UNIVERSITY OF CALCUTTA

NotificationNo.CSR/18/2023

It is notified for information of all concerned that in terms of the provisions of Section 54 of the Calcutta University Act, 1979, (as amended), and, in exercise of her powers under 9(6) of the said Act, the Vice-Chancellor has, by an order dated 17.07.2023 approved the syllabus of the under mentioned subjects semester wise Four-year (Honours & Honours with Research) /Three-year (Multidisciplinary) programme of U.G. courses of studies, as applicable under CCF,2022, under this University, as laid down in the accompanying pamphlet.

SL.NO.	NAME OF SUBJECTS
1.	ENVIRONMENTAL Science
2.	Physics
3.	French
4.	Sanskrit (Honours)
5.	Arabic
6.	Library & Information Studies
7.	Statistics
8.	Electronics
9.	Household Art (Minor/MDC)
10.	Microbiology (Revised syllabus After incorporating some amendments, in the syllabus Published in CSR/13/23, Dt.12/07/2023)
11.	Psychology (Revised syllabus After incorporating some amendments, in the syllabus Published in CSR/13/23, Dt.12/07/2023)
12.	Hindi (Revised syllabus After incorporating some amendments, in the syllabus Published in CSR/13/23, Dt.12/07/2023)
13.	B.B.A. (Honours syllabus After incorporating some amendments, in the syllabus Published in CSR/13/23, Dt.12/07/2023)

The above shall be effective from the academic session 2023-2024.

24.7.2023

SENATE HOUSE

KOLKATA-700 073

The 24th July, 2023

Prof.(Dr.) Debasis Das

Registrar

The Proposed Structure for B.Sc Environmental Science (3 & 4 years) as per NEP

Semester	Paper	Subject of Paper	Th+Pr	Level of Course
1ST	DSCC 1	Fundamentals of Environment	75 + 25	100
2ND	DSCC 2	Principles of Ecology	75 + 25	
3RD	DSCC 3	Environmental Chemistry	75 + 25	
	DSCC 4	Environmental Physics and Climate science	75 + 25	200
4TH	DSCC 5	Environmental Geosciences	75 + 25	
	DSCC 6	Environmental Pollution	75 + 25	
	DSCC 7	Biodiversity and Conservation	75 + 25	
	DSCC 8	Environmental Microbiology & Biotechnology	75 + 25	
5TH	DSCC 9	Hydrology and Pedology	75 + 25	
	DSCC 10	Energy and Environment	75 + 25	
	DSCC 11	Environmental Legislations and Policy	75 + 25	300
6TH	DSCC 12	Remote Sensing and GIS	75 + 25	
	DSCC 13	Disaster Management	75 + 25	3 years B.Sc
	DSCC 14	Waste Management	75 + 25	
	DSCC 15	Environmental Impact Assessment	75 + 25	
7TH	DSCC 16	Sustainable Development	75 + 25	
	DSCC 17	Environmental Management	75 + 25	
	DSCC 18	Natural Resource Management	75 + 25	400
	DSCC 19	Environmental Documentation and Research Methodology	75 + 25	4 year B.Sc, (Hons.) With or without research
	DSCC 20*	Wildlife and Habitat Management	75 + 25	
8TH	DSCC 21	Environmental Economics	75 + 25	
	DSCC 22	Environmental Health and Toxicology	75 + 25	
	DSCC 23	Statistics & Environmental Modelling	75 + 25	
	DSCC 24*	Industrial Health & Safety	75 + 25	
	DSCC 25*	Instrumentation: Environmental Application	75 + 25	
1ST	SEC 1	Environment and Society	100	
2ND	SEC 2**	Urban Environment Management	100	
3RD	SEC 3	Green Technology	100	

* Those who will not qualify or opt for B.SC (Hons. with Research) will have to go for these papers.

** **SEC 2** will be optional paper.

The first 8 courses (DSC/CC 1 to DSC/CC 8) will be offered as **Minor** courses.

The nomenclature of courses will be in accordance with the University Regulations.

DISCIPLINE SPECIFIC CORE COURSE 1

Fundamentals of Environment (Theory 75 + Practical 25)

[50 Lectures Theory]

Unit-1: Basic concepts of Environmental Science: **(10 Lectures)**
Concept of environment and its components – physical components (Lithosphere, Hydrosphere and Atmosphere), socioeconomic and cultural component; Principle and scope of Environmental science; Multidisciplinary approach of Environmental science; Basic concept of sustainable development goals & Mission LIFE.

Unit-2: Climatic zones: **(5 Lectures)**
Equatorial, Tropical, Sub-Tropical, Temperate, Tundra.-Position and characteristics of the climatic zones.

Unit-3: Living matter and approach to evolutionary biology **(25 Lectures)**
Living matter on the basis of cell- Cytological study as unit of life, ultrastructure and functions of cytoplasmic and nucleoplasmic organelles like plasma membrane, mitochondria, golgi bodies, endoplasmic reticulum, ribosome, lysosome and nucleus.

Biochemical and molecular basis of origin of life, Theories of organic evolution: Lamarckism, Darwinism, and mutation theory. Concept of Neo-darwinism, Isolating mechanism and speciation, Hardy Weinberg Equilibrium and Genetic drift.

Unit-4: Global Environmental Issues **(10 Lectures)**
Concept of Deforestation, Basic concept of urban & industrial pollution, concept of Ecological footprints and carrying capacity, Climate change, Ozone layer depletion, Loss of biodiversity.

PRACTICAL:

1. Assignment on global environmental issues. (15)
2. Viva-voce (10)

DISCIPLINE SPECIFIC CORE COURSE 2

Principles of Ecology (Theory 75 + Practical 25)

[50 Lectures Theory]

Unit1: Introduction to Ecology (12 lectures)

Basic concepts and definitions: ecology, autecology; synecology; landscape, habitat and niche, ecozones, biosphere, ecosystems, ecosystem stability, resistance and resilience; major terrestrial biomes. Ecological amplitude; Liebig's Law of Minimum; Shelford's Law of Tolerance; phenotypic plasticity; ecotypes; ecoclines; acclimation; 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, natality, mortality, life tables, survivorship curves, age structure; population growth form: exponential, logistic; r- and k-selection; dispersion, distribution, fluctuation, interaction and regulation. Concept of metapopulation;

Unit 3: Community Ecology (8 lectures)

Concept of major and minor community; approach of community study: zonal and gradient. Species diversity, discrete versus continuum community view; community structure and organization: physiognomy, sociability, species associations, periodicity, biomass, stability, keystone species, ecotone and edge effect; ecological succession: primary and secondary successions, models and types of successions, concept of climax, examples of succession, Models of succession: competitive and stress-tolerance strategies.

Unit 4: Ecosystem ecology (15 lectures)

Ecosystem- Definition, 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; impacts of invasion on ecosystem and communities.

Unit 5: Biogeochemical cycles and nutrient cycling (7 lectures)

Carbon cycle; oxygen cycle; nitrogen cycle; phosphorus cycle; sulphur 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.

PRACTICAL:

1. Local Field study on ecosystem with report submission. (15)
2. Viva-voce (10)

DISCIPLINE SPECIFIC CORE COURSE 3

Environmental Chemistry (Theory 75 + Practical 25)

[50 Lectures Theory]

Unit 1: 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.

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.

Unit 3: Atmospheric chemistry (7 lectures)

Photochemical reactions in atmosphere; smog formation, types of smog (sulphur smog and photochemical smog), Chemistry of particulate matters, aerosols; chemistry of acid rain, chemistry of NOx and SOx ; free radicals and ozone layer depletion, role of CFCs in ozone depletion.

Unit 4: Water chemistry (8 lectures)

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

Unit 5: Soil chemistry (8 lectures)

Soil composition; inorganic and organic components in soil; soil colloids; cation and anion exchange reactions in soil; nitrogen, phosphorus and potassium in soil.

Unit 6: Green chemistry (12 lectures)

Introduction to green chemistry, Principles of Green Chemistry, the concept of atom economy and chemical synthesis, Important techniques used in green chemistry. Application of green chemistry, viz. replacement of ozone depleting substances including CFCs, manufacture of biodegradable polymers, use of H_2O_2 as benign bleaching agents in paper industry.

PRACTICAL:

Water and Soil analysis: pH, Electrical conductivity, Total Hardness of water, Total Alkalinity of water, Dissolved Oxygen, Chloride of water.

Soil pH, Electrical conductivity of soil extract (ECe). (15)

Laboratory Note book (5)

Viva voce (5)

DISCIPLINE SPECIFIC CORE COURSE 4

Environmental Physics and Climate Science (Theory 75 + Practical 25)

[50 Lectures Theory]

Unit 1: Fundamentals of environmental physics (20 lectures)

Part A: Basic concepts of light and matter; spectroscopic concepts: Introduction to the concept of absorption and emission spectrum and transmission of light, Beer-Lambert law; scattering of light, Rayleigh and Mia scattering.

Part B: Concept of system, Basic concepts of pressure, force, work and energy; Laws of thermodynamics; Concept of enthalpy, entropy, Free energy. Heat transfer - conduction, convection and radiation, Concept of black body and Planck's constant. Carnot engine and its application in simple engine. Energy efficiency. Gas laws: Charles' law, Boyle's law, Avogadro's law.

Unit 2: Basic atmospheric physics (15 lectures)

Concept of Albedo, solar constant, Heat budget of the earth atmospheric system. Types of forces and their relation (pressure gradient, viscous, Coriolis, gravitational, centripetal, and centrifugal force); lapse rate (dry and moist adiabatic); Radiation Inversion ad subsidence inversion, concept of mixing depth, concept of pollutant dispersal, Point source Gaussian plume model.

Unit 3: Climate Sciences (15 lectures)

Concept of Weather and Climate. Introduction to climate parameters: temperature, humidity: absolute, relative and specific humidity, dew point, atmospheric pressure. Climatological normal.

Earths conveyor belt. Ocean circulation, Ocean – atmosphere interactions. Generation and morphology of cyclone and anticyclonic systems. El Nino – ENSO, La Nina. Indian monsoon. Climate classification: Thornthwaite classification and Köppen's classification

PRACTICAL:

Recording of Atmospheric temperature, Atmospheric pressure, Relative Humidity, Wind speed, Rainfall. (10)

Laboratory Note book (5)

Viva voce (10)

DISCIPLINE SPECIFIC CORE COURSE 5

Environmental Geosciences (Theory 75 + Practical 25)

[50 Lectures Theory]

Unit 1: History of Earth (5 lectures)

Formation and evolution of the Earth, geological time scale and major changes on the Earth's surface. Big impact hypothesis, Oxygen catastrophe, snowball earth, Wilsons cycle.

