DEPARTMENT OF ENVIRONMENTAL SCIENCE
DHANAMANJURI UNIVERSITY, IMPHAL
MANIPUR-795001

Name of the programme: M.Sc. Environmental Science (1 Year Programme)

The duration of the study programme will be of one year period comprising of two 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

THEORY PAPERS	COURSE CODE	COURSE TITLE	CONTACT HRS/ PAPER	CREDIT	MARKS		
					IA	EA	TOTAL
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 2

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 XI- ENVIRONMENTAL HEALTH AND TOXICOLOGY

Credits: 4 COURSE CODE: ENV: 613

Marks: 100

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.
- critically assess how ISO standards help industries achieve sustainability, pollution prevention, and international competitiveness.

UNIT I- Introduction to Environmental Management

Definition, scope and nature of environmental management; ethical, legal and financial reasons for maintaining and promoting environmental management; importance of sustainability; role of national governments and international bodies in formulating a framework for the regulation of environmental management; reasons for implementing an environmental management system (EMS); key features and appropriate content of an effective EMS based on the requirements of ISO 14001; benefits and limitations of introducing a formal EMS into the workplace; key members of the ISO 14000 family of standards and their purpose.

UNIT II- Environmental Impact Assessment

Course Objectives (COs):

1. To introduce the concept, scope, and significance of Environmental Impact Analysis (EIA), Environmental Impact Assessment (EIA), and Environmental Management Plan (EMP).
2. To highlight the role of EIA as an environmental management tool for sustainable development.
3. To study the Government of India guidelines, notifications, and legal framework for EIA.
4. To provide knowledge of impact assessment methodologies and techniques for baseline studies.
5. To understand cost-benefit analysis in relation to environmental projects.
6. To familiarize students with the EIA process in India including scoping, baseline data collection, impact prediction, public hearing, appraisal, and clearance.
7. To explore restoration and rehabilitation technologies for mitigating environmental damages.
8. To introduce the concept of Environmental Audit (EA), its definition, types, objectives, and guidelines.
9. To explain the need for environmental audit at both local and global levels as a tool for compliance, monitoring, and sustainability.

Course Learning Outcomes (LOs):

After completing this unit, students will be able to**:**

- understanding of EIA
- define and differentiate Environmental Impact Analysis, EIA, and EMP.
- explain how EIA functions as an environmental management tool.
- discuss the legal framework, guidelines, and notifications governing EIA in India (EIA Notification 2006 & amendments).

Methodologies & Procedures

- apply different impact assessment methodologies (checklists, matrices, overlays, networks, GIS-based models).
- conduct a baseline study and interpret its role in predicting environmental impacts.
- perform a cost-benefit analysis to evaluate project feasibility considering environmental aspects.
- 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,** types and classification.
2. To understand the **prediction, perception, and human adjustments** to hazardous activities.
3. To explain **disaster management cycle, 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** of hazards **and disaster management cycle**.
- describe methods of **response, rehabilitation, resilience, and mitigation**.

UNIT I- Introduction to Hazards and Disasters

Introduction to concepts of- hazards and disaster, types and classification, prediction and perception of hazards; Concept of residence time, risk, resilience; concept of disaster risk assessment; disaster management cycle; adjustment to hazardous activities.

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 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

Credits: 4 COURSE CODE: ENV: 616
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. **determine 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.

List of 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 COURSE CODE: ENV: 618
Marks: 100

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), students will able to:

1. **Deduction of climate types from a climograph**
- learn classification of climates based on temperature and rainfall.
- can identify Koppen's or Thornthwaite's climate types from given data.

2. **Preparation of ombrothermic diagram (temperature, humidity & rainfall data)**
- develop skills in climatic data representation.
- can prepare ombrothermic charts to assess seasonal climatic variations.

3. **Interpretation of topographical sheet**
- learn map-reading and interpretation of relief features.
- can extract information on slope, drainage, vegetation, settlements, etc.

4. **Collection and interpretation of weather map**
- understand weather symbols and synoptic charts.
- can interpret atmospheric pressure, wind, cloud cover, and predict weather.

5. **Location of earthquake epicentre from seismogram**
- learn earthquake data interpretation.
- can calculate epicentre location using time-distance curves from seismograms.

6. **Interpretation of seismogram**
- understand seismic waves and earthquake intensity.
- can analyze P-waves, S-waves, and magnitude from a seismogram.

7. **Determination of solar intensity by lux meter**
- learn solar radiation measurement techniques.
- can measure and compare solar intensity for energy assessment.

