

**Punyashlok Ahilyadevi Holkar Solapur
University, Solapur**



Name of the Faculty: Science & Technology

Syllabus: ENVIRONMENTAL SCIENCE

As per National Education Policy (NEP 2020)

Name of the Course: M. Sc Part- I (Sem I & II)

[Syllabus to be implemented from June- 2026]

PROGRAM PREAMBLE

The M.Sc. Environmental Science programme offered by the School of Earth Sciences under the Faculty of Science and Technology at Punyashlok Ahilyadevi Holkar Solapur University is designed to provide advanced, multidisciplinary, and research-oriented education in the field of Environmental Science in accordance with the National Education Policy (NEP) 2020 and UGC guidelines. The programme aims to prepare students for emerging environmental challenges and the new paradigm of global environmental change by developing scientific knowledge, technical expertise, analytical skills, and innovative approaches for environmental monitoring, assessment, conservation, restoration, and sustainable management of natural resources.

Environmental Science is an interdisciplinary field integrating physical sciences, biological sciences, earth sciences, social sciences, geospatial technologies, environmental engineering, sustainability studies, and policy frameworks to understand and solve complex environmental problems at local, regional, national, and global scales. The programme focuses on key areas such as climate change, pollution control, biodiversity conservation, environmental health, water resource management, sustainable development, ESG (Environmental, Social and Governance), environmental governance, ecological restoration, disaster management, and environmental sustainability. Special emphasis is given to environmental issues relevant to semi-arid regions such as Solapur and Maharashtra, including drought, water scarcity, land degradation, urban environmental stress, industrial pollution, and climate variability.

The curriculum is meticulously designed under the Credit Framework of NEP-2020 to ensure holistic development, employability, entrepreneurship, skill enhancement, and research competency among students. The programme structure consists of two academic years with four semesters and a minimum of 88 credits. It incorporates Discipline-Specific Courses, Generic Electives, Skill Enhancement Courses, Value Addition Courses, internships, field-based learning, research projects, and multidisciplinary electives. Students exiting after successful completion of the first year and required credits may be awarded a Post Graduate Diploma in Environmental Science as per NEP provisions.

The programme emphasizes experiential and outcome-based learning through classroom teaching, laboratory practical's, field surveys, GIS and Remote Sensing applications, AI-based environmental analytics, environmental auditing, seminars, assignments, project work, industrial visits, internships, and exposure to field-based best environmental practices. Educational visits to forests, wildlife areas, wetlands, industries, pollution control facilities, research laboratories, botanical and zoological gardens, and environmentally significant sites

are encouraged to provide practical understanding and professional exposure. Continuous Assessment (CA) and End Semester University Assessment (UA) are adopted for evaluation under the credit and grading system.

The School of Earth Sciences continuously strives to strengthen academic excellence, innovation, sustainability education, and research culture through curriculum revision, interdisciplinary collaborations, community engagement, and partnerships with industries, government agencies, NGOs, and national/international research institutions. The programme aims to develop skilled environmental professionals, researchers, academicians, consultants, policy planners, GIS and sustainability experts, entrepreneurs, and socially responsible citizens capable of contributing effectively toward environmental protection, climate resilience, ecological restoration, sustainable development goals, and national environmental priorities.

PROGRAMME OBJECTIVES (POs)

The objectives of the M.Sc. Environmental Science programme are:

1. To provide advanced and interdisciplinary knowledge in Environmental Science, sustainability, climate change, biodiversity, pollution control, and natural resource management.
2. To develop scientific, analytical, technical, and problem-solving skills required for understanding and addressing complex environmental issues.
3. To impart practical training in environmental monitoring, laboratory techniques, GIS, Remote Sensing, environmental modelling, AI applications, and environmental data analysis.
4. To promote research aptitude, scientific writing, innovation, and critical thinking for conducting quality environmental research and consultancy.
5. To prepare students for careers in environmental consultancy, ESG and sustainability sectors, pollution control agencies, industries, NGOs, research organizations, academia, and government departments.
6. To strengthen field-based learning, environmental surveys, industrial exposure, internship training, and community-oriented environmental practices.
7. To develop competency in environmental legislation, environmental impact assessment (EIA), environmental auditing, carbon management, and environmental governance.
8. To encourage sustainable environmental practices, ethical values, leadership qualities, entrepreneurship, and professional responsibility among students.
9. To create awareness regarding regional environmental issues of Maharashtra and semi-arid ecosystems, including drought management, watershed development, groundwater conservation, and climate resilience.
10. To prepare students for higher education, doctoral research, competitive examinations, and multidisciplinary professional opportunities in emerging environmental sectors.

PROGRAMME OUTCOMES (POs)

After successful completion of the M.Sc. Environmental Science programme, students will be able to:

Major Courses

- **PO1:** Demonstrate in-depth knowledge and understanding of core concepts, theories, and methodologies in the chosen major discipline.
- **PO2:** Apply disciplinary knowledge to solve complex problems, analyze data, and make informed decisions in professional and research contexts.

Minor Courses:

- **PO3:** Acquire complementary knowledge and skills from a related or distinct discipline, enhancing interdisciplinary understanding and versatility.

Open Electives/General Electives:

- **PO4:** Explore diverse subjects beyond the core discipline, fostering a broad-based education and cultivating critical thinking and creativity.

Vocational and Skill Enhancement Courses:

- **PO5:** Gain hands-on experience and technical proficiency in specific vocational areas, preparing for immediate career opportunities.

Ability Enhancement Courses (AEC), Indian Knowledge System (IKS), and Value Education Courses (VEC):

- **PO6:** Understand and appreciate the rich heritage of the Indian Knowledge System, integrating traditional wisdom with modern education.
- **PO7:** Develop ability enhancement skills like communication and life skills along with ethical values, social responsibility, and a strong sense of citizenship, contributing positively to society.

Field Projects/Internship/Apprenticeship/Community Engagement Projects/ On Job Training/ Internship/Apprenticeship:

- **PO8:** Apply theoretical knowledge to real-world situations through field projects, internships, community engagement and On job Training for gaining practical experience and problem-solving skills.

Research Methodologies and Research Project:

- **PO9:** Acquire research skills, including data collection, analysis, and interpretation, fostering a scientific approach to problem-solving to develop independent research projects handling capabilities

PROGRAMME SPECIFIC OUTCOMES (PSOs)

After successful completion of the M.Sc. Environmental Science programme, students will be able to:

- **PSO1: Comprehensive Understanding of Environmental Systems:** Students will possess a thorough comprehension of the Earth's environmental systems, including the interactions between the atmosphere, hydrosphere, lithosphere, and biosphere.
- **PSO2: Proficiency in Environmental Analysis:** Students will develop skills in analysing environmental data, conducting fieldwork, and employing laboratory techniques to assess environmental quality and identify potential hazards.
- **PSO3: Sustainable Resource Management:** Students will be equipped with the knowledge and tools to develop sustainable strategies for managing natural resources, minimizing environmental degradation, and promoting conservation efforts.
- **PSO4: Problem-Solving Skills:** Through coursework and practical experience, students will enhance their critical thinking and problem-solving abilities, enabling them to address complex environmental challenges effectively.
- **PSO5: Awareness of Environmental Policies and Regulations:** Students will gain an understanding of environmental laws, regulations, and policies at local, national, and international levels, preparing them for careers in compliance, advocacy, and policymaking.
- **PSO6: Effective Communication:** Students will be proficient in communicating scientific concepts and findings to diverse audiences, including policymakers, stakeholders, and the general public, facilitating informed decision-making and public engagement.
- **PSO7: Interdisciplinary Approach:** The interdisciplinary nature of environmental science education will enable graduates to integrate knowledge from various fields, such as biology, chemistry, geology, geography, and sociology, to address complex environmental issues comprehensively.
- **PSO8: Research and Innovation:** Students will have the opportunity to engage in research projects, exploring cutting-edge topics in environmental science and contributing to the advancement of knowledge in the field.
- **PSO9: Career Opportunities:** Completion of a M. Sc in Environmental Science opens up a wide range of career opportunities in sectors such as environmental consulting, resource management, conservation organizations, government agencies, non-profit organizations, academia, and private industry.
- **PSO10: Global Citizenship:** Students will emerge as environmentally conscious global citizens, equipped with the skills, knowledge, and values necessary to contribute positively to environmental sustainability and address pressing environmental challenges facing society.

About National Education Policy (NEP) – 2020

With the directions and guidelines issued by **Government of Maharashtra resolution dated 20th April 2023 and 16th May, 2023** regarding the implementation of NEP at UG and PG level, the Punyashlok Ahilyadevi Holkar Solapur University, Solapur has taken decision to implement NEP 2020 with Choice Based Credit System (CBCS) at Post Graduate level. This has been done to achieve the goals and objectives set in NEP-2020 such as- worldwide recognition, acceptability, horizontal as well as vertical mobility for students completing post-graduate degree.

The CBCS provides an opportunity for the students to select from the prescribed courses comprising core, elective/minor or skill based. The courses can be evaluated following the grading system, which is considered to be better than the conventional marks system. Therefore, it is necessary to introduce uniform grading system in the entire higher education in India. This will benefit the students to move across institutions within India to begin with and across countries. The uniform grading system will also enable potential employers in assessing performance of candidates.

1. DESIGN OF PG/MASTER PROGRAMMES:

The structure of the One/Two-year Master's degree programme have the flexibility to offer following PG degree options:

- a) A two-year PG programme with one exit option for those who have completed the three-year Bachelor's Degree Programme: Level 6.5, Minimum of 80 and Maximum of 88 credits.
- b) Students, after successful completion of a minimum 40 and maximum of 44 credits in first year of two-year PG programme may opt for exit. Such students will be awarded PG Diploma in that relevant subject.
- c) A one-year Master's programme for students who are completing a four-year Bachelor's programme with honours or honours with Research: Level 6.5, minimum of 40 and Maximum of 44 credits.
- d) A one-year/two-semester Post-Graduate Diploma programme builds on a three-year Bachelor's degree and requires a minimum of 40 and a maximum of 44 credits: Level 6.0
- e) An integrated five-year Master's programme with multiple entry and exit options at different levels e.g., the student may exit at the end of the third year with a Bachelor's degree, with an entry to a Master's programme in another HEI. A 5-year Integrated Bachelor's and Master's programmes shall have minimum of 200 and maximum of 220

credits.

- f) The specializations in PG Programmes will be based on DSC only. The curricular design of first year of two-year PG Programme will be aligned to that of fourth-year of four-year Honors UG Degree Programmes. Research Methodology (aligned with seventh semester of fourth year of Honors and Honors with Research Degree of four-year UG Programmes) and Internship of 4 credits (aligned with the eighth semester of the fourth year of Honors Degree of four-year UG Programmes) shall be introduced in the first semester and in the second semester, respectively of first year of Two-Year PG Programmes. Second Year PG Programmes will include Research Projects of 10-12 Credits divided uniformly over the third and fourth semester.

2. DEFINITIONS OF KEYWORDS:

- a. **Academic Year:** Two consecutive (one odd + one even) semesters constitute one academic year.
- b. **Choice Based Credit System (CBCS):** The CBCS will provides options for students to select courses from the prescribed courses (core, open elective, discipline elective, ability and skill enhancement language, soft skill courses and so on).
- c. **Course:** Usually referred to as ‘papers’ is a component of a programme. All courses need not carry the same weight. The courses will define learning objectives and learning outcomes. A course will be designed to comprise Contact Hours / tutorials / laboratory work / field work / project work / vocational training / viva / seminars / term papers / assignments/ presentations / self-study or a combination of some of these.
- d. **Credit-Based Semester System (CBSS):** Under the CBSS, the requirement for awarding a degree /diploma /certificate is prescribed in terms of the number of credits to be earned.
- e. **Credit:** A unit by which the course work is measured. It determines the number of hours of instructions required per week in a semester. One credit is equivalent to one hour of lecture or tutorial or two hours of practical work/field work per week in a semester. It will generally be equal to 15 hours of instructions.
- f. **Grade Point:** It is a numerical weight allotted to each letter grade on a 10-point scale.
- g. **Credit Point:** It is the product of grade points and the number of credits for a course.
- h. **Letter Grade:** It is an index of the performance of students in a said course. Grades are denoted by letters O, A+, A, B+, B, C, D and F.
- i. **Programme:** A programme leading to the award of a degree, diploma, or Certificate.

- j. Semester:** Each semester will consist of over 15 weeks of academic work equivalent to 90 actual teaching days. The odd semester may be generally scheduled from June to November and even semester from January to May.
- k. Semester Grade Point Average (SGPA):** It is a measure of performance of work done in a semester. It is the ratio of total credit points secured by a student in various courses registered in a semester and the full course credits taken during that semester. It shall be expressed up to two decimal places.
- l. Cumulative Grade Point Average (CGPA):** It measures the overall cumulative performance of a student over all the semesters of a programme. The CGPA is the ratio of total credit points secured by a student in various courses in all the semesters and the sum of the total credits of all courses in all the semesters. It is expressed up to two decimal places.

