KANNUR UNIVERSITY
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(Abstract)

FYIMP in Environmental Science -offered by Dept.of Environmental Studies ,Mangattuparamba Campus - Scheme & Syllabus - Approved and Implemented w.e.f. the Academic year 2025-26 - Orders- issued

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ACADEMIC C SECTION

ACAD C/ACAD C1/17136/2025 Dated: 26.09.2025

Read:-1. U O No ACAD D/ACAD D5/23315/2023 (I) dated 22.02.2025

2. Circular No. ACAD C/ACAD C3/12564/2023 dated 05.03.2025
3. E mail dated 07.07.2025 from the Head, Dept. of Environmental Sciences
4. E mail dated 06.08.2025 from the Dean , Faculty of Science.
5. E mail dated 07.08.2025 from the Head, Dept. of Environmental Sciences
6. Orders of Vice Chancellor in file of even no, dated 07.08.2025
7. Minutes of the meeting of Standing Committee of Academic Council held on 08.08.2025
8. Orders of Vice Chancellor in file of even no, dated 01.09.2025

ORDER

1.The proposals to start Five Year Integrated Masters Programmes in Environmental Science at the Dept. of Environmental Studies, Kannur University Mangattuparamba Campus w.e.f 2025 admission was approved, vide the paper read (1) above.

2. Subsequently, directions were given to Head of the Departments concerned, vide the paper read (2) above to submit the entire Syllabus (all semesters) of FYIMP to be offered by their Department w .e .f the academic year 2025-26 with the minutes of Department Council.

3. Accordingly, the Head , Department of Environmental Studies, vide the paper read (3) above , submitted the Scheme and Syllabus of FYIMP Environmental Science, along with the minutes of the meeting of the Department Council, for approval and implementation w .e .f the Academic year 2025-26.

4.The Scheme and Syllabus of the above programme was forwarded to the Dean, Faculty of Science for verification and the Dean, vide the paper read (4) above opined that the content and structure of the programme are acceptable , and has also suggested that the term 'Programme' should be used instead of 'Course'.

5. The suggestion was intimated to the Head, Dept. of Environmental Studies and the Head. Dept. of Environmental Studies forwarded the scheme and syllabus of FYIM Programme in Environmental Science after correcting it in accordance with the remarks from the Dean, vide the paper read (5) above.

6. Considering the matter, the Vice Chancellor has ordered to place the syllabus before the consideration of Standing Committee of the Academic Council.

7.The Standing Committee of the Academic Council, vide paper read (7),considered the scheme

and syllabus of Five Year Integrated Programme in Environmental Science at the Department of Environmental Studies, Kannur University Mangattuparamba Campus to be implemented w. e. f 2025 admission and recommended to approve the same.

8.The Vice Chancellor, after considering the recommendations of Standing Committee of the Academic Council and in exercise of the powers of the Academic Council conferred under Section 11(1) Chapter III of Kannur University Act, 1996 and all other enabling provisions read together with, approved the scheme and syllabus of Five Year Integrated Programme in Environmental Science at the Department of Environmental Studies, Kannur University Mangattuparamba Campus for implementation w. e. f 2025 admission.

9.The scheme and syllabus of Five Year Integrated Programme in Environmental Science at the Department of Environmental Studies, Kannur University Mangattuparamba Campus implemented w. e. f 2025 admission is attached with this U.O. and uploaded in the website of the University (www. kannuruniv.ac.in).

Orders are issued accordingly.

Sd/-
Jisha K P
Assistant Registrar II
For REGISTRAR

To: 1. Head, Dept.of Environmental Science, Mangattuparamba Campus
2.Nodal Officer, FYIMP

Copy To: 1. PS to VC, PA to R, PA to CE
2. JR II (Exam)
3. EP IV/EG I/EXC I Sections (Exam)
4. IT Cell (to publish in the website)
5. Computer Programmer
6. SF/DF/FC

KANNUR UNIVERSITY
CIVIL STATION P.O.
KANNUR
Pin-670 002
THAVAKKARA

Forwarded / By Order

SECTION OFFICER

FIVE-YEAR INTEGRATED MASTERS PROGRAMME

IN

ENVIRONMENTAL SCIENCE

SCHEME AND SYLLABUS

(Under choice-based credit and semester system)

based on

Kannur University Five-Year Integrated Regulation

2025-26 ACADEMIC YEAR ADMISSION ONWARDS

KANNUR UNIVERSITY

DEPARTMENT OF ENVIRONMENTAL SCIENCES

KANNUR UNIVERSITY, MANGATTUPARAMBA CAMPUS

DEPARTMENT OF ENVIRONMENTAL STUDIES

KANNUR UNIVERSITY MANGATTUPARAMBA CAMPUS

FIVE-YEAR INTEGRATED MASTERS PROGRAMME IN ENVIRONMENTAL SCIENCE

INTRODUCTION:

The five-year integrated programme integrates undergraduate and postgraduate studies seamlessly over five years, offering a holistic approach to learning. Students will engage in a rigorous curriculum that covers foundational courses in Environmental Science alongside specialized training in clinical assessment, intervention techniques, and research methodologies. The programme provides students with a firm foundation in both research and practical skills and develops an understanding and appreciation for the dialectical relationship between the scientific and professional practice of Environmental Science. Environmental problems are increasing at a rapid rate, and the fact is to deal with the current environmental problems in India, especially in Kerala, we have severe inadequacy in terms of Environmental Science professionals based on available numbers. In this context, the need for a five-year integrated programme is inevitable to bridge the gap. The scope of employing these professionals after completing the programme is at a large level.

The five-year Environmental Science integrated programme will cater comprehensive training to the admitted students by integrating various aspects of environmental science, starting from foundation courses and in-depth training in assessment, intervention, research, supervision, and consultation, ensuring that students receive holistic and comprehensive training. This prepares them to excel in diverse professional roles within the field. The advantage of the proposed programme is that the interdisciplinary approach can incorporate insights from related disciplines (wood science, geography, IT, statistics, Psychology and History) fostering an interdisciplinary approach. This approach enhances students' ability to understand and address complex environmental issues from multiple perspectives, enriching their problem-solving skills.

Environmental Science is a dynamic field with constant developments. An integrated programme can adapt to emerging trends and incorporate the latest research

findings, technological advancements, and evidence-based practices, ensuring that graduates stay relevant in their careers. By integrating practical experience and supervised internship training, the programme can enhance students' analytical skills. This hands-on approach prepares them for the challenges of real-world environmental monitoring, making them more competent and confident practitioners.

A well-rounded programme can foster a research-oriented mindset among students. Encouraging research activities within the programme can contribute to the advancement of Environmental Science as a discipline and promote innovation in environmental management. Given the diverse cultural context of Kerala and its surrounding areas, an integrated programme can emphasize cultural competence and sensitivity. This ensures that future environmentalists are equipped to understand and address the unique needs of individuals from different cultural backgrounds. Integrating opportunities for networking and collaboration with professionals in the field can provide students with valuable connections. This can open doors to internships, job opportunities, and collaborations, ultimately enhancing their professional development.

