SYLLABUS

Master of Science (M.Sc.)

in

ENVIRONMENTAL SCIENCE

Learning Outcome based Curriculum Framework (LOCF): Syllabus based on LOCF of Master (M.Sc.) programme in Environmental Science

Department of Environmental Science
Dhanamanjuri University, Manipur
Imphal-795001

DEPARTMENT OF ENVIRONMENTAL SCIENCE
DHANAMANJURI UNIVERSITY, IMPHAL
MANIPUR-795001

Name of the programme: M.Sc. Environmental Science

The duration of the study programme will be of two years period comprising of four semesters. Each session shall be of six months. The course comprises of four different components *viz*, 1) Teaching, 2) Laboratory work, 3) Field work and 4) Dissertation or Project work. The candidate will be assessed at the end of each session.

COURSE STRUCTURE

Semester 1

COURSE TYPE	COURSE CODE	COURSE TITLE	CONTACT HRS/ PAPER	CREDITS	MARKS		
					IA	EA	TOTAl
THEORY PAPERS							
CORE -I	ENV-501	Fundamentals of Environmental Science and Ecology	104	4	20	80	100
CORE -II	ENV-502	Environmental Chemistry	104	4	20	80	100
CORE -III	ENV-503	Environmental Geosciences	104	4	20	80	100
CORE IV	ENV-504	Fundamentals of Environmental Statistics and Computer Applications	104	4	20	80	100
PRACTICAL PAPERS							
CORE PRACTICAL -I	ENV-505	Laboratory – I	80	4	-	-	100
CORE PRACTICAL -II	ENV-506	Laboratory - II	80	4	-	-	100
TOTAL			**576**	**24**			**600**

Semester 2							
THEORY PAPERS							
CORE -V	ENV-507	Evironmental Pollution-I	104	4	20	80	100
CORE -VI	ENV-508	Environmental pollution-II	104	4	20	80	100
CORE -VII	ENV-509	Environmental Microbiology and Biotechnology	104	4	20	80	100
CORE -VIII	ENV-510	Environmental Ethics and Movements	104	4	20	80	100
OPEN ELECTIVE	ENV-OPE-04	Environmental Awareness -Problems and Issues of North-East India	104	4	20	80	100
PRACTICAL PAPERS							
CORE PRACTICAL - III	ENV-511	Laboratory - III	80	4	-	-	100
CORE PRACTICAL - IV	ENV-512	Laboratory - IV	80	4	-	-	100
TOTAL			**680**	**28**			**700**

Semester 3							
THEORY PAPERS							
CORE -IX	ENV-613	Environmental health and Toxicology	104	4	20	80	100
CORE -X	ENV-614	Environmental Management	104	4	20	80	100
ELECTIVE -I	EVS-615	Disaster Management	102	4	20	80	100
ELECTIVE -II	EVS-616	Remote Sensing and GIS	102	4	20	80	100
PRACTICAL PAPERS							
CORE PRACTICAL-V	ENV-617	Laboratory - V	80	4	-	-	100
ELECTIVE PRACTICAL- I	ENV-618	Laboratory -VI	80	4	-	-	100
TOTAL			**572**	**24**			**600**

Semester 4

THEORY PAPERS							
CORE -XI	ENV-619	Conservation Biology	104	4	20	80	100
CORE -XII	ENV-620	Environmental Economics, and Natural Resource Management	104	4	20	80	100
ELECTIVE -III	ENV-621	Environmental Laws and Policies	102	4	20	80	100
ELECTIVE -IV	ENV-622	Research Methodology	102	4	20	80	100
PRACTICAL PAPERS							
CORE PRACTICAL-VI	ENV-623	Laboratory - VII	80	4	-	-	100
ELECTIVE PRACTICAL-II	ENV-624	Dissertation	80	4	-	-	100
TOTAL			**572**	**24**			**600**
OVERALL TOTAL			**2400**	**100**			**2400**

EA- End Semester Assessment, EP- Elective Practical, IA- Internal Assessment, C- Core, E-Elective, OPE- Open Elective, P- Practical

M.Sc. 1st Semester

CORE I: FUNDAMENTALS OF ENVIRONMENTAL SCIENCE AND ECOLOGY

Credits: 4 COURSE CODE: ENV: 501

Marks: 100

UNIT I: Introduction to Environmental Science

Course Objectives (COs):

1. **To introduce the concept of environment** – its structure, components, and historical perspectives.
2. **To develop an understanding of the interdisciplinary nature** of environmental science, integrating physical, chemical, biological, and social aspects.
3. **To study the major segments of the environment** (atmosphere, hydrosphere, lithosphere, biosphere) and their structure, composition, and interactions.
4. **To analyze the role of the social environment and limiting factors** in influencing natural and human systems.
5. **To understand the principles of thermodynamics** and how energy flows through environmental systems.
6. **To apply the first and second laws of thermodynamics, along with entropy, enthalpy, and Gibbs free energy** to explain environmental and ecological processes.

Course Learning Outcomes (LOs):

After completing these topics, students will be able to:

1. **Explain the concept and scope of environment and environmental science**, including its historical evolution and interdisciplinary nature.
2. **Identify and describe the major environmental segments** (atmosphere, hydrosphere, lithosphere, biosphere) and explain their structure and composition.
3. **Analyze the influence of social environment and limiting factors** on ecosystems and resource utilization.
4. **Demonstrate an understanding of energy flow in the environment** using thermodynamic principles.
5. **Apply the first and second laws of thermodynamics** to ecological processes, energy conservation, and environmental management.
6. **Interpret the concepts of entropy, enthalpy, and Gibbs free energy** in relation to natural processes and environmental sustainability.
7. **Integrate environmental and thermodynamic knowledge** to assess human impacts, ecosystem functioning, and sustainable practices.

UNIT I: Introduction to Environmental Science

Concept of environment, historical perspectives, scope and interdisciplinary nature of environmental science; Segments of environment- structure and composition of atmosphere, hydrosphere, lithosphere and biosphere; Social environment; Limiting factors.

Thermodynamics- energy, laws governing energy flow, the first- and second- law of thermodynamics, entropy, enthalpy, Gibb's energy.

UNIT II: Ecosystem: Concepts and Principles

Course Objectives (COs):

1. To introduce the **concept of ecosystem** and its structural and functional components.
2. To understand the **biotic (producers, consumers, decomposers) and abiotic factors** that regulate ecosystem functioning.
3. To explain **energy flow, primary and secondary productivity**, and the role of **food chains, food webs, and trophic relations**.
4. To study **biogeochemical cycles** (carbon, nitrogen, phosphorus, sulphur) and their environmental significance.
5. To understand the concept of **ecological pyramids, energy models, and the Gaia hypothesis**.
6. To classify and analyze **different types of ecosystems, their geographical distribution, and major biomes**.
7. To develop a holistic view of ecosystem interactions, resilience, and sustainability.

Course Learning Outcomes (LOs):

After completing these topics, students will be able to:

1. **Define and explain the concept of ecosystem** and its importance in environmental science.
2. **Differentiate biotic and abiotic components** and explain their roles in ecosystem functioning.
3. **Illustrate food chains, food webs, and trophic relationships**, showing how energy is transferred across different levels.
4. **Analyze primary and secondary productivity** and relate them to energy flow in ecosystems.
5. **Describe major biogeochemical cycles** (carbon, nitrogen, phosphorus, sulphur) and explain their ecological significance.
6. **Interpret ecological pyramids** (number, biomass, energy) and their relevance to ecosystem structure.
7. **Evaluate the Gaia hypothesis and energy models** as frameworks for understanding global ecological balance.
8. **Classify ecosystems and biomes** based on geography, distribution, and climatic zones.
9. **Compare different types of ecosystems** (terrestrial, aquatic, etc.) in terms of structure, productivity, and biodiversity.
10. **Apply ecological knowledge to environmental management and conservation strategies**.

UNIT II: Ecosystem: Concepts and Principles

Concepts of ecosystem; Components of ecosystem- biotic and abiotic factors- producers, consumers and decomposers, food chain, food web; Dynamics of ecosystem– energy flow; primary and secondary productivity; Biogeochemical cycles- carbon, nitrogen, phosphorus, sulphur cycles; Trophic relation; Ecological pyramids; Gaia hypothesis; Energy model and energy relation in ecosystem; Types of ecosystems; Geographical classification, distribution and zone, major biomes;

UNIT III: Population Ecology

Course Objectives (COs):

1. To introduce the **concept and definition of population** in ecological studies.
2. To understand the **characteristics of populations**, including density, natality, mortality, and age distribution.
3. To study **population growth forms, fluctuations, and dispersal patterns** (migration, immigration, emigration).
4. To analyze the **causes and impacts of population explosion** and explore control measures.
5. To explain the concept of **carrying capacity** in ecosystems and human populations.
6. To differentiate between **r-strategy and K-strategy** in population dynamics.

Course Learning Outcomes (LOs):

After completing these topics, students will be able to:

1. **Define population and describe its key ecological characteristics** (density, natality, mortality, age structure).
2. **Explain population growth patterns** (logistic, exponential) and identify factors influencing fluctuations.
3. **Analyze different modes of dispersal** (migration, immigration, emigration) and their ecological consequences.
4. **Assess the causes and effects of population explosion** on natural resources, environment, and society.
5. **Evaluate population control measures** for sustainable development.
6. **Explain the concept of carrying capacity** and apply it to ecological and human population contexts.
7. **Differentiate between r-selected and K-selected species strategies** with examples.
8. **Apply population ecology principles** to resource management, conservation biology, and environmental planning.

UNIT III: Population Ecology

Definition; characteristics of population- density, natality, mortality, age distribution, population growth forms and population fluctuations; population dispersal- migration, immigration and emigration; Population explosion- causes and control measures; Concept of carrying capacity; r- selection strategy and k- selection strategy.

UNIT IV: Community Ecology

Course Objectives (COs):

1. To introduce the **concept of community** and its analytical and synthetic characteristics.
2. To explain the **concept of niche, keystone species, ecotypes, guilds, and edge effect** in shaping community structure.
3. To understand **ecological concepts** such as ecological niche, ecological equivalents, and ecological footprint.
4. To study the **processes of community development and succession**.

5. To analyze **biological interactions** (mutualism, parasitism, predation, competition, commensalism, positive and negative interactions) within communities.
6. To apply community ecology concepts in **conservation, biodiversity management, and sustainability**.

Course Learning Outcomes (LOs):

After completing these topics, students will be able to:

1. **Define ecological community** and differentiate its analytical and synthetic characters.
2. **Explain ecological niche and keystone species** and their importance in ecosystem balance.
3. **Differentiate ecotypes, guilds, edge effect, and ecological equivalents** with relevant examples.
4. **Analyze ecological footprint** to assess human impact on ecosystems.
5. **Explain community development and succession** processes in natural ecosystems.
6. **Evaluate different types of biological interactions** (mutualism, parasitism, predation, competition, commensalism) and their role in community dynamics.
7. **Interpret positive and negative interactions** in maintaining ecological stability.
8. **Apply community ecology principles** to biodiversity conservation, ecosystem management, and sustainable development.

UNIT IV: Community Ecology

Concept of community; Analytical and synthetic characters of community; Concept of niche; Keystone species; Ecotypes; Guilds; Edge effect; Ecological niche; Ecological equivalents; Ecological footprint; Community development; Biological interactions- mutualism, parasitism, prey-predator relations, competition, positive and negative interaction, commensalism, parasitism and predation.

Suggested Books:

1. Botkin DB (2011) *Environmental Science*: *Earth as a Living Planet*. John Wiley and Sons, New Delhi.
2. Odum E and Barett GW (2005) *Fundamentals of Ecology*. Thomson Asia Pvt. Ltd., Singapore.
3. Chapin III FS, Matson PA, Vitousek PM (2012) *Principles of Terrestrial Ecosystem Ecology*. 2nd Edition Springer.
4. Kormondi EJ (1999) *Concept of Ecology*. Prentice Hall of India. New Delhi.
5. Ambasht RS and Ambasht NK (1996) *A Text Book of Plant Ecology*. Students' Friends & Co, Lanka, Varanasi India.
6. Sharma PD (2008) *Ecology and Environment*. Rastogi Publication, New Delhi.

CORE II: ENVIRONMENTAL CHEMISTRY

Credits: 4
Marks: 100

COURSE CODE: ENV: 502

UNIT I: Fundamentals of Environmental Chemistry

Course Objectives (COs):

1. To introduce the **modern periodic table** and fundamental chemical concepts like molecular weight, equivalent weight, and mole concept.
2. To develop an understanding of **solution chemistry** – normality, molarity, molality, and stoichiometry.
3. To study the **principles of volumetric analysis**, including acid–base titrations and the use of primary and secondary standards.
4. To provide skills in **preparation of standard solutions and calculation of concentrations** using molecular weights and specific gravities.
5. To understand **ionic equilibria** concepts such as ionic product of water, buffer solutions, solubility products, solubility of gases in water, and the carbonate system.
6. To explain **chemical speciation** and its significance in environmental systems.

Course Learning Outcomes (LOs):

After completing these topics, students will be able to:

1. **Explain the modern periodic table** and apply concepts of molecular weight, equivalent weight, and mole concept in chemical calculations.
2. **Differentiate between normality, molarity, and molality** and perform stoichiometric calculations.
3. **Apply principles of volumetric analysis** to perform acid–base titrations accurately.
4. **Prepare standard solutions** using primary and secondary standards with correct procedures.
5. **Calculate solution concentrations** using molecular weights and specific gravities.
6. **Explain ionic product of water and buffer action** and apply them to environmental processes.
7. **Evaluate solubility products and gas solubility in water**, with emphasis on environmental systems (e.g., oxygen and carbon dioxide in aquatic systems).
8. **Interpret the carbonate system and chemical speciation** in natural waters and their role in environmental chemistry.
9. **Apply chemical knowledge** to analyze and solve environmental problems related to water chemistry, pollution, and ecological balance.

UNIT I: Fundamentals of Environmental Chemistry

Introduction to modern periodic table, molecular weight, equivalent weight, mole concept, normality, molarity, molality, stoichiometry- concept, volumetric analysis- principles of acid-base titrations, Primary and secondary standards- preparations, Calculations of concentration of solutions using specific gravities and molecular weights. Ionic products of water, Buffer solutions; Solubility products, Solubility of gases in water, Carbonate system; Chemical speciation.

UNIT II: Water Chemistry

Course Objectives (COs):

1. To introduce the **chemistry of inland water bodies** such as lakes, rivers, streams, estuaries, and wetlands.
2. To understand the **physico-chemical characteristics of water** that determine quality and ecological health.
3. To provide knowledge of **water sampling methods** for reliable analysis.
4. To study the **principles of determination** of key water quality parameters (DO, BOD, COD, pH, EC, TDS, hardness, chloride, sodium, potassium, phosphate).
5. To explain **water quality standards** and their significance in environmental monitoring and management.

Course Learning Outcomes (LOs):

After completing these topics, students will be able to:

1. **Describe the chemistry of inland water bodies** (lakes, rivers, estuaries, wetlands) and explain their ecological importance.
2. **Identify and analyze physico-chemical characteristics of water** that influence aquatic systems.
3. **Apply appropriate water sampling methods** for different types of water bodies.
4. **Explain the principles of measurement** of DO, BOD, COD, pH, EC, TDS, hardness, chloride, sodium, potassium, and phosphate.
5. **Perform calculations and analysis** related to these parameters in laboratory or field conditions.
6. **Interpret water quality data** and assess ecological health and pollution status.
7. **Evaluate water quality standards** (national and international) and apply them to environmental management and pollution control.
8. **Integrate chemical, ecological, and regulatory knowledge** to suggest solutions for maintaining water quality.

UNIT II: Water Chemistry

Chemistry of water bodies: lakes, rivers, and estuaries; Physico-chemical characteristics of water; Sampling methods of water; Principles of determination of DO, BOD, COD, pH, electrical conductivity, dissolved solids, hardness, chloride, sodium, potassium and phosphate; Drinking water quality standards.

UNIT III: Atmospheric Chemistry

Course Objectives (COs):

1. To introduce the **chemical composition of air**, including particles, ions, and radicals in the atmosphere.
2. To understand **chemical processes** involved in the formation of inorganic and organic particulate matter.
3. To study **thermochemical and photochemical reactions** occurring in the atmosphere.
4. To explain the chemistry and environmental effects of **smog, acid rain, oxygen, and ozone**.

5. To provide knowledge of **units of measurement** used in atmospheric chemistry (ppm, ppb, $\mu g/m^3$).

Course Learning Outcomes (LOs):

After completing these topics, students will be able to:

1. **Describe the chemical composition of air**, including suspended particles, ions, and reactive radicals.
2. **Explain the processes leading to the formation of particulate matter** (inorganic and organic) and its environmental implications.
3. **Analyze thermochemical and photochemical reactions** in the atmosphere and their role in air pollution.
4. **Differentiate between types of smog** (classical vs photochemical) and explain their chemistry and effects.
5. **Explain the chemistry of acid rain** and its ecological and structural impacts.
6. **Discuss the role of oxygen and ozone chemistry** in atmospheric balance and environmental protection.
7. **Apply correct units of measurement** (ppm, ppb, $\mu g/m^3$) for quantifying atmospheric pollutants.

Interpret atmospheric chemistry processes in relation to air pollution, climate change, and environmental health.

UNIT III: Atmospheric Chemistry

Chemical composition of air- particles, ions and radicals in the atmosphere; Chemical processes for formation of inorganic and organic particulate matter. Thermochemical and photochemical reactions in the atmosphere; Smog, Acid rain, Chemistry of oxygen and ozone; Units of measurement- ppm (v/v), ppb (v/v), $\mu g/m^3$.

UNIT IV: Soil Chemistry

Course Objectives (COs):

1. To introduce the **processes of weathering of rocks** and the formation of soil profiles.
2. To study the **inorganic and organic components of soil** and their ecological significance.
3. To understand the **major rock-forming minerals** and **soil-forming factors**.
4. To explain **soil properties** – chemical, physical, and mineralogical – and their role in ecosystem functioning.
5. To explore **soil respiration and nutrient functions** in soil health and fertility.
6. To analyze **physico-chemical properties of soil** such as temperature, texture, structure, and colloidal behavior.
7. To study **ion exchange reactions, soil pH, and nutrient availability** in soils.

Course Learning Outcomes (LOs):

After completing these topics, students will be able to:

1. **Describe the processes of rock weathering** and explain soil profile formation.
2. **Differentiate between inorganic and organic components of soil** and their ecological importance.
3. **Identify major rock-forming minerals** and explain soil-forming factors.
4. **Explain physical, chemical, and mineralogical properties of soil** and their role in soil fertility.

5. **Analyze soil respiration and nutrient functions** in supporting plant and microbial life.
6. **Evaluate physico-chemical properties of soil** (temperature, texture, structure, minerals, colloids).
7. **Explain ion exchange reactions in soil** and their importance in nutrient retention and mobility.
8. **Interpret soil pH** and its effect on nutrient availability and crop productivity.

Apply soil science concepts to environmental management, agriculture, and land-use planning.

UNIT IV: Soil Chemistry

Weathering of rocks, soil profile, inorganic and organic components of soil; Major rock formation minerals, soil forming factors, soil properties, chemical and mineralogical properties of soil; Soil respiration and nutrient functions.

