NabadwipVidyasagar College

Department of Environmental Science

Under Graduate Programme

Programme Outcome (PO) and Course Outcome (CO)

Program Outcome (PO):

- Investigate the complexities of the natural environment and our relationship with it.
- Explore the problems we face in understanding our natural environment and in living sustainability.
- Develop scientific, interpretive and creative thinking skills.
- Learn to apply quantitative analysis and field research techniques.
- Learn geographical information systems to study environmental change.

Semester	Course Code-& Title	Course Content	Course Outcome (CO)
I	UG-ENVS-H-CC-01- Earth And Earth Surface Processes	**Unit-1- History of Earth** • Formation of the Earth: formation and composition of core, mantle, crust, atmosphere and hydrosphere; • Chemical composition of earth; geological time scale and major changes on the earth's surface; • Holocene and the emergence of humans, role of humans in shaping landscapes; • Development of cultural landscapes.	**CO 1.** Create in student's ability to understand about changes in Earth's history with time. **CO 2.** Students will be able to analyze formation of Solar System, Earth, Atmosphere and Hydrosphere through study of Solar System and history of Earth. **CO 3.** Students will learn about the development of landscape
		Unit-2- Earth System Process • Movement of lithosphere plates; mantle convection and plate	**CO 4.** Students will be able to analyze role of Plate Tectonics in Various Earth Surface Processes.

		tectonics, major plates and hot spots, plate boundaries; sea floor spread; • Earthquakes; volcanic activities; orogeny; • Continental drift, Pangaea and present day continents, paleontological evidences of plate tectonics; continental collision and mountain formation with specific example of the Himalaya.	**CO 5.** Students will learn about the process of continental drift and volcanic activity.
		UNIT-3- Minerals And Rocks • Minerals and important rock forming minerals; • Rock cycle: lithification and metamorphism; Three rock laws; • Rock structure, igneous, sedimentary and metamorphic rocks; • Weathering: physical, biogeochemical processes; • Erosion: physical processes of erosion, factors affecting erosion; • Agents of erosion: rivers and streams, glacial and aeolian transportation and deposition of sediments by running water, wind and glaciers.	**CO 6.** Students will be able to Evaluate the role of different types of Rocks in Rock Cycle **CO 7.** Students will learn about the rock structures and types **CO 8.** Students will learn the significance of Weathering and Erosion over Earth Surface
		Unit-4- Earth Surface Process • Atmosphere: evolution of earth's atmosphere, composition of	**CO 8.** Students will learn about the atmospheric evolution and atmospheric composition.

		atmosphere, physical and optical properties, circulation; • Interfaces: atmosphere–ocean interface, atmosphere–land interface, ocean–land interface; • Land surface processes: fluvial and glacial processes, rivers and geomorphology; types of glaciers, glacier dynamics, erosional and depositional processes and glaciated landscapes; coastal processes.	**CO 9.** Students will learn about the interface, ocean–land interface; atmosphere–ocean interface, atmosphere–land **CO 10.** Students will learn about the geomorphology and glacier geomorphology.
		UNIT-5- Importance Of Being Mountain • Formation of Peninsular Indian mountain systems - Western and Eastern Ghats, Vindhyas, Aravallis, etc. Formation of the Himalaya; • Development of glaciers, perennial river systems and evolution of monsoon in Indian subcontinent; • Formation of Indo-Gangetic Plains.	**CO 11.** Students will learn about the formation of Indian mountains, most importantly Himalaya **CO 12.** Students will learn about the formation of Indo-Gangetic Plains
	ENVS-H-CC-P - 01- Practical	• Hand specimen: rocks and minerals • Microscopic studies of thin section of rock and minerals. • Topographical sheet interpretation	**CO 13.** Students will have hands on experience about the rock types, mineralogy and topographic map interpretation.
	UG-ENVS-H-CC-02- Environmental	**Unit-1- Fundamental Of Environmental Chemistry**	**CO 14.** Students will learn about the basics of physical chemistry relating to atomic structure and chemical bonds.

	Chemistry and Environmental Physics	• Atomic structure, electronic configuration, periodic properties of elements (ionization potential, electron affinity and electronegativity), • Types of chemical bonds (ionic, covalent, coordinate and hydrogen bonds), mole concept, molarity and normality, quantitative volumetric analysis. • Thermodynamic system; types of chemical & reactions products; solutes and solvents; redox reactions, concepts of pH equation, electrochemical cells. • Basic concepts of organic chemistry, hydrocarbons, aliphatic and aromatic compounds, organic functional groups, polarity of the functional groups, xenobiotic compounds like pesticides and dyes, synthetic polymers.	**CO 15.** Students will learn about different thermodynamic systems in chemical reactions. **CO 16.** Students will learn about the basic concepts of organic compounds and groups.
		Unit-2- Atmospheric Chemistry • Composition of atmosphere; photochemical reactions in atmosphere; smog formation, types of smog (sulphur smog and photochemical smog), • Aerosols; chemistry of acid rain, case studies;	**CO 17.** Students will learn about the chemical interactions of different components within the atmosphere. **CO 18.** Students will learn about the ozone layer chemistry and agents of ozone degradation.

		• Reactions of NO_2 and SO_2; • Free radicals and ozone layer depletion, role of CFCs in ozone depletion	
		Unit-3- Water Chemistry • Chemical and physical properties of water; • Water quality parameters (physical, chemical & biological), • Heavy metal in water, solubility of metals, complex formation and chelation; colloidal particles; • Water quality monitoring.	**CO 19 To** provide the basic knowledge of water properties. **CO 20** To understand various Water Quality Parameters. **CO 21** Develop in depth knowledge about estimation of various Water Quality Parameters. **CO 22** Students will learn about heavy metal in water, and solubility of metals. **CO 23** Analyse the cause of complex formation and chelation. **CO 24** Learners gets to understand about colloidal particles. **CO 25** Students will learn the water quality monitoring techniques.
		Unit-4- Soil Chemistry • Soil composition; relation between organic carbon and organic matter, inorganic and organic components in soil; soil humus; cation and anion exchange reactions in soil; • Nitrogen, phosphorus and potassium in soil; phenolic compounds in soil; soil quality monitoring.	**CO 26** Learners get the idea of soil composition and soil chemistry through this section. **CO 27.** Students will learn about soil quality monitoring techniques.
		Unit-5- Fundamental Of Environmental Physics • Basic concepts of light and matter; quantum mechanics (relation between energy, wavelength and frequency),	**CO 28** Learners get the idea of various laws of quantum mechanics. **CO 29** Learners get the concept of absorption and types of scattering.

		black body radiation, Kirchhoff's law, Boltzmann equation, spectroscopic concepts: • Introduction to the concept of absorption and transmission of light, Beer–Lambert law, photovoltaic and solar cells; scattering of light, Rayleigh and Mia scattering. • Basic concepts of pressure, force, work and energy; types of forces and their relation (pressure gradient, viscous, Coriolis, gravitational, centripetal, and centrifugal force); concept of heat transfer, conduction, convection; concept of temperature, lapse rate (dry and moist adiabatic); laws of thermodynamics; concept of heat and work, Carnot engine, transmission of electrical power, efficiency of turbines, wind mills and hydroelectric power plants.	**CO 30.** Students will learn about physical process of atmosphere.
		Unit-6- Movement Of Pollutant In Environment Diffusion and dispersion, point and area source pollutants, pollutant dispersal; Gaussian plume model, mixing heights, hydraulic potential, Darcy's equation, types of flow, turbulence.	**CO 31.** Students will learn about movement of pollutant in atmosphere based on mathematical approach.