Unit 2: Earth system processes (12 lectures)

Movement of lithosphere plates; mantle convection and plate tectonics, major plates and hotspots, plate boundaries; sea floor spread; earthquakes; volcanic activities; continental drift theory, Evidences of continental drift theory and plate tectonics. Orogeny: formation of Himalayas; Isostasy; Gravitational and magnetic fields of the earth;

Geological processes: Fluvial, glacial and aeolian processes, Weathering: physical, biogeochemical processes; erosion: physical processes of erosion, factors affecting erosion;

Landforms created by Glacial, riverine and aeolian processes. Coastal processes and associated landforms. Earth's rotation and Atmospheric circulation; Interfaces: atmosphere-ocean interface, atmosphere-land interface, ocean-land interface.

Unit 3: Rocks, weathering and minerals (10 lectures)

Introduction to different major rock types, Rock cycle: lithification and metamorphism; Three rock laws; Minerals: general structures & properties, Broad classification on the basic of mineral composition and rock forming and ore forming minerals.

Unit 4: Geomorphology & Mapping (12 lectures)

The general concept on geomorphology: Plains, plateau, slopes, hills. Concept of faults and folds: syncline & anticlines. Drainage patterns.

Concept of map: Scale of map, concept of projection system (Azimuthal & UTM), fundamental idea on topographical sheet and interpretation.

Unit 5: Geology of India (11 lectures)

Stratigraphy of India: The Archaean formation, Dharwar system, Cuddapah system, Vindhyan system.

Physiography of India: Himalayan region, Great plains of India, Peninsular India, Indian desert, Coastal plains, Indian Islands.

PRACTICAL:

1. Identification of rocks & minerals (Hand Specimen)	9
2. Topological sheet interpretation.	8
3. Laboratory notebook and Viva Voce	8

DISCIPLINE SPECIFIC CORE COURSE 6

Environmental Pollution (Theory 75 + Practical 25)

[50 Lectures Theory]

Unit 1: Concept of Pollutants and Environmental Pollution (5 lectures)

Definition of pollution; pollutants; source and type of pollutants: point source, line source, area source, classification of pollutants. Solubility of pollutants (hydrophilic and lipophilic pollutants), transfer of pollutants within different mediums, local, regional and global implications of Environmental pollution.

Unit 2: Air pollution (14 lectures)

Sources and types of pollutants- Natural and anthropogenic sources, primary and secondary pollutants. Sampling and monitoring of air pollutants (gaseous and particulates); period, frequency and duration of sampling. PAN, photochemical smog, acid rain. Effects of different pollutants on human health (NOx, SOx, PM, CO, CO_2, hydrocarbons and VOCs) and control measures; indoor air pollution: sources and effects on human health. Vehicular air pollution and urban air quality. Control devices for particulate matter: Principle and working of: settling chamber, centrifugal collectors, wet collectors, fabric filters and electrostatic precipitator. Control of gaseous air pollutants through adsorption, absorption, condensation and combustion including catalytic combustion. Socio-political perspectives of air pollution and health. Air quality criteria and standards, Ambient air quality: monitoring and standards (National Ambient Air Quality Standards of India); MINAS, air quality index. Case study: implementation of CNG in NCT of Delhi.

Unit 3: Water pollution (15 lectures)

Sources of surface and ground water pollution; water quality parameters and standards; organic waste and water pollution; Concept of water quality parameters: pH, EC, turbidity, TDS, ions responsible for hardness of water, chlorides, salinity, DO, BOD, COD, nitrates, phosphates, sulphates, heavy metals and organic contaminants. Microbiological analysis – MPN. Drinking water standards: Indian standards, effect of water contaminants on human health (nitrate, fluoride, arsenic, chlorine, cadmium, mercury, pesticides); eutrophication; concept and working of effluent treatment plants (ETPs).Drinking water treatment: Coagulation and flocculation, Sedimentation and Filtration, Disinfection and Softening. 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. Case study: Ganga Action Plan; Yamuna Action Plan.

Unit 4: Soil pollution (3 lectures)

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

Unit 5: Noise pollution (5 lectures)

Noise pollution-sources; frequency, intensity and permissible ambient noise levels; measurement of noise indices (L_{eq}, L_{10}, L_{90}, L_{50}, L_{DN}, TNI) effect on communication, impacts on life forms and humans - working efficiency, physical and mental health; Noise abatement strategies.

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); radiation standards, radiation protection.

Thermal Pollution- Sources of Thermal Pollution, Heat Islands, causes and effects of thermal pollution.

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; Methods of Abatement of Marine Pollution; coastal area management.

PRACTICAL:

1. Analysis of BOD, COD, Noise (dB(A), SPM, RSPM (Demonstration), Dust fall rate, Soil respiration. (15)
2. Viva Voce (5),
3. Laboratory notebook (5)

DISCIPLINE SPECIFIC CORE COURSE 7

Biodiversity and Conservation (Theory 75 + Practical 25)

[50 Lectures Theory]

Unit 1: Biodiversity patterns and estimation (15 lectures)

Definition of Biodiversity, Types: Genetic diversity, Species diversity, Ecosystem Diversity. Biodiversity estimates: alpha diversity, beta diversity & gamma diversity. Biodiversity assessment and indices: frequency, density, abundance, relative abundance, Shannon Weiner Index, Simpson's index, Simpsons Index of diversity, Evenness index. Concept of Guild, Keystone and Flagship species.

Spatial patterns of biodiversity across latitudinal and altitudinal changes. Metapopulation, Mid domain hypothesis. Intermediate Disturbance Hypothesis.

Unit 2: Importance of biodiversity (8 lectures)

Ecological services – primary productivity. Roles of biota in hydrological cycle, biogeochemical cycling.

Ecosystem services - purification of water and air, climate control, pest control, pollination, and formation and protection of soil.

Other values: social, aesthetic, consumptive, and ethical values of biodiversity.

Biodiversity valuation – NTFPs/NWFPs, Market and Nonmarket values, Tangible and non-tangible values, use and non-use values. Option value, Existence value, Bequest value.

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; developmental projects; invasive species; land use changes; overgrazing; man wildlife conflicts; consequences of biodiversity loss; Mass Extinction events.

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), captive breeding.

Role of IUCN in global biodiversity conservation, IUCN Red List categorization - guidelines, practice and application; Red Data book; Concept of Scheduled species as per Wildlife (Protection) Act, 1972 in India.

Scopes of Biodiversity Act, 2002 in conservation. PBR, Role of local communities and traditional knowledge in conservation; afforestation; social forestry; agroforestry; joint forest management; Ecological Restoration.

Unit 5: Biodiversity in India (7 lectures)

India as a mega diversity nation; Biodiversity Hotspot criteria and Hotspots in Indian subcontinent. Phytogeographic and zoogeographic zones of the country; forest types and forest cover in India; National Biodiversity Action Plan, 2015.

PRACTICAL:

1. Estimation of Biodiversity parameters and indices: Frequency, Density, abundance, Relative abundance, Shannon Weiner's index, Simpson's index of diversity. (5)

2. Field work in any geographical region, viz. Forest, Hills, Coasts, Mangroves and Wetlands (Calculation of parameters Frequency, density, abundance, relative abundance and indices like Shannon wiener diversity index, Simpson's index, Simpson's index of diversity, evenness index) and report submission. (15).

3. Viva voce (5).

DISCIPLINE SPECIFIC CORE COURSE 8

Environmental Microbiology & Biotechnology (Theory 75 + Practical 25)

[50 Lectures Theory]

Unit 1: Basic Concepts of Microbiology (5 lectures)

Classification of microorganisms, different factors for microbial growth, staining techniques in microbiology (Simple staining, Negative staining, Gram staining, capsule staining)

Unit-2: Microbiology of Air, Water and Soil (10 lectures)

Microbiology of Air: Factors affecting the survival of microorganisms in air; Sources of microorganisms; Air-borne pathogens and its role on public health; Sampling techniques for microbiological air quality**.**

Microbiology of Water: Common microorganisms encountered in freshwater sources; Self-purification of water; Common sources of microbial pollution in water; Assessment of microbiological quality of water; Characteristics of pollution indicator microorganisms; Selection and quantification of indicator organism in freshwater.

Microbiology of Soil: Beneficial and pathogenic microbes in agriculture; Soil as a microbial growth medium; Characteristics of soil microenvironment for microbes; Interaction of microorganisms and plant in soil; Role of microorganism in maintaining the soil fertility.

Unit-3: Concept of Biotechnology (10 lectures)

Central dogma of life: basic structure of DNA and RNA, concept of genetic materials, gene functions, concept of Replication, Transcription and Translation in prokaryotes. Concept of chromosome: numerical and structural aberrations.

Unit 4: Biotechnological Applications (8 lectures)

Recombinant DNA: Basic concepts. 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. Application of Southern, Western and Northern blot. Basics of PCR, RAPD, RFLP.

Unit 5: Biotechnology of wastewater and solid waste treatment (10 lectures)

Wastewater treatment: anaerobic, aerobic process, 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 6: Safe products and processes (5 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 7: GMOs and LMOs (2 lectures)

Concept of GMOs and LMOs, case studies, biosafety protocol

PRACTICAL:

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

DISCIPLINE SPECIFIC CORE COURSE 9

Hydrology and Pedology (Theory 75 + Practical 25)

[50 Lectures Theory]

Unit 1: Water resource (13 lectures)

Sources and types of water; Hydrological cycle; Introduction to surface and ground water; water table; vertical distribution of water; formation and properties of aquifers; hydraulic potential, Darcy's equation, techniques for ground water recharge, infiltration, evaporation.

Unit 2: Wetlands and watershed management (10 lectures)

Definition of a wetland; types of wetlands (fresh water and marine); ecological and hydrological functions of wetlands; aquatic organisms of wetlands. Threats to wetlands; wetland conservation and management; Ramsar Convention, 1971; major wetlands of India. Watershed and drainage basins; importance of watershed and watershed management, Role of state in water resources management. Environmental issues relating to damming on water.

Unit 3: Water resource in India (4 lectures)

Demand for water (agriculture, industrial, domestic); overuse and depletion of surface and ground water resources.

Unit 4: 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; soil biodiversity.

Soil resistance and resilience, 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.

Unit 5: Introduction to Land Resource (5 lectures)

Land as a resource, ecological and economic importance of land; 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 6: Soil erosion and Land degradation and its' management (8 lectures)

Type and causes of soil erosion; 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, 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.

Different techniques of soil conservation (mechanical and biological) Sustainable land use planning; land tenure and land policy; Participatory land management.

PRACTICAL:

Water and Soil analysis: Total Dissolved Solids. Total Suspended Solids, Calcium and Magnesium Hardness, Salinity (By chemical method).

Organic Carbon of soil. Carbonate & Bicarbonate of soil, Water Holding capacity (15)

Laboratory Note book (5)

Viva voce (5)

DISCIPLINE SPECIFIC CORE COURSE 10

Energy and Environment (Theory 75 + Practical 25)

[50 Lectures Theory]

Unit 1: Energy resources (12 lectures)

Energy: forms and importance; Global energy resources; renewable and non-renewable resources; conventional and non-conventional energy resources; Fossil fuels: classification, composition, physico-chemical characteristics and energy content of coal, petroleum and natural gas; distribution and availability of energy resources; 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 security, energy subsidies; environmental costs.