8. **Determination of Air Quality Index (AQI) from given data**
- develop understanding of AQI calculation.
- can compute AQI and classify air quality levels (Good, Moderate, Poor, etc.).

9. **Measurement of noise level using sound level meter**
- learn noise pollution monitoring.
- can measure noise levels and compare them with CPCB standards.

10. **Estimation of air quality parameters – respirable dust, SPM etc.**
- train in particulate matter sampling.
- 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)**
- develop geospatial analysis skills.

- 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. 2nd 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)

After completing 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)

After completing 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

---

.

Course Learning Outcomes (LOs)
After completing this Unit, students will be able to:

- describe the physiological and behavioural 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)
After completing 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)

After completing 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)
After completing 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)

After completing 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
   Occasional Monographs-11,22,41,42,51,70,77,87.
   Environment International- 42,51,71,72,75,76,84,85,86.
7. Francois Ramade, 1984. Ecology of natural resources, John Wiley & Sons Ltd.
8. Odum, E. P., 1971. Fundamentals of Ecology, W.B. Saunders Co., USA, 574p
9. Mann, K.H. 2000. Coastal Ecology & Management, Ecology of Coastal Waters with Implications for Management (2nd Edition) Chap.2-5, pp18-78 & Chap. 16, pp280-303.
10. Global Change and Natural Resource Management, Vitousek, P.M. 1994. Beyound global warming:Ecology and global change. Ecology 75,1861-1876.
11. Agarwal, K.C. 2001. Environmental Biology, Nidhi Publication Ltd. Bikaner.
12. Cunningham,W.P., Cooper,T.H., Gorhani, E. & Hepworth, M.T. 2001. Environmental Encyclopedia, Jaico Publishing House.
13. Heywood, V.H. & Watson, R.T. 1995. Global Biodiversity Assessment, Cambridge Univ. Press.
14. Miller, T.G. Jr.Environmental Science, Wadsworth Publishing Co. (TB).
15. Townsend, C, Harper, J. And Michael Begon. Essential of Ecology. Blackwell Science.

ELECTIVE III: ENVIRONMENTAL LAWS AND POLICIES

Credits: 4 COURSE CODE: ENV: 621
Marks: 100

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)

After completing 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.

UNIT II – Urban Development, Planning and Policy in Post-Independent India
Course Objectives (COs)

1. To introduce students to the history and phases of urban policy in India from 1951 to the present.
2. To analyze the status, structure, and challenges of urban local bodies and urban governance.
3. To study India's urbanization trends, major issues, and planning approaches across different Five-Year Plans.
4. To examine sources of urban finance, infrastructure planning, land policy, and housing strategies.
5. To explore sector-specific urban challenges such as housing, transport, water supply, sewerage, drainage, waste management, and sustainability.
6. To review national policies and missions, including the National Urban Sanitation Policy, JNNURM, and Smart Cities Mission.
7. To understand strategies for alleviating urban poverty through sustainable livelihoods and enterprises.

Course Learning Outcomes)LOs)
After completing this Unit, students will be able to:

- describe the evolution of urban policies in India across three major phases (1951–2009).
- assess the status of urban local bodies, urban governance systems, and financial frameworks.
- analyze India's urbanization scenario and identify key issues addressed in the Tenth and Twelfth Five-Year Plans.
- evaluate the effectiveness of plan assistance, infrastructure reforms, and fiscal balance in urban development.
- explain the role of land policy and housing in shaping urban growth and sustainability.
- apply sector-specific knowledge to challenges in housing, urban transport, water supply, sewerage, storm drainage, solid waste management, and environmental sustainability.
- interpret the objectives and provisions of the National Urban Sanitation Policy and JNNURM under the 12th Five-Year Plan.
- assess strategies for alleviating urban poverty through sustainable livelihoods and enterprise development.
- critically evaluate the Smart City initiative in the context of sustainable and inclusive urban development.

UNIT II- Urban Development, Planning and Policy in Post-Independent India
Urbanization in India, urban policy – the first phase (1951-1966), the second phase (1969-1984) and the third phase (1986- 2009); Urban Development – status of urban local bodies, urbanization scenario in India, major issues in urbanization for the tenth plan, urban governance, sources of urban finances, plan assistance for infrastructure, broad based reforms in the urban sector, land policy and housing, fiscal balance; Sector specific approach - affordable housing, urban transport, water supply, sewerage, storm water drainage, solid waste management and environmental sustainability of the cities, national urban sanitation policy, alleviating urban poverty- creating sustainable livelihoods and enterprises, JNNURM under the 12^{th} five year plan; Smart city.