	ENVS-H-CC-P-02-Practical	• Preparation of primary and secondary standard solutions. • Estimation of metals using standard potassium dichromate/ potassium permanganate solution. • Measurement of physicochemical parameters of soil and water samples (pH, conductivity, hardness, alkalinity), soil organic matter.	**CO 32.** Students will get hand on experience on preparation of solutions. **CO 33.** Students will expertise in some metal estimation. **CO 34.** Students will get skilled in measuring physicochemical parameters of soil and water samples.
II	**UG-ENVS-H-CC-03-Water And Water Resources**	**Unit-1- Introduction** Sources and types of water; hydrological cycle; precipitation, runoff, infiltration, evaporation, evapotranspiration; classification of water resources (oceans, rivers, lakes and wetlands).	**CO 35.** Students will learn about the cyclic movement of water and classification of water resources
		Unit-2- Properties Of Water Physical: temperature, colour, odour, total dissolved solids and total suspended solids; Chemical: major inorganic and organic constituents, dissolved gases, DO, COD, BOD, acidity and alkalinity, electrical conductivity, sodium adsorption ratio; Biological: phytoplankton, phytobenthic, zooplankton, macroinvertebrates and microbes.	**CO 36.** Students will get to know about physical properties of water. **CO 37.** Students will get to know about chemical properties of water. **CO 38.** Students will get to know about biological properties of water.

		Unit-3- Surface And Subsurface Water Introduction to surface and ground water; surface and ground water pollution; water table; vertical distribution of water; formation and properties of aquifers; techniques for ground water recharge; river structure and patterns; watershed and drainage basins; importance of watershed and watershed management; rain water harvesting in urban settings.	**CO 39 .** Learners will get to know about properties water table and its impotence. **CO 40 .** Students will get to know about different water management techniques.
		Unit-4- Wetlands And Their Management Definition of a wetland; types of wetlands (fresh water and marine); ecological significance of wetlands; threats to wetlands; wetland conservation and management; Ramsar Convention, 1971; major wetlands of India.	**CO 41 .** Students will get the understandings about wetlands. **CO 42 .** Learners will get to know about different organizations protecting wetlands.
		Unit-5- Marine Resource Management Marine resources; commercial use of marine resources; threats to marine ecosystems and resources; marine	**CO 43 .** Students will get to know about the value of marine system. **CO 44 .** Learners will get to know about threats of marine system and proper management practices.

		ecosystem and resource management (planning approach, construction techniques and monitoring of coastal zones).	
		Unit-6- Water Resource In India Demand for water (agriculture, industrial, domestic); overuse and depletion of surface and ground water resources; water quality standards in India; hot spots of surface water; role of state in water resource management.	**CO 45 .** Students will get to know present water demand and quality standard in India.
		Unit-7- Water Resource Conflicts Water resources and sharing problems, case studies on Kaveri and Krishna river water disputes; Multipurpose river valley projects in India and their environmental and social impacts; case studies of dams. - Narmada and Tehri dam – social and ecological losses versus economic benefits; International conflicts on water sharing between India and her neighbours; agreements to resolve these conflicts.	**CO 46 .** Case studies give an idea of water resource conflicts at national and international levels in the Indian context.
		Unit-8- Major Laws And Treaties National water policy; water pollution (control and prevention) Act 1972; Indus water treaty; Ganges water treaty; Teesta water treaty; National River	**CO 47.** Students are given descriptions of the main laws and policies relating to the management of water resources.

		linking plan: ecological and economic impacts.	
	UG-ENVS-H-CC-P -03-Practical	• Field study related to rainwater harvesting /groundwater wells and document preparation. • Field visit to wetland and document preparation. • Water demand in domestic/ agricultural fields/ industrial areas through preparation of survey sheets followed by documentation	**CO 48** A field trip can help learners gain a better understanding of rainwater harvesting in practice. **CO 49** A field trip can help learners gain a better understanding of wetland and its importance. **CO 50** A survey can help learners gain a better understanding of water demand of the survey area.
	UG-ENVS-H-CC-04-Land And Soil Conservation and Management	**Unit-1- Introduction** • Land as a resource, soil health; ecological and economic importance of soil; • Types and causes of soil degradation; impact of soil loss and soil degradation on agriculture and food security; • Need for soil conservation and restoration of soil fertility.	**CO 51 .** Students will learn about the importance of soil. **CO 52.** Students will learn about causes of soil degradation; impact of soil loss and soil degradation on agriculture **CO 53 .** Students will learn about Need for soil conservation
		Unit-2- Fundamentals Of Soil Science Soil formation; classification of soil; soil architecture; physical properties of soil; soil texture; soil water holding capacity; soil temperature; soil colloids; soil acidity and alkalinity; soil	**CO 54 .** Students will learn about the soil composition. **CO 55 .** Students will learn about the physic-chemical properties of soil.

		salinity and sodicity; soil organic matter; micronutrients of soil; nitrogen, sulphur, potassium and phosphorus economy of soil; soil biodiversity	
		Unit-3- Soil Degradation – Causes Soil resistance and resilience; nature and types of soil erosion; non-erosive and erosive soil degradation; losses of soil moisture and its regulation; nutrient depletion; soil pollution due to mining and mineral extraction, industrial and urban development, toxic organic chemicals, and organic contaminants in soils; fertilizers and fertilizer management; recycling of soil nutrients.	**CO 56 .** Students will learn about cause and effect of soil degradation **CO 57 .** Students will learn about effects of using fertilizers
		Unit-4- Land use Changes And Land Degradation Land resources: types and evaluation; biological and physical phenomena in land degradation; visual indicators of land degradation; drivers of land degradation - deforestation, desertification; habitat loss, loss of biodiversity; range land degradation; land salinization; drivers of land use	**CO 58 .** Students will learn about the cause and effects of land degradation **CO 59 .** Students will learn about drivers of land degradation - deforestation, desertification; habitat loss **CO 60 .** Students will learn about change in major geographic zones and biodiverse regions with particular reference to the Himalaya and the Western Ghats

		and land cover change in major geographic zones and biodiverse regions with particular reference to the Himalaya and the Western Ghats	
		Unit-5- Costs Of Land Degradation Economic valuation of land degradation; onsite and offsite costs of land degradation; loss of ecosystem services; effects on farming communities; effects on food security; effects on nutrient cycles; future effects of soil degradation; emerging threats of land degradation to developing countries.	**CO 61 .** Students will learn about the Economic valuation of land degradation **CO 62 .** Students will learn about the Economic issues of ecosystem services
		Unit-6- Controlling Land Degradation Sustainable land use planning; role of databases and data analysis in land use planning control and management; land tenure and land policy; legal, institutional and sociological factors; participatory land degradation assessment; integrating land degradation assessment into conservation.	**CO 63 .** Students will learn about the Sustainable land use planning **CO 64. .** Students will learn about the land degradation assessment

