UNIVERSITY OF CALCUTTA

Notification No. CSR/89/2025

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 the exercise of his powers under 9(6) of the said Act, the Vice-Chancellor has, by an order dated 10.11.2025 approved the new revised Syllabus (Semester: 1 to 6) for 4-year Honours & Honours with Research & 3-year MDC Courses of Studies in Environmental Science, under CCF 2022.

The above shall take effect from the Odd semester examinations, 2025 and onwards.

28/11/2025

Prof.(Dr.) Debasis Das

Registrar

SENATE HOUSE

Kolkata-700073

28.11.2025

SyllabusforB.ScEnvironmentalScience
(4 years Hons. with /without Research)

[Up to Semester 6]

UnderCurriculumandCredit Framework, 2022

Semester	PaperCode	PaperName	Credits	Marks	Pgs.
1ST	ENV-M-CC1-1-Thand ENV-M-CC1-1-P	FundamentalsofEnvironment	4(3TH+1P)	75+25	06
2ND	ENV-M-CC2-2-Thand ENV-M-CC2-2-P	Principlesof Ecology	4(3TH+1P)	75+25	07
3RD	ENV-M-CC3-3-Thand ENV-M-CC3-3-P	EnvironmentalChemistry	4(3TH+1P)	75+25	08
	ENV-M-CC4-3-Thand ENV-M-CC4-3-P	EnvironmentalPhysicsand Climatescience	4(3TH+1P)	75+25	09
4TH	ENV-M-CC5-4-Thand ENV-M-CC5-4-P	EnvironmentalGeosciences	4(3TH+1P)	75+25	10
	ENV-M-CC6-4-Thand ENV-M-CC6-4-P	EnvironmentalPollution	4(3TH+1P)	75+25	11
	ENV-M-CC7-4-Thand ENV-M-CC7-4-P	BiodiversityandConservation	4(3TH+1P)	75+25	13
	ENV-M-CC8-4-Thand ENV-M-CC8-4-P	EnvironmentalMicrobiology& Biotechnology	4(3TH+1P)	75+25	15
5TH	ENV-M-CC9-5-Thand ENV-M-CC9-5-P	HydrologyandPedology	4(3TH+1P)	75+25	17
	ENV-M-CC10-5-Thand ENV-M-CC10-5-P	EnergyandEnvironment	4(3TH+1P)	75+25	19
	ENV-M-CC11-5-Thand ENV-M-CC11-5-P	EnvironmentalLegislationsand Policy	4(3TH+1P)	75+25	20
	ENV-M-CC12-5-Thand ENV-M-CC12-5-P	EnvironmentalImpact Assessment	4(3TH+1P)	75+25	21
6TH	ENV-M-CC13-6-Thand ENV-M-CC13-6-P	RemoteSensingandGIS	4(3TH+1P)	75+25	22
	ENV-M-CC14-6-Thand ENV-M-CC14-6-P	Environmental Management	4(3TH+1P)	75+25	23
	ENV-M-CC15-6-Thand ENV-M-CC15-6-P	WasteManagement	4(3TH+1P)	75+25	24

SKILLENHANCEMENTCOURSE(SEC)

Semester	Papercode	PaperName	Credit	Marks	Pg.
1ST	ENV-M-SEC1-1-Th	EnvironmentandSociety	4	100	26
2ND	ENV-M-SEC2-2-Th	UrbanEnvironment Management	4	100	27
3RD	ENV-M-SEC3-3-Th	GreenTechnology	4	100	28

SyllabusforB.ScEnvironmentalScience (MINOR)
(with 4years B.Sc in other subjects)
UnderCurriculumandCreditFramework,2022

Minor 1 (M1)

Semester	Paper code	Paper Name	Credit	Marks	Pg.
1ST	MENV-MN-1-1-Thand MENV-MN-1-1-P	FundamentalsofEnvironment	4(3TH+1P)	75+25	29
2ND	MENV-MN-2-2-Thand MENV-MN-2-P	Principlesof Ecology	4(3TH+1P)	75+25	30
5TH / 6TH	MENV-MN-3-Thand MENV-MN-3-P	EnvironmentalChemistry	4(3TH+1P)	75+25	31
5TH / 6TH	MENV-MN-4-Thand MENV-MN-4-P	EnvironmentalPollution	4(3TH+1P)	75+25	32

Minor 2 (M2)

Semester	Paper code	Paper Name	Credit	Marks	
3rd	MENV-MN-1-1-Thand MENV-MN-1-1-P	FundamentalsofEnvironment	4(3TH+1P)	75+25	29
4th	MENV-MN-2-2-Thand MENV-MN-2-P	Principlesof Ecology	4(3TH+1P)	75+25	30
5TH / 6TH	MENV-MN-3-Thand MENV-MN-3-P	EnvironmentalChemistry	4(3TH+1P)	75+25	31
5TH / 6TH	MENV-MN-4-Thand MENV-MN-4-P	EnvironmentalPollution	4(3TH+1P)	75+25	32

SyllabusforB.ScEnvironmentalScience

(3 years Multidisciplinary - MDC)

UnderCurriculumandCreditFramework,2022

MDC Major1

Semester	PaperCode	PaperName	Credits	Marks	Pg.
1ST	M-ENV -CC1-1-Thand M-ENV-CC1-1-P	FundamentalsofEnvironment	4(3TH+1P)	75+25	34
2ND	M-ENV-CC2-2-Thand M-ENV-CC2-2-P	Principlesof Ecology	4(3TH+1P)	75+25	35
3RD	M-ENV-CC3-3-Thand M-ENV-CC3-3-P	EnvironmentalChemistry	4(3TH+1P)	75+25	36
4TH	M-ENV-CC4-4-Thand M-ENV-CC4-4-P	EnvironmentalPollution	4(3TH+1P)	75+25	37
	M-ENV-CC5-4-Thand M-ENV-CC5-4-P	Natural Resources, Biodiversity and Conservation	4(3TH+1P)	75+25	39
5TH	M-ENV-CC6-5-Thand M-ENV-CC6-5-P	Environmental Management and Environmental Impact Assessment (EIA)	4(3TH+1P)	75+25	41
	M-ENV-CC7-5-Thand M-ENV-CC7-5-P	Environmental Legislation and Policy	4(3TH+1P)	75+25	42
6TH	M-ENV-CC8-6-Thand M-ENV-CC8-6-P	Disaster Management	4(3TH+1P)	75+25	43

MDC Major 2

Semester	PaperCode	PaperName	Credits	Marks	Pg.
1ST	M-ENV -CC1-1-Thand M-ENV-CC1-1-P	FundamentalsofEnvironment	4(3TH+1P)	75+25	34
2ND	M-ENV-CC2-2-Thand M-ENV-CC2-2-P	Principlesof Ecology	4(3TH+1P)	75+25	35
3RD	M-ENV-CC3-3-Thand M-ENV-CC3-3-P	EnvironmentalChemistry	4(3TH+1P)	75+25	36
4TH	M-ENV-CC4-4-Thand M-ENV-CC4-4-P	EnvironmentalPollution	4(3TH+1P)	75+25	37
	M-ENV-CC5-4-Thand M-ENV-CC5-4-P	Natural Resources, Biodiversity and Conservation	4(3TH+1P)	75+25	39
5TH	M-ENV-CC6-5-Thand M-ENV-CC6-5-P	Environmental Management and Environmental Impact Assessment (EIA)	4(3TH+1P)	75+25	41
6TH	M-ENV-CC7-6-Thand M-ENV-CC7-6-P	Environmental Legislation and Policy	4(3TH+1P)	75+25	42
	M-ENV-CC8-6-Thand M-ENV-CC8-6-P	Disaster Management	4(3TH+1P)	75+25	43

MDC MINOR 1

Semester	PaperCode	PaperName	Credits	Marks	Pg.
3RD	M-ENV -MN1-1-Thand M-ENV-MN1-1-P	FundamentalsofEnvironment	4(3TH+1P)	75+25	34
4TH	M-ENV-MN2-2-Thand M-ENV-MN2-2-P	Principlesof Ecology	4(3TH+1P)	75+25	35
5TH	M-ENV-MN3-3-Thand M-ENV-MN3-3-P	EnvironmentalChemistry	4(3TH+1P)	75+25	36
	M-ENV-MN4-4-Thand M-ENV-MN4-4-P	EnvironmentalPollution	4(3TH+1P)	75+25	37
6TH	M-ENV-MN5-4-Thand M-ENV-MN5-4-P	Natural Resources, Biodiversity and Conservation	4(3TH+1P)	75+25	39
	M-ENV-MN6-5-Thand M-ENV-MN6-5-P	Environmental Management and Environmental Impact Assessment (EIA)	4(3TH+1P)	75+25	41

MDC: SKILLENHANCEMENTCOURSE(SEC)					
Semester	Papercode	PaperName	Credit	Marks	Pg.
1st/ 2nd / 3rd	M-ENV-SEC--Th	UrbanEnvironment Management	4	100	27

IINTERDISCIPLINARY COURSE (IDC) [for B.Sc 4yrs Hons. with/without Research and 3yrs MDC]					
Semester	Papercode	PaperName	Credit	Marks	Pg.
1ST / 2ND /3RD	ENV-D-IDC-Th & ENV-D-IDC -Pr	ENVIRONMENTAL SCIENCE	2TH+1P	75	45

SyllabusforB.ScEnvironmentalScience

[4 year B.Sc Hons. with/ without Research]

DISCIPLINESPECIFICCORECOURSE1

ENV-M-CC1-1-Th:FundamentalsofEnvironment

(Theory 75 + Practical 25)

[50LecturesTheory]

Unit-1:Basic concepts of Environmental Science: **(10 Lectures)**
Conceptofenvironmentanditscomponents–physicalcomponents(Lithosphere, Hydrosphere and Atmosphere), socioeconomic and cultural component; Principle and scope ofEnvironmentalscience;MultidisciplinaryapproachofEnvironmentalscience;Basic concept of sustainable development goals & Mission LIFE.