Unit 3: Energy, environment and society (11 lectures)

Energy production as driver of environmental change; nature, scope and analysis of local and global impacts of energy use on the environment; 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: Future aspects of energy use and energy conservation (20 lectures)

Current and future energy use patterns in the world and in India; evolution of energy use over time; alternative sources as energy – Principle and generation of solar energy (solar collectors, photo-voltaic modules, solar ponds), wind energy, geothermal energy; tidal energy, OTEC; nuclear energy, energy from biomass, biofuels; need for energy efficiency; energy conservation and sustainability; action strategies for sustainable energy management from a future perspective.

PRACTICAL:

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 (5)

DISCIPLINE SPECIFIC CORE COURSE 11

Environmental Legislation and Policy (Theory 75 + Practical 25)

[50 Lectures Theory]

Unit 1: Introduction (5 lectures)
Introduction to Policy and and Rules. Constitution of India; fundamental rights; fundamental duties; Union of India; union list, state list, concurrent list.

Unit 2: Evolution of environmental legislation and policy (10 lectures)
Provision of Environmental Conservation - British India: Indian Penal Code 1860, Independent India: Van Mahotsava 1950, National Forest Policy 1952, National Forest Policy 1988.; National Water Policy, 2002; National Environment Policy, 2006.

Unit 3: Environmental legislation in India (25 lectures)
Constitutional provision for environmental protection: Article 48A (The protection and improvement of environment and safeguarding of forests and wildlife); Article 51A(g) (Fundamental duties). Policy Statement on environment and development, PIL and public hearing.

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 and Rules 1986; Motor Vehicle Act 1988; The Public Liability Insurance Act 1991; The National Environment Appellate Authority Act,1997; 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, Coastal Regulation Zones (CRZ) 1991 amended from time to time.

Unit 5: International laws and policy (10 lectures)
Ramsar convention (1971); Stockholm Conference 1972; United Nations Conference on Environment and Development 1992; Rio de Janeiro (Rio Declaration, Agenda 21, Convention on Biodiversity); Montreal Protocol 1987; Basel Convention (1989, 1992); UNFCCC, Kyoto Protocol, 1997, Clean Development Mechanism (CDM); Copenhagen and Paris summits; World Summit at Johannesburg, 2002, IPCC, UNEP, IGBP

PRACTICAL:

1. Review of Law Case studies on Environmental Issues and power point presentation. (25)

DISCIPLINE SCEFICIC CORE COURSE 12

Remote Sensing and GIS (Theory 75 + Practical 25)

[50 Lectures Theory]

Unit 1: Science of Remote Sensing (8 lectures)

Remote Sensing: definitions and principles; Active and Passive remote sensing. Electromagnetic (EME) spectrum, Properties of UV, Visible, Infra Red, Thermal and Microwave ranges, Interaction of EMR with Earth's surface; Atmospheric windows, Principles of Radar and Laser and Lidar.

Unit 2: Techniques of Remote Sensing (15 lectures)

Platforms: Satellite remote sensing, Polar orbital and Geostationary satellites, Aerial photography platforms. Landsat and Indian satellites : IRS -1A/1B/1C/1D, Resourcesat, Cartosat series 1,2& 3.

Sensors: Concept of Resolution : Spatial, Spectral, Radiometric, Temporal. Type of sensors. Sensors used in Indian satellites. Different sensors like LISS, WiFS. TM.

Image acquisition & interpretation: Concept of Georeferencing, Spectral signatures and attributes: colour, shape, size, shadow, association etc. Concept on False colour composite (FCC). Ground truthing. Supervised and unsupervised classification and mapping.

Unit 3: Global Positioning System (4 lectures)

The fundamentals of GPS. GPS satellite networks, Differential GPS.

Unit 4: Geographical Information Systems (13 lectures)

Definitions and components; spatial and non-spatial data; raster and vector data; Thematic mapping, idea of overlay, database generation; database management system; Overview of GIS software packages, Fundamentals of Arc GIS and QGIS.

Unit 5: Application of Remote Sensing and GIS (10 lectures)

Fundamentals of vegetation indices: NDVI, LAI, SVI, Application of remote sensing and GIS in management of water resources and forest resources, land use planning & agriculture, marine and atmospheric studies, disaster management, Wildlife management and urban planning and management.

PRACTICAL:

Fundamentals of QGIS : Georeferencing, image interpretation, Supervised & unsupervised classification, digitization, preparation of simple thematic maps. (5)

Preparation of a GIS project in groups. (10)

Viva Voce: (10)

DISCIPLINE SPECIFIC CORE COURSE 13

Disaster Management (Theory 75 + Practical 25)

[50 Lectures Theory]

Unit 1: Introduction (5 lectures)

Definition of hazard; Differences among hazard and disaster. Concept of risk and vulnerability; Reasons of vulnerability - rapid population growth, urban expansion, environmental pollution, epidemics, industrial accidents, inadequacy in infrastructural supports, government policies.

Unit 2: Natural hazards (12 lectures)

Natural hazards: hydrological, atmospheric & geological hazards; Earthquake: seismic waves, Epicentre & Hypocentre, Volcanoes: types, causes of volcanism, geographic distribution; Floods: types and nature, reasons, frequency of flooding; Drought: types of drought-meteorological, agricultural, hydrological, and famine; Landslides: Morphology of landslide, Causes and types of landslides, Landslide analysis, Glacial Lake Outburst Floods (GLOF); Tornadoes, cyclone & hurricanes; Tsunamis: causes and location of tsunamis; Slow onset hazards: Coastal erosion, sea level changes and its impact on coastal areas and coastal zone management. Epidemics & Pandemics: causes and reasons of spread. Case studies of Bhuj Earth quake, Indian Ocean tsunami, 2004, COVID-19.

Unit 3: Anthropogenic or human induced hazards (10 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 (5 lectures)

Two components of risk: likelihood and consequences, qualitative likelihood measurement; Categories of consequences (direct losses, indirect losses, tangible losses, and intangible losses); Application of geoinformatics in risk assessment and disaster management.

Unit 5: Disaster Management & Mitigation (12 lectures)

Disaster Management cycle. Change in Concept of Disaster management to Disaster Risk Reduction. 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. Community Based Disaster Management.
Management of Earthquake, Landslide, Volcanism, Tsunami, GLOF, Flood, Cyclone, Wildfire and Fire disasters. Emergency preparedness planning for Industrial Accidents.

Post disaster issues: Physical rehabilitation, Social rehabilitation, Economic restructuring, Psychological distress, Crimes. Case studies: Uttarakhand Flash flood, Built it better: from Supercyclone 1999 to Phailin in 2013, Built it better: from Aila 2009 to Amphan, 2020.

Unit 6: National and International perspective of Disaster management (6 lectures) International Efforts for disaster management. Hyogo framework, Sendai Framework 2015 – 2030. 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; Disaster Management Act, 2005.

PRACTICAL:

1. Preparation of disaster management plan and its presentation. 20
2. Viva voce 5

DISCIPLINE SPECIFIC CORE COURSE 14

Waste Management (Theory 75 + Practical 25)

[50 Lectures Theory]

Unit-1: Basic concept of waste management: (2 lectures)
Defining waste, Classification of wastes, Concept of waste management; Waste minimization technologies.

Unit-2: Solid waste management (15 lectures)
Sources and generation of solid waste, their classification and chemical composition; characterization of municipal solid waste; hazardous waste and biomedical waste.

Municipal solid waste management: composition; segregation of MSW, onsite disposal; open dumps; sanitary landfills; environmental consequences.

Bio-medical waste management: generation; segregation; colour codes; disposal and treatments; Health consequences. Biomedical waste management in India.

E-waste management: generation; segregation; disposal and treatments; Environmental impacts.

Hazardous waste management: Definition, identification and classification of hazardous waste; Waste Minimization; Waste Exchange; Recycling. Treatment Technologies: Biological, Chemical; Physico-Chemical Treatment: Incineration, Stabilization, Solidification; Disposal Of Hazardous Waste.

Unit 3: 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 4: Resource Recovery (6 lectures)
5R - reduce, reuse, recycle, recovery and residual management; biological processing - composting, anaerobic digestion, aerobic treatment; reductive dehalogenation; mechanical biological treatment; green techniques for waste treatment.

Unit 5: Waste-to-Wealth and concept of Circular economy (7 lectures)
Concept of energy recovery from waste; refuse derived fuel (RDF); different WTE processes: combustion, pyrolysis, landfill gas (LFG) recovery; anaerobic digestion; gasification. Value added products from waste; Fly ash utilization and disposal Garbage farming; Sewage fed fisheries; Composting.

Unit 6: Integrated waste management **(4 lectures)**

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

Unit 7: Policies for solid waste management **(10 lectures)**

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

PRACTICAL:

1. Visit to a Waste Management site and Report submission. (15)
2. Viva-voce (10)

DISCIPLINE SPECIFIC CORE COURSE 15

Environmental Impact Assessment (Theory 75 + Practical 25)

[50 Lectures Theory]

Unit 1: Introduction to Environmental Impact assessment (EIA) (10 lectures):
Definitions, Introduction and concepts of Environmental Impact assessment; Rationale and historical development of EIA; Environmental impact assessment in international level: the scopes laid out by funding agencies. Genesis and development of the concept in India.
Types of EIA: Rapid EIA, Comprehensive EIA, Strategic EIA. Social Impact assessment, Marine Impact assessment.

Unit 2: EIA in Practice (18 lectures):
General methodologies of EIA; synchronisation of EIA with project cycle.
Steps of EIA as per EIA Notification, 2006: Screening, Scoping, DPR & Terms of Reference; baseline data collection/generation, Impact identification and prediction methodologies – checklist, network, overlay, Leopold matrix; BEES; Public consultation, Environmental Impact Statement (EIS). Expected outcomes of EIA after appraisal.

Unit 3: Environmental Management Plan (6 Lectures):
Principle and components of EMP. Synchronisation of EMP with the project cycle, Importance of EMP.

Unit 4: EIA regulations in India (16 lectures)
EIA Notification 2006, 2009: scopes and structures, formation and roles of SEIAA, EAC, SEAC. current issues in EIA: Fundamentals of the latest EIA notification (Draft) 2020; Case study of hydropower projects, Thermal power projects, Mining projects, Building project.

PRACTICAL:

1. Preparation of a preliminary environmental impact assessment report using Leopold matrix from given baseline data of any original project or hypothetical project and its presentation. 20
2. Viva Voce. 5

DISCIPLINE SPECIFIC CORE COURSE 16

Sustainable Development (Theory 75 + Practical 25)

Unit 1: Fundamentals of Sustainable Development (6 Lectures)

The conflicts between Environment and development. The definition and genesis of the term Sustainable Development. Brudtlands' Commission Report. The need for sustainable development. The role of World Commission on Environment and Development in conceiving the concept of sustainable development.