DURATION: 5 Years (10 Semester)

INTAKE: 20 Students

OBJECTIVES OF THE PROGRAMME:

- ✧ The programme is organized as a five-year (ten-semester) programme with essential theoretical inputs and supervised research projects. On completion of the course, the students are expected to:
- ✧ To provide an integrated knowledge of diverse disciplines and training various theoretical and applied aspects of environmental science and management leading to a Master's Degree.
- ✧ To establish advanced facilities and promote research and technology development to solve environmental issues and problems.
- ✧ To undertake consultancy projects in environment, disaster management, Environmental impact assessment (EIA), Remote Sensing (RS), Geographical Information System (GIS), Forest and Wild Life Management.
- ✧ To establish good networking of academic collaboration with national and

international organizations, institutions, industries and exchange of faculty and students.

- ✧ To offer environmental information, education, and communication services and offer extension activities like environmental awareness programs for school, college students and the public.

The programme contents will be abreast with the latest development in the area of study. The students have to do a full-time institutional or industrial training/project work for six months, enabling them to have valuable hands-on experience. The theory, practical, project work and training activities of this programme prepare the student to acquire knowledge, skills, and expertise on specified subjects along with the integrated knowledge of all relevant disciplines.

ELIGIBILITIES:

Admission is offered to students who have completed and passed higher secondary 12th Standard education in any Science stream from the state/central higher secondary board and any other equivalent government-approved board of examinations in India or abroad with a minimum of 50% marks (as per university regulations).

Admission Procedure:

The selection of the candidate is based on the marks obtained in the entrance examination.

Entrance examination:

The candidate has to undergo a one-and-a-half-hour (90 minutes) written test consisting of 50 objective-type questions.

Sl. No	Area	Number of Questions
1	General Environmental Science	25
2	Reasoning Skills	10
3	English Language Skills	10
4	General Knowledge and Current Affairs	05
	Total	50 Questions

Environmental Science – Syllabus for Entrance Examination:

Basics of Environmental Science

Basics of Biology, Chemistry, Physics

Learning

Memory

Motivation & Emotion

PROGRAMME DETAILS:

A student must register for the required number of courses at the beginning of each semester. No students shall register for more than 24 credits and less than 16 credits per semester. This programme offers three exit options to the students to get their degree in **Environmental Science/Environmental Science with honors degree/MSc in Environmental Science.**

Exit Options:

A total of 133 credits with three years shall be the minimum for successful completion of the BSc Environmental Science Degree (For Exit with UG = 133)

A total of 177 credits with four years shall be the minimum for successful completion of the BSc Environmental Science Honors Degree with Major in Environmental Science/Research (For Exit with UG Honours/Honours with Research, the total credit = 177)

A total of 217 credits with five years shall be the minimum for successful completion of the MSc in Environmental Science.

Course Mapping - BSc Environmental Science – Total Credit 133

Semester	DSC Credit 4	DSE Credit 4	AEC Credit 3	SEC Credit 3	MDC Credit 3	VAC Credit 3	Internship Credit 4	Total Courses	Total Credits
I	A-1 B-1 C-1		AEC-1 AEC-2		MDC-1			6	21
II	A-2 A-3 B/C-2 B/C-3		AEC-3		MDC-2			6	22

III	A-4 A-5 A-6 A-7				MDC-3	VAC-1		6	22
IV	A-8 A-9 A-10 A-11			SEC-1		VAC-2		6	22
V	A-12 A-13 A-14 A-15	DSE-1		SEC-2				6	23
VI	A-16 A-17 A-18	DSE-2		SEC-3			Internship 4 Credit*	6	23
Total	Major-18 B/C-4	2	3	3	3	2	1	36	133

DSC - Discipline Specific Course, DSE - Discipline Specific Elective, AEC - Ability Enhancement Course, SEC - Skill Enhancement Course, MDC - Multi Disciplinary Course, VAC - Value Added Course, A - Major, B - Minor, C - Minor

* An internship of 4 credits can be completed as 2 credits internship twice, or 4 credits at a single stretch between semesters 3 and 6.

Course Mapping: BSc Environmental Science/Honors with Research/Major in Environmental Science with a total Credit of 177 & MSc in Environmental Science with a total Credit of 217.

Semester	**DSC Credit 4**	**DSE Credit 4**		**MOOC Credit 4**	**Internship Credit 4**	**Total Courses**	**Total Credits**
VII	A-19 A-20 A/B/C- 21 A/B/C- 22	DSE-3 DSE-4 DSE-5	5 Courses with 2 DSC from A, 1 DSE from A and choice of DSC or DSE	MOOC / Online – 1 (4C)		6	24

			from A/B/C – including specialized capstone courses				
VIII	A/B/C- 23	DSE-6	I DSC or DSE	MOOC / Online – 2	Project /Dissertation - 12Credit (Honours with Research) For Honours – additional 3 4C Courses in DSC or DSE		20
Student exit 4-year degree (Hons/Hons with Research) with Major in Environmental Science							
IX	A-24 A-25 A-26 A-27 A-28	-	-	One 4 Credit Internship in lieu of one DSC and/or One 4 C MOOC/Online/blended course in lieu of one DSC			20
X	Research			Dissertation 20 credits			20
Student exit with 5-year Integrated MSc Degree in Environmental Science*							

*For FYIMP, the 40 credits in 5th year can also be obtained with coursework alone or research alone.

PATHWAYS OF THE PROGRAMME:

Discipline-Specific Foundation and Pathway Courses for a 3-Year Degree:

Students shall acquire the following credits for the discipline-specific foundation and pathway courses for a 3-year degree programme. The student who wishes to exit with a degree after three years needs to acquire a minimum of 94 credits from discipline-specific foundation and pathway courses, approximately 70% of the total credit requirement for the three-year programme. The suggested credit distribution for each of the subcategories of discipline-specific courses is given below. It should be noted that based on the student's choice of the pathway, the number of credits under major and minor may vary.

Sl.No	Curricular Components	Minimum Credits
1	Major pathway courses	68 Credits
2	Minor pathway courses	28 Credits
3	Internship	4 Credits

Discipline-Specific Foundation and Pathway Courses for Four-Year Honours/Honours with Research Degree:

Students shall successfully complete a minimum of 33 credits from general foundation courses and a minimum of 94 credits from discipline-specific foundation and pathway courses, and another 6 credits from courses of students' choice (major or minor) to complete 100 credits as described above to enter the fourth year for the honors programme. The student who enters the honours programme after successfully acquiring 133 credits is required to earn an additional 44 credits within one year from the discipline-specific capstone components, minor components, and research. The suggested credit distribution for each of the subcategories of different levels of courses is given below:

Sl. No.	Curricular Components	Honours	Honours with Research
1	Major pathway/capstone courses	20 Credits	20 Credits
2	Minor pathway courses	12 Credits	12 Credits
3	Additional Major pathway courses	12 Credits	
4	Research project/dissertation	-	12 Credits

Note: For Honours with a research programme the mentor will specify the relevant major and minor pathway courses and the credits

Discipline-Specific Courses for the Five-Year Integrated Master's Programme:

Students who completed a four-year honours with a minimum of 177 credits should earn an additional 40 credits for the fifth year for the award of a Five-Year Integrated PG degree.