Unit-2:Climaticzones: **(5Lectures)**
Equatorial,Tropical,Sub-Tropical,Temperate,Tundra.-Positionandcharacteristicsofthe climatic zones.

Unit-3: Living matter and approach to evolutionary biology **(25Lectures)**
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-M-CC1-1-P:FundamentalsofEnvironment

1. Assignmenton global environmentalissues. **(15)**
2. Viva-voce **(10)**

DISCIPLINESPECIFICCORECOURSE2

ENV-M-CC2-2-Th:PrinciplesofEcology

(Theory 75 + Practical 25)

[50LecturesTheory]

Unit1:Introductionto Ecology (12lectures)

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 (8lectures)

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.

Unit3:CommunityEcology (8lectures)

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.

Unit4:Ecosystem ecology (15lectures)

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; impactsof 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-M-CC2-2-P:PrinciplesofEcology

1. LocalField studyonecosystemwith reportsubmission. **(15)**
2. Viva-voce **(10)**

DISCIPLINESPECIFICCORECOURSE3

ENV-M-CC3-3-Th:EnvironmentalChemistry

(Theory 75 + Practical 25)

[50LecturesTheory]

Unit 1: Fundamentals of environmental chemistry (15lectures)

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.

Unit3:Atmospheric chemistry (7lectures)

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.

Unit4:Waterchemistry (8lectures)

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.

Unit5:Soil chemistry (8lectures)

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 (12lectures)

Introductiontogreenchemistry,PrinciplesofGreenChemistry,theconceptofatom 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-M-CC3-3-P:EnvironmentalChemistry

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

   SoilpH,Electricalconductivityofsoilextract(ECe). **(15)**

2. LaboratoryNotebook **(5)**
3. Vivavoce **(5)**

DISCIPLINESPECIFICCORECOURSE4

ENV-M-CC4-3-Th:EnvironmentalPhysicsandClimateScience

(Theory 75 + Practical 25)

[50LecturesTheory]

Unit 1: Fundamentals of environmental physics (20lectures)

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, Conceptofblack bodyand Planck'sconstant. Carnot engineand its application in simple engine. Energy efficiency. Gas laws: Charles' law, Boyle's law, Avogadro's law.

Unit 2: Basic atmospheric physics (15lectures)

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.

Unit3: Climate Sciences (15lectures)

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. Indianmonsoon. Climateclassification:ThornthwaiteclassificationandKöppen'sclassification

ENV-M-CC4-3-P:EnvironmentalPhysicsandClimateScience

1. RecordingofAtmospherictemperature,Atmosphericpressure,RelativeHumidity, Wind speed, Rainfall. **(10)**
2. LaboratoryNotebook **(5)**
3. Vivavoce **(10)**

DISCIPLINESPECIFICCORECOURSE5

ENV-M-CC5-4-Th:EnvironmentalGeosciences

(Theory 75 + Practical 25)

[50LecturesTheory]

Unit1:History ofEarth (5lectures)

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

Unit 2:Earth systemprocesses (12lectures)

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;
Geologicalprocesses:Fluvial,glacialandaeolianprocesses,Weathering:physical, biogeochemical processes; erosion: physical processes of erosion, factors affecting erosion; LandformscreatedbyGlacial,riverineandaeolianprocesses.Coastalprocessesand 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)

Introductiontodifferentmajorrocktypes,Rockcycle:lithificationandmetamorphism; Three rocklaws;Minerals:generalstructures&properties,Broadclassificationonthebasicof 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.
*Conceptofmap:*Scaleofmap,conceptofprojectionsystem(Azimuthal&UTM), fundamental idea on topographical sheet and interpretation.

Unit5:GeologyofIndia (11lectures)

*StratigraphyofIndia:*TheArchaeanformation,Dharwarsystem,Cuddapahsystem, Vindhyan system.
*PhysiographyofIndia:*Himalayanregion,GreatplainsofIndia,PeninsularIndia,Indian desert, Coastal plains, Indian Islands.

ENV-M-CC5-4-P:EnvironmentalGeosciences

1. Identificationofrocks&minerals(HandSpecimen) **(9)**

2. Topologicalsheetinterpretation. **(8)**

3. LaboratorynotebookandVivaVoce **(8)**

DISCIPLINESPECIFICCORECOURSE6

ENV-M-CC6-4-Th:EnvironmentalPollution

(Theory 75 + Practical 25)

[50LecturesTheory]

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

Definitionof pollution; pollutants;sourceand typeofpollutants: pointsource, linesource, areasource,classification of pollutants.Solubilityof pollutants (hydrophilicand lipophilic pollutants),transferofpollutantswithindifferentmediums,local,regionalandglobal implications of Environmental pollution.

Unit2:Airpollution (14lectures)

Sources and types of pollutants- Natural and anthropogenic sources, primary and secondary pollutants. Sampling and monitoring of air pollutants (gaseous and particulates); period, frequencyanddurationofsampling.PAN,photochemicalsmog,acidrain.Effectsofdifferent pollutants on human health (NOx, SOx, PM, CO, CO_2, hydrocarbons andVOCs) 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.

Unit3:Waterpollution (15lectures)

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: GangaAction Plan; YamunaAction Plan.

Unit4:Soil pollution (3lectures)

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

Unit 5:Noisepollution (5lectures)

Noise pollution-sources; frequency, intensity and permissible ambient noise levels; measurement of noiseindices (L_{eq},L_{10}, L_{90}, L_{50}, L_{DN}, TNI) effecton 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 andsources ofradioactive pollution; effectofradiationonhumanhealth (somatic and genetic effects); radiation standards, radiation protection.

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

Unit7:Marinepollution (4lectures)

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-M-CC6-4-P:EnvironmentalPollution

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

DISCIPLINESPECIFICCORECOURSE7

ENV-M-CC7-4-Th:BiodiversityandConservation

(Theory 75 + Practical 25)

[50LecturesTheory]

Unit 1: Biodiversity patterns and estimation (15 lectures)

Definition of Biodiversity, Types: Genetic diversity, Species diversity, Ecosystem Diversity. Biodiversityestimates:alphadiversity,betadiversity&gammadiversity.Biodiversity assessment and indices: frequency, density, abundance, relative abundance, Shannon Weiner Index,Simpson'sindex,SimpsonsIndexofdiversity,Evennessindex.ConceptofGuild, Keystone and Flagship species.

Spatialpatternsofbiodiversityacrosslatitudinalandaltitudinalchanges.Metapopulation, Mid domain hypothesis. Intermediate Disturbance Hypothesis.

Unit 2: Importance of biodiversity (8 lectures)

Ecologicalservices–primaryproductivity.Rolesofbiotainhydrologicalcycle, biogeochemical cycling.

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

Othervalues:social, aesthetic,consumptive,andethicalvaluesofbiodiversity.

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

Unit3:Threatstobiodiversity (10lectures)

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)

Importanceofbiodiversitypatternsinconservation;In-situconservation(BiosphereReserves,NationalParks,WildlifeSanctuaries);Ex-situconservation(botanicalgardens, zoologicalgardens,gene banks,seed and seedling banks,pollen culture, tissue culture and DNA banks), captive breeding.

RoleofIUCNinglobalbiodiversityconservation,IUCNRedListcategorization -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 inIndia **(7lectures)**

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

ENV-M-CC7-4-P:BiodiversityandConservation

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. Vivavoce **(5)**

DISCIPLINESPECIFICCORECOURSE8

ENV-M-CC8-4-Th:EnvironmentalMicrobiology&Biotechnology

(Theory 75 + Practical 25)

[50LecturesTheory]

Unit 1: Basic Concepts of Microbiology (5 lectures)

Classificationofmicroorganisms,differentfactorsformicrobialgrowth,stainingtechniques in microbiology (Simple staining, Negative staining, Gram staining, capsule staining)

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

MicrobiologyofAir: Factorsaffectingthesurvivalofmicroorganismsinair;Sourcesof 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 pathogenicmicrobes 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, genefunctions,concept of Replication, Transcription and Translation in prokaryotes. Concept of chromosome: numerical and structural aberrations.

Unit 4: Biotechnological Applications (8 lectures)

RecombinantDNA:Basicconcepts. EnzymesformanipulationofDNA:restriction enzymes,polymerases(DNA/RNApolymerases,transferase,reversetranscriptase),other DNA modifying enzymes (nucleases, ligase, phosphatases, polynucleotide kinase); genomic andcDNAlibraries:construction,screeninganduses;cloningandexpressionvectors. 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,pumpandtreatmethod,useofbioreactorsfor

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.

