization in rural and urban environments; changes in demand in major world economies; energy subsidies; environmental costs.

##### **Unit 3: Energy, environment and society**

**(15 lectures)**

Energy production as driver of environmental change; nature, scope and analysis of local and global impacts of energy use on the environment; fossil fuel burning and related issues of air pollution, nuclear energy and related issues such as radioactive waste, spent fuel; energy production, transformation and utilization associated environmental impacts (Chernobyl and Fukushima nuclear accidents, construction of dams, environmental pollution); energy over-consumption and its impact on the environment, economy, and global change; social inequalities related to energy production, distribution, and use; energy conservation.

##### **Unit 4: Our energy future**

**(16 lectures)**

Current and future energy use patterns in the world and in India; evolution of energy use over time; alternative sources as green energy (biofuels, wind energy, solar energy, geothermal energy; tidal energy, ocean energy; nuclear energy); need for energy efficiency; energy conservation and sustainability; action strategies for sustainable energy management from a future perspective

## **DSE A1: ENV-A-DSE-A-5-1-P**

1. Calculation of energy efficiency from given data. (10)
2. Preparation of energy audit of a domestic unit and report submission. (10)
3. Viva-voce (10)

## **DSE B2 ENV-A-DSE-B-5-2-TH : SOLID WASTE MANAGEMENT**

**Theory (50 Lectures)**

### **Unit 1: Introduction**

**(3 lectures)**

Sources and generation of solid waste, their classification and chemical composition; characterization of municipal solid waste; hazardous waste and biomedical waste.

### **Unit 2: Effect of solid waste disposal on environment**

**(5 lectures)**

Impact of solid waste on environment, human and plant health; effect of solid waste and industrial effluent discharge on water quality and aquatic life; mining waste and land degradation; effect of land fill leachate on soil characteristics and ground water pollution.

### **Unit 3: Solid waste Management**

**(12 lectures)**

Different techniques used in collection, storage, transportation and disposal of solid waste (municipal, hazardous and biomedical waste); landfill (traditional and sanitary landfill design); thermal treatment (pyrolysis and incineration) of waste material; drawbacks in waste management techniques.

### **Unit 4: Industrial waste management**

**(6 lectures)**

Types of industrial waste: hazardous and non-hazardous; effect of industrial waste on air, water and soil; industrial waste management and its importance; stack emission control and emission monitoring; effluent treatment plant and sewage treatment plant.

### **Unit 5: Resource Recovery**

**(6 lectures)**

4R - reduce, reuse, recycle and recover; biological processing - composting, anaerobic digestion, aerobic treatment; reductive dehalogenation; mechanical biological treatment; green techniques for waste treatment.

### **Unit 6: Waste-to-energy (WTE)**

**(4 lectures)**

Concept of energy recovery from waste; refuse derived fuel (RDF); different WTE processes: combustion, pyrolysis, landfill gas (LFG) recovery; anaerobic digestion; gasification.

**Unit 7: Integrated waste management****(4 lectures)**

Concept of Integrated waste management; waste management hierarchy; methods and importance of Integrated waste management.

**Unit 8: Policies for solid waste management****(10 lectures)**

Municipal Solid Wastes (Management and Handling) Rules 2000; Hazardous Wastes Management and Handling Rules 1989; Bio-Medical Waste (Management and Handling) Rules 1998; Plastic Waste (Management and Handling) Rules, 2011; E-Waste (Management) Rules, 2016

**DSE B2: ENV-A-DSE-B-5-2-P**

1. Visit to a Solid Waste Management site and Report submission. (20)
2. Viva-voce (10)

**DSE B3: ENV-A-DSE-B-5-3-TH: ENVIRONMENTAL HEALTH AND TOXICOLOGY****Theory (50 Lectures)****Unit 1: Epidemiology and Health****(6 lectures)**

Concept of Health and Disease, principles of epidemiology and epidemiological methods, aims of epidemiology, measurement of mortality, measurement of morbidity.

**Unit 2: Concept of Disease****(10 lectures)**

Concept of screening the diseases, some communicable diseases like small pox, cholera, acute diarrheal disease, viral hepatitis, water borne pathogens, vector borne diseases, diseases caused by contaminated food and water, soil borne infections, insect borne diseases.

**Unit 3: Concept of Immunology****(12 lectures)**

Elementary idea about antigens and antibody, hyper sensitivity, allergic reactions, pollens and their allergens. Immunological techniques.

**Unit 4: Community and Health****(2 lectures)**

Communication for health education, health care of the country.

**Unit 5: Basic Concept of Toxicology****(20 lectures)**

Different types of toxicant, toxicity test, toxicity by different factors, exposure effect relationship, different route of exposure, synergistic and antagonistic effect, Bioaccumulation and Biomagnification. Detoxification, toxico-dynamics.

**DSE B3: ENV-A-DSE-B-5-3-P**

1. LC<sub>50</sub> calculation by probit analysis with data provided. (10)
2. Study of Nuclear abnormalities in the erythrocytes of fish/ from root tip of *Allium cepa* (10)
3. Viva-voce (5), Laboratory notebooks (5)



## **CC 13 (6<sup>TH</sup> SEMESTER) ENV-A-CC-6-13-TH: ENVIRONMENTAL POLLUTION AND HUMAN HEALTH**

**Theory (50 Lectures)**

### **Unit 1: Introduction**

**(9 lecture)**

Definition of pollution; pollutants; classification of pollutants. Solubility of pollutants (hydrophilic and lipophilic pollutants), transfer of pollutants within different mediums, role of chelating agents in transferring pollutants, concept of biotransformation and bioaccumulation, concept of radioactivity, radioactive decay and half-life of pollutants, organometallic compounds, acid mine drainage.

### **Unit 2: Air pollution**

**(8 lectures)**

Ambient air quality: monitoring and standards (National Ambient Air Quality Standards of India); air quality index; sources and types of pollutants (primary and secondary); smog (case study); effects of different pollutants on human health (NO<sub>x</sub>, SO<sub>x</sub>, PM, CO, CO<sub>2</sub>, hydrocarbons and VOCs) and control measures; indoor air pollution: sources and effects on human health.