Three pathways are suggested to earn 40 credits for the fifth year for the Integrated Master's programme as given below:

Sl. No.	Curricular Components	Coursework	Research thesis/Project/Patent	Total Credits
1	Coursework + Research	20 Credits	20 Credits	40

2	Coursework	40 Credits	-	40
3	Research		40	40

The mentor shall specify the courses for coursework; the course level should be 500. The curricular components and credits shall be modified by the university as and when the regulations are modified/finalized by the UGC/Kerala State Higher Education Committee.

The programme pathway is a degree with a single Major: A student pursuing the FYIMP in a specific discipline shall be awarded a major degree if he secures at least 50% of the total credits in the specific discipline required for the award of the Degree in that discipline. This pathway may be recommended to those students who opt for an in-depth study in a particular discipline without systematically exploring any other discipline. The students pursuing FYIMP in a specific discipline shall be awarded a UG Degree in a Major discipline if they secure a minimum of 68 credits in that Major discipline from 17 courses (total credits of 133 required for the three-year programme). The remaining 32 credits (28 credits from 7 different courses and 4 credits from the internship) in Discipline-Specific Courses (DSC) can be acquired either from the same Major discipline or from other disciplines. If the students continue to the fourth year of FYIMP, to be eligible for a UG Honours Degree in the Major discipline, they should earn a further 32 credits in that Major discipline from capstone-level courses and projects and an additional 8 credits from any discipline.

Other Options:

Major with Multiple discipline Pathway (Multidisciplinary)
Major with Minor pathway
Interdisciplinary Major
Major with Vocational Minor pathway

TOTAL CREDITS FOR SIX SEMESTERS (THREE-YEAR EXIT) = 133:

COURSES	CREDITS	SEMESTERS
Major/Minor Stream (DSC /DSE)	96 (4 credit courses)	Within all six semesters
Multidisciplinary Courses (MDC)	9 (3 credit three courses)	1 to 4
Value Addition Courses (VAC)	6 (3 credits two courses)	1 to 4

Ability Enhancement Courses (AEC)	9 (3 credits three courses)	1 & 2
Internship/Field Visit	4 (either one 4C internship or two 2C internships)	3 to 6
Total credits for Semester 7 and 8	133	

TOTAL CREDITS FOR SEMESTERS 7 & 8 = 44:

COURSES	CREDITS	SEMESTERS
Major/Minor Stream (DSC /DSE)	24 (4 credits 6 courses)	7
Additional DSC/DSE for Honours (in Major Discipline	12 (2 DSC and 1 DSE in the Major)	8
MOOC / ONLINE COURSES (Blended Mode)	8 (4 credits 2 courses)	7 & 8
Total credits for Semester 7 and 8	44*	-

*For Honours with Research 12 credits Project in Semester 8 and for Honours additional 12 credits DSC/DSE in Semester 8, which should include Capstone level courses

TOTAL CREDITS FOR SEMESTERS 9 & 10 = 40:

Pathway 1

COURSES	CREDITS	SEMESTERS
Coursework	20 (4 credits 5 courses) *	9
Research	20 Credits	10

*Among the 5 courses in semester 9, one course can be online/MOOC/blended mode at level 500, and one course can be a 4-credit internship.

Pathway 2

COURSES	CREDITS	SEMESTERS
Coursework	20 (4 credits 5 courses) *	9
Internship (Group Project)	20 credits	10

*Among the 5 courses in semester 9, one course can be online/MOOC/blended mode at level 500, and one course can be a 4 credit Internship

Pathway 3

COURSES	CREDITS	SEMESTERS
Coursework	20	9
Internship	20 (4 credits 5 courses) *	10

*In the semester 10, only one internship with a level of 500 is included. The internship can be completed at universities and research institutes that exist in India and abroad.

KANNUR UNIVERSITY

DEPARTMENT OF ENVIRONMENTAL STUDIES

FIVE-YEAR INTEGRATED MASTERS PROGRAMME IN ENVIRONMENTAL SCIENCE

PROGRAMME OUTCOMES:

PO1: Critical Thinking: Take informed actions after identifying the assumptions that frame our thinking and actions, checking out the degree to which these assumptions are accurate and valid, and looking at our ideas and decisions (intellectual, organizational, and personal) from different perspectives.

PO2: Problem Solving: Identify, formulate, conduct investigations, and find solutions to problems based on in-depth knowledge of relevant domains.

PO3: Communication: Speak, read, write, and listen clearly in person and through electronic media in English/the language of the discipline, and make meaning of the world by connecting people, ideas, books, media, and technology.

PO4: Responsible Citizenship: Demonstrate empathetic social concern and the ability to act with an informed awareness of issues.

PO5: Ethics: Recognize different value systems, including your own; understand the moral dimensions of your decisions; and accept responsibility for them.

PO6: Self-directed and Life-long Learning: Acquire the ability to engage in independent and life-long learning in the broadest context of socio-technological changes.

PO7: Environmental Sustainability and Global Perspective: Develop an understanding of global standards to foster a legal environment. Learn and practice to critically analyzing the legal issues from local, national, and international concerns.

PROGRAMME SPECIFIC OUTCOMES:

PSO 1 : Demonstrate the ability to adapt to a rapidly changing environment and apply new skills**.**

PSO 2 : Demonstrate the spirit of compassion, kinship and commitment for

National Harmony

PSO 3 : Apply the concept of ICT modules in the learning process

PSO 4 : Inculcate the environmental and human values in students

PSO 5 : Evaluate and strengthen the environmental protection measures through technological innovations and activities

PSO 6 : Design and set up consultancy projects in disaster management, Environmental Impact Assessment (EIA), Remote Sensing (RS), Geographical Information System (GIS), Forest and Wildlife Management, and Environmental Audit.

PSO 7 : Apply the skill to use advanced instrumentation facilities and propose new technology to solve environmental issues and problems.

