SYLLABUS

OF

Two Year PG: Master of Science Degree Program with Exit option

IN

ENVIRONMENTAL SCIENCES
SEMESTER (I–IV)

(As per National Education Policy-2020)

DEPARTMENT OF ENVIRONMENTAL SCIENCES
SCHOOL OF BIOLOGICAL SCIENCES

DR. HARISINGH GOUR VISHAWAVIDYALAYA
(A CENTRAL UNIVERSITY)
SAGAR, MADHYA PRADESH
(2023-2025)

Preamble

Environment is defined as the total of all living and non-living things in nature that affect an individual's survival and development. The field of Environmental Science examines the role of human beings in architecting their environment. It provides the framework for researching ways to achieve sustainability. Due to the immense diversity, Environmental Science encompasses a broad scope and employs a multidisciplinary approach.

The Stockholm Conference in 1972 set the global direction for the nations to prioritize environmental protection and preservation. India, recognizing its international commitment made significant amendments to its Constitution, by introducing Article 48A and 51A(g) to address environmental responsibilities and duties. In subsequent years, environmental concerns escalated as pollution levels increased in cities and water bodies, forests and land suffered degradation. It is now evident that interventions are crucial to understand the environmental impacts of pollution, biodiversity loss, climate change, and their effects on hydrological systems, agriculture, livelihoods, and the economy. Therefore, Environmental Science education has become an imperative tool to mitigate these problems at regional and global levels.

The M.Sc. in Environmental Sciences program aims to meet the demand for scientific professionals capable of addressing environmental issues at local, regional, and global scales. The curriculum embraces a multidisciplinary approach, placing research and learning at its core throughout the program.

[A] Department Vision

To conduct cutting-edge research and innovative teaching to nurture environmental leaders who can tackle pressing environmental challenges. We envision a future where our students, armed with multidisciplinary knowledge and passion for sustainability, drive meaningful change and shape a more environmentally conscious world.

1. Department Mission Statements:

- Provide high quality scientific expertise in Environmental Science to meet ongoing challenges related to climate change, resource depletion, environmental pollution, biodiversity loss, and energy - water crisis.

- Build essential skills for future environmental leaders to develop sustainable solutions for pressing environmental, societal, and climatic issues through environmental engineering, modelling, innovative resource management methods, and conservation strategies.

- Create environmental educators and researchers who can effectively communicate scientific knowledge on current and future environmental change and crises to both specialists and the world.

2. Program Educational Objectives (PEOs):

- To create awareness and innovation to deal with environmental issues.
- To create awareness and knowledge about sustainability.
- To produce confident, technical, creative, and employable postgraduates.

[B] Background of Syllabus

1. Introduction

The multidisciplinary nature of Environmental Science demands an approach that bridges the gap between pure sciences, engineering, and humanities. Therefore, it is essential to set clear expectations for Environmental Science postgraduates' achievements. Accordingly, the curriculum was developed with a learning outcome-based approach (LOBA).

The curriculum comprehensively addresses the broad scope of Environmental Science in line with the Choice-Based Credit System (CBCS) for M.Sc. in Environmental Sciences, aligned with the National Education Policy – 2020. The primary goal is to provide students with a holistic understanding of the subject, emphasizing core content, skills, values, and enhanced abilities.

The syllabus prioritizes the key aspects of environmental knowledge by recognizing its vast

spectrum. It aims to equip students with in-depth knowledge and enhance their employability across various sectors. Special attention is given to emerging techniques and a contemporary understanding of the subject within the evolving global context.

2. Flexibility

- The program is flexible enough to allow the students to prepare themselves according to their requirements.
- Students will have an exit option at the end of First Year with PG Diploma.

3. Qualification descriptors for the graduates

- The qualification descriptors like Discipline knowledge, Skills, Technical hand, Competence, and communication shall be the basis of scientific theories and principles, critical thinking, and decision making.
- The major expected learning outcomes of the M.Sc. program in Environmental Sciences shall include the following:

(a) Knowledge & Understanding:

- ✓ *Demonstrate* extensive and systematic knowledge of Environmental Science.
- ✓ *Insightfully* address the contemporary questions pertaining to the environment of both national and global importance.
- ✓ *Engage* in the field of Environmental Sciences and its allied areas.

(b) Skills &Techniques:

- ✓ *Show* the ability to apply the knowledge in a critical and organized manner for the evaluation and elucidation of complex environmental problems e.g., issues related to ecosystems, air, water, and soil pollution, human health hazards, biodiversity loss, food security and agricultural issues.
- ✓ *Demonstrate* the ability to identify the role of Environmental Science in formulating sustainable solutions to environmental problems.
- ✓ *Demonstrate* the ability to design and develop eco-friendly products and processes towards accomplishment of the sustainable development goals.
- ✓ *Exhibit* efficiency to model, simulate, and assess environmental conditions based on the available data.

(c) Competence:

- ✓ *Communicate* effectively.
- ✓ *Ability* to work as a team and contribute towards effective planning, management, and implementations of projects/programs.
- ✓ *Exhibit* ability to think and execute independent research projects/programs, evaluate the outcomes, and make a conclusive and comprehensive report.
- ✓ *Capability* to identify his or her strengths and limitations and develop a lifelong learning attitude.

4. Graduate Attributes

Graduate Attributes (GAs) are independently measurable outcomes that signify the capabilities of the graduates given as below:

- **GA1.** Erudition of acquaintance: In-depth knowledge and understanding of the discipline or professional area across the boundaries of nations with an aptitude to identify, access, analyze and synthesize existing and new knowledge, and integrate them accordingly.
- **GA2.** Analytical Thinking: Critically address multifaceted scientific problems and make decisions for synchronizing information to formulate innovative and intellectual advances.
- **GA3.** Problem Solving: Address and solve scientific visa-vis environmental problems with rational and original thinking considering public health, cultural, and societal factors.
- **GA4**.Application of modern tools: understanding and hands-on acquaintance of modern tools in environmental analysis and experimentation.
- **GA5.** Multidisciplinary competence: Accumulate interdisciplinary knowledge and explore new areas of knowledge acquisition.
- **GA6**.Communication skill: Communicate scientific/technological knowhow and new learning to the scientific community and the society at large with strong conviction and confidence so that humanity benefits from the knowledge and technological development.
- **GA7**. Life-long Learning: Possess the ability to prepare and engage in the life-long learning process and show ability to transfer the acquired skills.
- **GA8**. Ethical values and Social Responsibility: Strong academic integrity, professional code of conduct, ethical values, and sense of responsibility towards societal needs and sustainability.
- **GA9.** Futuristic attitude: Ability to recognize and address current environmental scenarios, scientific and technological progress, lifestyle change, and biophysical evolutions with a futuristic view. Commitment towards sustainable developmental goals in terms of economic welfare, social equity and proactive long-term environment management.

[C] Programme Learning Outcomes (POs)

- The program has been designed in such a way that the students acquire strong theoretical and practical knowledge in various domains of Environmental Sciences.

- The program includes detailed information on Ecology and Environment, Resource Management, Environmental Pollution, Environmental Biology, Environmental Impact Assessment, Environmental Chemistry, Environmental Geosciences, Climate Change, Water and Wastewater Treatment, Remote Sensing Application, Solid and Hazardous Waste Management, Instrumentation and Biostatistics, Environmental Toxicology, Energy and Environment, etc.

- All the domains are supported with more comprehensive study along with deep knowledge on the subject as it is an urgent requirement of society to develop a better future through formal means.

- The practical courses have been designed to equip the students with laboratory skills in environmental monitoring and assessment in the areas of air, water and soil.

- The students will be able to design and conduct experiments, as well as analyze and interpret data in a meaningful form.

- The program will offer students the knowledge and skills that would enable them to undertake advanced studies in Environmental Sciences and related areas that involve the assessment of Natural Resources and Environmental Pollution and Management.

- The students will get exposure to a wide range of careers that combine Environmental Management and Impact Assessment, Remote Sensing, Hazardous Waste Management, Industrial Safety, Biodiversity and Wildlife Conservation.

- The students will gain domain knowledge and know-how for a successful career in academia, industry, research and consultancy.

- Further, students will learn values for lifelong learning to meet the ever-evolving professional demands by developing ethical, interpersonal and team skills.

- Students will acquire the sense of responsibility to safeguard the environment as a constitutional duty.

[D] Eligibility

B.Sc. degree or equivalent in any branch of basic or applied science under 10+2+3 or 10+2+4 pattern of education or B.E./B.tech. /MBBS with a minimum of 50% marks or an equivalent GPA (also with a minimum of 50% aggregate or an equivalent GPA at the 10th and 10+2 levels) will be deemed eligible for admission to the M.Sc. program in Environmental Sciences.

Total student intake : 15

Duration : 2 Years (4 Semester) full-time program (with an exit option at the end of one year)

Tuition fee : **21,305/- INR (**as approved by the 22nd meeting of Finance Committee, dated: July 27, 2023: Agenda FC:22:23:8).

Structure of the program

a) Number of Discipline Specific Major Courses **: 08**

b) Number of Multidisciplinary Major Courses **: 06**

c) Number of Skill Enhancement Courses **: 03**

Scheme of the examination

a) Mid Semester – I Examination **: 20 Marks**

b) Mid Semester – II - Internal Assessment **: 20 Marks**

c) End Semester Examination **: 60 Marks**

COURSE STRUCTURE

Academic Year: 2023-2025

Diploma and Post Graduate Degree at the end of each year of exit respectively, of the Two-year Postgraduate Programme

S. No.	Exit Options	Credits Required
1	P.G. Diploma upon the successful completion of First year (Two Semesters) of the Two-year Master's Degree Programme	47
2	Master's Degree: At the successful completion of the Second Year (Four Semesters) of the Two-year Master's Degree Programme	88

Semester-I							
S. No.	**Nature of the Course**	**Course Code**	**Course Title**	**Credits**			
				L	**T**	**P**	**C**
1	Discipline Specific Major-1	ENV-DSM-121	Fundamentals of Environmental Sciences (T)	3	1	0	**4**
2	Discipline Specific Major-1	ENV-DSM-122	Fundamentals of Environmental Sciences (P)	0	0	4	**2**
3	Discipline Specific Major-2	ENV-DSM-123	Environmental Chemistry and Toxicology (T)	3	1	0	**4**
4	Discipline Specific Major-2	ENV-DSM-124	Environmental Chemistry and Toxicology (P)	0	0	4	**2**
5	Multidisciplinary Major - 3	ENV-MDM-121	Environmental Biology (T)	3	0	0	**3**
6	Multidisciplinary Major - 3	ENV-MDM-122	Environmental Biology (P)	0	0	4	**2**
7	Multidisciplinary Major - 4	ENV-MDM-123	Environmental Geosciences and Oceanography (T)	3	0	0	**3**
8	Skill Enhancement Course-5	ENV-SEC-121	Statistical Methods and Data Analysis (T)	2	1	0	**3**
			Total				**23**
Semester-II							
S. No.	**Nature of the Course**	**Course Code**	**Course Title**	**Credits**			
				L	**T**	**P**	**C**
1	Discipline Specific Major-1	ENV-DSM-221	Water and Wastewater Treatment (T)	3	1	0	**4**
2	Discipline Specific Major-1	ENV-DSM-222	Water and Wastewater Treatment (P)	0	0	4	**2**
3	Discipline Specific Major-2	ENV-DSM-223	Air Pollution and Control Techniques (T)	3	1	0	**4**
4	Discipline Specific Major-2	ENV-DSM-224	Air Pollution and Control Techniques (P)	0	0	4	**2**
5	Multidisciplinary Major - 3	ENV-MDM-221	Remote Sensing and GIS (T)	3	0	0	**3**
6	Multidisciplinary Major - 3	ENV-MDM-222	Remote Sensing and GIS (P)	0	0	4	**2**
7	Multidisciplinary Major - 4	ENV-MDM-223	Natural Resource Management (T)	3	0	0	**3**
8	Skill Enhancement Course-5	ENV-SEC-221	Analytical Instrumentation (T)	3	0	0	**3**
9	Study Tour	ENV-SEC-222	Study Tour	0	1	0	**1**
			Total				**24**
Exit option with P.G. Diploma upon the successful completion of first year (Two Semesters) of the Two year Master's Degree Program							