### **Unit 3: Water pollution**

**(8 lectures)**

Sources of surface and ground water pollution; water quality parameters and standards; organic waste and water pollution; eutrophication; COD, BOD, DO; effect of water contaminants on human health (nitrate, fluoride, arsenic, chlorine, cadmium, mercury, pesticides); water borne diseases; concept and working of effluent treatment plants (ETPs).

### **Unit 4: Soil pollution**

**(4 lectures)**

Causes of soil pollution and degradation; effect of soil pollution on environment, vegetation and other life forms; control strategies.

### **Unit 5: Noise pollution**

**(3 lectures)**

Noise pollution-sources; frequency, intensity and permissible ambient noise levels; effect on communication, impacts on life forms and humans - working efficiency, physical and mental health; control measures.

### **Unit 6: Radioactive and thermal pollution**

**(4 lectures)**

Radioactive material and sources of radioactive pollution; effect of radiation on human health (somatic and genetic effects); thermal pollution and its effects.

**Unit 7: Marine pollution****(4 lectures)**

Marine resources and their importance; sources of marine pollution; oil spill and its effects; coral reefs and their demise; coastal area management; existing challenges and management techniques (planning, construction, environmental monitoring of coastal zones).

**Unit 8: Pollution control****(10 lectures)**

Activated Sludge Process (ASP) – Trickling Filters – oxidation ponds, fluidized bed reactors, membrane bioreactor neutralization, ETP sludge management; digesters, up flow anaerobic sludge blanket reactor, fixed film reactors, sequencing batch reactors, hybrid reactors, bioscrubbers, biotrickling filters; regulatory framework for pollution monitoring and control; case study: Ganga Action Plan; Yamuna Action Plan; implementation of CNG in NCT of Delhi.

**CC 13 (6<sup>TH</sup> SEMESTER) ENV-A-CC-6-13-P: ENVIRONMENTAL POLLUTION AND HUMAN HEALTH**

1. BOD, COD, Noise (dB(A), SPM, RSPM, Dust fall rate, Soil respiration. (20)
2. Viva Voce (5), Laboratory notebook (5)

## **CC 14 (6<sup>TH</sup> SEMESTER) ENV-A-CC-6-14-TH: NATURAL RESOURCE MANAGEMENT AND SUSTAINABILITY**

**Theory (50 Lectures)**

### **Unit 1: Introduction**

**(7 lectures)**

Resource and reserves; classification of natural resources; renewable and non-renewable resources; resource degradation; resource conservation; resource availability and factors influencing its availability; land resources; water resources; fisheries and other marine resources; energy resources; mineral resources; human impact on natural resources; ecological, social and economic dimension of resource management.

### **Unit 2: Natural resources and conservation**

**(7 lectures)**

Forest resources: economic and ecological importance of forests, forest management strategies, sustainable forestry; water resources: supply, renewal, and use of water resources, freshwater shortages, strategies of water conservation; soil resources: importance of soil, soil conservation strategies; food resources: world food problem, techniques to increase world food production, green revolution.

### **Unit 3: Mineral resources**

**(8 lectures)**

Mineral resources and the rock cycle; identified resources; undiscovered resources; reserves; types of mining: surface, subsurface, open-pit, dredging, strip; reserve-to-production ratio; global consumption patterns of mineral resources techniques to increase mineral resource supplies; ocean mining for mineral resources; environmental effects of extracting and using mineral resources.

### **Unit 4: Energy resources**

**(20 lectures)**

**Part A:** Oil: formation, exploration, extraction and processing, oil shale, tar sands; natural gas: exploration, liquefied petroleum gas, liquefied natural gas; coal: reserves, classification, formation, extraction, processing, coal gasification; environmental impacts of non-renewable energy consumption; impact of energy consumption on global economy; application of green technology; future energy options and challenges.

**Part B:** Energy efficiency; life cycle cost; cogeneration; solar energy: technology, advantages, passive and active solar heating system, solar thermal systems, solar cells, 1NN solar mission; hydropower: technology, potential, operational costs, benefits of hydropower development; nuclear power: nuclear fission, fusion, reactors, pros and cons of nuclear power, storage of radioactive waste, radioactive contamination; tidal energy; wave energy; ocean thermal energy conversion (OTEC); geothermal energy; energy from biomass; bio-diesel.

## **Unit 5: Resource management**

**(8 lectures)**

Approaches in resource management: ecological approach; economic approach; ethnological approach; implications of the approaches; integrated resource management strategies; concept of sustainability science: different approach towards sustainable development and its different constituents; sustainability of society, resources and framework; sustainable energy strategy; principles of energy conservation; Indian renewable energy programme.

### **CC 14 (6<sup>TH</sup> SEMESTER) ENV-A-CC-6-14-P: : NATURAL RESOURCE MANAGEMENT AND SUSTAINABILITY**

1. Project Work: Submission of report & presentation (30)

## DISCIPLINE SPECIFIC ELECTIVE

### 6<sup>TH</sup> SEMESTER

**ENV-A-DSE-B-6-1-TH+P AND ANY ONE FROM ENV-A-DSE-A-6-2-TH+P OR ENV-A-DSE-A-6--3-TH+P**

**DSE B1: ENV-A-DSE-B-6-1-TH: NATURAL HAZARDS AND DISASTER MANAGEMENT**

**Theory (50 Lectures)**

#### **Unit 1: Introduction**

**(3 lectures)**

Definition of hazard; natural, technological, and context hazards; concept of risk and vulnerability; reasons of vulnerability - rapid population growth, urban expansion, environmental pollution, epidemics, industrial accidents, inadequate government policies.

#### **Unit 2: Natural hazards**

**(16 lectures)**

Natural hazards: hydrological, atmospheric & geological hazards; earthquake: seismic waves, epicenter; volcanoes: causes of volcanism, geographic distribution; floods: types and nature, frequency of flooding; landslides: causes and types of landslides, landslide analysis; drought: types of drought-meteorological, agricultural, hydrological, and famine; Glacial Lake Outburst Floods (GLOF); tornadoes, cyclone & hurricanes; tsunamis: causes and location of tsunamis; coastal erosion, sea level changes and its impact on coastal areas and coastal zone management.