Unit7:GMOs andLMOs **(2lectures)**

ConceptofGMOsandLMOs, casestudies, biosafety protocol

ENV-M-CC8-4-P:EnvironmentalMicrobiology&Biotechnology

1. GramStaining,Totalcoliformcount(MPN), ABOBloodgrouping. **(5)**
2. Reviewpaper preparation/presentationontopicsrelatedtoEnvironmentalBiotechnology.**(15)**
3. Viva-voce. **(5)**

DISCIPLINESPECIFICCORECOURSE9

ENV-M-CC9-5-Th:HydrologyandPedology (Theory 75 + Practical 25)

[50LecturesTheory]

Unit1:Waterresource (13lectures)

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 (10lectures)

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, Roleof state in water resources management. Environmental issues relating to damming on water.

Unit3:WaterresourceinIndia (4lectures)

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

Unit 4: Fundamentals of soil science (10lectures)

Soil formation; classification of soil; soil architecture; physical propertiesof 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 (5lectures)

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 (8lectures)

Type andcauses of soil erosion; biologicaland physical phenomena; visual indicatorsofland degradation; drivers of land degradation - deforestation, desertification; habitat loss, loss of biodiversity; range land degradation; land salinization; human population pressure, poverty, socio-economicandinstitutionalfactors,lossofecosystemservices;effectsonfarming

communities;effectsonfoodsecurity;effectsonnutrientcycles;futureeffectsofsoildegradation; emerging threats of land degradation to developing countries.

Differenttechniquesofsoilconservation(mechanicalandbiological)Sustainablelanduse planning; land tenure and land policy; Participatory land management.

ENV-M-CC9-5-P:HydrologyandPedology

1. *WaterandSoilanalysis:*TotalDissolvedSolids.TotalSuspendedSolids,Calciumand Magnesium Hardness, Salinity (By chemical method).

   OrganicCarbonofsoil.Carbonate&Bicarbonateofsoil,WaterHoldingcapacity **(15)**

2. LaboratoryNotebook **(5)**
3. Vivavoce **(5)**

DISCIPLINESPECIFICCORECOURSE10

ENV-M-CC10-5-Th:EnergyandEnvironment

(Theory 75 + Practical 25)

[50LecturesTheory]

Unit1:Energyresources (12lectures)

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.

Unit2:Energydemand (7lectures)

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.

Unit3:Energy,environmentandsociety(11lectures)

Energy productionas driver of environmental change; nature, scope and analysis of local and global impacts ofenergy use onthe environment;energy over-consumption and its impacton 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 andfuture energyuse patternsintheworld andinIndia;evolutionof energyuse over time;alternativesourcesasenergy–Principleandgenerationofsolarenergy(solar collectors,photo-voltaicmodules,solarponds),windenergy,geothermalenergy;tidalenergy, OTEC;nuclearenergy,energyfrombiomass,biofuels;needforenergyefficiency;energy conservation and sustainability; action strategies for sustainable energy management from a future perspective.

ENV-M-CC10-5-P:EnergyandEnvironment

1. Calculationofenergyefficiencyfromgivendata. **(10)**
2. Preparationofenergyauditofadomesticunitand reportsubmission. **(10)**
3. Viva-voce **(5)**

DISCIPLINESPECIFICCORECOURSE11

ENV-M-CC11-5-Th:EnvironmentalLegislationandPolicy

(Theory 75 + Practical 25)

[50LecturesTheory]

Unit1:Introduction (5lectures)

IntroductiontoPolicyandandRules. Constitutionof India;fundamentalrights;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:VanMahotsava 1950, NationalForestPolicy1952,NationalForest Policy 1988.; National Water Policy, 2002; National Environment Policy, 2006.

Unit 3: Environmental legislation in India (25 lectures)

Constitutionalprovisionforenvironmentalprotection:Article48A(Theprotectionandimproveme ntofenvironmentandsafeguardingofforestsandwildlife);Article51A(g) (Fundamentalduties).PolicyStatementonenvironmentanddevelopment,PILandpublic hearing.

The Indian ForestAct 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 VehicleAct 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 TribunalAct 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

ENV-M-CC11-5-P:EnvironmentalLegislationandPolicy

1. ReviewofLawCasestudieson EnvironmentalIssuesandpower pointpresentation.**(25)**

DISCIPLINESPECIFICCORECOURSE12

ENV-M-CC12-5-Th:EnvironmentalImpactAssessment

(Theory 75 + Practical 25)

[50LecturesTheory]

Unit 1: Introduction to Environmental Impact assessment (EIA) (10 lectures)

Definitions,Introduction and conceptsof EnvironmentalImpact assessment;Rationaleand historical development of EIA; Environmental impact assessment in international level: thescopes 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,MarineImpact assessment.

Unit2:EIAinPractice (18lectures)

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 EIAafter appraisal.

Unit3:EnvironmentalManagement Plan (6Lectures)

Principle and components of EMP. Synchronisation of EMP with the project cycle, Importance of EMP. Hazop study. Emergency preparedness.

Unit 4:EIAregulationsinIndia (16lectures)

EIA Notification 2006, 2009: scopes and structures, formation and roles of SEIAA, EAC, SEAC. Current issues in EIA:Fundamentals of the latest EIAnotification(Draft) 2020; Case study of hydropower projects, Thermal power projects, Mining projects, Building project.

ENV-M-CC12-5-P:EnvironmentalImpactAssessment

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. VivaVoce. (**5)**

DISCIPLINESPECIFICCORECOURSE13

ENV-M-CC13-6-Th:RemoteSensingandGIS

(Theory 75 + Practical 25)

[50LecturesTheory]

Unit 1: Science of Remote Sensing (8 lectures)

Remote Sensing: definitions and principles; Active and Passive remote sensing. Electromagnetic(EME)spectrum,PropertiesofUV,Visible,Infrared,Thermaland Microwaveranges,InteractionofEMRwithEarth'ssurface;Atmosphericwindows, Principles of Radar and Laser and Lidar.

Unit 2: Techniques of Remote Sensing (15 lectures)

Platforms:Satelliteremotesensing,PolarorbitalandGeostationarysatellites,Aerial photographyplatforms.LandsatandIndiansatellites: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:GlobalPositioningSystem (4lectures)

ThefundamentalsofGPS.GPSsatellitenetworks,Differential GPS.

Unit 4: Geographical Information Systems (13lectures)

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 (10lectures)

Fundamentalsofvegetationindices:NDVI,LAI, SVI,ApplicationofremotesensingandGIS 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.

ENV-M-CC13-6-P:RemoteSensingandGIS

1. Fundamentalsof QGIS:Georeferencing,imageinterpretation,Supervised & unsupervisedclassification, digitization, preparationofsimplethematicmaps.**(5)**
2. PreparationofaGISprojectingroups. **(10)**
3. VivaVoce **(10)**

DISCIPLINESPECIFICCORECOURSE14

ENV-M-CC14-6-Th:EnvironmentalManagement

(Theory 75 + Practical 25)

[50LecturesTheory]

Unit1:StrategiesofEnvironmental Management (5Lectures)

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.

Unit2:EnvironmentalManagement System (10Lectures)

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 14000Series: The genesis, steps, internal audit, external audit and certification procedure step by step.Profit maximisation through of certification.

Unit 3: Tools of environmental management (17 Lectures)

EnvironmentalAudit: Objectives, types of environmental audit, importance of audit, Steps of audit.Lifecycleassessment:Definition,importanceandprocedure.Environmentaldatabases,environmental compliances, report writing, IFC and World bank performance standard and capturing thosein ESIA report.

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 ofchambers of commerce.

ENV-M-CC14-6-P:EnvironmentalManagement

1. PreparationofanEnvironmentalManagementPlan onthe basisofgivenscenario. **(10)**
2. Reviewof aCSRcasestudy andreport submission. **(10)**
3. Vivavoce **(5)**

DISCIPLINESPECIFICCORECOURSE15

ENV-M-CC15-6-Th:WasteManagement

(Theory 75 + Practical 25)

[50LecturesTheory]

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

Unit-2:Solid waste management (15 lectures)
Sourcesandgenerationofsolidwaste,theirclassificationandchemicalcomposition; 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-medicalwastemanagement:generation;segregation;colourcodes;disposalandtreatments; Health consequences. Biomedical waste management in India.

E-wastemanagement:generation;segregation;disposalandtreatments;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.

Unit4:ResourceRecovery (6lectures)
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 addedproductsfromwaste;FlyashutilizationanddisposalGarbagefarming;Sewagefed fisheries; Composting.

Unit 6: Integrated waste management (4lectures)

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

Unit7:Policiesforsolid wastemanagement (10lectures)

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

ENV-M-CC15-6-P:WasteManagement

1. VisittoaWasteManagementsiteandReportsubmission. **(15)**
2. Viva-voce **(10)**

SKILLENHANCEMENTCOURSE01

ENV-M-SEC1-1-Th: EnvironmentandSociety

M-ENV-SEC1-1-Th:EnvironmentandSociety

(Theory100)

[50LecturesTheory]

Unit1:EnvironmentalLiteracy (4lectures)

Environmentalliteracy(formalandnon-formaleducation)

Unit 2: Societal view of the environment (18Lectures)

Man–Environmentrelationships:naturecentric,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,Foodinsecurity,poverty,environmentalrefugees,climatechange mitigationandadaptation.Gender-basedviolence,genderandenvironmentdebate,Ecofeminism.

