UNIVERSITY OF LUCKNOW
Department of Botany

Master of Science Programme in Environmental Science (Two Year) Under NEP-2024 Framework

University of Lucknow
Master of Science (M.Sc.) Programme in Environmental Science
(Two Year)
PG Ordinance (NEP) 2024

1. **Applicability:**
   These regulations shall apply to the **Master in Environmental Science** from the session 2025-26.

2. **Minimum eligibility for admission:**
   A three/four-year Bachelor's degree or equivalent in science except B.Sc. Agriculture awarded by a University or Institute established as per law and recognized as equivalent by this university with a minimum of 45% percentage marks or equivalent grade, shall constitute the minimum requirement for admission to the Master in Environment Science program.

3. **Programme objectives:**
   M.Sc. Environmental Science programme, within the Department of Botany, was launched in 1993 to provide an opportunity to study the inter-disciplinary field of science, including an internship in the IVth Semester to acquire appropriate practical training/skills in environmental science. The overall aim of this program is to train the students so that they may choose their career in teaching/research and industrial organizations for handling environment-related issues based on their acquired relevant scientific knowledge.

4. **Programme Outcomes:**
   Upon successful completion of the M.Sc. Environmental Science Programme, the student will
   - Acquire adequate knowledge about the relevance of environmental science, the earth, and its environment (biosphere, atmosphere, lithosphere, hydrosphere)
   - Understand the ecosystem, ecology, energy resources, and biotic community.
   - Learn about phytogeography, vegetational zones, and forest types
   - Understand biotic responses to environmental stress, management of natural resources, and their conservation.
   - Become well-versed with agricultural practices in India for diversified cropping systems.
   - Understand current issues like global warming, climate change, and environmental pollution and its management through bioremediation, e-waste management, and environmental planning law.
   - Gain knowledge that would help maintain the clean, green, and sustainable existence of various ecosystems for human beings.

5. **Specific Programme Outcomes (PSOs):**
   PSO1: To produce quality HRD for preparing necessary road maps/plans to ensure sustainable use of natural resources in an era of climate change, to save the natural planet, the earth, for future generations
   PSO2: To promote the concept of re-cycling and bio-conservation of agricultural waste in value-added products
   PSO3: To apply environmental engineering to mitigate adverse biotic and abiotic environmental variables for the flora and fauna
   PSO4: To promote Eco-tourism for enhancing socio-economy linked with forest ecosystems and wildlife eco-zones
   PSO5: To extend awareness amongst the people and society for keeping the environment healthy and safeguarding the population from the deleterious consequences of pollutants for the sustainability of quality of life.

6. **Course Structure:**

The course structure of the Master of Environment Science Programme (Two Year) shall be as under

Course No.	Name of the Course	Credit	Remark
	Semester I		
EVS-CC-1	The Earth and its Environment	04	Core Course
EVS-CC-2	Environmental and Air Pollution	04	Core Course
EVS-CC-3	Biotic Resources	04	Core Course
EVS-CC-4	Radiation, Noise, Industrial and Thermal Pollution	04	Core Course
EVS-CC-5	Practical based on EVS-CC-1 to EVS-CC-4	02	Core Course
EVS-VC-IRA	Sustainable Utilization and Management of Natural Resources	02	Value-added Credited course (Intradepartmental)
	Semester Total	**20**	
	Semester II		
EVS-CC-6	Biotic Community and Community Dynamics	04	Core Course
EVS-CC-7	Water Resources: Water Pollution Management	04	Core Course
EVS-CC-8	Abiotic Natural Resources	04	Core Course
EVS-CC-9	Biotic Responses to Environmental Stresses	04	Core Course
EVS-CC-10	Practical based on EVS-CC-6 to EVS-CC-10	02	Core Course
EVS-VC-IER	Eco-friendly Environment	02	Value-added Credited course (Interdepartmental)
	Semester Total	**20**	
	Semester III		
EVS-CC-11	Environmental Policies and Management	04	Core Course
EVS-CC-12	Environmental Biotechnology and Agriculture	04	Core Course
EVS-CC-13	Academic Tour	04	Academic Tour
EVS-EC-14A	Wetlands and their Management	04	Elective
EVS-EC-14B	Climate Change and Related Global Issues		
EVS-EC-15A	Nanotechnology and Sustainable Agriculture	02	Elective
EVS-EC-15B	Ecotourism		
EVS-IN	Internship/ Field Work	02	Internship
	Semester Total	**20**	
	Semester IV		
EVS-MT	Master Thesis/ Dissertation	20	Master Thesis
	Semester Total	**20**	
	GRAND TOTAL	**80**	