	UG-ENVS-H-CC-P -04-Practical	• Determination of soil organic matter, nutrients (N, P, K), Soil water holding capacity, Soil texture analysis. • Soil profile study. • Identification of degraded land using remote sensing data and topographical sheets	**CO 65**.Students will have hands on experience about the Determination of soil organic matter, nutrients (N, P, K), Soil water holding capacity, Soil texture analysis **CO 66** . student will learn soil profile study
III	**UG-ENVS-H-CC-05-Ecology And Ecosystems**	**Unit 1- Introduction** Basic concepts and definitions: ecology, landscape, habitat, ecozones, biosphere, ecosystems, ecosystem stability, resistance and resilience; autecology; synecology; major terrestrial biomes.	**CO 67 .** Students will learn about the basic concept of ecology and ecosystem
		Unit 2- Ecology Of Individuals Ecological amplitude; L i m i t i n g f a c t o r s ; Liebig's Law of the Minimum; Shelford's Law of Tolerance; phenotypic plasticity; ecotypes; ecoclines; acclimation; ecological niche; types of niche: Eltonian niche, Hutchinsonian niche, fundamental niche, realized niche; niche breadth; niche partitioning; niche differentiation; thermoregulation;	**CO 68** . Students will learn about the study of ecology of individuals and their role in ecosystem. **CO 69 .** Students will learn about the ecological niche

		strategies of adaptation in plants and animals.	
		Unit 3- Ecology Of Population Concept of population and meta-population; r- and K-selection; characteristics of population: density, dispersion, natality, mortality, life tables, survivorship curves, age structure; population growth: geometric, exponential, logistic, density-dependent; limits to population growth; deterministic and stochastic models of population dynamics; rudreal, competitive and stress-tolerance strategies.	**CO 70.** Students will learn about the population ecology **CO 71**. Students will learn about the population characteristics. **CO 72 .** Students will learn about the population growth and growth limits. **CO 73 .** Students will learn about the deterministic and stochastic models of population dynamics
		Unit 4- Ecology of Communities Discrete versus continuum community view; community structure and organization: physiognomy, sociability, species associations, periodicity, biomass, stability, keystone species, ecotone and edge effect; species interactions: mutualism, symbiotic relationships, commensalism, amensalism, proto cooperation, predation, competition,	**CO 74.** Students will learn about the community ecology **CO 75 .** Students will learn about the population stability and interrelationship and cooperation.

		parasitism, mimicry, herbivory; ecological succession: types, processes and models.	
		Unit 5- Ecosystem Ecology E cosystem structure and functions; abiotic and biotic components of ecosystem; ecosystem metabolism; primary production and models of energy flow; secondary production and trophic efficiency; ecosystem connections: food chain, food web; models of energy flow; ecological efficiencies; ecological pyramids; ecosystem services; Some model ecosystems: forest, grassland, lentic, lotic, estuarine, marine, desert, wetlands.	**CO 76 .** Students will learn about the components of ecosystem ecology **CO 77.** Students will learn about the ecosystem productivity **CO 78.** Students will learn about the energy flow in ecosystem **CO 79.** Students will learn Some model ecosystems: forest, grassland, lentic, lotic, estuarine, marine, desert, wetlands
		Unit 6- Biogeochemical Cycle And Nutrient Cycling Concepts of pools, flux, turnover time; types of biogeochemical cycles; carbon cycle; nitrogen cycle; phosphorus cycle; sulphur cycle; hydrological cycle; nutrient cycle models; nutrient budget; impact of anthropogenic	**CO 80.** Students will learn about the biogeochemical cycle in ecosystem and nutrient conservation **CO 81.** Students will learn about nutrient pool

		activities on the nutrient cycles; nutrient conservation strategies.	
		UNIT 7- Biological Invasions Concept of exotics and invasive; natural spread versus man-induced invasions; characteristics of invaders; stages of invasion; mechanisms of invasions; invasive pathways; impacts of invasion on ecosystem and communities; economic costs of biological invasions.	**CO 82.** Students will learn about the invasion in ecosystem and role of induced species.
	UG-ENVS-H-CC-P -05- Practical	• Qualitative and quantitative analysis of planktons of aquatic systems. • Determination of species, dominance and frequency using quadrate/ plot method. • Determination of dissolved oxygen, free carbon dioxide and primary productivity of water samples collected from aquatic ecosystems. • Ecological field visit: pond/forest/river/wetland or other ecosystem	**CO 83.**Students will identify the plankton from aquatic systems and learn the frequency analysis. **CO 84.** Students will learn about the dissolved oxygen, free carbon dioxide and primary productivity of water samples collected from aquatic ecosystems.
	UG-ENVS-H-CC-06- Biodiversity And Conservation	**Unit-1- Levels Of Organization In Living World** From genes to ecosystems; tree of life; history of character transformation; organic evolution through geographic	**CO 85.** Learners are given descriptions of the phylogenetic tree. **CO 86.** Learners are given the concept of species and the process of speciation.

		time scale; species concept – what's in a name?; how many species are there on earth?; concept and types of speciation	
		Unit-2- Biodiversity Patterns Spatial patterns: latitudinal and elevational trends in biodiversity; temporal patterns: seasonal fluctuations in biodiversity patterns; importance of biodiversity patterns in conservation.	**CO 87.** Students comprehend the patterns of biodiversity. **CO 88.** Learners are given the idea of importance of biodiversity patterns in conservation.
		Unit-3- Biodiversity Estimation Sampling strategies and surveys: floristic, faunal, and aquatic; qualitative and quantitative methods: scoring, habitat assessment, richness, density, frequency, abundance, evenness, diversity, biomass estimation; community diversity estimation: alpha, beta and gamma diversity; molecular techniques: RAPD, RFLP, AFLP; NCBI database, BLAST analyses.	**CO 89.** Students get an understanding of the various biodiversity sampling and survey methods. **CO 90.** Learners get to learn about biodiversity measurement methods discussed in this section.
		Unit-4- Importance Of Biodiversity Economic values – medicinal plants, drugs, fisheries and livelihoods; ecological services – primary productivity, role in hydrological cycle,	**CO 91.** Students study the numerous values of biodiversity for the sustainability of ecosystems.

		biogeochemical cycling; ecosystem services – purification of water and air, nutrient cycling, climate control, pest control, pollination, and formation and protection of soil; social, aesthetic, consumptive, and ethical values of biodiversity.	
		Unit-5- Threats To Biodiversity Natural and anthropogenic disturbances; habitat loss, habitat degradation, and habitat fragmentation; climate change; pollution; hunting; over-exploitation; deforestation; hydropower development; invasive species; land use changes; overgrazing; man wildlife conflicts; consequences of biodiversity loss; Intermediate Disturbance Hypothesis	**CO 92.** Learners get to learn that the decline in biodiversity can be attributed to a variety of factors.
		Unit-6- Biodiversity Conservation In-situ conservation (Biosphere Reserves, National Parks, Wildlife Sanctuaries); Ex-situ conservation (botanical gardens, zoological gardens, gene banks, seed and seedling banks, pollen culture, tissue culture and DNA banks), role of local communities and	**CO 93.** Through recommended preventive steps, students learn how to mitigate the threat to biodiversity. **CO 94.** Learners get to learn about organizations working to conserve biodiversity.

		traditional knowledge in conservation; biodiversity hotspots; IUCN Red List categorization – guidelines, practice and application; Red Data book; ecological restoration; afforestation; social forestry; agro forestry; joint forest management; role of remote sensing in management of natural resources.	
		Unit-7- Biodiversity In India India as a mega diversity nation; phytogeographic and zoogeographic zones of the country; forest types and forest cover in India; fish and fisheries of India; impact of hydropower development on biological diversity; status of protected areas and biosphere reserves in the country; National Biodiversity Action Plan. Biological diversity Act & rule (2002/ 2004) implementation status.	**CO 95.** This section discusses the current biodiversity situation in India as well as relevant regulations.
	UG-ENVS-H-CC-P-06-Practical	• Biodiversity measurement techniques: Biodiversity richness and diversity indexes. • IUCN red list categorisation-Guideline criteria • Ecorestoration – site visit.	**CO 96**. Hand on experience is achieved on biodiversity measurement from tabulated data. **CO 97.** Field visit of an ecorestorated site provides knowledge of restoration techniques and monitoring activities.