#### **Unit 3: Anthropogenic hazards**

**(15 lectures)**

Impacts of anthropogenic activities such as rapid urbanization, injudicious ground water extraction, sand mining from river bank, deforestation, mangroves destruction; role of construction along river banks in elevating flood hazard; disturbing flood plains. deforestation and landslide hazards associated with it; large scale developmental projects, like dams and nuclear reactors in hazard prone zones; nature and impact of accidents, wildfires and biophysical hazards. Case studies of Bhopal, Minamata and Chernobyl disaster.

#### **Unit 4: Risk and vulnerability assessment**

**(4 lectures)**

Two components of risk: likelihood and consequences, qualitative likelihood measurement index; categories of consequences (direct losses, indirect losses, tangible losses, and intangible losses); application of geoinformatics in hazard, risk & vulnerability assessment.

#### **Unit 5: Mitigation and preparedness**

**(6 lectures)**

Concept of mitigation; types of mitigation: structural and non-structural mitigation, use of technologies in mitigations such as barrier, deflection and retention systems; concept of preparedness; importance of planning, exercise, and training in preparedness; role of public, education and media in hazard preparedness.

### **Unit 6: Disaster management in India**

**(6 lectures)**

Lessons from the past considering the examples of Bhuj earthquake, tsunami disaster, and Bhopal tragedy; National Disaster Management Framework, national response mechanism, role of government bodies such as NDMC and IMD; role of armed forces and media in disaster management; role of space technology in disaster management; case study of efficient disaster management during cyclone 'Phailin' in 2013.

### **DSE B1 ENV-A-DSE-B-6-1-P**

1. Preparation of disaster management plan for any of the following disaster flood, earthquake, cyclone, fire outbreak and report submission. (20)
2. Viva-voce (10)

**DSE A2:**

### **ENV-A-DSE-A-6-2-TH: ENVIRONMENTAL ECONOMICS AND STATISTICS**

**Theory (50 Lectures)**

### **Unit 1: Economic solutions to environmental problems**

**(15 lectures)**

Social costs and benefits of environmental programmes: marginal social benefit of abatement, marginal social cost of abatement; pollution control: policies for controlling air and water pollution, disposal of toxic and hazardous waste- standards vs. emissions charges, environmental subsidies, modelling and emission charges; polluter pay principles; pollution permit trading system.

### **Unit 2: Natural resource economics**

**(5 lectures)**

Economics of non-renewable resources; economics of fuels and minerals; Hotelling's rule and extensions; taxation; economics of renewable resources; economics of water use, management of fisheries and forests; introduction to natural resource accounting.

### **Unit 3: Tools for environmental economic policy**

**(10 lectures)**

Growth and environment; environmental audit and accounting, Kuznets curve, environmental risk analysis, assessing benefits and cost for environmental decision making; cost benefit analysis and

valuation: discounting, principles of Cost-Benefit Analysis, estimation of costs and benefits, techniques of valuation, adjusting and comparing environmental benefits and costs.

**Unit 4: Statistical techniques applied to Environmental systems (20 lectures)**

Variables, population and Sampling, sampling methods, sampling error, frequency distribution, bar diagram, pie diagram, arithmetic and geometric mean, mode, median, measures of deviation, null and alternative hypothesis, probability distribution, t-test,  $\chi^2$  Test, correlation and regression.

**DSE A2**

**ENV-A-DSE-A-6-2-P**

1. Numerical problems on biostatistics Chi-Square test (Goodness of fit, Contingency) Student's t test (Paired and Unpaired) (20)
2. Viva-voce (5), Laboratory Notebooks (5)

**DSE A3:**

**ENV-A-DSE-A-6-3-TH: GREEN TECHNOLOGIES**

**Unit 1: Green infrastructure, planning and economy (14 lectures)**

Green buildings; history of green buildings, need and relevance of green buildings over conventional buildings, construction of green buildings; associated costs and benefits; outlined examples of green buildings; LEED certified building; Eco-mark certification, establishment of Eco-mark in India, its importance and implementation; Green planning: role of governmental bodies, land use planning, concept of green cities, waste reduction and recycling in cities, role of informal sector in waste management, public transportation for sustainable development, green belts.

**Unit 2: Applications of green technologies (14 lectures)**

Increase in energy efficiency: cogeneration, motor system optimization, oxy-fuel firing, isothermal melting process, energy efficient fume hoods, compact fluorescent lights (CFLs), motion detection lighting, or programmable thermostats). Green House Gas (GHG) emissions reduction: carbon capture and storage (CCS) technologies, purchase and use of carbon offsets, promotion and/ or subsidy of alternative forms of transportation for employees, such as carpools, fuel efficient vehicles, and mass transit, methane emissions reduction and/or reuse).

Pollution reduction and removal (Flue Gas Desulfurization (FGD) methods, catalytic or thermal destruction of NO<sub>x</sub>, Fluidized Bed Combustion, Dioxins reduction and removal methods, Thermal Oxidizers or Wet Scrubbers to neutralize chemicals or heavy metals, solvent recovery systems, Low Volatile Organic Compound (VOC) paints and sealers).

**Unit 3: Green chemistry****(12 lectures)**

Introduction to green chemistry; principles and recognition of green criteria in chemistry; bio- degradable and bio-accumulative products in environment; green nanotechnology; reagents, reactions and technologies that should be and realistically could be replaced by green alternatives; photodegradable plastic bags.

**Unit 5: Green future****(10 lectures)**

Agenda of green development; reduction of ecological footprint; role of green technologies towards a sustainable future; major challenges and their resolution for implementation of green technologies; green practices to conserve natural resources (organic agriculture, agroforestry, reducing paper usage and consumption, etc.); emphasis on waste reduction instead of recycling, emphasis on innovation for green future; role of advancement in science in developing environmental friendly technologies.