Physico-chemical properties of soil- temperature, texture, structure, minerals of soil- colloids in soil; Ion exchange reactions in soil, soil pH.

Suggested Books:

1. De AK (2001) *Environmental Chemistry*. Wiley Eastern India Ltd.
2. Trivedy RN (2002) *A Text Book of Environmental Science*. Arnold Publications, Delhi.
3. Santra SC (2000) *Text Book of Environmental Science*. New Central Book Publishers.
4. Sharma BK and Kaur H (1994) *Environmental Chemistry*. Goel Publishing House, Meerut.
5. Esmarch SG (1958) *Fundamentals of Inorganic Chemistry*. McGraw Hill Publishers, NY.

CORE III: ENVIRONMENTAL GEOSCIENCES

COURSE CODE: ENV: 503

Credits: 4
Marks: 100

UNIT I: Basic Concepts

Course Objectives (COs):

1. To introduce the **origin and evolution of Earth and its environment**.
2. To study the **internal structure of Earth** and its physical properties.
3. To explain **geomagnetism, remnant magnetism, paleomagnetism, and gravity**, and their role in understanding Earth's history.
4. To understand the theory of **plate tectonics** and related processes such as seafloor spreading, mid-oceanic ridges, and trenches.
5. To study **lithospheric plate margins, types of boundaries, and causes of plate movement**.
6. To analyze major geological processes including **continental drift, mountain building, faulting, and folding**.

Course Learning Outcomes (LOs):

After completing these topics, students will be able to:

1. **Explain the evolution of Earth and its environment** from geological and environmental perspectives.
2. **Describe the internal structure of Earth** (core, mantle, crust) and their physical and chemical characteristics.
3. **Interpret geomagnetism, remnant magnetism, paleomagnetism, and gravity data** to understand Earth's processes.
4. **Explain the theory of plate tectonics** and evaluate evidence for seafloor spreading and continental drift.
5. **Differentiate lithospheric plate margins** (convergent, divergent, transform) and explain their geodynamic processes.
6. **Analyze the causes of plate movement** and their role in shaping Earth's surface.
7. **Describe geological processes such as mountain building, faulting, and folding** and their environmental implications.
8. **Apply geological knowledge** to natural hazard assessment (earthquakes, volcanoes, mountain systems) and resource management.

UNIT I: Basic Concepts

Evolution of earth and its environment; internal structure of the earth; geomagnetism, remnant magnetism, paleomagnetism, gravity and figure of the earth.

Plate tectonics- sea floor spreading, mid oceanic ridges, trenches, lithospheric plate margins and types, causes of movement, continental drift, mountain building, fault and fold.

UNIT II: Rocks, Minerals and Soil

Course Objectives (COs):

1. To introduce the **concept of the rock cycle** and the processes that shape Earth materials.
2. To study **agents, types, and products of weathering** and their role in soil and landscape formation.
3. To understand the **formation, classification, and properties of rocks and minerals**, including stress and strain effects.
4. To provide knowledge of **soil classification and survey methods**.
5. To analyze **land capability, classification, and land use planning** for sustainable development.
6. To understand **soil erosion processes, soil conservation, and major soil types of India**.

Course Learning Outcomes (LOs):

After completing these topics, students will be able to:

1. **Explain the rock cycle** and describe the processes of rock formation and transformation.
2. **Identify agents and types of weathering** and explain their role in producing soils and sediments.
3. **Classify rocks and minerals** based on formation, properties, and stress–strain relationships.
4. **Differentiate soils by classification systems** and explain soil survey techniques.
5. **Evaluate land capability classes** and apply them in land use planning and development.
6. **Describe soil erosion processes** and propose conservation measures.
7. **Identify major soil types of India** and relate them to agricultural and ecological potential.
8. **Apply knowledge of rocks, soils, and land use** in sustainable environmental and resource management.

UNIT II: Rocks, Minerals and Soil

Concept of rock cycle; Agents, types, and products of weathering; Rocks and minerals formation, classification, stress and strain; Soil- classification, survey; Land capability, classification, landuse, planning and development; Soil erosion and soil types of India.

UNIT III: Atmosphere

Course Objectives (COs):

1. To introduce the **origin and structure of the atmosphere** and its role in sustaining life.
2. To study **insolation, heat budget, and energy balance** of the Earth–atmosphere system.
3. To understand the **distribution of temperature, pressure, humidity, and wind systems**.
4. To provide knowledge of **atmospheric thermodynamics**, including the equation of state of dry and moist air.
5. To explain **hydrostatic balance, atmospheric equilibrium, stability and instability** of air masses.
6. To study **temperature lapse rate, inversions, diffusion, and turbulence** in the atmosphere.
7. To introduce the concepts of **mixing height and windrose** for atmospheric and environmental applications.

Course Learning Outcomes (LOs):

After completing these topics, students will be able to:

1. **Describe the origin and layered structure of the atmosphere** and its significance for weather and climate.
2. **Explain insolation and Earth's heat budget** and analyze their role in climate regulation.
3. **Interpret the spatial distribution of temperature, pressure, humidity, and wind** across different regions.
4. **Apply the equation of state of dry and moist air** in atmospheric thermodynamics.
5. **Explain hydrostatic balance and atmospheric equilibrium** and assess conditions of stability and instability.
6. **Differentiate between types of lapse rates and temperature inversions** and their environmental implications (e.g., smog).
7. **Analyze diffusion and turbulence of air** in relation to pollutant transport and dispersion.
8. **Apply the concepts of mixing height and windrose** in air quality studies, meteorology, and environmental planning.
9. **Integrate atmospheric science knowledge** into applications such as climate studies, pollution dispersion modeling, and weather forecasting.

UNIT III: Atmosphere

Origin and structure of atmosphere; insolation and heat budget; temperature and pressure distribution, humidity and wind; Atmospheric thermodynamics- equation of state of dry and moist air; Hydrostatic balance and atmospheric equilibrium-stability, instability, temperature lapse rate and inversion; Diffusion and turbulence of air; Mixing height, windrose.

UNIT IV: Oceanography

Course Objectives (COs):

1. To explain the **general circulation of the atmosphere** and its role in global climate systems.
2. To study **atmospheric disturbances** such as cyclones, anticyclones, and tropical storms.
3. To introduce **El-Niño, La-Niña, and ENSO phenomena** and their global climatic impacts.
4. To understand the **elements of weather and climate, climate controls, and climatic variability**.
5. To analyze the **concept of climate change and its environmental implications**.
6. To study **air masses** – their origin, modification, classification – and **fronts** with their characteristics.
7. To explain the **Indian monsoon system**, its origin, mechanism, seasonal distribution, and associated western disturbances.

Course Learning Outcomes (LOs):

After completing these topics, students will be able to:

1. **Explain the general atmospheric circulation** and its impact on global and regional climates.
2. **Differentiate between cyclones, anticyclones, and tropical disturbances** and assess their environmental consequences.

3. **Describe El-Niño, La-Niña, and ENSO phenomena** and evaluate their influence on global weather variability.
4. **Identify elements of weather and climate** and explain the major controls influencing them.
5. **Analyze climatic variability and climate change** and discuss their ecological and societal impacts.
6. **Define and classify air masses** and explain their role in shaping weather patterns.
7. **Explain the formation and classification of fronts** and their association with weather systems.
8. **Describe the origin, concept, and distribution of the Indian monsoon** and interpret the role of western disturbances in seasonal rainfall.
9. **Apply climatological knowledge** to agriculture, disaster management, and climate change adaptation strategies.

UNIT IV: Oceanography

General circulation; Atmospheric disturbances- cyclones, anticyclones and tropical disturbances; El-Nino, La-Nina, ENSO, elements of weather systems and climate; climate controls; climatic variability and climate change, climate types and distribution; Air mass- definition, source modification and classification; front characteristics and classification; Indian monsoon- origin, concept and distribution and western disturbance.

Suggested Books:

1. Lal DS (2004) *Climatology*. Chaitanya Publishing House, Allahabad.
2. Keller EA (1942) *Introduction to Environmental Geology*. 5th edition. Prentice Hall.
3. Lundgren L (1986*) Environmental Geology*. Prentice Hall, Engelwood Cliffs, New Jersey.
4. Pal AS (1988) *Introduction to Micrometeorology*, Academic Press.
5. Bell FG (1999) *Geological Hazards*. Routledge, London.
6. Singh S (2005) *Climatology*. Prayak Pustak Bhawan.
7. Mukherjee PK (2006) A Text Book of Geology. The World Press Pvt. Ltd., Kolkata.

CORE IV: FUNDAMENTALS OF ENVIRONMENTAL STATISTICS AND COMPUTER APPLICATION

Credits: 4

COURSE CODE: ENV: 504

Marks: 100

UNIT I: Measures of Central Tendency and Dispersion

Course Objectives (COs):

1. To introduce the concepts of **population and sample** in statistical analysis.
2. To understand **types of data, classification, summarization, and graphical representation techniques**.
3. To develop knowledge of **frequency distribution and descriptive statistics** (mean, median, mode).
4. To study **measures of dispersion** such as range, variance, standard deviation, and coefficient of variation.
5. To explain **correlation and regression analysis** and their application in prediction.
6. To understand the concepts of **skewness and kurtosis** for distribution analysis.

Course Learning Outcomes (LOs):

After completing these topics, students will be able to:

1. **Differentiate between population and sample** and apply sampling techniques in statistical studies.
2. **Classify and summarize different types of data** and represent them using diagrams and graphs.
3. **Construct and interpret frequency tables** and apply descriptive measures (mean, median, mode).
4. **Calculate and analyze measures of dispersion** including variance, standard deviation, and coefficient of variation.
5. **Apply correlation and regression methods** to identify relationships and make predictions.
6. **Interpret skewness and kurtosis** to describe the nature of data distribution.
7. **Use statistical tools effectively** in environmental, ecological, and social science research.
8. **Apply quantitative methods** for data-driven decision-making in environmental studies.

UNIT I: Measures of Central Tendency and Dispersion

Population and sample; Types of data, classification, summarization and diagrammatic graphic representation of data; Frequency table, mean, median, mode, measure of dispersion, standard deviation, variance, correlation, regression and prediction. Co-efficient of variation, skewness and Kurtosis.

UNIT II: Test of Significance

Course Objectives (COs):

1. To introduce the **concept of probability** and its application in environmental and scientific studies.
2. To study **probability distributions** (binomial, Poisson, normal) and their significance.
3. To provide knowledge of **hypothesis testing** using Z-test, T-test, and Chi-square test.
4. To explain **sampling distribution and standard error** and their applications in estimation.
5. To introduce **tests of equality of variances** (Bartlett's test) and their relevance in data analysis.
6. To study the principles of **analysis of variance (ANOVA)** for comparing means of multiple groups (one-way and two-way).

Course Learning Outcomes (LOs):

After completing these topics, students will be able to:

1. **Apply probability concepts** to environmental and statistical problems.
2. **Use binomial, Poisson, and normal distributions** for analyzing real-world datasets.
3. **Perform hypothesis testing** using Z-test, T-test, and Chi-square test for different research problems.
4. **Explain sampling distribution and standard error** and apply them in parameter estimation.
5. **Apply Bartlett's test** to check equality of variances across samples.
6. **Conduct one-way and two-way ANOVA** for comparing means across multiple groups.
7. **Interpret statistical results** and draw valid scientific conclusions.
8. **Integrate probability and inferential statistics tools** into environmental science research and decision-making.

UNIT II: Test of Significance

Probability, distribution- binomial; Poisson normal; Z-test, T-test, Chi-square test, Sampling distribution; Standard error and its uses. Test of equality of K-variance (Bartlett's test), analysis of variance (ANOVA) - one way and -two way.

UNIT III: Basic Principles of Field Experimentation

Course Objectives (COs):

1. To introduce the **principles of experimental design** – randomization, replication, and local control.
2. To explain the **layout and analysis of data** under different experimental designs.
3. To study **Completely Randomized Design (CRD), Randomized Block Design (RBD), and Latin Square Design (LSD)**.
4. To provide knowledge of **factorial experiments** and their application in multi-factor studies.
5. To understand **split-plot and strip-plot designs** and their significance in complex experiments.
6. To develop the ability to **analyze, interpret, and present experimental results** scientifically.

Course Learning Outcomes (LOs):

After completing these topics, students will be able to:

1. **Explain the basic principles of experimental design** – randomization, replication, and local control.
2. **Design and analyze experiments** using CRD, RBD, and LSD approaches.
3. **Apply factorial design** for studying interactions among multiple factors.
4. **Develop and interpret split-plot and strip-plot designs** for complex experimental settings.
5. **Perform statistical analysis of experimental data** using appropriate methods.
6. **Compare efficiencies of different designs** and select suitable ones for environmental, agricultural, or ecological studies.
7. **Interpret results scientifically** and draw valid conclusions from experimental data.
8. **Apply experimental design principles** to improve reliability and accuracy of environmental and scientific research.

UNIT III: Basic Principles of Field Experimentation

Randomization, replication, and local control; Lay out and analysis of data of completely Randomized Block Design, Randomized Block Design, Latin Square Designs, Factorial Design, Split plot and Strip plot designs.

UNIT IV: Computer Fundamentals

Course Objectives (COs):

1. To introduce the use of **MS-Excel** for data entry, organization, and statistical analysis.
2. To develop skills in **creating tables, sorting data, preparing charts, and calculating averages** using Excel functions.
3. To enable students to perform **basic statistical analysis and reporting** using MS-Word.
4. To familiarize students with **biological databases available on the internet** and their applications.
5. To enhance the ability to **collect, manage, and analyze biological and environmental datasets** using digital tools.

Course Learning Outcomes (LOs):

After completing these topics, students will be able to:

1. **Prepare tables and organize datasets** efficiently using MS-Excel.
2. **Sort, filter, and visualize data** through different types of charts (bar, pie, line, scatter, etc.).
3. **Calculate averages, percentages, and descriptive statistics** using Excel functions.
4. **Perform statistical analysis and documentation** in MS-Word with proper formatting.
5. **Search, collect, and analyze biological and environmental data** using online databases.
6. **Integrate digital tools** to support research, data interpretation, and scientific reporting.
7. **Present data in professional formats** for academic and research purposes.

UNIT IV: Computer Fundamentals

Preparation of tables, sorting of data, creating of chart and calculation of average using MS-Excel. Statistical analysis of data using MS-Word. Collection and analysis of biological data bases using internet.

Suggested Books:

1. Khan IA and Khanum A (1999) *Fundamentals of Biostatistics*. UKAAS Publication, Hyderabad.
2. Bhuyan KC (2017) *Advance Biostatistics*. NCBA.
3. Gurumani N (2006) *Research Methodology for Biological Sciences*. MJP Publishers, Chennai.
4. Zar JH (1999) *Biostatistical Analysis*. 4th edition, Pearson Education (Singapore) Pte. Ltd., Delhi.
5. Pardeep KJ and Gurdeep R (2004) *Biostatistics*. Krishna Prakashan Media (P) Ltd., Meerut.

CORE PRACTICAL- I
(LABORATORY –I)

Credits: 4
Marks: 100

COURSE CODE: ENV: 505

Ecology

Course Objectives (COs):

1. To train students in **ecological sampling techniques** and determination of appropriate sample size.
2. To study **vegetation community parameters** (frequency, density, basal area, abundance, IVI, diversity indices).
3. To provide hands-on experience in **measuring biomass, standing crop, and primary productivity** of ecosystems.
4. To familiarize students with **plankton and faunal diversity assessment methods** across different ecosystems.
5. To introduce methods for assessing **plant physiological traits** like leaf area index and chlorophyll content.
6. To build skills in **sampling and analysis of water and plankton** for ecological studies.

Course Learning Outcomes (LOs):

After successful completion, students will be able to:

1. **Determine the requisite size of quadrats** for ecological sampling.
2. **Quantitatively analyze vegetation communities** using frequency, density, basal area, abundance, IVI, and various diversity indices (Shannon, Pielou's, Simpson's).
3. **Estimate biomass and standing crop** of plant communities.
4. **Measure primary productivity** in aquatic ecosystems.
5. **Assess plankton diversity** across freshwater and marine ecosystems.
6. **Evaluate faunal diversity** in different land-use patterns.
7. **Calculate leaf area index and chlorophyll content** as indicators of plant growth and productivity.
8. **Apply standard sampling methods** for water and plankton collection.
9. **Develop practical field and laboratory skills** essential for ecological research and environmental monitoring.

Ecology

1. Determination of requisite size of quadrat.
2. Study of grassland and forest vegetation community parameters- frequency, density, basal area, abundance, IVI and other diversity indices (Shannon diversity index, Peilou's eveness index, Simpson's dominance index).
3. Study of biomass/ standing crop of plant community.
4. Study of productivity of an aquatic ecosystem.
5. Study of plankton diversity in different aquatic ecosystem.
6. Study of faunal diversity in different landuse.
7. Study of leaf area index.

8. Estimation of chlorophyll content.
9. Methods for water and plankton sampling.

Biostatistics

Course Objectives (COs):

1. To develop computational skills in **basic statistical measures** such as mean deviation, standard deviation, and standard error.
2. To train students in applying **tests of significance** (Z-test, T-test, Chi-square test) for biological and environmental data.
3. To enable understanding and calculation of **regression coefficients** for predictive analysis.
4. To introduce students to the **application of ANOVA (Analysis of Variance)** for testing differences among groups.

Course Learning Outcomes (LOs):

After successful completion, students will be able to:

1. **Calculate mean deviation, standard deviation, and standard error** to analyze variability in datasets.
2. **Perform statistical hypothesis testing** using Z-test, T-test, and Chi-square test.
3. **Determine regression coefficients** and apply regression analysis for prediction and correlation studies.
4. **Apply ANOVA techniques** (one-way and two-way) to compare group means in experimental data.
5. **Interpret statistical results** and draw valid scientific conclusions from biological and environmental datasets.

Biostatistics

1. Calculation of mean deviation, standard deviation and standard error of mean.
2. Estimation of test of significance (Z-, T- and Chi-square).
3. Calculation of regression co-efficient.
4. Application of analysis of variance.

Suggested Books:

1. Mishra R (1968) *Ecology Work Book*. Oxford & IBH Publishing Co. New Delhi.
2. Ambasht RS and Ambasht NK (1996) *A Text Book of Plant Ecology*. Students' Friends & Co, Lanka, Varanasi India.

CORE PRACTICAL- II
(LABORATORY-II)

Credits: 4
Marks: 100

COURSE CODE: ENV: 506

Environmental Chemistry

Course Objectives (COs):

1. To train students in the **preparation of standard solutions** for environmental and chemical analysis.
2. To provide hands-on experience in **soil sampling methods** and determination of key soil physico-chemical properties.
3. To introduce students to **surface and groundwater sampling techniques** for environmental monitoring.
4. To develop practical skills in assessing **physico-chemical properties of water**, ensuring water quality analysis.

Course Learning Outcomes (LOs):

After successful completion, students will be able to:

1. **Prepare and standardize chemical solutions** for laboratory experiments.
2. Perform **soil sampling and analyze soil physico-chemical properties** (moisture, texture, bulk density, pH, temperature, EC, CEC).
3. Conduct **surface and groundwater sampling** following proper protocols.
4. Measure **key water quality parameters** such as TDS, EC, pH, salinity, and CO_2.
5. **Interpret soil and water quality results** to assess their suitability for ecological and environmental purposes.