	UG-ENVS-H-CC-07-Atmosphere And Global Climate Change	**Unit-1- Fundamentals Of Atmospheric Chemistry** Atmospheric structure and composition, Milankovitch cycles. Chemistry of atmospheric particles and gases; smog – types and processes; photochemical processes; ions and radicals in atmosphere; acid-base reactions in atmosphere; atmospheric water; role of hydroxyl and hydroperoxyl radicals in atmosphere. Green house gases (GHGs); greenhouse effect; global warming	**CO 98.** This section discusses structure and composition of atmosphere. **CO 99.** Learners get to learn about chemical processes occurring in atmosphere. **CO 100.** Learners get to learn about the concept of greenhouse effect.
		Unit-2- Meteorology And Atmospheric Stability Meteorological parameters (temperature, relative humidity, wind speed and direction, precipitation); atmospheric stability and mixing heights; temperature inversion; plume behavior; Gaussian plume model. Movement of air masses; atmosphere and climate; air and sea interaction; southern oscillation; western disturbances; El Nino and La Nina; tropical cyclone; Indian monsoon and	**CO 101.** Learners get to learn about different meteorological parameters. **CO 102.** Learners get the understanding about atmospheric stability. **CO 103.** Learners get to learn about various climatic conditions in different scales.

		its development, changing monsoon in Holocene in the Indian subcontinent, its impact on agriculture and Indus valley civilization; effect of urbanization on micro climate; Asian brown clouds.	
		Unit-3- Global Warming And Climate Change Earth's climate through ages; trends of global warming and climate change; drivers of global warming and the potential of different green house gases (GHGs) causing the climate change; atmospheric windows; impact of climate change on atmosphere, weather patterns, sea level rise, agricultural productivity and biological responses - range shift of species, CO2 fertilization and agriculture; impact on economy and spread of human diseases.	**CO 104**. Students get to learn about causes and impact of Global Warming And Climate Change.
		Unit-4-Ozone Layer Depletion Ozone layer or ozone shield; importance of ozone layer; ozone layer depletion and causes; Chapman cycle; process of spring time ozone depletion over Antarctica; ozone depleting substances (ODS); effects of ozone	**CO 105.** Learners get the understanding on Ozone depletion. **CO 106.** Students get the understanding on international protocols targeting ozone layer protection.

		depletion; mitigation measures and international protocols.	
		Unit-5- Climate Change And Policy Environmental policy debate; International agreements; Montreal protocol 1987; Kyoto protocol 1997; Convention on Climate Change; carbon credit and carbon trading; clean development mechanism.	**CO 107.** Students get knowledge on several national and international policies targeting climate change.
	UG-ENVS-H-CC-P -07-Practical	• Preparation of meteorological charts, graphs and windrose • Handling of meteorological data recording instruments (Rain gauge, Anemometer, wet bulb dry bulb thermometer, Barometer) and their uses • Field visit to meteorological centre.	**CO 108.** Understanding and preparation of different meteorological charts from data collected using different meteorological instruments are main focus of these practical. **CO 109.** A field trip can help learners gain a better understanding of how the meteorological centre works.
	UG-ENVS-H-SEC-01a-Remote Sensing, Geographic Information System & Modelling	**UNIT 1- Remote Sensing** • Definitions and principles • Electromagnetic spectrum • Interaction of EMR with Earth's Surface • Spectral signature • Satellites and Sensors • Aerial photography and image interpretation	**CO 110.** To develop basic knowledge of remote sensing. **CO 111.** To provide the concept of Electromagnetic radiation, electromagnetic spectrum , and relationship between wavelength, velocity and frequency of electromagnetic waves. **CO 112.** Students are able to learn the interaction of electromagnetic radiation with Earth's surface. **CO 113.** To understand the concept of spectral signature. **CO 114.** To study different types of satellites and sensors are used in remote sensing and other sectors. **CO 115.** Students are able to learn about aerial photography, satellite image.

			CO 116. To identify and extract meaningful information from the imagery.
		UNIT 2- Geographyical information systems • Definitions and components • Spatial and non-spatial data; Raster and Vector data • Database generation ; Database management system • Land use/ Land Cover mapping • Overview of GIS software packages • GPS survey • Data import, processing and mapping	**CO 117.** To develop basic knowledge of GIS. **CO 118**. To provided knowledge of Geographical analysis by Raster and vector data. **CO 119**. To provide basic knowledge of data, database and database management systems. **CO 120**. To provide knowledge about basic GIS softwares used in various industries. **CO 121.** To create a knowledge of GPS/ Global Positioning System. **CO 122.** Students are able to learn the process of GIS and mapping.
		UNIT 3 - Applications and case studies of remote sensing and GIS in geosciences • Water resource management • land use planning • Forest resources • Agriculture, marine and atmospheric studies	**CO 123.** Be able to describe application of Remote Sensing and GIS Technology in various fields in the environment.
		UNIT 4- Basic elements of statistical analysis Basic elements of statistical analyses: sampling; types of distribution – normal, binomial, poisson; measurements of central tendency and dispersion; skewness;	**CO 124.** Students are able to learn the basic statistical elements. **CO 125.** Students are able to learn about different type of statistical test methods.

		kurtosis; hypothesis testing; parametric and non-parametric tests; correlation and regression; curve fitting; analysis of variance.	
		Unit 5: Demonstrative exercise • Visual interpretation of standard False Colour Composite (FCC) data. • Thematic map generation. • Digitisation of thematic layer. • Overlay analysis of thematic layer in GIS environment. • GIS laboratory visit.	**CO 126.** Students will learn about the interpretation techniques of different types of maps.
IV	**UG-ENVS-H-CC-08-Bio-Systematics and Biogeography**	**Unit-1- Biosystematics - Concept And Approaches** Definition of biosystematics; taxonomic identification; keys; field inventory; herbarium; museum; botanical gardens; taxonomic literature; nomenclature; evidence from anatomy, palynology, ultrastructure, cytology, phytochemistry, numerical and molecular methods; taxonomy databases.	**CO 127.** Students will learn about the taxonomy and biosystematics **CO 128.** Students will learn the nomenclature, classical nomenclature and advanced theory on it.
		Unit-2- Taxonomic Hierarchy Concept of taxa (species, genus, family, order, class, phylum, kingdom);	**CO 129.** Students will have the concept of taxa and categories in taxonomic hierarchy.

		concept of species (taxonomic, typological, biological, evolutionary, phylogenetic); categories and taxonomic hierarchy.	
		Unit-3- Nomenclature And Systems Of Classification Principles and rules (International Code of Botanical and Zoological Nomenclature); ranks and names; types and typification; author citation; valid publication; rejection of names; principle of priority and its limitations; names of hybrids; classification systems of Bentham and Hooker; Angiosperm Phylogeny Group (APG III) classification.	**CO 130.** Students will learn about the Principles and rules of Botanical and Zoological Nomenclature **CO 131.** Students will learn about classification systems of Bentham and Hooker and Angiosperm Phylogeny Group (APG III) classification.
		Unit-4- Numerical And Molecular Systematics Characters; variations; operational taxonomic units; character weighting and coding; phenograms; cladograms; DNA barcoding; phylogenetic tree (rooted, unrooted, ultrametric trees).	**CO 132.** Students will learn the numerical and molecular systematics
		Unit-5- Biogeography- An Overview Earth's history; paleo-records of diversity and diversification;	**CO 133.** Students will learn the biogeography rules **CO 134.** Students will learn the types and processes of speciation – allopatric, parapatric, sympatric

		continental drift and plate tectonics and their role in biogeographic patterns – past and present; biogeographical dynamics of climate change and Ice Age. Genes as unit of evolutionary change; mutation; genetic drift; gene flow; natural selection; geographic and ecological variation; biogeographical rules – Gloger's rule, Bergmann's rule, Allen's rule, Geist rule; biogeographical realms and their fauna; endemic, rare, exotic, and cosmopolitan species. Types and processes of speciation – allopatric, parapatric, sympatric; ecological diversification; adaptive radiation, convergent and parallel evolution; dispersal and immigration; means of dispersal and barriers to dispersal; extinction.	
		Unit-6- Conservation Biogeography Application of biogeographical rules in design of protected area and biosphere reserves; use of remote sensing in conservational planning.	**CO 135 .** Students will learn the Application of biogeographical rules in design of protected area and biosphere reserves; use of remote sensing in conservational planning
	UG-ENVS-H-CC-P-08-Practical	• Demonstration of typification procedure.	**CO 136.** Students will learn the typification procedure.