3. STRUCTURE AND CREDIT DISTRIBUTION OF PG DEGREE PROGRAM

Credit Distribution for Two Year PG Programme with one Exit Option/ One Year PG Programme is as given below:

(2 Yr PG)	Level	Sem. (2 Yr)	Major		RM	OJT / FP	RP	Cum. Cr.	Degree
			Mandatory	Electives					
I	6.0	Sem I	12-14 (2*4 +2*2 or 3*4+2)	4	4			20-22	PG Diploma (after 3 Yr Degree)
		Sem II	12-14 (2*4 +2*2 or 3*4+2)	4		4		20-22	
Cum. Cr: PGDiploma			24-28	8	4	4	-	40-44	
Exit option: PG Diploma (40-44 Credits) after Three Year UG Degree									
II	6.5	Sem III	12-14 (2*4 +2*2 or 3*4+2)	4			4	20-22	PG Degree After 3- Yr UG/PG Degree after 4- Yr UG
		Sem IV	10-12 (2*4 +2 or 3*4)	4			6	20-22	
Cum. Cr. for 1 Yr PG			22-26	8			10	40-44	
Cum. Cr. for 2 Yr PG			46-54	16	4	4	10	80-88	
2 Years-4 Sem. PG Degree (80-88 credits) after Three Year UG Degree or 1 Year-2 Sem PG Degree (40-44 credits) after Four Year UG Degree									
	8.0		Course Work Min. 12 (3*4)			Training in Teaching / Education/ Pedagogy: 4	16 + Ph. D. Work		Ph.D. in Subject

Abbreviations: DSC: Discipline Specific Course, DSE: Discipline Specific Elective, FP: Field projects OJT: On Job Training: Internship/ Apprenticeship, RM: Research Methodology, RP: Research Project, L: Lectures, P: Practical's, Th: Theory, Pr: Practical's., Cumulative Credits: Cum. Cr.

- (a) Credits offered per Semester will be a Minimum of 20 and a Maximum of 22. While minimum credits are mandatory as per National Credit Framework, the Universities can evolve the mechanism for providing Semester/ Levelwise credit attainment flexibility within the broad framework.
- (b) Under the One-year PG Diploma program, and two-year master's Degree program, the students must complete on-the-job training/internship of 04 credits during summer break, after completion of the second semester of the first year in the respective Major Subject.
- (c) The 4 Credits Research Methodology Component is mandatory in the First Year.
- (d) Since the Master's Programme is based on DSC Specialization, the PG curricular framework will not include Minor Subject. Electives selected in the PG program may be **Relevant to OR Supportive of** the Major Subject chosen. The Statutory authorities of the University or Autonomous College can take a decision in this regard.
- (e) The students will have to undertake a research project of 4 credits in Semester III and a research project of 6 credits in Semester IV in the second year of the two-year master's degree program. This is also applicable to the students admitted to oneyear PG program after completion of four-year UG Program.
- (f) Colleges already having permission and recognition for the PG degree programme along with UG degree programme in the same Major shall be automatically allowed to continue PG degree programme in the same Major without undergoing any additional procedures. Similarly, the colleges with approved PG programme and Ph.D. Research Centre in the same Major shall be automatically allowed to continue PG and Ph. D. Degree programme without undergoing any additional procedures.
- (g) The exit option at the end of one year of the Master's degree program will commence from next year. Students who have joined a two-year Master's degree program may opt for exit at the end of the first year and earn a PG Diploma.
- (h) The PG Diploma may be awarded to a student provided they have earned the requisite credits in one year including on-the-job training of 04 credits during summer break, after completion of the second semester of the first year in the respective Major Subject.
- (i) The one-year Master's Degree Program will begin with effect from Academic Year 2027-28.
- (j) Re-entry to complete the PG degree, after taking the exit option, will be permissible up to 05 years from the date of admission to the PG program.

Eligibility for Admission:

1. B.Sc. Any Science Subject) / B.E./B.Tech. /B.Sc. Agriculture / Horticulture / Entrepreneurship / B. Pharmacy /B.C.A. / B. Architecture / B.Sc. Home Science / Food & Nutrition/Food Science/Food Technology.
2. Candidates with a B.E./B.Tech degree who have qualified in the current GATE examination are eligible for Direct Admission to the M.Sc. Environmental Science program.
3. Candidates with a B.Sc. degree who are on the waiting list for the M.Sc. Entrance Examination in Chemistry, Physics, Microbiology, Biotechnology, AGPM, Botany or Zoology at Punyashlok Ahilyadevi Holkar Solapur University are eligible for Direct Admission. Admission is based on the Entrance Examination conducted by PAH Solapur University, Solapur
4. Medium of Instruction: English

Punyashlok Ahilyadevi Holkar Solapur University, Solapur
Faculty of Science and Technology : Proposed structure as per NEP-2020
Proposed structure for Two Year PG Program (M.Sc. Part I) Environmental Science

Level / Difficulty	SEM	Major					Field Project/ RP/CC/Internship/ Apprenticeship/ Community Engagement & Services	Credits	Cumulative Credits
		Mandatory	Practical	Elective	Practical Elective	Minor			
4.5 100 - 400	I	DSC 1-1 (4 credits) Environmental Science and Global Environmental Issues	Practical DSC 1-1 (2 credits) Environmental Science and Global Environmental Issues	DSE 1-1 (4 credits) 1. Ecology, Ecosystem Dynamics and Biodiversity 2. Energy and Environment 3. Natural Resource Management (NRM)	Practical based on DSE 1-1 (2credits) 1. Ecology, Ecosystem Dynamics and Biodiversity 2. Energy and Environment 3. Natural Resource Management (NRM)	RM (Research Methodology) (4 credits)	-	22	22
		DSC 1-2 (4 credits) Environmental Chemistry and Analytical Techniques	Practical DSC 1-2 (2 credits) Environmental Chemistry and Analytical Techniques						
Exit option: Award of PG Diploma in Discipline with 44 credits OR Continue with Discipline									
5.0/400	II	DSC 1-3 (4 credits) Water and Wastewater Treatment Engineering	Practical DSC 1-3 (2 credits) Water and Wastewater Treatment Engineering	DSE 1-2 (4credits) 1. Climate Change Science, Adaptation and Mitigation 2. Environmental Microbiology, Biotechnology & Nanotechnology 3. Environmental Geospatial Technologies and Applications	Practical based on DSE 1-2 (2credits) 1. Climate Change Science, Adaptation and Mitigation 2. Environmental Microbiology, Biotechnology & Nanotechnology 3. Environmental Geospatial Technologies and Applications	-	OJT/In-House Project/ Internship/ Apprenticeship (4 Credit)	22	22 PG Diploma in Discipline (44)
		DSC 1-4 (4 credits) Environmental Pollution Control and Management	Practical DSC 1-4 (2 credits) Environmental Pollution Control and Management						

Abbreviations: OJT: On Job Training; **Internship/ Apprenticeship, FP:** Field projects, **RM:** Research Methodology, **RP:** Research Project

PUNYASHLOK AHILYADEVJI HOLKAR

SOLAPUR UNIVERSITY, SOLAPUR

M.Sc. Environmental Science Choice Based Credit System (CBCS)

Course Structure (NEP-2020)

M.Sc. Part-I Environmental Science w.e.f. June 2026

M.Sc. Part I Semester -I										
Paper Code	Title of the Paper	Credits	Contact hours/week			Distribution of Marks for Examination				
			Th (L)	Pr (P)	Total	External		Internal		Total
						Th	Pr	Th	Pr	
DSC 1-1	Environmental Science and Global Environmental Issues	4	4	---	4	60	---	40	---	100
DSC 1-2	Environmental Chemistry and Analytical techniques	4	4	---	4	60	---	40	---	100
DSE 1-1	1. Ecology, Ecosystem Dynamics and Biodiversity	4	4	---	4	60	---	40	---	100
	2. Energy and Environment									
	3. Natural Resource Management									
RM	Research Methodology	4	4	---	4	60	---	40	---	100
DSC-1P	Practical-1	2	---	4	4	---	30	---	20	50
DSC-2P	Practical-2	2	---	4	4	---	30	---	20	50
DSE-1P	Practical-3	2	---	4	4	---	30	---	20	50
Total for Semester-I		22	16	12	28	240	90	160	60	550

M.Sc. Part I, Semester –II										
Code	Title of the Paper	Credits	Contact hours / week			Distribution of Marks for Examination				
			Th (L)	Pr	Total	External		Internal		Total
						Th	Pr	Th	Pr	
DSC 1-3	Water and Wastewater Treatment Engineering	4	4	---	4	60	---	40	---	100
DSC 1-4	Environmental Pollution Control and Management	4	4	---	4	60	---	40	---	100
DSE 1-2	1.Climate Change Science, Adaptation and Mitigation	4	4	---	4	60	---	40	---	100
	2.Environmental Microbiology, Biotechnology & Nanotechnology									
	3.Environmental Geospatial Technologies and Applications									
OJT/FP	OJT/FP/ In-house Project /Internship/Apprenticeship	4	---	4	4	---	60	---	40	100
DSC-3P	Practical-4	2	---	4	4	--	30	---	20	50
DSC-4P	Practical-5	2	---	4	4	---	30	---	20	50
DSE-2P	Practical-6	2	---	4	4	---	30	---	20	50
Total for Semester-II		22	12	16	28	180	150	120	100	550

M.Sc. Part I (Semester I & II)

Semester	Credits	Contact hours/week			Distribution of Marks for Examination				
		Th (L)	Pr	Total	External		Internal		Total
					Th	Pr	Th	Pr	
I	22	16	12	28	240	90	160	60	550
II	22	12	16	28	180	150	120	100	550
I + II	44	28	28	56	420	240	180	160	1100

Abbreviations: DSC: Discipline Specific Course, DSE: Discipline Specific Elective, FP: Field projects
OJT: On Job Training: Internship/ Apprenticeship, RM: Research Methodology, RP: Research Project,
L: Lectures, P: Practical's, Th: Theory, Pr: Practical's.

- ✓ 4 Credits of Theory = 4 Hours of Teaching per Week
- ✓ 2 Credits of Practical = 4 Hours per week

SYLLABUS: M.Sc. Part I, Semester –I

DSC 1-1	Environmental Science and Global Environmental Issues	Total Contact Hrs. 60
Credits:04	Load/week:04	UA - Marks:60 CA - Internal:40

Course Objectives

1. To introduce students to the multidisciplinary foundations of Environmental Science, ecological principles, environmental sustainability, and contemporary environmental challenges at local, national, and global levels.
2. To develop analytical, ethical, technical, and decision-making skills related to environmental management, climate change mitigation, sustainable development, ecological conservation, environmental disaster management, and environmental governance.

Course Outcomes (COs)

1. Explain the basic concepts, scope, multidisciplinary nature, and ecological foundations of Environmental Science.
2. Describe the structure, composition, and interactions of atmosphere, hydrosphere, lithosphere, and biosphere in maintaining environmental balance.
3. Analyze major global environmental issues including climate change, global warming, ozone depletion, pollution, and their environmental and societal impacts.
4. Evaluate environmental disasters, international environmental agreements, and the role of global organizations and policies in environmental protection and sustainable development.

Unit	Contents	Contact Hrs.
I	Fundamentals of Environmental Science Introduction to Environmental Science: definition, scope, principles, and significance. Multidisciplinary nature of Environmental Science involving chemistry, physics, biology, mathematics, geology, geography, and social sciences. Components of environment and their interactions. Ecology and ecosystem concepts. Human-environment interactions, environmental relationship dynamics, natural resource utilization, and resource conflicts. Environmental degradation and sustainability concepts. Role of environmental education in solving environmental problems.	15 Hrs.
II	Structure and Components of the Environment Concept and structure of the environment. Atmosphere: definition, structure, composition, and functions. Hydrosphere: distribution, structure, hydrological cycle, and importance of water resources. Lithosphere: structure of the Earth, rocks, minerals, soil formation, and land resources. Biosphere: concept, structure, biomes, biodiversity, and ecological interactions. Interrelationship among atmosphere, hydrosphere, lithosphere, and biosphere in maintaining environmental balance.	15 Hrs.
III	Global Environmental Issues and Climate Change	15 Hrs.

	Greenhouse effect and greenhouse gases: sources, impacts, consequences, and mitigation measures. Global warming and climate change: causes, evidence, impacts, adaptation, and mitigation strategies. Climate change scenario at global and Indian levels. Acid rain, brown haze, photochemical smog, urban air pollution, nuclear winter, ozone layer depletion, and desertification.	
IV	Environmental Disasters and Global Environmental Governance Environmental disasters and their impacts: Bhopal Gas Tragedy, Chernobyl Nuclear Disaster, Fukushima Nuclear Disaster, Love Canal Tragedy, and Minamata Disease. Genetically Modified (GM) crops: applications, benefits, risks, and environmental concerns. Establishment and role of UNEP. Major international environmental conferences and initiatives: Stockholm Conference, Rio Earth Summit, Agenda 21, Sustainable Development Goals (SDGs), UNFCCC, Convention on Biological Diversity (CBD), Kyoto Protocol.	15 Hrs.

Reference Books:

1. Chapman, J.L. and Reiss M.J. (2005) Ecology Principles and Applications, Cambridge University Press, London.
2. E. P. Odum (1996) Fundamentals of Ecology, Nataraj Publisher, Dehra Dun.
3. Environment And Ecology-EAS105/EAS 205-R. Rajagopalan
4. S.V.S. Rana (2005) Essentials of Ecology and Environmental Sciences, Prentice Hall of India, New Delhi.
5. Environmental Science – Wiley India.
6. Principles of Environmental Science and Engineering – Prentice Hall India.
7. Environmental Science: Toward a Sustainable Future – Pearson Education.
8. Fundamentals of Ecology – Cengage Learning.
9. Environmental Chemistry – New Age International Publishers.
10. Textbook of Environmental Studies – S. Chand Publishing.
11. Global Warming and Climate Change – APH Publishing Corporation.
12. Climate Change and India – TERI Press.
13. Environmental Pollution and Control – Galgotia Publications.

DSC 1-2	Environmental Chemistry and Analytical Techniques	Total Contact Hrs. 60
Credits:04	Load/week:04	UA - Marks:60 CA - Internal:40

Course Objectives

1. To provide comprehensive knowledge of environmental chemistry, atmospheric, aquatic, and soil chemistry, including geochemical processes, toxic pollutants, and their environmental impacts.
2. To develop analytical, technical, and problem-solving skills in environmental monitoring, green chemistry, pollution control, and the application of modern analytical techniques for sustainable environmental management.