Semester-III							
S. No.	**Nature of the Course**	**Course Code**	**Course Title**	**Credits**			
				L	**T**	**P**	**C**
1	Discipline Specific Major-1	ENV-DSM-321	Solid Waste Management (T)	3	1	0	**4**
2	Discipline Specific Major-1	ENV-DSM-322	Solid Waste Management (P)	0	0	4	**2**
3	Discipline Specific Major-2	ENV-DSM-323	Energy and Environment (T)	3	1	0	**4**
4	Discipline Specific Major-2	ENV-DSM-324	Energy and Environment (P)	0	0	4	**2**
5	Multidisciplinary Major - 3	ENV-MDM-321	Atmospheric Sciences and Climate Change (T)	3	0	0	**3**
6	Multidisciplinary Major - 3	ENV-MDM-322	Atmospheric Sciences and Climate Change (P)	0	0	4	**2**
7	Multidisciplinary Major - 4	ENV-MDM-323	Environmental Economics and Sustainable Development (T)	3	0	0	**3**
8	Skill Enhancement Course-5	ENV-SEC-321	Disaster Management and Risk Analysis (T)	3	0	0	**3**
			Total				**23**
Semester-IV							
S. No.	**Nature of the Course**	**Course Code**	**Course Title**	**Credits**			
				L	**T**	**P**	**C**
1	Discipline Specific Major-1	ENV-DSM-421	Environmental Assessment, Management and Legislation (T)	3	0	0	**3**
2	Discipline Specific Major-2	ENV-DSM-422	Dissertation	0	0	15	**15**
			Total				**18**

Semester I

Department of Environmental Sciences						
Class	**Subject**	**Sem.**	**Course Code**	**Course Title**	**Marks**	**Credits**
M.Sc.	**Environmental Sciences**	**I**	**ENV-DSM-121**	**Fundamentals of Environmental Sciences (Theory)**	**Mid Sem.-40** **End Sem.-60**	**3-1-0=4**

Course objectives:

- To introduce the basics of environmental sciences, structure and function of different compartments of the environment.
- To develop scientific perspective on emerging national and global environmental issues.
- To develop insights into the role of environmental agencies, laws, treaties and conventions for the protection and conservation of environment.

Unit 1 **12 hours**

Basic Introduction: Definition, Principles and Scope of Environmental Science; Structure and composition of atmosphere, hydrosphere, lithosphere and biosphere; Interaction between Earth, Man and Environment; Biogeographic provinces of the world and agro-climatic zones of India.

Unit 2 **12 hours**

Environmental Factors: Physico-chemical and biological properties of environment: sunlight, air, water, soil, temperature, pressure, humidity, climate, inorganic and organic components, microbes in air, water and soil, flora and fauna; Biogeochemical cycles: hydrological cycles, carbon cycle, oxygen cycle, nitrogen cycle, sulfur cycle, phosphorus cycle.

Unit 3 **12 hours**

Contemporary Environmental Issues: Overpopulation; Natural resource exploitation; Pollution; Global warming; Climate change; Ozone layer depletion; Acid rain; Deforestation and Desertification; Soil erosion and degradation; Biodiversity loss.

Unit 4 **12 hours**

Social Perspectives of Environment: Social impacts of growing human population and affluence, poverty, Food and water insecurity, consumerism and waste production; Problems related to major developmental projects, resettlement and rehabilitation; Sustainable development; Environmental movements in India: Bishnoi Movement, Chipko Movement, Silent Valley Movement, Appiko Movement, Narmada Bachao Andolan and Tehri Dam Conflict.

Unit 5 **12 hours**

Environmental Protection: Government programmes for the protection and enrichment of Environment: National Action Plan on Climate Change, National River conservation plan: Namami Gange, Yamuna Action Plan and river interlinking; National Forest Policy, 1988, National Water Policy, 2002, National Environmental Policy, 2006. International environmental treaties and conventions; Role of international and national environmental agencies; Environmental education and awareness; Environmental ethics.

Course outcome: At the completion of this course the students will be able to:

- Understand the basics of environmental sciences, its structure and function.
- Understand various environmental issues and its impacts on humans and society.
- Understand the role of environmental agencies, laws, treaties and conventions for the protection and conservation of environment.

Essential readings:

1. Singh J.S., Singh S.P. and Gupta S.R. (2017) Ecology, environmental Science & Conservation, S. Chand Publications.
2. De A.K. (2006) Environment Chemistry, New Age International Pvt Ltd Publishers.
3. Santra S.C. (2011) Environmental Science, New Central Book Agencies, Pvt., Ltd. Kolkata.
4. Peavy H.S., Rowe D.R. and Tchobanoglous G. (1985) Environmental Engineering. McGraw-Hill Book Company, Singapore.

5. Sharma B.K. and Kaur H. (2016). Environmental Chemistry, Pragati Prakashan Meerut.
6. Cunningham W. and Cunningham M.A. (2010) Principles of Environmental Science, McGraw-Hill Higher Education.
7. Pickering K.T. and Owen L.A. (2006) An introduction to global environmental issues, 2nd Edition, Taylor & Francis.

Suggested readings:

1. Mallick K. (2021) Environmental Movements in India, Amsterdam University Press.
2. Kumar A. and Karthikeyan S (2015) Environmental Policies in India, Gyan Publishing House.
3. Singh J. and Pandey G. (2005) Natural Resource Management and Conservation, Kalyani Publishers.
4. Rana S.V.S. (2005) Essentials of Ecology and Environmental Sciences, Prentice Hall of India, New Delhi

Department of Environmental Sciences						
Class	**Subject**	**Sem.**	**Course Code**	**Course Title**	**Marks**	**Credits**
M.Sc.	**Environmental Sciences**	**I**	**ENV-DSM-122**	**Fundamentals of Environmental Sciences (Practical)**	**Mid Sem- 40 End Sem- 60**	**0-0-4=2**

Practical:

1. Identify geographical features in survey of India topographic sheets.
2. Visit nearby regions of university to observe and analyze the distribution, availability, and usage patterns of different natural resources.
3. Assess signs of resource degradation such as soil erosion, water pollution and habitat destruction in the nearby regions of the University.
4. Conduct biodiversity assessment in the forested area of university and identify flora and fauna.
5. Measurement of photo density flux by Luxmeter
6. Determine the temperature and relative humidity of air by thermo-hygrometer.
7. Analyze physical characteristics of the water samples collected from different locations of university.

Essential readings:

1. Singh J.S., Singh S.P. and Gupta S.R. (2017) Ecology, environmental Science & Conservation, S. Chand Publications.
2. Rana S.V.S. (2005) Essentials of Ecology and Environmental Sciences, Prentice Hall of India, New Delhi
3. Cunningham W. and Cunningham M.A. (2010) Principles of Environmental Science, McGraw-Hill Higher Education.
4. Pickering K.T. and Owen L. A. (2006) An introduction to global environmental issues, 2nd Edition, Taylor & Francis.

Suggested readings:

1. Mallick K. (2021) Environmental Movements in India, Amsterdam University Press.
2. Kumar A. and Karthikeyan, S (2015) Environmental Policies in India, Gyan Publishing House.
3. Singh J. and Pandey G. (2005) Natural Resource Management and Conservation, Kalyani Publishers.

Department of Environmental Sciences						
Class	**Subject**	**Sem.**	**Course Code**	**Course Title**	**Marks**	**Credits**
M.Sc.	**Environmental Sciences**	**I**	**ENV-DSM-123**	**Environmental Chemistry and Toxicology (Theory)**	**Mid Sem. -40 End Sem. -60**	**3-1-0 = 4**

Course objectives:

- Understand the role of chemistry in environmental science.
- Provide fundamental knowledge on the fate of pollutants in different spheres of the environment.
- Introduce the basic concepts, approaches and principles of toxicology.
- Explain the mechanisms of action of environmental toxicants in causing a toxic response in living organisms.

Unit 1 **10 hours**

Fundamentals of Environmental Chemistry: Definition and Scope, Concept of Molarity, Molality, Normality, Percent and ppm (mg/l) solutions; Stoichiometry, Gibbs energy, Chemical potential, Chemical kinetics and equilibria; Solubility of gases in water; Radionuclides.

Unit 2 **12 hours**

Atmospheric Chemistry: Particles, ions and radicals in the atmosphere; Chemical speciation; Primary and secondary pollutants; Formation of particulate matter; Photochemical reactions in the atmosphere; Dioxins; Furans and Global warming.

Unit 3 **14 hours**

Hydro- and Soil Chemistry: Water: Acid-base equilibria; Buffer solution; Carbonate system, Complexation, Precipitation, Redox reactions; Inorganic and organic contaminants in water.
Soil: Soil pH, Texture, Structure, Water-holding capacity, Bulk density, Cation exchange capacity, Exchangeable bases; Soil organic matter; Micro and macro nutrients in the soil.

Unit 4 **12 hours**

Basics of Toxicology: Definition and scope; Toxicological aspects of Arsenic, Cadmium, Lead, Mercury, Carbon monoxide, Ozone, Peroxyacetyl nitrate, Pesticides and Carcinogens in air, water and soil; Acute and chronic toxicity; Dose synergism and antagonism; Dose response curves.

Unit 5 **12 hours**

Toxicity testing and Kinetics
Definition, Purpose, Criteria for selection of test organism; Methodologies, Estimation of LC_{50} Consensus toxicity factors; Absorption - Routes of toxicants exposure: Gastro-intestinal tract, Respiratory tract, Dermal; Biotransformation: Phase-I and Phase-II reactions; Excretion: Urinary, Faecal, Respiratory and Other routes.

Course outcomes: At the end of the course, the students will be able to:

- Understand the sources, nature, and effects of various environmental pollutants.
- Students will get a clear idea regarding the effects of toxicants and understand the discipline's relevancy to real world issues.

Essential readings:

1. Sharma B.K., and Kaur H. (2016). Environmental Chemistry, Pragati Prakashan Meerut.
2. De A.K. (2016), Environmental Chemistry, New Age International (P) Ltd.