EVS – Environmental Science; CC – Core Course; EVS -VC-IRA– Value added course (Credited); EVS-EL –Elective; EVS-VC-IER – Interdepartmental Course; EVS-IN - Semester Internship

7. Course Outlines:

M.Sc. ENVIRONMENTAL SCIENCE (SEMESTER -I)
EVS-CC-1: THE EARTH AND ITS ENVIRONMENT
4 Credits/40 Hours

Course outcomes:

After completion of the course, the student will understand about -

- The principles of Environmental Science and components of the environment.
- Edaphic factor, soil formation process, composition, properties, and Problem soil.
- Soil pollution and degradation of soil.
- Concept of Energy, conservation, and future sources of energy.

Unit–I
Definition, principle, and relevance of environmental science Lithosphere; Origin of earth. Oceanic and Continental differentiation and composition of core, mantle, and crust. Atmosphere; Concepts and atmospheric layers Hydrosphere; basic concepts (salty and freshwater) Biosphere; basic concepts and diversity, its resources and diversification
Unit–II
Edaphic factor; Soil formation, Basic concept of essential mineral nutrients. Processes (Weathering and Pedogenesis), Factors affecting soil formation. Soil profile: Composition, Organic matter (Humus) Properties; Physical (texture and structure, color, temperature, and density Chemical; pH, soil colloids, ion-exchange processes, soil buffering; Biological (soil living organisms and their functions) Problem Soils; Acid, Saline, Sodic soils and their reclamation processes. Soil types of India.
Unit–III
Soil pollution, types of soil pollutants, IoT, and AI in Soil Monitoring Emerging soil pollutants: Microplastics in Soil, Nanomaterials, Persistent Organic Pollutants (POPs) Effects of soil pollutants on soil biodiversity: Bioaccumulation of Pollutants in Crops and living beings. Heavy metal pollution in soil and plants. Bioremediation of soil pollutants,
Unit–IV
Soil degradation: causes, effects Degraded soil types and management Deforestation and land degradation. Mitigation: Sustainable practices
Unit–V
Energy: Gibb's free energy concepts, enthalpy, Classification of Energy sources; Conventional (Fossil fuels and their global distribution, petrol, coal, biomass, etc.) and non-conventional energy sources, Earth's energy budget. Energy conservation: Production efficiency, transportation, and utilization of energy National and global energy scenarios, potentials and limitations of conventional energy sources. Future sources of energy: Solar, Hydrogen, Biofuels (alcohol, Petro crops), and fuel cells (Lithium, PEMFCS, SOFCs, AFCs, etc.)

Suggested readings:

1. Environmental Science, S. C. Santra, New Central Book Agency, Pvt. Ltd.,2001.
2. Environmental Science, Richard T. Wright, and Bernard J. Nebel, Prentice Hall of India Pvt. Ltd. New Delhi, 2002.
3. Encyclopedia of Ecology, Environment and Pollution Control, R. Swarup, S.N. Mishra, V.P. Jauhari, Mittal Publication, New Delhi, 1999.
4. The Nature and Properties of Soils, Nyle C. Brady and Ray R.Weil, Pearson, Edu.Pvt. Ltd.2002.

M.Sc. ENVIRONMENTAL SCIENCE (SEMESTER - I)
EVS-CC-2: ENVIRONMENTAL AND AIR POLLUTION

4 Credits/40Hours

Course outcomes:

After completion of the course, the student will understand about-

- Environmental Pollution and mitigation strategies.
- Global warming, climate change, greenhouse effect, ozone layer depletion, and acid rain problems and solutions.
- Air pollution and their monitoring techniques.
- Management of air pollutants.
- Airborne microbes, dust, and pollen allergies
- Meteorological parameters.