Unit 2: The Sustainability Science (10 Lectures)

Concept of sustainability. Introduction to deep ecology shallow ecology. Development and conflicts among weak and strong sustainability concepts. Development of concept of carrying capacity of the earth and ecological footprints. Sustainability Index.

Unit 3: Global efforts for Sustainable development (20 Lectures)

Rio Summit and sustainable development. 27 Principles of sustainable development. Role of International Chamber of Commerce (ICC) in promotion of sustainable development. Business Charter. Role of UNDP, UNFAO, UNHCR, WMF, AWB in promotion of sustainable development. The evolution through decades: Millennium Ecosystem Assessment, Millennium Development Goals (2000 -2015) and Sustainable Development Goals (2016 -2030).

Unit 4: Sustainable Urban Development (7 Lectures)

The problems of urban area: urban sprawls, slums, urban heat islands. Sustainable urban planning. Urban resource management, urban waste disposal and ways of recycling.

Unit 5: Sustainable Agriculture (7 Lectures)

Concept of sustainable agriculture. Green revolution and its environmental impacts. Concept of Green farming. Drip irrigation, No tillage agriculture, Integrated Pest Management.

PRACTICAL:

1. Poster or Model presentation on any aspect of sustainable development. 10
2. Preparation of an Urban survey report on any aspect of sustainable development. 10
3. Viva Voce 5

DISCIPLINE SPECIFIC CORE COURSE 17

Environmental Management (Theory 75 + Practical 25)

[50 Lectures Theory]

Unit 1: Strategies of Environmental Management (8 Lectures):
The strategies of reducing resource consumption and environmental damages: alternative technologies, cleaner fuel, by-product recovery, waste to wealth concept, end of pipe treatments. Corporate strategy and the environment.

Unit 2: Environmental Management System (12 Lectures):
Definition and structure of environmental management system (EMS). Deming cycle of management. Functions of management. Importance of management system in achieving environmental goals. Certification of Environmental Management system: ISO 14000 Series: The genesis, steps, internal audit, external audit and certification procedure step by step. Profit maximisation through of certification.

Unit 3: Tools of environmental management (12 Lectures):
Environmental Audit: Objectives, types of environmental audit, importance of audit, Steps of audit. Life cycle assessment: Definition, importance and procedure. Ecolabelling and Ecomark. Environmental Risk assessment. Hazop study. Emergency preparedness.

Unit 4: Corporate framework of environmental management (18 Lectures):
Carbon credit methodology (Verra, GCE), Plastic credit methodology, GHG emissions quantification methods. ESG framework: the concept, criteria and areas of application. Corporate Social Responsibility (CSR), Corporate Environment Responsibility (CER) and environmental protection, Extended Producers Responsibility (EPR). Case studies of zero waste organisation, carbon neutral organisation, water neutral organisation. Roles of chambers of commerce.

PRACTICAL:

1. Preparation of an Environmental Management Plan on the basis of given scenario. (10)
2. Review of a CSR case study and report submission. (10)
3. Viva voce (5)

DISCIPLINE SPECIFIC CORE COURSE 18

Natural Resource Management (Theory 75 + Practical 25)

[50 Lectures Theory]

Unit 1: Introduction (10 Lectures)

Resource and reserves; classification of natural resources; renewable and non-renewable resources; resource degradation; resource conservation; resource availability and factors influencing its availability; human impact on natural resources.

Unit 2: Natural resources and conservation (10 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 (10 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; ocean mining for mineral resources; environmental effects of extracting and using mineral resources.

Unit 4: Marine Resource (10 Lectures)

Physical marine resources: Polymetallic nodules, Gas hydrates, Salt extraction. Biological Marine resources: Coral reef, Mangroves, Sea grass beds. Environmental impacts of marine resource extraction.

Unit 5: Resource management (10 Lectures)

Approaches in resource management: ecological approach; economic approach; ethnological approach; implications of the approaches; integrated resource management strategies.

PRACTICAL:

Project on any environmental or natural resource related issues, submission and presentation. (20)

Viva voce (5)

DISCIPLINE SPECIFIC CORE COURSE 19

Environmental Documentation and Research Methodology (Theory 75 + Practical 25)

[50 Lectures Theory]

Unit 1: Basics of documentation (14 Lectures)

Definition and types of documentation: database and graphical documentation, audio-visual documentation, editing, voice communication, social media, blog, vlog, podcast, reels; ethical considerations in doing documentation, documentation and plagiarism, biblio -management. Role of social media in environmental protection.

Unit 2: Environmental documentation (10 Lectures)

Application of environmental documentation, Environmental databases, environmental compliances, report writing, IFC and World bank performance standard and capturing those in ESIA report. Concept and components of grant writing.

Unit 3: Introduction to research methodology (8 Lectures)

Concept of research, Objectives of Research, Significance of Research. Data-Information-Knowledge – Wisdom (DIKW) system of information processing. Basic research techniques, framing research hypothesis, Computer applications in research.

Unit 4: Environmental research methodology (18 Lectures)

Concept of secondary and primary data sources. Spatial and non-spatial data. Environmental sampling: sampling designs, sampling types, representative samples – its characteristics. Sampling errors, calibration. Concept of control, blank and standards. Concept of detection limits. Quality of data: accuracy, precision, testing hypothesis and Type I, Type II errors.

Environmental sampling techniques - air, water, soil, noise, aquatic and soil biota. Sample handling, transportation and preservation.

PRACTICAL/ASSIGNMENT:

1. Preparation of an audio-visual document related to any one environmental issues. (10)
2. Environmental grant writing. (10)
3. Viva voce (5)

DISCIPLINE SPECIFIC CORE COURSE 20

Wildlife and Habitat Management (Theory 75 + Practical 25)

[50 Lectures Theory]

Unit-1: Wildlife and Forest: (2 lectures)

Values of wildlife: Ecological, Economic, Cultural, Aesthetic, Scientific, Recreational and Medicinal. Importance of Forests, Forest types in India

Unit-2: Biogeography (8 lectures)

Ecology of dispersal and faunal exchange, barriers, mode of dispersal; island biogeography theory; dispersal and vicariance biogeography; Applied Biogeography; biogeographical realms, provinces and ecoregions; India's biogeographic classification and Protected Area network. Terrestrial Biomes, Ecoregions, Biogeographic zones and provinces of India.

Unit-3: Habitat Ecology (8 lectures)

Introduction to Habitat Ecology - Historical, ecological & evolutionary perspectives of Habitat Ecology. Inventory, evaluation and monitoring of wildlife habitat - Measuring wildlife habitat, availability, quality. Animals signs as indicators of habitat. Feral population, Monitoring changes in habitat parameters, use and availability of habitat resources.

Unit 4: Wildlife Population estimation (10 lectures)

Sampling designs for population estimation, population estimation methods: Distance based Sampling Methods, Mark-Recapture for Closed Population, Indices, and Estimation of Demographic parameters. Monitoring population and other demographic parameters, Predator-Prey Dynamics, Mark-Recapture models. Capture and handling techniques, Identification and marking techniques, camera trap, scat analysis, radio telemetry.

Unit 5: Wildlife conservation (10 lectures)

Prehistoric association between wildlife and humans in India: records from Bhimbetka wall paintings; conservation of wildlife in the reign of king Ashoka: excerpts from rock edicts. Concept of modern conservation with special reference to forest and wildlife management, Protected Area Network including Marine Protected Area, conservation verses preservation; concept of stakeholders in wildlife conservation. International conservation bodies; IUCN UNDP, FAO, WWF. Legal Provisions for Wildlife conservation practices in India; Species conservation projects in India (Tiger, Rhino, Elephant, Crocodile); Species Reintroduction (Cheetah); Role of scientific institution and NGOs in Conservation; Conservation outside protected areas. Significance of ecological restoration in conservation. Marine conservation Issues; Coral Bleaching, Regulating whaling, shark finning.

Unit 6: Wildlife and Forest Management (12 lectures)

Introduction to forestry, principles of forest management, forest and wildlife as natural resources Understanding wildlife management, Principles and practices of wildlife management, Course and fine filter approaches for wildlife Management; wildlife management plans. Need for wildlife management planning. Analysis of wildlife management problems. Park-people interface conflict and objectives of human dimensions in management; Eco-development what, why, where; Community participation; Wildlife adoption; Human-wildlife Conflict and management (Elephant, Tiger, Leopard); Wildlife Forensics- Overview; Wildlife crime in India case studies

PRACTICAL:

1. Field study to *in-situ/ex-situ* conservation site and report submission (15)
2. Viva-voce (10)

DISCIPLINE SPECIFIC CORE COURSE 21

Environmental Economics (Theory 75 + Practical 25)

[50 Lectures Theory]

Unit 1: Fundamentals of environmental economics (12 lectures)
Genesis and scopes of Environmental Economics, Concept of Production cost, Social cost, marginal cost and benefit. Social costs and benefits of environmental programmes: marginal social benefit of abatement, marginal social cost of abatement. consumers behaviour: Demand and Supply curve, law of diminishing returns.

Unit 2: Tools for environmental economic policy (20 lectures):
Growth and environment; Kuznets curve, environmental risk analysis, assessing benefits and cost for environmental decision making; discounting, principles of Cost-Benefit Analysis, estimation of costs and benefits, adjusting and comparing environmental benefits and costs. Environmental Accounting: Concept and types.
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. Taxation.

Unit 3: Natural resource economics (5 lectures)
Economics of non-renewable resources; economics of fuels and minerals; Hotelling's rule and extensions; Economics of renewable resources; economics of water use, management of fisheries and forests; concept of MSY.

Unit 4: Environmental Valuation: (13 lectures):
Concept of Total Economic Value (TEV) of environment. Direct valuation methodology: market value, opportunity cost analysis. Indirect valuation methodology: Concept of willingness to pay (WTP) and willingness to accept (WTA), Hedonic pricing, Travel cost methodology, Contingent valuation methodology. Damage cost analysis.

PRACTICAL:

1. Case study on environmental or natural resource valuation or damage cost analysis or cost benefit analysis of any activity. 20
2. Viva voce 5

DISCIPLINE SPECIFIC CORE COURSE 22

Environmental Health and Toxicology (Theory 75 + Practical 25)

[50 Lectures Theory]

Unit 1: Epidemiology and Health (15 lectures)

Concept of Health and Disease, Etiology of disease. Principles of epidemiology and epidemiological methods, aims of epidemiology, measurement of mortality, measurement of morbidity. Environmental Health-Concept, Principle and Components, Environmental Intervention Models-Clinical, Public Health and Environmental Stewardship, Health and Environment-DPSEEA framework, Occupational health and Health consequences of different occupations- Anthracosis, Silicosis, Asbestosis

Unit 2: Concept of Disease (7 lectures)

Concept of screening the diseases, water borne diseases: Cholera and Diarrhoeal diseases, vector borne diseases: Dengue and Malaria, Food poisoning and foodborne illness, Air borne disease: Tuberculosis, Pollens and their allergens, Hypersensitivity.