Unit 3: Environmental Problems: global perspectives (12 Lectures)

Classifying environmental problems, Multi-purpose river valley projects and their environmentalandsocialimpacts,socialandecologicallossesversuseconomicbenefits, 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.

SKILLENHANCEMENTCOURSE02

ENV-M-SEC2-2-Th:UrbanEnvironmentalManagement

M-ENV-SEC-Th:UrbanEnvironmentalManagement

(Theory 100)

[50LecturesTheory]

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

ConceptofUrbanisation.Driversofurbanisation:Demographic,physical,socialand economic. Metros, cities and towns as sources and sinks of resources; resource consumption and its social, cultural, economic and ecological perspectives; urban transformation; Impacts ofurbanisationonenvironment,increasingchallengesposedbymodernityfortheenvironment.

Unit2:Urban dwelling (12lectures)

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; environmentalcostsofurbaninfrastructure.Urbanhealthproblemsandprophylaxismeasures.

Unit 3:Naturalspacesinacity (10lectures)

Conceptof'controllednature';scope,importanceandthreatstonatureinthecity;organization andplanningofgreenspacessuchasparks,gardensandpublicspaces;conceptofgreenbelts; urban natural forest ecosystem as green lungs.

Unit 4: Planning and environmental management (10lectures)

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

Unit5:NationalandInternationaleffortsinurban management (10lectures)

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.

SKILLENHANCEMENTCOURSE03

ENV-M-SEC3-3-Th:GreenTechnology

M-ENV-SEC3-3-Th:GreenTechnology

(Theory100)

[50LecturesTheory]

Unit 1: **Green infrastructure, planning and economy(15 lectures)**
Green buildings; history of green buildings, need and relevance of green buildings over conventionalbuildings,constructionofgreenbuildings;associatedcostsandbenefits;outlined examplesofgreenbuildings;Greenplanning:roleofgovernmentalbodies, landuseplanning, conceptofgreencities,wastereductionandrecyclingincities,roleofinformalsectorinwaste management, public transportation for sustainable development, green belts.

Unit 2: Applications of green technologies (18 lectures) Increaseinenergyefficiency:cogeneration,motorsystemoptimization,oxy-fuelfiring, isothermal melting process, energy efficient fume hoods, compact fluorescent lights (CFLs), motiondetectionlighting,orprogrammablethermostats).Green HouseGas(GHG) emissions reduction:carboncaptureandstorage(CCS)technologies,purchaseanduseofcarbonoffsets, promotionand/orsubsidyofalternativeformsoftransportationforemployees,suchas carpools, fuel efficient vehicles, and mass transit, methane emissions reduction and/or reuse). Pollutionreductionandremoval(FlueGasDesulfurization(FGD)methods,catalyticor thermaldestructionofNOX,FluidizedBedCombustion,Dioxinsreductionandremoval methods,ThermalOxidizersorWetScrubberstoneutralizechemicalsorheavymetals, solvent recovery systems, Low Volatile Organic Compound (VOC) paints and sealers).

Unit3:Greenchemistry (7lectures)
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.

Unit4:Greenfuture (10lectures)
Agenda of green development; reduction of ecological footprint; role of green technologies towardsasustainablefuture;majorchallengesandtheirresolutionforimplementationofgreen technologies; green practices to conserve natural resources (organic agriculture, agroforestry,
reducingpaperusageandconsumption,etc.);emphasisonwastereductioninsteadofrecycling, emphasis on innovation for green future; role of advancement in science in developing environmental friendly technologies.

SyllabusforB.ScEnvironmentalScience (MINOR)(with 4years B.Sc in other subjects) UnderCurriculumandCreditFramework,2022

MENV-MN-1-1-Th andMENV-MN-1-1-P

FundamentalsofEnvironment

(Theory75+Practical25) [50 Lectures Theory]

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

Conceptofenvironmentanditscomponents–physicalcomponents(Lithosphere, Hydrosphere and Atmosphere), socioeconomic and cultural component; Principle and scope ofEnvironmentalscience;MultidisciplinaryapproachofEnvironmentalscience;Basic concept of sustainable development goals & Mission LIFE.

Unit-2:Climaticzones: **(5Lectures)**

Equatorial,Tropical,Sub-Tropical,Temperate,Tundra.-Positionandcharacteristicsofthe climatic zones.

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

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.

MENV-MN-1-1-P:FundamentalsofEnvironment

1. Assignmenton global environmentalissues. **(15)**
2. Viva-voce **(10)**

MENV-MN-2-2-Th andMENV-MN-2-2-P

PrinciplesofEcology

(Theory 75 + Practical 25)

[50LecturesTheory]

Unit1:Introductionto Ecology (12lectures)

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 (8lectures)

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.

Unit3:CommunityEcology (8lectures)

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.

Unit4:Ecosystem ecology (15lectures)

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; impactsof 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.

MENV-MN-2-2-P:PrinciplesofEcology

3. LocalField studyonecosystemwith reportsubmission. **(15)**
4. Viva-voce **(10)**

MENV-MN-3-Th and MENV-MN-3-P

(Either in 5th or 6th Semester)

EnvironmentalChemistry

(Theory 75 + Practical 25)

[50LecturesTheory]

Unit 1: Fundamentals of environmental chemistry (15lectures)

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.

Unit3:Atmospheric chemistry (7lectures)

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.

Unit4:Waterchemistry (8lectures)

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.

Unit5:Soil chemistry (8lectures)

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 (12lectures)

Introductiontogreenchemistry,PrinciplesofGreenChemistry,theconceptofatom 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.

MENV-MN-3-P:EnvironmentalChemistry

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

   SoilpH,Electricalconductivityofsoilextract(ECe). **(15)**

2. LaboratoryNotebook **(5)**
3. Vivavoce **(5)**

MENV-MN-4-Th and MENV-MN-4-P

(Either in 5th or 6th Semester)

EnvironmentalPollution

(Theory 75 + Practical 25)

[50LecturesTheory]

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

Definitionof pollution; pollutants;sourceand typeofpollutants: pointsource, linesource, areasource,classification of pollutants.Solubilityof pollutants (hydrophilicand lipophilic pollutants),transferofpollutantswithindifferentmediums,local,regionalandglobal implications of Environmental pollution.

Unit2:Airpollution (14lectures)

Sources and types of pollutants- Natural and anthropogenic sources, primary and secondary pollutants. Sampling and monitoring of air pollutants (gaseous and particulates); period, frequencyanddurationofsampling.PAN,photochemicalsmog,acidrain.Effectsofdifferent pollutants on human health (NOx, SOx, PM, CO, CO_2, hydrocarbons andVOCs) 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.

Unit3:Waterpollution (15lectures)

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: GangaAction Plan; YamunaAction Plan.

Unit4:Soil pollution (3lectures)

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

Unit 5:Noisepollution (5lectures)

Noise pollution-sources; frequency, intensity and permissible ambient noise levels; measurement of noiseindices (L_{eq},L_{10}, L_{90}, L_{50}, L_{DN}, TNI) effecton 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 andsources ofradioactive pollution; effectofradiationonhumanhealth (somatic and genetic effects); radiation standards, radiation protection.

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

Unit7:Marinepollution (4lectures)

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.

MENV-MN-4-P:EnvironmentalPollution

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

SyllabusforB.ScEnvironmentalScience [3 year Multidisciplinary] (MDC)

CORECOURSE1/MN1

M-ENV-CC1-1-Th:/M-ENV-MN1-3-Th

FundamentalsofEnvironment

(Theory75+Practical25) [50 Lectures Theory]

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

Conceptofenvironmentanditscomponents–physicalcomponents(Lithosphere,Hydrosphere and Atmosphere), socioeconomic and cultural component; Principle and scope ofEnvironmentalscience;MultidisciplinaryapproachofEnvironmentalscience;Basic concept of sustainable development goals & Mission LIFE.

Unit-2:Climaticzones: **(5Lectures)**

Equatorial,Tropical,Sub-Tropical,Temperate,Tundra.-Positionandcharacteristicsofthe climatic zones.

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

Livingmatteronthebasisofcell-Cytologicalstudyasunitoflife,ultrastructureandfunctions of cytoplasmic and nucleoplasmic organelles like plasma membrane, mitochondria, golgi bodies, endoplasmic reticulum, ribosome, lysosome and nucleus.

Biochemicalandmolecularbasisoforiginoflife,Theoriesoforganicevolution: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)**

ConceptofDeforestation,Basicconceptofurban&industrialpollution,conceptofEcological footprintsandcarryingcapacity, Climatechange, Ozonelayerdepletion,Lossof biodiversity.