Environmental Chemistry

1. Preparation of standard solutions.
2. Basic methods of soil sampling.
3. Determination of soil physico-chemical properties- moisture content, texture, bulk density, pH, temperature, electrical conductivity, cation exchange capacity.
4. Basic methods of surface and ground water sampling.
5. Determination of physico-chemical properties of water- total dissolved solids, electrical conductivity, Dissolved Oxygen, pH, salinity, CO_2.

Environmental Geoscience

Course Objectives (COs):

1. To familiarize students with the **measurement of key meteorological parameters** (pressure, humidity, wind, rainfall, temperature).
2. To provide practical training in **geological surveying and map preparation**.
3. To introduce students to the **identification of structural features** such as faults and folds.
4. To develop skills in the **identification and classification of common rocks and minerals** based on their physical properties.

Course Learning Outcomes (LOs):

After completing this practical course, students will be able to:

1. **Measure and record meteorological parameters** (pressure, humidity, wind speed/direction, temperature, rainfall) and construct a **windrose diagram**.
2. Perform **geological surveys** and prepare **topographic and geological maps** for environmental applications.
3. **Identify fault lines** and understand their significance in tectonics and natural hazards.
4. **Identify and characterize common rocks and minerals** by observing their physical and chemical properties.

Apply meteorological and geological knowledge in **environmental impact assessments, disaster studies, and natural resource management**.

Environmental Geoscience

1. Determination of meteorological parameters- atmospheric pressure, relative humidity, wind speed, wind direction, construction of windrose, temperature, rainfall.
2. Geological surveying and preparation of survey maps.
3. Determination of fault line.
4. Identification of common rocks and minerals and their properties.

Suggested Books:

1. Chhatwal GR, Mehra MC, Satake M, Katyal T, Katyal, M and Nagahiro T (1992) *Enivronmental Analysis (Air, Water and Soil)*. Anmol Publications, New Delhi India.
2. Manivasakan N (1985) *Physico-chemical Examinations of Water, Sewage and Industrial Effluents*. 1st Edition. Prakati Prakashan, Meerut.
3. Trivedy RK and Goel PK (1986) *Chemical and Biological Methods for Water Pollution Studies*. Environmental Publication, Karad.
4. APHA (2012) *Standard Methods for the Examination of Water and Waste Water*. 22nd Edition. American Public Health Publication, Washington DC.

M.Sc. 2nd Semester

CORE V: ENVIRONMENTAL POLLUTION-I

Credits: 4

COURSE CODE: ENV: 507

Marks: 100

UNIT I - Introduction to Environmental Pollution

Course Objectives (COs):

1. To understand the **concept of Earth as a system** and its natural balance.
2. To study the **historical perspectives** of environmental pollution and human interactions with nature.
3. To define and classify **environmental pollution, pollutants, and contaminants**.
4. To identify the **sources and nature of pollutants/contaminants** (natural vs anthropogenic; physical, chemical, biological, thermal, etc.).
5. To explore the **major causes of environmental pollution** and the role of **environmental awareness in ancient times**.

Course Learning Outcomes (LOs):

After completing this unit, students will be able to:

1. **Explain Earth as a self-regulating system** and its environmental components.
2. **Describe the historical evolution** of environmental pollution from ancient to modern times.
3. **Define environmental pollution, pollutants, and contaminants**, and distinguish between them.
4. **Classify environmental pollution** based on types (air, water, soil, noise, thermal, etc.) and the nature of pollutants.
5. **Identify natural and anthropogenic sources** of environmental contaminants.
6. **Analyze the causes and consequences of environmental pollution** in human and ecological systems.
7. Appreciate **early environmental awareness and traditional practices** that promoted sustainability.

UNIT I - Introduction to Environmental Pollution

Earth as a system; pollution of environment in ancient times; history of the emergence of environmental pollution; definition, and types of environmental pollution; definition of pollutant and contaminant; major sources of pollutants/ contaminants- natural and anthropogenic; nature of pollutants/ contaminants- physical, chemical, biological, thermal etc. major causes of environmental pollution; environmental awareness in ancient times.

UNIT II - Air Pollution

Course Objectives (COs):

1. To define **air pollution** and classify **air pollutants** into primary, secondary, particulate, and gaseous forms.
2. To study the **natural and anthropogenic sources** of air pollution and the **sources and sinks** of major pollutants (SOx, NOx, COx, hydrocarbons, particulates).

3. To understand **methods of monitoring air pollutants** such as SOx, NOx, COx, and suspended particulate matter (SPM).
4. To evaluate the **impacts of air pollution** on human health, plants, animals, materials, and climate.
5. To learn various **air pollution control and abatement technologies** for particulate and gaseous pollutants.
6. To explore **indoor air pollution** and **vehicular pollution**, along with strategies for their control.

Course Learning Outcomes (LOs):

After completing this unit, students will be able to:

1. **Define and classify air pollutants** into primary/secondary and particulate/gaseous categories.
2. **Differentiate between natural and anthropogenic sources** of air pollution and explain the **sources and sinks** of SOx, NOx, COx, hydrocarbons, and particulates.
3. **Apply methods of monitoring** major air pollutants (SOx, NOx, COx, SPM) using standard techniques.
4. **Analyze the effects of air pollution** on humans, flora, fauna, materials, and climate systems.
5. **Evaluate air pollution control methods** for particulates (gravity settling chambers, cyclones, electrostatic precipitators, filters) and gaseous pollutants (adsorption, absorption, combustion, flue gas desulphurization).
6. **Assess indoor and vehicular air pollution** problems and propose effective mitigation measures.

UNIT II - Air Pollution

Air pollution - Definition; Air Pollutants - types of air pollutants: Primary and Secondary, particulate and Gaseous; sources of air pollution - natural and anthropogenic sources, sources and Sinks of SOx, NOx, COx, HCs, and particulate matters; Methods of monitoring air pollutants- SOx, NOx, COx and SPM; Effect of air pollution on human health, plants, animals, materials and climate; Air pollution control and abatement – control of particulate matter: gravity settling chambers, centrifugal collectors, precipitators, fabric filters; control of gaseous pollutants: Adsorption, absorption, combustion, flue gas desulphurization; indoor air pollution; vehicular pollution and its control.

UNIT III - Water Pollution

Course Objectives (COs):

1. To define **water pollution** and study its types: surface, groundwater, and marine pollution.
2. To understand the **sources (point and non-point)** and **causes** of water pollution.
3. To analyze the **effects of water pollution** on human health, plants, animals, and ecosystems.
4. To examine the specific **effects of marine and groundwater pollution** on ecosystems and resources.
5. To learn about **control measures and abatement strategies** for water pollution.
6. To understand **sewage and wastewater treatment methods**: primary, secondary, and advanced treatment techniques.

Course Learning Outcomes (LOs):

After completing this unit, students will be able to:

1. **Define water pollution** and classify it into surface water, groundwater, and marine pollution.

2. **Differentiate between point and non-point sources** of water pollution and explain their causes.
3. **Analyze the effects of water pollution** on human health, flora, fauna, and the environment.
4. **Assess the impacts of marine pollution** on the marine ecosystem and **groundwater pollution** on freshwater resources.
5. **Evaluate and propose control measures** for reducing water pollution from various sources.
6. **Explain and compare wastewater treatment methods** – primary, secondary, and advanced – for effective water quality management.

UNIT III - Water Pollution

Water pollution - definition; types – surface water pollution, groundwater pollution, marine pollution; sources of water pollution- point and non-point; causes of surface water, groundwater and marine pollution; Effects of water pollution on human health, plants, animals, environments; effects of marine pollution on the marine ecosystem; effects of groundwater pollution; control measures and abatement of water pollution; sewage and waste water treatment methods- primary, secondary and other advanced treatment techniques.

UNIT IV - Soil Pollution

Course Objectives (COs):

1. To define **soil pollution** and understand its scope.
2. To study the **sources of soil pollution**, including agricultural, industrial, municipal, and mining activities.
3. To understand the impact of **industrial waste effluents and heavy metals** on soil components.
4. To analyze the **degradation and persistence** of pesticides (insecticides, fungicides, weedicides) in soil.
5. To examine the **interaction of synthetic fertilizers (N, P, K)** with soil properties.
6. To assess the **effects of soil pollution** on ecosystems, environment, and human health.
7. To learn about **soil pollution control measures** for sustainable land use and agriculture.

Course Learning Outcomes (LOs):

After completing this unit, students will be able to:

1. **Define soil pollution** and explain its major causes.
2. **Identify and evaluate sources of soil pollution** such as agriculture, industry, municipal waste, landfill leachates, plastics, radioactive leakage, and mining.
3. **Explain the interactions of heavy metals** and industrial effluents with soil components.
4. **Analyze the degradation pathways** of insecticides, fungicides, and weedicides in soil.
5. **Assess the role of synthetic fertilizers (N, P, K)** and their interactions with different soil components.
6. **Evaluate the effects of soil pollution** on soil fertility, environment, ecosystems, and human health.
7. **Recommend soil pollution control measures** to minimize risks and promote soil health.

UNIT IV - Soil Pollution

Soil pollution definition; sources of soil pollution – agricultural practices, industrial municipal discharges, solid waste dumping, landfill leachates, plastics, radioactive leakage, mining activities etc.; Industrial waste

effluents and heavy metals interaction with the soil components; degradation of different insecticides, fungicides, weedicides in soil; interaction of synthetic fertilizers (N,P and K) and their interactions with different components of soil; effects of soil pollution on environment; soil pollution control measures.

Suggested Books:

1. Bell JNB (2002) *Air Pollution and Plant Life.* 2nd Edition, John Wiley and Sons.
2. Fellenberg G (1999) *Chemistry of Pollution*, John Wiley and Sons.
3. Trivedi RK (2003) *An Introduction to Air Pollution*. DVS Publication.
4. Trivedi RK and Goel PK (2010). *An Introduction to Air Pollution*, 2nd edition, DVS Publication New Delhi.
5. Reddy PJ (2011) *Pollution and Global Warming.* BSP Books Pvt. Ltd., Kolkata.
6. Arya SP (1999) *Air Pollution Meteorology and Dispersion*. Oxford University Press, London.
7. Cunningham WP and Saigo WB (2005) *Environmental Science*. McGraw Hill, New York.
8. El-Halwagi MM (1997) *Pollution Prevention through Processes Integration*. Academic Press, Washington.
9. De AK (2010) *Environmental Chemistry*. New Age International, New Delhi.
10. Kush S (2001) *Automobile Polllution*. Sarup Publications, New Delhi.

CORE VI: ENVIRONMENTAL POLLUTION-II

Credits: 4 COURSE CODE: ENV: 508

Marks: 100

UNIT I - Noise Pollution

Course Objectives (COs):

1. To define the **concept of noise pollution** and its significance.
2. To study the **sources of noise pollution**, both indoor and outdoor.
3. To understand **exposure levels of noise** and standards in different environments.
4. To examine the **effects of noise pollution** on humans, animals, and environment.
5. To learn about **noise measurement instruments** such as noise dosimeter and sound level meter.
6. To introduce the **source-path-receiver concept** in noise control.
7. To explore **noise control measures** at the source, during transmission, and at the receiver.

Course Learning Outcomes (LOs):

After completing this unit, students will be able to:

1. **Define and explain noise pollution** and its conceptual framework.
2. **Identify sources of indoor and outdoor noise pollution** in different environments.
3. **Assess exposure levels and apply noise pollution standards** for workplace, residential, and industrial settings.
4. **Evaluate the harmful effects of noise pollution** on physical and mental health, communication, productivity, and wildlife.
5. **Operate and interpret noise measuring instruments** (noise dosimeter, sound level meter).
6. **Apply the source-path-receiver concept** to analyze noise control strategies.
7. **Recommend noise control techniques** at the source, along the transmission path, and by protecting the receiver.

UNIT I - Noise Pollution

Noise pollution - Definition and concept; sources of noise pollution; indoor and outdoor noise pollution; exposure levels of noise; standards of measuring noise pollution in different environment; Effect of noise pollution; Instruments for measuring noise – noise dosimeter, sound level meter; source-path-receiver concept in noise control; noise control - source, transmission path and protecting the receiver.

UNIT II - Radioactive and Thermal Pollution

Course Objectives (COs):

1. To understand the **concept and definition** of radioactive pollution.
2. To study **types and sources** of radioactivity – natural and man-made.
3. To learn about **radioactive decay** and **radiation dose** measurement.
4. To analyze the **interaction of radiation with living organisms**.
5. To evaluate **biological impacts and health hazards** of radiation exposure.

6. To study **safety and protection measures** against ionizing radiation.
7. To examine **control measures and disposal methods** of radioactive wastes.

Course Learning Outcomes (LOs):

By the end of this unit, students will be able to:

1. **Define radioactive pollution** and explain its key concepts.
2. **Differentiate between natural and man-made radioactivity.**
3. **Explain radioactive decay and calculate radiation dose levels.**
4. **Describe how radiation interacts with cells, tissues, and organisms.**
5. **Evaluate health hazards** (e.g., cancer, genetic mutations, organ damage) from radiation.
6. **Apply protection measures** against ionizing radiation in different fields (medical, nuclear, industry).
7. **Recommend safe disposal techniques** for radioactive materials.

Thermal Pollution

Course Objectives (COs):

1. To define and explain the **concept of thermal pollution**.
2. To identify the **sources of thermal pollution** (industrial discharge, power plants, etc.).
3. To study the **biological and chemical impacts** of thermal pollution on aquatic ecosystems.
4. To introduce **mitigation measures** and technologies to reduce thermal pollution.

Course Learning Outcomes (LOs):

By the end of this unit, students will be able to:

1. **Define thermal pollution** and identify its sources.
2. **Explain biological impacts** (loss of biodiversity, reduced dissolved oxygen, fish kills).
3. **Explain chemical impacts** (alteration in water chemistry, eutrophication).
4. **Suggest mitigation measures** (cooling ponds, cooling towers, waste heat utilization, regulation).

UNIT II - Radioactive and Thermal Pollution

Radioactive pollution – definition and concept; types and sources of radioactivity; natural and man-made radioactivity; radioactive decay; radiation dose; interaction of radiation with living matter; Biological impact and health hazards associated with radiation; protection against ionizing isotopes from its application; control measures of radioactive pollution; radioactive material disposal.

Thermal pollution – definition and sources; biological and chemical effect of thermal pollution; mitigation measures for thermal pollution.

UNIT III - Solid Waste Pollution and Management

Course Objectives (COs):

1. To understand the **definition and concept** of solid waste and its pollution.
2. To study the **causes, effects, and control measures** of solid waste pollution.
3. To learn about **characterization, chemical composition, and classification** of solid waste.
4. To analyze different **methods of management and disposal** of solid waste.
5. To evaluate the role of **advanced methods** such as **composting, vermi-composting, pyrolysis, and waste-to-energy.**

6. To promote **sustainable waste minimization technologies** like the **3Rs (Reduce, Reuse, Recycle)** and refuse-derived fuel.

Course Learning Outcomes (LOs):

By the end of this unit, students will be able to:

1. **Define solid waste pollution** and explain its major causes.
2. **Describe the effects of solid waste** on environment, human health, and ecosystems.
3. **Classify solid waste** (municipal, industrial, biomedical, agricultural, hazardous, e-waste).
4. **Analyze the chemical composition and characteristics** of solid waste.
5. **Explain and compare methods of solid waste management**, including:
    - Collection and transportation
    - Open dumping and sanitary landfilling
    - Ocean dumping
    - Incineration and pyrolysis
    - Composting and vermi-composting
6. **Discuss recycling strategies** for different types of waste.
7. **Apply waste minimization technologies** such as **3Rs, RDF, and waste-to-energy conversion**.

UNIT III - Solid Waste Pollution and Management

Solid waste – definition; causes, effects and control measures of solid waste pollution; characterization, chemical composition, classification of solid waste; Methods of management and disposal of solid waste-collection, transportation, processing, open dumping, ocean dumping, sanitary landfill, incineration, pyrolysis, composting, vermi-composting; Recycling of solid waste; Waste minimization technologies – 3Rs concept, refuse derived fuel, waste to energy.

UNIT - IV Biomedical, Hazardous and E-Waste Management

1. Biomedical Waste

Course Objectives (COs):

1. To define biomedical waste and understand its **sources and classification**.
2. To study the **problems and risks** associated with biomedical waste.
3. To learn about **treatment and safe disposal techniques**.

Course Learning Outcomes (LOs):

By the end of this topic, students will be able to:

- Define **biomedical waste** and identify its **major sources** (hospitals, clinics, labs, veterinary centers, etc.).
- Classify biomedical waste (infectious, pathological, sharps, pharmaceuticals, radioactive, chemical).
- Explain **problems and risks** (disease transmission, environmental contamination).
- Describe **treatment and disposal methods**: incineration, autoclaving, microwaving, chemical disinfection, secured landfills.

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2. Hazardous Waste

Course Objective (COs):

1. To define **hazardous waste** and learn methods of identification and classification.

2. To understand **management strategies** for hazardous waste (generation to disposal).
3. To analyze **treatment methods** (physical, chemical, thermal, biological).

Course Learning Outcome (Los):

Students will be able to:

- Define **hazardous waste** and explain its characteristics (ignitability, corrosivity, reactivity, toxicity).
- Classify hazardous waste (industrial, chemical, biomedical, radioactive, e-waste).
- Explain **hazardous waste management steps**: generation → storage → collection → transportation → processing → disposal.
- Discuss **treatment methods**:
    - Physical (filtration, encapsulation)
    - Chemical (neutralization, precipitation)
    - Thermal (incineration, pyrolysis)
    - Biological (bioremediation, composting of some hazardous organics).

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3. E-Waste (Electronic Waste)

Course Objective (COs):

1. To define **E-waste** and study its **composition, sources, and types**.
2. To understand the **status of E-waste generation in India and globally**.
3. To evaluate **recycling and management strategies** for E-waste.

Course Learning Outcome (Los):

Students will be able to:

- Define **E-waste** and list its sources (computers, mobiles, TVs, batteries, home appliances).
- Describe **composition** (plastics, metals like Pb, Hg, Cd, rare earths, glass).
- Compare **E-waste generation** in India vs global scenario.
- Explain **recycling and recovery processes** (manual dismantling, mechanical shredding, smelting, hydrometallurgy).
- Analyze the **environmental and health consequences** of E-waste (heavy metal leaching, toxic fumes, soil and water contamination).

UNIT - IV Biomedical, Hazardous and E-Waste Management

Biomedical waste – definition, sources, and classification; problems associated with biomedical waste; treatment and disposal techniques of biomedical waste.

Hazardous waste - definition, identification and classification; hazardous waste management - generation, storage, collection, transportation, processing, disposal; treatment of hazardous waste - physical, chemical, thermal and biological.

E-waste - definition, composition, sources and types; E-waste generation in India; E-waste in the global context; recycling of E-waste; environmental consequences of E-waste.

Suggested Books:

1. Fellenberg G (1999) *Chemistry of Pollution*, John Wiley and Sons.
2. Reddy PJ (2011) *Pollution and Global Warming.* BSP Books Pvt. Ltd., Kolkata.