3. Manahan E.S. (2022). Environmental Chemistry, CRC Press.
4. Wild A. (1993). Soils and the Environment. Cambridge University Press, Cambridge.
5. Subramanium M.A. (2010). Toxicological Principals and Methods. MJP Publishers, India.
6. Dayal P.G., (2010). Environmental Toxicology in 3 Volumes. Dominant Publishers & Distributors, India.
7. Klaassen C.D., and Watkins, J.B. (2003). Essentials of Toxicology, McGraw Hill Professional, New Delhi.

Suggested readings:

1. Alloway B.J., and Ayres D.C. (1997). Chemical Principles of Environmental Pollution. Blackie Academic and Professional, London.
2. Hemond H.F., and Fechner E. (1994). Chemical Fate and Transport in the Environment. Academic Press, San Diego.
3. Karikalan V.L. (2002). Environmental Engineering. Dhanpati Rai & Co. Pvt. Ltd. Delhi.
4. Rowell D.L. (1994). Soil Science: Methods and Applications. Longman Harlow.
5. Sawyer C.N. McCarty P.L. and Parkin G.F. (1994). Chemistry for Environmental Engineering. McGraw Hill Inc., New York.

Department of Environmental Sciences						
Class	**Subject**	**Sem.**	**Course Code**	**Course Title**	**Marks**	**Credits**
M.Sc.	**Environmental Sciences**	**I**	**ENV-DSM-124**	**Environmental Chemistry and Toxicology (Practical)**	**Mid Sem- 40 End Sem- 60**	**0-0-4=2**

Practical:

1. Preparation of laboratory solutions.
2. Analysis of relative humidity in air.
3. Analysis of hardness in water sample.
4. Analysis of turbidity in water sample.
5. Analysis of soil texture.
6. Analysis of water holding capacity in the soil.
7. Analysis of soil pH.

Essential readings:

1. Standard Methods for the Examination of Water and Waste Water, (24th Ed.), APHA, (2005) Washington, D.C.
2. Sharma B.K., and Kaur H. (2016). Environmental Chemistry, Pragati Prakashan Meerut.
3. De A.K. (2016). Environmental Chemistry, New Age International (P) Ltd.
4. Subramanium M.A. (2010). Toxicological Principals and Methods. MJP Publishers, India.
5. Dayal P.G. (2010). Environmental Toxicology in 3 Volumes. Dominant Publishers & Distributors, India.
6. Klaassen C.D., and Watkins, J.B. (2003). Essentials of Toxicology, McGraw Hill Professional, New Delhi.

Suggested readings:

1. Hemond H.F., and Fechner E. (1994). Chemical Fate and Transport in the Environment. Academic Press, San Diego.
2. Rowell D.L. (1994). Soil Science: Methods and Applications. Longman Harlow.
3. Sawyer C.N., McCarty P.L., and Parkin G.F. (1994). Chemistry for Environmental Engineering. McGraw Hill Inc., New York.
4. Dwigh E.D. (2010). Toxicology: A Manual for Students and Practitioners. Gale, Making Modern Laws, Philadelphia; New York.

Department of Environmental Sciences						
Class	**Subject**	**Sem.**	**Course Code**	**Course Title**	**Marks**	**Credits**
M.Sc.	**Environmental Sciences**	**I**	**ENV-MDM-121**	**Environmental Biology (Theory)**	**Mid Sem - 40 End Sem - 60**	**3-0-0=3**

Course objectives:

- Understand the fundamental principles of ecology as an interdisciplinary science.
- Explain the structure and functions of ecosystems, including energy flow, food chains, and biogeochemical cycles.
- Discuss the concept of biodiversity, its importance, threats, and conservation strategies.
- Explore the principles of environmental biotechnology and its applications in environmental remediation.

Unit 1 **9 hours**

Fundamentals of Ecology: Ecology as an inter-disciplinary science; Origin of life and speciation; Human Ecology and Settlement; Ecosystem Structure - Biotic and Abiotic components; Ecosystem Functions - Energy flow in ecosystems, energy flow models, food chains and food webs; Ecological succession; Species diversity, Concept of ecotone, edge effects, ecological habitats and niche. Ecosystem stability and factors affecting stability. Ecosystem services.

Unit 2 **9 hours**

Ecosystems and Biomes: Basis of Ecosystem classification; Types of Ecosystems: Desert (hot and cold), forest, rangeland, wetlands, lotic, lentic, estuarine (mangrove); Oceanic. Biomes: Concept, classification and distribution; Characteristics of different biomes: Tundra, Taiga, Grassland, Deciduous Forest biome, Highland Icy Alpine Biome, Chapparal, Savanna, Tropical Rain Forest.

Unit 3 **9 hours**

Population and Community ecology: Characteristics of population, concept of carrying capacity, population growth and regulations; Population fluctuations, dispersion and metapopulation; Concept of 'r' and 'k' species; Keystone species; Community ecology: Definition, community concept, types, and interaction - predation, herbivory, parasitism, and allelopathy; Biological invasions.

Unit 4 **9 hours**

Biodiversity and its conservation: Definition, types, importance of biodiversity and threats to biodiversity; Concept and basis of identification of 'Hotspots'; hotspots in India; Measures of biodiversity; Strategies for biodiversity conservation: in situ, ex situ and in vitro conservation; National parks, Sanctuaries, Protected areas and Sacred groves in India; Concepts of gene pool, biopiracy and bioprospecting; Concept of restoration ecology. Extinct, Rare, Endangered and Threatened flora and fauna of India.

Unit 5 **9 hours**

Environmental Biotechnology: Bioremediation – definition, types and role of plants and microbes for in situ and ex situ remediation; Bioindicators, Biofertilizers, Biofuels and Biosensors, Biopesticides, Bio-polymers.

Course outcome: At the completion of this course the students will be able to:

- Understand the interdisciplinary nature of environmental biology.
- Explain key ecological concepts and their practical relevance.
- Discuss the importance of biodiversity conservation.
- Understand the principles of environmental biotechnology and its applications.

Essential readings:

1. Singh, J. S., Singh, S. P., & Gupta, S. R. (2014). *Ecology, environmental science & conservation*. S. Chand Publishing.
2. Odum, E. P. (2017). Fundamentals of Ecology, Cengage India Private Limited; 5th edition (15 November 2017).
3. Krishnamurthy, K. V. (2018). An Advanced Textbook on Biodiversity: Principles and Practice. India: CBS Publishers & Distributors.
4. Thakur, I.S. (2011). Environmental Biotechnology: Basic Concepts and Applications, 2nd Edition, I.K. International, New Delhi

Suggested readings:

1. Pimm, S. L. (2014). The World According to Pimm: A Scientist Audits the Earth. McGraw-Hill Education.
2. Levin, S. A. (1999). Fragile Dominion: Complexity and the Commons. Perseus Books.
3. Bhattacharyya B.C., and Banerjee R. (2007). Environmental biotechnology, Oxford University Press.

Department of Environmental Sciences						
Class	**Subject**	**Sem.**	**Course Code**	**Course Title**	**Marks**	**Credits**
M.Sc.	**Environmental Sciences**	**I**	**ENV-MDM-122**	**Environmental Biology (Practical)**	**Mid Sem.-40** **End Sem.-60**	**0-0-4=2**

Practical:

1. Conduct quadrat sampling to assess plant species composition, density, and diversity in different habitats.
2. Record temperature, humidity, and light levels at multiple locations to understand microclimate variations.
3. Create transects across microclimate gradients to understand how vegetation responds to environmental variation.
4. Compare the vegetation structure and diversity in areas with and without invasive species.
5. Identifying common insect pollinators and their floral preferences.
6. Investigate seedling growth under different light conditions.
7. Leaf litter decomposition experiment to understand nutrient cycling.
8. Collect ecological data during fieldwork and use statistical software for data handling and analysis.
9. Demonstrating rhizosphere effect.
10. Development of compost from organic Waste.

Essential readings:

1. Quinn, G. P., Keough, M. J. (n.d.). Experimental Design and Data Analysis for Biologists. United Kingdom: Cambridge University Press.
2. Magurran, A. E. (2013). Measuring Biological Diversity. Germany: Wiley.

Suggested readings:

1. Bhattacharyya B.C., and Banerjee R. (2007) Environmental biotechnology, Oxford University Press.

Department of Environmental Sciences						
Class	**Subject**	**Sem.**	**Course Code**	**Course Title**	**Marks**	**Credits**
M.Sc.	**Environmental Sciences**	**I**	**ENV-MDM-123**	**Environmental Geosciences and Oceanography (Theory)**	**Mid Sem. –40 End Sem. –60**	**3-0-0 = 3**

Course objectives:

- To give an overview of earth system science and interrelationships with the ocean.
- To demonstrate systematic, extensive, and coherent knowledge of earth structure, its processes, and evolution.
- To impart knowledge about the principles of ocean science, composition, and sea water properties.
- To discuss the ocean currents, air-sea interface, atmospheric winds, coastal landforms, life complexity and marine resources.

Unit 1 **9 hours**

Introduction to Earth Processes: Origin of planets system, Earth as an evolving planet, Geological time scale, Primary differentiation and Multi-layered structure of earth, Magma, Plate tectonics theory, Sea floor spreading, Mountain building

Unit 2 **9 hours**

Earth's Materials: Minerals: atomic structure, physico-chemical properties of minerals; Rock: Igneous, Sedimentary, Metamorphic; Characteristics, classification and composition of different rocks, Rock cycle, Metamorphism, Rock deformation

Unit 3 **9 hours**

Weathering and Surface Processes: Weathering and Erosion; Mass wasting: classification, catastrophic mass movements; Landforms related to aeolian, fluvial and glacial processes.

Unit 4 **9 hours**

Basics of Oceanography: Origin and geography of ocean, Early exploration of seas, Ocean basin, Ocean floor topography, Sediments; Seawater: physical, chemical and biological properties

Unit 5 **9 hours**

Ocean circulation and Coastal landforms: Air-Sea interaction, Ocean currents and gyres, Ekman transport, Thermohaline circulation El Niño Southern Oscillation, Tides, Coast: classification, coastal landforms and processes, Life in the ocean

Course outcomes:

- Acquaint with holistic understanding of planet earth's dynamic processes and linkage with ocean science.
- Ability to recognize the origin of earth, structure, physio-chemical characteristics, tectonic and geological processes.
- Become familiar with the importance of oceanography, theory of plate tectonics and its relationship to the formation of major features of seafloor.
- Understanding of ocean circulation, wave generation, coastal processes, marine life and consequences due to climate change on the oceans.

Essential readings:

1. Singh S. (2017) Physical Geography, Allahabad, Prayag Pustak Bhavan.
2. John G., Thomas H. J, Press F, and Siever R. (2006). Understanding Earth, 5th Ed. W. H. Freeman.
3. Siddhartha K. (2014) Oceanography: A Brief Introduction, New Delhi, Kisalaya Publications Pvt. Ltd.
4. Kale V. S. and Gupta A. (2012) Introduction to Geomorphology, Orient Longman, Bangalore.