		• Field visit for floral and faunal assessment of an area. • Criteria used for designation of a protected area- preparation of worksheet. • Study of invasive species distribution and documentation.	**CO 137.** Through filed visit students learn the floral and faunal assessment and protected area criterian. **CO 138.** Students will study the invasive species and their characters.
	UG-ENVS-H-CC-09-Natural Resource Management And Sustainability	**Unit-1- Introduction** Resource and reserves; classification of natural resources; renewable and non-renewable resources; resource degradation; resource conservation; resource availability and factors influencing its availability; land resources; water resources; fisheries and other marine resources; energy resources; mineral resources; human impact on natural resources; ecological, social and economic dimension of resource management.	**CO 139.** Students will study the Classification of resource. **CO 140.** Students will learn the human impact on natural resources.
		Unit-2- Natural Resources And Conservation Water resources: supply, renewal, and use of water resources, freshwater shortages, strategies of water conservation; soil resources: importance of soil, soil conservation	**CO 141.** Students will get the understanding on different natural resources and their importance. **CO 142.** Students will learn the resource management strategies in this section.

		strategies; food resources: world food problem, techniques to increase world food production, green revolution. Forest resources: economic and ecological importance of forests, forest management strategies, sustainable forestry. Mineral resources and the rock cycle; identified resources; undiscovered resources; reserves; types of mining: surface, subsurface, open-pit, dredging, strip; reserve-to-production ratio; global consumption patterns of mineral resources techniques to increase mineral resource supplies; ocean mining for mineral resources; environmental effects of extracting and using mineral resources.	
		Unit-3- Energy Resources-Non-Renewable & Renewable Oil: formation, exploration, extraction and processing, oil shale, tar sands; natural gas: exploration, liquefied petroleum gas, liquefied natural gas; coal: reserves, classification,	**CO 143.** Students will learn about the non-renewable energy resource. **CO 144.** Students will learn the different approaches towards energy dependency.

		formation, extraction, processing, coal gasification; environmental impacts of non renewable energy consumption; impact of energy consumption on global economy; application of green technology; future energy options and challenges. Energy efficiency; life cycle cost; cogeneration; solar energy: technology, advantages, passive and active solar heating system, solar thermal systems, solar cells, JNN solar mission; hydropower: technology, potential, operational costs, benefits of hydropower development; nuclear power: nuclear fission, fusion, reactors, pros and cons of nuclear power, storage of radioactive waste, radioactive contamination; tidal energy; wave energy; ocean thermal energy conversion (OTEC); geothermal energy; energy from biomass; bio-diesel.	
		Unit-4- Resource Management Approaches in resource management: ecological approach; economic	**CO 145.** Students will get to know about several approaches regarding resource management.

		approach; ethnological approach; implications of the approaches; integrated resource management strategies; concept of sustainability science: different approach towards sustainable development and its different constituents; sustainability of society, resources and framework; sustainable energy strategy; principles of energy conservation; Indian renewable energy programme.	**CO 146.** Students will learn about Indian renewable energy programme.
	UG-ENVS-H-CC-P -09- Practical	• Forest area mapping techniques. • Water bodies mapping techniques. • Water audit of college/ industry. • Energy audit of college/ industry. • Environmental audit of college. • Visit to mine area, forest area and aquaculture farm.	**CO 147.** Learner get an experience on mapping technique as well as resource auditing method. **CO 148.** A field trip can help learners gain a better understanding of different natural resources.
	UG-ENVS-H-CC-10- Environmental Pollution and Human Health	**Unit-1- Introduction** Definition of pollution; pollutants; classification of pollutants	**CO 149.** Basic concept of pollution and pollutants are covered in this section.
		Unit-2- Air Pollution Ambient air quality: monitoring and standards (National Ambient Air Quality Standards of India); air quality index; sources and types of pollutants	**CO 150.** This topic helps learner to understand the type air pollutants, their sources, effects, emission standards and controlling measures.

		(primary and secondary); smog (case study); effects of different pollutants on human health (NOx, SOx, PM, CO, CO2, hydrocarbons and VOCs) and control measures; indoor air pollution: sources, effects on human health and remedial strategies. Vehicular pollution and control measures.	
		Unit-3- Water Pollution Sources of surface and ground water pollution; water quality parameters and standards; organic waste and water pollution; eutrophication; water quality monitoring, COD, BOD, DO; effect of water contaminants on human health (nitrate, fluoride, arsenic, chlorine, cadmium, mercury, pesticides); water borne diseases; concept and working of effluent treatment plants (ETPs).	**CO 151.** Learners get to know about different sources of water pollutants, standards and their impacts on human health.
		Unit-4- Soil Pollution Causes of soil pollution and degradation; effect of soil pollution on environment, vegetation and other life forms; control strategies.	**CO 152.** Learner develops an understanding over the causes, effects, and preventative strategies of soil pollution.
		Unit-5- Noise Pollution	**CO 153.** Sources, properties and impacts of Noise on living organisms are mentioned in this topic.

		Noise pollution – sources; frequency, intensity and permissible ambient noise levels; effect on communication, impacts on life forms and humans - working efficiency, physical and mental health; control measures.	
		Unit-6- Radioactive And Thermal Pollution Radioactive material and sources of radioactive pollution; effect of radiation on human health (somatic and genetic effects); thermal pollution and its effects.	**CO 154.** This section develops an understanding of the source and impact of radioactive and thermal pollution.
		Unit-7- Marine Pollution Marine resources and their importance; sources of marine pollution; oil spill and its effects; coral reefs and their demise; coastal area management; existing challenges and management techniques (planning, construction, environmental monitoring of coastal zones).	**CO 155.** The study would impart an idea of the different source of marine pollutants and their impacts on marine ecosystem.
		Unit-8- Chemistry Of Environmental Pollutants	**CO 156.** Learners develop a better understanding of the chemical properties of environmental pollutants.

		Solubility of pollutants (hydrophilic and lipophilic pollutants), transfer of pollutants within different mediums, role of chelating agents in transferring pollutants, concept of biotransformation and bioaccumulation, concept of radioactivity, radioactive decay and half-life of pollutants, organometallic compounds, acid mine drainage.	
		Unit-9- Pollution Control Activated Sludge Process (ASP) – Trickling Filters – oxidation ponds, fluidized bed reactors, membrane bioreactor neutralization, ETP sludge management; digesters, up flow anaerobic sludge blanket reactor, fixed film reactors, sequencing batch reactors, hybrid reactors, bioscrubbers, biotrickling filters; regulatory framework for pollution monitoring and control; case study: Ganga Action Plan; Yamuna Action Plan; implementation of CNG in NCT of Delhi. Application of clean technologies for pollution control.	**CO 157.** Different technological advancement in pollution control with some case studies are followed by learner.

	UG-ENVS-H-CC-P-10-Practical	• Estimation of Ground & surface water quality parameters (COD, BOD, DO, nitrate, fluoride, arsenic, chlorine, cadmium, mercury, pesticides). • Estimation of air quality parameters (NOx, SOx, SPM). • Field visit to effluent treatment plants (ETP)/ sewage treatment plants (STP). • Total coliform load of water sample. • Noise monitoring (Leq).	**CO 158.** Students get experience on analytical procedures relating to water, air and noise pollutants. **CO 159.** A field trip can help learners gain a better understanding of how the effluent treatment plants (ETP)/ sewage treatment plants (STP) works.
	UG-ENVS-H-SEC-02a-Environmental Impact and Risk Assessment	**Unit-1 Environmental Impact Assessment** • Definition ,introduction and concepts • Rationale and historical development of EIA • Scope and methodologies of EIA • Role of project proponents. project developers and consultants • Impact identification and prediction; baseline data collection; Environmental Impact Statement; Environmental Management Plan	**CO 160.** This will help in enhancing knowledge of Environmental Impact assessment Process, methodologies of Environmental Impact assessment **CO 161.** Create an understanding among students about what is the role of various authorities involved in the EIA process. **CO 162.** Explain the processes of EIA step by step. **CO 163.** Explain the basic concept of Environmental Management Plan
		Unit-2 Rapid EIA • Strategic Environmental Assessment • Social impact Assessment	**CO 164.** To develop clear thinking about social impact assessment. **CO 165.** Students will be able to Evaluate costs and benefits of EIA.