M-ENV-CC1-1-P/M-ENV-MN-1-3-P: FundamentalsofEnvironment

1. Assignmentonglobalenvironmentalissues. **(15)**
2. Viva-voce **(10)**

CORECOURSE2/MN2

M-ENV-CC2-2-Th:/M-ENV-MN2-4-Th
PrinciplesofEcology
(Theory75+Practical25)
[50 Lectures Theory]

Unit1:IntroductiontoEcology (12lectures)

Basicconceptsanddefinitions:ecology,autecology;synecology;landscape,habitatandniche, 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:PopulationEcology (8lectures)

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 (8lectures)

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.

Unit4:Ecosystem ecology (15lectures)

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 productionandmodelsofenergyflow;secondaryproductionandtrophicefficiency;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; impactsof invasion on ecosystem and communities.

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

Carbon cycle; oxygen cycle; nitrogen cycle; phosphorus cycle; sulphur cycle; nutrient cycle models;ecosysteminputofnutrients;bioticaccumulation;ecosystemlosses;nutrientsupply anduptake;roleofmycorrhizae;decompositionandnutrientrelease;nutrientuseefficiency; nutrient budget; nutrient conservation strategies.

M-ENV-CC2-2-P/M-ENV-MN2-4-P:PrinciplesofEcology

1. LocalFieldstudyonecosystem withreportsubmission. **(15)**
2. Viva-voce **(10)**

CORECOURSE3 / MN 3

M-ENV-CC3-3-Th/M-ENV-MN3-5-Th

EnvironmentalChemistry(Theory75+Practical25)

[50 Lectures Theory]

Unit 1: Fundamentals of environmental chemistry (15lectures)

PartA: Atomicstructure,electronicconfiguration,periodicpropertiesofelements(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.

Unit3:Atmosphericchemistry (7lectures)

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.

Unit4:Waterchemistry (8lectures)

Chemicalandphysicalpropertiesofwater;Gasesinwater,Henry'sLaw,alkalinityandacidity of water, hardness of water, complex formation and chelation; heavy metals in water. Colloid chemistry.

Unit5:Soil chemistry (8lectures)

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

Unit6:Greenchemistry (12lectures)

Introductiontogreenchemistry, PrinciplesofGreenChemistry, theconceptofatom 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.

M-ENV-CC3-3-P/M-ENV-MN3-5-P:EnvironmentalChemistry

1. *WaterandSoil analysis:* pH,Electricalconductivity,TotalHardnessofwater,Total Alkalinity of water, Dissolved Oxygen, Chloride of water.

   SoilpH,Electricalconductivityofsoilextract (ECe). **(15)**

2. LaboratoryNote book **(5)**
3. Vivavoce **(5)**

CORECOURSE4 /MN 4

M-ENV-CC4-4-Th:/M-ENV-MN4-5-Th

EnvironmentalPollution(Theory75+Practical25) [50 Lectures Theory]

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

Definition of pollution; pollutants;source and type ofpollutants: pointsource, line source, areasource,classification of pollutants.Solubilityof pollutants (hydrophilicand lipophilic pollutants),transferofpollutantswithindifferentmediums,local,regionalandglobal implications of Environmental pollution.

Unit2:Airpollution (14lectures)

Sources and types of pollutants- Natural and anthropogenic sources, primary and secondary pollutants. Sampling and monitoring of air pollutants (gaseous and particulates); period, frequencyanddurationofsampling. PAN,photochemicalsmog,acidrain.Effectsofdifferent 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 andurbanairquality.Controldevicesforparticulatematter:Principleandworkingof:settling chamber, centrifugal collectors, wet collectors, fabric filters and electrostatic precipitator. Controlofgaseousairpollutantsthroughadsorption,absorption,condensationandcombustion 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.

Unit3:Waterpollution (15lectures)

Sourcesofsurfaceandgroundwaterpollution;waterqualityparametersandstandards;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,heavymetalsandorganiccontaminants.Microbiologicalanalysis–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 bioreactorneutralization,ETPsludgemanagement;digesters,upflowanaerobicsludgeblanket reactor, fixed film reactors, sequencing batch reactors, hybrid reactors, bioscrubbers, biotrickling filters. Case study: Ganga Action Plan; Yamuna Action Plan.

Unit4:Soil pollution (3lectures)

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

Unit 5:Noisepollution (5lectures)

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)

Radioactivematerialandsourcesofradioactivepollution;effectofradiationonhumanhealth (somatic and genetic effects); radiation standards, radiation protection.

ThermalPollution-SourcesofThermalPollution,HeatIslands,causesandeffectsofthermal pollution.

Unit 7:Marinepollution (4lectures)

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.

M-ENV-CC4-4-P/M-ENV-MN4-5-P:EnvironmentalPollution

4. Analysis of BOD, COD, Noise (dB(A), SPM, RSPM (Demonstration), Dust fall rate, Soilrespiration. **(15)**
5. VivaVoce **(5)**
6. Laboratory notebook **(5)**

CORECOURSE5 / MN 5

M-ENV-CC5-4-Th:/M-ENV-MN5-6-Th
NaturalResources,Biodiversity andConservation
(Theory 75 + Practical 25)
[50LecturesTheory]

Unit1:Introduction (10Lectures)

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.

Unit2:Resourcemanagement(10Lectures)

Approachesinresourcemanagement:ecologicalapproach;economicapproach;ethnological approach; implications of the approaches; integrated resource management strategies.

Unit3:Biodiversity patterns (5 lectures)

DefinitionofBiodiversity,Types:Geneticdiversity,Speciesdiversity,EcosystemDiversity. Biodiversityestimates:alphadiversity,betadiversity&gammadiversity.

Unit 4: Importance of biodiversity (7lectures)

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

Ecosystemservices-purificationofwaterandair,climatecontrol,pestcontrol,pollination, and formation and protection of soil.

Othervalues:social,aesthetic,consumptive,andethicalvaluesof biodiversity.

Biodiversityvaluation–NTFPs/NWFPs,MarketandNonmarketvalues,Tangibleandnon-tangible values, use and non-use values. Option value, Existence value, Bequest value.

Unit 5:Threats tobiodiversity (10lectures)

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 6: Conservation of biodiversity (10lectures)

Importanceofbiodiversitypatternsinconservation;In-situconservation(BiosphereReserves,NationalParks,WildlifeSanctuaries);Ex-situconservation(botanicalgardens, zoologicalgardens,gene banks,seed and seedling banks,pollen culture, tissue culture and DNA banks), captive breeding.

Roleof IUCNinglobalbiodiversity conservation,IUCNRedList 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 oflocalcommunitiesandtraditionalknowledgeinconservation;afforestation;socialforestry; agroforestry; joint forest management; Ecological Restoration.

M-ENV-CC5-4-P/M-ENV-MN5-6-P
NaturalResources,BiodiversityandConservation

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 local area (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. Vivavoce **(5)**

CORECOURSE6 / MN 6

M-ENV-CC6-5-Th/M-ENV-MN6-6-Th

EnvironmentalManagementandEnvironmentalImpactAssessment(EIA)

(Theory75+Practical25)

[50LecturesTheory]

Unit1:StrategiesofEnvironmental Management (8Lectures)

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: Tools of environmental management (12 Lectures)

EnvironmentalAudit:Objectives,typesofenvironmentalaudit,importanceofaudit,Steps ofaudit.Lifecycleassessment:Definition,importanceandprocedure.Ecolabelling and Ecomark. Environmental Risk assessment. Hazop study. Emergency preparedness.

Unit 3: Introduction to Environmental Impact assessment (EIA) (8 lectures)

Definitions,IntroductionandconceptsofEnvironmentalImpactassessment;Rationaleand historical development of EIA. Types of EIA: Rapid EIA, Comprehensive EIA, Strategic EIA. Social Impact assessment,MarineImpact assessment.

Unit4:EIAin Practice (12lectures)

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.

Unit5:EIAregulationsinIndia (10lectures)

EIA Notification 2006, 2009: scopes and structures, formation and roles of SEIAA, EAC, SEAC.CurrentissuesinEIA: FundamentalsofthelatestEIAnotification (Draft)2020;Case study of hydropower projects, Thermal power projects, Mining projects, Building project.

M-ENV-CC6-5-P/M-ENV-MN6-6-P:EnvironmentalManagement&EIA

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. VivaVoce. (**5**)

CORECOURSE7

M-ENV-CC7-5/6-Th

EnvironmentalLegislationandPolicy (Theory 75 + Practical 25)

[50LecturesTheory]

Unit1:Introduction (5lectures)

Introduction toPolicyand and Rules. Constitutionof India;fundamentalrights; fundamental duties; Union of India; union list, state list, concurrent list.

Unit 2: Evolution of environmental legislation and policy (10 lectures)

ProvisionofEnvironmentalConservation-BritishIndia:IndianPenalCode1860,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)

Constitutionalprovisionforenvironmentalprotection:Article48A(Theprotectionand improvementofenvironmentandsafeguardingofforestsandwildlife);Article51A(g) (Fundamentalduties).PolicyStatementonenvironmentanddevelopment,PIL andpublic hearing.