Unit–I
Concepts of pollution, Primary and secondary pollutants. Emerging pollutants: Microplastics, Nanoplastics: Sources, impacts on ecosystems, and human health. Pharmaceutical and Personal Care Products (PPCPs): Their ecological consequences. Endocrine Disruptors: Effects on wildlife and humans. Global warming, climate change, greenhouse effects, ozone layer depletion, acid rain. Pollution of the near-Earth environment (Space debris) and management Effects of climate change and pollution in pristine environments.
Unit–II
Air pollution: pollutants types, natural and anthropogenic sources. Particulate air pollutants, dust pollution, carbon, fly ash, asbestos, smog. Gaseous air pollutants-SO_2, NO_2, NO, CO, CH_4, O_3. Environmental monitoring of particulate and gaseous air pollutants. Environmental levels and effects of common particulate and gaseous air pollutants. Vehicular pollutants and their impact on the environment, Acid rain.
Unit–III
Air Pollution control measures: Management of particulate and non-particulate air pollutants. Air quality control decision system (AQCDS), quality decision support system (QDSS), Models of air pollution control (Beijing model, etc.). Emerging trends in controlling air pollution: Graded response action plan (GRAP), GRAP2, GRAP3, GRAP4. Rule Five, Use of e-vehicles, CNG, etc.
Unit–IV
Types of allergens, Dust and pollen allergies, protection, and control measures. Airborne microbes and health hazards. Toxic hazardous chemicals in environment, their sources and management, Mutagenic and carcinogenic agents, Toxicity tests (LC50/EC50). Smart Cities: Pollution monitoring and reduction strategies. Artificial intelligence in environmental management.
Unit–V
Meteorological parameters - pressure, temperature, precipitation, precipitation index, humidity, mixing ratio, saturation mixing ratio, radiation and wind velocity, adiabatic lapse rate, environmental lapse rate. Wind: Types of winds and inversions, wind roses. Coriolis force, pressure gradient force, frictional force, geo-strophic wind field, gradient wind Climates of India, western disturbances, Indian monsoon, droughts, *El Nino*, *La Nina* effects

Suggested readings:

1. Air Pollution and its Control, A. Kumar, Shree Press, 2019.
2. Environmental Science, S. C. Santra, New Central Book Agency Pvt. Ltd., 2001.
3. Climate Change: An Iterdisciplinary Introduction by Thomas Brewer, Publisher-Springer

4. Introduction to Environmental Engineering and Science, Gilbert M. Masters Wendell P.Ela, Publisher-Pearson Education India
5. Environmental Engineering by Peavy, Howard S, Rowe, Donald R, Tchobanoglous George, Publisher-New York: McGraw Hill
6. Environmental Pollution Management and Control for Sustainable Development By-RK Khitolia. Publisher-S Chand

M.Sc. ENVIRONMENTAL SCIENCE (SEMESTER - I)
EVS-CC-3: BIOTIC RESOURCES
4 Credits/40Hours

Course outcome:

After completion of the course, the student will understand the

- National forest policy, Forest Protection Act, and Wildlife Protection Act
- Gain knowledge of Biotic resources and rules and regulations for management

- Basic concepts Social, Agroforestry, Silviculture and Apiculture
- Concepts of Hotspots, biodiversity conservation, and identification of plants

Unit-I
Global and national forest cover, their importance Sustainable and eco-friendly development and exploitation of forest resources Laws and policies related to forest resources: constitutional provisions in India (Article 48A & 51A). Wildlife Protection Act, 1972, Forest Conservation Act, 1980, National Forest Policy1988, Biological Diversity Act 2002, and JFM Forest cover monitoring and related agencies: ISFR, FRI, and IIRS Reasons for depletion of forest cover, conservation of forest
Unit–II
Social and Agroforestry: agroforestry buffers. Agriculture and Pisciculture: Relevance and economic importance Silviculture: Basic concepts, approaches and importance Apiculture: habitat restoration and importance
Unit–III
Wildlife and its importance, diversity trends and gradients management in biodiversity, biodiversity prospecting and role of NGOs in wildlife management, Mega diversity zones, Concept and basis of 'Hotspots'; hotspots in India. Social factors affecting wildlife depletion, vulnerability of species, IUCN threat list, categories, red-data list, Threatened flora and fauna of India Cost valuation of biodiversity, Earth summit and follow-up actions, conventions on biodiversity and sustainable development, and socio-environmental issues related to wildlife. Threats to wildlife diversity, major causes and extinction of wildlife.
Unit–IV
Biodiversity conservation: *in-situ, ex-situ,* and *in-vitro* conservation. Measures of biodiversity. Biosphere reserves, National parks, Sanctuaries, Protected areas, and Sacred groves in India. Concepts of gene pool, bio-piracy, and bio-prospecting. Concept of restoration ecology. Ecotourism, the concept of eco-planning for eco-friendly development. Tribals and their role in wildlife conservation, community participation, and capacity-building programs for sustainable exploitation of wildlife resources for the socioeconomic development of tribals.
Unit-V
Importance and scope of basic taxonomical studies in biodiversity science and conservation. Identification and nomenclature of plants based on Bentham and Hooker's system of classification. Taxonomic database- perspective and challenges