UNIT III – Environmental Laws of India – I

Course Objectives(COs)

1. To introduce students to the environmental provisions enshrined in the Constitution of India.
2. To study the need for environmental legislation and the role of laws in sustainable resource management.

3. To examine specific constitutional articles (48A, 51A(g), 243, 243(G), 243(W), 246, 248) relevant to environment and citizen duties.
4. To familiarize students with major environmental and allied legislations such as the Indian Forest Act (1927), Indian forest conservation Acts; Public Liability Insurance Act (1991), Motor Vehicle Act (1988), and the National Environment Tribunal Act (1995).
5. To understand the relevance of intellectual property rights, Merchant Shipping (Amendment) Act (1970), and Factories Act (1948) in environmental protection and regulation.

Course Learning Outcomes(LOs)

After completing this Unit, students will be able to:

- explain the environmental provisions in the Constitution of India and their significance in governance and policy-making.
- interpret the roles of fundamental duties (Article 51A(g)) and directive principles (Article 48A) in environmental protection.
- analyze the constitutional articles (243, 243(G), 243(W), 246, 248) related to environmental governance and local administration.
- demonstrate understanding of major Indian environmental legislations such as the Indian Forest Act (1927), Indian forest conservation Acts, Public Liability Insurance Act (1991), Motor Vehicle Act (1988), and National Environment Tribunal Act (1995).
- evaluate the application of intellectual property rights, Merchant Shipping (Amendment) Act, and Factories Act in environmental management and compliance.
- integrate knowledge of constitutional provisions and legislation to assess contemporary environmental governance and policy challenges in India.

UNIT III- Environmental laws of India - I

Environmental provisions in the constitution of India; need for environmental legislation; Article 48(A), 49 51A(g) as fundamental duties of citizens and directive principles of state policy; Article 243, 243(G) and (W); Article 246, 248 and other articles related to environment; Indian Forest Act; Indian Forest conservation Acts; Public Liability Insurance Act, 1991; Motor Vehicle Act, 1988; National Environment Tribunal, 1995; Intellectual Property Right; The Merchant Shipping (Amendment) Act, 1970; The Factories Act, 1948.

UNIT IV – Environmental Laws of India – II

Course Objectives(COs)

1. To familiarize students with major environmental legislation and rules in India.
2. To study laws related to prevention and control of pollution (air, water, noise, and hazardous waste).
3. To examine legislation governing biodiversity, wildlife protection, forest conservation, and waste management.
4. To analyze the evolution, scope, and enforcement mechanisms of key environmental acts and rules.
5. To understand the responsibilities of individuals, industries, and government agencies under these regulations.

Course Learning Outcomes(LOs)

After completing this Unit, students will be able to:

- explain the objectives, provisions, and amendments of the Water (Prevention and Control of Pollution) Act, 1974 and Air (Prevention and Control of Pollution) Act, 1981.
- interpret the Environmental (Protection) Act, 1986 and its role in regulating environmental standards and compliance.

- analyze sector-specific regulations such as the Bio-Medical Waste Management Rule (2016), Hazardous Waste (Management and Handling) Rule (1989), Plastic Waste Management Rule (2016), Solid Waste Management Rule (2016), and the Noise Pollution (Regulation) Act (2000).
- evaluate the Wildlife (Protection) Act, 1972, Forest (Conservation) Act, 1980, and Biodiversity Act, 2002 for biodiversity and forest conservation.
- assess the responsibilities of citizens, industries, and government agencies under these laws.
- apply knowledge of environmental legislation to critically evaluate real-world environmental compliance, governance, and management challenges.

UNIT IV- Environmental laws of India - II

Water (Prevention and Control of Pollution) Act, 1974 as amended up to 1988; Air (Prevention and Control of Pollution) Act, 1981; Environmental (Protection) Act, 1986; Boi-Medical Waste Management Rule, 2016; Wildlife (Protection) Act, 1972; Forest (Conservation) Act, 1980; Hazardous Waste (Management and Handling) Rule, 1989; Plastic Waste Management Rule, 2016; Biodiversity Act, 2002; The Noise Pollution (Regulation) Act, 2000; Solid Waste Management Rule, 2016.