Course Outcomes (COs)

1. Explain the fundamental concepts of Environmental Chemistry, thermodynamics, electrochemistry, radiochemistry, and chemical processes occurring in different environmental segments.
2. Analyze atmospheric and aquatic chemical processes, air and water pollutants, water quality parameters, and environmental issues related to climate change and pollution.
3. Interpret soil chemical properties, geochemical cycles, behaviour of toxic chemicals, and the environmental impacts of pollutants and agrochemicals on ecosystems.
4. Apply principles of green chemistry and modern environmental analytical techniques for environmental monitoring, pollution assessment, and sustainable environmental management.

Unit	Contents	Contact Hrs.
I	Fundamentals of Environmental Chemistry Concept, scope, and importance of Environmental Chemistry. Chemistry of atmosphere, hydrosphere, lithosphere, and biosphere. Basic chemical concepts: elements, valency, mole concept, molarity, molality, normality, standard solutions, titration, solubility product, thermodynamics, Gibbs free energy, chemical potential, activity, fugacity, electrochemistry, redox reactions, Nernst equation, chemical kinetics, and equilibrium. Colloids, adsorption, absorption, emulsions, hydrocarbons, radioactive substances, radionuclides.	15 Hrs.
II	Atmospheric and Aquatic Chemistry Atmospheric chemistry: composition and structure of atmosphere, chemical speciation, particles, ions, radicals, aerosols, thermochemical and photochemical reactions, particulate matter formation, ozone chemistry, CFCs, air pollutants, photochemical smog, acid rain. Aquatic chemistry: structure and properties of water, water quality parameters, pH, conductivity, turbidity, alkalinity, hardness, DO, BOD, COD, water pollutants and heavy metals.	15 Hrs.
III	Soil Chemistry, Geochemistry, and Toxic Chemicals	15 Hrs.

	<p>Soil profile, physical and chemical composition of soil, humus, organic and inorganic components, saline, acidic, and alkaline soils, macro and micronutrients, NPK cycles, C:N ratio, cation exchange capacity (CEC), ion exchange, adsorption, Effects of fertilizers, pesticides, and agrochemicals on soil quality.</p> <p>Environmental geochemistry: major, trace, and rare earth elements (REE), geochemical cycles, mobility of trace elements. Toxic chemicals and pollutants: arsenic, cadmium, lead, mercury, CO, ozone, PAN, MIC, detergents, dyes, pesticides, polymers, pharmaceuticals, carcinogens, and persistent organic pollutants (POPs).</p>	
IV	<p>Green Chemistry and Environmental Analytical Techniques</p> <p>Principles and applications of green chemistry and green technology, atom economy, green reagents, green solvents, cleaner production, pollution prevention technologies.</p> <p>Environmental analytical techniques and instrumentation: titrimetry, gravimetry, conductometry, pH metry, potentiometry, colorimetry, nephelometry, fluorimetry, flame photometry, UV-Visible spectrophotometry, IR spectroscopy, AAS, chromatography, XRF, XRD, NMR, electrophoresis, particulate and gaseous pollutant samplers.</p>	15 Hrs.

Reference Books:

1. Chemistry of the Environment, Bailey, R.A. (1978). Academic Press.
2. Environmental Chemistry (7th Ed), Manahan S.E. (2000). Lewis Publications, Florida, U.S.A.
3. Toxic Chemicals, health and the Environment, Lave, L.B and Upton, A.C. 1987. The Hopkins Press Ltd., London.
4. Environmental Chemistry, I Ed. Sharma B.K and Kaur H. (1995)., Goel Publishing House.
5. Environmental Chemistry -Tyagi O.D. and Mehra M. (1990). Anmol Publications.
6. Vogel's Textbook of Quantitative Inorganic Analysis. (1978). IV Ed., Longman Group Ltd.
7. Environmental Chemistry by A.K. De, published by New Age International Publishers, New Delhi.
8. Environmental Chemistry by B.K. Sharma, published by Krishna Prakashan Media Pvt. Ltd., Meerut.
9. Fundamentals of Environmental Chemistry by Stanley E. Manahan, published by CRC Press, Taylor & Francis Group.
10. Environmental Chemistry and Pollution Control by S.S. Dara and D.D. Mishra, published by S. Chand & Company Ltd., New Delhi.
11. Environmental Science and Engineering by J.G. Henry and G.W. Heinke, published by Prentice Hall of India Pvt. Ltd., New Delhi.
12. Soil Chemistry by Daniel G. Strawn, Hinrich L. Bohn, and George A. O'Connor, published by Wiley Blackwell Publications.
13. Introduction to Atmospheric Chemistry by Daniel J. Jacob, published by Princeton

University Press.

14. Aquatic Chemistry by Werner Stumm and James J. Morgan, published by Wiley-Interscience Publications.
15. Environmental Geochemistry edited by Heinrich D. Holland and Karl K. Turekian, published by Elsevier Academic Press.
16. Green Chemistry: Theory and Practice by Paul T. Anastas and John C. Warner, published by Oxford University Press.
17. Green Chemistry by V.K. Ahluwalia, published by Narosa Publishing House, New Delhi.
18. Instrumental Methods of Chemical Analysis by G. Chatwal and S. Anand, published by Himalaya Publishing House, Mumbai.
19. Basic Concepts of Analytical Chemistry by S.M. Khopkar, published by New Age International Publishers, New Delhi.
20. Environmental Analytical Chemistry by F.W. Fifield and D. Haines, published by Blackwell Science Ltd., UK.

DSE 1-1	1. Ecology, Ecosystem Dynamics and Biodiversity	Total Contact Hrs. 60
Credits:04	Load/week:04	UA - Marks:60 CA - Internal:40

Course Objectives

1. To provide comprehensive understanding of ecological principles, ecosystem dynamics, population and community ecology, biogeochemical cycles, and biogeographic patterns.
2. To develop knowledge and analytical skills related to biodiversity conservation, ecosystem management, ecological restoration, and sustainable environmental conservation practices.

Course Outcomes (COs)

1. Explain the fundamental principles of ecology, ecosystem structure and functions, ecological energetics, and biogeographic distribution of organisms.
2. Analyze ecosystem dynamics, biogeochemical cycles, ecosystem productivity, and the ecological significance of terrestrial and aquatic ecosystems.
3. Interpret population and community ecological processes including species interactions, ecological succession, population regulation, and species distribution patterns.
4. Evaluate biodiversity patterns, threats to biodiversity, conservation strategies, protected area management, and the role of national and international policies in biodiversity conservation and ecosystem management.

Unit	Contents	Contact Hrs.
I	Fundamentals of Ecology and Biogeography Definition, principles, scope, and significance of ecology. Major branches and historical development of ecology. Origin and evolution of life, geological time scale, and evolution of ecosystems. Concepts of habitat, niche, adaptation, and ecological tolerance. Structure and functions of ecosystems. Biotic and abiotic components and their interactions. Food chain, food web, trophic levels, and ecological pyramids.	15 Hrs.
II	Ecosystem Dynamics and Biogeochemical Cycles Concept, structure, and functional components of ecosystems. Energy flow in ecosystems, ecological energetics, ecosystem models, productivity, and ecological efficiency. Types, structure, and characteristics of ecosystems: terrestrial ecosystems (forest, grassland, desert, tundra) and aquatic ecosystems (pond, lake, river, marine, estuarine, and wetland ecosystems). Natural and man-made ecosystems. Forest ecosystems and major forest types of India. Biogeochemical cycles: hydrological, carbon, nitrogen, phosphorus, sulfur, and oxygen cycles.	15 Hrs.
III	Population and Community Ecology Population ecology: population characteristics, natality, mortality, age structure, dispersion, and population growth models. Population dynamics and population regulation. Population interactions: competition, predation, parasitism, mutualism, commensalism, and exploitation. Concepts of	15 Hrs.

	metapopulation, demes, dispersal, ecological niche, and niche differentiation. Community ecology: species diversity, abundance, dominance, ecotone, edge effect, ecotypes, keystone species, flagship species, umbrella species, and indicator species. Ecological succession: types, mechanisms, and climax concepts.	
IV	Biodiversity and Conservation Ecology Levels, patterns, values, Biodiversity hotspots of the world and India. Threats to biodiversity including habitat loss, fragmentation, overexploitation, and invasive alien species. Biological invasion: concept, pathways, mechanisms, impacts, and major invasive species in India. Speciation: concept, types, and processes. Endangered, endemic, rare, and threatened species. IUCN categories, Red Data Book, Green Data Book, and threatened flora and fauna of India. Principles and strategies of biodiversity conservation including in-situ and ex-situ conservation, protected areas, biosphere reserves, national parks, wildlife sanctuaries, community reserves, and ecosystem management. Wetland conservation, ecotourism, and responsible tourism.	15 Hrs.

Reference Books:

1. Environmental Science by Santra S. C., New Central Book Agency (P) Limited (2001).
2. Development, Ecology and Climate Change: Issues and Challenges: Volume 1 by Mohinder Kumar Slariya CreateSpace Independent Publication; (2015).
3. Environmental Issues in India: A Reader, by Rangarajan, Pearson Education India; (2006).
4. Fundamentals of Ecology by Eugene P. Odum and Gary W. Barrett, published by Cengage Learning India Pvt. Ltd.
5. Ecology and Environment by P.D. Sharma, published by Rastogi Publications, Meerut.
6. Concepts of Ecology by Edward J. Kormondy, published by Pearson Education.
7. Elements of Ecology by Thomas M. Smith and Robert Leo Smith, published by Pearson Education.
8. Environmental Biology by P.D. Sharma, published by Rastogi Publications, Meerut.
9. Biodiversity by E.O. Wilson, published by National Academy Press, Washington D.C.
10. Biodiversity and Conservation by K.V. Krishnamurthy, published by Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.
11. Conservation Biology by Richard B. Primack, published by Sinauer Associates Inc. Publishers.
12. Wetlands Ecology and Management by Sharad K. Jain and Vijay P. Singh, published by Springer Publications.
13. Biogeography by C. Barry Cox and Peter D. Moore, published by Blackwell Scientific Publications.
14. Environmental Science by Daniel B. Botkin and Edward A. Keller, published by Wiley India Pvt. Ltd.
15. Ecology: From Individuals to Ecosystems by Michael Begon, Colin R. Townsend, and John L. Harper, published by Wiley-Blackwell Publications.

DSE 1-1	2. Energy and Environment	Total Contact Hrs. 60
Credits:04	Load/week:04	UA - Marks:60 CA - Internal:40

Course Objectives

1. To provide comprehensive understanding of energy resources, energy flow, thermodynamic principles, and conventional and non-conventional energy systems in relation to environmental sustainability.
2. To develop analytical and technical knowledge regarding renewable energy technologies, energy conservation, waste-to-energy systems, and sustainable energy management practices.

Course Outcomes (COs)

1. Explain the fundamental concepts of energy flow, thermodynamics, chemical reactions, nuclear energy, and their environmental significance.
2. Analyze conventional energy resources, global energy demand, energy management practices, and environmental impacts of energy production and consumption.
3. Evaluate renewable and non-conventional energy resources including solar, wind, geothermal, hydrogen, and biomass energy systems for sustainable development.
4. Apply knowledge of waste-to-energy technologies, biogas production, environmental standards, and sustainable energy strategies for environmental management and clean energy generation.

Unit	Contents	Contact Hrs.
I	Fundamentals of Energy and Energy Flow Concept, forms, and significance of energy. Laws of thermodynamics and principles of energy flow. Dynamic equilibrium, spontaneous processes, entropy, and energy transformations. Basics of chemical kinetics and chemical reactions. Structure of atoms, elements, molecules, compounds, and mixtures. Chemical species and environmental chemical reactions. Fundamentals of nuclear chemistry: atomic nucleus, radioactivity, isotopes, nuclear reactions, fission, fusion, and environmental implications of nuclear energy.	15 Hrs.
II	Conventional Energy Resources and Energy Management Global energy resources: renewable and non-renewable energy resources, distribution, availability, and utilization. Historical and present global energy demand and consumption patterns. Energy use in domestic, industrial, agricultural, and transportation sectors. Energy economics, energy subsidies, and environmental costs of energy production and consumption. Conventional energy resources: coal, petroleum, natural gas, thermal power, hydropower, and nuclear energy. Solar energy input and energy balance of Earth. Uranium resources, nuclear reactors, nuclear fuel cycle, and risks associated with nuclear accidents.	15 Hrs.

III	Non-Conventional and Biological Energy Resources Introduction, importance, and present status of non-conventional energy resources. Solar energy technologies: photovoltaic systems and solar heating. Wind energy, tidal energy, geothermal energy, hydrogen energy, and fuel cells. Biomass energy: biomass resources, biofuels, biogas, biodiesel, bioethanol, and energy plantations. Energy crops and waste biomass utilization. Biomass conversion technologies and power generation from biomass.	15 Hrs.
IV	Energy from Waste and Future Energy Scenario Concept and importance of waste-to-energy technologies. Energy generation from municipal solid waste, industrial waste, agricultural residues, sewage, and water-based biomass. Biogas technology: types of biogas plants, biogas generation process, digesters, and applications of biogas in India with special reference to Gujarat and rural development programs. Utilization of effluents for energy production, cost-benefit analysis, annual savings, and financial assistance schemes from government organizations for biogas and renewable energy sectors. Environmental standards and pollution control measures for waste-to-energy plants and gas clean-up technologies.	15 Hrs.