The Indian Forest Act 1927; The Wildlife (Protection) Act 1972; The Water (Prevention and ControlofPollution)Act1974TheWater(PreventionandControlofPollution)CessAct1977; TheForests(Conservation)Act1980;TheAir(PreventionandControlofPollution)Act1981; TheEnvironment(Protection)Act1986andRules 1986;MotorVehicleAct1988;ThePublic LiabilityInsuranceAct1991;TheNationalEnvironmentAppellateAuthorityAct,1997;Noise Pollution (Regulation and Control) Rules 2000;; The Biological Diversity Act 2002; The ScheduleTribesandotherTraditionalDwellers(RecognitionofForestsRights)Act2006;The NationalGreenTribunalAct2010,CoastalRegulationZones(CRZ)1991amendedfromtime to time.

Unit 5: International laws and policy (10 lectures)

Ramsar convention (1971); Stockholm Conference 1972; United Nations Conference on EnvironmentandDevelopment1992;RiodeJaneiro(RioDeclaration,Agenda21,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

M-ENV-CC7-5/6-P:EnvironmentalLegislationandPolicy

1.ReviewofLawCasestudieson EnvironmentalIssuesand powerpointpresentation.**(25)**

CORECOURSE8

M-ENV-CC8-6-Th:DisasterManagement(Theory75+Practical25) [50 Lectures Theory]

Unit1:Introduction (5lectures)

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.

Unit2:Natural hazards (12lectures)

Natural hazards: hydrological, atmospheric & geological hazards; Earthquake: seismicwaves, 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:causesandlocationoftsunamis;Slowonsethazards:Coastalerosion,sealevel changes and its impact on coastal areas and coastal zone management. Epidemics & Pandemics: causesandreasonsofspread.CasestudiesofBhujEarthquake,IndianOceantsunami,2004,COVID- 19.

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

Impactsofanthropogenicactivitiessuchasrapidurbanization,injudiciousgroundwater extraction,sandminingfromriverbank,deforestation,mangrovesdestruction;roleof constructionalongriverbanksinelevatingfloodhazard;disturbingfloodplains.deforestationandlandslid ehazardsassociatedwithit;largescaledevelopmentalprojects,likedams 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 componentsofrisk:likelihoodandconsequences,qualitativelikelihoodmeasurement;Categories ofconsequences(directlosses,indirectlosses,tangiblelosses,andintangible losses); Application of geoinformatics in risk assessment and disaster management.

Unit5:DisasterManagement&Mitigation (12lectures)

DisasterManagementcycle.ChangeinConceptofDisastermanagementtoDisasterRiskReduction. Concept of mitigation; types of mitigation: structural and non-structural mitigation, use of technologiesinmitigationssuchasbarrier,deflectionandretentionsystems;conceptofpreparedness; 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 Flashflood,Builtitbetter:fromSupercyclone1999to*Phailin*in2013,Builtitbetter:from*Aila*2009 to *Amphan*, 2020.

Unit6:NationalandInternationalperspectiveofDisastermanagement(6lectures)

International Efforts for disaster management. Hyogo framework, Sendai Framework 2015 – 2030. NationalDisasterManagementFramework,Nationalresponsemechanism,roleofgovernmentbodies 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.

M-ENV-CC8-6-P:Disaster Management

1. Preparationofdisastermanagementplananditspresentation. **(20)**
2. Vivavoce **(5)**

SyllabusforInterdisciplinaryCourse(IDC)

Environmental Science [ENVD]

ENV-D-Th:EnvironmentalScience(Theory50+Practical25)

Unit1:UnderstandingtheEnvironment (5Lectures)

Concept of environment and its Transdisciplinary approach, perspectives of environmentalism, Environmental ethics, Man-environment relationships, Environment-society interface, conflict between environment and development. Concept of carrying capacity, resilience and ecological footprints. Carbon footprint and low carbon economy.

Unit 2: Environmental systems (6 Lectures)

Concept of atmosphere, lithosphere, hydrosphere and biosphere and their interactions. Importance of biogeochemical cycles (Carbon, Nitrogen, Sulphur, Phosphorous), Global heat budget, basics of climate and weather, meteorological parameters, climatic zones of the world Basics concept of renewable energy resources.

Introduction to Biodiversity and its' types (genetic, species, ecosystem diversity; α, β & γ diversity), importance of biodiversity.

Unit 3: Environmental vulnerability (8 Lectures)

Environmentaldegradation:qualitativeandquantitative.Air,waterandsoilpollutionsource, impacts and remedial measures.

Concept of Municipal solid waste and hazardous waste, 5Rs of waste management, basic concept of circular economy.

Biodiversityloss:extentofloss,naturalandanthropogeniccausesandimpactofbiodiversity loss on ecology and economy.

Climate change: past and present scenario of climate change. drivers of climate change. impactofclimatechangeonseallevelrise,biodiversity,agriculture,diseaseprevalence,food security, migration and demographic changes.

Unit 4: Environmental Health (5Lectures)

ConceptofEnvironmentalhealth:definitionandcomponents.Environmentalrisk factorsWaterbornediseases:Choleraand Diarrhoealdiseases. Vectorbornediseases: DengueandMalaria.OccupationalhealthandHealthconsequencesofdifferentoccupations - Silicosis, Asbestosis. Basics of Xenobiotics.

Unit 5: Sustainable development (6 Lectures)

ConceptsofsustainabilityGenesisofSustainableDevelopment–Brundtland'scommission. Rio declaration – Agenda 21. Sustainable Development Goals (SDG). Sustainability developmentindex,Sustainabilityinthecontextofenergyuse,

agriculture, industry and urbanization. Watershed management and sustainable landuse. Concept of sustainable agriculture.

Unit 6: Disaster Management: (5Lectures)

Typesofdisasters,disasterpredictionandprevention,preandpostdisaster management.DisasterManagementcycle.Casestudiesofnaturaldisasters–Cyclone *'Phailin'*, Cyclone *'Amphun'*, Kerala floods and anthropogenic disasters- Bhopal gas tragedy, Chernobyl disaster. Disaster management Act (2005) of India.

Unit 7: Tools for addressing environmental challenges (7 Lectures)

Monitoringandabatementtechnologyforairpollution(monitoringofgaseousand particulatespollutantsandabatementtechnologies –bagfilter,scrubber,ESP,cyclone precipitator)waterpollution (monitoring ofDO,BOD,COD,coliform andprimary treatment,secondarytreatment,tertiarytreatmenttechnologies);Soilpollutionabatement through bioremediation.

EnvironmentalapplicationofRemotesensingand GIS.

Unit8:EnvironmentalManagementtoolsforSustainabledevelopment:(8Lectures)

Global and National Initiatives: Convention on Biological Diversity, 1992; Kyoto Protocol, 1997, Montreal Protocol, 1987; Basel convention, 1989, Copenhagen, 2009, Rio+20, 2012; Paris Accord, 2015. Environmental Management System and ISO 14001, Ecolabelling and Ecomark, Basics of Environmental Impact Assessment, Life Cycle Assessment. Clean Development Mechanism: Carbon trading and Polluters Pay principle.

ENV-D-Pr:PRACTICAL:

1. Measurement of meteorological parameters: Relative humidity, Rainfall, Atmospheric pressure, Wind speed. **10**
2. Biodiversitydocumentationanditsquantification(Frequency,Density,Shannon Weiner and Simpson's index of diversity). **10**
3. Submissionofassignmentonanycasestudyofanysustainableenvironmental management (land, energy, agriculture, water, industrial pollution etc.) **5**

SuggestedReading:

1. AbbasiT.andAbbasiS.A.,2010.*RenewableEnergyResources:TheirImapcton Global warming and Pollution.* PHI.
2. Abraham, C.M. 1999. *Environmental Jurisprudence in India*. Kluwer Law International.
3. Agarwal,A.andNarain,S.1997.*DyingWisdom.*CSEPublication.
4. Agawal,A.,Narain,S.andKhurana,I.2001.*MakingWaterEverybody'sBusiness.* CSEPublication.
5. Anastas,P.T.&Warner,J.C.1998.*GreenChemistry: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.,PepperI.L.,Brussean,M.2004.EnvironmentalMonitoringand Characterization. Academic Press.
8. Asnani,P.U.2006.Solidwastemanagement.*IndiaInfrastructureRepart570.*
9. Bagchi,A.2004. *DesignofLandfillsandIntegratedSolidWasteManagement*. John Wiley & Sons.
10. BairdC.,andCannM.,2005.*EnvironmentalChemistry(3rdEd.)*.WHFreemanand Co.
11. BanerjeeP.K.,2006.*TextbookofGeology*,WorldPress.
12. BanerjeeP.K.,2011. *IntroductiontoBiostatistics*.S,Chand.
13. Bansil,P.C.2004.*WaterManagementinIndia*.ConceptPublishingCompany,India.
14. Barrow,C.J.2000.*SocialImpactAssessment:AnIntroduction.*OxfordUniversity Press.
15. Barry,R.G.2003.*Atmasphere, WeatherandClimate*.RoutledgePress,UK.
16. BawaK.S.,PrimackR.B,OommenM.A.2004.*ConservationBiology:APrimerfor South Asia.* University Press.
17. Blackman,W.C.2001.*BasicHazardausWasteManagement*.CRC Press.
18. Bluman, 2007.*ElementaryStatistics:A stepbyStepApproach*.McGrawhill.
19. BlythF.G.H.,andFreitasM.H.2006.*AGeologyforEngineers(7thEd.&1stIndian ed.).* Elsevier.
20. Boeker,E.&Grondelle,R.2011.*EnvironmentalPhysics:SustainableEnergyandClimate Change*. Wiley
21. BoyleG.,2004.*RenewableEnergy:PowerforSustainableFuture.*OxfordUniversity Press.
22. Brady,N.C.&Well,R.R.2007.*TheNatureandPropertiesofSoils*(13thedition), Pearson Education Inc.
23. Brebbia,C.A.2013.*WaterResourcesManagementVII*.WITPress.
24. Coppola D.P. 2007. *Introduction to International Disaster Management*. Butterworth Heinemann.