Mapping of Programme Outcomes to PSOs:

PSO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
PSO 1	5	4	1	3	2	1	2
PSO 2	4	5	3	5	4	2	2
PSO 3	5	5	4	5	5	5	5
PSO 4	5	5	4	5	5	3	4
PSO 5	5	5	4	5	4	4	4
PSO 6	5	4	5	5	5	5	3
PSO 7	5	5	4	5	5	5	5
PSO 8	5	4	5	5	5	4	5
PSO 9	3	4	1	3	3	4	4
PSO 10	5	5	4	5	5	5	5
PSO 11	5	4	4	5	3	3	3

Scale: 5=Completely Matching, 4=Very Strongly Matching, 3= Moderately Matching, 2= Slightly Matching, 1= Least Matching

FIVE-YEAR INTEGRATED MASTERS PROGRAMME
IN
ENVIRONMENTAL SCIENCE

PROGRAMME STRUCTURE

SEMESTER – I								
Course Code	**Title of the Paper**	**Credits**	**Contact Hours/Week**			**Weightage Ratio**		
			L	**T/S**	**P**	**CCE**	**ESE**	**T**
KU01DSCEVS101	Fundamentals of Environmental Science	4	2	1	1	50	50	100
	AEC-1	3	2	1		50	50	100
	AEC-2	3	2	1		50	50	100
	MDC-1 (opt from other Dept.)	3	2	1		50	50	100
	Minor B1 ~ Basics of Environmental Chemistry/opt from other Dept.)	4	2	1	1	50	50	100
	Minor C1 ~ Basics of Atmospheric science/opt from Geography Dept.)	4	2	1	1	50	50	100
Total Credits		21						
SEMESTER – II								
KU02DSCEVS102	Environmental Pollution I	4	2	1	1	50	50	100
KU02DSCEVS103	Fundamentals of Ecology	4	2	1	1	50	50	100
	AEC-3	3	2	1		50	50	100
	Minor B2 ~ (opt from Wood science/History Dept.)	4	2	1	1	50	50	100
	Minor C2 ~ (opt from History/Statistics/Wood science Dept.)	4	2	1	1	50	50	100
	MDC-2	3	2	1		50	50	100
Total Credits		22						
SEMESTER – III								
KU03DSCEVS201	Environmental Geology	4	2	1	1	50	50	100
KU03DSCEVS202	Biodiversity Conservation	4	2	1	1	50	50	100

KU03DSCEVS203	Fundamentals of Environmental Chemistry	4	2	1	1	50	50	100
KU03DSCEVS204	Practical in Ecology	4	2	1	1	50	50	100
	MDC-3	3	2	1		50	50	100
	VAC-1	3	2	1		50	50	100
Total Credits		22						
SEMESTER – IV								
KU04DSCEVS205	Advanced Environmental Chemistry	4	2	1	1	50	50	100
KU04DSCEVS206	Basics of Hydrology	4	2	1	1	50	50	100
KU04DSCEVS207	Energy and Environment	4	2	1	1	50	50	100
KU04DSCEVS208	Environmental Chemistry Practical I	4	2	1	1	50	50	100
	SEC-1	3	2	1		50	50	100
	VAC-2	3	2	1		50	50	100
Total Credits		22						
SEMESTER – V								
KU05DSCEVS301	Environmental Toxicology	4	2	1	1	50	50	100
KU05DSCEVS302	Atmospheric Science and Meteorology	4	2	1	1	50	50	100
KU05DSCEVS303	Environmental Microbiology	4	2	1	1	50	50	100
KU05DSCEVS304	Practical in Environmental Microbiology	4	2	1	1	50	50	100
KU05DSEEVS301	Climate Change and Environmental Ethics	4	2	1	1	50	50	100
KU05DSEEVS302	Agroecology		2	1	1	50	50	100
KU05DSEEVS303	Ecotourism		2	1	1	50	50	100
	SEC-2	3	2	1				100
Total Credits		23						

SEMESTER – VI								
KU06DSCEVS305	Research Methodology	4	2	1	1	50	50	100
KU06DSCEVS306	Environmental Pollution II	4	2	1	1	50	50	100
KU06DSCEVS307	Instrumentation Techniques	4	2	1	1	50	50	100
KU06DSEEVS304	Green Technology	4	2	1	1	50	50	100
KU06DSEEVS305	Wetland Ecology		2	1	1	50	50	100
	SEC-3	3						
KU06INTEVS301	Internship	4		4		50	50	100
Total Credits		23						
SEMESTER – VII								
KU07DSCEVS401	Disaster Management	4	2	1	1	50	50	100
KU07DSCEVS402	Remote Sensing and GIS	4	2	1	1	50	50	100
KU07DSCEVS403	Sustainable Development	4	2	1	1	50	50	100
KU07DSCEVS404	Occupational Health and Safety	4	2	1	1	50	50	100
KU07DSEEVS401	Industry Processes and Pollution	4	2	1	1	50	50	100
KU07DSEEVS402	Environmental, Social and Governance (ESG)		2	1	1	50	50	100
KU07DSEEVS403	Human rights and Environmental Justice		2	1	1	50	50	100
	Field Work	4						100
Total Credits		**24**						
SEMESTER – VIII								
KU08DSCEVS405	Environmental Economics and Policy Analysis	4	2	1	1	50	50	100
KU08DSCEVS406	Environmental Impact Assessment	4	2	1	1	50	50	100
KU08DSCEVS407	Environmental Engineering	4	2	1	1	50	50	100
KU08DSEEVS404	Carbon Neutrality	4	2	1	1	50	50	100
KU08DSEEVS405	Renewable and Non-renewable Energy		2	1	1	50	50	100
KU08DSEEVS406	Nature-based Solutions for Environmental Challenges		2	1	1	50	50	100
KU08DSEEVS407	AI in Environmental Science		2	1	1	50	50	100
	MOOC - Online	4						100

KU08RPHEVS401	Capstone Project in Honours with Research Programme	12		8	4	50	50	100
Total Credits		20						
SEMESTER – IX								
KU09DSCEVS501	Nanotechnology for Environmental Applications	4	2	1	1	50	50	100
KU09DSCEVS502	Solid Waste Management	4	2	1	1	50	50	100
KU09DSCEVS503	Environmental Management and Environmental Audit	4	2	1	1	50	50	100
KU09DSCEVS504	Environmental Law and Policies	4	2	1	1	50	50	100
KU09CIPEVS501	Capstone Internship-1/MOOC - Online/Signature Course	4		4		50	50	100
Total Credits		20						
SEMESTER – X								
KU10RPHEVS501	Capstone Research Programme*	20	2	1	1	50	50	100
			2	1	1	50	50	100
			2	1	1	50	50	100
			2	1	1	50	50	100
			2	1	1	50	50	100
				16	4	50	50	100
				20		50	50	100
Total Credits		20						

*If opting for the research pathway, students will take 20 credits of research.

**If the student is opting for an internship pathway, they will complete 20 credits of supervised clinical training. Other students will follow the coursework pathway of 20 credits.

SEMESTER I

Course Title	**FUNDAMENTALS OF ENVIRONMENTAL SCIENCE**
Semester	**One**
Course Code	**KU01DSCEVS101**
Course Type	**Discipline-Specific Core**
Course Credit	**4**
Prerequisite	**Basic knowledge in Biology, Physical Science and Chemical Science**
Course Objectives	● Understand the basic principles and scope of Environmental Science. ● Identify key ecosystem components, processes, and biodiversity importance. ● Examine the types and management of natural resources. ● Analyse human impacts on the environment and explore mitigation strategies. ● Engage with sustainable practices for environmental protection and conservation.