3. Reddy PJ (2011) *Municipal Solid Waste Management, Processing, Energy Recovery Global Examples*. BSP Books Pvt. Ltd. Hyderabad.
4. Rao MN and Sultana R (2012) *Solid and Hazardous Waste Management.* BS Publications.
5. Cunningham WP and Saigo WB (2005) *Environmental Science*. McGraw Hill, New York.
6. El-Halwagi MM (1997) *Pollution Prevention through Processes Integration*. Academic Press, Washington.
7. De AK (2010) *Environmental Chemistry*. New Age International, New Delhi.
8. Kush S (2001) *Automobile Polllution*. Sarup Publications, New Delhi.

CORE VII: ENVIRONMENTAL MICROBIOLOGY AND BIOTECHNOLOGY

Credits: 4
Marks: 100

COURSE CODE: ENV: 509

UNIT I: Introduction to Environmental Microbiology

Course Objectives (COs):

1. To introduce the **concept, scope, history, and importance** of environmental microbiology.
2. To understand the **role of microorganisms in ecosystems** (soil, water, air).
3. To study the **classification and characteristics of microorganisms** relevant to the environment.
4. To analyze the **role of microbes in soil** (mycorrhiza, rhizosphere interactions, nutrient cycling).
5. To explore **microbial distribution in aquatic environments** (upwelling zones, benthic microbes, biofouling).
6. To understand **techniques for studying aquatic microorganisms**.
7. To examine **airborne pathogens and bioaerosols** including their **pathways (launching, transport, deposition)**.
8. To assess the **environmental factors** (humidity, temperature, radiation, oxygen) influencing microbial survival and dispersal.

Course Learning Outcomes (LOs):

By the end of this unit, students will be able to:

Introduction & Scope

- Define **environmental microbiology** and explain its **scope, history, and importance**.

Microbes in Ecosystem

- Describe the **classification and characteristics** of microorganisms.
- Explain the **ecological roles of microbes** in soil, water, and air.

Soil Microbiology

- Explain the **role of soil microbes** in nutrient cycling, organic matter decomposition, and soil fertility.
- Describe **mycorrhiza** (symbiotic fungi–plant interaction) and its benefits.
- Define **rhizosphere** and explain its significance in **plant-microbe interactions**.

Aquatic Microbiology

- Describe the **distribution of microorganisms** in aquatic systems (surface, deep water, benthic).
- Explain concepts of **upwelling** and microbial roles in aquatic productivity.
- Define and explain **biofouling** (microbial colonization of surfaces in aquatic environments).
- List **techniques used for studying aquatic microorganisms** (microscopy, plating, molecular methods).

Aeromicrobiology

- Define **airborne pathogens** and **bioaerosols**.
- Explain the **aeromicrobiological pathway**: launching, transport, deposition.
- Identify **factors influencing microbial survival in the air** (relative humidity, temperature, UV radiation, oxygen levels).

UNIT I: Introduction to Environmental Microbiology

Introduction - concept, scope, history and importance of environmental microbiology; microorganisms as a component of ecosystem; classification and characteristics of microorganisms; Microbes in soil and their role; mycorrhiza, rhizosphere and their significance; Microorganisms in the aquatic environment and their distribution- updwelling; benthic microorganisms; biofouling; techniques for the study of aquatic microorganisms; Airborne pathogens; nature of bioaerosols; aeromicrobiological pathway – launching, transport, deposition; factors influencing microbes in the air- relative humidity, temperature, radiation, oxygen.

UNIT II- Applied Environmental Microbiology

Course Objectives (COs):

1. To understand how **microbes interact with environmental factors** in biodegradation and ecosystem functioning.
2. To study the **role of microorganisms in biogeochemical cycles** (C, N, S, P cycles).
3. To analyze **microbial corrosion** and its environmental/economic impact.
4. To learn about **biodegradation of pesticides and hydrocarbons** by microbes.
5. To understand **microbial fermentation** and its industrial/environmental applications.
6. To explore **bioremediation and bio-restoration**, particularly of **mine spoils**.
7. To study **bioactive compounds from aquatic microbes** (antibacterial and therapeutic potential).
8. To learn the role of microbes in **public health and sanitation** (food industries, hospitals, animal houses).
9. To understand **biosafety principles** in laboratories and industrial setups.
10. To examine **bioaerosols and their control** using ventilation, filtration, biocides, and isolation techniques.

Course Learning Outcomes (LOs):

By the end of this unit, students will be able to:

Microbes in Biodegradation & Biogeochemical Cycles

- Explain how microbes interact with environmental factors in **biodegradation processes**.
- Describe the microbial role in **carbon, nitrogen, sulfur, and phosphorus cycles**.

Biodegradation & Bioremediation

- Explain **microbial corrosion** and its prevention.
- Discuss microbial degradation of **pesticides** and **hydrocarbons**.
- Describe microbial role in **fermentation** (industrial and environmental uses).
- Explain microbial role in **bioremediation** and **bio-restoration of mine spoils**.

Aquatic Microorganisms & Bioactive Compounds

- Identify **antibacterial and bioactive compounds** produced by aquatic microbes.
- Discuss their potential applications in medicine and biotechnology.

Public Health Microbiology

- Define **sanitation and disinfection** concepts.
- Explain **microbial control in industrial and food processing units**.
- Describe sanitation needs for **animal houses, hospitals, and fermentation units**.
- Demonstrate understanding of **biosafety principles** in laboratories.

Bioaerosols & Control

- Define **bioaerosols** and explain their impact on health.
- Describe **control methods**: ventilation, filtration, biocidal treatment, and isolation.

UNIT II- Applied Environmental Microbiology

Interaction of microbes with environmental factors in biodegradation processes; role of microorganisms in biogeochemical cycles; microbial corrosions; biodegradation of pesticides, hydrocarbons; microbial fermentation; bio-restoration of mine spoils; antibacterial and bioactive compounds from aquatic micro-organisms; microbes and public health - general concepts of sanitation and disinfection, sanitation of industrial and food processing units, safe location of animal houses, hospitals, industrial fermentation units, biosafety in the laboratories; bioaerosols control – ventilation, filtration, biocidal control and isolation.

UNIT III- Introduction to Environmental Biotechnology

Course Objectives (COs):

1. To introduce the **concept, principles, and scope** of environmental biotechnology.
2. To understand the **role and applications** of biotechnology in solving environmental problems.
3. To study the **basic molecular biology techniques** such as **gene cloning, hybridization, and PCR**.
4. To learn about **plasmids, phage vectors, and gene transfer methods**.
5. To understand the use of **biomarkers** and their role in environmental monitoring.
6. To explore **modern tools** in biotechnology (GMOs, biosensors, bioplastics, biofuels, DNA sensing).
7. To analyze the **biotechnological solutions for environmental issues** such as polymer biodegradation and oil spill bioremediation.
8. To review the **latest advances and trends** in environmental biotechnology and its global market potential.

Course Learning Outcomes (LOs):

By the end of this course, students will be able to:

Fundamentals

- Define **environmental biotechnology** and explain its **scope, principles, and significance**.
- Describe the **development and market trends** in environmental biotechnology.

Molecular Techniques

- Explain the **concept and process of gene cloning**.
- Describe **basic techniques of cloning** including restriction digestion, ligation, and transformation.
- Explain the principle and application of **PCR** and **nucleic acid hybridization**.
- Understand **introduction of cloned genes** into new hosts using **plasmid and phage vector systems**.

Environmental Applications

- Explain the role of **biomarkers** in environmental monitoring.
- Discuss the use of **GMOs** and **cell biological methods** in environmental biotechnology.
- Describe applications of **biosensors** in pollution detection.

- Evaluate the potential of **bioplastics and biofuels** as sustainable alternatives.
- Explain **DNA sensing techniques** and their applications.
- Analyze **polymer biodegradation** and **oil spill bioremediation** using biotechnological methods.

Advanced Understanding

- Identify **latest advances and trends** in environmental biotechnology.
- Evaluate the **role of biotechnology in sustainable development** and environmental protection.

UNIT III- Introduction to Environmental Biotechnology

Environmental biotechnology – definition, basic concepts, principle, scope and role; development in environmental biotechnology; the market for environmental biotechnology; gene cloning, hybridization; Basic techniques in gene cloning; Polymerase chain reaction, nucleic acid hybridization; introduction of cloned genes into new host using plasmids and phagevector system; biomarkers; latest advances and trends in environmental biotechnology; utilization of modern biological and biochemical tools such as GMO, cell biological methods, biosensors, bioplastics and biofuel; DNA sensing, polymer biodegradation, oil spill bioremediation.

UNIT IV- Applied Environmental Biotechnology

Course Objectives (COs):

1. To understand the role of **biotechnology in biodiversity conservation** and sustainable utilization.
2. To study the applications of biotechnology in **agriculture, forestry, and wasteland reclamation**.
3. To examine biotechnological approaches for **renewable energy production**.
4. To explore the use of biotechnology in **industry** (biomining, enzymes, biosurfactants).
5. To understand the applications of biotechnology in **pollution control and environmental restoration**.
6. To evaluate the merits and demerits of biotechnology-based conservation and industrial methods.

Course Learning Outcomes (LOs):

By the end of this section, students will be able to:

Biodiversity & Conservation

- Explain the role of **biotechnology in biodiversity conservation and utilization**.
- Assess the **advantages and limitations** of conservation methods (e.g., in-situ vs ex-situ, tissue culture, genetic engineering).

Agriculture & Forestry

- Describe the role of **biofertilizers and biopesticides** in sustainable agriculture.
- Understand the application of **micropropagation** in reforestation.
- Explain **induction of genetic variability and heritability** in forestry improvement programs.

Wasteland Reclamation

- Analyze **biotechnological strategies for reclamation of degraded and wasteland ecosystems**.

Energy Production

- Explain the production processes and benefits of **bioethanol, biodiesel, biomass, and biogas**.
- Evaluate the role of **bioenergy in reducing dependency on fossil fuels**.

Industrial Applications

- Understand **biomining techniques** for metal recovery.
- Discuss the role of **enzymes in bakery industries**.
- Describe the significance of **biosurfactants** in industry and environment.

Pollution Control

- Explain **bioremediation techniques** for pollution abatement.
- Understand the concept of **bioindicators** in environmental monitoring.
- Describe the role of **phytoremediation** in restoring polluted sites.

UNIT IV- Applied Environmental Biotechnology

Biotechnology and biodiversity- conservation and utilization methods, their merits and demerits; biotechnology and agriculture – biofertilizers and biopesticides; biotechnology and forestry- reforestation through micro-propagation, induction of genetic variability and hereditability; biotechnology and wasteland - reclamation of wasteland; biotechnology and energy production – bioethanol, biodiesel, biomass and biogas; biotechnology and industry- biomining, application of enzyme in bakery, and biosurfactants; biotechnology and pollution control- bioremediation, restoration of polluted sites and bioindicators; phytoremediation of polluted sites.

Suggested books:

1. Burtrand JC, Caumette P and Lebaron P (2015) *Environmental Microbiology: Fundamentals and Applications: Microbial Ecology*, Springer.
2. Evans GM and Furlong, JC (2004) *Environmental Biotechnology – Theory and Application,* John Wiley and Sons, USA.
3. Jjemba PK (2004) *Environmental Microbiology: Principles and Applications*, Science Publishers Inc., Enfield.
4. Maier RM, Pepper IL and Gerba CP (2009) *Environmental Microbiology,* 2nd Edition, Elsevier Inc.
5. Mara and Horan N (2003) *Handbook of Water and Wastewater Microbiology*, Academic Press, Elsevier.
6. McKane L and Kandel J (1995) *Microbiology: Essentials and Applications*, 2nd Edition, McGraw Hill Education.
7. Mohapatra PK (2008) *Textbook of Environmental Microbiology*, I.K. International (P) Ltd.
8. Olguin CJ Sanchez G and Hernandez E (2000) *Environmental Biotechnology and Cleaner Bioprocesses,* Taylor & Francis.
9. Pelzar MJ, Chan ECS and Krieg NR (1993) *Microbiology, Concepts and Applications*, 5th, Edition, McGraw Hill.
10. Pepper IL and Gerba CP (2005) *Environmental Microbiology – Laboratory Manual*, Elsevier, USA.
11. Ramesh KV (2008) *Environmental Microbiology*, MJP publishers.
12. Ratledge C and Kristiansen B (2003) *Basic Biotechnology*, 2nd Edition, Cambridge University Press.
13. Schmidt TM and Schaechter M (2012) *Topics in Ecological and Environmental Microbiology*, 3rd Edition, Academic Press, Elsevier.

CORE VIII: ENVIRONMENTAL ETHICS AND MOVEMENTS

Credits: 4

COURSE CODE: ENV: 510

Marks: 100

UNIT I- Environmental Ethics

Course Objectives (COs):

1. To introduce the **concept of ethics** and its application to environmental conservation.
2. To study the **historical perspective** of protecting nature across civilizations.
3. To understand the **Indian concept of nature**, universal oneness (Vasudaiva Kudumbakam), and traditional ecological values.
4. To examine various ethical standpoints – **anthropocentrism, speciesism, biocentrism, animal rights, ecocentrism, and ecofeminism**.
5. To compare **Eastern and Western philosophies** in relation to the environment.
6. To establish the connection between **ecology, economics, and ethics**.
7. To study **eco-philosophy**, particularly Arne Naess's ideas of **Deep Ecology and Shallow Ecology**, and the concept of **Ecosophy**.

Course Learning Outcomes (LOs):

By the end of this section, students will be able to:

Foundations of Ethics & History

- Define **environmental ethics** and explain its significance in conservation.
- Trace the **historical evolution of ethical thought** in protecting and conserving the environment.

Indian Concept of Nature

- Understand and explain the **Indian ecological philosophy** rooted in the idea of **Vasudaiva Kudumbakam (Universal Oneness)**.
- Appreciate the **value of wilderness** in Indian and global contexts.

Ethical Standpoints

- Differentiate between **anthropocentrism, speciesism, biocentrism, ecocentrism, ecofeminism, and animal rights philosophies**.
- Critically evaluate the strengths and weaknesses of each ethical perspective in addressing modern environmental issues.

Philosophical Approaches

- Compare **Western philosophies (utilitarian, mechanistic)** with **Eastern philosophies (holistic, spiritual)** in relation to environment.
- Explain the relationship between **ecology, economics, and ethics** in sustainable development.

Eco-Philosophy & Ecosophy

- Describe **Arne Naess's distinction between Deep Ecology and Shallow Ecology**.
- Define **Ecosophy** and explain its role as a guiding ecological platform for sustainability.

UNIT I- Environmental Ethics

Introduction to ethics; historical perspective of conserving and protecting the environment; Indian concept of nature – universal oneness Vasudaiva Kudumbakam; value of wilderness; anthropocentrism; speciesism; biocentrism; animal right; ecocentrism; ecofeminism; western and eastern philosophies of environment;

ecology, economics and ethics-the link; eco-philosophy –Arn Neass's distinction between Deep Ecology and Shallow Ecology; Ecological platform- concept of ecosophy.

UNIT II- Environmental Sociology

Course Objectives (COs):

1. To trace the **historical perspective of environmental problems** and their roots in human development.
2. To analyze the relationship between **social behavior and the environment**.
3. To examine the role of **consumerism, economic systems, and inequality** in creating or mitigating environmental issues.
4. To understand the **gender–environment relationship**, focusing on women's roles in conservation and the burden of environmental degradation.
5. To study how the **poor and marginalized communities** access and depend on environmental resources compared to the rich.
6. To evaluate the concepts of **privilege, responsibility, and environmental justice**.
7. To understand the importance of **corporate social responsibility (CSR)** in sustainable environmental management.

Course Learning Outcomes (LOs):

By the end of this section, students will be able to:

Historical & Social Dimensions

- Explain the **historical evolution of environmental problems** and link them to industrialization, urbanization, and modernization.
- Assess how **human social behavior** influences environmental degradation and conservation.

Economy & Consumerism

- Critically analyze the relationship between **consumerism and environmental exploitation**.
- Evaluate the link between **economic growth and environmental sustainability**.

Inequality, Gender & Environment

- Discuss how **social and economic inequalities** shape access to environmental resources.
- Explain the connection between **gender roles and environmental sustainability**, with examples of women in resource management.
- Compare how the **poor and rich** interact with and impact the environment differently.

Environmental Justice & Responsibility

- Define and discuss the concept of **environmental justice**.
- Identify the **roles of privilege and responsibility** in promoting sustainability.
- Evaluate **corporate social responsibility (CSR)** initiatives related to the environment.

UNIT II- Environmental Sociology

Historical perspective of environmental problems; social behaviour and environment; consumerism; economy and environment; inequality and environment; gender and environment; the poor and their access to their environment; the rich and their environment; privilege and responsibilities in environmental justice; corporate social responsibility- environment

UNIT III- Environmental Movements

Course Objectives (COs):

1. To study the role of **people's initiatives** in environmental conservation in both Western and Indian contexts.
2. To understand **Gandhian, Marxist, and Indian perspectives** on environmentalism.
3. To analyze the **major environmental movements in India** (Chipko, Silent Valley, Appiko, Narmada Bachao Andolan).
4. To critically examine **man–animal conflicts** and **conflicts over water** as key socio-environmental challenges.
5. To evaluate the **effectiveness of grassroots movements** in shaping environmental policy and awareness.

Course Learning Outcomes (LOs):

By the end of this unit, students will be able to:

Philosophical & Historical Perspectives

- Compare **Western environmental initiatives** with **Indian approaches**.
- Explain **Gandhian environmentalism** (simplicity, self-sufficiency, non-violence), **Marxist views** (class, labor, exploitation of nature), and **Indian traditional environmentalism** (spirituality, harmony with nature).

Case Studies of Movements

- Describe the **Chipko Movement** and its role in forest conservation.
- Explain the **Silent Valley Project Movement** against deforestation.
- Analyze the **Appiko Movement** in Karnataka for afforestation and conservation.
- Evaluate the **Narmada Bachao Andolan** and its concerns over displacement, dam construction, and river ecology.

Conflict Understanding

- Define and assess **man–animal conflict**, its causes, and implications for biodiversity and livelihoods.
- Discuss **conflicts over water** (interstate, community-level, or between agriculture and industry) and propose sustainable solutions.

Critical Evaluation

- Assess the **impact of people's movements** on policy, conservation, and environmental awareness.
- Reflect on how **grassroots struggles shape environmental justice**.

UNIT III- Environmental Movements

People's initiatives to save the environment in the western world; Gandhian-, Marxism- and Indian environmentalism; Chipko movement; Silent Valley project movement; Appiko movement; Narmada Bacchao Andolan movement. Conflicts: man-animal conflict; conflict over water

UNIT IV- Traditional Ecological Knowledge

Course Objectives (COs):

1. To introduce the concept of **traditional ecological knowledge (TEK)** and its relevance in environmental conservation.
2. To compare **modern science** and **traditional knowledge systems**, highlighting complementarities and differences.
3. To study **indigenous knowledge practices** with emphasis on **Northeast India**.
4. To examine the role of traditional practices in **biodiversity conservation, agriculture, pest management, and water management**.
5. To explore the **scope of TEK in mitigating and adapting to climate change**.

Course Learning Outcomes (LOs):

By the end of this unit, students will be able to:

Understanding & Comparison

- Define **traditional knowledge of conservation** and explain how it differs from modern scientific approaches.
- Appreciate the **philosophy of harmony with nature** in traditional systems compared to reductionist modern science.