Unit3: Community and Health (3 lectures)

Communication for health education, Introduction to health programmes of India. Demography and family planning.

Unit 4: Concept of Toxicology (10 lectures)

Different types of toxicant, Xenobiotics, different route of exposure, exposure effect relationship, synergistic and antagonistic effect, Absorption, Distribution, Metabolism and Excretion of toxicants (Phase I and Phase II reactions). Detoxification, toxico-dynamics.

Unit 5: Toxicity assay (7 lectures)

Acute and chronic toxicity; Dose- Response Relationship- Median lethal concentration (LD_{50} and LC_{50}); Sublethal concentration and safe concentration (NOEL, MATC); Whole Effluent Toxicity (WET) test; Bioassay - types, methodologies and application; Toxico Kinetics and toxicokinetic analysis.

Unit 6: Ecotoxicology (8 lectures)

Biomarkers; Bioaccumulation; Biomagnification; Bioconcentration factor; Risk assessment; Effects on population and ecosystems; Damage process and action *of* toxicants; Toxicity of heavy metal and metalloids (Pb, Cd, Cr, Hg and As)

PRACTICAL:

1. LC50 calculation by probit analysis with data provided. (7)
2. Study of Nuclear abnormalities in the erythrocytes of fish/ from root tip of *Allium cepa* (10)
3. Viva-voce (5), Laboratory notebooks (3)

DISCIPLINE SPECIFIC CORE COURSE 23

Statistics and Environmental Modelling (Theory 100)

[50 Lectures Theory]

Unit-1 Introduction **(4 lectures)**

Data presentation, Frequency, Histogram, Piechart, pictograms

Unit 2: **Elements and tools of statistical analysis**: **(30 lectures)**

Sampling; Basic concept of probability theory, Sampling theory, Distributions - Normal, log-normal, Binomial, Poisson, t, 2 and F-distribution. Attributes and Variables: types of variables, scales of measurement Distribution- Normal, t and r, Poisson and Binomial; measurement of Central tendency and Dispersion, Standard error, Moments – measure of Skewness and Kurtosis, Tests of hypothesis and significance. Correlation Regression, tests of hypothesis (Student t-test, X^2-test ANOVA: one-way and two-way); significance and confidence limits, degrees of freedom.

Unit-3: Environmental modelling **(16 lectures)**

Introduction to environmental system analysis; Concept of environmental modelling; Approaches to development of models, linear simple and multiple regression models; Validation and forecasting Modelling techniques; Model performance, accuracy and utilization; Models of population growth and interactions- Lotka-Volterra model, Leslie's matrix model, point source stream pollution model, box model, Air pollution modelling and prediction, Modelling of non-reacting pollutants, pollutant transformations.

PRACTICAL:

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

DISCIPLINE SPECIFIC CORE COURSE 24

Industrial Health and Safety (Theory 75 + Practical 25)

[50 Lectures Theory]

Unit 1: Introduction to Industrial and occupational health: (16 Lectures)
Introduction to occupational health hazards. Introduction to physical and mental health issues. Hazards faced by employees in different sectors: chemical industries, waste handling, nuclear plants, transport system, IT sectors, Health care sectors, small and medium scale enterprises, law enforcement, disaster management, education and research sector.

Unit 2: Unorganised sectors and social issues related to occupation: (10 Lectures)
Occupational health issues in unorganised sectors and their consequences: silicosis, asbestosis, heat stress, carcinoma, orthopaedics and neurological problems from physical stress. Social issues: HIV/AIDS, migration related health problems, Workplace gender discrimination, maternity and menstrual hygiene issues.

Unit 3: Fundamentals of Safety: (12 Lectures)
Concept of safety and risk. Safety and productivity. Importance and types of safety protocols in different sectors. Ventilation and maintenance of indoor and outdoor environment for workers, important of nutritional status.

Ergonomics: definition, the importance in maintenance of general health.

Unit 4: Policies and Regulations for Industrial health and safety: (12 Lectures)
International Labour Organisation (ILO), ISO 45001 (OHS), Promotional Framework for Occupational Safety and Health Convention, 2006.

Constitutional framework on health and safety of employees in India, National Policy on Safety, Health and Environment at Workplace (NPSHEW), Factories Act, 1948 (the safety aspects only).

PRACTICAL:

1. Submission of assignment on any one issue of health and safety in India with documented data and presentation in form of a public communication (Blog or short video). 15
2. Viva voce 10

DISCIPLINE SPECIFIC CORE COURSE 25

Instrumentation: Environmental Application (Theory 75 + Practical 25)

[50 Lectures Theory]

Unit 1: Analytical methods and Analytical instruments (10 lectures)

Basics principles of titrimetry, gravimetry, bomb calorimetry, spectroscope, diffraction, chromatography, electronic transition, fundamentals of optics and photometry, principles of microscopy.

Unit 2: Spectroscopy (15 lectures)

Introduction, basic principles, Electromagnetic radiations and interactions with matters: Define Spectroscopy, Types of spectroscopy, Absorption spectrum, Emission spectra, Wave length and Wave number, Electromagnetic radiation, Quantisation of energy, Electronic, vibrational and rotational spectroscopy. Franck– Condon principle, Jablonski diagram, radiative, non-radiative pathways, fluorescence and phosphorescence. Absorption of radiation, Beer-Lambert's law, deviation of Beer- Lambert's equation and its limitations. UV-Visible spectroscopy, Fluorescence spectroscopy, IR/Raman spectroscopy, Flame Photometry, Atomic Absorption Spectroscopy, NMR Spectroscopy and Mass spectroscopy**.**

Unit 3: Diffraction (5 lectures)

Principle of diffraction and X-ray diffraction: X- ray spectra, Bragg's law and intensity of X- rays, Mosley's law, XRD techniques.

Unit 4: Chromatography (10 lectures)

Gas Chromatography: Principle, carrier gas, stationery phase, instrumentation, sample injection, column detectors (TCD, FID, ECD), effect of temperature on retention, qualitative and quantitative analysis.

High Performance Liquid Chromatography: Principle, instrumentation, column, sample injection, detectors (absorbance, refractive index, electrochemical), mobile phase selection, ion pair chromatography.

Unit 5: Environmental Application (10 lectures)

Introduction to sampling techniques and analytical methods to measure environmental contamination in air, water, soils. Safe Laboratory Practices, Quality assurance and Quality control

PRACTICAL:

1. To study the principle and applications of following instruments (autoclave, incubator, BOD incubator, hot air oven, light microscope, pH meter, conductivity meter, spectrophotometer) (10)
2. Constructing a calibration curve from chromatograms of calibration standards (5)
3. Laboratory Notebook and Viva-Voce (10)

SKILL ENHANCEMENT COURSE 01

Environment and Society (Theory 100)

[50 Lectures Theory]

Unit 1: Environmental Literacy (4 lectures)
Environmental literacy (formal and non-formal education)

Unit 2: Societal view of the environment (18 Lectures)
Man – Environment relationships: nature centric, religionistic, conservationist, pro-development. Environmental Ethics: Kantian and Rawlsian theories of ethics. North – south conflicts, Environmentalism. Colours of environmentalism: green, bright green, light green. Discrimination, inequality, Food insecurity, poverty, environmental refugees, climate change mitigation and adaptation. Gender-based violence, gender and environment debate, Ecofeminism.

Unit 3: Environmental Problems: global perspectives (12 Lectures)
Classifying environmental problems, Multi-purpose river valley projects and their environmental and social impacts, social and ecological losses versus economic benefits, overpopulation. Climate negotiations.

Unit 4: Environmental movements (16 Lectures)
Bishnoi Movement, *Silent Valley movement,* Chipko and Appiko movement, Narmada and Tehri dam movements, Johad movement, Greta Thunberg's story. JFM movement.

SKILL ENHANCEMENT COURSE 02

Urban Environmental Management (Theory 100)

[50 Lectures Theory]

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

Concept of Urbanisation. Drivers of urbanisation: Demographic, physical, social and economic. Metros, cities and towns as sources and sinks of resources; resource consumption and its social, cultural, economic and ecological perspectives; urban transformation; Impacts of urbanisation on environment, increasing challenges posed by modernity for the environment.

Unit 2: Urban dwelling (12 lectures)

Housing scenario across a range of large-medium-small cities; poverty and slums in an urban context; urban drainage, energy consumption and waste disposal as well as accumulation; environmental costs of urban infrastructure. Urban health problems and prophylaxis measures.

Unit 3: Natural spaces in a city (10 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 4: Planning and environmental management (10 lectures)

Green city concept. Introduction to green buildings, need and relevance of green buildings over conventional buildings, construction of green building. LEED certification, GRIHA certification. rainwater harvesting (Corporation and Municipal areas);

Unit 5: National and International efforts in urban management (10 lectures)

UN Conference on Human settlement – Habita I, 1976; Habita II, 1996 and Hbitat III 2016. Habitat and sustainable development goals. Smart City concept. National Urban Policy Framework of India, 2020. Jawaharlal Nehru National Urban Renewal Mission (JNNURM), 2005.

SKILL ENHANCEMENT COURSE 03

Green Technology (Theory 100)

[50 Lectures Theory]

Unit 1: **Green infrastructure, planning and economy** **(15 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; 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 **(18 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 NOX, 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 **(7 lectures)**

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

Unit 4: 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.

Suggested Reading:

1. Abbasi T. and Abbasi S.A., 2010. *Renewable Energy Resources: Their Imapct on Global warming and Pollution.* PHI.
2. Abraham, C.M. 1999. *Environmental Jurisprudence in India*. Kluwer Law International.
3. Agarwal, A. and Narain, S. 1997. *Dying Wisdom.* CSE Publication.
4. Agawal, A., Narain, S. and Khurana, I. 2001. *Making Water Everybody's Business.* CSE Publication.
5. Anastas, P.T. & Warner, **J**.C. 1998. *Green Chemistry: Theary & Practice*. Oxford University Press
6. APHA, 2023. *Standard Methods for the Examination of Water and Waste water (24th ed).* APHA.
7. Artiola, J.F., Pepper I.L., Brussean, M. 2004. Environmental Monitoring and Characterization. Academic Press.
8. Asnani, P.U. 2006. Solid waste management. *India Infrastructure Repart 570*.
9. Bagchi,A. 2004. *Design of Landfills and Integrated Solid Waste Management*. John Wiley & Sons.
10. Baird C., and Cann M., 2005. *Environmental Chemistry (3rd Ed.)*. W H Freeman and Co.
11. Banejee P.K., 2006. *Textbook of Geology*, World Press.
12. Banerjee P.K., 2011. *Introduction to Biostatistics.* S,Chand.
13. Bansil, P.C. 2004. *Water Management in India*. Concept Publishing Company, India.
14. Barrow, C.J.2000. *Social Impact Assessment: An Introduction.* Oxford University Press.
15. Barry, R. G. 2003. *Atmasphere, Weather and Climate*. Routledge Press, UK.
16. Bawa K.S., Primack R.B, Oommen M.A. 2004. *Conservation Biology: A Primer for South Asia.* University Press.
17. Blackman, W.C. 2001. *Basic Hazardaus Waste Management*. CRC Press.
18. Bluman, 2007. *Elementary Statistics: A step by Step Approach*. Mc Grawhill.
19. Blyth F.G.H., and Freitas M.H. 2006. *A Geology for Engineers (7th Ed.& 1st Indian ed).* Elsevier.
20. Boeker,E.&Grondelle,R.2011.*Environmental Physics:SustainableEnergy and Climate Change*. Wiley
21. Boyle G., 2004. *Renewable Energy: Power for Sustainable Future.* Oxford University Press.
22. Brady, N.C. &Well,R.R. 2007.*The Nature and Properties of Soils*(13thedition),Pearson Education Inc.
23. Brebbia, C.A. 2013.*Water Resources Management VII.* WIT Press.
24. Bridge,J.,&Demicco,R.2008.*EarthSur!aceProcesses,Land!ormsandSedimentdeposits*. Cambridge University Press.