25. Craig,J.R.,Vaughan.D.J.&Skinner.B.L.1996.*ResourcesoftheEarth:Origin,Use, andEnvironmental Impacts*(2nd edition). Prentice Hall, New Jersey.
26. Craig.J.R.,Vaughan,D.J.,Skinner.B.J.1996.*ResourcesoftheEarth:Origin,use, and environmental impact*(2nd edition). Prentice Hall, New Jersey.
27. Critchfield,H.J.2012.*GeneralClimatology(4th&Indianedition),*PHI.
28. Cutter, S.L. 2012.*Hazards Vulnerability andEnvironmentalJustice*. Earth Scan, Routledge Press.
29. DasAsimK.2010.*EnvironmentalChemistrywithGreenChemistry*.Booksand Allied.
30. Das,N.G.*StatisticalMethods*.McGrawHill Publication.
31. Demers,M.N.2005.*FundamentalsafGeagraphicInfarmatianSystem*.Wiley&Sons.
32. Divan,S.&Rosencranz,A.2001.*EnvironmentalLawandPalicyinIndia*.OxfordUniversity Press.
33. D'Monte,Darryl.1985.*IndustryversusEnvironmentTemplesarTambs*.ThreeControvers ies, Delhi, CSE.
34. Elliott,D.1997.*Sustainable Technology. Energy, Society and Environment* (Chapter3).NewYork,RoutledgePress.
35. EmilianiC.1992.*PlanetEarth,*CambridgeUniversity Press.
36. Evans,G.G.&Furlong,J.2010.*EnvironmentalBiotechnology:Theoryand Application* (2nd edition). Wiley-Blackwell Publications.
37. Farndon,J.andParker,S.2009.*TheIllustratedEncyclopediaofMineralsRocks& Fossils of the World,* Hermes House.
38. Forinash,K.2010.*FoundationofEnvironmentalPhysics*.IslandPress.
39. Freeman,A.M.2003.*MillenniumEcosystemAssessment:ConceptualFramework*. Island Press.
40. Freeman,A.M.2001.*Measuresof valueandResources:ResourcesfortheFuture*. Washington DC.
41. Futuyma,D.J.2009.*Evalutian*(2nd edition).SinauerAssociates.
42. Gaston,K.J.&Spicer,J.I.1998.*Biodiversity:AnIntroduction*.BlackwellScience, London, UK.
43. Gaston,K.J.2010.*UrbanEcology*.CambridgeUniversityPress,NewYork.
44. Gillespie,J.H.1991.*TheCausesofMolecularEvalutian*.OxfordUniversityPress.
45. Ginley,D.S.& Cahen,D.2011.*FundamentalsofMaterials forEnergyand Environmental Sustainability*. Cambridge University Press.
46. Glasson,J.,Therivel,R.,Chadwick,A.1994.*IntroductiontaEnvironmentalImpactAssessm ent*. London, Research Press,UK.
47. Graur,D.&Li,W.H.1999.*Fundamentals OF Molecular Evaluation* (2nd edition). Sinauer Associates.
48. Groom.B.&Jenkins.M.2000.*GlobalBiodiversity:Earth'sLivingResourcesinthe21st Cent ury*
49. Guha,P.K.2013.*RemoteSensingfortheBeginner(3rd ed.),AffiliatedEastWest Press.*

50. Gupta,K.R.2006.*EnvironmentalLegislationinIndia*.AtlanticPublishersand Distributors.
51. Gurevitch,J.,Scheiner,S.M.,&Fox,G.A.2002.*TheEcologyofPlants*.Sinauer associates incorporated.
52. Gurjar,B.R., Molina,L.T.& Ojha C.S.P. 2010. *Air Pallution: Health and Environmental Impacts*. CRC Press, Taylor&Francis.
53. Hardy,J.T.2003.*ClimateChange:Causes,EffectsandSalutians*.JohnWiley&Sons.
54. HavlinJ.L.,BeatonJ.D.,Tisdale,S.L.,NelsonW.L,2013.*SoilFertilityandFertilizer: An Introduction to Nutrient Management (8th Ed.).* PHI / Pearson.
55. HenryJ.G.andHeinkeG.W.2004.*Environmental ScienceandEngineering(2nd Ed.).* PHI.
56. Hester,R.E.&Harrison,R.M.1998.*AirPallutianandHealth*.TheRoyalSocietyofChemis try, UK.
57. Hewwood,I.,Cornelius,S.,Carver,S.2009.*AnIntroductiontoGeographical Information Systems (3rd ed.).* Pearson.
58. Hites,R.A.2012.*ElementsofEnvironmentalChemistry*(2nd edition).Wiley&Sons.
59. Husain,Majid2020.GeographyofIndia(9thEd.).McGraw Hill.
60. JensonJ.R.2003.*RemoteSensingoftheEnvironment:AnEarthResourcePerspective*. Pearson.
61. JohnM.Fryxell,AnthonyR.E.Sinclair,GraemeCaughley2014WildlifeEcology, Conservation, and Management, (3rd Edition), Wiley Blackwell
62. Johnson,D.L.2006. *LandDegradation*(2nd edition).Rowman&Littlefield Publishers.
63. Jordening,H.J.&WinterJ.2005.*EnvironmentalBiotechnology:Conceptsand Applications*. John Wiley & Sons.
64. Judith,P.1999.*HandbookofEnvironmentalImpactAssessment*.BlackwellScience.
65. Keller,E.A.20ll.*IntroductiontoEnvironmentalGeology*(5th edition).PearsonPrentice Hall.
66. Keller,E.A.1996.*IntroductiontaEnvironmentalGealagy*.PrenticeHall,UpperSaddleRiv er, New Jersey.
67. Klee,G.A.1991.*ConservationofNaturalResources*.PrenticeHallPublication.
68. Krebs C.2009.*Ecology:ExperimentalAnalysisofDistributionandAbundance(6th Ed.).* Pearson.
69. Krebs,C.1999.EcologicalMethodology(2ndEd).BenjaminCummings.
70. Krishnamurthy,K.V.2004.*AnAdvancedTextBookaJBiodiversity-Principles and Practices*.
71. LalD.S.2011.*Climatology*.ShardaPustakBhawan.
72. Leeder,M.,Arlucea,M.P.2005.*PhysicalProcessesinEarthandEnvironmental Sciences.* Blackwell Publishing.
73. Leelakrishnan,P.2008.*EnvironmentalLawinIndia*(3rd edition).LexisNexisIndia.
74. LillesandT.M.andKieferR.W.,2011.*RemoteSensingandImageInterpretation(6th ed.).* Wiely.

75. Lodish,H.F.,Baltimore,D.,Berk,A.Zipursky,S.L.Matsudiara,P.&Darnell,J. 1995.*Molecular Cell Biology*. W.H. Freeman.

76. Lomolino,M.V.,Riddle,B.R.,Whittaker,R.J.&Brown,J.H.2010.*Biageagraphy*(4th edition) Sinauer Associates, Sunderland.

77. Loreau,M.&Inchausti,P.2002.*BiodiversityandEcosystemfunctioning:Synthesis and Perspectives.* Oxford University Press, Oxford, UK.

78. Loucks,D.P.,Stedinger,J.R.&Haith,D.A.1981.*WaterResourceSystems Planning and Analysis*. Englewood Cliffs, NJ, Prentice Hall.

79. Manahan,S.E.2000.*FundamentalsofEnvironmentalChemistry*.CRCPress.

80. Manahan,S.E.2015.*WaterChemistry*.CRCPress.

81. Mani,M.S.1974.*EcologyandBiogeographyinIndia*.Dr.WJunk Publishers., TheHague.

82. Marriott,B.1997.*EnvironmentalImpactAssessment:APracticalGuide*.McGraw-Hill, New York, USA.

83. Marsh,W.M.&Dozier,J.1983.*LandscapePlanning:EnvironmentalApplications*.JohnWi ley and Sons.

84. Masters, G.M., andElaW,P.,2008. *IntroductiontoEnvironmentalEngineeringand Science (3rd Ed.).*Pearson.

85. Mathez,E.A.2009.*ClimateChange:TheScienceafGlabalWarmingandourEnergy Future*. Columbia University Press.

86. Mays,L.W.2006.*WaterResourcesSustainability*.TheMcGraw-HillPublications.

87. McDougall,F.R.,White,P.R.,Franke,M.,&Hindle,P.2008.*IntegratedSolidWaste Management: A Life Cycle Inventory*. John Wiley & Sons.