Modules	Content	Module Outcome
Module I Introduction to Environmental Science (15 hours)	**1.1 Definition and Scope** Definition of environment and environmental science - Interdisciplinary nature and relevance in modern society **1.2 Structure and Components of the Environment** Lithosphere, Hydrosphere, Atmosphere, and Biosphere - Biotic and abiotic components **1.3 Man-Environment Relationship** Human dependence on nature - Environmental ethics **1.4 Sustainable Development** Concept, need, and principles - UN Sustainable Development Goals (SDGs)	The student will be able to: • Understand the concept and importance of environmental science • Describe the components of the environment • Relate human activities to environmental change • Comprehend sustainability and the UN-SDGs framework
Module II Ecosystem and Biodiversity (20 hours)	**2.1 Concept of Ecosystem** Definition, structure, and components (biotic and abiotic) - Functions: energy flow and nutrient cycling **2.2 Food Relationships** Trophic levels - Food chains and food webs - Ecological pyramids (number, biomass, energy) **2.3 Types of Ecosystems** Forest, grassland, desert, aquatic (freshwater and marine) - Characteristics and examples **2.4 Biodiversity** Levels: genetic, species, ecosystem - Values of biodiversity (ecological, economic, cultural)	• Explain the structure and functions of ecosystems. • Analyse different food relationships and trophic levels. • Differentiate between ecosystem types. • Understand biodiversity value

	Threats to biodiversity (habitat loss, pollution, invasive species) - Conservation methods: in-situ and ex-situ	and conservation strategies.
Module III Natural Resources and Management (20 hours)	**3.1 Classification of Natural Resources** Renewable and non-renewable - Resource use and overexploitation **3.2 Water Resources** Sources and uses - Water scarcity and conservation - Rainwater harvesting and watershed management **3.3 Forest Resources** Importance and types of forests - Deforestation and afforestation - Forest management and community participation (e.g., Joint Forest Management) **3.4 Energy Resources** Conventional (coal, petroleum, natural gas) - Non-conventional (solar, wind, biomass, geothermal, tidal) - Energy conservation and sustainable use **3.5 Soil and Land Resources** Types and uses of soil - Soil degradation and conservation practices - Land-use planning and sustainable agriculture	• Identify various types of natural resources • Explain issues and management practices for water, forest, and energy resources • Discuss soil conservation and sustainable agriculture practices
Module IV Environmental Issues and Human Impact (20 hours)	**4.1 Environmental Pollution** Air, water, soil, and noise pollution: causes, effects, control measures - E-waste and plastic pollution **4.2 Global Environmental Issues** Climate change and global warming - Ozone layer depletion - Acid rain - Loss of biodiversity and desertification **4.3 Solid Waste Management** Sources and types of solid waste - Disposal methods: composting, landfilling, incineration - Waste minimization and recycling **4.4 Environmental Policies and Practices** Major environmental legislations in India (Water Act, Air Act, Environment Protection Act) - Role of Central and State Pollution Control Boards - Role of individual and community in environmental protection	• Recognize types and sources of environmental pollution • Discuss global environmental issues and their impact • Understand waste management techniques • Explain environmental laws and individual responsibility
Module V Teacher Specific Module (5 Hours)	Areas of content, transaction, and evaluation are decided by the faculty.	
References	**Core compulsory reading** 1. Agarwal, K. C. (2001). *Environmental Biology*. Nidhi Publishers Ltd. 2. Bharucha, E., & Rai, J. (2002). *The biodiversity of India*. Mapin Publishing Pvt. 3. Clark, R. B., Frid, C., & Attrill, M. (1997). *Marine pollution*. Oxford University Press. 4. Cunningham, E., Cooper, & Hepworth, G. &. (1999). *Environmental*	

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Course Outcomes	**CO1:** Understand the basic concepts and scope of Environmental Science. **CO2:** Explain ecosystem structure, functions, and biodiversity significance. **CO3**: Identify and evaluate the use and conservation of natural resources. **CO4:** Recognize key environmental problems and their impacts. **CO5:** Demonstrate awareness of environmental laws and sustainable practices. **CO6:** Apply environmental knowledge to real-world issues and solutions.

Teaching Learning Strategies	Direct Instruction: Brainstorming Lecture, Explicit Teaching, E-learning (Video) Interactive Instruction: Active co-operative learning, Seminars, Group Assignments, Library work and Group discussion, Presentation by individual students/Group representative Field work and field visits
Mode of Transaction	Face to face: Lecture method & Demonstration method Learner centered technique: Computer assisted learning & Individual project teaching

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	**50**
Continuous Evaluation	**50**
● **Test papers**	**20**
● **Tutorial with Seminar presentations/Discussions/Debate, etc.**	**20**
● **Assignment**	**10**

Sample questions to test outcomes.

1. Mention any two causes of biodiversity loss.
2. Discuss any three major global environmental issues.
3. Differentiate between renewable and non-renewable resources with examples.
4. What are the types of ecosystems? Explain their peculiarities.
5. Elaborate on the role of legislation and public participation in environmental protection in India.

SEMESTER II

Course Title	ENVIRONMENTAL POLLUTION I
Semester	**Two**
Course Code	**KU02DSCEVS102**
Course Type	**Discipline-Specific Core**
Course Credit	**4**
Prerequisite	**Basics of Environmental Science**
Course Objectives	The course aims ● To develop an understanding of different types of pollution affecting the environment. ● To explore the sources, effects, and control measures of major environmental pollutants. ● To impart knowledge about monitoring techniques and pollution mitigation strategies. ● To promote awareness and responsibility towards pollution prevention and environmental protection.

Modules	Content	Module Outcome
Module I Introduction to Environmental Pollution (10 hours)	**1.1 Definition and Scope** What is pollution? Environmental pollution vs. contamination - Classification of pollutants **1.2 Causes of Environmental Pollution** Population, urbanization, industrialization, resource consumption, deforestation, agriculture, and transportation. **1.3 Sources of pollution** Point vs. non-point sources; natural vs. anthropogenic. **1.4 Pollution and public health** Linkages between pollution and disease burden, overview of environmental epidemiology.	The student will be able to: ● Define and differentiate various types of environmental pollution. ● Classify pollutants based on their physical, chemical, and biological nature. ● Explain the major causes and consequences of environmental degradation. ● Relate pollution to public health issues and environmental epidemiology.
Module II Air Pollution & Water Pollution (25 hours)	**2.1 Air Pollution** Definition, Air pollutants and their sources - Types of air pollutants - primary and secondary air pollutants - Gaseous, solid and bio pollutants. **2.2 Movements and Reactions of Pollutants in the Atmosphere** Reactions of pollutants in the air to form smog and PAN - Acid rain, ozone depletion, greenhouse effect	● Identify major air pollutants and categorize them. ● Evaluate the effects of air pollution on human health, ecosystems,