25. Coppola D.P. 2007. *Introduction to International Disaster Management*. Butterworth Heinemann.
26. Craig, J.R., Vaughan. D.**J**. &Skinner. B.L. 1996. *Resources of the Earth: Origin, Use, and Environmental Impacts*(2nd edition). Prentice Hall, New **J**ersey.
27. Craig. **J**.R., Vaughan, D.J., Skinner. B.J. 1996. *Resources of the Earth: Origin, use, and environmental impact*(2nd edition). Prentice Hall, New **J**ersey.
28. Critchfield, H.J. 2012. *General Climatology (4th & Indian edition),* PHI.
29. Cutter, S.L. 2012.*Hazards Vulnerability and Environmental Justice*. Earth Scan, Routledge Press.
30. Das Asim K. 2010. *Environmental Chemistry with Green Chemistry.* Books and Allied.
31. Das, N.G. *Statistical Methods.* McGraw Hill Publication.
32. Demers, M.N. 2005. *Fundamentals af Geagraphic Infarmatian System*. Wiley &Sons.
33. Divan,S.&Rosencranz,A.2001.*EnvironmentalLawandPalicyinIndia*.OxfordUniversity Press.
34. D'Monte, Darryl. 1985. *Industry versus Environment Templesar Tambs*. Three Controversies, Delhi, CSE.
35. Elliott,D.1997.*Sustainable Technology. Energy, Society and Environment* (Chapter3). New York, Routledge Press.
36. Emiliani C. 1992. *Planet Earth,* Cambridge University Press.
37. Evans, G.G.& Furlong, J.2010. *Environmental Biotechnology: Theory and Application* (2nd edition). Wiley-Blackwell Publications.
38. Farndon, J. and Parker, S. 2009. *The Illustrated Encyclopedia of Minerals Rocks & Fossils of the World,* Hermes House.
39. Forinash, K. 2010. *Foundation of Environmental Physics*. Island Press.
40. Freeman, A.M. 2003. *Millennium Ecosystem Assessment: Conceptual Framework*. Island Press.
41. Freeman,A.M. 2001. *Measures of value and Resources: Resources for the Future*. Washington DC.
42. Futuyma, D.J.2009. *Evalutian*(2nd edition). Sinauer Associates.
43. Gaston, K.J. & Spicer, J.I.1998. *Biodiversity: An Introduction.* Blackwell Science, London, UK.
44. Gaston, K.J.2010. *Urban Ecology*. Cambridge UniversityPress, New York.
45. Gillespie, **J**. H. 1991. *The Causes of Molecular Evalutian*. Oxford University Press.
46. Ginley, D.S. & Cahen, D. 2011. *Fundamentals of Materials for Energy and Environmental Sustainability*. Cambridge University Press.
47. Glasson,J.,Therivel,R.,Chadwick,A.1994.*IntroductiontaEnvironmentalImpactAssessment*. London, Research Press,UK.
48. Graur,D.&Li,W.H.1999.*Fundamentals OF Molecular Evaluation* (2nd edition). Sinauer Associates.
49. Groom.B.&**J**enkins.M.2000.*GlobalBiodiversity:Earth'sLivingResourcesinthe21st Century*

50. Guha, P.K. 2013. *Remote Sensing for the Beginner (3rd ed.), Affiliated East West Press.*
51. Gupta, K.R. 2006. *Environmental Legislation in India*. Atlantic Publishers and Distributors.
52. Gurevitch, J., Scheiner, S.M., &Fox, G.A. 2002. *The Ecology of Plants*. Sinauer associates incorporated.
53. Gurjar,B.R., Molina,L.T.& Ojha C.S.P. 2010. *Air Pallution: Health and Environmental Impacts*. CRC Press, Taylor&Francis.
54. Hardy, **J**.T. 2003. *Climate Change: Causes, Effects and Salutians*. **J**ohn Wiley &Sons.
55. Havlin J.L., Beaton J.D., Tisdale,S.L., Nelson W.L, 2013. *Soil Fertility and Fertilizer: An Introduction to Nutrient Management (8th Ed.).* PHI / Pearson.
56. Henry J.G. and Heinke G.W. 2004. *Environmental Science and Engineering (2nd Ed.).* PHI.
57. Hester,R.E.&Harrison,R.M.1998.*AirPallutianandHealth*.TheRoyalSocietyofChemistry, UK.
58. Hewwood, I., Cornelius, S., Carver, S. 2009. *An Introduction to Geographical Information Systems (3rd ed.).* Pearson.
59. Hites, R.A. 2012. *Elements of Environmental Chemistry*(2nd edition). Wiley &Sons.
60. Husain, Majid 2020. Geography of India (9th Ed.). Mc Graw Hill.
61. Jenson J.R. 2003. *Remote Sensing of the Environment: An Earth Resource Perspective.* Pearson.
62. John M. Fryxell, Anthony R. E. Sinclair, Graeme Caughley 2014 Wildlife Ecology, Conservation, and Management, (3rd Edition), Wiley Blackwell
63. **J**ohnson, D.L. 2006. *Land Degradation*(2nd edition). Rowman & Little field Publishers.
64. **J**ordening, H.J. & Winter J.2005. *Environmental Biotechnology: Concepts and Applications*. **J**ohn Wiley & Sons.
65. **J**udith, P. 1999. *Handbook of Environmental Impact Assessment*. Blackwell Science.
66. Keller, E.A. 20ll. *Introduction to Environmental Geology* (5th edition). Pearson Prentice Hall.
67. Keller,E.A.1996.*IntroductiontaEnvironmentalGealagy*.PrenticeHall,UpperSaddleRiver, New **J**ersey.
68. Klee, G.A. 1991. *Conservation of Natural Resources*. Prentice Hall Publication.
69. Krebs C. 2009. *Ecology: Experimental Analysis of Distribution and Abundance (6th Ed.).* Pearson.
70. Krebs, C. 1999. Ecological Methodology (2nd Ed). Benjamin Cummings.
71. Krishnamurthy,K.V.2004.*AnAdvancedTextBookaJBiodiversity-Principles and Practices*.
72. Lal D.S. 2011. *Climatology.* Sharda Pustak Bhawan.
73. Leeder, M., Arlucea, M.P. 2005. *Physical Processes in Earth and Environmental Sciences.* Blackwell Publishing.
74. Leelakrishnan, P. 2008.*Environmental Law in India*(3rd edition).LexisNexis India.

75. Lillesand T.M. and Kiefer R.W., 2011. *Remote Sensing and Image Interpretation (6th ed.).* Wiely.
76. Lodish, H.F., Baltimore,D., Berk, A.Zipursky, S.L.Matsudiara, P.&Darnell, **J**. 1995.*Molecular Cell Biology*. W.H. Freeman.
77. Lomolino, M.V., Riddle,B.R., Whittaker, R.J. &Brown, **J**.H. 2010.*Biageagraphy*(4th edition) Sinauer Associates, Sunderland.
78. Loreau, M. &Inchausti, P. 2002. *Biodiversity and Ecosystem functioning: Synthesis and Perspectives.* Oxford University Press, Oxford, UK.
79. Loucks,D.P.,Stedinger,**J**.R.&Haith,D.A.1981.*WaterResourceSystems Planning and Analysis*. Englewood Cliffs, NJ, Prentice Hall.
80. Manhan, S. E. 2000. *Fundamentals of Environmental Chemistry*. CRC Press.
81. Manhan, S. E. 2015. *Water Chemistry*. CRC Press.
82. Mani, M.S. 1974. *Ecology and Biogeography in India*. Dr. W**J**unk Publishers., TheHague.
83. Marriott,B.1997.*Environmental Impact Assessment: A Practical Guide*. McGraw-Hill, New York, USA.
84. Marsh,W.M.&Dozier,J.1983.*LandscapePlanning:EnvironmentalApplications*.**J**ohnWiley and Sons.
85. Masters, G.M., and Ela W,P., 2008. *Introduction to Environmental Engineering and Science (3rd Ed.).*Pearson.
86. Mathez, E.A. 2009. *Climate Change: The Science af Glabal Warming and our Energy Future*. Columbia University Press.
87. Mays, L.W. 2006.*Water Resources Sustainability*. The McGraw-Hill Publications.
88. McDougall, F.R., White, P. R., Franke, M., &Hindle, P. 2008. *Integrated Solid Waste Management: A Life Cycle Inventory*. John Wiley & Sons.
89. McMurry J.H., and Fay, R.C, 2008. *Chemistry (5th Ed.),* Pearson.
90. Miller G.T., 1996. *Living in the Environment (9th Ed.) Wadsworth publication.*
91. Miller, G.T 2012. *Environmental Science*. Wadsworth Publishing Co.
92. Minkoff, E.C. 1983. *Evalutianary Bialagy*. Addison Wesley. Publishing Company.
93. Mitra, A.P., Sharma, S., Bhattacharya, S., Garg,A., Devotta, S. &Sen, K.2004. *Climate Change and India*. Universities Press, India.
94. Narain S., 2017. *Environment Reader for Universities*. CES Delhi Publication.
95. Narayanan, P. 2000. *Essentials of Biophysics.* New Age Publications.
96. Nei, M. 1987. *Molecular Evolutionary Genetics*. Columbia University press.
97. Odum, E.P. 1971. *Fundamentals of Ecology*. W.B. Sounders Natraj publication (Indian edition).
98. Owen,O.S,Chiras,D.D,&Reganold,**1**.P. 1998. *Natural Resaurce Canservatian–Management for Sustainable Future* (7thedition). Prentice Hall.
99. Pandey G.N. 2013. *Environmental Management.* Vikash.
100. Pandit,M.K.&GrumbineR.E.2012.Ongoingandproposedhydropowerdevelopmentinthe Himalayaand its impact on terrestrial biodiversity. *Conservation Biology* 26: 1061-1071.