Regional & Cultural Knowledge

- Describe **traditional ecological knowledge systems in Northeast India**, including shifting cultivation (jhum), agroforestry, community-managed forests, and sacred landscapes.
- Recognize the role of **sacred groves** as biodiversity hotspots and cultural conservation zones.

Applications in Conservation & Agriculture

- Explain the **gene pool concept** in crop breeding based on indigenous seed-saving practices.
- Discuss **traditional pest management techniques** (plant-based repellents, intercropping, biological controls).
- Understand **agrarian calendars** and their role in synchronizing farming practices with seasonal cycles.
- Analyze traditional **water conservation and irrigation methods** (tanks, step-wells, bamboo drip irrigation).

Climate Change & Modern Relevance

- Assess the **potential of TEK in climate change mitigation and adaptation** strategies.
- Evaluate how integrating **traditional knowledge with modern science** can strengthen biodiversity conservation and sustainable development.

UNIT IV- Traditional Ecological Knowledge

Traditional knowledge of conservation; differences between modern science and traditional knowledge systems; traditional ecological knowledge systems, -northeast India; scopes of applications of traditional knowledge in- biodiversity conservation- sacred groves, gene pool concept in crop breeding, pest management; mitigating and adapting climate change; agrarian calendar; water conservation and irrigation

Suggested books:

1. Callicott JB and Ames RT (1989) *Nature in Asian Traditions of Thought*. State University of New York.

2. Zimmerman (ME) (1989) *Congesting Earth's Future: Radical Ecology and Post Modernity*. University of California Press.
3. Pasmore J (1988) *Man's Responsibility for Nature*. Indian Edition, Routledge, London and New York.
4. Mies M and Shiva V (1993) *Ecofeminism*. Rawat Publication, Jaipur, India.
5. Ramakrishnan PS, Saxena KG, Chandrashekara UM (1998) *Conserving the Sacred: For Biodiversity Management*. Oxford Publication.
6. Bell MM and Ashwood LL (2006) *An Invitation to Environmental Sociology*. 5th Edition, Sage Publication.
7. King L, McCarthy D and Auriffeilee (1993) *Environmental Socoilogy from Analysis to Action*. 3rd Edition. Rowman and Littlefield Publishers
8. Patil RB (2009) *Environment in Indian Society- Problems and Prospects*. Mittal Publications, Daryaganj, New Delhi.
9. Srivastava DC (2005) *Readings in Environmental Ethics: Multidisciplinary Perspective*. Rawat Publication, Jaipur.
10. Donald A. Grafta: 'Speciesism', Encyclopedia of Applied Ethics (ed. Ruth Chadwick et al.,), Academic Press, 1998, Vol.IV.
11. Tom Regan: 'Animal Rights, Human Wrongs', Environmental Philosophy: from AAnimal Rights to Radical Ecology (eds. Michael E. Zimmerman et al.,), Prentice Hall, 1993.
12. M. Vannucci. Human Ecology in Vedas.

OPEN ELECTIVE: ENVIRONMENTAL AWARENESS, ISSUES AND PROBLEMS OF NORTHEAST INDIA

Credits: 4
Marks: 100

COURSE CODE: ENV: OPE-04

UNIT I: Issues related to Industrialization and Economic Development

Course Objectives (COs):

1. To examine the **environmental impacts** caused by major industries such as oil refineries, cement plants, paper mills, and wood-based industries.
2. To analyze the consequences of **mining and quarrying activities**, including coal, lime, sand, stone, and earth extraction.
3. To understand the **effects of petroleum and natural gas extraction** on ecosystems and communities.
4. To evaluate the **environmental and socio-economic implications of mega hydroelectric projects and multipurpose dams**.
5. To develop critical thinking about **balancing development and environmental sustainability**.

Course Learning Outcomes (LOs):

By the end of this unit, students will be able to:

Industrial Impacts

- Describe how **oil refineries** cause air, water, and soil pollution (emission of hydrocarbons, oil spills, toxic waste).
- Explain the **cement industry's impact** (dust emissions, CO_2 release, landscape degradation).
- Discuss the effects of **paper mills** (effluent discharge, bleaching chemicals, water use).
- Analyze the role of **wood-based industries** in **deforestation, biodiversity loss, and soil erosion**.

Mining & Quarrying Impacts

- Assess environmental effects of **coal and lime mining** (deforestation, acid mine drainage, heavy metal contamination).
- Evaluate the consequences of **sand, stone, and earth quarrying** (riverbank erosion, groundwater depletion, habitat destruction).

Extraction Impacts

- Understand the ecological and social impacts of **petroleum and natural gas extraction** (oil spills, methane leaks, displacement of local communities).

Mega Projects

- Identify the **environmental impacts of mega hydroelectric projects** (submergence of forests, biodiversity loss, alteration of river ecology).
- Assess the **socio-economic consequences** of **multipurpose dams** (displacement of people, loss of livelihoods, cultural impacts).

Sustainability & Alternatives

- Critically evaluate **trade-offs between industrial development and environmental protection**.
- Suggest **mitigation measures** and sustainable practices for reducing environmental impacts of these industries.

UNIT I: Issues related to Industrialization and Economic Development

Environmental impacts of oil refineries, cement plants, paper mills, wood based industries; environmental impacts of coal and lime mining, quarrying of sand, stone and earth from hills and rivers, extraction of petroleum and natural gas, environmental and socio-economic implications of mega hydro electric projects, multipurpose mega dams.

UNIT II: Issues related to Population Growth and Deforestation

Course Objectives (COs):

1. To understand the link between **population growth, urbanization, and environmental degradation**.
2. To analyze the **impact of vehicles in urban centers on air quality**.
3. To examine the causes and consequences of **deforestation, forest cover changes, and forest fires**.
4. To explore the **ecological and cultural significance of sacred forests and groves** and the challenges they face.
5. To assess the extent of **biodiversity loss** and its ecological consequences.
6. To critically analyze the **issues faced by National Parks**, with special reference to **Keibul Lamjao National Park** and **Kaziranga National Park**.

Course Learning Outcomes (LOs):

By the end of this unit, students will be able to:

Population & Urbanization

- Explain how **rapid population growth** increases pressure on natural resources, land, and water.
- Assess how **urbanization** leads to habitat destruction, waste generation, and pollution.
- Analyze the impact of the **growth of vehicles** in cities on **air quality** (vehicular emissions, particulate matter, greenhouse gases, smog formation).

Forest Issues

- Describe the drivers and consequences of **deforestation and forest cover change** (habitat loss, soil erosion, carbon cycle imbalance).
- Understand the ecological impacts of **forest fires** (loss of biodiversity, release of CO_2, altered nutrient cycling).
- Recognize the **cultural and ecological value of sacred forests and sacred groves**, and discuss the threats of modernization, urban encroachment, and declining traditional practices.

Biodiversity Loss

- Identify the major drivers of **biodiversity loss** (deforestation, poaching, climate change, invasive species, pollution).
- Discuss the **ecological imbalance** and reduced ecosystem services caused by biodiversity decline.

National Parks – Case Studies

- **Keibul Lamjao National Park (Manipur):**
  - Understand its uniqueness as the only floating National Park (phumdis in Loktak Lake).
  - Assess the **threats to the endangered Sangai deer** (brow-antlered deer), habitat degradation, water quality decline due to Loktak hydro-project.
- **Kaziranga National Park (Assam):**

- Analyze its significance as a **UNESCO World Heritage Site** and home of the **one-horned rhinoceros**.
- Identify issues like **poaching, human-animal conflict, floods, encroachment, and infrastructure development pressures**.

Sustainability Thinking

- Suggest measures to **balance population growth and urban development with environmental protection**.
- Propose strategies for **conservation of forests, sacred groves, biodiversity, and National Parks**.

UNIT II: Issues related to Population Growth and Deforestation

Population growth, urbanization, growth of vehicles in urban centers and its resultant effect on air quality, deforestation and changes in forest cover, forest fire, issues and concerns related to sacred forests and sacred groves, biodiversity loss, problems associated with important National Parks like Keibul Lamjao National Park, Kaziranga National Park

UNIT III: Issues related to Agriculture

Course Objectives (COs):

1. To understand the **environmental and socio-economic problems** associated with traditional agricultural practices like shifting cultivation.
2. To critically assess the **impacts of modern agriculture**, including high-yielding varieties (HYVs), synthetic fertilizers, and pesticides.
3. To analyze the **consequences of unsustainable agricultural practices** such as monoculture and agricultural burning.
4. To study the implications of **land use change**, especially the conversion of agricultural land for non-agricultural purposes.
5. To explore the role of **indigenous knowledge systems** in promoting sustainable agriculture.
6. To recognize the **potential of Northeast India** as an organic capital due to traditional eco-friendly farming practices.

Course Learning Outcomes (LOs):

By the end of this unit, students will be able to:

Shifting Cultivation (Jhum Cultivation)

- Define shifting cultivation and explain its practice in NE India.
- Identify problems: **deforestation, soil erosion, loss of soil fertility, decline in fallow cycle, biodiversity loss, carbon emissions, food insecurity**.

High Yielding Varieties (HYVs)

- Explain how HYVs increased food production during the Green Revolution.
- Assess impacts: **reduced genetic diversity, increased dependence on irrigation, fertilizers and pesticides, soil degradation, groundwater depletion**.

Fertilizers & Pesticides

- Describe benefits of synthetic fertilizers and pesticides in boosting yields.
- Critically analyze negative effects: **soil acidification, water pollution (eutrophication), pesticide resistance, bioaccumulation, health hazards to humans and animals**.

Agricultural Burning

- Explain the purpose (clearing land, managing residues).
- Discuss consequences: **air pollution (PM, CO_2, NOx), smog, respiratory diseases, greenhouse gas emissions, soil nutrient loss**.

Monoculture Farming

- Define monoculture and its widespread practice.
- Highlight problems: **soil nutrient depletion, vulnerability to pests/diseases, reduced biodiversity, increased chemical dependency**.

Land Use Change

- Discuss drivers: **urbanization, industrialization, infrastructure development**.
- Analyze impacts: **loss of fertile land, habitat destruction, reduced agricultural productivity, food insecurity**.

Indigenous Knowledge & Sustainable Agriculture

- Recognize **traditional practices** like crop rotation, mixed cropping, use of organic manure, pest control using natural methods.
- Understand how indigenous methods **maintain soil fertility, conserve biodiversity, and reduce chemical inputs**.

Northeast India's Potential for Organic Farming

- Understand why NE is called the **"organic capital of India"**:
    - Low use of chemical inputs historically.
    - Rich biodiversity and favorable climate.
    - Large tribal population practicing traditional eco-friendly farming.
- Discuss opportunities: **export potential, eco-labeling, sustainable rural economy**.
- Identify challenges: **market access, certification costs, low mechanization**.

UNIT III: Issues related to Agriculture

Problems associated with shifting cultivation; impact of introduction of high yielding varieties; use of synthetic and artificial fertilizers and pesticides; impacts of agricultural burning; problems of monoculture; change in land use pattern –conversion of agricultural land for settlement, industry and other economic activities; indigenous knowledge and sustainable agriculture; NE's potentialities for organic capital of India.

UNIT IV: Issues related to Water Resources

Course Objectives (COs):

1. To study the **importance and utilization of water resources** in Northeast India.
2. To analyze **factors affecting water resources** such as climate, population growth, agriculture, and industrialization.
3. To understand the **ecological and socio-economic significance of Ramsar sites** (Loktak, Deepor Beel, Rudrasagar).
4. To examine the **causes of wetland depletion** with a special focus on Manipur.
5. To evaluate the **impacts of tourism and economic activities** on wetlands.
6. To learn about **strategies for wetland conservation and management**.
7. To assess the **pollution levels of important rivers** (Brahmaputra, Barak, Nambul) and their implications for ecosystems and society.

Course Learning Outcomes (LOs):

Utilization of Water Resources

- Explain how water is used in NE India for **drinking, irrigation, hydroelectric power, fishing, navigation, tourism, and industry**.
- Identify challenges in sustainable utilization due to **over-extraction, climate variability, and pollution**.

Factors Affecting Water Resources in NE India

- **High rainfall** but uneven distribution.
- **Deforestation and shifting cultivation** causing siltation of rivers/lakes.
- **Urbanization and population growth** leading to overuse and contamination.
- **Hydroelectric projects** altering river flow and fish migration.
- **Climate change** affecting monsoon cycles and glacial melt.

Ramsar Sites of NE India

- **Loktak Lake (Manipur):** Famous for **phumdis** (floating biomass), Keibul Lamjao National Park (home of Sangai deer). Issues – siltation, pollution, Ithai barrage altering water levels, tourism pressure, fish depletion.
- **Deepor Beel (Assam):** A wetland and bird sanctuary near Guwahati. Issues – garbage dumping, encroachment, industrial effluents, railway track cutting through wetland, conflict between conservation & urban expansion.
- **Rudrasagar Lake (Tripura):** Supports ecological balance and water storage. Issues – shrinking area, siltation, invasive weeds, pollution, unplanned tourism.

Impacts of Tourism & Economic Activities

- **Positive:** Income, jobs, eco-tourism opportunities.
- **Negative:** Habitat disturbance, littering, boat traffic, sewage disposal, water pollution, and cultural commercialization.

Reasons for Depletion of Wetlands (with reference to Manipur)

- Ithai barrage altering natural hydrology of Loktak Lake.
- Agricultural runoff and pesticide pollution.
- Encroachment for settlement and agriculture.
- Deforestation in catchment areas → soil erosion & siltation.
- Overfishing and unsustainable harvesting of aquatic plants.
- Climate variability and reduced inflow of fresh water.

Strategies for Conservation of Wetlands

- Strict enforcement of **Ramsar Convention guidelines**.
- **Community participation** (e.g., fishermen cooperatives, local NGOs).
- **Eco-tourism** instead of mass tourism.
- **Desiltation and weed removal** programs.
- **Pollution control** – sewage treatment plants, banning dumping of solid waste.
- **Hydrological restoration** – better water flow regulation from barrages/dams.
- **Awareness and education** about wetland importance.

Pollution of Important Rivers in NE India

- **Brahmaputra River System:** Major issues – erosion, siltation, pesticide runoff, industrial waste, municipal sewage. Floods worsen pollution.

- **Barak River:** Affected by paper mills, pesticides from tea gardens, untreated sewage, and oil refinery waste.
- **Nambul River (Manipur):** One of the most polluted rivers due to **sewage disposal, solid waste dumping, agricultural runoff**, leading to eutrophication before it enters Loktak Lake.

UNIT IV: Issues related to Water Resources

Utilization of water resources; factors affecting water resources in NE India; issues associated with Ramsar Sites of NE India – Loktak Lake, Deepor Beel, Rudrasagar Lake - impacts of tourism, conflict between economic activities and environmental concerns, reasons for depletion of wetland in NE India with special reference to Manipur, strategies for conservation of wetlands; pollution of important rivers – Brahmaputra River System, Barak River, Nambul River etc.

Suggested books:

1. Singh OP (2006) *Environment and Natural Resources*
2. Tiwari BK and Kumar C (2008) Forest products of Meghalaya Mining environment – O P Singh (2005).
3. Methodological issues in mountain research – Ramakrishnan P S, K G Saxena, S Pathak and S Singh (2003).
4. Sacred forests of Meghalaya – Tiwari BK, SK Barik and RS Tripathi (1999).
5. Conservation and management of biological resources in Himalaya - Ramakrishnan P S, A N Purohit, K G Saxena, K S Rao and R K Maqikhuri (1996).
6. Shifting agriculture in Asia – Saxena K G, Luohui Liang and K Rerkasem (2007).
7. Mountain biodiversity, Land Use Dynamics and Traditional Ecological Knowledge - Ramakrishnan P S (2000).

CORE PRACTICAL-III
(LABORATORY – III)

Credits: 4
Marks: 100

COURSE CODE: ENV: 511

Course Objectives (COs):

1. To provide hands-on training in the **analysis of physico-chemical parameters of water**.
2. To develop the ability to **determine major ions and nutrients** (alkalinity, hardness, chloride, sulphate, phosphate, nitrate, ammonia, fluoride, boron, etc.) in water samples.
3. To introduce students to **instrumental techniques** such as **flame photometry** for sodium and potassium estimation.
4. To enable students to assess **potable water quality** and compare it with **WHO/ISI standards**.
5. To inculcate skills for **field-based environmental assessment** including sampling, data collection, and interpretation.
6. To build capacity for **environmental monitoring, pollution detection, and sustainable management** of water resources.

Course Learning Outcomes (LOs):

After completing these experiments, students will be able to:

Chemical Parameters of Water

- **Total Alkalinity:** Determine buffering capacity of water against acids.
- **Phosphate, Nitrate, Ammonia:** Measure nutrient levels and understand their role in **eutrophication and pollution**.
- **Total Hardness, Calcium, Magnesium:** Assess suitability of water for **drinking, irrigation, and industry**.
- **Chloride:** Evaluate pollution from **domestic sewage and industrial effluents**.
- **Sulphate:** Detect sulphate pollution and its effect on **taste, corrosion, and health**.

Instrumental Analysis

- **Sodium & Potassium (Flame Photometer):** Develop skill in using **instrumental methods** for detecting cations in water.
- **Boron:** Learn estimation techniques for **minor but important nutrients/toxins**.
- **Fluoride:** Determine fluoride content in groundwater and relate it to **dental health (fluorosis) and safety standards**.

Field Study & Environmental Assessment

- Conduct **field visits** to collect water samples from rivers, lakes, wells, and treatment plants.
- Apply **analytical methods** to real-world samples and assess pollution sources.
- Correlate laboratory results with **environmental conditions, human activities, and policy implications**.

Overall Competence

- Compare results with **permissible limits (WHO/BIS standards)**.
- Interpret water quality data for **drinking, agriculture, and industrial suitability**.
- Gain practical experience in **environmental monitoring and reporting**.

- Develop awareness of the **link between water chemistry and environmental health.**

List of suggestive Practical:

1. Determination of total alkalinity of water.
2. Determination of phosphate of water.
3. Determination of nitrate of water.
4. Determination of ammonia of water.
5. Determination of total hardness of water.
6. Determination of calcium and magnesium of water.
7. Determination of chloride of water.
8. Determination of sulphate of water.
9. Determination of sodium of water by flame photometer.
10. Determination of potassium of water by flame photometer.
11. Estimation of fluoride in a given ground water sample.
12. Field study for environmental assessment.

CORE PRACTICAL-IV
(LABORATORY – IV)

Credits: 4

COURSE CODE: ENV: 512

Marks: 100

Course Objectives (COs):

1. To provide practical skills in **isolation, identification, and characterization** of microorganisms from water, soil, and environmental samples.
2. To train students in **microscopy, staining, and microbial culture techniques**.
3. To understand the role of microbes in **ecosystem functioning, pollution detection, and public health**.
4. To gain competence in **enumeration methods** (SPC, MPN, viable counts) for water/soil quality assessment.
5. To develop the ability to relate **microbial diversity and pathogenicity** with environmental sustainability and disease transmission.
6. To conduct **field-based microbial/environmental assessments** linking lab results to real-world problems.