	and global warming - Factors affecting air pollutants and their mode of actions: climate, temperature, humidity and wind currents. **2.3 Impacts of Air Pollution** On human being, plants, materials, buildings and climate. **2.4 Control Measures of Air Pollution** Filters, scrubbers, electrostatic precipitators, green buffers. **2.5 Water Pollution** Definition, water pollutants, sources (Domestic, agricultural, industrial, surface runoff) - Types of water pollution - Point and nonpoint source of water pollution- surface and groundwater pollution. **2.6 Impacts of Water Pollution** on human beings, animals, plants and environment. **2.7 Control Measures of Water Pollution** Bioremediation, phytoremediation, wastewater treatment.	buildings, and climate. ● Describe and assess control technologies such as scrubbers, filters, and green buffers. ● Identify major pollutants in water and soil and their sources. ● Explain waterborne diseases, and groundwater contamination processes.
Module III Soil / Land pollution & Noise pollution (20 hours)	**1.1 Soil Pollution** Natural sources - Natural calamities. Anthropogenic sources - Agricultural practices, Industrial and Municipal discharges - Municipal solid waste dumping - Landfill leachates - Plastics - Radioactive leakage - Mining activities and electronic wastes. **3.2 Impacts of Soil / Land Pollution**– Soil fertility - Soil microorganisms - Effects on plants and animals. **3.3 Control Measures** **3.4 Noise Pollution** Definition and concept of Noise pollution - Sources of noise pollution: Indoor and outdoor noise pollution, Natural and Anthropogenic sources. **3.5 Impacts of Noise Pollution** On human beings, animals, plants and environment. **3.6 Control Measures** Noise pollution rules and zoning.	● Evaluate the impact of agrochemicals, industrial effluents, and heavy metals on soil health. ● Apply techniques such as bioremediation and phytoremediation to mitigate pollution. ● Conduct basic water and soil quality assessments using standard testing protocols. ● Apply and understand the noise-reducing technologies in transportation and other industries level ● Create public awareness on the harmful effects of noise pollution.
Module IV Radioactive Pollution, Thermal and Marine	**4.1 Radioactive pollution** Definition and scope of the study - Ionizing vs. non-ionizing radiation - Sources: Natural (radon), anthropogenic (nuclear plants, medical) - Effects: Cancer, mutations, ecological disruption -	● Assess the health and ecological impacts of thermal pollution.

Pollution (20 hours)	Radioactive pollution episodes - Precautions and control measures. **4.2 Thermal pollution.** Impacts of thermal pollution - aquatic fauna and flora - Control measures of thermal pollution. **4.3 Marine pollution** Definition and sources of marine pollution -Natural and Anthropogenic sources - Control measures - Pollution status of coastal and ocean waters - Oil pollution, sources, effects and control measures.	● Differentiate between ionizing and non-ionizing radiation and their effects. ● Understand monitoring and safety measures for radiation exposure. ● Suggest preventive and mitigation strategies for each type of pollution. ● Apply and implement the proper safety measures and disposal methods, and a healthier environment for future generations. ● Construct a model for proper disposal of waste
Module V Teacher Specific Module (5 Hours)	Areas of content, transaction, and evaluation are decided by the faculty.	
References	**Core compulsory reading** 1. Sharma, B.K. & Kaur, H. (1996). *Environmental Chemistry*. Goel Publishing House. 2. De, A. K. (2012). *Environmental chemistry* (6th ed.). New Delhi, India: New Age International Publishers. 3. Khopkar, S. M. (2004). *Environmental pollution: Monitoring and control*. New Delhi, India: New Age International (P) Ltd. 4. Hill, M. K. (1997). *Understanding environmental pollution*. Cambridge, UK: Cambridge University Press. 5. Rudra, T., & Gandhi, G. (2010). *Marine Pollution Control and Management*. Jnanada Prakashan. 6. Trivedi, P. R., & Raj, G. (1992). *Environmental water and soil analysis*. 7. Krishnamurthy, Aishwarya. (2016). *Water pollution and its control*. Mittal Publications. 8. Trivedi, R.K., & Goel, P.K. (1998). *Introduction to Air Pollution*. ABD Publishers. 9. Cunningham, W.P., & Cunningham, M.A. (2008). *Environmental Science: A Global Concern*. McGraw Hill. 10. Rao, M.N., & Rao, H.V.N. (2009). *Air Pollution*. Tata McGraw-Hill. **Core suggested readings**	

	11. Tyagi, O. D., & Mehra, M. (1990). *Textbook of environmental chemistry*. Anmol Publications. 12. Ahluwalia, V. K. (2017). *Environmental chemistry*. Ane Books Pvt. Ltd. 13. Misra, S., & Panday, S. (2008). *Essential environmental Studies*. CRC Press. 14. Abbasi, S. A. (1998). *Environmental pollution and its control*. Cogent International.

Course Outcomes	**CO1:** Apply and analyze the details about source, types and impacts of air, water and soil pollution **CO2:** Identify the sampling and analysis of the air, water and soil pollutants in the environment **CO3:** Evaluate the various air, water soil pollution control measures **CO4:** Explain pollution control technologies and legislations. **CO5:** Propose solutions to reduce pollution and promote sustainability.

Teaching Learning Strategies	Direct Instruction: Brainstorming Lecture, Explicit Teaching, E-learning (Video) Interactive Instruction: Active co-operative learning, Seminars, Group Assignments, Library work and Group discussion, Presentation by individual student/ Group representative Field work and field visits
Mode of Transaction	Face to face: Lecture method & Demonstration method Learner centered technique: Computer assisted learning & Individual project teaching

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	**50**
Continuous Evaluation	**50**
● **Test papers**	**20**
● **Tutorial with Seminar presentations/Discussions/Debate, etc.**	**20**
● **Assignment**	**10**

Sample questions to test outcomes

1. Write the major impacts of anthropogenic activities on the natural environment?
2. What are the causes and effects of agricultural pollution?
3. Explain the environmental costs of industrialization
4. Discuss air pollution and its control measures.
5. Enumerate the various standard procedures for the estimation of water pollution parameters.

Course Title	FUNDAMENTALS OF ECOLOGY
Semester	**Two**
Course Code	**KU02DSCEVS103**
Course Type	**Discipline-Specific Core**
Course Credit	**4**
Prerequisite	**Basics of Biology**
Course Objectives	The Course aims ● To introduce the foundational concepts and scope of ecology. ● To develop an understanding of ecological levels of organization and ecosystem functioning. ● To enable students to examine population and community-level interactions in natural environments. ● To provide in-depth knowledge of ecological succession, nutrient cycles, and energy flow. ● To understand anthropogenic impacts and ecosystem homeostasis.