Suggested Books:

1. Environmental law in India, Singh, G. (2005), McMillan, New Delhi.
2. Environmental law and Policy in India, Diwan, S. And Rosencrany, A. (2001), Oxford University Press, New Delhi.
3. Pollution Control Legislations, (1999), Vol. I and II, Tamil Nadu Pollution Control Board, Chennai.
4. Global Environmental Policies, Tiwari, R.K. (2007), ABD Publishers.
5. Environmental Policies, Sinha, P. C., Anmol Publications Pvt. Ltd. New Delhi (1998).
6. Environmental Governance: The Global Challenge, Lamont, C., Affiliated East-West Press Pvt. Ltd., New Delhi (1998).
7. Anti-Pollution Acts (30 and Commentaries published theorem).
8. Constitution of India (referred articles from Part-III, Part-IV and Part-VI-A).
9. Pares Distn. Environmental Laws in Indias.
10. P. Leelakrishnan, Environmental and the last (Bullorthworths, Latold, edn.).
11. Batra, L. A Review of Urbanization and Urban Policy in post-independent India, working paper series (CSLG/WP/12), centre for the study of law and governance, JNU, New Delhi (2009). Retrieved from http//www.jnu.ac.in/ default/file/1... on 23/3/19.
12. Planning Commission, Urban Development, retrieved from planning commission. nic. in /hackathon.
13. Ian Hodge. 1995. Environmental Economics – A textbook, Sterling Publishers Pvt. Ltd. New Delhi.

ELECTIVE IV: RESEARCH METHODOLOGY AND INSTRUMENTATION

Credits: 4 COURSE CODE: ENV: 622

Marks: 100

UNIT I – Research Methodology: An Introduction

Course Objectives (COs)

1. To introduce students to the meaning, purpose, and significance of research.
2. To explore the objectives, motivations, and types of research.
3. To explain different research approaches and the distinction between research methods and methodology.
4. To familiarize students with the research process, scientific method, and criteria of good research.
5. To discuss common problems and challenges encountered by researchers, particularly in the Indian context.

Course Learning Outcomes(LOs)

After completing this course, students will be able to:

- define research and explain its significance in scientific and practical contexts.
- identify the objectives and motivations behind conducting research.
- differentiate between types of research (basic, applied, descriptive, analytical, etc.) and research approaches.
- distinguish between research methods and methodology and understand their appropriate applications.
- explain the steps of the research process and the role of the scientific method in research.
- evaluate the criteria of good research and apply them to design and assess research projects.
- recognize common challenges faced by researchers in India and propose solutions to overcome them.

UNIT I- Research Methodology - An Introduction

Meaning of research; objectives of research; motivation in research; types of research; research approaches; significance of research; research method versus methodology; research and scientific method; importance of knowing how research is done; research process; research process; criteria of good research; problems encountered by researchers in India.

UNIT II – Field and Laboratory Research

Course Objectives (COs)

1. To introduce students to various methods of data collection, including primary and secondary sources.
2. To explain specific techniques for primary data collection such as observation, interviews, questionnaires, and schedules, and highlight their differences.
3. To familiarize students with data analysis and interpretation techniques, including precautions to ensure accuracy.
4. To provide knowledge and skills for effective research report writing, including steps, mechanics, layout, and oral presentation.
5. To emphasize ethical considerations and best practices in research data handling and reporting.

Course Learning Outcomes
After completing this Unit, students will be able to:

- Select and apply appropriate methods for collecting primary and secondary data.
- differentiate between observation, interview, questionnaire, and schedule methods and determine their suitability for research objectives.
- analyze and interpret collected data using correct techniques while taking necessary precautions.
- Prepare comprehensive research reports, following standard formats, layouts, and presentation guidelines.
- present research findings effectively through oral presentations.
- demonstrate ethical and professional conduct in data collection, analysis, and reporting.

UNIT II- Field and Laboratory Research
Method of data collection- collection of primary data: observation method, interview method, collection of data through questionnaire and schedule, difference between questionnaire and schedule, some other methods of data collection; collection of secondary data; analysis of data; data interpretation- techniques and precautions; report writing- steps, mechanics and precautions; report- types, layout and oral presentation.

UNIT III – Basic Analytical Equipment
Course Objectives (COs)

1. To introduce students to the principles, working mechanisms, and environmental applications of key analytical instruments.
2. To study measurement devices such as pH meters, conductivity meters, and nephelometers.
3. To familiarize students with microscopy techniques (light and electron microscopes) and their applications in environmental studies.
4. To explain the principles, types, and functions of centrifuges, electrophoretic techniques, and radioimmunoassay methods.
5. To provide understanding of air and particle sampling instruments, including high-volume samplers, respirable samplers, impactors, cyclones, particle size analyzers, and gas analyzers.