101. Park,K. 2015. *Park's Textbook of Preventive and Social Medicine* (23rd edition). Banarsi das Bhanot Publishers.
102. Pepper,I.L.,Gerba,C.P.& Brusseau,M.L. 2006. *Environmental and Pallutian Science.* Elsevier.
103. Perman, R. 2003. *Natural Resource and Environmental Economics*. Pearson Education.
104. Philander,S.G. 2012. *Encyclopedia of Global Warming and Climate Cha*nge (2nd edition).Sage Publications.
105. Pimentel, D.(Ed.).2011.*Biological invasions:Economic and environmental costs of alien plant, animal, and microbe species*. CRC Press.
106. Pine,J.C.2009.*NaturalHazardsAnalysis:ReducingtheImpactaJDisasters*. CRC Press, Taylor and Francis Group.
107. Prasad CVRK, 2005, *Elementary Exercises in Geology*, University Press.
108. Prescott, Harley and Klein, 2008. *Microbiology (7th ed.)*. McGrawhill.
109. Primack, R.B. 2002. *Essentials of Canservatian Biology* (3rd edition). Sinauer Associates, Sunderland, USA.
110. Purohit, S.S. &Ranjan, R. 2007.*Ecology, Environment & Pollution*. Agrobios Publications.
111. Radojevic, M. and Baskin V.N. 1999. *Practical Environmental Analysis.* Royal Society of Chemistry, Cambridge.
112. Ramachandra T.V., 2009. *Municipal Solid Waste Management*. TERI press.
113. Ramade, F. 1984. *Ecology of Natural Resources*. John Wiley & Sons Ltd.
114. Rastogi, B.B. *Biostatistics.* MEDTEC.
115. Richards, **J**.A. &**J**ia, X. 1999.*Remate Sensing and Digital Image Processing*. Springer.
116. Richter, M. & Weiland, U. (ed.). 2012.*Applied Urban Ecology*. Wiley-Blackwell, UK.
117. Ricklef, R.E., and Miller G.L., 1999. *Ecology (4th Ed.).* Freeman.
118. Rittman,B.E. &McCarty,P.L.2001. *Environmental Biotechnology. Principles and Applications.* McGraw-Hill, New York.
119. Sabins, F.F. 1996. *Remote Sensing: Principles an Interpretation*. W.H. Freeman.
120. Santra S.C. 2005. *Environmental Science (2nd Ed.)*. New Central Book Agency.
121. Sawyer C.N, McCarty P.L. and Parkin G.F.,2003. *Chemistry for Environmental Engineering and Science (5th Ed., Indian Ed.2017)*. McGraw Hill Education.
122. Scherr,S.J.1999.*Soildegradation:Athreattodeveloping-countryfoodsecurityby2020?*(Vol.27). International Food Policy Research Institute.
123. Schneid,T.D.& Collins,L. 2001. *Disaster Management and Preparedness*. Lewis Publishers, New York, NY.
124. Schwab G.O., Fangmeier, D.D. Elliot, W.J., Frevert R.K., 2005. *Soil and Water Conservation Engineering (4th Ed.).* Wiely.
125. Schward & Zhang, 2003. *Fundamentals of Groundwater*. **J**ohn Willey and Sons.
126. Scragg A. 2005. *Environmental Biotechnology (2nd Ed.)*. Oxford University press.
127. Sengar D.S. 2012. *Environmental Law.* PHI.
128. Sharma P.D 2014 *Environmental Biology and Toxicology*. Rastogi Publications
129. Shastri, S.C. 2022. Environmental Law (7TH Ed.). EBC publications.

130. Shaw R., and Krishnamurthy R.R., 2009. *Disaster: Global Challenges and Local Solutions.*
131. Silberberg M.S., 2016. *Chemistry: The molecular Nature of Matter and Change (7th Ed.).* McGraw Hill Higher Education.
132. Sincero A.P. and Sincero G.A., 2012. *Environmental Engineering (Indian Ed.).* PHI.
133. Singh, K. &Shishodia,A.2007. *Environmental Economics: Theory and Applications*. Sage publications.
134. Singh, G. 2012. *Plant Systematics: Theory and Practice* (3rdedition). Oxford &IBH Pvt.Ltd., New Delhi.
135. Singh, Parbin, 2016. Engineering and General Geology (8th Ed.), Katson Books.
136. Singh, Savindra, 2017. Physical Geology. Pravalika publications.
137. Singh,**J**.S., Singh,S.P.& Gupta,S.2006. *Ecology, Environment and Resource Conservation. A*namaya Publications, New Delhi.
138. Smith, K. 2001. *Environmental Hazards: Assessing Risk and Reducing Disaster*. Routledge Press.
139. Smith, R.L. and Smith, T.M. 2001. Ecology and Field Biology. Benjamin Cummings.
140. Snustad, D.P. &Simmons, M.J.2011. *Principles of Genetics*(6thedition). **J**ohnWiley & Sons.
141. Sodhi,N.S. &Ehrlich, P.R.(Eds). 2010. *Conservation Biology for All*. Oxford University Press.
142. Subrahmanyam N.S. and Sambamurty A.V.S.S. 2006. *Ecology (2nd ed.).* Narosa.
143. Taylor D.J., Green NPO, Stout G.W., 2005. *Biological Science (3rd ed).* Cambridge University Press.
144. Thompson and Fredrick. 1997. *Ecological Design and Planning.* Jhon Wiley and Sons.
145. Thornbury Willium D. 2002. *Principles of Geomorphology,* CBS Publishers and Distributers.
146. Tieten berg, T. H.& Lewis,L. 2010. *Environmental Economics and Policy*. Addison-Wesley.
147. Tietenberg, T. 2004. *Environmental and Natural Resource Economics* (6th Edition). Pearson Education Pvt.Ltd.
148. Tiwari, G.N. &Ghosal. M.K. 2005. *Renewable Energy Resources: Basic Principles and*
149. Todd, D.K. and Mays L.W., 2011. *Ground Water Hydrology (3RD Ed).* Wiley.
150. Tortora, Funke and Case, 2001. *An Introduction to Microbiology (7th ed.).* Benjamin & Cummins.
151. Turner, R.K., Pearce, D., &Bateman, I. 1994. *Environmental Economics: An Elementary Introduction*. Harvester Wheatsheaf.
152. US EPA. 1999. *Guide for Industrial Waste Management*. Washington D.C.
153. Valoon G.W. and Duffy S.J. 2000. *Environmental Chemistry: A global perspective (Indian Edition).* Oxford University Press.
154. Venkat, A. 2011. *Environmental Law and Policy*. PHI Learning Private Ltd.
155. Vesilind,P.**1**.,Peirce,**1**.**1**.,&Weiner R.F.1990. *Environmental Pollution and Control*. Butterwth- Heinemann, USA.
156. Vickers, A. 2001. *Handbook of Water Use and Conservation*. Water Plow Press.

157. Vogel's *textbook of quantitative inorganic analysis, including elementary instrumental analysis* 1978 (4th ed.) Longman
158. Wainwright, M. 1999. *An Introduction to Environmental Biotechnology*. Springer.
159. Wallace,**J**.M.&Hobbs,P.V.1977. *Atmaspheric Science: An Introductory Survey*. Academic Press, New York.
160. Welford R. 1996. *Corporate Environmental Management.* University Press.
161. Wheeler,Q.D.&MeierR.2000.*SpeciesCanceptsandPhylageneticTheary:ADebate.*Col umbia University Press, New York.
162. Whitaker, J. C., & Mancini, R. K. (2018). Technical documentation and process. CRC Press.
163. Wilkins,**J**.S. 2009. *Species: A Histary af the Idea*(Vol. 1). University of California Press.
164. Williams, D.M., Ebach, M.C. 2008. *Faundatians of Systematics and Biogeography*. Springer.
165. Zar, **1**.H. 2010. *Biostatistical Analysis*(5thedition). Prentice Hall Publications.
166. Zhu,D.,Asnani,P.U.,Zurbrugg,C.,Anapolsky,S.&Mani,S.2008.*ImpravingMunicipalS alid waste Management in India.* The World Bank, Washington D.C.

Proposed Syllabus for B.Sc Environmental Science

(3 years Multidisciplinary)

Under Curriculum and Credit Framework, 2022

(1st, 2nd 3rd and 4th Semester)

Semester	Paper Code	Paper Name	Credits	Marks
1ST	ENV-MD-CC1-1-Th and ENV-MD-CC1-1-P	Fundamentals of Environment	4 (3TH +1P)	75+25
2ND	ENV-MD-CC2-2-Th and ENV-MD-CC2-2-P	Principles of Ecology	4 (3TH +1P)	75+25
3RD	ENV-MD-CC3-3-Th and ENV-MD-CC3-3-P	Environmental Chemistry	4 (3TH +1P)	75+25
4TH	ENV-MD-CC4-4-Th and ENV-MD-CC4-4-P	Environmental Pollution	4 (3TH +1P)	75+25

SKILL ENHANCEMENT COURSE (SEC)				
Semester	**Paper code**	**Paper Name**	**Credit**	**Marks**
1ST	ENV-MD-SEC1-1-Th	Environment and Society	4	100
2ND	ENV-MD-SEC2-2-Th	Urban Environment Management	4	100
3RD	ENV-MD-SEC3-3-Th	Green Technology	4	100

Marks= 25 marks per credit.

CORE COURSE 1

ENV-MD-CC1-1-Th: Fundamentals of Environment

(Theory 75 + Practical 25)

[50 Lectures Theory]

Unit-1: Basic concepts of Environmental Science: **(10 Lectures)**

Concept of environment and its components – physical components (Lithosphere, Hydrosphere and Atmosphere), socioeconomic and cultural component; Principle and scope of Environmental science; Multidisciplinary approach of Environmental science; Basic concept of sustainable development goals & Mission LIFE.

Unit-2: Climatic zones: **(5 Lectures)**

Equatorial, Tropical, Sub-Tropical, Temperate, Tundra.-Position and characteristics of the climatic zones.

Unit-3: Living matter and approach to evolutionary biology **(25 Lectures)**

Living matter on the basis of cell- Cytological study as unit of life, ultrastructure and functions of cytoplasmic and nucleoplasmic organelles like plasma membrane, mitochondria, golgi bodies, endoplasmic reticulum, ribosome, lysosome and nucleus.

Biochemical and molecular basis of origin of life, Theories of organic evolution: Lamarckism, Darwinism, and mutation theory. Concept of Neo-darwinism, Isolating mechanism and speciation, Hardy Weinberg Equilibrium and Genetic drift.

Unit-4: Global Environmental Issues **(10 Lectures)**

Concept of Deforestation, Basic concept of urban & industrial pollution, concept of Ecological footprints and carrying capacity, Climate change, Ozone layer depletion, Loss of biodiversity.