5. Thompson D. M. and Haase D. G. (2007) Processes That Shape the Earth. Chelsea House Publications.
6. Robert H. S. (2009) Introduction to physical oceanography. Orange Grove Texts Plus

Suggested readings:

1. Don L. A. (1989) Theory of the Earth. Blackwell Scientific Publications.
2. Garrison T.S, and Ellis R. (2016) Essentials of Oceanography, 8th Edition, Cengage Learning.
3. Daniel B. B, and Edward A. K. (2010) Environmental Science: Earth as a Living Planet. 8th Edition Wiley, John & Sons.
4. Bridge J. and Demicco R. (2008) Earth Surface Processes, Landforms and Sediment Deposits. Cambridge University Press
5. Sc. D. William and S. Von Arx (1974) Introduction to physical oceanography. Addison-Wesley Publishing Company

Department of Environmental Sciences						
Class	**Subject**	**Sem.**	**Course Code**	**Course Title**	**Marks**	**Credits**
M.Sc.	**Environmental Sciences**	**I**	**ENV-SEC-121**	**Statistical Methods and Data Analysis (Theory)**	**Mid Sem. -40 End Sem. - 60**	**2-1-0 = 3**

Course objectives:

- To introduce the fundamental concept of statistics and its importance in the field of environmental sciences.
- To provide adequate knowledge of data collection, organization, presentation, and their interpretation.
- To learn descriptive statistics, sampling, hypothesis, and probability distribution.
- To learn scientific view about significant use of parametric and non-parametric statistical tests.

Unit 1 **9 hours**

Variables and Graphs: Population and Sample, Variables: Discrete and Continuous; Data: Classification, Collection and tabulation of data, Frequency distribution; Graphical representation: Line chart, Pie chart, Bar chart, Box and Whiskers plot

Unit 2 **9 hours**

Descriptive statistics: Measures of central tendency: Mean, Median, Mode; Dispersion: Range, Interquartile range, Standard deviation, Variance, Skewness, Kurtosis, and Moments

Unit 3 **9 hours**

Sampling theory, Hypothesis Testing and Probability distribution: Elementary sampling theory, Estimation, Testing hypotheses: Confidence interval, t-test, $\chi 2$ test, F-test, ANOVA test; Probability distributions: Binomial, Normal, and Poisson

Unit 4 **9 hours**

Regression and Correlation analysis: Regression line, Regression coefficient, Standard error of estimate, Regression fit, Types of correlation, Coefficient of determination

Unit 5 **9 hours**

Statistical software's and Data analysis: Excel, SPSS, Multivariate statistical analysis: Factor analysis, Cluster analysis, Man- Whitney U test, Kruskal-Wallis test

Course outcomes:

- Get familiar with organizing, presenting, and interpreting complex datasets in simplified manner.
- Understand the basic principles of sampling design and hypotheses testing.
- Ability to perform vital statistical estimation, finding relationships and appropriate statistical tests among target variables.
- Able to compute probabilities and different forms of probability distribution for data analysis.

Essential readings:

1. Gupta S. C. (2019). Fundamentals of Statistics, Himalayan publication.
2. Gupta, S.C., and Kapoor, V.K. (2000). Fundamentals of Mathematical Statistics, S Chand and Sons.
3. Bailey N. T. J. (1995). Statistical Methods in Biology, Cambridge University Press.
4. Wayne R.O. (2018). Environmental Statistics and Data Analysis, CRC Press.

Suggested readings:

1. Mohanty P. K. and Patel S. K. (2015) Basic statistics, Scientific Publishers, New Delhi.
2. Sokal R. R. and Rohlf J. F. (2009) Introduction to Biostatistics, Dover Publications, Inc, NY.
3. Sheldon M. R. (2017) Introductory to Statistics, Academic Press, Elsevier.

Semester II

Department of Environmental Sciences						
Class	**Subject**	**Sem.**	**Course Code**	**Course Title**	**Marks**	**Credits**
M.Sc.	**Environmental Sciences**	**II**	**ENV-DSM-221**	**Water and Wastewater Treatment (Theory)**	**Mid Sem. – 40 End Sem. – 60**	**3-1-0= 4**

Course objectives:

- Gain knowledge on sources of water, importance of water quality and its standards for usage.
- To understand the objectives of water and wastewater treatment technologies.
- Understand the operation of water and wastewater treatment system.

Unit 1 **11 hours**

Water: Types of water resources: Surface water, Ground water, Causes and effects of water resource depletion; Per capita demand; Water quality standards; Concept of colour, Odour, Turbidity, pH, Conductivity, TDS, Hardness, Chlorides, Nitrates, Phosphates, Sulphates and Heavy metals.

Unit 2 **13 hours**

Water Pollution and Treatment: Types and sources of water pollution; Impact on humans, plants and animals; Eutrophication; Biological magnification; DO; BOD; COD; and Microbiological analysis – MPN. Treatment methods: Screens; Sedimentation, Filtration, Coagulation, Flocculation, Disinfection and Softening.

Unit 3 **13 hours**

Wastewater: Characteristics of industrial wastewater, Types of industrial pollutants. List of Green, Orange and Red industries. Wastewater from different industries along with their discharge standards (Distillery, Sugar, Paper and Pulp, Textile, Dairy, Pharmaceutical).

Unit 4 **13 hours**

Wastewater Treatment: Primary treatment: Screens, Grit chambers, Sedimentation, Skimming Tanks, Flocculation, Equalization, and Neutralization; Secondary treatment: Aerated lagoons, Trickling filters, Activated sludge process, Oxidation Pond, Aerobic and Anaerobic decomposition of sewage; Tertiary treatment and Sludge treatment.

Unit 5 **10 hours**

Economics of Waste Treatment: Benefits of pollution abatement; Primary, secondary and intangible benefits; Capital and operating cost of different treatment processes for industrial waste.

Course outcomes: At the end of the course, the student will be able to understand:

- Various types of water pollutants and their monitoring methods.
- Understanding the characteristics of industrial effluent and their effects on environment.
- Understand the importance of industrial wastewater management and its benefits.

Essential readings:

1. Metcalf and Eddy Inc., (2017) Wastewater Engineering- Treatment and Reuse, McGraw Hill Publishing Co. Ltd., New Delhi.
2. Tchobanoglous G. and Burton F.L. (1979) Waste Water Engineering: Treatment, Disposal, and Reuse. Tata McGraw Hill, New Delhi.

3. Raju B.S.N. (1995) Water Supply and Wastewater Engineering, Tata McGraw Hill Pvt. Co. Ltd., New Delhi.
4. Punima B.C. and Jain A. (2016) Wastewater Engineering, Laxmi Publications (P) Ltd., New Delhi.
5. Benefield R.D. and Randal C.W. (1980) Biological Process Design for Wastewater Treatment, Prentice Hall, Englewood Chiffs, New Jersey.
6. Karia G.L. and Christian R.A. (2001) Wastewater Treatment Concepts and Design Approach, Prentice Hall of India Pvt. Ltd., New Delhi.

Suggested readings:

1. Standard Methods for the Examination of Water and Waste Water, (24th Ed.), APHA, (2005) Washington, D.C.
2. Santra S.C. (2011) Environmental Science, New Central Book Agencies, Pvt., Ltd. Kolkata
3. Peavy H.S. Rowe D.R. and Tchobanoglous G. (1985) Environmental Engineering. McGraw-Hill Book Company, Singapore.
4. Lee C.C. and Lin S.D. (1999) Handbook of Environmental Engineering Calculations, McGraw Hill, New York.
5. Cheremisinoff N.P. (1996) Bio-Technology for Waste and Wastewater Treatment William Andrew Publishing.

Department of Environmental Sciences						
Class	**Subject**	**Sem.**	**Course Code**	**Course Title**	**Marks**	**Credits**
M.Sc.	**Environmental Sciences**	**II**	**ENV-DSM-222**	**Water and Wastewater Treatment (Practical)**	**Mid Sem- 40 End Sem- 60**	**0-0-4=2**

Practical:

1. Determination of pH and conductivity in water.
2. Determination of Total Solids in water.
3. Determination of Alkalinity in water sample.
4. Determination of Optimum Coagulant dosage in waste water sample.
5. Determination of Dissolved Oxygen for the given sample
6. Determination of BOD for the given sample.
7. Determination of COD for given sample.

Essential readings:

1. Standard Methods for the Examination of Water and Waste Water, (24th Ed.), APHA, (2005) Washington, D.C.
2. Metcalf and Eddy Inc., (2017) Wastewater Engineering- Treatment and Reuse, McGraw Hill Publishing Co. Ltd., New Delhi.
3. Tchobanoglous G. and Burton F.L. (1979) Waste Water Engineering: Treatment, Disposal, and Reuse. Tata McGraw Hill, New Delhi.
4. Punima B.C. and Jain A. (2016) Wastewater Engineering, Laxmi Publications (P) Ltd., New Delhi.
5. Karia G.L. and Christian R.A. (2001) Wastewater Treatment Concepts and Design Approach, Prentice Hall of India Pvt. Ltd., New Delhi.

Suggested readings:

1. Raju B.S.N. (1995) Water Supply and Wastewater Engineering, Tata McGraw Hill Pvt. Co. Ltd., New Delhi.
2. Santra S.C. (2011) Environmental Science, New Central Book Agencies, Pvt., Ltd. Kolkata
3. Peavy H.S. Rowe D.R. and Tchobanoglous G. (1985) Environmental Engineering. McGraw-Hill Book Company, Singapore.
4. Lee C.C. and Lin S.D. (1999) Handbook of Environmental Engineering Calculations, McGraw Hill, New York.
5. Cheremisinoff N.P. (1996) Bio-Technology for Waste and Wastewater Treatment William Andrew Publishing.

Department of Environmental Sciences						
Class	**Subject**	**Sem.**	**Course Code**	**Course Title**	**Marks**	**Credits**
M.Sc.	**Environmental Sciences**	**II**	**ENV-DSM-223**	**Air Pollution and Control Techniques (Theory)**	**Mid Sem.-40 End Sem.- 60**	**3-1-0 = 4**

Course objectives:

- To impart a general understanding of air quality, pollutant types, causing agents and adverse impacts at local, regional, and global scales.
- To provide deeper understanding of meteorological parameter's role in transport and diffusion of air pollutants.
- To demonstrate the planning of measurement and monitoring of air pollutants.
- To discuss the various types of air pollution control equipment, their design principles, and limitations.

Unit 1 **12 hours**

Introduction to Air Pollution: Air pollution: classification, types, sources, impacts; Criteria pollutants, Behaviour and Fate; Indoor air quality, Status of air pollution in India, Air quality standards and indices, Atmospheric brown cloud, Air pollution & Climate change-the global linkages

Noise Pollution: Sources, Measurement, Impacts and indices, Effect of meteorological parameters on noise propagation; Noise exposure levels and standards

Unit 2 **12 hours**

Meteorology and Air Pollution Chemistry: Scale of meteorology: Pressure, Temperature, Precipitation, Humidity, Wind; Atmospheric stability, Mixing height, Inversions, Wind rose; Transport and dispersion of air pollutants, Plume behaviour, Photochemistry of troposphere, Gas to particle conversion.

Unit 3 **12 hours**

Air Pollution Modelling: Principles of air quality modelling, Deterministic, stochastic and simulation models, Dispersion models - Gaussian models, Box models, Chemical transport models, Photochemical models; Model validation and uncertainties

Unit 4 **12 hours**

Monitoring & Measurement of Air Pollution: Ambient and indoor air quality measurements, Selection of monitoring sites, Measurement techniques, Sampling and analysis of trace gases and particulate matters, Biomonitoring of air quality

Unit 5 **12 hours**

Air Pollution Control Technology: Principles of air pollution control technology, Green technology, Particulate matter control techniques: Gravitational settling chambers, Centrifugal collectors, Wet collectors, Fabric filters, Electrostatic precipitator; Gaseous pollutants control technique: Adsorption, Absorption, Oxidation, Desulphurization, Scrubbers, Condensers, Settling chamber, Noise control and abatement measures.