Reference Books:

1. Energy and Environment by R.A. Hinrichs and M. Kleinbach, published by Thomson Learning, USA.
2. Renewable Energy Resources by John Twidell and Tony Weir, published by Taylor & Francis Group, UK.
3. Non-Conventional Energy Sources by G.D. Rai, published by Khanna Publishers, New Delhi.
4. Energy Technology by S. Rao and B.B. Parulekar, published by Khanna Publishers, New Delhi.
5. Renewable Energy: Power for a Sustainable Future by Godfrey Boyle, published by Oxford University Press, UK.
6. Fundamentals of Renewable Energy Sources by G.N. Tiwari and M.K. Ghosal, published by Narosa Publishing House, New Delhi.
7. Biogas Technology by K. Kishore, published by TERI Press, New Delhi.
8. Waste to Energy Conversion Technology by Kalyani Bhattacharya, published by CBS Publishers & Distributors, New Delhi.
9. Solar Energy Engineering by Soteris A. Kalogirou, published by Academic Press, Elsevier.
10. Principles of Solar Engineering by D.Y. Goswami, Frank Kreith, and Jan F. Kreider, published by Taylor & Francis Group.
11. Wind Energy Explained by James F. Manwell, Jon G. McGowan, and Anthony L. Rogers, published by Wiley Publications.
12. Biomass Energy Systems by D.O. Hall and R.P. Overend, published by Wiley Publications.

DSE 1-1	3. Natural Resource Management	Total Contact Hrs. 60
Credits:04	Load/week:04	UA - Marks:60 CA - Internal:40

Course Objectives

1. To provide comprehensive knowledge of the principles, assessment, conservation, and sustainable management of natural resources, including land, water, forests, biodiversity, energy, and mineral resources at local, national, and global levels.
2. To develop skills in applying modern tools, resource management strategies, environmental policies, and sustainable development approaches for addressing natural resource challenges and promoting environmental resilience.

Course Outcomes (COs)

1. Explain the concepts, classification, distribution, utilization patterns, and sustainability issues associated with various natural resources and their role in environmental management.
2. Assess land, soil, water, forest, biodiversity, energy, and mineral resources using scientific methods, geospatial technologies, and resource assessment techniques.
3. Evaluate resource conservation strategies, watershed management approaches, biodiversity conservation measures, and sustainable resource utilization practices for environmental protection and climate resilience.
4. Apply principles of integrated natural resource management, environmental governance, resource policies, and sustainable development frameworks to solve real-world environmental and resource management problems.

Unit	Contents	Contact Hrs.
I	Fundamentals of Natural Resource Management and Resource Assessment Concept, scope, principles, and significance of Natural Resource Management (NRM). Classification of natural resources: renewable, non-renewable, perpetual, biotic, and abiotic resources. Natural resource availability, distribution, utilization patterns, and resource depletion at global, national, and regional scales. Resource economics and environmental valuation. Sustainable development and Sustainable Development Goals (SDGs) in relation to resource management. Resource conservation principles and carrying capacity concepts. Resource inventory, mapping, monitoring, and assessment techniques. Natural resource conflicts, environmental governance, and community participation in resource management.	15 Hrs.
II	Land, Soil, Water and Watershed Resource Management Land resources: classification, land capability, land use and land cover systems, land degradation, desertification, salinization, waterlogging, and	15 Hrs.

	soil erosion. Soil resources: soil formation, soil fertility, soil health, nutrient management, soil conservation measures, and sustainable soil management practices. Water resources: surface water and groundwater resources, water budgeting, water scarcity, water quality issues, and integrated water resource management (IWRM). Watershed management principles, watershed development programs, river basin management, rainwater harvesting, groundwater recharge, farm ponds, percolation tanks, and check dams.	
III	Forest, Biodiversity and Biological Resource Management Forest resources: status, distribution, classification, ecological and economic importance of forests. Forest degradation, deforestation, forest fragmentation, and forest conservation strategies. Sustainable Forest Management (SFM), Joint Forest Management (JFM), social forestry, agroforestry, urban forestry, and community forestry. Biodiversity resources: levels, values, threats, and conservation strategies. In-situ and ex-situ conservation approaches. Protected area network: biosphere reserves, national parks, wildlife sanctuaries, conservation reserves, and community reserves. Management of wetlands, grasslands, mangroves, and coastal ecosystems. Biological resources and ecosystem services. Biological Diversity Act, 2002, People's Biodiversity Registers (PBRs), and Biodiversity Management Committees (BMCs).	15 Hrs.
IV	Energy, Mineral and Integrated Natural Resource Management Energy resources: conventional and non-conventional energy resources, energy conservation, energy efficiency, renewable energy technologies, and sustainable energy management. Mineral resources: occurrence, exploration, extraction, utilization, environmental impacts of mining, mine reclamation, and sustainable mining practices. Management of agricultural resources, rangelands, fisheries, and coastal resources. Climate change and natural resource management. Ecosystem-based adaptation and nature-based solutions. Environmental policies and legal frameworks related to natural resource management in India.	15 Hrs.

Reference Books:

1. Owen, O.S. and Chiras, D.D. – *Natural Resource Conservation: Management for a Sustainable Future* – Pearson Education, New Delhi.
2. Randall, A. – *Resource Economics: An Economic Approach to Natural Resource and Environmental Policy* – John Wiley & Sons.
3. Rees, J. – *Natural Resources: Allocation, Economics and Policy* – Routledge Publications.
4. Barrow, C.J. – *Environmental Management and Development* – Routledge, London.
5. Miller, G.T. and Spoolman, S.E. – *Environmental Science* – Cengage Learning.
6. Singh, J.S., Singh, S.P. and Gupta, S.R. – *Ecology, Environment and Resource Conservation* – Anamaya Publishers, New Delhi.

7. Kumar, B.M. and Nair, P.K.R. – *Tropical Homegardens: A Time-Tested Example of Sustainable Agroforestry* – Springer Publications.
8. Mather, A.S. and Chapman, K. – *Environmental Resources* – Longman Scientific Publications.
9. Murthy, J.V.S. – *Watershed Management* – New Age International Publishers.
10. Michael, A.M. – *Irrigation Theory and Practice* – Vikas Publishing House.
11. Brady, N.C. and Weil, R.R. – *The Nature and Properties of Soils* – Pearson Education.
12. Sengupta, M. – *Environmental Geology* – CBS Publishers & Distributors.
13. Khoshoo, T.N. – *Environmental Priorities in India and Sustainable Development* – Oxford University Press.
14. Primack, R.B. – *Essentials of Conservation Biology* – Sinauer Associates.
15. Khanna, D.R. and Singh, V.P. – *Forest Ecology and Biodiversity Conservation* – Discovery Publishing House.
16. Twidell, J. and Weir, T. – *Renewable Energy Resources* – Taylor & Francis.
17. Boyle, G. – *Renewable Energy: Power for a Sustainable Future* – Oxford University Press.
18. Danielson, L. and Lang, R. – *Mineral Resources and Environmental Management* – Springer Publications.
19. Rajagopalan, R. – *Environmental Studies: From Crisis to Cure* – Oxford University Press.
20. Agarwal, A., Narain, S. and Khurana, I. – *Making Water Everybody's Business: Practice and Policy of Water Harvesting* – Centre for Science and Environment (CSE), New Delhi.

RM	Research Methodology	Total Contact Hrs. 60
Credits:04	Load/week:04	UA - Marks:60 CA - Internal:40

Course Objectives

1. To provide comprehensive understanding of research methodology, scientific approaches, data collection techniques, and research design in Environmental Science.
2. To develop scientific writing, research communication, ethical practices, and intellectual property management skills for environmental research and academic publications.

Course Outcomes (COs)

1. Explain the principles, types, and methodologies of scientific research and formulate research problems, objectives, and hypotheses in Environmental Science.
2. Apply research design, sampling methods, field techniques, and data collection approaches for environmental studies and investigations.
3. Develop scientific writing and communication skills for preparation of research papers, dissertations, project proposals, reports, and academic presentations.
4. Evaluate research ethics, publication practices, plagiarism issues, and intellectual property rights related to environmental research and innovation.

Unit	Contents	Contact Hrs.
I	Fundamentals of Research Methodology Concept, scope, objectives, and significance of research in Environmental Science. Principles of scientific research and experimentation in natural and environmental sciences. Types and characteristics of research: basic, applied, exploratory, descriptive, analytical, experimental, interdisciplinary, and action research. Research process and identification of research problems. Formulation of aims, objectives, and hypotheses. Research planning and components of research design, methods of research. Introduction to scientific databases, indexing, citation systems, ScienceDirect, Scopus, PubMed, Google Scholar, and e-resources.	15 Hrs.
II	Research Design, Data Collection, and Field Methodology Selection of research topics and research methodology. Literature review, library consultation, bibliography preparation, and reference management. Methods of data collection and environmental surveys. Sampling techniques and field methods for environmental studies. Questionnaire preparation, socio-economic surveys, participatory approaches. Data recording, tabulation, classification, and interpretation. Environmental monitoring methods for air, water, soil, biodiversity, and socio-environmental studies. Use of GPS, GIS, remote sensing, drones, and digital tools.	15 Hrs.
III	Scientific Writing and Research Communication Scientific writing techniques and communication skills. Preparation of abstracts, manuscripts, dissertations, theses, technical reports, review	15 Hrs.

	articles, project proposals, and research papers. Structure, formatting, and organization of scientific documents. Citation methods, footnotes, bibliography preparation, and referencing styles. Editing, proofreading, and evaluation of scientific reports and research papers. Scientific communication skills and use of digital platforms for research dissemination and academic publication.	
IV	Research Ethics, Publication, and Intellectual Property Rights Preparation and submission of research articles to scientific journals. Manuscript preparation including typing, formatting, spacing, headings, tables, illustrations, indexing, keywords, abbreviations, symbols, units, and scientific terminology. Publication ethics, plagiarism, plagiarism detection tools, and ethical issues in environmental research. Intellectual Property Rights (IPR): copyright, trademark, geographical indications, industrial design, and patents. Patent filing, drafting of claims, and patent granting procedures.	15 Hrs.

Reference Books:

1. Research Methodology: Methods and Techniques by C.R. Kothari and Gaurav Garg, published by New Age International Publishers, New Delhi.
2. Research Methodology by R. Panneerselvam, published by PHI Learning Pvt. Ltd., New Delhi.
3. Scientific Method in Environmental Sciences by G. Tyler Miller and Scott Spoolman, published by Cengage Learning.
4. Practical Research: Planning and Design by Paul D. Leedy and Jeanne Ellis Ormrod, published by Pearson Education.
5. Research Methods for Environmental Studies by Mark S. Reed and Evan D.G. Fraser, published by Wiley Publications.
6. The Craft of Research by Wayne C. Booth, Gregory G. Colomb, and Joseph M. Williams, published by University of Chicago Press.
7. Scientific Writing and Communication by Angelika H. Hofmann, published by Oxford University Press.
8. Writing Research Papers by James D. Lester and James D. Lester Jr., published by Pearson Education.
9. Environmental Research Methodology by R.M. Lodha, published by RBSA Publishers, Jaipur.
10. Biostatistics and Research Methodology by P. Ramakrishnan, published by Saras Publications.
11. Research Ethics and Publication by A. Chatterjee, published by Oxford University Press.
12. Essentials of Research Design and methodology by G. Marcyk David Demattes and David festinger, Essential of behavioral Science,2005, John wiley and sons' New jersey.
13. Fundamentals of Research methodology and data collection by Chinelo Igwenagy, Enugu state Writessity of Science and technology, 2016 Research Gate Publications.
14. Research methodology: A Step-by-step guide for beginners by Ranjit Kumar 2011 Sage Publication, London UK.

PRACTICAL'S

DSC-1P	Practical – 1: Based on DSC 1-1 Environmental Science and Global Environmental Issues	Total Contact Hrs. 60
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Practical's:

1. Study and identification of biotic and abiotic components of the environment.
2. Preparation and analysis of food chains, food webs, and ecological pyramids of different ecosystems.
3. Measurement of atmospheric parameters such as temperature, humidity, and rainfall using basic meteorological instruments.
4. Field study of ecosystem structure and functions in terrestrial or aquatic ecosystems.
5. Identification and classification of rocks, minerals, and soil types from local areas.
6. Soil analysis for texture, moisture, pH, and organic matter content.
7. Study of hydrological cycle and assessment of local water resources.
8. Identification of local flora and fauna and preparation of biodiversity records.
9. Identification of ecological indicators.
10. Environmental pollution survey and assessment of air, water, soil, or noise pollution in nearby areas.
11. Field visit to forest, wetland, river, industrial area, or biodiversity park for ecosystem study.

Practical References:

1. Environmental Biology: Practical Manual by P.D. Sharma, published by Rastogi Publications, Meerut.
2. Laboratory Manual in Environmental Science by M. Anji Reddy, published by BS Publications, Hyderabad.
3. Fundamentals of Ecology by Eugene P. Odum and Gary W. Barrett, published by Cengage Learning India Pvt. Ltd.
4. Standard Methods for the Examination of Water and Wastewater by APHA, AWWA, and WEF, published by American Public Health Association, Washington D.C.
5. Environmental Chemistry Laboratory Manual by A.K. De, published by New Age International Publishers, New Delhi.
6. Methods in Environmental Analysis by R.K. Trivedy and P.K. Goel, published by Environmental Publications, Karad.
7. Practical Ecology by P.S. Verma and V.K. Agarwal, published by S. Chand Publishing, New Delhi.