88. McMurryJ.H.,andFay,R.C,2008.*Chemistry(5thEd.)*,Pearson.

89. MillerG.T.,1996.*LivingintheEnvironment(9thEd.)Wadsworthpublication.*

90. Miller,G.T2012.*EnvironmentalScience*.WadsworthPublishingCo.

91. Minkoff,E.C.1983.*EvalutianaryBialagy*.AddisonWesley.PublishingCompany.

92. Mitra,A.P.,Sharma,S.,Bhattacharya,S.,Garg,A.,Devotta,S.&Sen,K.2004.*Climate Change and India*. Universities Press, India.

93. NarainS.,2017.*EnvironmentReaderforUniversities*.CESDelhiPublication.

94. Narayanan,P.2000.*EssentialsofBiophysics.*NewAgePublications.

95. Nei,M.1987.*MolecularEvolutionaryGenetics*.ColumbiaUniversitypress.

96. Odum,E.P.1971.*FundamentalsofEcology*.W.B.SoundersNatrajpublication (Indian edition).

97. Owen,O.S,Chiras,D.D,&Reganold,l.P. 1998. *Natural Resaurce Canservatian-Management for Sustainable Future* (7thedition). Prentice Hall.

98. PandeyG.N.2013.*EnvironmentalManagement.*Vikash.

99. Pandit,M.K.&GrumbineR.E.2012.Ongoingandproposedhydropowerdevelopmentinthe Himalayaanditsimpactonterrestrialbiodiversity.*ConservationBiology*26:1061- 1071.

100. Park,K.2015.*Park'sTextbookofPreventiveandSocialMedicine*(23rdedition). Banarsi das Bhanot Publishers.

101. Perman,R.2003.*NaturalResourceandEnvironmentalEconomics*.Pearson Education.

102. Philander,S.G.2012.*EncyclopediaafGlobalWarmingandClimateCha*nge (2nd edition).Sage Publications.

103. Pimentel,D.(Ed.).2011.*Biologicalinvasions:Economicandenvironmentalcostsof alien plant, animal, and microbe species*. CRC Press.

104. Pine,J.C.2009.*NaturalHazardsAnalysis:ReducingtheImpactaJDisasters*. CRC Press, Taylor and Francis Group.

105. PrasadCVRK,2005,*ElementaryExercisesinGeology*,UniversityPress.

106. Prescott,HarleyandKlein,2008.*Microbiology(7th ed.)*.McGrawhill.

107. Primack,R.B.2002.*Essentialsof CanservatianBiology*(3rd edition). Sinauer Associates, Sunderland, USA.

108. Purohit,S.S.&Ranjan,R.2007.*Ecology,Environment&Pollution*.AgrobiosPublication s.

109. Radojevic,M.andBaskinV.N.1999.*PracticalEnvironmentalAnalysis*.Royal Society of Chemistry, Cambridge.

110. RamachandraT.V.,2009.*MunicipalSolidWasteManagement*.TERIpress.

111. Ramade,F.1984.*EcologyofNaturalResources*.JohnWiley&SonsLtd.

112. Rastogi,B.B.*Biostatistics*.MEDTEC.

113. Richards,J.A.&Jia,X.1999.*RemateSensingandDigitalImageProcessing*. Springer.

114. Richter,M.&Weiland,U.(ed.).2012.*AppliedUrbanEcology*.Wiley-Blackwell, UK.

115. Ricklef,R.E.,andMillerG.L.,1999.*Ecology(4thEd.)*.Freeman.

116. Rittman,B.E. &McCarty,P.L.2001. *Environmental Biotechnology. Principles and Applications.* McGraw-Hill, New York.

117. Sabins,F.F.1996.*RemoteSensing:PrinciplesanInterpretation*.W.H.Freeman.

118. SantraS.C.2011.*EnvironmentalScience(3rdEd.)*.NewCentralBookAgency.

119. SawyerC.N,McCartyP.L.andParkinG.F.,2003.*ChemistryforEnvironmental Engineering and Science (5th Ed., Indian Ed.2017)*. McGraw Hill Education.

120. Scherr,S.J.1999.*Soildegradation:Athreattodeveloping-countryfoodsecurityby2020?*(Vol.27). International Food Policy Research Institute.

121. Schneid,T.D.&Collins,L.2001.*DisasterManagementandPreparedness*.Lewis Publishers, New York, NY.

122. SchwabG.O.,Fangmeier,D.D.Elliot,W.J.,FrevertR.K.,2005.*SoilandWater Conservation Engineering (4th Ed.)*. Wiely.

123. Schward&Zhang,2003.*FundamentalsofGroundwater*.JohnWilleyandSons.

124. ScraggA.2005.*EnvironmentalBiotechnology(2ndEd.)*.OxfordUniversity press.

125. SengarD.S.2012.*EnvironmentalLaw*.PHI.

126. SharmaP.D2014*EnvironmentalBiologyandToxicology*.RastogiPublications

127. Shastri,S.C. 2022.Environmental Law(7THEd.).EBC publications.

128. ShawR.,andKrishnamurthyR.R.,2009.*Disaster:GlobalChallengesandLocal Solutions.*

129. SilberbergM.S.,2016.*Chemistry:ThemolecularNatureofMatterandChange(7th Ed.).* McGraw Hill Higher Education.

130. SinceroA.P.andSinceroG.A.,2012.*EnvironmentalEngineering(IndianEd.).*PHI.

131. Singh,K.&Shishodia,A.2007.*EnvironmentalEconomics:TheoryandApplications*. Sage publications.

132. Singh,G.2012.*PlantSystematics:TheoryandPractice*(3rdedition).Oxford&IBH Pvt.Ltd., New Delhi.

133. Singh,Parbin,2016.EngineeringandGeneralGeology(8thEd.),Katson Books.

134. Singh,Savindra,2017.PhysicalGeology.Pravalikapublications.

135. Singh,J.S., Singh,S.P.& Gupta,S.2006. *Ecology, Environment and Resource Conservation. A*namaya Publications, New Delhi.

136. Smith,K.2001.*EnvironmentalHazards:AssessingRiskandReducingDisaster*. Routledge Press.

137. Smith,R.L.andSmith,T.M.2001.EcologyandFieldBiology.Benjamin Cummings.

138. Snustad,D.P.&Simmons,M.J.2011.*PrinciplesofGenetics*(6thedition).JohnWiley&Sons .

139. Sodhi,N.S.&Ehrlich,P.R.(Eds).2010.*ConservationBiologyforAll*.OxfordUniversity Press.

140. SubrahmanyamN.S.andSambamurtyA.V.S.S.2006. *Ecology(2nded.).*Narosa.

141. Taylor D.J., GreenNPO, StoutG.W., 2005. *Biological Science(3rd ed).* Cambridge University Press.

142. ThompsonandFredrick.1997.*EcologicalDesignandPlanning.*JhonWileyandSons.

143. ThornburyWilliumD.2002.*PrinciplesofGeomorphology,*CBSPublishersand Distributers.

144. Tietenberg,T.H.&Lewis,L.2010.*EnvironmentalEconomicsandPolicy*.Addison-Wesley.

145. Tietenberg,T.2004.*EnvironmentalandNaturalResourceEconomics*(6thEdition). Pearson Education Pvt.Ltd.

146. Tiwari, G.N. &Ghosal. M.K. 2005. *Renewable Energy Resources: Basic Principlesand*

147. Todd,D.K.andMaysL.W.,2011.*GroundWaterHydrology(3RDEd).*Wiley.

148. Tortora,FunkeandCase,2001.*AnIntroductiontoMicrobiology(7thed.).* Benjamin&Cummins.

149. Turner,R.K.,Pearce,D.,&Bateman,I.1994.*EnvironmentalEconomics:An Elementary Introduction.* Harvester Wheatsheaf.

150. USEPA.1999.*GuideforIndustrialWasteManagement*.WashingtonD.C.

151. Valoon G.W. and Duffy S.J. 2000. *Environmental Chemistry: A global perspective(Indian Edition).* Oxford University Press.

152. Venkat,A.2011.*EnvironmentalLawandPolicy*.PHILearningPrivateLtd.

153. Vesilind,P.1.,Peirce,1.1.,&WeinerR.F.1990.*EnvironmentalPollutionandControl*. Butterwth- Heinemann, USA.

154. Vickers,A.2001.*HandbookofWaterUseandConservation*.WaterPlowPress.

155. Vogel's*textbookofquantitativeinorganicanalysis,includingelementaryinstrumental analysis* 1978 (4th ed.) Longman

156. Wainwright,M.1999.*AnIntroductiontoEnvironmentalBiotechnology*.Springer.

157. Wallace,J.M.&Hobbs,P.V.1977.*AtmasphericScience:AnIntroductorySurvey*. Academic Press, New York.

158. WelfordR.1996.*CorporateEnvironmentalManagement.* UniversityPress.

159. Whitaker,J.C.,&Mancini,R.K.2018.Technicaldocumentationandprocess.CRC Press.

160. Wilkins,J.S.2009.*Species:AHistaryaftheIdea*(Vol.1).Universityof California Press.

161. Williams,D.M.,Ebach,M.C.2008.*FaundatiansofSystematicsand Biogeography*. Springer.

162. Zar, 1.H.2010.*BiostatisticalAnalysis*(5thedition).Prentice