**DSE A3: ENV-A-DSE-A-6-3-P**

1. Analysis of stability of vermicompost by compost respiration method. (10)
2. Analysis of rainwater harvesting potential in uraban/rural catchments (10)
3. Viva-voce (5), Laboratory Notebooks (5)



## Suggested Readings:

1. Abbasi T. and Abbasi S.A., 2010. *Renewable Energy Resources: Their Impact on Global warming and Pollution*. PHI.
2. Abraham, C.M. 1999. *Environmental Jurisprudence in India*. Kluwer Law International.
3. APHA, 2012. *Standard Methods for the Examination of Water and Waste water (21<sup>st</sup> ed)*. APHA.
4. Anastas, P.T. & Warner, J.C. 1998. *Green Chemistry: Theory & Practice*. Oxford University Press
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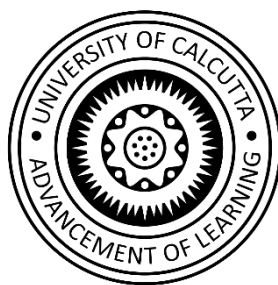
**MODEL COURSE CURRICULUM FOR UNDERGRADUATE COURSES  
UNDER CHOICE BASED CREDIT SYSTEM**

**FINAL SYLLABUS FOR**

**BACHELOR IN**

**ENVIRONMENTAL SCIENCE**

**(GENERAL)**



**UNIVERSITY OF CALCUTTA**

| SEMESTER | COURSES  | DETAILS OF THE COURSE  | CREDIT |
|----------|--|--|--------|
| I        | CORE COURSE<br>ENV-G-CC/GE-1-1-TH                    | Fundamentals of Environmental Science  | 4      |
|          | CORE COURSE<br>ENV-G-CC/GE-1-1- P                    | Fundamentals of Environmental Science  | 2      |
|          | ABILITY ENHACEMENT COURSE<br>AECC 1                  | English Communications/MIL   | 2      |
| II       | CORE COURSE<br>ENV-G-CC/GE-2-2-TH                    | Ecology and Biodiversity   | 4      |
|          | CORE COURSE<br>ENV-G-CC/GE-2-2-P                     | Ecology and Biodiversity   | 2      |
|          | ABILITY ENHACEMENT COURSE<br>AECC 2                  | Environmental Studies  | 2      |
| III      | CORE COURSE<br>ENV-G-CC/GE-3-3-TH                    | Chemistry of Environment   | 4      |
|          | CORE COURSE<br>ENV-G-CC/GE-3-3-P                     | Chemistry of Environment   | 2      |
|          | SKILL ENHANCEMENT COURSE<br>ENV-G-SEC-3-A1-TH        | Environmental Laws and policy,<br>Environmental Audit and EIA                                  | 2      |
| IV       | CORE COURSE<br>ENV-G-CC/GE-4-4-TH                    | Environmental Physics and Meteorology  | 4      |
|          | CORE COURSE<br>ENV-G-CC/GE-4-4-P                     | Environmental Physics and Meteorology  | 2      |
|          | SKILL ENHANCEMENT COURSE<br>ENV-G-SEC-4-B1-TH        | Applications of Environmental<br>Biotechnology   | 2      |
| V        | DISCIPLINE SPECIFIC ELECTIVES<br>ENV-G-DSE-A--5-X-TH | A1) Energy and Environment<br>A2) Environmental Economics and Statistics<br>(Any one Paper)    | 4      |
|          | DISCIPLINE SPECIFIC ELECTIVES<br>ENV-G-DSE-A-5-X-P   | A1) Energy and Environment<br>A2) Environmental Economics and Statistics<br>(Any one Paper)    | 2      |
|          | SKILL ENHANCEMENT COURSE<br>ENV-G-SEC-5-A2-TH        | Environmental Pollution and Green<br>Technologies  | 2      |
| VI       | DISCIPLINE SPECIFIC ELECTIVES<br>ENV-G-DSE-B-6-X-TH  | B1) Natural Hazard and Disaster<br>Management<br>B2) Solid Waste Management (Any one<br>Paper) | 4      |
|          | DISCIPLINE SPECIFIC ELECTIVES<br>ENV-G-DSE-B-6-X-P   | Natural Hazard and Disaster Management!<br>Solid Waste Management<br>(Any one Paper)           | 2      |
|          | SKILL ENHANCEMENT COURSE<br>ENV-G-SEC-6-B2-TH        | Remote sensing, GIS and its applications   | 2      |
|          |  |  |        |

THEORY PRACTICAL

CORE COURSE (CC): THEORY (CREDIT 4), PRACTICAL (CREDIT 2) (CC: 12\*) 12X4 =48, 12X2=24  
DISCIPLINE SPECIFIC ELECTIVE (DSE):TH (CREDIT 4), PRAC. (CREDIT 2) (DSE: 6\*\*) 6X4 =24, 6X2= 12  
SKILL ENHANCEMENT COURSE (SEC): THEORY (CREDIT 2) (SEC: 4\*\*) 4X2 = 8  
[Any one Paper either in 3<sup>rd</sup> or 5<sup>th</sup> Semester from SEC A Any one Paper either in 4<sup>th</sup> or 6<sup>th</sup> Semester from SEC B]  
ABILITY ENHACEMENT COMPULSORY COURSE (AECC) THEORY (CREDIT 2) 2X2 = 4

\*Covering three subjects; \*Covering two subjects

**TOTAL COURSE = 42 (24 THEORY+18 PRACTICAL)**

**TOTAL CREDITS = 120 (86 THEORY+ 36 PRACTICAL)**



# Semester Wise Environmental Science General Courses

## Semester-I

### **ENV-G-CC/GE-1-1-TH: Fundamentals of Environmental Science**

**Theory: 50 Lectures**

#### **Unit 1: Concept of Environment and Environmental Science: (15 Lectures)**

Definition, Types and Components of Environment (Atmosphere, Hydrosphere, Lithosphere and Biosphere); Environmental Science: An overview; Scopes and Objective of Environmental and Ecological Science; Man – Environment relationships; Growth of Environmental and Ecological science in India.