Course outcome:

- Ability to characterize the air pollutants, their role in the atmosphere, and state of air pollution in India.
- Develop understanding of measurement and monitoring of ambient and indoor air pollutants.
- Acquire knowledge of evaluation and selection of appropriate pollution control devices and policies to reduce target pollutants by technological innovation.

Essential readings:

1. Seinfeld J. H., and Pandis, S.N. (2006). Atmospheric Chemistry and Physics: From Air Pollution to Climate Change, John Wiley & Sons, INC.
2. Masters G.M. (2004). Introduction to environmental engineering and science. Prentice-Hall.
3. De A.K. (2006). Environment Chemistry, New Age International Pvt Ltd Publishers; 6th ed.
4. Peavy H.S., Rowe D.R., and Tchobanoglous (1985). Environmental Engineering. McGraw Hill series
5. Cunningham W.P., and Saigo W.B. (2005). Environmental Science, McGraw Hill, New York.
6. Santra, S. C. (2001). Environmental Science. New Central Book Agencies, Pvt., Ltd. Kolkata.

Suggested readings:

1. Rao C.S. (1991). Environmental Pollution Control Engineering, Wiley.
2. Manahan S.E. (1993). Fundamentals of Environmental Chemistry. Publisher: Lewis.
3. Sportisse B. (2009). Fundamentals in Air Pollution: From Process to Modelling. Springer.
4. Holton J. R. (2004). An Introduction to Dynamic Meteorology. The International Geophysics Publisher: Academic Press
5. Bell J.N.B. (2002). Air Pollution and Plant Life. John Wiley and Sons, New Delhi.

Department of Environmental Sciences						
Class	**Subject**	**Sem.**	**Course Code**	**Course Title**	**Marks**	**Credits**
M.Sc.	**Environmental Sciences**	**II**	**ENV-DSM-224**	**Air Pollution and Control Techniques (Practical)**	**Mid Sem- 40** **End Sem- 60**	**0-0-4=2**

Practical:

1. Sampling and analysis of Sulphur dioxide (SO_2) in ambient air.
2. Sampling and analysis of Nitrogen dioxide (NO_2) in ambient air.
3. Sampling and analysis of $PM_{2.5}$ and PM_{10} in ambient air.
4. Sampling and analysis of Ozone (O_3) in ambient air.
5. Sampling and analysis of Ammonia (NH_3) in ambient air.
6. Sampling and monitoring of air pollutants in indoor microenvironments.
7. Pollution measurement at any location using Air Quality Index (AQI).
8. Measurement of noise indices L10, L50, L90 and Leq
9. Measurement of Traffic Noise Index (TNI) and Day-Night Index (DNI)

Essential readings:

1. Seinfeld J. H., and Pandis, S.N. (2006). Atmospheric Chemistry and Physics: From Air Pollution to Climate Change, John Wiley & Sons, INC.
2. Masters G.M. (2004). Introduction to environmental engineering and science. Prentice-Hall.
3. De A.K. (2006). Environment Chemistry, New Age International Pvt Ltd Publishers; 6th ed.

Suggested Readings

1. Rao C.S. (1991). Environmental Pollution Control Engineering, Wiley.
2. Manahan S.E. (1993). Fundamentals of Environmental Chemistry. Publisher: Lewis.

Department of Environmental Sciences						
Class	**Subject**	**Sem.**	**Course Code**	**Course Title**	**Marks**	**Credits**
M.Sc.	**Environmental Sciences**	**II**	**ENV-MDM-221**	**Remote Sensing and GIS (Theory)**	**Mid Sem: 40 End Sem: 60**	**3-0-0=3**

Course objectives:

- To provide a comprehensive understanding of remote sensing principles, technologies, and applications in environmental sciences.
- To explore the fundamentals of Geographic Information Systems (GIS) and their integration with remote sensing data for spatial analysis.
- To emphasize the application of remote sensing and GIS in addressing environmental challenges and sustainable development.

Unit 1 **12 hours**

Introduction to Remote Sensing: Remote Sensing: Definition, principles, and applications; Electromagnetic Radiation (EMR): Nature and characteristics; Interaction of EMR with the Earth's atmosphere and surface; Atmospheric windows and their significance in remote sensing; Types of remote sensing platforms and sensors; Image acquisition and interpretation techniques

Unit 2 **12 hours**

Fundamentals of Geographic Information Systems (GIS): Introduction to GIS: Concepts and components; Spatial data representation and analysis in GIS; GIS data sources, data management, and data quality

Unit 3 **12 hours**

Image Processing Techniques in Remote Sensing: Image enhancement and classification techniques; Change detection and image fusion techniques; Image processing and classification using remote sensing software

Unit 4 **12 hours**

Spatial Analysis with GIS: Spatial data analysis and modelling in GIS; Spatial interpolation, buffering, and overlay analysis; Spatial analysis and modelling using GIS software

Unit 5 **12 hours**

Environmental Applications of Remote Sensing and GIS: Land cover and land use mapping; Monitoring environmental changes and assessing impacts; Natural resource management and conservation

Course outcomes:

- Demonstrate proficiency in the principles and techniques of remote sensing, including data acquisition, processing, and analysis.
- Apply GIS tools for spatial data management, spatial analysis, and visualization of environmental information.
- Utilize remote sensing and GIS data to identify and assess environmental changes, land use patterns, and natural resource management.
- Analyze environmental problems using remote sensing and GIS to propose evidence-based solutions and policies for sustainable development.

Essential readings:

1. Jensen, J. R. (2015). Remote Sensing of the Environment: An Earth Resource Perspective (2nd ed.). Pearson.
2. Lillesand, T. M., Kiefer, R. W., Chipman, J. W. (2011). Remote Sensing and Image Interpretation, 6th Edition. India: Wiley India Pvt. Limited.

3. Heywood, D. I., Cornelius, S., Carver, S. (2011). An Introduction to Geographical Information Systems. United Kingdom: Prentice Hall.

Suggested readings:

1. Longley, P. A., Goodchild, M. F., Maguire, D. J., & Rhind, D. W. (2015). Geographic Information Science & Systems (4th ed.). Wiley.
2. Wang G., & Weng Q. (2020) Remote Sensing of Natural Resources. United Kingdom: CRC Press.

Department of Environmental Sciences						
Class	**Subject**	**Sem.**	**Course Code**	**Course Title**	**Marks**	**Credits**
M.Sc.	**Environmental Sciences**	**II**	**ENV-DSM-222**	**Remote Sensing and GIS (Practical)**	**Mid Sem: 40** **End Sem: 60**	**0-0-4=2**

Practical:

1. Preprocess satellite images (e.g., Landsat, Sentinel) using digital image processing techniques.
2. Create and digitize geospatial datasets (e.g., land use, vegetation cover) from various data sources.
3. Perform spatial analysis to identify hotspots of environmental factors (e.g., pollution, biodiversity).
4. Monitor changes in land use and land cover over time using time-series satellite images.
5. Analyze land use trends and their implications for the environment.
6. Use remote sensing data to assess the health and status of natural resources (e.g., forests, water bodies).
7. Implement change detection techniques to monitor resource degradation and conservation efforts.
8. Create thematic maps and visualizations of environmental data using GIS software.
9. Apply remote sensing techniques to assess and monitor environmental disasters (e.g., wildfires, floods).
10. Use GIS tools to support environmental decision-making and planning.

Essential readings:

1. Jensen, J. R. (2015). Introductory Digital Image Processing: A Remote Sensing Perspective (4th ed.). Pearson.
2. Longley, P. A., Goodchild, M. F., Maguire, D. J., & Rhind, D. W. (2015). Geographic Information Science & Systems (4th ed.). Wiley.

Suggested readings:

1. De Smith, M. J., Goodchild, M. F., & Longley, P. A. (2020). Geospatial Analysis: A Comprehensive Guide to Principles, Techniques, and Software Tools (6th ed.). The Winchelsea Press.

Department of Environmental Sciences						
Class	**Subject**	**Sem.**	**Course Code**	**Course Title**	**Marks**	**Credits**
M.Sc.	**Environmental Sciences**	**II**	**ENV-MDM-223**	**Natural Resource Management (Theory)**	**Mid Sem.-40** **End Sem.-60**	**3-0-0=3**

Course objectives:

- To provide an advanced understanding of natural resource management principles and practices, focusing on bioresources, water, energy and soil resources.
- To analyze the complex environmental issues associated with natural resource use and conservation and develop critical thinking for effective decision-making.
- To equip students with advanced technical and research skills in assessing, monitoring, and managing natural resources using innovative tools and techniques.

Unit 1 **6 hours**

Introduction to Natural Resources: Introduction and their consumption patterns; Classification; distribution and uses; Factors influencing resource availability; Reserve-to-production ratio; Degradation of natural resources; Concept of conservation; Approaches to natural resource management and their implications; Integrated resource management strategies.

Unit 2 **8 hours**

Soil and mineral resources Management: Pedogenesis, Soil profiling, Soil classification, Soil erosion and control measures, Desertification, Soil degradation and reclamation; Minerals: Types and characteristics; Extraction methods and their environmental impacts; Mine reclamation; Sustainable mining practices; Conservation and substitution technology for critical materials.

Unit 3 **10 hours**

Water Resources Management: Hydrological cycle and its components; Classification of water resources; Water demand, allocation, and conflicts; Surface and ground water resource depletion; Integrated water resources management approaches: rainwater harvesting and management, watershed management, River Basin Management; Wetland Conservation and Restoration; Water conservation initiatives in India.

Unit 4 **10 hours**

Forest Management: Major Forest types, their characteristics and distribution; Use and over-exploitation of forest resources; Sustainable Forestry Practices: Selective Logging, Reforestation, Agroforestry; Forest Ecosystem Services; Timber Certification and Sustainable Harvesting; Forest Management Plans; Invasive Species Management.

Unit 5 **11 hours**

Wildlife Management: Wildlife Conservation and Biodiversity; Habitat Preservation and Restoration; Human-Wildlife Conflict Resolution; Sustainable Wildlife Management; Capture and Handling of Wildlife; Captive breeding and Propagation; Protected Area Planning; Wildlife corridors and connecting the protected areas; Satellite Cores; Eco sensitive Zones, Sustainable Grazing and Grassland Restoration; Conservation Ethics and Values of Wildlife in India

Course outcome: At the completion of this course the students will be able to:

- Demonstrate an advanced understanding of the principles and complexities of natural resource management.
- Apply advanced technical skills to assess and monitor natural resources and develop conservation plans to enhance resource sustainability.
- Evaluate the ecological, economic and social implications of different natural resource management strategies and propose sustainable solutions.