Suggested readings:

1. The Biodiversity of India, Erach Bharucha, 2002, Mapin Publishing.
2. An Advanced Textbook on Biodiversity. Principles and Practice, K. V. Krishnamurthy, 2018, Oxford and IBH Publishing.
3. Flowering Plants Identification & Aesthetic Characteristics. H.Singh, Shyam Singh and AK Singh. Krishna Prakashan Media Pvt Ltd. Meerut. 2022

M.Sc. ENVIRONMENTAL SCIENCE (SEMESTER - I)
EVS-CC-4: RADIATION, NOISE, INDUSTRIAL AND THERMAL POLLUTION
4 Credits/40 Hours

Course outcomes:

After completion of the course, the student will understand about-

- Radiation pollution, radiation hazards, protection measures, and bioindicators of radionucleotides
- Industrial and Thermal pollution
- Solid waste types, sources, and management of landfill sites through plantation
- Noise pollution, hazardous limits, and the role of plants in the management of noise pollution

Unit–I
Radiation Pollution: sources, biological effects of ionizing radiations, radiation protection and mitigation Radioactive fallouts and protective measures Radiation Pollution Abatement: nuclear waste management, innovative shielding materials, IoT-enabled radiation monitoring, fusion energy safety, radio-pharmaceutical waste handling.
Unit–II
Noise pollution: tolerable and hazardous limits of noise Effects of noise pollution on biotic community and human health Noise Pollution Abatement: advanced soundproofing materials, urban noise mapping with IoT sensors, smart city noise management, industrial noise reduction technologies, vehicle noise control systems, urban planning to reduce noise pollution
Unit–III
Industrial pollution: definition and types of industrial pollutants Source and effects of industrial wastes and its impact on the environment Industrial Pollution Management: advanced emission control technologies, zero-liquid discharge systems, industrial wastewater treatment, ETP, solid waste conversion to energy source
Unit–IV
Thermal pollution: Sources and impact on flora, fauna, and human beings Control measures: advanced cooling technologies, thermal pollution impact assessment, use of artificial wetlands, mitigation in power plants, and aquatic ecosystem restoration Solid waste: Sources, their impact on the environment, Strategies of solid waste disposal, solid waste treatment plant, and management of landfills through the plantation Solid Waste Management: recycling, composting, waste-to-energy, circular economy, Integrated Solid Waste Management (ISWM), and advanced AI-based technologies.
Unit–V
Bio-indicators of environment: Types: Pollution, Ecological, Biodiversity, and noise pollution Phytoaccumulator, Pollution-sensitive plants. Role of plants in the management of Radiation, Thermal, soil, and noise pollution

Suggested readings:

1. Industrial Pollution Prevention, Thomas T. Shen, Springer,1999. Textbook of Noise Pollution and Its Control, S.C. Bhatia, Atlantic Publishers and Distributors Pvt. Ltd, 2007.
2. Environmental Challenges of the 21st Century, Arvind Kumar, APH Publishing Corporation, New Delhi, 2003.
3. Introduction to Environmental Engineering and Science. Gilbert M. Masters Wendell P.Ela, Publisher Pearson Education India.

M.Sc. ENVIRONMENTAL SCIENCE (SEMESTER - I)
EVS-CC-5: PRACTICAL BASED ON EVS-CC-1 TO EVS-CC-4
02Credits

Course outcomes:

After completion of the course, the student will know about-

- Composition, properties, and characteristics of soil.
- Soil profile and mineral types of soil.
- Air pollution and monitoring methods
- Airborne microbes, dust, and pollen allergies.
- Meteorological parameters and application of different apparatus.

- Radiation pollution, radiation hazards, and noise pollution.
- Industrial and Thermal pollution.
- Solid waste types, sources, and management of landfill sites through plantation
- Identification and Taxonomic description of plants of interest.
- Conservation of biodiversity: National Parks, Sanctuaries, Biosphere Reserve etc.

M.Sc. ENVIRONMENTAL SCIENCE (SEMESTER - II)
EVS-CC-6: BIOTIC COMMUNITY AND COMMUNITY DYNAMICS
4 Credits/40 Hours

Course outcome:
After completion of the course, the student will understand-

- The Ecosystem and population ecology
- Community concept and classification
- Concept of ecotone, edge effect, and ecological niche
- Ecological succession, biogeochemical cycles, and animal behavior

Unit-I
Ecosystem: concept, structure, biotic and abiotic components, productivity (gross and net productivity), decomposition (role of detrivores), ecosystem classification (aquatic and terrestrial ecosystem), ecosystem disturbance. Ecosystem function: energy flow, energy flow models, food chains, and food webs. Ecosystem modeling: concept, basic categories of models their architecture, parameter estimation, and sensitivity analysis.