Modules	Content	Module Outcome
Module I: Introduction to Ecology and Environmental Factors (12 hours)	**1.1 Historical Background and Development of Ecology** Contributions of Darwin, Haeckel, Odum Branches: autecology, synecology, habitat ecology **1.2 Levels of Ecological Organization** Organism → Population → Community → Ecosystem → Landscape → Biome → Biosphere **1.3 Abiotic Environmental Factors** Light, temperature, water, humidity, salinity, fire, wind - Adaptations in plants and animals to different abiotic conditions Topographic Factors: height of mountains, direction of mountains and valleys, steepness of slope and exposure of slope Edaphic factors: Soil - soil formation, soil profile, soil erosion, soil conservation **1.4 Biotic Environmental Factors** Intraspecific and interspecific interactions Competition, symbiosis, predation. **1.5 Laws of Limiting Factors** Liebig's law of minimum - Shelford's law of tolerance	The students will be able to: ● Understand ecological organization and foundational ecological principles. ● Analyse how abiotic and biotic factors influence organisms' survival and distribution. ● Identify and analyze the adaptations of plants and animals which will help to protect them.
Module II: Population and Community Ecology (23 hours)	**2.1 Population Characteristics** Population growth and its dynamics - Density, natality, mortality, dispersal, age distribution, sex ratio - Malthus theory - Population growth models: exponential and logistic **2.2 Population Regulation** Density-dependent and independent factors - r- and K-selection strategies **2.3 Community Structure and Dynamics**	● Understand and apply principles of population ecology. ● Evaluate community patterns and species interactions.

	Community structure and stratification, species richness and heterogeneity, abundance, dominance, species diversity indices (Simpson's, Shannon-Weiner) - Ecotone, edge effect, ecological equivalent. **2.4 Vegetation Analysis** Quadrat, Transect and Point quadrat method of samplings - Determination of quadrat size and quadrat number (Wiegerts' and Hendricks Methods) - Girth class and Height class measurement. **2.5 Ecological Niche** Concept, types, niche overlap, competitive exclusion principle **2.6 Species Interactions** Mutualism, commensalism, amensalism, predation, parasitism, competition - Co-evolution and keystone species **2.7 Ecological Adaptations** Plants: hydrophytes, mesophytes, xerophytes, and halophytes - Animals: aquatic conditions-hydrocoles; amphibious conditions or sec. hydrocoles - Terrestrial: mesocoles and xerocoles	
Module III: Ecosystems and Energy Flow (20 hours)	**3.1 Concept and Components of Ecosystems** Structure: Biotic and abiotic components Functions: Nutrient cycling, energy flow **3.2 Ecosystem Types and Examples** Aquatic: freshwater (pond, lake, river), marine - Terrestrial: forest, grassland, desert, tundra **3.3 Energy Flow Models** Food chains (grazing and detritus) - Food webs, Trophic levels - Ecological pyramids (number, biomass, energy) **3.4 Productivity and Biomass** Primary productivity (GPP, NPP) - Secondary productivity and measurement **3.5 Ecosystem Regulation** Homeostasis, feedback mechanisms - Gaia Hypothesis	● Comprehend the structural-functional aspects of ecosystems. ● Analyse energy dynamics and productivity in natural systems.

Module IV: Ecological Succession, Biogeochemical Cycles, and Human Impacts (20 hours)	**4.1 Ecological Succession** Types: primary and secondary Seres: xerosere, hydrosere Stages: nudation, invasion, competition, climax **4.2 Biogeochemical Cycles** Carbon, Nitrogen, Phosphorus, Sulphur, Water cycles - Human disruptions in natural cycles **4.3 Ecosystem Services and Biodiversity Significance** Provisioning, regulating, supporting, and cultural services **4.4 Human Impacts on Ecosystems** Habitat destruction, deforestation, urbanization, climate change, invasive species **4.5 Restoration Ecology and Conservation Principles** Ecological restoration methods - Role of protected areas and ecological engineering **4.6 Museology -** Plants and Animals - Collection and Preservation - Major Herbaria and Museums. **4.7 Taxonomy and Biosystematics**	• Evaluate succession, nutrient cycles, and ecosystem services. • Assess ecological consequences of anthropogenic actions and importance of conservation.
Module V: Teacher Specific Module (5 Hours)	Areas of content, transaction, and evaluation are decided by the faculty.	
References	**Core compulsory reading** 1. Odum, E.P. & Barrett, G.W. (2005). *Fundamentals of Ecology.* Cengage Learning. 2. Verma, P. S., & Agarwal, V. K. (2000). *Environmental Biology: Principles of Ecology*. S Chand & Company. 3. Sharma, P. D. (2017). *Environmental Biology and Toxicology* (3rd rev. ed., 2nd reprint). Rastogi Publications. 4. Sharma, P. D. (2017). *Ecology and Environment* (13th ed.). Rastogi Publications. 5. Nair, P. K. G. (1990). *Principles of environmental biology*. Himalaya Publishing House, New Delhi 6. Rana, S. (2013). *Essentials of Ecology and Environmental Science*. PHI Learning Pvt. Ltd. 7. Chawla, S. (2012). *A Textbook of Environmental Studies*. Tata McGraw-Hill Education. 8. Dash, M. C. (2009). *Fundamentals of Ecology* (3rd ed.). Tata McGraw-Hill Publishing. 9. Nasim, S. A. (2011). *Elements of Ecology*. Axis Books. **Core suggested reading** 10. Arora, M. P. (2023). *Ecology* (5th ed.). Himalaya Publishing House. 11. Smith, B., & Enger, E. (2012). *Environmental science*. McGraw-Hill Education. 12. Wang, H. (Ed.). (2016). *Principles of soil science*. Callisto Reference. 13. Introduction to Environmental Studies, Turk & Turk	

	14. Smith, R. L. (1997). *Ecology and field biology* (5th ed.). HarperCollins College Publishers. 15. Kormondy, E.J. (2009). *Concepts of Ecology*. Pearson Education. 16. Smith, R.L. & Smith, T.M. (2015). *Elements of Ecology*. Pearson. 17. Begon, M., Townsend, C.R., & Harper, J.L. (2006). *Ecology: From Individuals to Ecosystems.* Wiley-Blackwell. 18. Miller, G.T. & Spoolman, S. (2012). *Living in the Environment.* Brooks/Cole. 19. Molles, M.C. (2016). *Ecology: Concepts and Applications.* McGraw Hill Education.

Course Outcomes	**CO1:** Define and explain key ecological concepts and levels of biological organization. **CO2:** Analyse the factors affecting population dynamics and species interactions. **CO3:** Describe the structure, types, and functioning of ecosystems. **CO4:** Explain the processes of ecological succession and nutrient cycling. **CO5:** Evaluate human influence on ecological balance and ecosystem resilience.

Teaching Learning Strategies	Direct Instruction: Brainstorming Lecture, Explicit Teaching, E-learning (Video) Interactive Instruction: Active co-operative learning, Seminars, Group Assignments, Library work and Group discussion, Presentation by individual students/Group representative Field work and field visits
Mode of Transaction	Face to face: Lecture method & Demonstration method Learner centered technique: Computer assisted learning & Individual project teaching

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	**50**
Continuous Evaluation	**50**
● **Test papers**	**20**
● **Tutorial with Seminar presentations/Discussions/Debate, etc.**	**20**
● **Assignment**	**10**

Sample questions to test outcomes.