Essential readings:

1. Chiras D. and Reganold J. (2009) Natural Resource conservation: Management for a sustainable Future, Addison Wesley, Boston
2. Kesler S.E. and Simon A.D. (2002) Mineral Resources, Economics and the Environment, CBS Publishers ND
3. Hunter M.L. (2020) Fundamentals of Conservation Biology, Blackwell Science Inc., Cambridge, Massachusetts
4. Loucks, D. P., van Beek, E. (2017). Water Resource Systems Planning and Management: An Introduction to Methods, Models, and Applications. Germany: Springer International Publishing.
5. Singh K.K. (2008) Natural Resources Conservation & Management. M D Publications Pvt. Ltd
6. R. Gopal., 2021. Fundamentals of Wildlife Management. Natraj Publishers

Suggested readings:

1. Singh J. and Pandey G. (2005) Natural Resource Management and Conservation, Kalyani Publishers
2. Roonwal G.S., Shahriar, K. and Ranjbar H. (2016) Mineral Resources and Development, Daya Publishing House
3. Challa, S.N.M. (2020) Water Resources Engineering: Principles and Practice, New age international publishers
4. Agnew C. and Woodhouse P. (2010) Water Resources and Development, Routledge, London
5. Singh M.P. (2007) Forest Environment and Biodiversity, 2nd Edition, Daya Publishing House, New Delhi

Department of Environmental Sciences						
Class	**Subject**	**Sem.**	**Course Code**	**Course Title**	**Marks**	**Credits**
M. Sc.	**Environmental Sciences**	**II**	**ENV-SEC-221**	**Analytical Techniques (Theory)**	**Mid Sem.-40** **End Sem.-60**	**3-0-0=3**

Course objectives:

- To develop sampling skills required in environmental monitoring
- To provide scientific understanding of instruments, their operation and applications
- Ability to perform analytical experiments and data interpretation

Unit1 **9 hours**

Fundamentals of instrumentation: Introduction to instrumentation, measurements, sensitivity and selectivity, Calibration; Quality assurance and quality control; Sampling: methods for solid, liquid and gaseous matrix; sample collection and storage; sample preparation.

Basic techniques: Gravimetric and volumetric analysis; Colorimetry; Turbidimetry and Nephelometry; Electrophoresis.

Unit 2 **9 hours**

Spectroscopic Techniques: UV- Visible spectrophotometer; Flame photometry; Atomic absorption spectrophotometry; Plasma Emission Spectroscopy; X-Ray Fluorescence, X-Ray Diffraction; Vibrational Spectroscopy; Laser-Based Techniques.

Unit 3 **9 hours**

Chromatography and Mass Spectroscopy: Fundamentals of chromatography; Paper chromatography, Thin layer chromatography, Gas liquid chromatography, Liquid chromatography, High performance liquid chromatography, Ion-exchange chromatography; Gas chromatography–mass spectrometry, Liquid Chromatography-Mass Spectrometry; Nuclear Magnetic Resonance Spectroscopy.

Unit 4 **9 hours**

Microscopy: Fundamentals of microscopy; Types of microscopy; Optical microscopy: Bright field and dark field, Phase contrast, Fluorescence, Confocal; Electron microscopy: Scanning electron microscopy, Transmission electron microscopy and Atomic force microscopy; Mapping and imaging of environmental samples.

Unit 5 **9 hours**

Radiochemical Techniques: Radioactivity; Measurement of stable isotopes; Radioactive labeling; tracer techniques; Neutron activation analysis; Scintillation detectors, Gas filled detectors; Semiconductor detector and storage phosphors.

Course outcome: At the completion of this course, the students will be able to:

- Understand the fundamentals of underlying principles related to various instrumentation techniques
- Use suitable sampling methods for the collection of different environmental samples.
- Apply various analytical methods for quantitative and qualitative analysis of environmental samples

Essential readings:

1. De A.K. (1994) Environmental Chemistry. New Age International Ltd. New Delhi.
2. Keith L.H. (1988) Principles of Environmental Sampling. American Chemical Society.
3. Ewing G.W. (1985) Instrumental Methods of Chemical Analysis, 5th Edition, Mc-Graw Hill Book Company.

4. Wilson K. and Walker J. (2010) Principles and Techniques of Biochemistry and Molecular Biology, 7th Edition, Cambridge University Press.
5. Chatwal G.R. and Anand S.K. (2007) Instrumental Methods of Chemical Analysis. Himalaya Publishing House, Delhi.

Suggested readings:

1. Reeve R. (2002) Introduction to Environmental Analysis. John Willey and Sons.
2. Khopkar S.M. (2015) Basic Concepts of Analytical Chemistry. Wiley Eastern Ltd., New Delhi.
3. Mitra S. and Kebbekus B.B. (2018) Environmental Chemical Analysis. CRC Press.
4. Skoog D. A., Holler F.J. and Crouch S.R. (2017) Principles of Instrumental Analysis. Cengage learning.
5. Willard H.H., Merritt L.L, Deen, J.A. and Settle, F.A. (2015) Instrumental Methods of Analysis. CBS Publishers and Distributers, New Delhi.

Department of Environmental Sciences						
Class	**Subject**	**Sem.**	**Course Code**	**Course Title**	**Marks**	**Credits**
M.Sc.	**Environmental Sciences**	**II**	**ENV-SEC-222**	**Study Tour**	**S/US**	**0-1-0=1**
Students must visit a local industry, river, protected area, important institutions, or other designated site and create a study report. Evaluation will be based on the quality of the report.						

***Note: S: Satisfied**

US: Unsatisfied

Semester III

Department of Environmental Sciences						
Class	**Subject**	**Sem.**	**Course Code**	**Course Title**	**Marks**	**Credits**
M.Sc.	**Environmental Sciences**	**III**	**ENV-DSM-321**	**Solid Waste Management (Theory)**	**Mid Sem. -40 End Sem. -60**	**3-1-0 = 4**

Course objectives:

- To provide comprehensive overview of types and sources of solid waste
- To acquaint the students with the process of handing, collection and processing of solid waste
- To create an understanding of methods for treatment and disposal of solid waste

Unit 1 **12 hours**

Introduction to solid waste: Definition, types and sources; Sampling and characterization; Generation: factors affecting and rate measurement; impact of solid waste on environment, human and plant health.

Unit 2 **12 hours**

Handling, collection and processing: On-site handling; Storage; Collection; Transfer and transport; Processing: mechanical volume and size reduction, component separation; screening; drying and dewatering; Waste minimization strategies.

Unit 3 **12 hours**

Disposal methods: Open dumping: site selection and impacts of open dumping; Sanitary landfills: site selection, costs, liner and covers, leachate control and treatment, gas recovery and control, landfill monitoring and reclamation; Composting: aerobic and anaerobic; Thermal treatment: incineration, pyrolysis; gasification; Energy recovery; Solid Waste Management Rules.

Unit 4 **12 hours**

Hazardous Waste: Definition; Identification and classification; Sources and characteristics; Pathways, fates, and transformation of hazardous waste releases; Handling, collection, storage and transport; Treatment and Disposal methods; Treatment of contaminated and disposal sites; Hazardous and Other Waste (Management and Transboundary Movement) Rules, 2016.

Unit 5 **12 hours**

Biomedical Waste Management: Sources; Categories and classification; Collection; Segregation, labeling and handling; Treatment and Disposal techniques; Bio-Medical Waste Management Rules, 2016.
E-Waste Management: Characteristics; Generation; Collection; Transport; Recycling and Disposal methods; E-waste (Management) Rules 2016.
Radioactive waste Management: Types; Characteristics; Collection and disposal methods.

Course outcome:

On completion of the course the students will be able to:

- Have sound understanding of the waste generation process and characteristics of different types of solid wastes.
- Have in-depth knowledge of strategies related to waste minimization, storage, collection, transport, processing and disposal of solid waste.

Essential readings:

1. Peavy, H. S., Rowe, D. R. and Tchobanoglous, G. (2010). Environmental Engineering, New York: McGraw-Hill.
2. Tchobanoglous G. and Kreith F. (2002) Handbook of Solid Waste Management, 2nd Edition, McGraw- Hill.
3. Blackman W.C. (2001) Basic Hazardous Waste Management, CRC Press.
4. Sheha R.R. and Someda H.H. (2008) Hazardous Waste: Classifications and Treatment Technologies, Nova Science Publishers, Inc. New York.

5. McDougall F.R., White P.R., Franke M. and Hindle P. (2008) Integrated Solid Waste Management: A Life Cycle Inventory, John Wiley & Sons.

Suggested readings:

1. Rao M.N. and Sultana R. (2012) Solid and Hazardous Waste Management, BS Publications, Hyderabad.
2. Bagchi A. (2004) Design of Landfills and Integrated Solid Waste Management, John Wiley & Sons.
3. Ramachandra T.V. (2006) Management of Municipal Solid Waste, Capital Publishing Company.

Department of Environmental Sciences						
Class	**Subject**	**Sem.**	**Course Code**	**Course Title**	**Marks**	**Credits**
M.Sc.	**Environmental Sciences**	**III**	**ENV-DSM-322**	**Solid Waste Management (Practical)**	**Mid Sem- 40 End Sem- 60**	**0-0-4=2**

Practical:

1. To collect solid waste using sampling techniques like coning and quartering method from different locations of the University.
2. To determine various components of municipal solid waste in your location
3. To determine the moisture percent of the waste sample.
4. To determine the volatile matter percentage in the sample.
5. To determine the total organic carbon content in the solid waste.
6. To estimate Kjeldahl Nitrogen in solid waste sample.
7. To determine the available phosphorus in solid waste samples.
8. To determine the field capacity of soil sample.

Essential readings:

1. Peavy H. S., Rowe D. R., and Tchobanoglous G. (2010). Environmental Engineering, New York: McGraw-Hill.
2. Tchobanoglous G., and Kreith F. (2002) Handbook of Solid Waste Management, 2nd Edition, McGraw- Hill.

Suggested readings:

1. Rao M.N., and Sultana R. (2012) Solid and Hazardous Waste Management, BS Publications, Hyderabad.

Department of Environmental Sciences						
Class	**Subject**	**Sem.**	**Course Code**	**Course Title**	**Marks**	**Credits**
M.Sc.	**Environmental Sciences**	**III**	**ENV-DSM-323**	**Energy and Environment (Theory)**	**Mid Sem. - 40 End Sem. - 60**	**3-1-0 = 4**

Course objectives:

- Understand energy scenario, sources, and their utilization.
- Understand the perturbing effects of over-exploitation of energy sources on the environment.
- Understand various methods of energy conservation, energy management, and its economic analysis.

Unit 1 **11 hours**

Introduction to Energy: Definition, forms and classification of energy; Measurement of energy; Indian and Global energy resources; Pattern of energy consumption. Environmental implications of energy resources; Carbon foot print.

Unit 2 **13 hours**

Conventional Energy Sources: Fossil fuels: Classification, Composition, Physico-chemical characteristics; Energy content of Coal, Petroleum and Natural gas; Shale oil; Coal bed Methane; Gas hydrates; Gross-calorific value and Net-calorific value.
Nuclear energy - Fission and Fusion; Nuclear fuels; Nuclear reactor: Principles and types.

Unit 3 **13 hours**

Non-conventional Energy Sources: Solar radiation and its spectral characteristics; Solar energy (solar collectors, photo-voltaic cells, Solar ponds); Principal and applications of Hydro-power; Tidal energy; Ocean thermal energy conversion; Wind power and Geothermal energy.