Course Learning Outcomes(LOs)
After completing this Unit, students will be able to:

- explain the working principles and applications of pH meters, conductivity meters, and nephelometers in environmental monitoring.
- describe the basic principles and environmental applications of light and electron microscopy.
- identify different types of centrifuges, their functions, and applications in environmental and laboratory analysis.
- apply electrophoretic and radioimmunoassay techniques in environmental research.
- operate and interpret results from air sampling and particle measurement instruments such as high-volume samplers, respirable samplers, impactors, cyclones, particle size analyzers, and gas analyzers.
- integrate knowledge of instrumentation to monitor, analyze, and manage environmental parameters effectively.

UNIT III- Basic Analytical Equipments
Principle, working mechanism and environmental applications of pH meter, conductivity meter, nephlometer; basic principles and applications of light and electron microscopes; types, function and applications of centrifuges; – principle, types and environmental application of electrophoretic techniques

and radio immune assay techniques; principles, working, and applications of high volume sampler, respirable sampler, impactors, cyclone, particle size analyser, gas analyser.

UNIT IV – Spectroscopy and Chromatography
Course Objectives (COs)

1. To introduce students to the various ranges of electromagnetic radiation and their interactions with matter.
2. To study the principles, working mechanisms, types, and environmental applications of key spectroscopic instruments including colorimeter, UV-Vis spectrophotometer, fluorimeter, flame photometer, AAS, AES, ICP-MS, IR, NMR spectrophotometer, and XRD.
3. To explain the principles and concepts of chromatography, including stationary and mobile phases, partition, and adsorption coefficients.
4. To familiarize students with different chromatographic techniques such as paper chromatography, thin-layer chromatography, ion exchange, gas-solid, gas-liquid chromatography, GC-MS, and high-performance liquid chromatography (HPLC).
5. To demonstrate the environmental applications of spectroscopy and chromatography in monitoring and analyzing pollutants.

Course Learning Outcomes(LOs)
After completing this unit, students will be able to:

- explain the interaction of electromagnetic radiation with matter and its relevance to environmental analysis.
- describe the principles, working, types, and applications of colorimeters, UV-Vis spectrophotometers, fluorimeters, flame photometers, AAS, AES, ICP-MS, IR, NMR, and XRD instruments.
- understand and apply the basic concepts of chromatography, including stationary and mobile phases and partition/adsorption coefficients.
- operate and interpret results from paper, thin-layer, ion exchange, gas-solid, gas-liquid, GC-MS, and HPLC techniques.
- apply spectroscopic and chromatographic methods to monitor, analyze, and quantify environmental pollutants effectively.
- integrate analytical techniques knowledge to design environmental monitoring and research protocols.

UNIT IV- Spectroscopy and Chromatography
Various ranges of electromagnetic radiation – interaction of electromagnetic radiation with matter, spectrophotometer – principle, working mechanism, types and applications of colorimeter, UV and visible spectrophotometer, fluorimeter, flame photometer, AAS, AES, ICP-MS, IR, NMR spectrophotometer and XRD spectrometer.
Principle and concept of chromatography – stationary phase, mobile phase, partition and adsorption coefficients. Working principle, instrumentation and environmental applications of paper, thin layer, ion exchange, gas solid, gas liquid, GC – MS and high performance liquid chromatography.

Suggested Books:

1. Bour E J. 1982. Introduction to chemical instrumentation, 4th edition, Wiley and Sons, NY.
2. Christian, G D. 2001. Analytical Chemistry, 5th Edition, John Wiley and Sons Inc., India.
3. Khopkar, S M. 1993. Environmental Pollution Analysis, Wiley Eastern Ltd.