Unit-II
Population characteristics: natality, mortality, fecundity, fertility, density, and dispersion. Population growth curve (logistic and exponential), r and K selection, survivorship curves, the concept of carrying capacity, and population regulation (density-dependent and independent). Life history strategies, the concept of metapopulation, theory of island biogeography, population fluctuation, age-structured population, life table, and Lotka-Volterra model.
Unit-III
Community: concept, characteristics and structure, functional classification, community gradient, and boundaries (ecotone and edge effect). Study of vegetation (quantitative and qualitative life form, Raunkiaer's life form). Bio interaction (positive and negative), levels of species diversity and its measurement, diversity index (Simpsons and Shannon diversity index), and species composition (dominant, keystone, umbrella, flagship, and indicator species).
Unit-IV
Ecological adaptations in plants: hydrophytes, xerophytes, halophytes, psammophytes and lithophytes. Gene ecology (ecomorph, ecades, ecophene, ecotypes). Ecological habitat and niche: niche overlapping, niche types and size, ecological equivalents, competitive exclusion principle (Gause's principle), resource partitioning, and character displacement.
Unit-V
Ecological succession: concept, process, model, and hypothesis (monoclimax, polyclimax, and climax pattern hypothesis). Biogeochemical cycles – nitrogen, carbon, phosphorus, and sulfur. Animal Behavior: Altruism (reciprocal and reproductive altruism), theory of inclusive fitness, Hamilton's rule, kin selection, and mating systems in animals (monogamous and polygamous).

Suggested readings:

1. Environmental Science: S.C. Santra, New Central Book Agency, Pvt. Ltd., 2001.
2. FundamentalsofEcology,3rdedition,P.Odum, Natraj Publications,1971.
3. Plant Ecology and Phytogeography, P.D. Sharma, Rastogi Publications, 2019.
4. Concepts of Ecology and Environment, Ajey Singh, Pragati Publication, 2022.

M.Sc. ENVIRONMENTAL SCIENCE (SEMESTER - II)

EVS-CC-7: WATER RESOURCES: POLLUTION AND MANAGEMENT

4 Credits/40 Hours

Course outcomes:

After completion of the course, the student will understand about-

- Water pollution and groundwater pollution
- Water quality standards and water sampling techniques
- Management of water pollutants, ETP, and its functioning
- Soil pollution and its types and Bioremediation of soil pollution
- Microbial water quality
- Phyto-remediation

Unit-I
Water pollution: Source types (biodegradable and non-degradable), major sources, environmental levels, and effects on plants and animals Management of water pollutants: Industrial, domestic, and agricultural runoff Industrial and domestic wastewater treatment methods, STP, and ETP designs and functions Plastic pollution in water: Global efforts such as the UN treaty on plastic waste
Unit-II

Water uses; Physico-chemical properties of fresh water and marine water resources Water quality standards and water sampling techniques Ocean Acidification: Effects on marine biodiversity, Oil Spills and Heavy Metals: Long-term environmental consequences. Dead Zones and Eutrophication: Causes and restoration strategies.
Unit-III
Physico-chemical and microbiological properties of groundwater Groundwater pollution, major sources, and its impact on biotic communities and human life Groundwater salinity: sources, spread and impact of groundwater salinity on humans and Crops Ghyben-Herzberg relation between fresh-saline water.
Unit–IV
Microbial water quality assessment for identifying waterborne diseases and their health hazards Bioremediation techniques: Phytoremediation and constructed wetlands for the management of Polluted areas Fluoride pollution of groundwater and its management Advanced wastewater treatment, IoT monitoring, nanotechnology, nature-based solutions, biodegradable plastics, zero liquid discharge, water recycling, and addressing emerging contaminants like microplastics and PFAS.
Unit–V
Water management; Wetlands: Natural and constructed wetlands Wetlands distribution and conservation strategies Ramsar sites and convention

Suggested readings:

1. Water Pollution: Causes, Effects and Control, P.K.Goel, New Age International, 2006.
2. A Book Review on Soil Pollution: A Hidden Reality, N. R. Eugenio, M. McLaughlin, D. Pennock (Rome: FAO), 2018.
3. The Nature and Properties of Soils, Nyle C. Brady and Ray R. Weil, Pearson Education Pvt. Ltd., 2002.