Unit 4 **13 hours**

Bioenergy: Biomass as an energy source; Characteristics of biomass; Energy plantations, Biomass conversion technologies; Types of biofuels - Biodiesel, Bioethanol, Biogas, Biohydrogen and Microbial fuel cell – importance and applications.

Unit 5 **10 hours**

Conservation and Management of Energy: Environmental degradation due to energy production and utilization; Principles of energy conservation; Objectives and principles of energy management; Energy Audit: need, types, and methodology.

Course outcome:

- Learn the overview of energy resources and their consumption patterns worldwide
- Gain knowledge on conventional and non-conventional energy sources and associated harvesting technologies
- Learn the conservation and management practices for energy resources

Essential readings:

1. Manjunatha, S.R. (2010). An Introduction to Environmental Energy Resource. Cyber Tech Publications, India.
2. Abbasi, S.A., and Abbasi, N. (2002). Renewable Energy Sources and their environmental impact. Prentice Hall of India, New Delhi.
3. Kalbande, S., Bhale, V.M., and Sedani, S.R. (2022). Textbook of Green Energy Technologies, Narendra Publishing House, New Delhi.
4. Kanoğlu, M., Çengel, Y.A., and Cimbala, J.M. (2020). Fundamentals and Applications of Renewable Energy. McGraw-Hill Education. United States.

5. Abbi, Y., and Jain, S. (2015). Handbook on Energy and Environment management. The Energy Resources Institute, TERI.
6. Bhushan, C. (2014). State of renewable energy in India: A citizen's report. Centre for Science and Environment, New Delhi.
7. Glassley, W.E. (2014). Geothermal energy: Renewable energy and the environment, 2nd edition, CRC press, London
8. Sergio, C.C. (2013). Introduction to biomass Energy Conversions. CRC press.

Suggested readings:

1. Sawhney, G.S. (2012). Non - Conventional Energy Resources, PHI Learning Private Limited, New Delhi.
2. Ahmed, F.Z., and Ramesh, C.B. (2011). Handbook of Renewable Energy Technology. World Scientific Publishing Company.
3. Lal, B., and Sarma, P.M. (2011). Wealth from waste: Trends and technologies, TERI.
4. MNRE (2011). Griha manual volume - 3: Technical manual for trainers on building and system design optimization renewable energy application, Ministry of New and Renewable Energy.
5. Zobaa, A.F., and Bansal, R. (2011). Handbook of Renewable Energy Technology, World Scientific Publishing Co., Singapore.
6. Gupta, H., and Roy, S. (2006). Geothermal energy: An alternative resource for the 21st century, Elsevier Science Ltd.
7. John, T. (2021). Renewable Energy Resources. Routledge, Taylor & Francis Books India Pvt. Ltd. England.

Department of Environmental Sciences						
Class	**Subject**	**Sem.**	**Course Code**	**Course Title**	**Marks**	**Credits**
M.Sc.	**Environmental Sciences**	**III**	**ENV-DSM-324**	**Energy and Environment (Practical)**	**Mid Sem- 40 End Sem- 60**	**0-0-4=2**

Practical:

1. To study the working of solar ponds.
2. To calculate the calorific value of coals.
3. To study principal and designing of biogas plants.
4. To study the production process of bio-fuels.
5. Preparation of compost from organic waste.
6. Preparation of Vermicompost using kitchen waste.

Essential readings:

1. Manjunatha, S.R. (2010). An Introduction to Environmental Energy Resource. Cyber Tech Publications, India.
2. Abbasi, S.A., and Abbasi, N. (2002). Renewable Energy Sources and their environmental impact. Prentice Hall of India, New Delhi.
3. Kalbande, S., Bhale, V.M., and Sedani, S.R. (2022). Textbook of Green Energy Technologies, Narendra Publishing House, New Delhi.
4. Kanoğlu, M., Çengel, Y.A., and Cimbala, J.M. (2020). Fundamentals and Applications of Renewable Energy. McGraw-Hill Education. United States.
5. Abbi, Y., and Jain, S. (2015). Handbook on Energy and Environment management. The Energy Resources Institute, TERI.

Suggested readings:

1. Sawhney, G.S. (2012). Non - Conventional Energy Resources, PHI Learning Private Limited, New Delhi.
2. Ahmed, F.Z., and Ramesh, C.B. (2011). Handbook of Renewable Energy Technology. World Scientific Publishing Company.
3. MNRE (2011). Griha manual volume - 3: Technical manual for trainers on building and system design optimization renewable energy application, Ministry of New and Renewable Energy.
4. Zobaa, A. F., and Bansal, R. (2011). Handbook of Renewable Energy Technology, World Scientific Publishing Co., Singapore.
5. John T. (2021). Renewable Energy Resources (4th Edition). Routledge, Taylor & Francis Books India Pvt. Ltd. England.

Department of Environmental Sciences						
Class	**Subject**	**Sem.**	**Course Code**	**Course Title**	**Marks**	**Credits**
M.Sc.	**Environmental Sciences**	**III**	**ENV-MDM-321**	**Atmospheric Sciences and Climate Change (Theory)**	**Mid Sem.-40 End Sem.- 60**	**3-0-0 = 3**

Course objectives:

- To demonstrate the sound understanding of atmospheric systems and interactions with the physical environment.
- To integrate specific thermodynamic and radiative properties of atmosphere into multidisciplinary nature of earth system.
- To develop a deep understanding of atmospheric processes and dynamics, global circulation, and climatic pattern.
- To educate about climate change, current and future scenario, drivers of climate change, impacts, mitigation measures and policies.

Unit 1 **9 hours**

Introduction to the Atmospheric System: History and Evolution, Optical properties, Mass, Composition, Vertical structure of the atmosphere, Elements of weather and climate, Insolation and Heat budget: Spectrum of radiation, Distribution of insolation, Heat budget of earth and atmosphere, Latitudinal heat balance.

Unit 2 **9 hours**

Atmospheric Thermodynamics and Radiative transfer: Gas laws, Hydrostatic equation, Laws of thermodynamics, Adiabatic processes, Potential temperature, Normand's rule, Entropy, The Clausius–Clapeyron equation, Blackbody radiation: Planck function, Wien's displacement law, Stefan–Boltzmann law, Kirchhoff's Law

Unit 3 **9 hours**

Precipitation and Atmospheric Dynamics: Atmospheric moisture: Condensation, Precipitation, Cloud, Fog, Dew and Frost; Air pressure and Winds: Measurement, Horizontal and altitudinal variation, Pressure belts and winds; Pressure gradient force, Coriolis force, Geostrophic flow, Gradient winds

Unit 4 **9 hours**

Atmospheric Circulation and Weather Patterns: Local Winds, Katabatic and Anabatic winds, Global Circulation, Weather system, ITCZ, Jet streams, Monsoons, Fronts, Cyclone Formation, El-Nino, Climate classification (Koppen's and Thornthwaite), Weather forecasting and Climate prediction

Unit 5 **9 hours**

The Changing Climate: Climate system, Detection of climate change, Past and present, Natural and anthropogenic causes, Global warming and Ozone layer depletion, Climate sensitivity and Feedback mechanisms, Impacts of climate change and Risk assessment, Future climate scenarios, Mitigation measures and Policies, International treaties and protocols

Course outcomes:

- Acquaint with broad overview of fundamental concept of atmospheric system and physical principles to understand atmospheric and climate change processes.
- Understanding the role of thermodynamic and meteorological concept in atmospheric-climatic processes.
- Become familiar with the atmospheric circulation, weather system, climatic classification, weather forecasting and prediction.
- Comprehend role of drivers of climate change, scale of variability, projection, adaptation, and mitigation strategies.

Essential readings:

1. Wallace, J.M.J., and Hobbs, P.V. (2006) Atmospheric Science: An Introductory Survey, 2nd Edition, Academic Press.
2. Seinfeld, J.H., and Pandis, S.N. (2006) Atmospheric Chemistry and Physics: From Air Pollution to Climate Change, John Wiley & Sons, INC.
3. Lutgens, F.K., and Tarbuck, J. (2010) The Atmosphere: An Introduction to Meteorology, Phi (Prentice-hall New Arrivals).
4. Menon, P.A. (1993). Our Weather, National Trust, India.

Suggested readings:

1. Masters, G.M. (2004) Introduction to environmental engineering and science. Prentice-Hall.
2. Hardy, J.T. (2003) Climate Change: Causes, effects and solutions, John Wiley and Sons.
3. Barbara, J., Finlayson-Pitts, Pitts James N. JR. (1999) Chemistry of the Upper and Lower Atmosphere: Theory, Experiments, and Applications, Academic Press.
4. Strahler, A.H., and Strahler, A.N. (1992) Modern Physical Geography, John Wiley and Sons.

Department of Environmental Sciences						
Class	**Subject**	**Sem.**	**Course Code**	**Course Title**	**Marks**	**Credits**
M.Sc.	**Environmental Sciences**	**III**	**ENV-MDM-322**	**Atmospheric Sciences and Climate Change (Practical)**	**Mid Sem- 40** **End Sem- 60**	**0-0-4=2**

Practical:

1. Understand the practical use of Automated Weather Monitoring Station.
2. Analysis of diurnal and seasonal variability of atmospheric pressure, temperature, humidity, and rainfall.
3. Measurement of solar radiation, soil moisture and soil temperature.
4. Measurement of wind (speed and direction) and preparation of wind rose diagram.
5. Trend analysis and anomaly measurement of weather parameters.

Essential readings:

1. Wallace, J.M.J., and Hobbs, P.V. (2006) Atmospheric Science: An Introductory Survey, 2nd Edition, Academic Press.
2. Seinfeld, J.H., and Pandis, S.N. (2006) Atmospheric Chemistry and Physics: From Air Pollution to Climate Change, John Wiley & Sons, INC.
3. Lutgens, F.K., and Tarbuck J. (2010) The Atmosphere: An Introduction to Meteorology, Phi (Prentice-hall New Arrivals).
4. Menon, P.A. (1993). Our Weather, National Trust, India.

Suggested readings:

1. Masters G.M. (2004) Introduction to environmental engineering and science. Prentice-Hall.
2. Hardy, J.T. (2003) Climate Change: Causes, effects and solutions, John Wiley and Sons.
3. Barbara J. Finlayson-Pitts, Pitts James N. JR. (1999) Chemistry of the Upper and Lower Atmosphere: Theory, Experiments, and Applications, Academic Press.
4. Strahler A.H., and Strahle,r A.N. (1992) Modern Physical Geography, John Wiley and Sons.

Department of Environmental Sciences						
Class	**Subject**	**Sem.**	**Course Code**	**Course Title**	**Marks**	**Credits**
M.Sc.	**Environmental Sciences**	**III**	**ENV-MDM-323**	**Environmental Economics and Sustainable Development (T)**	**Mid Sem: 40 End Sem: 60**	**3-0-0=3**

Course objectives:

- To understand the principles of environmental economics and their application in analyzing the allocation of scarce resources to address environmental challenges.
- To examine the role of policy and governance in promoting sustainable development and effective environmental management.
- To critically analyze environmental policies for global challenges, considering historical, current, and future requirements.