4. Manahan, S E. 2007. Environmental Chemistry, 7th Edition, Lewis Publications, Florida, USA.
5. Manly, 2001. Statistics for Environmental Science and Management, Chapman and Hall/ CRC Press, Boca FL, USA.
6. Petter Laake, Haakon Breien Benestad. Academic Press, 05-Nov-2007.
7. Research Methodology in the Medical and Biological Sciences (Google Book).
8. Skoog D A., Holler F J and Nieman T. A. 1980. Principles of Instrumental Analysis, 5th Edition, Thomson Asia Pvt., Singapore.
9. Vogel AI. 1988. Quantitative Analysis, 6th Edition, Prentice Hall Inc.
10. Willard H H, Marrit, L L and Dean, J A. 1976. Instrumental Methods of Anaslysis, 5th Edition, Van Nostand Reinhold.
11. Kothari C. R. 2004. Research Methodology- Methods & Techniques, 2nd Revised Edition, New Age International Pvt. Ltd. Publishers, New Delhi.
12. Pandey, P and Pandey, M. M. 2015. Research Methodology: Tools & Techniques, 1st Edition, Bridge Center, Buzau, Al. Marghiloman, Romania, European Union.
13. http://www.bio.umass.edu/biology/forms/content/499e-research-methodology.
14. www.perl.org/
15. Blastalgorithm.com/
16. www.fao.org/docrep/W729E/w7295e08.htm
17. Itl.nist.gov/div898/handbook/eda/section3/eda35b.html
18. www.computerhope.com/os.htm
19. euacademic.org/bookUpload/9.pdf

CORE PRACTICAL VI
(LABORATORY – VII)

Credits: 4 COURSE CODE: ENV: 623

Marks: 100

Course Objectives (COs):

1. To provide hands-on experience in studying plant and animal adaptations to various environmental conditions.
2. To train students in environmental monitoring, assessment, and data collection techniques.
3. To introduce practical methods for analyzing water, soil, and solid waste quality.
4. To develop skills in laboratory techniques such as buffer preparation, measurement of soil respiration, and energy audits.
5. To enhance the ability to interpret experimental data and relate findings to environmental processes and management.

Course Learning Outcomes(LOs)

On successful completion of these Practical, students will be able to:

- Identify and study morphological and physiological adaptations of plants (Hydrophytes, Halophytes, Xerophytes, Epiphytes) and animals (Sandy, Muddy, Rocky, Fossorial, Aerial, Volant, Desert species).
- Conduct energy audits and compute energy usage in real-life environmental settings.
- Compute Water Quality Index (WQI) and assess water body health.
- Measure soil respiration and understand its ecological significance.
- Prepare buffer solutions and perform standard laboratory procedures accurately.
- Assess light penetration in aquatic systems using Secchi Disc method.
- Apply basic methods of solid waste sampling and determine waste composition, moisture content, dry matter, pH, and electrical conductivity.
- Analyze decomposition processes and interpret results for environmental management purposes.
- Develop practical problem-solving skills and laboratory safety awareness.

List of Practical:

1. Study of plant adaptations under various environmental conditions – Hydrophytes, Halophytes, Xerophytes and Epiphytes.
2. Ecological adaptation study of animals –Sandy, Muddy, Rocky, Fussorial, Arial, Volant, Desert etc
3. Case study on energy audit of environmental science department.
4. Computation of Water Quality Index (WQI).
5. Study of common weeds and pests.
6. Measurement of soil respiration
7. Preparation of buffer solution
8. To study the light penetration of a pond by Secchi Disc method.
9. Basic methods of solid waste sampling.
10. Determination of solid waste composition, characteristics, decomposition analysis, moisture content, dry matter analysis, pH, electrical conductivity.

ELECTIVE PRACTICAL II
(DISSERTATION)

Credits: 4 COURSE CODE: ENV: 624
Marks: 100

Dissertation

Course Objectives (COs):

1.To introduce students to various methods of data collection, including primary and secondary sources.
2.To explain specific techniques for primary data collection such as observation, interviews, questionnaires, and schedules, and highlight their differences.
3.To familiarize students with data analysis and interpretation techniques, including precautions to ensure accuracy.
4.To provide knowledge and skills for effective research report writing, including steps, mechanics, layout, and oral presentation.
5.To emphasize ethical considerations and best practices in research data handling and reporting.

Course Learning Outcomes(LOs)

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

- select and apply appropriate methods for collecting primary and secondary data.
- differentiate between observation, interview, questionnaire, and schedule methods and determine their suitability for research objectives.
- to train students in environmental monitoring, assessment, and data collection techniques.
- to introduce practical methods for analyzing water, soil, and solid waste quality.
- to develop skills in laboratory techniques such as buffer preparation, measurement of soil respiration, and energy audits.
- to enhance the ability to interpret experimental data and relate findings to environmental processes and management.
- analyze and interpret collected data using correct techniques while taking necessary precautions.
- prepare comprehensive research reports, following standard formats, layouts, and presentation guidelines.
- present research findings effectively through oral presentations.
- demonstrate ethical and professional conduct in data collection, analysis, and reporting.
- to provide hands-on experience in studying plant and animal to various environmental conditions.