#### **Unit 2: Environmental Literacy: (5 Lectures)**

Environmental literacy (formal and non-formal education)

#### **Unit3: Environmental Problems and Global Environmental Issues: (15 Lectures)**

Classifying environmental problems, Green House effect, Climate change, Acid deposition, Desertification, Ozone layer depletion.

#### **Unit 4: Important atmospheric events: (8 Lectures)**

Western disturbance, Tropical cyclones, Monsoon, El-nino phenomenon.

#### **Unit 5: Climatic zone of the world: (7 Lectures)**

Equatorial, Tropical, Sub-Tropical, Tundra.

### **ENV-G-CC/GE-1-1-P: Fundamentals of Environmental Science (Practical)**

1. Study of Laboratory safety rules. (5)
2. To study the principle and applications of following instruments  
(autoclave, incubator, BODincubator, hot air oven, light microscope, pH meter, conductivity meter, spectrophotometer) (10)
3. Assignment on Environmental Education and global environmental issues. (10)
4. Viva Voce. (5)

## **Semester-II**

### **ENV-G-CC/GE-2-2-TH: Ecology and Biodiversity**

**Theory: 50 Lectures**

#### **Unit 1: Ecological Concepts:**

**(6 Lectures)**

Subdivisions and development phases of ecology, Autecology - definition, distribution, phenological studies; Synecology - basic ideas, definition; food chains, food webs and trophic levels.

#### **Unit 2. Population and Community Ecology:**

**(7 Lectures)**

Definition; Population characteristics, growth mortality, survivorship and dynamics; Community structures and characters; Predation; Competition; Symbiosis; Defensive Mechanism; Resilience and stability; Basic concept of ecological succession.

#### **Unit 3: Ecosystem ecology:**

**(10 Lectures)**

Basic concept of ecosystem, structural and functional aspects of ecosystems; Raymond Lindeman - Trophic level dynamics, Ecological pyramids; Productivity concept of ecosystem; Concept of limiting factors - **Liebig's** law of minimum, Shelford's law of tolerance; Cycling of nutrients.

#### **Unit 4: Concept and Importance of Biodiversity:**

**(4 Lectures)**

Definition; Types; India as megadiverse country; Values (Direct and indirect) and Services of Biodiversity.

#### **Unit 5: Threats to Biodiversity:**

**(5 Lectures)**

Natural and Anthropogenic disturbances; Habitat loss, Habitat degradation, and Habitat fragmentation; Climate change; pollution; hunting; over-exploitation; deforestation; invasive species; land use changes; overgrazing etc.

#### **Unit 6: Measurement of Biodiversity:**

**(6 Lectures)**

Different types of biodiversity measurement indices viz. Shannon Wiener biodiversity index, Simpson index, Evenness index, frequency, abundance, density, relative density.

#### **Unit 7: Conservation of Biodiversity:**

**(12 Lectures)**

Importance of biodiversity patterns in conservation; In-situ conservation (Biosphere Reserves, National Parks, Wildlife Sanctuaries); Ex-situ conservation (botanical gardens, zoological gardens, gene banks, seed and seedling banks, pollen culture, tissue culture and DNA banks), role of local communities and traditional knowledge in conservation; Biodiversity Hotspots; IUCN Red List categorization - guidelines, practice and application; Red Data book; Joint forest management, Sanctuary and Biosphere reserve - difference and location in India. People's biodiversity register (PBR); Importance of Wetland, its conservation, Ramsar Convention.

### **ENV-G-CC/GE-2-2-P: Ecology and Biodiversity (Practical)**

1. Field study on ecology and biodiversity of flora and fauna of a local area/ex-situ conservation site and field report submission. **(10)**
- 2.. Identification of environmentally important flora and fauna with characteristics features. (Herbarium/specimens) (15)
3. Viva Voce. (5)

## Semester-III

### **ENV-G-CC/GE-3-3-TH: Chemistry of the Environment**

**Theory: 50 Lectures**

**Unit 1: Basics of General Chemistry: (8 Lectures)**

Molecular weight, Equivalent Weight, Molarity, Normality, Oxidation and Reduction Reactions; Brief idea of Metals and Nonmetals; Aromatic & Aliphatic compounds, Saturated and unsaturated hydrocarbons.

**Unit 2: Basics of Chemical Equilibrium and Kinetics: (4 Lectures)**

Stoichiometry; Chemical equilibrium; Acid-base reactions (acidity, alkalinity, buffer and buffer capacity).

**Unit 3: Water Chemistry: (10 Lectures)**

Fundamentals of water quality; Concept of DO, BOD, COD, Hardness; Principles of sedimentation, coagulation, filtration.

**Unit 4: Air Chemistry: (12 Lectures)**

Classification of elements, particles, ions and radicals in the atmosphere; Chemical process for formation of inorganic and organic particulate matters in air; PM-10, PM-2.5, Sulphur Oxides Chemistry, Nitrogen Oxides Chemistry, Carbon Oxides Chemistry, VOCs (Volatile Organic Compounds), PAHs (Polycyclic Aromatic Hydrocarbons), Peroxyacetyl nitrate (PAN) and Photochemical smog; Ozone chemistry.

**Unit 5: Soil Chemistry: (8 Lectures)**

Soil composition; relation between organic carbon and organic matter; inorganic and organic components in soil; soil humus; cation and anion exchange reactions in soil; nitrogen, phosphorus and potassium pathways in soil.

**Unit 6: Chemistry of Heavy metals: (8 Lectures)**

Pb, Hg, Cd and As - Physical and chemical properties; Behavior of heavy metals and their compounds in environment.