DSC-2P	Practical – 2: Based on DSC 1-2 Environmental Chemistry and Analytical Techniques	Total Contact Hrs. 60
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Practical's:

- 1) Sampling technique of water and wastewater
- 2) Determination of pH – pH metric method and Determination of Electrical Conductance – Conductivity meter method
- 3) Estimation of Turbidity – Nephelometric method
- 4) TS, TSS & TDS – Gravimetric and Filtration method
- 5) Estimation of Acidity – Alkalimetric method / CO₂ – NaOH titration method and Estimation of Alkalinity – Acidimetric method
- 6) Estimation of Hardness – EDTA Complexometric method
- 7) Estimation of Chlorides – Argentometric method
- 8) Estimation of Dissolved Oxygen – Modified Winkler's method
- 9) Estimation of Biochemical Oxygen Demand (BOD)
- 10) Estimation of Chemical Oxygen Demand (COD)
- 11) Estimation of Nitrates – Phenoldisulfonic Acid method
- 12) Estimation of Fluorides – Fluoride meter method/SPADNS Reagent method
- 13) Estimation of Sulphates – Barium chloride method
- 14) Principal, Working, demonstration and applications of flame photometer, Turbidity meter, Colorimeter and HVS / AFD ambient sampler
- 15) Visit to Instrumentation Centre for XRD, XRF, NMR, AAS, GC-MS and UV spectrophotometer.

Practical References:

- 1) Trivedi, P. K. and Goel, P. K. (1984). Chemical and Biological Methods of Water Pollution Studies. Environmental Publication.
- 2) Standard Methods for the Examination of Water and Wastewater by APHA, AWWA, and WEF, published by American Public Health Association, Washington D.C.
- 3) Nandini, N. (2009). Handbook on water quality monitoring and Assessment. Sapna Book House, Bengaluru.
- 4) Sawyer, C. N. and Mc Carty, P. L. (1978). Chemistry for Environmental Engineering. Mc Graw – Hill International.
- 5) Saxena M M. (1990). Environmental Analysis: Water, Soil and Air. Edition, 2. Publisher, Agro Botanical Pub.
- 6) Standard Methods for Examination of Water and Wastewater. (2017). APHA – WEF.
- 7) Zhang, C. (2007). Fundamentals of environmental sampling and analysis. John Wiley & Son.

DSE-1P	Practical – 3: Based on DSE 1-1 (Any one) 1. Ecology, Ecosystem Dynamics and Biodiversity 2. Energy and Environment 3. Natural Resource Management	Total Contact Hrs. 60
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Practical's: 1. Ecology, Ecosystem Dynamics and Biodiversity

1. Determination of minimum size of a quadrat for study of a grassland study.
2. Determination of frequency, diversity and dominance of different species in grassland ecosystem.
3. Determination of Important Value Index some species in a grassland ecosystem.
4. Measurement of productivity of the pond ecosystem by Winkler's Oxygen liberation method.
5. Measurement of ecological parameters such as species richness, dominance, diversity indices, and evenness.
6. Study of ecological succession and community structure in terrestrial or aquatic ecosystems.
7. Field survey and mapping of habitats, niches, and ecotones in nearby ecosystems.
8. Assessment of soil and water characteristics influencing ecosystem dynamics.
9. Biodiversity assessment and documentation in forest, grassland, wetland, river, or urban ecosystems.
10. Study of invasive alien species and their ecological impacts in local environments.
11. Field visit to protected areas, wildlife sanctuaries, biodiversity parks, wetlands, or national parks for ecological observations.

Practical's: 2. Energy and Environment

1. Assessment of household, institutional, or industrial energy consumption patterns and energy auditing.
2. Determination of calorific value of solid or liquid fuels using calorimeter.
3. Measurement and estimation of solar radiation and solar energy potential.
4. Study of wind energy systems and calculation of wind energy potential using meteorological data.
5. Preparation and operation of small-scale biogas plant or biogas generation model.
6. Estimation of biomass energy potential from agricultural residues and organic wastes.
7. Field visit to solar power plant, wind farm, hydropower station, thermal power plant, or biogas plant.
8. Survey and assessment of waste generation and waste-to-energy potential in urban or rural areas.

Practical's: 3. Natural Resource Management

1. Preparation of natural resource inventory and classification of renewable and non-renewable resources.
2. Estimation of water demand and water budgeting for a village, institution, or urban area.
3. Calculation of carrying capacity and ecological footprint using standard methodologies.
4. Preparation and analysis of watershed maps using topographical sheets, GIS, and GPS data.
5. Preparation of People's Biodiversity Register (PBR) format and biodiversity documentation.
6. Field study of soil erosion, land degradation, salinity, waterlogging, and desertification-affected areas.
7. Watershed delineation and field assessment of watershed management structures such as check dams, farm ponds, percolation tanks, and recharge structures.
8. Survey and assessment of groundwater resources, wells, borewells, and groundwater recharge systems.
9. Forest vegetation analysis using quadrat, transect, and point-centered quarter methods.
10. Field visit to protected areas, biodiversity parks, wildlife sanctuaries, community reserves, or biosphere reserves.
11. Survey of renewable energy installations such as solar parks, biogas plants, wind energy systems, and biomass energy projects.
12. Field visit to mining areas for assessment of environmental impacts and mine reclamation practices.
13. Visit to a watershed development projects, forest ecosystem or protected area, a renewable energy project (solar/wind/biogas), wetland ecosystem, mining area and mine reclamation site, village implementing integrated natural resource management (INRM) practices.

Practical References:

1. Ecology and Environment by P.D. Sharma, published by Rastogi Publications, Meerut.
2. A Handbook of Field and Laboratory Methods for General Ecology by James E. Brower, Jerrold H. Zar, and Carl N. von Ende, published by McGraw-Hill Publications.
3. Practical Ecology by P.S. Verma and V.K. Agarwal, published by S. Chand Publishing, New Delhi.
4. Biodiversity: Concepts, Conservation and Management by S.S. Negi, published by International Book Distributors, Dehradun.
5. Renewable Energy Sources and Emerging Technologies by D.P. Kothari, K.C. Singal, and Rakesh Ranjan, published by PHI Learning Pvt. Ltd., New Delhi.
6. Biogas Technology by K. Kishore, published by TERI Press, New Delhi.
7. Renewable Energy: Power for a Sustainable Future by Godfrey Boyle, published by Oxford University Press.
8. Solar Energy Engineering by S.P. Sukhatme and J.K. Nayak, published by McGraw-Hill Education.
9. A Textbook of Practical Geology by G.B. Mahapatra, published by CBS Publishers and Distributors, New Delhi.
10. Geomorphology by Savindra Singh, published by Prayag Pustak Bhawan, Allahabad.
11. Introduction to Oceanography by Harold V. Thurman and Alan P. Trujillo, published by Pearson Education.

12. Atmosphere, Weather and Climate by Roger G. Barry and Richard J. Chorley, published by Routledge Publications.
13. Michael, A.M. and Ojha, T.P. – *Principles of Agricultural Engineering (Vol. I)* – Jain Brothers Publishers, New Delhi.
14. Murthy, J.V.S. – *Watershed Management* – New Age International Publishers, New Delhi.
15. Brady, N.C. and Weil, R.R. – *The Nature and Properties of Soils* – Pearson Education, New Delhi.
16. Misra, R. – *Ecology Workbook* – Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
17. Singh, J.S., Singh, S.P. and Gupta, S.R. – *Ecology, Environment and Resource Conservation* – S. Chand Publishing, New Delhi.
18. Kumar, B.M. and Nair, P.K.R. – *Tropical Homegardens and Agroforestry Systems* – Springer Publications, Netherlands.
19. Twidell, J. and Weir, T. – *Renewable Energy Resources* – Taylor & Francis Group, London.
20. Rajagopalan, R. – *Environmental Studies: From Crisis to Cure* – Oxford University Press, New Delhi.

SYLLABUS: M.Sc. Part I Semester –II

M.Sc. Part I, Semester –II		
Code	Title of the Paper	Credits
DSC-3	Water and Wastewater Treatment Engineering	4
DSC-4	Environmental Pollution Control and Management	4
DSE-2	1. Climate Change Science, Adaptation and Mitigation	4
	2. Environmental Microbiology, Biotechnology and Nanotechnology	
	3. Environmental Geospatial Technologies and Applications	
OJT/FP	OJT/FP/ In-house Project/Internship/Apprenticeship	4
DSC-3P	Practical-4	2
DSC-4P	Practical-5	2
DSE-2P	Practical-6	2
Total for Semester-II		22

Syllabus - M.Sc. Part I, Semester –II

DSC 1-3	Water and Wastewater Treatment Engineering	Total Contact Hrs. 60
Credits:04	Load/week:04	UA - Marks:60 CA - Internal:40

Course Objectives

1. To provide fundamental and applied knowledge of water demand estimation, water quality standards, and wastewater treatment systems used in environmental management.
2. To develop understanding of physical, chemical, biological, and advanced treatment processes involved in water and wastewater purification and pollution control.

Course Outcomes (COs)

1. Analyze water demand, population forecasting methods, and interpret drinking water quality standards (BIS and WHO).
2. Explain and apply physical and physico-chemical treatment processes used in water and wastewater treatment systems.
3. Understand and evaluate biological wastewater treatment systems including aerobic, anaerobic, and constructed wetland technologies.
4. Assess advanced treatment technologies, membrane systems, disinfection methods, and sludge management strategies for sustainable wastewater treatment.

Unit	Contents	Contact Hrs.
I	<p>Water Demand, Quality Standards and Treatment Systems</p> <p>Water resources and water demand: domestic, institutional, industrial, agricultural, commercial, firefighting, and recreational water consumption. Water requirement estimation and per capita demand. Population forecasting methods for water supply and wastewater generation: arithmetic increase method, geometric increase method, incremental increase method, and logistic growth model. Water quality and standards: drinking water quality standards as per BIS, WHO guidelines, and packaged drinking water standards. Water quality parameters and significance in public health. Overview of WTP, ETP, CETP and STP.</p>	15 Hrs.
II	<p>Physical and Physico-Chemical Treatment Processes</p> <p>Principles and applications of physical unit operations in water and wastewater treatment.</p> <p><u>Design and functioning of screening systems:</u> bar screens, fine screens, and comminutors. Grit removal systems: grit chambers and detritus tanks. Skimming tanks and oil/grease removal systems.</p> <p><u>Sedimentation processes:</u> types of settling, sedimentation tanks, and clarifiers.</p> <p><u>Coagulation and flocculation:</u> principles, chemical coagulants, process control, and design considerations.</p>	15 Hrs.

	<u>Chemical treatment processes</u> : precipitation, pH adjustment, disinfection methods and operational parameters. Introduction to physicochemical treatment systems and their role in removal of suspended solids, colloids, oils, and microbial contaminants.	
III	<p>Biological Wastewater Treatment Systems</p> <p>Principles of biological treatment processes and microbial role in wastewater degradation.</p> <p><u>Aerobic treatment systems</u>: Activated Sludge Process (ASP), oxidation ponds, aerated lagoons, stabilization ponds, and their design and operational aspects.</p> <p><u>Anaerobic treatment systems</u>: septic tanks, Imhoff tanks, Upflow Anaerobic Sludge Blanket (UASB) reactors, trickling filters, Rotating Biological Contactors (RBCs), and Continuous Stirred Tank Reactors (CSTR).</p> <p><u>Advanced biological systems</u>: constructed wetlands and Root Zone Treatment Technology. Advantages, limitations, and applications of biological wastewater treatment systems.</p>	15 Hrs.
IV	<p>Advanced Treatment Processes and Sludge Management</p> <p>Activated carbon adsorption, PACT, advanced oxidation processes, and water softening methods.</p> <p><u>Membrane-based technologies</u>: microfiltration, ultrafiltration, nanofiltration, reverse osmosis, ion exchange systems, and membrane bioreactors (MBR).</p> <p><u>Disinfection techniques</u>: UV radiation, ozonation, chlorination, and emerging disinfection technologies. Wet air oxidation and advanced pollutant removal techniques.</p> <p><u>Wastewater reuse and disposal</u>: discharge into land, river, and marine environments with environmental considerations.</p> <p><u>Sludge management</u>: characteristics, generation, and treatment. Sludge processing methods including thickening, conditioning, dewatering, composting, vermicomposting, alkaline stabilization, incineration, sanitary landfilling, and bioremediation-based green technologies. Sustainable approaches in sludge and wastewater management and circular economy concepts.</p>	15 Hrs.

Reference Books:

1. Metcalf & Eddy, Inc. Wastewater Engineering: Treatment and Resource Recovery. McGraw-Hill Education.
2. Peavy, H.S., Rowe, D.R. and Tchobanoglous, G. Environmental Engineering. McGraw-Hill Book Company.
3. Davis, M.L. and Cornwell, D.A. Introduction to Environmental Engineering. McGraw-Hill Education.
4. Sawyer, C.N., McCarty, P.L. and Parkin, G.F. Chemistry for Environmental Engineering and Science. McGraw-Hill Education.
5. Hammer, M.J. and Hammer, M.J. Jr. Water and Wastewater Technology. Pearson Education.

6. Qasim, S.R. Wastewater Treatment Plants: Planning, Design and Operation. CRC Press.
7. Arceivala, S.J. Wastewater Treatment and Disposal. Marcel Dekker Inc.
8. CPHEEO Manual, Manual on Sewerage and Sewage Treatment Systems. Ministry of Housing and Urban Affairs, Government of India.
9. WHO. Guidelines for Drinking-water Quality. World Health Organization Publications.
10. BIS (Bureau of Indian Standards). Drinking Water Specification IS 10500. Bureau of Indian Standards.