		• Cost-Benefit analysis • Life cycle assessment • Environmental appraisal • Environmental management - principles, problems and strategies • Environmental planning • Environmental audit • Introduction of ISO and ISO 14000 • Sustainable development	**CO 166.** Student gained insight into advanced theoretical knowledge in methodologies in environmental management plan. **CO 167.** Got knowledge of environmental audit and ISO series. **CO 168.** Students will be able to Analyse the importance of strategies of sustainable development.
		Unit-3 EIA regulations in India • Status of EIA in India • Current issues in EIA • Case study of hydropower projects/thermal projects • Environmental audit	**CO 169.** Explain the current status and issues of EIA in India. **CO 170.** Explain various case studies of EIA related to various projects. **CO 171.** Got knowledge of environmental audit.
		Unit-4 Life Cycle assessment • concept • cradle to grave approach • Life Cycle inventory of solid waste • Role of LCA in waste management • Advantage and limitation of LCA • Case study on LCA of a product	**CO 172.** To explain the basic concept of life cycle assessment **CO 173.** Assess the environmental impact of solid waste management options and criticize the results **CO 174**. Discuss the case studies on LCA of a product

		Unit- Risk assessment • Introduction and scope • Project planning • Exposure assessment • toxicity assessment • Hazard identification and assessment • Risk characterization • Risk communication • Environmental monitoring; community involvement; legal and regulatory framework • Human and ecological risk assessment	**CO 175.** To provide basic knowledge of risk assessment and its scope. **CO 176.** Understand the importance of risk assessment. **CO 177.** To understand risk characterization and risk communication. **CO 178.** To enhance knowledge of Hazard identification and assessment. **CO 179.** Approaches for Environmental monitoring; legal and regulatory framework.
V	**UG-ENVS-H-Cc-11) Environmental Biotechnology**	**Unit 1: The structure and function of DNA, RNA and protein** Genetic materials of prokaryotes, viruses, eukaryotes and organelles; mobile DNA; chromosomal organization; Central dogma of biology. DNA: structural forms and their characteristics (B, A, C, D, T, Z); physical properties: UV absorption spectra, denaturation and renaturation kinetics; biological significance of different forms; Synthesis. RNA: structural forms and their	**CO 180.** Learners get to know about basic understandings of genetic materials. **CO 181.** Students get to know about Structure, properties and forms of DNA. **CO 182.** Students get to know about Structure, properties and forms of RNA. **CO 183.** Students get to know about Structure, properties and forms of protain.

		characteristics (rRNA, mRNA, tRNA; SnRNA, Si RNA, miRNA, hnRNA); biological significance of different types of RNA; synthesis. Protein: hierarchical structure (primary, secondary, tertiary, quaternary), types of amino acids; post- translational modifications and their significance; synthesis; types and their role: structural, functional (enzymes).	
		Unit 2: Recombinant DNA technology Concept of genetic engineering; Recombinant DNA: origin and current status; steps of preparation; toolkit of enzymes for manipulation of DNA: restriction enzymes, polymerases (DNA/RNA polymerases, transferase, reverse transcriptase), other DNA modifying enzymes (nucleases, ligase, phosphatases, polynucleotide kinase); genomic and cDNA libraries: construction, screening and uses; cloning and expression vectors (plasmids, bacteriophage, phagmids,	**CO 184.** Students get to know about different genetic technologies used in DNA configuration.

		cosmids, artificial chromosomes; nucleic acid microarrays	
		Unit 3: Bioremediation and ecological restoration Bioremediation: Concept, types, factors, applications, advantages and constraints; Specific bioremediation technologies (prepared beds, biopiles, composting, bioventing, biosparging, pump and treat method, constructed wet lands, use of bioreactors for bioremediation. Phytoremediation – types, mechanism, case studies); Wastewater treatment: anaerobic, aerobic process, methanogenesis, bioreactors, cell and protein (enzyme) immobilization techniques; constructed wetlands; remediation of degraded ecosystems; advantages and disadvantages; degradation of xenobiotics in environment: hydrocarbons, substituted hydrocarbons, pesticides, heavy metals degradative pathways.	**CO 185.** Learners get to know about different bioremediation and phytoremediation technique and degradation pathways of environmental xenobiotic.

		Unit 4: Ecologically safe products and processes 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, extraction; exploitation of microbes in copper and uranium extraction.	**CO 186.** This section helps learners understand the use of biotechnology to develop ecologically safe products for modern use.
	UG-ENVS-H-CC-P -11-Practical	• Isolation and characterisation of soil bacteria. • Gram staining of bacterial sample. • Enumeration of heterotrophic bacteria from water and soil samples (Spread plate/pore plate technique). • Determination of chlorophylls, enzymes (catalase, peroxidase and ascorbic acid of plant samples). • Bioassay of toxic compounds by enzyme assay or seed germination test. • Estimation of carbohydrate, protein and DNA.	**CO 187.** Learners get experience with different microbial testing methods. **CO 188.** Learners gain practical expertise with various organic component testing techniques. **CO 189.** Learners gain hands-on practise recognising the different cell division phases.

		• Study of mitotic and meotic stages (A. cepa and grasshopper testis or pollen)	
	UG-ENVS-H-CC-12-Evolutionary biology	**Unit 1: History of life on Earth** Paleontology and evolutionary history; evolutionary time scale; eras, periods and epoch; major events in the evolutionary time scale; origins of unicellular and multi cellular organisms; major groups of plants and animals; stages in primate evolution including Homo.	**CO 190.** Students will learn the life history on Earth, i.e. how life formed and how it evolved. **CO 191.** Students will learn about the human evolution.
		Unit 2: Introduction Lamarck's concept of evolution; Darwin's Evolutionary Theory: variation, adaptation, struggle, fitness and natural selection; Mendelism; spontaneity of mutations; The Evolutionary Synthesis.	**CO 192.** Students will learn the evolutionary theories and natural selection, criterion and process
		Unit 3: Evolution of unicellular life Origin of cells and unicellular evolution and basic biological molecules; abiotic synthesis of organic monomers and polymers; Oparin-Haldane hypothesis; study of Miller; the first cell; evolution of prokaryotes; origin of eukaryotic cells; evolution of unicellular	**CO 193.** Students will learn the Origin of cells and unicellular evolution and basic biological molecules

		eukaryotes; anaerobic metabolism, photosynthesis and aerobic metabolism.	
		Unit 4: Geography of evolution Biogeographic evidence of evolution; patterns of distribution; historical factors affecting geographic distribution; evolution of geographic patterns of diversity.	**CO 194.** Students will learn the biogeographic evidence of evolution; patterns of distribution, historical factors affecting geographic distribution
		Unit 5: Molecular evolution Neutral evolution; molecular divergence and molecular clocks; molecular tools in phylogeny, classification and identification; protein and nucleotide sequence analysis; origin of new genes and proteins; gene duplication and divergence.	**CO 195.** Students will learn the molecular theories of evolution and origin of genes and proteins
		Unit 6: Fundamentals of population genetics Concepts of populations, gene pool, gene frequency; concepts and rate of change in gene frequency through natural selection, migration and genetic drift; adaptive radiation; isolating mechanisms; speciation (allopatric,	**CO 196.** Students will learn the concepts of populations, gene pool, gene frequency **CO 197.** Students will learn the migration and speciation of species.