Course Learning Outcomes (LOs):

After completing these experiments, students will be able to:

Basic Microbiology & Microscopy

- Prepare **wet mounts** and observe living microorganisms from different water sources.
- Perform **simple and Gram staining** to differentiate bacterial cell types.
- Carry out **slide culture technique** for fungi/actinomycetes.

Microbial Isolation & Characterization

- Isolate and characterize **soil and water bacteria**.
- Identify parasitic and pathogenic microorganisms with their **characteristics and health implications**.
- Apply **population study techniques** for environmental microbial diversity.

Enumeration Techniques

- Perform **Total Viable Count (TVC)** in soil and water samples.
- Use **Standard Plate Count (SPC)** to study microbial load.
- Detect **faecal coliforms** using **Membrane Filtration Method**.
- Determine coliform bacteria in water by **Most Probable Number (MPN) method**.

Applied Environmental Microbiology

- Study the **components of a pond ecosystem** and their microbial interactions.
- Assess water quality and pollution levels using **microbial indicators**.
- Gain hands-on experience in detecting **pathogens linked to environmental contamination**.

Field Study Competence

- Collect samples and analyze them for microbial diversity and contamination.
- Apply laboratory methods to **environmental assessment and monitoring**.
- Correlate microbial findings with **ecological health, pollution, and human impact**.

List of suggestive Practical:

1. Preparations of temporary wet mount for the observation of living organisms in pond water/lake water/river water/polluted water.
2. Preparation of gram staining of a bacteria containing sample.
3. Isolation and characterisation of soil bacteria.
4. Study the components of a pond ecosystem.
5. Slide culture technique for examination of fungi/actinomycetes.
6. Estimation of total viable counts in water/soil samples.
7. Study of microorganisms in soil/water by Standard Plate Count (SPC).
8. Detection of faecal Coliform by Filter Membrane Method in water.
9. Identification with characteristics of some parasitic and other pathogenic disease microorganisms.
11. Isolation and population study of microorganisms from soil/water sample.
12. Staining of bacterial suspension by simple monochrome method.
13. Determination of Coliform by MPN, Standard Plate Count in water.

M.Sc. 3rd Semester

CORE XI- ENVIRONMENTAL HEALTH AND TOXICOLOGY

Credits: 4
Marks: 100

COURSE CODE: ENV: 613

UNIT I- Introduction to Environmental Toxicology

Course Objectives (COs):

1. To introduce the **fundamental principles, history, and scope of toxicology**.
2. To familiarize students with **toxicological terminology** and types of toxic effects.
3. To understand **factors influencing toxicity**, including **drug toxicity, acute vs. chronic effects, and selective toxicity**.
4. To study the **biochemical and molecular basis of toxicity**, including receptor-mediated events.
5. To examine **toxic responses** of cells, organs, and physiological systems (nervous, hepatic, renal, reproductive, etc.).
6. To analyze **dose–response relationships** and interpret toxicological data (LD_{50}, LC_{50}, TLV, toxicity curves).
7. To understand the **environmental implications of toxicants**, including bioaccumulation and biomagnification in food chains.

Course Learning Outcomes (LOs):

After completing this course, students will be able to:

Foundations of Toxicology

- Define toxicology, describe its **history and scope**, and explain its relevance to human health and environment.
- Identify and explain **basic toxicological terminologies** and toxic effects.

Toxic Effects & Mechanisms

- Differentiate between **acute, chronic, and selective toxicity**.
- Analyze **factors that influence toxicity** (dose, exposure route, age, genetics, environment).
- Explain **biochemical mechanisms of toxicity** including receptor-mediated events.

System-Specific Toxicology

- Describe **toxic responses at the cellular level** and in different body systems (nervous system, liver, kidney, GIT, blood, reproductive system).
- Correlate the impact of toxicants with **organ-specific functions and damage mechanisms**.

Toxicological Evaluation

- Interpret **dose–response relationships** and construct toxicity curves.
- Calculate and explain parameters like **LC_{50}, LD_{50}, TLV, and Margin of Safety**.
- Evaluate toxicity data to predict **risk assessment and safety standards**.

Environmental & Ecological Toxicology

- Explain processes of **bioaccumulation and biomagnification** in ecosystems.
- Assess the **ecological risks** of toxicants in the food chain and environment.

UNIT I- Introduction to Environmental Toxicology

Introduction, history and scope of toxicology; description and terminologies of toxic effects; factors influencing toxicity; drug toxicity; acute and chronic toxicity; selective toxicity; biochemical basis of toxicity – mechanisms of toxicity and receptor mediated events; general toxic responses of cells, organs, nervous system, gastrointestinal tract, liver, kidney, blood and reproductive system; dose response relationship – graded response time action curve, threshold limit value, LC_{50}/LD_{50}, margin of safety and toxicity curve; bioaccumulation and biomagnifications of toxic materials in food chain.

Course Objectives (COs):

1. To introduce different **toxic agents** – phyto-toxins, animal toxins, microbial toxins, and xenobiotics.
2. To study the **impact of environmental chemicals** (air and water pollutants) on human health and ecosystems.
3. To explain the **biochemical toxicology** of heavy metals (arsenic, cadmium, lead, mercury) and air pollutants (CO, ozone, PAN).
4. To understand the principles of **genetic toxicology** – types, classes, mechanisms, and metabolism of chemical carcinogens.
5. To discuss **teratogenicity and mutagenesis**, and their role in disease and heredity.
6. To provide knowledge of **antidotes, treatments, and detoxification strategies** for toxic exposures.

Course Learning Outcomes (LOs):

After completing this unit, students will be able to:

Toxic Agents

- Identify and classify **natural and synthetic toxic agents** (phyto-, animal, microbial toxins, xenobiotics).
- Explain their **sources, mechanisms of action, and health effects**.

Environmental Chemicals

- Describe the **toxicological effects of chemicals in air and water**.
- Evaluate the **biochemical pathways and toxicity** of arsenic, cadmium, lead, mercury, CO, ozone, and PAN.
- Relate environmental exposure to **disease burden and ecological damage**.

Genetic Toxicology

- Differentiate **types and classes of genetic toxicants**.
- Explain the **mode of action** of mutagens, carcinogens, and teratogens.
- Analyze the **metabolism of chemical carcinogens** and their link to cancer.

Health Implications

- Understand **mutagenesis and teratogenic effects** and their implications on heredity and fetal development.
- Interpret experimental evidence for **DNA damage, chromosomal aberrations, and genetic mutations**.

Management and Detoxification

- Describe the use of **antidotes and detoxification methods** for toxicant exposure.
- Suggest possible **therapeutic interventions** for different classes of toxicants.

- Relate detoxification strategies to **public health and environmental safety**.

UNIT II- Toxic Agents

Toxic agents – phyto-toxins, animal toxins, microbial toxins, xenobiotics; chemicals in the environment – air, water and their effects; biochemical aspects of arsenic, cadmium, lead, mercury, carbon monoxide, ozone and PAN; genetic toxicology – types, classes, mode of action, metabolism of chemical carcinogens; teratogenecity; mutagenesis; antidotes treatment and detoxification of toxicants.

Course Objectives (COs):

1. To define and understand the **concept of environmental health** and its historical development.
2. To study **chemical and physical hazards** in the environment and the **exposure pathways** affecting human health.
3. To explain the effects of **air, water, and soil quality** on public health.
4. To analyze the **linkages between environmental conditions and public health outcomes**.
5. To discuss the **management of hygiene in public places** for disease prevention.
6. To understand **social determinants of environmental health** and their role in health inequalities.
7. To introduce **human development indices** as indicators of health and well-being.
8. To examine **current and emerging challenges** in environmental health.
9. To highlight the **contribution of environmental health practices** to sustainable public health.

Course Learning Outcomes (LOs):

After completing this unit, students will be able to:

Foundations & Hazards

- Define **environmental health** and describe its **historical evolution**.
- Identify **chemical and physical hazards** and explain **human exposure pathways** (inhalation, ingestion, dermal contact).

Environmental Quality & Health Impacts

- Assess how **air, water, and soil quality** influence **human health and disease**.
- Explain **epidemiological linkages** between environmental degradation and public health.

Public Health & Hygiene

- Describe the importance of **hygiene in public spaces** for controlling infectious diseases.
- Suggest practical strategies for **environmental hygiene management**.

Social & Developmental Context

- Analyze the role of **social determinants** (poverty, education, housing, occupation) in shaping environmental health.
- Interpret **human development indices (HDI, life expectancy, literacy, etc.)** in the context of health.

Contemporary & Future Challenges

- Discuss **current environmental health issues** (climate change, pollution, urbanization, pandemics).
- Recognize **emerging challenges** such as antimicrobial resistance, e-waste, and chemical exposure.
- Appreciate the **role of environmental health** in ensuring overall **public health and sustainable development**.

UNIT III- Environmental Health

Definition of environmental health; historical perspectives; chemical and physical hazards in the environment and their pathways by which humans are exposed; effect of quality of air, water and soil on human health; understanding linkage between environment and public health; management of hygiene in public places.

Social determinants of environmental health; human developmental indices and good health; current environmental health issues and emerging challenges; contribution of environmental health to overall health of the public.

UNIT IV- Epidemiology and Occupational Health Hazards

Course Objectives (COs):

1. **To understand the modes of transmission of communicable diseases and differentiate between epidemic and endemic conditions.**
2. **To study the causes, symptoms, prevention and treatment of water-borne, food-borne, soil-borne and air-borne diseases.**
3. **To analyze the role of sanitation, poverty, and socio-economic conditions in the spread of infectious diseases.**
4. **To explain how lifestyle and built environment influence non-communicable diseases (NCDs) such as diabetes, hypertension, and cancer.**
5. **To provide knowledge of the occupational environment, including physical, chemical, biological and sociological aspects.**
6. **To identify various occupational hazards and occupational diseases associated with different types of work.**
7. **To understand the etiology, symptoms, and impacts of diseases such as pneumoconiosis, silicosis, anthracosis, byssinosis, bagassosis, asbestosis, farmers' lung, lead poisoning, radiation hazards, and occupational cancers.**
8. **To discuss preventive and protective measures (medical, engineering, administrative) to safeguard workers' health.**

Course Learning Outcomes (LOs):

After completing this unit, students will be able to:

Communicable Diseases

- **Describe the modes of transmission (direct, indirect, vector-borne, droplet, fomite) of communicable diseases.**
- **Differentiate between epidemic, endemic and pandemic situations.**
- **Identify major water-, food-, soil-, and air-borne diseases, their etiology, symptoms, and preventive measures.**
- **Explain the role of sanitation, hygiene, and poverty in disease prevalence (e.g., TB, malaria, diarrhoea, viral fevers).**

Non-Communicable Diseases (NCDs)

- **Discuss the impact of lifestyle choices and urban/built environment on diseases like diabetes, hypertension, cardiovascular diseases, and cancer.**

- **Suggest lifestyle modifications and preventive public health strategies for NCDs.**

Occupational Environment & Hazards

- **Recognize the physical, chemical, biological, and sociological aspects of occupational environments.**
- **Identify different occupational hazards (noise, dust, chemicals, biological pathogens, ergonomic stress).**
- **Classify occupational diseases and describe their causes, symptoms, and long-term health impacts.**

Occupational Health Protection

- **Explain preventive strategies like engineering controls (ventilation, dust suppression, protective equipment) and medical measures (health check-ups, vaccinations, monitoring).**
- **Evaluate policies and practices for occupational safety and health protection.**

UNIT IV- Epidemiology and Occupational Health Hazards

Communicable diseases – mode of transmission; epidemic and endemic diseases; causes, symptoms, preventive measures and treatment of water borne, food borne, soil borne and air borne diseases; role of sanitation and poverty on infectious diseases like TB, diarrhoea, malaria, viral diseases; role of lifestyle and built environment in non-communicable diseases like diabetes, hypertension etc.

Occupational environment – physical, chemical, biological and sociological aspects; occupational hazards – physical, chemical and biological hazards; occupational diseases – pneumoconiosis, silicosis, anthracosis, byssinosis, bagassosis, astertosis, farmers lung, lead poisoning, occupational cancer, occupational dermatitis, radiation exposure hazards; measures of health protection of occupational workers; prevention of occupational diseases – medical and engineering measures.

Suggested Books:

1. Asthana M and Asthana DK (1990) *Environmental Pollution and Toxicology*, Alka Printers.
2. Botkin, DB and Keller, EA (2004) *Environmental Science: Earth as a Living Planet*, John Wiley & Sons Inc., New York.
3. Cunningham, WP and Saigo, WB (2005) Environmental Science, Mcgraw Hill, New York.
4. Sharma, P.D., Environmental Biology and Toxicology, Rastogi and Lamporary, (1994).
5. Sood,A., Sarup and Sons, Toxicology, New Delhi (1999).
6. Frank, C.L. and Sam, K. Basic Toxicology: Fundamentals, target organs and risk assessment. 4th Edition, London: Taylor and Francis, (2002).
7. Tambrell, J. Introduction to Toxicology, London: Taylor and Francis, (2002).
8. Casseret, L.J. and Doull, J. Toxicology: The basic science of poisons, New York: Macmillan publishers, (1982).
9. Stake, M. Y., Mido, M. S., Sethi, S., Iqbal, A., Yasuhisa, H. And Taguchi, S. Environmental Toxicology, New Delhi: Discovery Publishing House, (1997).
10. Levin, S. A. Ecotoxicology: Problems and Approaches, New York: Springer – Verlag, (1989).

CORE X- ENVIRONMENTAL MANAGEMENT

Credits: 4 COURSE CODE: ENV: 614

Marks: 100

UNIT I- Introduction to Environmental Management

Course Objectives (COs):

1. **To introduce the definition, scope, and nature of environmental management as an academic and practical discipline.**
2. **To explain the ethical, legal, and financial reasons for promoting sustainable environmental management practices.**
3. **To highlight the importance of sustainability in resource use and environmental protection.**
4. **To examine the role of national governments and international organizations in environmental regulation and policy frameworks.**
5. **To understand the need for implementing an Environmental Management System (EMS) in industries and institutions.**
6. **To study the principles, features, and requirements of ISO 14001 as a model EMS.**
7. **To evaluate the benefits and limitations of adopting a formal EMS in the workplace.**
8. **To gain knowledge of the ISO 14000 family of standards, their scope, and specific functions in environmental management.**

Course Learning Outcomes (LOs):

After completing this unit, students will be able to:

Conceptual Understanding

- **Define environmental management and explain its scope, objectives, and nature.**
- **Identify and evaluate the ethical responsibilities, legal obligations, and financial drivers for environmental management.**

Sustainability & Governance

- **Analyze the importance of sustainability in modern development.**
- **Assess the role of governments, international conventions, and organizations (e.g., UNEP, UNFCCC, IPCC, national environmental acts) in shaping environmental policy and management.**

Environmental Management Systems (EMS)

- **Explain the concept and purpose of EMS in improving environmental performance of organizations.**
- **Identify the key features and content of an EMS as per ISO 14001 guidelines.**
- **Evaluate the advantages (compliance, cost savings, improved reputation) and limitations (cost, complexity, monitoring challenges) of EMS implementation.**

ISO Standards Knowledge

- **Describe the ISO 14000 family of standards and their interrelationships.**
- **Recognize the specific purpose of standards like ISO 14001 (EMS requirements), ISO 14004 (guidelines), ISO 14031 (performance evaluation), ISO 14040 series (life cycle assessment), etc.**

- **Describe the step-by-step procedure for EIA in India (screening → scoping → baseline data → impact analysis → mitigation → public hearing → appraisal → clearance).**

Mitigation & Rehabilitation

- **Suggest restoration and rehabilitation technologies for degraded ecosystems.**
- **Analyze the importance of public participation in environmental decision-making.**

Environmental Audit (EA)

- **Define environmental audit and explain its types (compliance audit, performance audit, risk audit, due diligence, etc.).**
- **State the aims and guidelines of environmental audit as per CPCB/MoEFCC.**
- **Justify the need for EA at local and global levels for sustainable industrial and policy practices.**

UNIT II- Environmental Impact Assessment

Introduction to environmental impact analysis, environmental impact assessment and environmental management plan; EIA as an environmental management tool; guidelines and notifications of Government of India; impact assessment methodologies; baseline study; cost-benefit analysis; procedure for EIA process in India; restoration and rehabilitation technologies; public hearing; and appraisal, recommendations and grant of environmental clearance; environmental audit – definition, types and aims; guidelines for environmental audit; need of environmental audit at local and global level

UNIT III- International and National efforts for Environmental Management - I

Course Objectives (COs):

1. **To introduce the International and national efforts for environmental management - like Global Convention**
2. **To explain the role of Global Organization like IPCC,UNEP,WWF,IUCN.**
3. **To understand the scope, principles, and objectives of National Organization like ATREE, CEE, NEERI, BSI, ZSI and PETA**

Course Learning Outcomes (LOs):

After completing this unit, students will be able to:

- **Explain the the role of Global Organization like IPCC,UNEP,WWF, IUCN.**
- **Understand the International and national efforts for environmental management - like Global Convention**
- **Define and Analyze the scope, principles, and objectives of National Organization like ATREE, CEE, NEERI, BSI, ZSI and PETA**

UNIT III- International and National efforts for Environmental Management - I

International and national efforts for environmental management – Global Conventions like Stockholm Conference, Rio Submit, Rio+10, Brundtland Commission, Rio+20, Montreal Protocol, Kyoto Protocol, Copenhagen Summit; Global Organizations like IPCC, UNEP, IUCN, WWF, FAO, WHO, Greenpeace, National Organizations like ATREE, BHNS, BSI, BVIEER, CEE, CSE, NEERI, NCF, PETA, SACON, TERI, WII, ZSI (Objectives, Activities and Achievements only).