DSC 1-4	Environmental Pollution, Control and Management	Total Contact Hrs. 60
Credits:04	Load/week:04	UA - Marks:60 CA - Internal:40

Course Objectives

1. To provide scientific understanding of major environmental pollutants in air, water, soil, solid waste, noise, and radiation along with their sources, impacts, and environmental behaviours.
2. To develop knowledge and skills in pollution control technologies, environmental monitoring, and sustainable waste management practices for environmental protection and regulatory compliance.

Course Outcomes (COs)

1. Identify and analyze different types of environmental pollutants and explain their sources, behaviour, and impacts on ecosystems and human health.
2. Evaluate air, water, soil, noise, solid waste, and radiation pollution control strategies and technologies used in environmental management.
3. Apply scientific principles and environmental standards (AQI, water quality, soil quality, radiation limits) for monitoring and assessment of pollution levels.
4. Develop sustainable solutions for pollution control, waste management, and environmental protection in accordance with national and global environmental policies.

Unit	Contents	Contact Hrs.
I	<p>Air and Noise Pollution Control</p> <p>Air Pollution: Definition, classification, and sources of air pollutants. Major pollutants: SO₂, NO₂, CO, O₃, HF, particulate matter, and photochemical oxidants. Formation of photochemical smog and its impacts. Effects of air pollution on human health, vegetation, ecosystems, and materials. Aeroallergens and allergic responses. Ozone layer depletion: causes, mechanisms, and consequences. Air quality standards, air quality index (AQI), and National Air Monitoring Programme (NAMP). Air pollution control strategies and technologies. Control devices: settling chambers, cyclones, fabric filters, wet scrubbers, and electrostatic precipitators.</p> <p>Noise Pollution: Definition of noise and sound pressure level (SPL). Decibel scale and measurement of noise. Sources of noise pollution: industrial, transportation, construction, and domestic activities. Effects of noise pollution on human health including hearing loss, stress, and sleep disturbance. Noise standards, permissible limits, and noise control measures including engineering, administrative, and protective approaches.</p>	15 Hrs.
II	<p>Water Pollution and Thermal Pollution</p> <p>a. Water Pollution: Types, classification, and sources of water pollution. Physico-chemical and biological characteristics of freshwater and marine systems. Water quality standards and parameters. Impacts of pollutants on</p>	15 Hrs.

	<p>aquatic ecosystems, human health, and agriculture. Oil pollution and marine pollution: fate and behavior of oil spills (spreading, evaporation, emulsification, dispersion). Water pollution control methods: bioremediation, bioaugmentation, and biostimulation. Water resource management strategies: rainwater harvesting, groundwater recharge, wastewater reuse, and industrial effluent recycling.</p> <p>b. Thermal Pollution: Definition, sources, and characteristics of thermal pollution. Impacts of temperature changes on aquatic ecosystems, microbial activity, and water quality. Effects on marine biodiversity and ecosystem functioning. Thermal pollution from power plants and industries. Control measures and mitigation strategies.</p>	
III	<p>Soil Pollution and Solid Waste Management</p> <p>a. Soil Pollution: Definition of soil pollution and contamination. Sources: agricultural chemicals, pesticides, fertilizers, industrial wastes, heavy metals, and radionuclides. Effects on soil fertility, structure, and productivity. Soil salinity, alkalinity, acidification, and land degradation. Soil pollution interactions with climate change including greenhouse gas emissions and carbon sequestration. Soil quality monitoring and remediation approaches.</p> <p>b. E-Waste and Hazardous Waste: Definition, sources, composition, and classification of e-waste and hazardous waste. Environmental and health impacts of improper disposal. Waste management practices: recycling, recovery, treatment, and safe disposal. Regulatory frameworks and sustainable management approaches.</p>	15 Hrs.
IV	<p>Solid Waste and Radiation Pollution Management</p> <p>a. Solid Waste Pollution: Types and classification of solid waste: municipal, industrial, biomedical, agricultural, and nuclear waste. Sources and environmental impacts. Waste management hierarchy: reduction, reuse, recycle, recovery, and disposal. Waste treatment methods: composting, vermicomposting, incineration, pyrolysis, landfilling, and waste-to-energy technologies. Transportation and handling of solid waste and environmental safety considerations.</p> <p>b. Radiation Pollution: Types of radiation: ionizing and non-ionizing. Natural and anthropogenic sources of radiation. Measurement and detection techniques for radiation. Biological effects of radiation on human health and environment. Nuclear reactor safety and radiation protection principles. Studies of nuclear accidents and environmental consequences.</p>	15 Hrs.

Reference Books:

1. Yogendra N Srivastava. (2009). Environmental Pollution. Ashish Publishing House - APH Publishing Corporation.
2. Trivedi P. R. (2004). Environmental Pollution and Control. Ashish Publishing House - APH Publishing Corporation.
3. Rao, C.S. – Environmental Pollution Control Engineering, New Age International Publishers.

4. Bhatia H. S. (2003). A Textbook on Environmental Pollution and Control. Galgotia Publications Private Limited, Delhi.
5. Mark L. Brusseau, Ian L. Pepper and Charles P. Gerba. (2019). Environmental and Pollution. Academic Press.
6. Marquita K. Hill. (2012). Understanding Environmental Pollution. Cambridge University Press.
7. Peirce, J. J., Vesilind, P. A., & Weiner, R. (1998). Environmental pollution and control. Butterworth-Heinemann.
8. Peavy, H.S., Rowe, D.R. & Tchobanoglous, G. – Environmental Engineering, McGraw-Hill Education.
9. Manahan, S.E. – Environmental Chemistry, CRC Press / Lewis Publishers.
10. Cunningham, W.P. & Cunningham, M.A. – Principles of Environmental Science, McGraw-Hill.
11. Masters, G.M. & Ela, W.P. – Introduction to Environmental Engineering and Science, Pearson Education.
12. Nathanson, J.A. – Basic Environmental Technology, Prentice Hall.
13. Neboor, J. & others – Environmental Pollution Control Engineering, CBS Publishers.
14. Central Pollution Control Board (CPCB) – Environmental Standards and Guidelines (India), Government of India Publications.
15. World Health Organization (WHO) – Air and Water Quality Guidelines, WHO Publications.

DSE 1-2	1. Climate Change Science, Adaptation and Mitigation	Total Contact Hrs. 60
Credits:04	Load/week:04	UA - Marks:60 CA - Internal:40

Course Objectives

1. To develop a scientific understanding of the Earth's climate system, climate variability, and the drivers and evidence of climate change at global, national, and regional scales.
2. To equip students with knowledge of climate change impacts, vulnerability assessment, adaptation strategies, and mitigation approaches including policy frameworks, technologies, and sustainable development pathways.

Course Outcomes (COs)

1. Explain the structure and functioning of the climate system, greenhouse effect, carbon cycle, and evidence of climate change using scientific principles.
2. Analyze the impacts of climate change on water resources, agriculture, ecosystems, biodiversity, and socio-economic systems, especially in Indian and semi-arid contexts like Solapur.
3. Evaluate climate change adaptation strategies including ecosystem-based adaptation, climate-smart agriculture, watershed management, and GIS-based vulnerability assessment.
4. Apply knowledge of climate mitigation approaches and global climate governance frameworks such as UNFCCC, IPCC, Paris Agreement, carbon trading, and renewable energy transitions for sustainable development.

Unit	Contents	Contact Hrs.
I	Fundamentals of Climate System and Climate Change Science Climate system: atmosphere, hydrosphere, biosphere, lithosphere interactions. Weather vs climate. Earth's energy balance and radiation budget. Greenhouse effect and greenhouse gases (CO ₂ , CH ₄ , N ₂ O, CFCs). Carbon cycle and climate feedback mechanisms. Climate variability and drivers of climate change (natural and anthropogenic). Evidence of climate change: temperature rise, sea level rise, glacier melting, and extreme events. Introduction to IPCC assessment reports and climate models.	15 Hrs.
II	Climate Change Impacts and Vulnerability Assessment Impacts of climate change on physical systems (heat waves, droughts, floods, cyclones). Impacts on water resources, agriculture, biodiversity, and ecosystems. Indian monsoon variability and regional climate change in Maharashtra and semi-arid regions like Solapur. Urban climate stress, heat island effect, and health impacts. Vulnerability assessment and risk mapping. Climate change and socio-economic systems including livelihoods, food security, and rural development.	15 Hrs.
III	Climate Change Adaptation and Resilience Strategies Concept of adaptation and adaptive capacity. Ecosystem-based adaptation and community-based adaptation. Water conservation strategies for drought-	15 Hrs.

	prone regions (rainwater harvesting, watershed management, groundwater recharge). Climate-smart agriculture and sustainable land management. Disaster risk reduction and early warning systems. Role of GIS and geospatial tools in climate adaptation planning. National Action Plan on Climate Change (NAPCC) and State Action Plans (SAPCC).	
IV	Climate Change Mitigation and Global Climate Governance Mitigation strategies: renewable energy (solar, wind, biomass), energy efficiency, carbon sequestration, afforestation and reforestation. Low-carbon development pathways and carbon footprint reduction. Carbon trading, clean development mechanisms (CDM), and net-zero concepts. International climate governance: UNFCCC, Kyoto Protocol, Paris Agreement, COP negotiations. Role of IPCC in global climate policy. Climate finance and sustainable development goals (SDGs), climate action (SDG-13).	15 Hrs.

Reference Books:

1. IPCC (Intergovernmental Panel on Climate Change) – Assessment Reports (AR6 and earlier reports), Cambridge University Press / IPCC Publications.
2. Archer, D. – Global Warming: Understanding the Forecast, Wiley-Blackwell Publications.
3. Ruddiman, W.F. – Earth’s Climate: Past and Future, W.H. Freeman and Company.
4. Houghton, J. – Global Warming: The Complete Briefing, Cambridge University Press.
5. Kumar, R. & Singh, J. – Climate Change and Sustainable Development, Springer Nature.
6. Singh, S. – Climate Change: Science, Impacts and Mitigation, Pearson Education India.
7. Dash, S.K. & Hunt, J.C.R. – Variability of the Indian Monsoon and Climate Change, Springer.
8. Pielke, R. – Climate Change: The Science, Impacts and Solutions, Routledge.
9. UNFCCC – Climate Change Reports and Conference Proceedings, United Nations Publications.
10. TERI (The Energy and Resources Institute) – Climate Change in India: Policy and Action Reports, TERI Press.
11. The Climate Solution: India's Climate Change Crisis and What We Can Do About It by Mridula Ramesh, Hachette India (2018).
12. Climate Change Biodiversity and Green Economy by H.S. Sharma S. Padmaja and Ganesh Sharma, Concept Publishing Company Pvt. Ltd. (2013).
13. Climate Change by Joseph Romm, OUP US (2018). Environment and Sustainable Development by M.H. Fulekar, Bhawana Pathak, R K Kale, Springer Nature (2013).
14. The Age of Sustainable Development by Jeffrey D. Sachs and Ban Ki-moon, Columbia University Press (2015).
15. Target 3 Billion: Innovative Solutions Towards Sustainable Development by APJ Abdul Kalam, Srijan Pal Singh, Penguin India (2011).

DSE 1-2	2. Environmental Microbiology, Biotechnology and Nanotechnology	Total Contact Hrs. 60
Credits:04	Load/week:04	UA - Marks:60 CA - Internal:40

Course Objectives

1. To develop a strong understanding of environmental microbiology, biotechnology, and nanotechnology principles and their roles in ecosystem functioning, environmental quality, and sustainable resource management.
2. To equip students with scientific knowledge and applied skills for utilizing microbial, biotechnological, and nanotechnological approaches in pollution control, environmental monitoring, waste management, climate change mitigation, and sustainable development.

Course Outcomes (COs)

1. Explain the diversity, ecology, metabolism, and environmental significance of microorganisms and their roles in biogeochemical cycles and ecosystem processes.
2. Apply environmental biotechnology techniques for bioremediation, wastewater treatment, waste management, environmental monitoring, and restoration of polluted ecosystems.
3. Evaluate the principles, applications, opportunities, and environmental implications of nanotechnology and advanced environmental technologies for pollution control and resource conservation.
4. Integrate microbiological, biotechnological, and nanotechnological approaches to address environmental challenges related to sustainability, climate change, circular bioeconomy, and ecosystem management.

Unit	Contents	Contact Hrs.
I	Fundamentals of Environmental Microbiology Introduction, scope, history, and significance of Environmental Microbiology. Classification, morphology, physiology, growth, and metabolism of microorganisms including bacteria, fungi, algae, protozoa, archaea, and viruses. Microbial ecology and microbial interactions. Microorganisms in air, water, soil, sediments, and extreme environments. Role of microorganisms in biogeochemical cycles of carbon, nitrogen, phosphorus, sulfur, and oxygen. Environmental factors affecting microbial growth and activity. Microbial indicators of environmental quality and public health. Introduction to environmental pathogens and microbial monitoring of environmental systems.	15 Hrs.
II	Environmental Biotechnology and Bioremediation Applications Principles and scope of Environmental Biotechnology. Recombinant DNA technology, genetic engineering, metagenomics, environmental genomics, and bioinformatics. Microbial degradation of environmental pollutants. Bioremediation principles and techniques: bioaugmentation, biostimulation, phytoremediation, rhizoremediation, mycoremediation, and biosorption. Biotechnology in wastewater treatment, solid waste management, hazardous	15 Hrs.

	waste treatment, and industrial pollution control. Biosensors and bioindicators for environmental monitoring. Biotechnology applications in environmental restoration and pollution management.	
III	Environmental Nanotechnology and Advanced Environmental Technologies Fundamentals of nanotechnology, nanomaterials, and nanoparticle synthesis (physical, chemical, and biological methods). Green synthesis of nanoparticles using plants and microorganisms. Characterization and properties of nanomaterials. Applications of nanotechnology in water purification, wastewater treatment, air pollution control, soil remediation, environmental monitoring, and waste management. Nanobiosensors and smart environmental monitoring systems. Nanotechnology in renewable energy, carbon capture, and climate change mitigation. Environmental fate, transport, ecotoxicology, and risk assessment of nanomaterials.	15 Hrs.
IV	Sustainable Environmental Technologies and Future Perspectives Biofertilizers, biopesticides, bioinoculants, and microbial technologies for sustainable agriculture. Bioenergy production: biogas, bioethanol, biodiesel, biohydrogen, and microbial fuel cells. Circular bioeconomy and resource recovery from waste. Integrated applications of microbiology, biotechnology, and nanotechnology in climate change mitigation, ecosystem restoration, water conservation, and pollution prevention. Biosafety, bioethics. Emerging trends: synthetic biology, environmental omics, artificial intelligence in biotechnology, nano-enabled environmental solutions, and green technologies.	15 Hrs.