M.Sc. ENVIRONMENTAL SCIENCE (SEMESTER - II)
EVS-CC-8: ABIOTIC NATURAL RESOURCES
4 Credits/40 Hours

Course outcome:
After completion of the course, the student will gain the knowledge of -

- Geological distribution of natural and mineral resources
- Knowledge of rocks, metallic and non-metallic mineral deposits
- Water and land management strategies
- Factors affecting soil erosions
- Soil and water conservation strategies

Unit-I
Abiotic natural resources, status, classification, and strategies for sustainable exploitation and development. Geological and geographical distribution of natural resources, Geothermal energy utilization. Resource efficiency technologies and Renewable energy systems.
Unit-II
Mineral types, their distribution and importance, mineral extraction and management. Classification and properties of rocks. Metallic and nonmetallic mineral deposits. Mine waste disposal, related problems, and impact of mining activities on health.
Unit-III
Water management strategies: watershed management, aquifer recharge, sustainable irrigation practices, water-use efficient technologies, climate-resilient water strategies. Rainwater harvesting: conventional and advanced methods, artificial recharge of ground waste water, and biological treatment of wastewater. Recycling of domestic and industrial wastewater, integrated water resource management (IWRM). Water governance and adaptive management approaches to address scarcity and pollution.
Unit-IV
Land Management: land use classification and degraded lands. Soil erosion and factors affecting soil erosion. Sustainable land use planning, restoration ecology, agroecology, carbon sequestration, climate resilience, community-based land stewardship, ecosystem-based adaptation. Legal and policy frameworks for sustainable land development.
Unit-V
Restoration of mined areas. Principles and methodologies for soil conservation and restoration of degraded land and contaminated soils. Economics of non-renewable and renewable resources, the optimal rate of extraction, Hotelling's rule. Economics of forestry, Accounting in the measurement of environmentally corrected GDP, Natural resource accounting (NRA), Concept of natural capital and sustainability.

Suggested readings:

1. Sustainable Water Resources Management: S Chandra and P. Ojha, American Society of Civil Engineers, 2017.
2. Natural Resource Conservation Management for a Sustainable Future: J. P. Reganold, Daniel D. Chiras, 2015.
3. Soil and Water Conservation Research in India: V.V. Dhruva Narayana, ICAR, Pusa, New Delhi, 1993.
4. The Nature and Properties of Soils, Nyle C. Brady and Ray R. Weil Pearson, Education Pvt. Ltd., 2002.

M.Sc. ENVIRONMENTAL SCIENCE (SEMESTER - II)
EVS-CC-9: BIOTIC RESPONSES TO ENVIRONMENTAL STRESSES
4 Credits/40Hours

Course outcome:

After completion of the course, the student will gain the knowledge about:

- Ecological adaptations
- Environmental stress physiology
- Ecological engineering
- Biomes and phytogeography
- Wetlands and their abatement and restoration

Unit–I
Basic concept of cell and cellular adaptations (Morphological changes according to environmental conditions) Ecological adaptations in plants: xerophytes, mesophytes, halophytes, psammophytes, oxalophytes Morphological, physiological, and anatomical features of aquatic and ecologically modified plants
Unit-II
Physiological and molecular responses to environmental stresses: drought, salinity, UV, heat and cold Physiological and molecular responses to environmental stresses: nutrients and pathogens Defense mechanism: Concept of reactive oxygen species, antioxidant enzymes, heat shock proteins
Unit III
Concept of signaling molecules, types of signaling pathways (Endocrine, Autocrine, Paracrine, Juxtacrine) Mechanism of signal transduction, cell surface, and intracellular receptors CGPCR, RTK, MAPK Signaling
Unit IV
Biomes and their types (Forest, grasslands, etc.), Phytogeography: Types and principals of plant distribution Vegetational Zones of India Forest types of India. Wetlands and their conservation.
Unit V
Biogeographical realms Biogeographical distribution of animals: principles and concepts Biogeographical zones of India Wallace's line, Allen's rule, Bergmann's rule, and the modern application of biography Paleobiogeography

Suggested readings:

1. Fundamentals of Ecology, E.P. Odum, Natraj Publications, 3rd edition,1971.
2. Plant Ecology and Phytogeography, P.D. Sharma, Rastogi Publications, 2019. Physiological Responses to Abiotic and Biotic Stress in Forest Trees, Heinz Rennenberg and Andrea Polle (eds.), MDPI books, 2019.
3. Plant Growth and Stress Physiology by Dharmendra K. Gupta and Manuel Piama *Eds,* Publisher Springer,
4. Elucidation of Abiotic Stress Signaling in Plants. Functional Genomics Perspective Vo; 1. Girdhar K Pandey *Eds,* Publisher Springer,

M.Sc. ENVIRONMENTAL SCIENCE (SEMESTER - II)
EVS-CC-10: PRACTICAL BASED ON EVS-CC-6 TO EVS-CC-9
02Credits

Course outcomes:

After completion of the course, the student will know about-

- Characteristics of ecological habitats and types of ecosystems
- Water pollution sources and pollutant types
- Physico-chemical properties of water
- Microbial water quality assessment
- Integrated water resource management
- Wastewater treatment, functioning of ETP and STP
- Morphological and anatomical adaptations of plants in aquatic, xerophytic habitats and at different abiotic stress conditions.

M.Sc. ENVIRONMENTAL SCIENCE (SEMESTER - III)
EVS-CC-11: ENVIRONMENTAL POLICY AND MANAGEMENT
4 Credits/40Hours

Course outcomes:

After completion of the course, the student will understand about-

- Environmental priorities in India, environmental education programs,
- Remote sensing, GIS and eco-auditing
- Environmental disasters, biomedical, and e-waste management
- National efforts for environmental management, National movements

- International Environmental Laws
- Environmental Impact Assessment, Eco-audit
- Biostatistics and various methods of data presentation

Unit–I
Environmental priorities in India, environmental disasters (natural, accidental, man-made environmental disasters) and their effects, management of environmental disasters, management of solid waste, biomedical and e-waste, treatment of domestic and industrial wastewater National movements for the conservation and protection of the environment National efforts for environmental management and environmental planning for sustainable Development Objective and guiding principles of environmental education, public awareness programs and Maintenance of environmental quality
Unit–II
Concept of geographical information system (GIS) Remote Sensing: Sensors and plate forms, image, geometry, scale and resolution, visual, Interpretation and principles of digital image processing Application of remote sensing in environmental pollutant identification and environmental quality management Application of remote sensing in hazard identification for extreme metrological events: wave and tsunami effects, tropical cyclones, landslides and avalanches, forecasting of earthquakes, precipitation, El-Nino, and melting of ice sheets
Unit–III
Emergence of International Environmental Law, fundamental principles, and application of International Environmental Law International environmental protection laws, right to environment and human rights, International Humanitarian law and environment conflict management, international convention and treaties Environmental protection laws in India for pollution control, natural resources, conservation, management, and their enforcement by key national Governmental and Non-Governmental Organizations and agencies
Unit–IV
Concept of Environment Impact Assessment (EIA) Components of EIA and EIA process National and State Environmental Appraisal Committee State environmental assessment authority and their role in environmental clearance of projects Environmental Impact Statement, Environmental Management Plan Eco-audit
Unit–V
Biostatistics and its application, statistical terms, and symbols, samples and sampling, data, and data presentation (tabular, graphical, and diagrammatic); Measures of Central tendency (mean, mode, median); Measures of dispersion: range, mean, deviation, standard deviation, and variance Correlation and regression analysis; t-test, chi-square test, one-way and two-way analysis of variance

Suggested readings:

1. Textbook on Environmental Law, Dr. N. Maheshwara Swamy, Asia Law House, 2013.
2. Handbook of Environmental Laws, Acts, Guidelines, volI, R.K.Trivedi,B.S. Publication, 2018.
3. Remote Sensing and GIS, Basudeb Bhatta, Oxford Publishing, 2nd edition, 2011.
4. Introduction to Environment Impact Assessment (Natural and Built Environment Series) by John. Glasson and Riki Therivel, Publisher- Routledge
5. Environment Impact Assessment Methodologies by AnjaneyuluYerramilli and Valli Manickam, BS Publications.

6. Statistical Procedures for Agricultural Research, K.A. Gomez and A.A. Gomez, John Wiley & Sons, New Delhi, 1976.
7. Experimental Design and Data Analysis for Biologists by Gerry P. Quinn and Michael J. Kleough, Cambridge University Press.
8. Essentials of Statistics by david Brink, David Brink, and Ventus Publishing ApS.