UNIT IV- International and National efforts for Environmental Management - II

Course Objectives (COs):

1. **To introduce the concepts of environmental labelling, eco-mark schemes, and green financing mechanisms for promoting sustainability.**
2. **To explain the role of Intellectual Property Rights (IPR) in environmental protection and sustainable innovation.**
3. **To explore the concept, principles, types, and scope of ecotourism as a sustainable economic activity.**
4. **To impart knowledge on Occupational Health and Safety Management Systems (OHSMS) and international standards like ISO 9000, OHSAS 18001.**
5. **To study Life Cycle Assessment (LCA), Material Flow Analysis (MFA), and eco-efficiency accounting as tools for sustainable production and consumption.**
6. **To introduce Environmental Audit – its definition, functions, principles, benefits, and cost implications.**
7. **To explain ecological footprint as a measure of sustainability.**
8. **To understand the scope, principles, and objectives of environmental education in both formal and non-formal systems, and strategies for public awareness.**
9. **To examine environmental conflict management methods to balance development and conservation.**
10. **To understand global mechanisms like Clean Development Mechanism (CDM), Comprehensive Environmental Pollution Index (CEPI), and strategies of Sustainable Development.**

Course Learning Outcomes (LOs):

After completing this unit, students will be able to:

- **Environmental Labelling & Financing**
- **Explain the eco-labelling (Eco-mark in India) scheme, its criteria, and role in consumer awareness.**
- **understand green funding, green taxes, and eco-friendly financial incentives for sustainable practices.**
- **describe the role of IPR in promoting green technologies and eco-innovations.**

Ecotourism & Sustainability

- **define ecotourism, its principles (conservation, community participation, sustainability), and different types (nature-based, cultural, adventure, rural, community-based).**
- **analyze its scope as a sustainable development tool in biodiversity-rich areas.**

Occupational Health & Safety Management

- **explain the role of OHSMS in industrial health and safety.**
- **differentiate between ISO 9000 (TQM & quality management), OHSAS 18001 (occupational health & safety).**
- **assess the importance of workplace safety, risk management, and compliance.**

Environmental Assessment Tools

- **conduct Life Cycle Assessment (LCA) of products to evaluate environmental impacts.**
- **apply Material Flow Analysis (MFA) for tracking resource use and efficiency.**
- **demonstrate how to calculate eco-efficiency indicators.**

- **define and explain Environmental Audit – its principles, types, benefits, and costs.**
- **assess ecological footprint as a measure of human impact on ecosystems.**
- **define environmental education, its principles, scope, and objectives.**
- **differentiate between formal and non-formal environmental education systems.**
- **design strategies for environmental awareness campaigns.**
- **apply conflict management strategies in addressing environmental disputes.**

Sustainability & Global Mechanisms

- **explain the Clean Development Mechanism (CDM) process, validation, and role in climate change mitigation.**
- **interpret the Comprehensive Environmental Pollution Index (CEPI) as a tool to assess industrial pollution clusters.**
- **critically analyze the concept and strategies of sustainable development at local, national, and global scales.**

UNIT IV- International and National efforts for Environmental Management - II

Environmental labelling; Green Funding and taxes; Intellectual Property Rights – scheme of labelling environmental friendly products (eco-mark); Ecotourism – concept, principles, types and scope; Occupational Health and Safety Management System (OHSMS); ISO 9000: A step towards TQM and Safety Management; OHSAS 18001; Life Cycle Assessment; Material flow analysis; Environmental Audit – definition, functions, basic principles, benefits and costs; accounting for eco-efficiency; Ecological Foot-printing; Environmental Education – meaning and scope, principle and objectives, environmental awareness strategies, formal and non-formal education; environmental conflict management; Clean Development Mechanisms – process and validation; Comprehensive Environmental Pollution Index (CEPI); Concept and Strategies of Sustainable Development.

Suggested Books:

1. Essentials of Environmental Studies – Joseph K and Nagendran R (2004).
2. Environmental Impact Assessment – Munn R E (1982).
3. Environmental Impact Assessment Methodologies - Anjaneyulu Y and Manickam W (2010).
4. Environmental Impact Assessment – Canter L (1996).
5. Environmental Impact Assessment – Srivastava A K (2003).
6. Introduction to Environmental Impact Assessment – Principles and Procedures, Practices and Prospects – Glasson J, Therival R and Chadwick A (1994).
7. Environmental Impact Assessment: Practical Solutions to Recurrent Problems–LawrencePD (2003).
8. Watershed Management in India – Murty J V S (1994).
9. Forest in India – Agarwal V P (1985).
10. The State of India's Environment: The Second Citizen's Report –CSE (2008).
11. Environmental Management in Practice, Nath, B. Hens, I., Compton, P. And Devuyst, D. (1998), Vol. I, Routledge, London and New York.
12. The ISO 14000 Handbook: The New International Environmental Management Standards, Cascio, J (1996), McGraw Hill Professional.
13. ISO 14004 – Environmental management systems: general guidelines on principles, systems and supporting techniques (ISO 14004: 1996, E).
14. ISO 14001 - Environmental management systems: Specifications with guidance for use (ISO 14001: 1996b (E), International Organization for standardization – Switzerland.

ELEECTIVE -I DISASTER MANAGEMENT

Credits: 4 COURSE CODE: ENV: 615

Marks: 100

UNIT I – Introduction to Hazards and Disasters

Course Objectives (COs):

1. To introduce the concepts of **hazards and disasters**.
2. To understand the **prediction, perception, and human adjustments** to hazardous activities.
3. To explain **natural cycles, residence time, and response strategies** to hazards.
4. To familiarize students with **rehabilitation, resilience, and mitigation** approaches.

Course Learning Outcomes (LOs):

After completing Unit I, students will be able to:

- differentiate between **hazards and disasters**.
- explain the **prediction and perception** of hazards.
- understand **residence time and natural cycles** of hazards.
- describe methods of **response, rehabilitation, resilience, and mitigation**.

UNIT I- Introduction to Hazards and Disasters

Introduction to concepts of- hazards and disaster, prediction and perception of hazards; adjustment to hazardous activities; rates of natural cycles; Concept of residence time; response; rehabilitation; resilience; mitigation

UNIT II – Landslides and Earthquakes

Course Objectives (COs):

1. To explain the **causes, prevention, and correction** of landslides.
2. To understand the **definition, magnitude, and intensity** of earthquakes.
3. To study **seismic waves, travel time, epicentre location**.
4. To analyze **geographical distribution, zonation, and destruction** caused by earthquakes.
5. To learn **mitigation, precautions, and do's & don'ts** during earthquakes and tsunamis.

Course Learning Outcomes (LOs):

After completing the unit, students will be able to:

- define and classify **landslides and earthquakes**.
- identify **causes, prevention, and mitigation** of landslides.
- differentiate between **intensity and magnitude** of earthquakes.
- describe **types of seismic waves** and calculate epicentre.
- discuss **earthquake zonation and geographical distribution**.
- recommend **safety measures during earthquakes and tsunamis**.

UNIT II- Landslides and Earthquakes

Landslide- definition, causes, prevention and correction; Landslide mitigation; Earthquakes- definition, intensity and magnitude of earthquake; Seismic waves- types, travel time; Location of epicentre; Nature of destruction; Geographical distribution of earthquake and zonation; protection from earthquake hazards, do's and don'ts during earthquake; Tsunami-causes and consequence, precaution

UNIT III – Floods, Tropical Cyclones, and Drought

Course Objectives (COs):

1.To introduce **causes, nature, and frequency** of floods.

2.To study **environmental effects and mitigation** of floods.

3.To explain the **formation, types, and consequences** of tropical cyclones.

4.To describe **coastal erosion processes**.

5.To analyze the **nature and effects of drought** on agriculture and livestock.

Course Learning Outcomes (LOs):

After completing the unit-III, students will be able to:

- identify **causes and environmental effects** of floods.
- suggest **mitigation strategies** during floods.
- explain the **formation, types, and impacts** of tropical cyclones.
- discuss **coastal erosion hazards**.
- evaluate the **impacts of drought on crops and animals**.

UNIT III- Floods, Tropical Cyclones and Drought

Floods- causes, nature and frequency; nature and extent of flood hazard; Environmental effects of flooding; mitigation during floods; Tropical cyclone- types, formation and consequences; Coastal erosion; Drought- nature and effect on the crops and animals.

UNIT IV – Fires, Avalanche, and Pest Infestations

Course Objectives (COs):

1.To understand the **causes, patterns, and impacts** of forest fires.

2.To analyze **fire accidents, precautions, and rehabilitation measures**.

3.To study **pest infestations and avalanche hazards**.

4.To identify hazards from **geotechnical projects (dams, highways, bridges)**.

5.To explain **disaster management concepts** – vulnerability, risk, preparedness, and resilience.

6.To introduce the **Disaster Management Act and Policy**.

Course Learning Outcomes (LOs):

After completing the unit IV, students will be able to:

- describe the **causes and mitigation** of forest fires and fire accidents.
- explain **impacts of pest infestations** on environment and agriculture.
- analyze **causes and consequences of avalanches**.
- recognize hazards linked to **dams, highways, and construction projects**.
- apply concepts of **vulnerability, risk, resilience, preparedness, and risk reduction** in disaster management.
- interpret the **Disaster Management Act and Policy framework in India**.

UNIT IV- Fires, Avalanche and Pest Infestations

Forest fires- causes, pattern, impact and mitigation on natural habitats; Fire accidents- causes, precaution, mitigation and rehabilitation; Pest infestations; Avalanche- causes and consequence; Hazards arising from geotechnical projects- construction of dams, highways, bridges; Disaster management-vulnerability, risk, capability, preparedness and mitigation, risk reduction and resilience; Disaster Management Act and Policy

Suggested Books:

1. Smith K (1992) *Environmental Hazards*. Routledge, London.
2. Bell FG (1999) *Geological Hazards*. Routledge, London.
3. Bryant E (1985) *Natural Hazards*. Cambridge University Press, London
4. Juire BMc, Mason I and Killburn C (2002) *Natural Hazards and Environmental Change*. Oxford University Press. New York.
5. Gupta HK (2003) *Disaster Management*. University Press. Pvt. Ltd., India
6. Jha MK (2010) *Natural and Anthropogenic Disasters: Vulnerability, Preparedness and Mitigation*. Springer.
7. Singh S, Leszek S and Syiemlieh HJ (2008) *Environmental Changes and Geomorphic Hazards*. Bookwell.

ELECTIVE-II REMOTE SENSING AND GIS

COURSE CODE: ENV: 616

Credits: 4
Marks: 100

UNIT I – Introduction to Remote Sensing

Course Objectives (COs):

1.To introduce the **definition, scope, and history** of remote sensing.
2.To explain the **principles of electromagnetic radiation (EMR)** and its interaction with matter.
3.To study **aerial photography** – types, scale, resolution, stereoscopy, and geometric properties.
4.To understand **relief displacement** in aerial photographs.

Course Learning Outcomes (LOs):

After completing Unit I, students will be able to:

- define and explain the **scope and historical development** of remote sensing.
- describe the **properties of EMR** and its interaction with matter.
- differentiate types of **aerial photographs** and interpret scale, resolution, and stereoscopy.
- understand **geometric distortions and relief displacement** in aerial imagery.

UNIT I- Introduction to Remote Sensing

Remote sensing- definition and scope; historical perspective in the development of remote sensing; Electromagnetic radiation- characteristics, interaction with matter and spectral region; Aerial photographs- types, scale, resolution; stereoscopy; Geometric properties of aerial photography; Relief displacement.

UNIT II – Remote Sensing Types and Platforms

Course Objectives (COs):

1.To explain the **types and spectral regions** of remote sensing.
2.To introduce **sensors and platforms** used in remote sensing.
3.To provide knowledge of **Indian and international satellites** (Landsat, IRS, IKONOS, CARTOSAT, QuickBird) and their sensors.

Course Learning Outcomes (LOs):

After completing the Unit II, students will be able to:

- Differentiate **types of remote sensing** (active, passive, thermal, microwave, etc.).
- Identify **spectral bands and regions** used in remote sensing.
- Compare various **satellite sensors and platforms**.
- Discuss the contributions of **Indian and global satellites** to remote sensing applications.

UNIT II- Remote Sensing types and platforms

Types of remote sensing; remote sensing regions and spectral bands; Platforms and sensors; Indian and foreign remote sensing satellites and their sensors- Landsat, IRS, IKONOS, CARTOSAT, QUICK BIRD.

UNIT III – Image Interpretation

Course Objectives (COs):

1.To explain **elements of aerial image interpretation**.

2.To describe **visual image interpretation and classification techniques** (supervised & unsupervised).

3.To demonstrate applications of **satellite imagery** in environmental and resource studies.

Course Learning Outcomes (LOs):

- after completing the Unit III, students will be able to:
- apply **visual interpretation keys** to aerial and satellite images.
- differentiate between **supervised and unsupervised image classification**.
- use satellite images for **environmental monitoring, landuse mapping, habitat &**
- **forest surveys, watershed & soil studies, flood/drought/landslide mapping, urban studies, rainfall & pollution monitoring**.

UNIT III- Image Interpretation

Elements of aerial image interpretation; visual interpretation; image classification procedure; supervised and unsupervised classifications; application of satellite imageries in environmental monitoring, landuse mapping, habitat analysis, forest survey, wetland survey, vegetation mapping, watershed management, soil conservation, drought and flood monitoring, landslide mapping, urban sprawl, rainfall mapping, pollution studies.

UNIT IV – Geographical Information System (GIS)

Course Objectives (COs):

1.To introduce the **concept, components, and data structures** in GIS.

2.To explain **raster vs vector data**, and merits/demerits.

3.To study GIS processes – **input, verification, storage, and output**.

4.To demonstrate **applications of GIS** in environmental and hazard studies.

5.To introduce **GPS – principles, components, and applications** in monitoring pollution and hazards.

Course Learning Outcomes (LOs):

After completing the Unit IV, students will be able to:

- define GIS and explain its **components and data structures**.
- differentiate **raster and vector data** with merits/demerits.
- apply GIS for **landuse mapping, habitat analysis, watershed management, hazard studies, and urban planning**.
- recognize GIS as a **decision-support system**.
- explain the **principles and applications of GPS** in environmental and hazard monitoring.

UNIT IV- Geographical Information System (GIS)

Introduction to GIS; components of GIS; geographical data- structure, raster and vector; Merits and demerits; Input, verification, storage and output of data; Application of GIS in environmental studies- land use mapping, habitat analysis; watershed management, natural hazard studies; landuse analysis, urban planning; GIS as a support system for decision making; GPS- Global Positioning System-principles, components, and its applications in pollution studies and environmental hazard monitoring;

Suggested books:

1. Lilesand TM and Kiefer RF (1987) *Remote Sensing and Image Interpretation.* John Wiley, Cambridge.
2. Ustin SL (2004) *Remote Sensing for Natural Resource Management and Environmental Monitoring.* John Wiley and Sons.
3. Barett EC and Curtis LF (1992) *Introduction to Environmental Remote Sensing.* Routledge, Taylor and Francis, New York.
4. Bhatta B (2011) *Remote Sensing and GIS.* Oxford University Press, New York.
5. Carrara Aand Guzzetti (1996) *Geographical Information Systems in Assessing Natural Hazards.* Kluwer Academic Publishers, Netherlands
6. Conway ED (1997) *An Introduction to Satellite Image Interpretation.* Maryland Space Grant Consortium
7. Johnson AI and Petterson (2008) *Geographical Information System (GIS) and Mapping: Practices and Standards.* ASTM International.
8. EL-Rabbany A (2002) *Introduction to GPS: The Global Positioning System.* Artech House.
9. Reddy MA (2008) Textbook of Remote Sensing and Geographical Systems. Second Edition, Book Syndicate.
10. Jensen JR (2000) *Remote Sensing the Environment.* Prentice Hall

CORE PRACTICAL- V
(LABORATORY-V)

Credits: 4 COURSE CODE: ENV: 617

Marks: 100

Course Objectives (General)

1. To provide hands-on training in **soil quality analysis** (physical, chemical, biological parameters).
2. To develop skills in **water quality and nutrient testing** relevant to agriculture and environment.
3. To understand the role of **nutrients, organic matter, and pollutants** in soil health and plant growth.
4. To train students in **toxicity testing, bioconcentration studies, and food adulteration detection**.
5. To sensitize students about the **role of NGOs and sustainable solid waste management practices**.

Course Learning Outcomes (Practical-wise): Students will be able to

I. **determine porosity and permeability of soil**.

II. **determine water holding capacity of soil, sodium, potassium, available phosphorus**

- can assess soil's suitability for crops based on water holding capacity.
- can detect sodium levels and assess soil quality for irrigation.
- can evaluate soil fertility status in terms of available potassium
- can measure available phosphorus to guide fertilizer application.
- can estimate nitrate content and its implication for crop productivity.

III. **determine of organic matter** for assessing soil he for assessing soil health

IV. study **Soil faunal diversity using pesticides** and the impact of pesticides on soil biodiversity.

- assess faunal diversity as an indicator of soil ecosystem health.

V. **Study toxicity test – LC & LD (Lethal Concentration/Dose)**

- can conduct LC/LD toxicity tests and interpret risk levels for organisms.

VI. **determination of bio-concentration factor (BCF) and** pollutants accumulate in organisms.

VII. **detect adulterants in common food items**.

- can perform simple tests for food safety and public health awareness.

VIII. **study on the role of an NGO in urban solid waste management**

- gain insight into NGO contributions and can critically evaluate sustainable waste practices.

Practical:

1. Determination of porosity and permeability of soil.
2. Determination of water holding capacity of soil.
3. Determination of sodium of a given soil sample.
4. Determination of potassium of a given soil sample.
5. Determination of available phosphorous of a given soil sample.
6. Estimation of nitrate nitrogen of a given soil sample.
7. Determination of alkalinity of a given soil sample.
8. Determination of chloride content of a given soil sample.
9. Determination of organic matter of a given soil sample.
10. Determination of calcium carbonate of a given soil sample.

11. Determination of boron of a given soil sample.
12. Determination of sulphate of a given soil sample.
13. Soil faunal diversity using pesticides.
14. Toxicity test – L_C & L_D
15. Determination of bio-concentration factor.
16. Food testing for adulteration.
17. Case study on the role of a NGO in urban solid waste management.

ELECTIVE PRACTICAL- I
(LABORATORY-VI)

Credits: 4
Marks: 100

COURSE CODE: ENV: 618

Course Objectives

1. To familiarize students with **tools and techniques for climatic, meteorological, and seismic analysis**.
2. To impart skills in **air quality and noise monitoring** using standard instruments.
3. To introduce students to **remote sensing, GIS, and GPS applications** in environmental monitoring.
4. To develop ability for **data interpretation, analysis, and visualization** in environmental studies.
5. To train students for **practical problem-solving** in climate, disaster, and pollution assessment.

Course Learning Outcomes (Experiment-wise)

1. **Deduction of climate types from a climograph**
   - CO: Learn classification of climates based on temperature and rainfall.
   - Outcome: Students can identify Koppen's or Thornthwaite's climate types from given data.
2. **Preparation of ombrothermic diagram (temperature, humidity & rainfall data)**
   - CO: Develop skills in climatic data representation.
   - Outcome: Students can prepare ombrothermic charts to assess seasonal climatic variations.
3. **Interpretation of topographical sheet**
   - CO: Learn map-reading and interpretation of relief features.
   - Outcome: Students can extract information on slope, drainage, vegetation, settlements, etc.
4. **Collection and interpretation of weather map**
   - CO: Understand weather symbols and synoptic charts.
   - Outcome: Students can interpret atmospheric pressure, wind, cloud cover, and predict weather.
5. **Location of earthquake epicentre from seismogram**
   - CO: Learn earthquake data interpretation.
   - Outcome: Students can calculate epicentre location using time-distance curves from seismograms.
6. **Interpretation of seismogram**
   - CO: Understand seismic waves and earthquake intensity.
   - Outcome: Students can analyze P-waves, S-waves, and magnitude from a seismogram.
7. **Determination of solar intensity by lux meter**
   - CO: Learn solar radiation measurement techniques.
   - Outcome: Students can measure and compare solar intensity for energy assessment.
8. **Determination of Air Quality Index (AQI) from given data**
   - CO: Develop understanding of AQI calculation.

- Outcome: Students can compute AQI and classify air quality levels (Good, Moderate, Poor, etc.).

9. **Measurement of noise level using sound level meter**
   - CO: Learn noise pollution monitoring.
   - Outcome: Students can measure noise levels and compare them with CPCB standards.
10. **Estimation of air quality parameters – respirable dust, SPM etc.**
- CO: Train in particulate matter sampling.
- Outcome: Students can measure PM10, PM2.5, and evaluate air quality.

11. **Practical on Remote Sensing & GIS (Google Earth Pro, ArcGIS, Digital Image Classification, GPS-based mapping)**
- CO: Develop geospatial analysis skills.
- Outcome: Students can acquire, process, and interpret remote sensing data for LU/LC classification, campus mapping, and environmental monitoring.