### **ENV-G-CC/GE-3-3-P: Chemistry of the Environment (Practical)**

1. Estimation of water quality parameters - pH, conductivity, free CO<sub>2</sub>, hardness, alkalinity, chloride, Dissolved oxygen. (10)
2. Estimation of Soil quality parameters - pH, conductivity, organic carbon. (10)
3. Viva Voce. (10)

## Semester-IV

### **ENV-G-CC/GE-4-4-TH: Environmental Physics and Meteorology**

**Theory 50 Lectures**

**Unit 1: Thermodynamics: (12 Lectures)**

Concept of System; First and second law of thermodynamics; Entropy; Enthalpy, Free energy; Chemical potential; Heat transfer process; Mass and energy transfer across the various interfaces; Material balance.

**Unit 2: Energy Interactions: (8 Lectures)**

Energy budget concept: Radiation fluxes, metabolism of latent heat exchange; Energy equilibrium between biotic and abiotic environmental component.

**Unit 3: Concept of Radiation Physics: (8 Lectures)**

Types of Electromagnetic radioactivity and its units, characterizations of various rays, application of radio isotopes; Biological effects of radiation.

**Unit 4: Techniques related to environmental physics: (10 Lectures)**

Acoustic radar; Application of LASER radiations; Electrical detection of airborne particles using surface ionization techniques; Biosensor: Concept and application.

**Unit 5: Concept of Meteorology: (12 Lectures)**

Basic knowledge of climatological parameters for environmental study; Weather and climate; Classification of Climate; Fundamentals of temperature, pressure, relative humidity, rainfall and wind speed; Concept of atmospheric stability; Mixing height, temperature inversion.

### **ENV-G-CC/GE-4-4-P: Environmental Physics and Meteorology (Practical)**

1. Recording of wind speed, relative humidity, atmospheric pressure, rainfall, insolation and light intensity. (10)
2. Visit to a Weather Station (one day) (10)
3. Viva-Voce (10)

## **SKILL ENHANCEMENT COURSE (SEC)**

**SEC-A** [Any one Paper either in 3<sup>rd</sup> or 5<sup>th</sup> Semester]

### **ENV-G-SEC-3-A1-TH: Environmental Laws and policy, Environmental Audit and EIA**

**Theory: 30 Lectures**

#### **Unit 1: Fundamental rights and duties in Indian Constitution; Policies related to Environment (8 Lectures)**

National Forest Policy 1952, National Forest Policy 1988; National Environment Policy, 2006

#### **Unit 2: Environmental legislation (10 Lectures)**

Legal definitions (environmental pollution, natural resource, biodiversity, forest, sustainable development); Article 48A (The protection and improvement of environment and safeguarding of forests and wildlife); Article 51 A (Fundamental duties).

The Indian Forest Act 1927; The Wildlife (Protection) Act 1972; The Water (Prevention and Control of Pollution) Act 1974; The Water (Prevention and Control of Pollution) Cess Act 1977; The Forests (Conservation) Act 1980; The Air (Prevention and Control of Pollution) Act 1981; The Environment (Protection) Act 1986; Motor Vehicle Act 1988; The Public Liability Insurance Act 1991; Noise Pollution (Regulation and Control) Rules 2000; The Biological Diversity Act 2002.

#### **Unit 3: Environmental Audit (6 Lectures)**

Overview of Environmental Audit, Basic steps of Environmental Audit, Benefits of Environmental Audit.

#### **Unit 4: Environmental Impact Assessment (6 Lectures)**

Definitions, introduction concepts and types; scope and methodologies of EIA, EIA regulations in Ind

# **ENV-G-SEC-5-A2-TH: Environmental Pollution and Green Technologies**

**Theory: 30 Lectures**

## **Unit 1: Introduction: (2 Lectures)**

Definition of pollution; pollutants; classification of pollutants (Physical, chemical and biological).

## **Unit 2: Air and Noise Pollution: (8 Lectures)**

Air borne particles and particulate matters, Temperature inversion, SO<sub>x</sub>, NO<sub>x</sub>, Hydrocarbons, Lead & other pollutants; Temperature inversion; photochemical Smog; Health effects of Air pollution; Adverse health effects of tobacco.

Measurement of Noise, Health effects of Noise pollution, Control of noise pollution.

## **Unit 3: Water pollution: (6 Lectures)**

Sources of surface and ground water pollution; Water quality parameters: COD, BOD, DO, hardness, alkalinity; Biological aspects of water pollution: MPN, Eutrophication; Biological indicator; Arsenic pollution of drinking water and its consequence: An overview.

## **Unit 4: Pesticide pollution: (2 Lectures)**

Classification of pesticide, Biological magnification of persistent organic pollutants.

## **Unit 5: Pollution control: (2 Lectures)**

Activated Sludge Process (ASP) - Trickling Filters - oxidation ponds, fluidized bed reactors, concept and working of effluent treatment plants (ETPs).

## **Unit 6: Green technologies and its applications: (10 Lectures)**

Definition and concepts: green technology, Green House Gas (GHG) emissions reduction: carbon capture and storage (CCS) technologies, fuel efficient vehicles, and mass transit, methane emissions reduction and/or reuse; Pollution reduction and removal (Flue Gas Desulfurization (FGD) methods; Rainwater Harvesting; Successful green technologies: wind turbines, solar panels; 3R's of green technology: recycle, renew and reduce.

**SEC-B [Any one Paper either in 4<sup>th</sup> or 6<sup>th</sup> Semester]**

**ENV-G-SEC-4-B1-TH: Applications of Environmental Biotechnology**

**Theory: 30 Lectures**

**Unit 1: Principles of different biotechnological methods: (10 Lectures)**

Plasmid preparation, restriction digestion, DNA ligation, PCR, RAPD and RFLP.

**Unit 2: Biotechnological applications: (3 Lectures)**

Biotechnological applications in medicine and industry.

**Unit 3: Application of Biotechnology in waste treatment: (7 Lectures)**

Wastewater treatment; solid waste treatment: sources and management (composting, vermiculture and methane production); Bioremediation; Phytoremediation.

**Unit 4: Ecologically safe products and processes: (7 Lectures)**

PGPR bacteria: biofertilizers, microbial insecticides and pesticides; Integrated pest management.

**Unit 5: GMs and GMOs: (3 Lectures)**

Concept of GM and GMOs; Biosafety protocol.