Reference Books:

1. Maier, R. M., Pepper, I. L. & Gerba, C. P. (2015). *Environmental Microbiology* (3rd Edition). Academic Press, USA.
2. Pepper, I. L., Gerba, C. P. & Gentry, T. J. (2018). *Environmental Microbiology* (4th Edition). Academic Press, USA.
3. Atlas, R. M. & Bartha, R. (1998). *Microbial Ecology: Fundamentals and Applications* (4th Edition). Benjamin/Cummings Publishing Company, USA.
4. Prescott, L. M., Harley, J. P. & Klein, D. A. (2017). *Microbiology* (10th Edition). McGraw-Hill Education, USA.
5. Madigan, M. T., Bender, K. S., Buckley, D. H., Sattley, W. M. & Stahl, D. A. (2021). *Brock Biology of Microorganisms* (16th Edition). Pearson Education, USA.
6. Rittmann, B. E. & McCarty, P. L. (2020). *Environmental Biotechnology: Principles and Applications*. McGraw-Hill Education, USA.
7. Scragg, A. H. (2018). *Environmental Biotechnology* (3rd Edition). Oxford University Press, UK.
8. Fulekar, M. H. (2010). *Environmental Biotechnology*. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.

9. Thakur, I. S. (2018). *Environmental Biotechnology: Basic Concepts and Applications*. I.K. International Publishing House Pvt. Ltd., New Delhi.
10. Singh, A., Kuhad, R. C. & Ward, O. P. (2009). *Advances in Applied Bioremediation*. Springer, Germany.
11. Bhardwaj, M. & Sharma, A. (2022). *Environmental Nanotechnology*. CBS Publishers & Distributors Pvt. Ltd., New Delhi.
12. Mohan, D. & Pittman, C. U. (2017). *Nanotechnology Applications for Clean Water*. Elsevier, Netherlands.
13. Bhushan, B. (2017). *Springer Handbook of Nanotechnology* (4th Edition). Springer, Germany.
14. Karn, B., Kuiken, T. & Otto, M. (2009). *Nanotechnology and In Situ Remediation: A Review of the Benefits and Potential Risks*. Springer, USA.
15. Kumar, A. & Roy, S. (2018). *Nanotechnology and Environmental Sustainability*. Wiley-Blackwell, USA.
16. Miller, G. T. & Spoolman, S. E. (2022). *Environmental Science and Sustainability* (17th Edition). Cengage Learning, USA.
17. Cunningham, W. P. & Cunningham, M. A. (2021). *Principles of Environmental Science* (10th Edition). McGraw-Hill Education, USA.
18. Khan, F. I. & Husain, T. (2019). *Environmental Management and Sustainable Development*. Springer Nature, Singapore.
19. Wang, L. K., Pereira, N. C. & Hung, Y. T. (2010). *Biological Treatment Processes*. Humana Press, USA.
20. Metcalf & Eddy Inc. (2014). *Wastewater Engineering: Treatment and Resource Recovery* (5th Edition). McGraw-Hill Education, USA.

DSE 1-2	3. Environmental Geospatial Technologies and Applications	Total Contact Hrs. 60
Credits:04	Load/week:04	UA - Marks:60 CA - Internal:40

Course Objectives

1. To provide conceptual and applied understanding of remote sensing, GIS, GPS, and UAS technologies for environmental studies and resource management.
2. To develop skills in spatial data acquisition, image processing, and geospatial analysis for environmental monitoring and decision-making.

Course Outcomes (COs)

1. Explain fundamental principles of remote sensing, electromagnetic radiation, and sensor systems used in Earth observation.
2. Interpret satellite imagery and apply image processing techniques for environmental analysis and mapping.
3. Apply GIS concepts, spatial data models, and analysis tools for environmental resource management and planning.
4. Integrate GPS, UAS (drones), Remote Sensing, and GIS for solving real-world environmental problems and sustainable management.

Unit	Contents	Contact Hrs.
I	Fundamentals of Remote Sensing History and development of remote sensing. Definition, concepts, and basic principles. Energy sources and radiation principles. Electromagnetic radiation (EMR) and its interaction with atmosphere and Earth surface materials. Sensors: active and passive sensors, and their types. Concept of spatial, spectral, temporal, and radiometric resolution. Spectral signatures of land, water, soil, and vegetation. Introduction to thermal, microwave, and hyperspectral remote sensing techniques. Spectral reflectance properties and their applications in environmental studies.	15 Hrs.
II	Remote Sensing Platforms, Data Products and Photogrammetry Aerial photography: types, scale, mosaics, and photographic systems. Orbital characteristics and seasonal effects in remote sensing data acquisition. Satellite remote sensing: geostationary and sun-synchronous satellites, satellite data products, and Indian space programmes. Fundamentals of photogrammetry: principles, types, and applications. Image interpretation techniques: visual and digital interpretation, interpretation elements, and tools. Digital image processing: image rectification, enhancement, classification, data fusion, and biophysical modeling. Overview of image processing software used in environmental applications.	15 Hrs.
III	Geographic Information System (GIS) and Spatial Data Analysis Definition, history, objectives, components, and applications of GIS. Types of spatial data: raster and vector data models. GIS data acquisition,	15 Hrs.

	digitization, editing, storage, and management. Spatial query, analysis, and visualization techniques. Concepts of geographic reference systems and map projections. Data measurement scales: nominal, ordinal, interval, and ratio. Topology: nodes, arcs, vertices, connectivity, adjacency, and containment. Remote sensing data products and their integration with GIS. Applications of GIS in environmental monitoring, natural resource management, land use/land cover studies, and coastal zone management.	
IV	GPS, Navigation Systems and UAV Applications Global Positioning System (GPS): history, principles, types, and applications. Introduction to IRNSS (NavIC) and modern navigation systems. Basics of spherical trigonometry in positioning systems. Unmanned Aircraft Systems (UAS)/drones: concepts, types, components, and operational principles. Expanding applications of UAS in environmental monitoring, agriculture, forestry, disaster management, urban planning, and security. Integration of Remote Sensing, GIS, GPS, and UAS for environmental assessment, resource mapping, and sustainable environmental management.	15 Hrs.

Reference Books:

1. Lillesand, T.M., Kiefer, R.W., and Chipman, J.W. *Remote Sensing and Image Interpretation*. Wiley.
2. Jensen, J.R. *Introductory Digital Image Processing: A Remote Sensing Perspective*. Prentice Hall.
3. Campbell, J.B. and Wynne, R.H. *Introduction to Remote Sensing*. Guilford Press.
4. Burrough, P.A. and McDonnell, R.A. *Principles of Geographical Information Systems*. Oxford University Press.
5. Chang, K. *Introduction to Geographic Information Systems*. McGraw-Hill Education.
6. Shan, J. and Toth, C.K. *Topographic Laser Ranging and Scanning: Principles and Processing*. CRC Press.
7. Srinivasan, R. *Remote Sensing Applications in Environmental Science*. Allied Publishers.
8. Joseph, G. *Fundamentals of Remote Sensing*. Universities Press (India).
9. Ahmed, E. L. Rabbany (2002): *Introduction to Global Positioning Systems*, Artech House, Boston.
10. Anji Reddy, M. (2008): *Textbook of Remote Sensing and Geographic Information System*, B.S. Publication, Hyderabad
11. Campbell, J. (2002): *Introduction to Remote Sensing*, Taylor & Francis, London
12. Demers, M. N.(2000):*Fundamentals of Geographic Information Systems*, John Wiley and Sons, New Delhi
13. Joseph, G. (2004): *Fundamentals of Remote Sensing*, Universities Press, Hyderabad, India

OJT/FP	OJT/FP/In-house Project/Internship/ Apprenticeship	Total Contact Hrs. 120
	Credits:04	UA - Marks:60 CA - Internal:40

OJT/FP (On Job Training, Internship/Apprenticeship/Field Project)

A) Industrial training:

Students are encouraged to undergo summer/winter in plant training in a suitable industry, consultancy, research laboratory, institute etc. so as to get firsthand experience of corporate environmental management.

B) Field Project Report (FP): Project Work Instructions for Students

(Total marks: 100. Project work: 60 marks, internal: 40 marks)

Candidates will write a field project report on issues related to Environmental Science under the guidance of their respective guides. Each student will work independently on the topic. The field project must consist of review of literature and produce a deep insight of the subject on the basis of personal research. Field project work will be initiated at the start of M.Sc. I year (IInd semester). The students will undertake field work in terms of collection of data and surveys. The field project will have to be submitted for appraisal and acceptance by the University. The students should submit their field project report in the following format.

1. **Abstract**
2. **Chapter I:** Introduction with Aims and Objectives: A background with historical information and a review of existing material or data on the subject along with the aims and objectives of the study.
3. **Chapter II:** Methodology with Material and Methods: Description of the issue, methodology adopted for the study.
4. **Chapter III:** Experimental: Presentation of data collected and detailed analysis of results.
5. **Chapter IV:** Result and Discussion: Discussion on the data and results obtained and Presentation of method suggested to solve the problem.
6. **Chapter V:** Summary and Conclusions: A summary of the dissertation and important conclusions drawn at the end of the investigation.
7. **Bibliography or References:** A list of references of cited in the text.

The Field Project Report should be typed on A4 size bond paper with 1.5 line spacing. Illustrations and photographs should be of high quality. The report should be flawless without any spelling mistakes or grammatical errors. Students will have to submit their field project

report one month Before the practical examination at the end of M.Sc. I year (IIndsemester). The field work report will carry 100 marks (Internal marks 20 and External marks 80). Assessment of the report will be done at the end of the year. Students have to present a Power Point Presentation. Assessment of the field work shall be done by the external examiner appointed by the PAH Solapur University.

C) Study visits: PAH Solapur University affiliated area and nearby places

- i) PAH Solapur University Instrumentation Centre
- ii) Uddyam Innovation & Incubation Centre, PAH Solapur University
- iii) Solapur Science Centre, Solapur
- iv) Forest Department Govt of Maharashtra DFO -Solapur
- v) Soil Laboratory Dept of Agriculture Govt of Maharashtra, Solapur
- vi) National Research Centre of Pomegranate (NRCP) Solapur
- vii) Krushi Vidyan Kendra Solapur
- viii) National Jawar Research Centre Solapur
- ix) National Great Indian Bird Sanctuary Nannaj Solapur
- x) Industrial visits – Chincholi MIDC, Akkalkot MIDC Solapur - Industries
- xi) National Thermal Power Station (NTPC) Solapur
- xii) Environmental Consultancy Services, NGO etc
- xiii) Ground Survey Development Authority (GSDA) Solapur
- xiv) Maharashtra Pollution Control Board, SRO - Solapur
- xv) Stone Quarry Mining Solapur
- xvi) Solapur Municipal Corporation, Solapur
- xvii) Solapur Collector Office, Solapur
- xviii) Solapur Jilha Parishad Solapur etc

D) Seminar: Student may select any environmental related topic of their choice (in consultation with the faculty) and make a power point presentation for 30 minutes. They shall be able to answer questions invited from the audience.

E) Field diary: The student shall prepare their field diary under the following heads

- i) Issue on local/regional/national problem of environmental interest (Case Studies).
- ii) About famous personalities in environmental movements.
- iii) New Acts and Judgments of environmental interests.

F) Guest lecture series: In each year guest lectures will be given by the faculty and other invited speakers on current topics and environmental issues. The course would run as a guest lecture series with compulsory attendance.

PRACTICAL'S

DSC-3P	Practical – 4: Based on DSC 1-3 Water and Wastewater Treatment Engineering	Total Contact Hrs. 60
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Practical's:

1. Draw and demonstrate flow charts/diagrams of Water Treatment Plant (WTP), Sewage Treatment Plant (STP), Effluent Treatment Plant (ETP), and Common Effluent Treatment Plant (CETP) with detailed explanation of unit operations and unit processes.
2. Calculations and exercises on population forecasting methods for water supply and wastewater generation using arithmetic, geometric, incremental increase, and logistic growth methods.
3. Determination of colour, odour, temperature, turbidity, pH, electrical conductivity, and total dissolved solids (TDS) of water and wastewater samples.
4. Determination of suspended solids, settleable solids, volatile solids, fixed solids, MLSS, MLVSS, Sludge Volume Index (SVI), and Sludge Density Index (SDI) in activated sludge samples.
5. Determination of oil and grease content in wastewater samples.
6. Determination of calcium, magnesium, sodium, potassium, ammonia nitrogen, nitrate, phosphate, and sulphate in water/wastewater samples.
7. Determination of residual chlorine and available chlorine in bleaching powder and chlorinated water samples.
8. Determination of optimum coagulant dosage by Jar Test and study of coagulation–flocculation processes for wastewater treatment.
9. Determination of optimum lime and soda dosage for hardness removal and softening of water.
10. Study and demonstration of sedimentation, filtration, adsorption, aeration, and disinfection processes used in water and wastewater treatment.
11. Preparation and operation of small laboratory models for sand filtration, activated carbon adsorption, and membrane filtration systems.
12. Estimation of sludge characteristics, sludge dewatering, composting, vermicomposting, and biogas generation from sludge or organic waste.
13. Preparation of practical record and field visit report on Water Treatment Plants (WTP), Sewage Treatment Plants (STP), Effluent Treatment Plants (ETP), and Common Effluent Treatment Plants (CETP) for the study of treatment units, process flow diagrams, operational practices, industrial wastewater treatment technologies, and environmental compliance systems.