Unit 1 **8 hours**

Introduction to Environmental Economics: Definition and scope of environmental economics; Economic analysis of environmental issues; Role of economics in sustainable development; Kuznets Curve: Economic growth and environmental degradation; Pareto Optimality: Balancing economic growth and environmental protection

Unit 2 **10 hours**

Valuation of Natural Resources and Ecosystem Services: Valuation techniques: revealed preference, stated preference, hedonic pricing; Challenges in valuing non-market goods and ecosystem services; Estimating the economic value of Natural Resources; Cost-benefit analysis and its applications in environmental decision-making

Unit 3 **10 hours**

Environmental Policy and Economic Theories: Environmental policy instruments and approaches; Command and control vs. market-based instruments; Economic incentives and environmental taxation; Property rights, externalities, and Coase Theorem; Pigouvian taxes, subsidies, and other market-based instruments

Unit 4 **9 hours**

Sustainable Development: Concepts and Theories: Sustainability concepts and indicators; Theories of sustainable development; Environmental justice and equity in sustainable development; Sustainable development goals and international agreements; Optimal extraction of renewable resources: fishery, forests, water; Hotelling's rule and resource scarcity; Natural resource accounting and incorporating environmental factors in economic analysis

Unit 5 **8 hours**

Economics of Sustainability and Global Challenges: Intergenerational equity and discounting: ethical dimensions of sustainability; Historical context and evolution of environmental policies; Economics of climate change: economic impact, mitigation strategies, policy implications; Future requirements for sustainable policies

Course outcomes:

- Demonstrate a comprehensive understanding of environmental economics principles and their relevance in analyzing environmental issues and policymaking.
- Evaluate the effectiveness of environmental policies and their impact on sustainable development and resource management.
- Apply advanced theories and models in environmental economics to assess complex environmental problems and propose sustainable solutions.
- Engage in critical discussions on global environmental challenges and contribute to evidence-based decision-making for sustainable development.

Essential readings:

1. Keohane, N., and Olmstead, S. (2016). Markets and the Environment (2nd ed.). Island Press.
2. Stavins, R. N. (Ed.). (2019). Economics of the Environment: Selected Readings (7th ed.). Edward Elgar Publishing.
3. Hanley, N., Shogren, J. F., White, B., and Papineau, M. (2013). Environmental Economics in Theory and Practice (2nd ed.). Palgrave Macmillan.
4. Tietenberg, T., and Lewis, L. (2020). Environmental and Natural Resource Economics (11th ed.). Routledge.

Suggested readings:

1. Dasgupta, P. (2007). The Economics of Climate Change: The Stern Review. Cambridge University Press.
2. Barbier, E. B. (2011). Scarcity and Frontiers: How Economies Have Developed Through Natural Resource Exploitation. Cambridge University Press.
3. Sen, A. (1999). Development as Freedom. Anchor Books.
4. Sachs, J. (2015). The Age of Sustainable Development. Columbia University Press.

Department of Environmental Sciences						
Class	**Subject**	**Sem.**	**Course Code**	**Course Title**	**Marks**	**Credits**
M.Sc.	**Environmental Sciences**	**III**	**ENV-SEC-321**	**Disaster Management and Risk Analysis (T)**	**Mid Sem. - 40 End Sem. - 60**	**3-0-0 = 3**

Course objectives:

- Understand the concepts and principles of disaster management and risk analysis.
- Analyse the causes and impacts of different types of disasters, particularly in the Indian context.
- Assess vulnerabilities and hazards to determine risks.
- Build necessary disaster response skills.

Unit 1 **15 hours**

Introduction to Disasters: Scope and definitions: hazard; disaster, and vulnerability; Risk: types, trends, causes and consequences of disasters; Vulnerability and Hazard Profile of India
Geological Hazards: Earthquakes, Volcanoes, Tsunami, Mass movements: Avalanche, Mud slides, and landslides.
Hydro-meteorological Hazards: Floods, droughts, cyclones, cloud burst, heat waves, cold waves.
Biological Hazards: Epidemics, Pandemic; Pest attacks
Man-made disaster: Road Accidents, Industrial Disasters, Chemical Spills, Forest Fires; Terrorism.

Unit 2 **8 hours**

Risk Assessment and Analysis: Risk perception and assessment; Vulnerability and exposure assessment; Hazard identification and analysis; Quantitative risk assessment tools; Early warning systems; Role of Information and communication technology in Disaster Management.

Unit 3 **8 hours**

Disaster Preparedness and Response: Disaster management cycle; Emergency response planning; Crisis management plan and standard operating procedures; Role of Central and State Governments; National Emergency Operation Centre; National and State Disaster Response Force; Adaptive management in post-disaster environmental recovery.

Unit 4 **7 hours**

Mitigation Strategies: Structural and non-structural mitigation measures; Involvement of various stakeholders; Importance of education and awareness in disaster mitigation; Community-based disaster management practices in India; National institutions and disaster management centres in the States. Case Studies of National and International importance.

Unit 5 **7 hours**

Ecosystem-based disaster risk reduction (Eco-DRR): Introduction to Eco-DRR, Linking Ecosystems and Disaster Risk Reduction; Role of Ecosystems in Mitigating Natural Disasters; Reforestation and Afforestation for Risk Reduction; Coastal and Wetland Restoration; Rehabilitation of Degraded Ecosystems; Integrating Ecosystems into Climate Adaptation; Local Communities' Role in Adaptation; Building Resilience Through Ecosystem-based Approaches; Case Studies in Eco-DRR.

Course outcomes:

- Identify potential hazards, vulnerabilities, and risks in the Indian context.
- Edify people about the importance of early preparedness in susceptible areas by creating awareness.
- The knowledge gained will enable the students to volunteer themselves in disaster management programs, thus helping the affected community.

Essential readings:

1. Quarantelli, E.L. (Ed.) (1998). What is a Disaster? New Answers to Old Questions. International Research Committee on Disasters.
2. Spatial Planning and Resilience Following Disasters: International and Comparative Perspectives. (2017). United Kingdom: Policy Press.
3. Integrating Nature-based Solutions for Climate Change Adaptation and Disaster Risk Management: A Practitioner's Guide. (2022). Philippines: Asian Development Bank.
4. UNISDR (2015). Sendai Framework for Disaster Risk Reduction 2015-2030. United Nations Office for Disaster Risk Reduction.

Suggested readings:

1. Alexander, D.E. (2013). Natural Disasters. Routledge.
2. Tierney, K.J. (2019). The Social Roots of Risk: Producing Disasters, Promoting Resilience. Stanford University Press.
3. Paton, D. (2008). Disasters and Communities: Vulnerability, Resilience and Preparedness. Disaster Prevention and Management: An International Journal, 17(3), 270-277.
4. Ghosh, S., and Choudhury, A. (Eds.). (2018). Disaster Management: Global Challenges and Local Solutions. Springer.
5. Bhan, S., Patel, S., Garg, T., Gera, R., and Singh, D. (2019). Disaster Risk Reduction and Climate Change Adaptation Strategies for Enhancing Community Resilience. Springer.

Semester IV

Department of Environmental Sciences						
Class	**Subject**	**Sem.**	**Course Code**	**Course Title**	**Marks**	**Credits**
M.Sc.	**Environmental Sciences**	**IV**	**ENV-DSM-421**	**Environmental Assessment, Management and Legislation (T)**	**Mid Sem: 40** **End Sem: 60**	**3-0-0=3**

Course objectives:

- To understand the need of Environmental laws and Impact Assessment and their significance in sustainable development.
- To explore the legal frameworks and regulations governing environmental protection and impact assessment.
- To critically evaluate the effectiveness of environmental laws and policies in addressing environmental challenges, including international treaties and conventions.

Unit 1 **9 hours**

Environmental Laws and Policy in India: Constitutional provisions in India: Article 48A and 51A; Water (Prevention and Control of Pollution) Act, 1974 and amendments; The Water (Prevention and Control of Pollution) Cess Act, 1977 and amendments; Air (Prevention and Control of Pollution) Act, 1981 and amendments; Environmental (Protection) Act, 1986 and amendments; The Public Liability Insurance Act, 1991 and Rules 1991; Coastal Regulation Zones (CRZ) 1991 and amendments; Indian Forest Act, 1927; Indian Wildlife (Protection) Act, 1972; Forest Conservation Act 1980; Forest Rights Act, 2006.

Unit 2 **9 hours**

Environmental Impact Assessment: Definition, scope and developments; Objectives and basic principles, Types; EIA Gazette Notification, 1994 & 2006; Category A and Category B Projects; Prior environment clearance requirements and stages; General EIA methodology: screening, scoping, impact identification: checklists, matrices, qualitative methods, networks and overlay maps, impact prediction, environmental evaluation system.

Unit 3 **9 hours**

Impact mitigation and monitoring: Mitigation methods and approaches; Appraisal; Review; Decision making; Public consultation and participation; Monitoring and auditing in EIA process; Environmental impact statement; Post-clearance monitoring Protocol.
Case studies: EIA of thermal power plant, pulp and paper mills, river valley projects, mining projects, urbanization and linear development.

Unit4 **9 hours**

Environmental Management Plan and Environmental Management Systems (EMS): Definition and purpose of an EMP; Components of an EMP: objectives, scope, responsibilities; Integration of EMP with EIA process; Developing a comprehensive EMP: steps and considerations; ISO 14000 series; ISO 9000.

Unit5 **9 hours**

Environmental Audit: Definition and principles; Types of environmental audits; Environmental auditing process: planning and preparation, audit team, examination of documented systems and internal control, site setting, site inspections and interviews, audit reporting and follow-up.
Life Cycle Assessment: Goal, scope and definition, life cycle inventory, impact assessment, interpretation.

Course outcomes: At the completion of this course, the students will be able to:

- Analyze and interpret environmental laws and regulations applicable in India.
- Demonstrate a comprehensive understanding of Environmental Impact Assessment process and its role in environmental management.
- Evaluate the strengths and weaknesses of environmental laws and policies in India, propose improvements, and assess their effectiveness.
- Identify and assess international treaties and conventions related to environmental protection and their implications for global environmental challenges.

Essential readings:

1. Glasson, J., Therivel, R., and Chadwick, A. (2018). Introduction to Environmental Impact Assessment (5th ed.). Routledge.
2. Curran, M. A. (2016). Life Cycle Assessment Handbook: A Guide for Environmentally Sustainable Products. Wiley.
3. Ong, B.T.C. (2005). Environmental Auditing: Fundamentals and Techniques. World Scientific.

Suggested readings:

1. Wood, C. (2003). Environmental Impact Assessment: A Comparative Review. Pearson Education.
2. Barrett, S., & Dannreuther, C. (Eds.). (2017). International Environmental Law and the Global South. Cambridge University Press.
3. Kohli, K., and Menon, M. (2021). Development of Environmental Laws in India. United Kingdom: Cambridge University Press.

Department of Environmental Sciences						
Class	**Subject**	**Sem.**	**Course Code**	**Course Title**	**Marks**	**Credits**
M.Sc.	**Environmental Sciences**	**IV**	**ENV-DSM-422**	**Dissertation**	**Report Submission: 75** **Viva-Voce: 25**	**0-0-30=15**
The project work will be carried out by the students in semester IV and work will be evaluated based on dissertation and final presentation. The Research Supervisor will be allotted at the end of second semester.						