		sympatric, peripatric and parapatric); convergent evolution; sexual selection; coevolution; Hardy-Weinberg Law.	
	UG-ENVS-H-CC-P-12-Practical	Field survey based analysis, exercise and interpretation: • Hardy-Weinberg Law and its applications. • Determination of change in allelic frequency due to natural selection, mutation and genetic drift based on data provided from suggested readings (Sl. 10 & 11).	**CO 198.** Students will learn about the Hardy-Weinberg Law and its applications and allelic frequency determination.
	UG-ENVS-H-DSE-01b-Ecotoxicology and Environmental Health	**Unit 1: Introduction to Environmental toxicology** Concepts of toxicants and xenobiotics: dose response relationship; EC50, LC50 and LD50: bioaccumulation and biomonitoring of chemical and biological factors influencing toxicity; types of toxicants and their effects in living systems.	**CO 199.** Students will learn about basic terms of toxicology. **CO 200 .** Students will learn about factors and impact of toxic substance on living system.
		Unit 2: Toxicity of heavy metals Sources, distribution; toxic effects of heavy metal (Lead, cadmium, chromium, mercury, arsenic, selenium); antidotal measures, case studies.	**CO 201.** Students will learn about sources, distribution and toxic effects of heavy metal **CO 202.** Students will learn about some case studies on metal toxicity.

		Unit 3: Pesticide toxicity Pesticide classification, nature, exposure routes, modes of action, biological health effect; concept of pesticide resistance.	**CO 203 .** Students will learn about classification, nature, exposure routes of pesticides. **CO 204.** Students will learn about biological health effect of pesticides.
		Unit 4: Emerging contaminants Concept, types and modes of action, environmental threats and health hazards, environmental disruptors and environmental carcinogens: categories, actions and toxic effects.	**CO 205.** Students will learn about environmental threats and health hazards due to pesticide pollution. **CO 206.** Students will learn about environmental carcinogens
		Unit 5: Environmental epidemiology Sources and impact on human life, present pollution and impact status in West Bengal; remedial measures; epidemiological studies with respect to arsenicosis, fluorosis, vector borne diseases.	**CO 207.** Students will learn about current impact status of epidemics in West Bengal **CO 208.** Students will learn about arsenicosis, fluorosis and some vector borne diseases.
		Unit 6: Environmental Health Basic concepts, physiological responses of human to relevant stress; industrial toxicology and occupational health hazards and toxic manifestations.	**CO 209.** Students will learn about various environmental stress. **CO 210.** Students will learn about industrial toxicology and occupational health hazards and toxic manifestations
	UG-ENVS-H-DSE-P-01b-Practical	• Toxicity bioassay through germination (LD50)	**CO 211.** Learners get experience on different toxicological assessment techniques.

		• Toxicity bioassay through microbial test • Epidemiological survey in arsenic affected areas.	**CO 212.** A field exposure can help learners to gain knowledge on survey technique and data analysis methods with brief understanding of epidemiological status of survey site.
	Discipline Specific Elective 02-UG-ENVS-H-DSE-02b-Waste and Wastewater Management	**Unit 1: Waste water treatment** Sources and generation of waste water; physicochemical and biological properties; primary, secondary and advanced treatment strategies (domestic/municipal and industrial wastewater treatment). Standards for wastewater discharge; reuse and recycling.	**CO 213.** To understand the basic concept of waste water and sources of waste water generation. **CO 214.** students will be able to study the properties of waste water. **CO 215.** Explain the various treatment processes of wastewater. **CO 216.** Briefly study the standard for waste water discharge.
		Unit 2: Effect of solid waste disposal on environment Definition, Types, characterization and chemical composition. Impact of solid waste on environment, human and plant health; effect of solid waste and industrial effluent discharge on water quality and aquatic life; municipal solid waste; hazardous waste and biomedical waste, mining waste and land degradation; effect of land fill leachate on soil characteristics and ground water pollution.	**CO 217.** To conceptually design solid waste and their types and characteristics. **CO 218.** Students will be able to explain the impacts of solid waste on the environment. **CO 219.** Be able to describe the effect of solid and liquid waste on water quality and aquatic life. **CO 220.** Students will recognize different categories of solid waste. **CO 221.** Students will learn how landfill leachate affects soil and groundwater.

		Unit 3: Solid waste management Different techniques used in collection, storage, transportation and disposal of solid waste (municipal, hazardous and biomedical waste); landfill (traditional and sanitary landfill design); thermal treatment (pyrolysis and incineration) of waste material; drawbacks in waste management techniques.	**CO 222.** Knowledge for the protection of the environment through effective waste management techniques. **CO 223.** Deep knowledge of disposal of solid waste. **CO 224.** Explain various thermal treatments of waste material. **CO 225.** Able to explain the drawbacks in waste management techniques
		Unit 4: Industrial waste management 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.	**CO 226.** Deep knowledge of Various types of industrial wastes and their direct , indirect impacts on the environment. **CO 227.** To conceptually design industrial waste treatment/management processes and its importance, **CO 228.** To describe stack emission control and monitoring techniques. **CO 229.** Be able to illustrate Effluent treatment plants and sewage treatment plants.
		Unit 5: Resource recovery 4R- reduce, reuse, recycle and recover; biological processing - composting, anaerobic digestion, aerobic treatment; reductive dehalogenation; mechanical biological treatment; green techniques for waste treatment. Waste- to- energy (WTE) - concept; refuse derived fuel (RDF);	**CO 230.** Knowledge to reduce , recycle and reuse of waste. **CO 231.** Understanding of green techniques for solid waste disposal. **CO 232.** Have an enhanced knowledge of green techniques for waste treatment. **CO 233.** Explain the concept of waste to Energy transformation and various processes of WTF.

		different WTE processes: combustion, pyrolysis, landfill gas (LFG) recovery; anaerobic digestion; gasification.	
		Unit 6: Integrated waste management Concept of Integrated waste management; waste management hierarchy; methods and importance of Integrated waste management.	**CO 234.** Basic concept of Integrated waste management **CO 235.** Develop innovative solutions of solid waste management. **CO 236.**To understand the importance of integrated waste management.
		Unit 7: Policies for solid waste management Municipal Solid Wastes (Management and Handling) Rules 2000; Hazardous Wastes Management and Handling Rules 1989; Bio-Medical Waste (Management and Handling) Rules 1998; Ecofriendly or green products.	**CO 237.** Be able to make connections with Policies for management of solid waste. **CO 238.** Be able to describe different eco-friendly or green products that can be use for controlling solid wastes.
	UG-ENVS-H-DSE-L -02b-Practical	• Physico-chemical characterisation of waste water (TSS, TDS, oil & grease, phenolics). • Sludge characterisation (moisture content, ash, VOC, metal etc.) • Visit to waste disposal sites and report preparation.	**CO 239.** Students get the skill to analyse physico-chemical characterisation of waste. **CO 240.** Field trip helps students to understand about waste disposal site.
VI	**Core Course 13 (Code: UG-ENVS-H-CC-13)**	**Unit 1: Introduction** Constitution of India; fundamental rights; fundamental duties; Union of	**CO 241.** In this section, learners get an overview of the fundamental structure of the Indian Constitution.