List of Practical:

1. Deduction of climate types on the basis of a given climograph.
2. Preparation of ombrothermic diagram from long term data of temperature, humidity and rainfall.
3. Interpretation of topographical sheet.
4. Collection and interpretation of weather map.
5. Location of earthquake's epicentre from seismogram.
6. Interpretation of seismogram.
7. Determination of solar intensity by lux meter.
8. Determination of Air Quality Index (AQI) from a given set of data.
9. Measurement of noise level of an area using sound level meter.
10. Estimation of air quality parameters- respirable dust, SPM etc.
11. Practical based on remote sensing and GIS – Google Earth Pro, Arc GIS Software, Data Acquisition, Digital Image Classification, Visual Image Interpretation for LU/LC Classification using Remote Sensing Data, DM Collage Campus Information using GPS,GIS and Arc GIS Software.

M.Sc. 4th Semester

CORE XI: CONSERVATION BIOLOGY

Credits: 4 COURSE CODE: ENV: 619

Marks: 100

UNIT I – Principles of Conservation Biology

Course Objectives (COs)

1. To introduce students to the fundamental concepts and principles of conservation biology.
2. To provide knowledge on biodiversity units, surrogates, and measures for species and ecosystem conservation.
3. To develop an understanding of rarity, extinction risks, and ecological correlates influencing conservation priorities.
4. To examine human-induced threats such as habitat loss, overharvesting, and resource exploitation.
5. To explore strategies for sustainable use of natural resources and restoration of degraded ecosystems.
6. To familiarize students with conservation practices such as ex-situ conservation, captive breeding, species reintroductions, and translocations.
7. To impart knowledge on protected area management, reserve design, and the application of island biogeography theory in conservation planning.

Course Learning Outcomes (LOs)

On successful completion of this unit, students will be able to:

- Explain the foundations, scope, and importance of conservation biology as a discipline.
- Identify and evaluate flagship, umbrella, keystone, and indicator species used as surrogates in conservation.
- Analyze different types of rarity, their ecological correlates, and implications for conservation priorities.
- Assess major threats to wildlife populations, including habitat destruction, fragmentation, and overexploitation.
- Propose strategies for sustainable use of natural resources to balance human needs and biodiversity conservation.
- Differentiate between in-situ and ex-situ conservation methods and evaluate their roles in species recovery programs.
- Apply principles of ecological restoration to design and assess conservation interventions such as captive breeding, reintroductions, and translocations.
- Evaluate the effectiveness of protected areas and apply island biogeography and reserve design principles for biodiversity conservation planning.

UNIT I- Principles of Conservation Biology

Foundations of conservation biology; units of conservation; Surrogates in conservation biology- flagship species, umbrella species, keystone species, indicator species; Rarity-typology, ecological correlates and conservation priorities; Threats to wild life populations - Factors influencing habitat loss and extinction; Overharvesting of natural resources and sustainable use; Ecological restorations- Ex-situ conservation, captive breeding, reintroductions, and translocations; Habitat loss and fragmentation; Protected Areas – Island biogeography theory and reserve design.

UNIT II – Conservation Genetics

Course Objectives (COs)

1. To provide the **principles and foundations of conservation biology** and their application in To introduce students to the fundamental units of genetics, including genes, DNA, RNA, and proteins.
2. To provide an understanding of genetic variation at individual, population, and meta-population levels.
3. To develop the ability to measure and interpret genetic diversity within and among populations.
4. To examine concepts of genetically effective population size and their role in population persistence.
5. To explore processes of co-adaptation, local adaptation, inbreeding depression, and outbreeding depression.
6. To study key evolutionary forces such as mutation, genetic drift, gene flow, and natural selection.
7. To apply genetic principles to conservation, population management, and evolutionary studies.

Course Learning Outcomes (LOs)

On successful completion of this Unit, students will be able to:

- Explain the structure and functions of genes, DNA, RNA, and proteins in relation to heredity.
- Differentiate between genetic variation within individuals, among populations, and across meta-populations.
- Apply methods to measure genetic diversity and interpret its significance for species survival.
- Calculate and analyze genetically effective population size and its implications for conservation biology.
- Evaluate the roles of co-adaptation and local adaptation in shaping population fitness.
- Assess the causes and consequences of inbreeding and outbreeding depression in natural and managed populations.
- Analyze the effects of mutation, genetic drift, and gene flow on population genetic structure.
- Explain the mechanisms of natural selection and its role in shaping genetic variation.
- Integrate genetic knowledge into conservation strategies and management of endangered species.

UNIT II- Conservation Genetics

Units of genetics-genes, DNA, RNA and proteins; genetic variation- variation within individuals, variation among populations, variations at the level of meta-population; measure of genetic diversity; genetically effective population size; co-adaptation, local adaptation; outbreeding depression, inbreeding depression; mutation, genetic drift; gene flow; natural selection.

UNIT III – Climate Change Ecology Course Objectives

Course Objectives (COs)

1. To introduce students to the spatio-temporal impacts of climate change on ecosystems and species.
2. To examine the physiological, behavioral, and ecological responses of species to climate change.
3. To analyze how climate change influences migration, breeding phenology, range shifts, and community dynamics.
4. To study extinction risks, invasive species, habitat disturbances, and critical habitat loss under changing climates.
5. To explore ecosystem-level responses of tropical forests, grasslands, montane and alpine systems, coastal and marine ecosystems.

6. To understand the link between climate change, human ecology, agricultural production, and food security.
7. To evaluate the effects of extreme weather events on biodiversity and ecosystem stability

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Course Learning Outcomes (LOs)

On successful completion of this Unit, students will be able to:

- Describe the physiological and behavioral responses of species to climate change.
- Explain how climate change affects migration patterns, breeding phenology, species distributions, and range shifts.
- Assess changes in community composition, ecosystem dynamics, and identify extinction risks caused by climate change.
- Analyze the role of climate change in promoting species invasions, habitat disturbances, and loss of critical wildlife habitats.
- Compare ecosystem responses across tropical forests, grasslands, montane forests, treelines, alpine vegetation, and marine ecosystems.
- Evaluate the socio-ecological dimensions of climate change, including impacts on human ecology and agriculture.
- Interpret how climate change affects food security at local, regional, and global scales.
- Assess the ecological consequences of extreme weather events and their implications for conservation and management.
- Integrate knowledge of climate change impacts into strategies for biodiversity conservation and ecosystem resilience.

UNIT III- Climate change Ecology

Spatio-temporal impacts of climate change on biological and ecological systems: physiological and behavioural responses – impacts on migration and breeding phenology – range shifts and species distribution – changes in community composition and dynamics – extinction risks – species invasions – habitat disturbances – loss of critical wildlife habitats – Ecosystem responses: tropical forests, grasslands, montane forests, treelines, alpine vegetations and coastal and marine ecosystems - climate change and human ecology - agricultural production and food security – extreme weather phenomena.

UNIT IV – Conservation Efforts

Course Objectives (COs)

1. To provide an overview of global conservation initiatives and protected area networks.
2. To study the functions and significance of UNESCO biosphere reserves and IUCN conservation categories.
3. To understand the role of international bodies such as WCMC and CITES in biodiversity conservation.
4. To explore the contributions of tourism, NGOs, and social movements to conservation efforts.
5. To familiarize students with intellectual property rights, patent laws, and their relevance to biodiversity.
6. To impart knowledge on key national legislations such as the Forest Conservation Act and the Wildlife Protection Act, along with their amendments.

Course Learning Outcomes(LOs)

On successful completion of this Unit, students will be able to:

- Explain the importance and functioning of the global protected area network and UNESCO biosphere reserves.
- Interpret the IUCN conservation categories and assess their application in biodiversity protection.
- Evaluate the roles of WCMC and CITES in regulating and monitoring international conservation efforts.
- Analyze the positive and negative impacts of tourism on biodiversity conservation.
- Critically assess the role of NGOs and social movements in shaping conservation policies and actions.
- Demonstrate understanding of patent rights, history of patent law, and the objectives of the patent system in relation to biodiversity and indigenous knowledge.
- Explain the provisions of the Forest Conservation Act and the Wildlife Protection Act, including their amendments, and their significance for conservation in India.

UNIT IV- Conservation efforts

Overview of global conservation efforts: global protected area network, protected areas and functions; UNESCO biosphere reserves; conservation status; IUCN conservation categories; WCMC, CITES; role of tourism in conservation; role of NGOs in conservation efforts; social movements concerning conservation issues; patent right, history of patent law and objectives of patent system; forest conservation act; wildlife protection act and amendments.

Suggested books:

1. Cox, G.W. 2005. Conservation Biology: Concepts and Applications. McGraw-Hill, Dubuque, Lowa, U.S.A.
2. McDonald, D. 2006. Key Topics in Conservation Biology, Blackwell Publishing.
3. Primack, R.B. 2014. Essentials of Conservation Biology. Sinauer Associates Inc., U. S. 6th edition.
4. Martha, J.G., Meffe, G.K. and Carroll, C.R. 2018. Principles of Conservation Biology. Sinauer Associates Inc., U. S. 3rd edition.
5. Mandai, F.B. and Nandi, N.C. 2009. Biodiversity: Concepts, Conservation and Biofuture. Asian Books Publication.
6. Malcolm L. Hunter Jr. And James P. Gibbs. 2006. Fundamentals of Conservation Biology. Wiley-Blackwell.
7. Fred Van Dyke. 2010. Conservation Biology: Foundation, Concepts and Applications. 2nd Edition Springer.
8. Environmental Law in India, Gurdeep Singh, 2005. McMillan, New Delhi.
9. Environmental Law and Policy in India, Shyam Dian and Armin Rosencrany, 2001. Oxford University Press, New Delhi.

CORE XII: ENVIRONMENTAL ECONOMICS AND NATURAL RESOURCE MANAGEMENT

Credits: 4 COURSE CODE: ENV: 620

Marks: 100

UNIT I- Introduction to Natural Resource Management

Course Objectives (COs)

1. To introduce students to the definition, concept, and classification of natural resources.
2. To study the factors influencing the availability, distribution, and utilization of natural resources.
3. To explore the interrelationships among different types of natural resources and their productivity concerns.
4. To analyze ecological, social, and economic dimensions of natural resource management.
5. To emphasize the importance of sustainable practices and the role of individuals in conserving and managing natural resources.

Course Learning Outcomes (LOs)

On successful completion of this Unit, students will be able to:

- Define and classify natural resources based on origin, renewability, and usage.
- Identify factors influencing the availability, distribution, and utilization of resources.
- Explain the interrelationships between different resource types and their implications for sustainability.
- Evaluate issues related to resource productivity and long-term sustainability.
- Analyze the ecological, social, and economic dimensions of natural resource management.
- Demonstrate awareness of the role of individuals and communities in sustainable resource management.
- Apply basic principles of NRM to real-world ecological and socio-economic challenges.

UNIT I- Introduction to Natural Resource Management

Natural resource- definition, concept, classification; factors influencing resource availability, distribution and uses; interrelationships among different types of natural resources; concern on productivity issues; ecological, social and economic dimensions of natural resource management; role of individual in natural resource management.

UNIT II – Resource Management Approaches and Paradigms

Course Objectives (COs)

1. To introduce students to ecological, economic, and ethnological approaches in resource management.
2. To analyze the implications of different management approaches and the need for integrated strategies.
3. To understand the relationship between poverty, resource scarcity, and management challenges in developing countries.
4. To trace the evolution and history of resource management paradigms.

5. To study the status, distribution, and management of forest, land, water, energy, food, fisheries, and mineral resources.
6. To examine environmental, social, and economic impacts of resource exploitation and strategies for sustainable use.

Course Learning Outcomes

On successful completion of this Unit, students will be able to:

- Compare ecological, economic, and ethnological approaches to resource management and explain their implications.
- Demonstrate understanding of integrated resource management strategies and their importance in sustainable development.
- Evaluate the links between poverty and resource scarcity in developing countries.
- Explain the evolution of resource management paradigms and their relevance in modern environmental policy.
- Assess the distribution, status, and management strategies of forest resources in developed and developing regions.
- Classify land use types, analyze land degradation issues, and propose sustainable land management strategies.
- Analyze the use and overutilization of surface and groundwater resources, with an emphasis on sustainable water management.
- Discuss the growing energy demand, the role of renewable/alternative energy sources, and sustainable energy strategies.
- Critically assess global food problems, food resource management, and agricultural sustainability.
- Evaluate the production, challenges, and sustainability issues related to fish and marine resources.
- Explain the exploitation of mineral resources and the associated environmental impacts.
- Integrate knowledge across resource types to propose holistic management strategies balancing ecological, economic, and social needs.

UNIT II- Resource Management Approaches and Paradigms

Ecological approach; economic approach; ethnological approach; implications of the approaches; integrated resource management strategies; poverty and implications in resource management in developing countries- poverty in developing countries, causes and link with resources scarcity and poverty. Resource management paradigms - the evolution and history of resource management paradigms; Forest resources- forest vegetation, distribution and status, forest management and developed and developing world strategies for forestry; Land resources- land as a resource, land use classification, land degradation; land management; Water resources - use and overutilization of surface and groundwater, water ecology and management; Energy resources - growing need of energy, use of alternate energy sources; Food resources - world food problems; Fish and other marine resources - production status, dependence on fish resources, issues and challenges in resource supply; Mineral resources - use and exploitation, environmental effects of extracting and using mineral resources.

UNIT III – Environmental Economics

Course Objectives (COs)

1. To introduce students to the foundations, scope, and principles of environmental economics.
2. To examine the interrelationship between economics, environment, and ecology in the context of development.
3. To provide an understanding of environmental economics trends, environmental goods, and their unique characteristics.
4. To analyze the concepts of sustainable development, its measures, and the Sustainable Development Goals (SDGs).
5. To study market functioning, failures, and the role of externalities in environmental and economic decision-making.
6. To apply principles of welfare economics, including the Pareto criterion, to environmental issues.

Course Learning Outcomes(LOs)

On successful completion of this Unit, students will be able to:

- Explain the history, scope, and principles of environmental economics.
- Analyze the interrelationship between environment, economy, and ecology in development processes.
- Describe the basics and current trends of environmental economics in relation to economic growth and development.
- Define and apply the concepts of sustainable development and evaluate strategies to achieve SDGs.
- Differentiate among environmental goods such as pure public goods, mixed goods, and public bads.
- Interpret consumption, demand, production, and supply dynamics in relation to environmental resources.
- Apply marginal analysis to assess costs, benefits, and trade-offs in environmental decision-making.
- Explain the nature of externalities, marginal social cost, marginal private cost, and marginal external growth.
- Evaluate different solutions to address externalities and market failures.
- Apply the principles of maximum social welfare and Pareto efficiency to environmental policy and management.

UNIT III- Environmental Economics

Introduction, world environmental history and economic development, nature and scope, principles of environmental economics, interrelationship between economics, environment and ecology, foundation of environmental economics; Environmental economics basics and trends, environment and economy, environmental and economic growth, environmental and development; Basic concept of sustainable development, measures for sustainable development, sustainable development goals; Main characteristics of environmental goods- pure public goods, mixed collective goods, public bads, externalities, consumption and demand, production and supply, marginal analysis, market and market failure, externality- marginal social cost, marginal private costs, marginal external growth, cost and solution to externalities; Principles of maximum social welfare- pareto Criterion.

UNIT IV – Resource Economics

Course Objectives (COs)

1. To introduce the economic principles underlying natural resource use and management.
2. To examine the impacts of population growth on environment and resource availability.
3. To explain the concept of common property resources and challenges of global resource sharing.
4. To analyze the relationship between international trade, world trade policies, and environmental sustainability.
5. To familiarize students with the methods of social and economic cost–benefit analysis (CBA) and their applications.
6. To study the economic aspects of environmental pollution, including private costs, social costs, and pollution control measures.

Course Learning Outcomes (LOs)

On successful completion of this Unit, students will be able to:

- Explain the principles of natural resource economics and their application in resource management.
- Analyze the environmental impacts of population growth at local, regional, and global levels.
- Define and evaluate the concept of common property resources and the challenges of their management.
- Assess global issues in environmental resource sharing and implications for sustainable development.
- Interpret the links between international trade, world trade practices, and environmental outcomes.
- Differentiate between social and economic CBA and apply them to evaluate environmental projects.
- Identify private costs, social costs, and externalities in environmental pollution.
- Propose economic and policy-based solutions for pollution control and sustainable resource management.

UNIT IV- Resource Economics

Economics of natural resources; population growth and its impacts on environment; the concept of common property resource; issues in global environmental resource shearing; world trade and the environment; international trade; social CBA, economic CBA, application of CBA; environmental pollution- control, private cost, and social cost.

Suggested books:

1. World Commission on Environment and Development; 'Our Common Future', Oxford University Press Publications.
2. Adiseshiah, M.S. (1987) Economics of Environment.
3. Victor, P.A.(1972) The Economics of Pollution, Mathau, London Publications.
4. Rogene and Buchoiz (1993) Principles of Environmental Management, Prentice Hall Publications.
5. Karpakam, M. (1991) Environmental; Economics, Stuling Pub. New Delhi.
6. Indian Institute of Ecology and Environment, New Delhi

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ELECTIVE III: ENVIRONMENTAL LAWS AND POLICIES

Credits: 4
Marks: 100

COURSE CODE: ENV: 621

UNIT I – Environmental Policies of India

Course Objectives (COs)

1. To introduce students to the nature and scope of environmental policies in India.
2. To study key national policies such as the National Environmental Policy (2006), EIA framework, and state-level environmental frameworks.
3. To familiarize students with the institutional roles of the Ministry of Environment, Forest and Climate Change, Pollution Control Boards, and ENVIS centres.
4. To analyze land use, population, industrialization, and urbanization policies in relation to environmental sustainability.
5. To examine the contributions of the National Committee on Environment and Planning (NCEP), Tiwari Committee, and Environment Action Plan in shaping policy.
6. To review major sectoral policies, including the National Forest Policy (1989), National Water Policy (2002), and National Energy Policy.

Course Learning Outcomes (LOs)

On successful completion of this Unit, students will be able to:

- Explain the objectives and principles of India's environmental policy framework.
- Interpret the provisions of the National Environmental Policy (2006) and the National Policy on EIA.
- Evaluate the role of central and state institutions (MoEFCC, CPCB, SPCBs, ENVIS Centres) in environmental governance.
- Analyze the impact of land use, population, industrialization, and urbanization policies on the environment.
- Assess the historical contributions of NCEP, Tiwari Committee, and Environment Action Plans in policy development.
- Compare and contrast the objectives and outcomes of the National Forest Policy (1989), National Water Policy (2002), and National Energy Policy.
- Apply knowledge of policies and frameworks to critically evaluate contemporary environmental governance challenges

UNIT I- Environmental Policies of India

Nature of Environmental Policies; National Environmental Policy, 2006; National Policy on EIA and Regulatory Framework; State Environmental Issues and Policy Frameworks; Role of Ministry of Forest, Environment and Climate Change, Central and State Pollution Control Boards, ENVIS Centres; Land Use Policy of India, Population, Industrialization and Urbanization Policies of GOI; National Committee on Environment and Planning (NCEP); Tiwari Committee; Environment Action Plan; National Forest Policy, 1989; National Water Policy, 2002; National Energy Policy.