M.Sc. ENVIRONMENTAL SCIENCE (SEMESTER - III)

EVS-CC-12: ENVIRONMENTAL BIOTECHNOLOGY AND AGRICULTURE

4 Credits/40Hours

Course outcome:

After completion of the course, the student will understand about-

- Agricultural practices in India and threats to sustainable agriculture
- Awareness regarding organic farming, slow-release fertilizer, and GM crops
- Tissue culture in agriculture and floriculture
- Bioconversion of agricultural waste, vermicomposting, and biogas generation
- Gene pool protection and greener genetic engineering

Unit–I
Environmental Biotechnology**:** An overview, concept, scope and market Biological control of air pollution. Bacterial examination of water for potability. Testing of water for physiochemical parameters including BOD & COD. Solid waste: Sources and management (composting, vermicomposting, and methane production).
Unit–II
Wastewater: origin, composition and treatment. Physical, chemical, and biological treatment of wastewater Aerobic processes: activated sludge, oxidation ponds, trickling filter towers, and rotating discs, Anaerobic processes: anaerobic digesters, anaerobic filters, and upflow sludge blanket reactors Microbiology and biochemistry of aerobic and anaerobic wastewater treatment processes Treatment of industrial effluents: distillery effluent, paper and pulp mill effluent, tannery effluent, textile dye effluent, removal of heavy metals from wastewater
Unit–III
Bioremediation: Introduction of Bioremediation; advantages and applications; Types of bioremediations, Natural (attenuation), *Ex-situ* and *In-situ*, Bio-augmentation and bio-stimulation, Solid phase and slurry phase bioremediation. Biodegradation: Aerobic vs. anaerobic Degradation; Microbial basis of Biodegradation; Biodegradation of Xenobiotics; Microbial degradation of pesticides Organic farming, Bio-fertilizers, Bio-pesticides, slow-release fertilizers and pesticides
Unit–IV
Biotechnological methods of pollution detection: General bioassays in pollution monitoring, cell biology in environmental monitoring, molecular biology in environmental monitoring, and biosensors in environmental analysis. Intellectual property rights and Patent in environment-related issues
Unit-V
Microbial Insecticides: Bacteria, fungi, and viruses. Use of R-DNA technology to enhance the efficacy of microbial insecticides. Microbes in oil recovery and bioleaching. Biodeterioration of stored plant food materials, leather, wool, metals, textiles, stone & related building. Control of microbial biodeterioration. Major water-borne diseases and air-borne microbes, Valorization

Suggested readings:

1. Hand book of Agriculture, ICAR, Pusa, New Delhi,1961.
2. Biodiversity and Biotechnology, Samit Ray and Arun K. Ray, New Central Book Agency, 2017.
3. Environmental Biotechnology: Fundamentals to Modern Techniques; Sibi G. 2022.
4. Environmental Biotechnology: Principles and Applications; Bruce E. Rittmann, Perry L. McCarty. Tata McGraw Hill. 2001.
5. Environmental Biotechnology: Theory and Application. Gareth M. Evans & Judith M. Furlong. John Wiley and Sons. John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester, West Sussex PO19 8SQ, England. 2003.

M.Sc. ENVIRONMENTAL SCIENCE (SEMESTER -III)

EVS-CC-13: ACADEMIC TOUR

4 Credits

- To provide students with practical exposure to diverse ecosystems, environmental challenges, and conservation practices.
- To enable students to observe and study natural and anthropogenic processes impacting the environment.
- To foster awareness of biodiversity, sustainability, and the role of environmental management in maintaining ecological balance.
- To develop skills for environmental assessment and data collection in the field.
- To encourage interdisciplinary learning through real-world applications of theoretical concepts in environmental science.

M.Sc. ENVIRONMENTAL SCIENCE (SEMESTER -III)

EVS-IN: INTERNSHIP/ FIELD WORK

2 Credits

M.Sc. ENVIRONMENTAL SCIENCE (SEMESTER -IV)

EVS-MT: Master Thesis/ Dissertation

20 Credits

The internship program for M.Sc. Environmental Science at Lucknow University provides practical exposure to real-world environmental challenges like pollution control and resource management. Students develop technical skills such as environmental impact assessment and data analysis, along with teamwork and communication abilities. It enhances industry readiness by familiarizing them with professional standards and regulatory frameworks. Internships also offer networking opportunities with experts, researchers, and policymakers, aiding future career prospects. Many students engage in impactful research or community initiatives, fostering environmental awareness. This experience helps clarify career goals, whether in research, industry, or policy-making. Graduates often secure roles in reputed organizations or pursue higher studies. Overall, the program bridges academic learning with professional application, ensuring well-rounded development.