Practical References:

1. Metcalf & Eddy, George Tchobanoglous, Franklin L. Burton and H. David Stensel – Wastewater Engineering: Treatment and Resource Recovery, McGraw Hill Education.
2. Hammer, M.J. and Hammer, M.J. Jr. – Water and Wastewater Technology, Pearson Education.
3. Peavy, H.S., Rowe, D.R. and Tchobanoglous, G. – Environmental Engineering, McGraw Hill.

4. Crittenden, J.C., Trussell, R.R., Hand, D.W., Howe, K.J. and Tchobanoglous, G. – Water Treatment: Principles and Design, John Wiley & Sons.
5. Cheremisinoff, N.P. – Handbook of Water and Wastewater Treatment Technology, Routledge Publications.
6. Garg, S.K. – Environmental Engineering: Water Supply Engineering, Khanna Publishers.
7. Garg, S.K. – Sewage Disposal and Air Pollution Engineering, Khanna Publishers.
8. Modi, P.N. – Water Supply Engineering, Standard Book House.
9. Arceivala, S.J. and Asolekar, S.R. – Wastewater Treatment for Pollution Control and Reuse, McGraw Hill Education.
10. Punmia, B.C., Jain, A.K. and Jain, A.K. – Environmental Engineering, Laxmi Publications.
11. Clair N. Sawyer, Perry L. McCarty and Gene F. Parkin – Chemistry for Environmental Engineering and Science, McGraw Hill.
12. Makarand M. Ghangrekar – Wastewater to Water: Principles, Technologies and Engineering Design, Springer Nature.
13. Manual on Water Supply and Treatment – Central Public Health and Environmental Engineering Organisation (CPHEEO), Ministry of Housing and Urban Affairs, Government of India.
14. Manual on Sewerage and Sewage Treatment Systems – CPHEEO, Government of India.
15. APHA, AWWA and WEF – Standard Methods for the Examination of Water and Wastewater, American Public Health Association.
16. Trivedi, P. K. and Goel, P. K. (1984). Chemical and Biological Methods of Water Pollution Studies. Environmental Publication.

DSC-4P	Practical – 5: Based on DSC 1-4 Environmental Pollution Control and Management	Total Contact Hrs. 60
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Practical's:

1. Determination of particulate matter (SPM, PM₁₀, and PM_{2.5}) in ambient air using High Volume Air Sampler or Respirable Dust Sampler.
2. Monitoring and estimation of gaseous air pollutants such as SO₂, NO₂, CO, and ozone from ambient air samples.
3. Measurement and analysis of Air Quality Index (AQI) using ambient air quality monitoring data.
4. Study and demonstration of air pollution control devices such as cyclone separator, bag filter, wet scrubber, and electrostatic precipitator using models or industrial setups.
5. Measurement of noise levels in industrial, commercial, residential, and silence zones using sound level meter and preparation of noise maps.
6. Study of thermal pollution effects by comparative analysis of temperature and dissolved oxygen in heated and non-heated water samples.
7. Estimation of WHC, Soil texture and soil profile
8. Determination of soil parameters such organic carbon, salinity, alkalinity, and cation exchange capacity (CEC).
9. Analysis of heavy metals or nutrient contamination in soil samples collected from agricultural or industrial areas.
10. Characterization and classification of municipal solid waste, biomedical waste, hazardous waste, agricultural waste, and e-waste.
11. Estimation of solid waste generation rate and composition analysis from household, institutional, or municipal sources.
12. Preparation and study of composting and vermicomposting units for organic solid waste management.
13. Study of waste segregation, recycling, recovery, and waste-to-energy technologies through practical demonstrations or case studies.
14. Field visits to air quality monitoring stations, wastewater treatment plants, industrial pollution control units, solid waste management facilities, biomedical waste treatment plants, hazardous waste disposal sites, recycling industries, or environmental laboratories for practical exposure and report preparation.

Reference Books:

1. Standard Methods for the Examination of Water and Wastewater – Standard laboratory manual for analysis of water and wastewater quality parameters.
2. Air Pollution by M. N. Rao and H. V. N. Rao – Comprehensive reference for air pollution monitoring, sampling techniques, and control technologies.
3. Environmental Chemistry by A. K. De – Useful for laboratory analysis of air, water, and soil pollutants.
4. Environmental Pollution Control Engineering by C. S. Rao – Standard book covering pollution control equipment, treatment methods, and engineering applications.
5. Introduction to Environmental Engineering and Science by Gilbert M. Masters and Wendell P. Ela – Useful for environmental monitoring and pollution management

practicals.

6. Soil Science and Management by Edward J. Plaster – Useful for soil analysis and soil pollution assessment practicals.
7. Noise Pollution and Control by S. P. Singal – Useful for noise monitoring, measurement, and control techniques.
8. Solid Waste Management by M. N. Rao and Razia Sultana – Covers solid waste characterization, treatment, and management practices.
9. Handbook of Methods in Environmental Studies by S. K. Maiti – Practical handbook for environmental sampling, monitoring, and analytical techniques.
10. Environmental Monitoring and Assessment by J. P. Hudson – Useful for field surveys, pollution assessment, and environmental quality monitoring.

DSE-2P	Practical – 6: Based on DSE 1-2 (Any One)	Total Contact Hrs. 60
	<ol style="list-style-type: none"> 1. Climate Change Science, Adaptation and Mitigation 2. Environmental Microbiology, Biotechnology and Nanotechnology 3. Environmental Geospatial Technologies and Applications 	

Practical's: 1. Climate Change Science, Adaptation and Mitigation

1. Study and interpretation of meteorological parameters such as temperature, humidity, rainfall, wind speed, atmospheric pressure, and solar radiation using standard meteorological instruments.
2. Analysis of long-term climatic data for identification of climate variability and climate change trends using statistical methods and graphical interpretation.
3. Estimation and comparison of greenhouse gas emissions from domestic, transport, agricultural, and industrial sectors using carbon emission calculation methods.
4. Estimation of carbon sequestration by using different methods.
5. Preparation and interpretation of climate graphs, climographs, hythergraphs, and weather maps using meteorological and climatological data.
6. Vulnerability assessment and climate risk mapping of drought-prone, flood-prone, or heat-stressed regions using environmental and socio-economic indicators.
7. Field assessment of urban heat island effects through microclimatic observations in urban, peri-urban, and rural areas.
8. Study of climate change impacts on agriculture, water resources, biodiversity, and local livelihoods through field surveys and questionnaire-based investigations.
9. Field visit to meteorological observatories, renewable energy plants, watershed projects, climate-resilient villages, environmental research institutes, or disaster management centres for practical exposure and report preparation.

Reference Books:

1. Fundamentals of Climatology by Michael Pidwirny – Useful for understanding climate systems, weather observations, and climatological practical applications.
2. Principles of Environmental Science by William P. Cunningham and Mary Ann Cunningham – Covers environmental monitoring, climate impacts, and sustainability assessment methods.
3. Atmosphere, Weather and Climate by Roger G. Barry and Richard J. Chorley – Standard reference for meteorological measurements, climatic analysis, and atmospheric processes.
4. Climate Change and India by R. Krishnan and co-authors – Important reference for Indian climate change impacts, adaptation, and vulnerability studies.
5. Remote Sensing and GIS by M. Anji Reddy – Useful for GIS, remote sensing, and climate-related spatial analysis practical's.
6. Introduction to Climate Change by D. K. Asthana and Meera Asthana – Useful for Indian perspectives on climate change and environmental management.
7. Renewable Energy Resources by John Twidell and Tony Weir – Reference for renewable energy assessment and climate mitigation practical's.

Practical's: 2. Environmental Microbiology, Biotechnology and Nanotechnology

1. Isolation, enumeration, and characterization of microorganisms from soil, water, and air samples using standard microbiological techniques.
2. Study of microbial growth curve and determination of growth rate under different environmental conditions.
3. Enumeration of total viable bacterial count by serial dilution and plate count methods.
4. Microscopic identification and staining of environmental microorganisms (Gram staining and simple staining techniques).
5. Determination of microbial load and coliform bacteria in drinking water and wastewater samples.
6. Study of activated sludge microorganisms and microbial communities involved in wastewater treatment.
7. Demonstration of biofertilizer-producing microorganisms and evaluation of their plant growth-promoting potential.
8. Bioremediation experiment for degradation of dyes, hydrocarbons, or organic pollutants using microbial cultures.
9. Preparation and operation of a laboratory-scale anaerobic digester for biogas production.
10. Production and estimation of bioethanol or biogas from organic wastes using microbial processes.
11. Green synthesis of nanoparticles using plant extracts or microbial cultures.
12. Assessment of adsorption efficiency of nanomaterials for removal of pollutants from water.
13. Study of microbial processes in wastewater treatment plants (STP/ETP/CETP).
14. Visit to biogas plants and study of anaerobic digestion processes and energy recovery.
15. Field study of biofertilizer and biopesticide production units.
16. Industrial visit to biotechnology industries, fermentation industries, or environmental biotechnology laboratories.

Reference Books:

1. Cappuccino, J.G. & Welsh, C.T. (2020). *Microbiology: A Laboratory Manual*. Pearson Education, New York.
2. Benson, H.J. (2019). *Microbiological Applications: Laboratory Manual in General Microbiology*. McGraw-Hill Education, USA.
3. Harrigan, W.F. (1998). *Laboratory Methods in Food and Dairy Microbiology*. Academic Press, London.
4. Atlas, R.M. (2010). *Handbook of Microbiological Media*. CRC Press, Boca Raton, USA.
5. Fulekar, M.H. (2010). *Environmental Biotechnology*. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
6. Trivedi, R.K. & Goel, P.K. (2018). *Practical Methods in Ecology and Environmental Science*. Environmental Publications, Karad.
7. Maiti, S.K. (2011). *Handbook of Methods in Environmental Studies* (Vol. I & II). ABD Publishers, Jaipur.

Practical's: 3. Environmental Geospatial Technologies and Applications

1. Interpretation of aerial photographs: study of single aerial photographs, vertical photographs, and stereo pairs.
2. Determination of scale, height, relief displacement, and parallax measurements from aerial photographs.
3. Study of electromagnetic spectrum, spectral signatures, and interpretation of spectral reflectance curves of vegetation, soil, and water bodies.
4. Overview and practical applications of ArcGIS, ENVI, IDRISI etc softwares.
5. Spatial data input and processing: scanning, georeferencing, on-screen digitization, topology creation, editing, and vector data preparation.
6. Preparation and management of geodatabases in ArcGIS including feature datasets, feature classes, shapefiles, and layers.
7. Georeferencing of maps and satellite images using coordinate systems, datums, and map projections.
8. Working with layers in ArcMap: classification, symbology, labelling, map layouts, and cartographic representation.
9. GPS survey and field data collection: waypoint marking, route mapping, coordinate recording, data import, processing, and map generation.
10. Practical applications and mapping using QGIS software for environmental studies.
11. Overview, image processing, and classification techniques using ERDAS Imagine software.
12. Use of Google Earth for environmental monitoring, terrain visualization, and spatial data interpretation.
13. Downloading, processing, and utilization of satellite data from NRSC, Bhuvan, USGS, and SRTM platforms.
14. Preparation of land use/land cover (LULC) maps, watershed delineation, drainage analysis, and DEM-based terrain analysis using satellite imagery and GIS techniques.
15. Field visit and demonstration of Unmanned Aircraft Systems (UAS)/drone operations and applications in environmental monitoring, agriculture, forestry, disaster management, and resource assessment.

Practical References:

1. Anji Reddy, M. *Remote Sensing and Geographical Information Systems* published by BS Publications, Hyderabad is a highly useful Indian practical-oriented book for GIS, GPS, and remote sensing applications in environmental science.
2. Narayana Panigrahi. *Geographical Information Science* published by Universities Press is an important Indian reference book for GIS practicals, spatial databases, and environmental applications.
3. Bhatta, B. *Remote Sensing and GIS* published by Oxford University Press India is a useful practical reference book covering image processing, GIS analysis, and geospatial technologies.
4. Siddiqui, M. A. *Introduction to Geographical Information Systems* published by Sharda Pustak Bhawan is a useful Indian book for GIS laboratory work and map analysis.
5. Reddy, M. A. *Textbook of Remote Sensing and Geographical Information Systems*

published by BS Publications is widely recommended for M.Sc. Environmental Science practical courses.

6. NRSC-ISRO Manuals and Bhuvan Tutorials published by the National Remote Sensing Centre and Indian Space Research Organisation are valuable Indian practical resources for satellite data handling, Bhuvan platform applications, and environmental geospatial analysis.
7. Joseph, G. *Fundamentals of Remote Sensing* published by Universities Press, Hyderabad is one of the best Indian reference books for remote sensing principles and practical environmental applications.
8. Kang-tsung Chang. *Geographic Information Systems* published by Tata McGraw Hill is a useful practical reference for GIS laboratory exercises and environmental mapping.
9. Arc GIS practical manual, ERDAS practical manual, QGIS practical manual, BHUVAN official website and NRSC official website.