ENV-MD-CC1-1-P: Fundamentals of Environment

1. Assignment on global environmental issues. **(15)**
2. Viva-voce **(10)**

CORE COURSE 2

ENV-MD-CC2-2-Th: Principles of Ecology

(Theory 75 + Practical 25)

[50 Lectures Theory]

Unit1: Introduction to Ecology (12 lectures)

Basic concepts and definitions: ecology, autecology; synecology; landscape, habitat and niche, ecozones, biosphere, ecosystems, ecosystem stability, resistance and resilience; major terrestrial biomes. Ecological amplitude; Liebig's Law of Minimum; Shelford's Law of Tolerance; phenotypic plasticity; ecotypes; ecoclines; acclimation; 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, natality, mortality, life tables, survivorship curves, age structure; population growth form: exponential, logistic; r- and k-selection; dispersion, distribution, fluctuation, interaction and regulation. Concept of metapopulation.

Unit 3: Community Ecology (8 lectures)

Concept of major and minor community; approach of community study: zonal and gradient. Species diversity, discrete versus continuum community view; community structure and organization: physiognomy, sociability, species associations, periodicity, biomass, stability, keystone species, ecotone and edge effect; ecological succession: primary and secondary successions, models and types of successions, concept of climax, examples of succession, Models of succession: competitive and stress-tolerance strategies.

Unit 4: Ecosystem ecology (15 lectures)

Ecosystem- Definition, 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; impacts of invasion on ecosystem and communities.

Unit 5: Biogeochemical cycles and nutrient cycling (7 lectures)

Carbon cycle; oxygen cycle; nitrogen cycle; phosphorus cycle; sulphur 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.

ENV-MD-CC2-2-P: Principles of Ecology

1. Local Field study on ecosystem with report submission. **(15)**
2. Viva-voce **(10)**

CORE COURSE 3

ENV-MD-CC3-3-Th: Environmental Chemistry

(Theory 75 + Practical 25)

[50 Lectures Theory]

Unit 1: 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.

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.

Unit 3: Atmospheric chemistry **(7 lectures)**

Photochemical reactions in atmosphere; smog formation, types of smog (sulphur smog and photochemical smog), Chemistry of particulate matters, aerosols; chemistry of acid rain, chemistry of NOx and SOx ; free radicals and ozone layer depletion, role of CFCs in ozone depletion.

Unit 4: Water chemistry **(8 lectures)**

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

Unit 5: Soil chemistry **(8 lectures)**

Soil composition; inorganic and organic components in soil; soil colloids; cation and anion exchange reactions in soil; nitrogen, phosphorus and potassium in soil.

Unit 6: Green chemistry **(12 lectures)**

Introduction to green chemistry, Principles of Green Chemistry, the concept of atom economy and chemical synthesis, Important techniques used in green chemistry. Application of green chemistry, viz. replacement of ozone depleting substances including CFCs, manufacture of biodegradable polymers, use of H_2O_2 as benign bleaching agents in paper industry.

ENV-MD-CC3-3-P: Environmental Chemistry

1. *Water and Soil analysis:* pH, Electrical conductivity, Total Hardness of water, Total Alkalinity of water, Dissolved Oxygen, Chloride of water.

   Soil pH, Electrical conductivity of soil extract (ECe). **(15)**

2. Laboratory Note book **(5)**
3. Viva voce **(5)**

CORE COURSE 4

ENV-MD-CC4-4-Th: Environmental Pollution

(Theory 75 + Practical 25)

[50 Lectures Theory]

Unit 1: Concept of Pollutants and Environmental Pollution (5 lectures)

Definition of pollution; pollutants; source and type of pollutants: point source, line source, area source, classification of pollutants. Solubility of pollutants (hydrophilic and lipophilic pollutants), transfer of pollutants within different mediums, local, regional and global implications of Environmental pollution.

Unit 2: Air pollution (14 lectures)

Sources and types of pollutants- Natural and anthropogenic sources, primary and secondary pollutants. Sampling and monitoring of air pollutants (gaseous and particulates); period, frequency and duration of sampling. PAN, photochemical smog, acid rain. Effects of different pollutants on human health (NOx, SOx, PM, CO, CO_2, hydrocarbons and VOCs) and control measures; indoor air pollution: sources and effects on human health. Vehicular air pollution and urban air quality. Control devices for particulate matter: Principle and working of: settling chamber, centrifugal collectors, wet collectors, fabric filters and electrostatic precipitator. Control of gaseous air pollutants through adsorption, absorption, condensation and combustion including catalytic combustion. Socio-political perspectives of air pollution and health. Air quality criteria and standards, Ambient air quality: monitoring and standards (National Ambient Air Quality Standards of India); MINAS, air quality index. Case study: implementation of CNG in NCT of Delhi.

Unit 3: Water pollution (15 lectures)

Sources of surface and ground water pollution; water quality parameters and standards; organic waste and water pollution; Concept of water quality parameters: pH, EC, turbidity, TDS, ions responsible for hardness of water, chlorides, salinity, DO, BOD, COD, nitrates, phosphates, sulphates, heavy metals and organic contaminants. Microbiological analysis – MPN. Drinking water standards: Indian standards, effect of water contaminants on human health (nitrate, fluoride, arsenic, chlorine, cadmium, mercury, pesticides); eutrophication; concept and working of effluent treatment plants (ETPs).Drinking water treatment: Coagulation and flocculation, Sedimentation and Filtration, Disinfection and Softening. 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. Case study: Ganga Action Plan; Yamuna Action Plan.

Unit 4: Soil pollution (3 lectures)

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

Unit 5: Noise pollution (5 lectures)

Noise pollution-sources; frequency, intensity and permissible ambient noise levels; measurement of noise indices (L_{eq}, L_{10}, L_{90}, L_{50}, L_{DN}, TNI) effect on communication, impacts on life forms and humans - working efficiency, physical and mental health; Noise abatement strategies.

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); radiation standards, radiation protection.

Thermal Pollution- Sources of Thermal Pollution, Heat Islands, causes and effects of thermal pollution.

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; Methods of Abatement of Marine Pollution; coastal area management.

ENV-MD-CC4-4-P: Environmental Pollution

1. Analysis of BOD, COD, Noise (dB(A), SPM, RSPM (Demonstration), Dust fall rate, Soil respiration. **(15)**
2. Viva Voce **(5)**
3. Laboratory notebook **(5)**

SKILL ENHANCEMENT COURSE 01

ENV-MD-SEC1-1-Th: Environment and Society

(Theory 100)

[50 Lectures Theory]

Unit 1: Environmental Literacy (4 lectures)
Environmental literacy (formal and non-formal education)

Unit 2: Societal view of the environment (18 Lectures)
Man – Environment relationships: nature centric, religionistic, conservationist, pro-development. Environmental Ethics: Kantian and Rawlsian theories of ethics. North – south conflicts, Environmentalism. Colours of environmentalism: green, bright green, light green. Discrimination, inequality, Food insecurity, poverty, environmental refugees, climate change mitigation and adaptation. Gender-based violence, gender and environment debate, Ecofeminism.

Unit 3: Environmental Problems: global perspectives (12 Lectures)
Classifying environmental problems, Multi-purpose river valley projects and their environmental and social impacts, social and ecological losses versus economic benefits, overpopulation. Climate negotiations.

Unit 4: Environmental movements (16 Lectures)
Bishnoi Movement, *Silent Valley movement,* Chipko and Appiko movement, Narmada and Tehri dam movements, Johad movement, Greta Thunberg's story. JFM movement.

SKILL ENHANCEMENT COURSE 02

ENV-MD-SEC2-2-Th: Urban Environmental Management

(Theory 100)

[50 Lectures Theory]

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

Concept of Urbanisation. Drivers of urbanisation: Demographic, physical, social and economic. Metros, cities and towns as sources and sinks of resources; resource consumption and its social, cultural, economic and ecological perspectives; urban transformation; Impacts of urbanisation on environment, increasing challenges posed by modernity for the environment.

Unit 2: Urban dwelling (12 lectures)

Housing scenario across a range of large-medium-small cities; poverty and slums in an urban context; urban drainage, energy consumption and waste disposal as well as accumulation; environmental costs of urban infrastructure. Urban health problems and prophylaxis measures.

Unit 3: Natural spaces in a city (10 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 4: Planning and environmental management (10 lectures)

Green city concept. Introduction to green buildings, need and relevance of green buildings over conventional buildings, construction of green building. LEED certification, GRIHA certification. rainwater harvesting (Corporation and Municipal areas);

Unit 5: National and International efforts in urban management (10 lectures)

UN Conference on Human settlement – Habita I, 1976; Habita II, 1996 and Hbitat III 2016. Habitat and sustainable development goals. Smart City concept. National Urban Policy Framework of India, 2020. Jawaharlal Nehru National Urban Renewal Mission (JNNURM), 2005.

SKILL ENHANCEMENT COURSE 03

ENV-MD-SEC3-3-Th: Green Technology

(Theory 100)

[50 Lectures Theory]

Unit 1: **Green infrastructure, planning and economy** **(15 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; 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 **(18 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 NOX, 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 **(7 lectures)**

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

Unit 4: 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.

Suggested Reading:

- Anastas, P.T. & Warner, J.C. 2000. *Green Chemistry*: Theory & Practice. Oxford University Press
- Arcceivala S. J. 2014. *Green Technologies for better future* Mcgraw Hill Publication.
- Chapman, Reiss. *Ecology: Principles and Applications*. 1999. Cambridge University Press.
- Das MC. 2009. *Fundamental of Ecology (3rd Ed)*. Mc Graw Hill Publication.
- De AK.2021. *Environmental Chemistry (10th Ed)*. New Age International Publications.
- Khopkar, S.M. 2018. *Environmental Pollution Monitoring and Control (2nd Ed.)*. New Age International Publications.
- Kormondy E J. 2017. *Concept of Ecology (4th Ed)*. Pearson.
- Manhan, S. E. 2017. *Fundamentals of Environmental Chemistry (10th Ed.)*. CRC Press.
- Miller G.T. 2014. *Environmental Science (10th Ed).* Cengage India Pvt. Ltd..
- Odum, E.P. 2017. *Fundamentals of Ecology (5th Ed.)*. Cengage India Pvt. Ltd..
- Purohit, S.S. &Ranjan, R. 2003. *Ecology, Environment & Pollution*. Agrobios Publications.
- Santra S.C. 2013. *Environmental Science (3rd Ed.)* New Central Book Agency.
- Sawyer C.N, McCarty P.L. and Parkin G.F. 2017. *Chemistry for Environmental Engineering and Science (5th Ed.)*. McGraw Hill Education.
- Sharma PD. 2014. *Ecology and Environment* (13th Ed.). Rastogi Publication.
- Valoon G.W. and Duffy S.J. 2011. *Environmental Chemistry: A global perspective (3rd Ed.).* Oxford University Press.