**ENV-G-SEC-6-B2-TH: Remote sensing, GIS and its applications**

**Theory: 30 Lectures**

**Unit 1: Remote Sensing: (8 Lectures)**

Definitions and principles; electromagnetic (EME) spectrum; spectral signature; satellites and sensors; aerial photography and image interpretation.

**Unit 2: Geographical Information Systems: (12 Lectures)**

Definitions and components; spatial and non-spatial data; raster and vector data; database generation; database management system; land use/ land cover mapping; GPS survey, data import, processing, and mapping.

**Unit 3: Applications of remote sensing and GIS: (8 Lectures)**

Water resource management, land use planning, forest and wildlife resources, agriculture, and atmospheric studies.



## **Semester-V**

### **DISCIPLINE SPECIFIC ELECTIVES**

#### **DSE-A [Elective Course (Any One from DSE-A1 and DSE-A2)]**

#### **ENV-G-DSE-A--5-X-TH**

#### **(DSE) A1: Energy and Environment**

**Theory: 50 Lectures**

#### **Unit 1: Energy resources: (10 Lectures)**

Defining energy; forms and importance; Global energy resources; renewable and non-renewable resources: distribution and availability.

#### **Unit 2: Energy demand: (10 Lectures)**

Global energy demand: historical and current perspective; energy demand and use in domestic, industrial, agriculture and transportation sector.

#### **Unit 3: Energy Resource Management: (20 Lectures)**

Conventional and non-conventional energy resources; Brief idea of energy production and environmental consequences involved (*viz.* Thermal, Hydel, Solar, Wind, Geothermal, Energy from oceans and Bio-energy); Need for energy efficiency; Energy conservation and sustainability; Action strategies for sustainable energy management from a future perspective.

#### **Unit 4: Energy Audit: (10 Lectures)**

Concept, purpose and methodology.

#### **ENV-G-DSE-A--5-X-P**

#### **(DSE) A 1: Energy and Environment (Practical)**

1. To determine energy efficiencies from the given data. (5)
3. Preparation of Energy audit of a domestic unit/office. (10)
4. Demonstration of water conservation techniques.
5. Demonstration of use of solar devices, photo-cells, wind-mills.
6. Demonstration of Biogas plant (S No. 4,5,6 =5)
7. Preparation of report on Energy Plantation /Visit to a water shed management project and field report preparation. (10)

## **ENV-G-DSE-A--5-X-TH**

### **(DSE) A2: Environmental Economics and Statistics**

**Theory: 50 Lectures**

**Unit 1: Concept of environmental economics: (4 Lectures)**

Economy and the environment.

**Unit 2: National resource economics: (10 Lectures)**

Economics of non-renewable resources; economics of fuels and minerals; Introduction to natural resource accounting.

**Unit 3: Tools for environmental economic policy: (12 Lectures)**

Growth and environment; environmental accounting, Kuznets curve, assessing benefits and cost for environmental decision making; cost benefit analysis; Economic valuation techniques of environmental benefits - various methods; Policies for controlling air and water pollution; polluter pay principles.

**Unit 4: Carbon trading: (9 Lectures)**

Carbon tax, carbon trading; clean development mechanism; clean production and technology and ecomark - concept only.

**Unit 5: Basic Statistics: (15 Lectures)**

Statistical Sampling, sampling units, estimation of sample size; Mean, mode, median, standard error and deviation, probability, correlation and regression; Testing of hypothesis: Null and alternative, chi-square and student's 't' test.

## **ENV-G-DSE-A--5-X-P**

### **DSEA2: Environmental Economics and Statistics (Practical)**

1. Numerical problems on biostatistics Chi-Square test and Student's t test). (20)
2. Viva -voce. (10)

## **Semester-VI**

### **DISCIPLINE SPECIFIC ELECTIVES**

#### **DSE-B [Elective Course (Any One from DSE-B1 and DSE-B2)]**

#### **ENV-G-DSE-B-6-X-TH**

#### **(DSE) B1: Natural Hazard and Disaster Management**

**Theory: 50 Lectures**

##### **Unit 1: Introduction: (12 Lectures)**

Definition of hazard and disaster; Natural, technological and context hazards; Concept of risk and vulnerability.

##### **Unit 2: Natural hazards: (16 Lectures)**

Natural hazards – earthquake; volcanoes - cause and effects; floods: types and nature, effects; landslides: causes and types of landslides, effects; drought: types of drought - meteorological, agricultural, hydrological and effects; tornadoes, cyclone & hurricanes; tsunamis: causes and location of tsunamis, effects.

##### **Unit 3: Anthropogenic hazards: (16 Lectures)**

Impacts of anthropogenic activities such as rapid urbanization, injudicious ground water extraction, deforestation; large scale developmental projects, like dams and nuclear reactors in hazard prone zones; Nature and impact of accidents; Case studies of Bhopal, Minamata and Chernobyl disaster.

##### **Unit 5: Disaster management: (6 Lectures)**

Disaster management cycle; Disaster management plan.

#### **ENV-G-DSE-B-6-X-P**

#### **(DSE) B1: Natural Hazard and Disaster Management (Practical)**

1. Project Report based on any two field-based case studies among following disasters and one disaster preparedness plan of respective college or locality: -Flood and waterlogging, Cyclone, Earthquake, Human Induced Disasters: Fire Hazards, Chemical, Industrial accidents. (15)
2. Poster preparation and presentation on topic related to national and international disaster and disaster management. (5)
3. Viva -voce (10)

## **ENV-G-DSE-B-6-X-TH**

### **(DSE) B2: Solid Waste Management**

**Theory: 50 Lectures**

#### **Unit 1: Solid Waste: (8 Lectures)**

Sources and generation of solid waste; their classification and chemical composition; characterization of municipal solid waste; hazardous waste and biomedical waste.

#### **Unit 2: Effect of solid waste disposal on environment: (8 Lectures)**

Impact of solid waste on environment, human and plant health; water quality and aquatic life; mining waste and land degradation; effect of land fill leachate on soil characteristics and ground water pollution.