	Environmental Legislation And Policy	India; union list, state list, concurrent list; legislature; state assemblies; judiciary; panchayats and municipal bodies; National Green Tribunal.	
		Unit 2: History of environmental legislation and policy Ancient period: worship of water, air, trees; Mauryan period: Kautilya's Arthashastra, Yajnavalkya smriti and Charaksamhita; Medieval period: forests as woodland and hunting Resources during Mughal reign; British India: Indian Penal Code 1860,Forest Act 1865, Fisheries Act 1897; Independent India: Van Mahotsava 1950, National Forest Policy 1952, Orissa River pollution and prevention Act 1953.	**CO 242 .** This topic helps learners to understand the evolution of environmental laws through ancient, medieval and British raj period.
		Unit 3: Environmental legislation Legal definitions (environmental pollution, natural resource, biodiversity, forest, sustainable development); Article 48A (The protection and improvement of environment and safeguarding of	**CO 243.** Learners get a brief idea about major articles depicting environmental protectionism in Indian constitution.

		forests and wildlife); Article 51 A (Fundamental duties).	
		Unit 4: Legislative instruments The Indian Forest Act 1927; The Wildlife (Protection) Act 1972; The Water (Prevention and Control of Pollution) Act 1974; The Forests (Conservation) Act 1980; The Air (Prevention and Control of Pollution) Act 1981; The Environment (Protection) Act 1986; The Public Liability Insurance Act 1991; Noise Pollution (Regulation and Control) Rules 2000; The Biological Diversity Act 2002; The Schedule Tribes and other Traditional Dwellers (Recognition of Forests Rights) Act 2006; The National Green Tribunal Act 2010; scheme and labeling of environment friendly products, Ecomarks	**CO 244.** Learners get a brief idea of various environmental laws in India.
		Unit 5: Government institutions Role of Ministry of Environment, Forests & Climate Change in environmental law and policy making; role of central and state pollution	**CO 245.** Learners get a brief idea on role of different government organization in policy making.

		control boards in environmental law and policy making.	
		Unit 6: Case studies National Green Tribunal: Aditya N Prasad vs. Union of India & Others; Ganga Tanneries Case: M.C. Mehta vs. Union of India 1988; environmental education case: M.C. Mehta vs. Union of India, WP 860/1991.	**CO 246.** Learners get a brief idea on some case studies related to environmental concern.
		Unit 7: International laws and policy Ramsar convention, 1971; Stockholm Conference 1972; United Nations Conference on Environment and Development 1992; Rio de Janeiro (Rio Declaration, Agenda 21); Montreal Protocol 1987; Kyoto Protocol 1997; Copenhagen and Paris summits.	**CO 247.** Learners get a brief idea about international laws and policies.
	UG-ENVS-H-CC-P -13 (Practical)	Field survey based analysis, exercise and interpretation: • Field visit for assessment of environmental policy adoption, environment safety policy adoption in industry and document preparation. • Survey on perception of environmental laws in communities/ societies and document preparation.	**CO 248.** A field exposure can help learners to gain understanding on how environmental policies are now applied in sectors and how widespread environmental awareness is today.

	CORECOURSE-14 (Code: UG-ENVS-H-CC-14) Urban Ecosystems	**Unit 1: Introduction** Introduction to urbanization; urban sprawl and associated environmental issues.	**CO 249. .** Students will learn about the urbanization and urban sprawl.
		Unit 2: Environment in an urban setting Man as the driver of urban ecosystem; commodification of nature; metros, cities and towns as sources and sinks of resources; resource consumption and its social, cultural, economic and ecological perspectives; urban transformation; increasing challenges posed by modernity for the environment; urban pollution (air, water, soil).	**CO 250.** Students will learn that how man is related to and urban ecosystem. **CO 251.** Students will learn about the urban transformation, increasing challenges posed by modernity for the environment and urban pollution.
		Unit 3: Urban dwelling Housing scenario across a range of large-medium-small cities; poverty and slums in an urban context; Town planning Acts and their environmental aspects; energy consumption and waste disposal as well as accumulation; environmental costs of urban infrastructure.	**CO 252.** Students will learn about the housing scenario across a range of large-medium-small cities. **CO 253.** Students will learn about the town planning Acts and their environmental aspects, energy consumption and waste disposal

		Unit 4: Urban interface with the environment Management of urban environment; alternative resources; policy and management decisions; urban settings as loci of sustainability; challenges associated with sustainability and urban future	**CO 254.** Students will learn the management of urban environment, policy about it and how it can be performed sustainabily.
		Unit 5: Natural spaces in a city Concept of 'controlled nature'; scope, importance and threats to nature in the city; organization and planning of green spaces such as parks, gardens and public spaces; concept of green belts; urban natural forest ecosystem as green lungs	**CO 255.** Students will learn about the natural spaces in the urban setting and role of urban green places. **CO 256.** Students will learn about the urban green belt development.
		Unit 6: Planning and environmental management Urban planning and its environmental aspects from historical and contemporary perspectives; benefits of environmental management; introduction to green buildings; urban governance; political complexity of applying ecological science to urban policy and planning, smart cities.	**CO 257.** Students will learn about the Urban planning and its environmental aspects from historical and contemporary perspectives. **CO 258.** Students will learn about the policy and planning of smart cities.

	UG-ENVS-H-CC-P -14-Practical	Field survey based analysis, exercise and interpretation: • Exercises: Students will carry out a group work in which the development of the infrastructure of the city of the future is explored and presented. The assignment concentrates on the development of one infrastructure (clean water, waste water or energy) in two possible surroundings (newly built city or transition from present to future situation). • Tutorial focusing on introducing the state-of-the-art technologies for drinking water supply, wastewater treatment, energy supply and material/nutrient recycling and recovery. • Individual assignment the student will perform a technological assessment for the solution of a specific urban environmental problem performing basic calculations on urban flows and their transformations and considering the sustainability outcome. • Field visits to experience various environmental technologies working in practice.	**CO 258.** Students will learn to make baseline study on future aspects of urban planning in eco-friendly manner through various excercises.

	UG-ENVS-H-DSE-03b-Instrumental Techniques for Environmental Analysis	**Unit 1: Introduction** Instrumental methods for environmental analysis.	**CO 259.** Students will learn about different instruments. **CO 260.** Students will learn about various analytical techniques.
		Unit 2: Principle and application Titrimetric, gravimetric, potentiometric, nephelometry, turbidimetry, spectrophotometry, spectrofluorimetry, flame photometry, atomic absorption spectrometry, inductively coupled plasma mass spectrometry, chromatographic techniques, gel electrophoresis, gas chromatography.	**CO 261 .** Students will learn about principles of different Instruments. **CO 262.** Learners will learn about applications of various analytical instrumants.
		Unit 3: Water and Soil sampling techniques and sample preparation Sampling methods, sample preservation, storage and processing techniques.	**CO 263.** Students will learn about soil sampling and sample handling methods. **CO 264.** Students will learn about water sampling and sample handling methods.
		Unit 4: Air quality sampling and analysis Air samplers, air sampling design, air sampling techniques and application, biomonitoring.	**CO 265.** Students will learn about components of air sampler assembly. **CO 266.** Students will learn about air sampling methods using different air sampler.
		Unit 5: Noise monitoring	**CO 267.** Students will learn about techniques for measurement of noise level

		Techniques for measurement of noise level; Abatement and protective measures	**CO 268.** Students will learn about abatement and protective measures during noise monitoring.
		Unit 6: Radioactivity Detection techniques and application.	**CO 269.** Students will learn about radioactivity detection instruments. **CO 270.** Students will learn about application of radioactivity detection instruments.
	UG-ENVS-H-DSE-P-03b-Practical	• Field survey based analysis, exercise and interpretation Principles and application of instruments and document preparation. • Demonstration of selected instruments and document preparation.	**CO 271.** The ability to handle instruments and a certain comprehension of the fundamental principles governing instrument operation are acquired by learners.
	UG-ENVS-H-DSE-04-Dissertation	UG-ENVS-H-DSE-L -04 Dissertation UG-ENVS-H-DSE-P -04 Practical	**CO 272.** Students learn to apply the knowledge acquired from entire curriculum. **CO 273.** Baseline idea of research work obtained by the learners. **CO 274.** Students realise the link between theory and practical knowledge in real life situation.