#### **Unit 3: Solid waste Management: (12 Lectures)**

Different techniques used in collection, storage, transportation and disposal of solid waste (municipal, hazardous and biomedical waste); landfill (traditional and sanitary landfill design); thermal treatment (pyrolysis and incineration) of waste material; drawbacks in waste management techniques; Concept of Integrated waste management.

#### **Unit 5: Resource Recovery: (10 Lectures)**

4R - reduce, reuse, recycle and recover; biological processing - composting, anaerobic digestion, aerobic treatment; reductive dehalogenation; mechanical biological treatment; green techniques for waste treatment.

#### **Unit 5: Policies for solid waste management: (12 Lectures)**

Municipal Solid Wastes (Management and Handling) Rules 2000; Hazardous Wastes Management and Handling Rules 1989; Bio-Medical Waste (Management and Handling) Rules 1998; Plastic Waste (Management and Handling) Rules, 2011; E-Waste (Management) Rules, 2016.

## **ENV-G-DSE-B-6-X-P**

### **(DSE) B 2 : Solid Waste Management (Practical)**

1. Demonstration of composting techniques including vermicomposting (5)
2. Study of soil microbial activity- Soil respiration (for stability and maturity of compost) (5)

3. Visit to sewage treatment plants/ Visit to waste water treatment plants/ Solid waste management site with field report preparation. (15)
4. Viva-Voce. (5)

## Suggested Readings:

1. Agarwal KM., Sikdar PK., Deb SC. A textbook of Environment. Mc millan India Ltd.
2. Anjaneyulu Y. Introduction to Environmental Science. B.S Publication.
3. Eger E, Smith B. Environmental Science. A Study of Interrelationships. McGraw-Hill Higher Education
4. Chapman, Reiss. Ecology: Principles and Applications. Cambridge University Press.
5. Kormondy EJ. Concept of Ecology. Prentice hall of India.
6. Kumar HD. Modern concepts in Ecology
7. Odum EP. Fundamentals of Ecology
8. Sharma PD. Ecology and Environment. Rastogi Publication.
9. Das MC. Fundamental of Ecology. Tata Mcgraw Hill Publication.
10. Gaston, KJ. & Spicer, J.I. 1998. *Biodiversity: An Introduction*. Blackwell Science, 11. London,
12. UK. Krishnamurthy, K.V. 2004. *An Advanced Text Book of Biodiversity - Principles and Practices*. Oxford and IBH Publications Co. Pvt. Ltd. New Delhi
13. Maiti, Maiti. Biodiversity: Perception, Peril and Preservation. PHI Learning Pvt. Ltd.
14. Banerjee SK. Environmental Chemistry.
15. Dara SS. A text book of Environmental Chemistry and Pollution Control.
16. De AK. Environmental Chemistry. New Age (P) Ltd.
17. Gupta PK. 2004. Methods in Environmental analysis - water, soil and air. Agrobios (India), Jodhpur
18. Jadhav HV. Elements of Environmental Chemistry
19. Moore JW, Moore EA. Environmental Chemistry
20. Peavy HS, Rowe DR. Environmental Engineering. McGraw Hill.
21. Glasson, J., Therivel, R., Chadwick, A. 1994. Introduction to Environmental Impact Assessment. London, Research Press, UK.
22. Judith, P. 1999. Handbook of Environmental Impact Assessment. Blackwell Science.
23. Marriott, B. 1997. Environmental Impact Assessment: A Practical Guide. McGraw-Hill, New York, USA.
24. Naseem, M. 2011. Environmental Law in India Mohammad. Kluwer Law International.
25. Venkat, A. 2011. Environmental Law and Policy. PHI Learning Private Ltd.
26. Rosencranz A, Divan S, Noble ML. 2001. Environmental law and policy in India. Tripathi.
27. Barry, R. G. 2003. Atmosphere, Weather and Climate. Routledge Press, UK.
28. Boeker, E. & Grondelle, R. 2011. Environmental Physics: Sustainable Energy and Climate Change. Wiley.
29. Forinash, K. 2010. Foundation of Environmental Physics. Island Press.
30. Singh, Savindra Climatology, Prayag Pustak Publication.
31. Rittman, B.E. & McCarty, P.L. 2001. Environmental Biotechnology. Principles and Applications. McGraw-Hill, New York.
32. Scagg, A.H. 2005. Environmental Biotechnology. Oxford University Press. World Commission on Environment and Development. Our Common Future. Oxford University Press.
33. Elliott, D. 1997. Sustainable Technology. Energy, Society and Environment (Chapter 3). New York, Routledge Press
34. Shastri M.N.1995, Energy Options : Himalaya Publishing House, New Delhi.
35. Das. NG. Statistical Methods.

36. Hanley N, Jason FS, White B. Environmental Economics in Theory and Practice. 1997. New Delhi. Macmillan - India.
37. Sankar U. (ed.) Environmental Economics. New Delhi. Oxford University Press, 2001.
38. Wayne RO Environmental Statistics and Data Analysis. 1995. CRC Press.
39. Arceivala. Waste water treatment for pollution control. Tata Mc Graw Hill
40. Chatwal, Anand. Instrumental Methods of Analysis.  
Schneid, T.D. & Collins, L. 2001. Disaster Management and Preparedness. Lewis Publishers, New York, NY.
41. Smith, K. 2001. Environmental Hazards: Assessing Risk and Reducing Disaster. Routledge Press.
42. Singh Savindra and Jeetendra, Disaster Management, Pravalika publication, Allahabad.
43. Khopkar. Environmental Pollution Analysis
44. Mastters GM. Introduction to Environmental Engineering & Science. Prentice Hall of India.
45. Rossetti, B.B Prospects and perspective of solid waste management., New age International.
46. Singh, J and Ramanathan, AL 2009. Solid Waste Management: Present and Future Challenges
47. Remote sensing and GIS (2<sup>nd</sup> Edition) Basudev Bhatta, Oxford University Press
48. Sabins, F.F. 1996. Remote Sensing: Principles an Interpretation. W.R. Freeman.