1. Define autecology and synecology.
2. Write a short note on the nitrogen cycle.
3. Define ecological pyramid with an example.
4. Explain energy flow in an ecosystem and the significance of ecological pyramids.
5. Analyse the anthropogenic impacts on nutrient cycles and suggest mitigation strategies

SEMESTER III

Course Title	ENVIRONMENTAL GEOLOGY
Semester	**Three**
Course Code	**KU03DSCEVS201**
Course Type	**Discipline-Specific Core**
Course Credit	**4**
Prerequisites	**Basics of Geology and Environmental Science**
Course Objectives	The course aims: ● To introduce the concept of the formation, evolution, structure, and composition of Earth. ● Understanding different types of weathering. ● Understand the weathering and erosion process of different geological agents and the associated landforms. ● Identify different rocks, rock-forming minerals, and soil-forming minerals. ● To understand the physical and chemical properties of minerals.

Modules	Contents	Module Outcome
Module I Introduction to Environmental Geology (15 Hours)	**1.1 Introduction to Geology** Definition, scope, and importance of geology in environmental science - Types of rocks and minerals - Earth's internal structure: Core, mantle, crust - Geological time scale and plate tectonics **1.2 Environmental Geology and its Impact** Environmental geology: Definition, scope, and relevance - The role of geology in environmental protection and conservation - Case studies of environmental impacts due to geological processes **1.3 Geological Agents** Exogenous, and endogenous geological agents. **1.4 Current views on the origin of earth.**	The student will be able to: ● Known the basic knowledge about environmental geology and its scope ● Gain knowledge in theories regarding the origin of Earth ● Analyze the internal structure of Earth
Module II Concept of Rocks and Soil Formation (20 Hours)	**2.1 Classification of Rocks** Igneous, Sedimentary and Metamorphic Rocks - Concept of rock cycle. **2.2 Weathering** Weathering reactions, erosion, transportation and deposition of sediments. **2.3 Soil Formation and Erosion** Soil types, properties, and formation processes (Pedogenesis) - Soil forming minerals - Physical and chemical properties of soil - Climate control on soil formation - Cation exchange capacity and mineralogical controls - Factors affecting soil formation - Soil profile - Classification of types of soil (Reference to India and Kerala) - Structure of soil.	● Classify different types of rocks. ● Describe the soil formation process weathering and types of soils in India and Kerala
Module III Geological Agents	**3.1 Wind** Development of characteristic features by wind (arid cycle) erosion and deposition - Pedestal rock -	● Identify the basic concepts of geological agents

(20 hours)	Mushroom topography - Inselberg - Ventifacts - Locus - Sand dunes. **1.2 River** Erosion, transportation and deposition of river (fluvial) cycle in different stages - Development of typical landforms by river erosion and deposition - V-shaped valley, Alluvial fans, natural levees, meander, ox-bow lakes, flood plains, peneplain and deltas - Types of rivers - Development of river. **1.3 Glaciers** Definition and types - Development of typical landforms by glacial erosion and deposition - Cirque, U-shaped valley, hanging valley, monadnocks, moraines, drumlin, Eskers and Varves - Characteristic features of glaciated regions. **3.4 Geochemical classification of elements** Abundance of elements in bulk earth, crust, hydrosphere, and biosphere - Partitioning of elements during surficial geologic processes - Geochemical recycling of elements. **3.5 Paleoclimate**	● Classify the geochemical elements ● Analyze the concept of paleoclimate
Module IV Crystals and Minerals (20 hours)	**4.1 Physical properties of minerals** Color, streak, opalescence, asterism, transparency, luster, luminescence, specific gravity, magnetic properties, electrical properties, and pyro- and piezoelectricity. **4.2 Chemical properties of minerals** Isomorphism, solid solution, polymorphism, allotropy, pseudomorphism, radioactivity, and silicate structures. **4.3 Composition and diagnostic properties of minerals** Quartz, feldspar, talc, gypsum, galena, beryl, corundum	● Identify the crystals and minerals ● Characterize the chemical and physical properties of minerals. ● Identify and diagnose the different minerals based on their properties
Module V Teacher Specific Module (5 Hours)	Areas of content, transaction, and evaluation are decided by the faculty.	
References	**Core compulsory reading** 1. Kesavulu, N. C. (1993). *Textbook of Engineering Geology*. Macmillan India Ltd. 2. Ghosh, G. N. (2000). *Atmospheric Science and Environment*. Allied Publishers Ltd. 3. Mukherjee, P. K. (1986). *A Textbook of Geology*. World Press. 4. Singh, S. K. (2008). *Engineering & General Geology* (8th ed.). S.K. Kataria & Sons. 5. Holmes, A., & Holmes, D. L. (1978). *Principles of Physical Geology* (3rd ed.). Thomas Nelson & Sons Ltd. 6. Strahler, A. N. (1981). *Physical Geology*. Harper & Row.	

	7. Robinson, E. S. (1982). *Basic Physical Geology*. John Wiley & Sons. 8. Read, H. H. (1979). *Rutley's Elements of Mineralogy* (26th ed.). T. Murby & Co. 9. Keller, E. A. (2016). *Environmental Geology* (10th ed.). Pearson Education. 10. Bell, F. G. (2006). *Environmental Geology* (6th ed.). Wiley-Blackwell. **Core suggested reading** 11. Klein, C., & Hurlbut, C. S., Jr. (1993). *Manual of Mineralogy* (21st ed.). John Wiley & Sons. 12. Battey, M. H. (1981). *Mineralogy for Students* (2nd ed.). Longman. 13. Dana, E. S., & Ford, W. E. (1922). *A Textbook of Mineralogy* (4th ed.). John Wiley & Sons. 14. Deer, W. A., Howie, R. A., & Zussman, J. (1992). *An Introduction to the Rock-Forming Minerals* (2nd ed.). Longman Scientific & Technical. 15. Mason, B., & Berry, L. G. (1968). *Elements of Mineralogy*. W. H. Freeman & Co. 16. Billings, M. P. (1972). *Structural Geology* (3rd ed.). Prentice-Hall. 17. Holmes, A. (1965). *Principles of Physical Geology* (2nd ed.). Ronald Press Company. 18. Berry, L. G., & Mason, B. (1959). *Mineralogy: Concepts, Descriptions, Determinations* (1st ed.). W. H. Freeman and Company. 19. Park, R. G. (1995). *Foundations of Structural Geology*. Routledge.

Course Outcomes	**CO1:** Understand the foundational concepts of geology and their relevance to environmental science. **CO2:** Know about weathering and soil formation. **CO3:** Acquire knowledge on geological agents. **CO4:** Explore properties of minerals.

Teaching Learning Strategies	Direct Instruction: Brainstorming Lecture, Explicit Teaching, E-learning (Video) Interactive Instruction: Active co-operative learning, Seminars, Group Assignments, Library work and Group discussion, Presentation by individual students/Group representative Fieldwork and field visits
Mode of Transaction	Face to face: Lecture method & Demonstration method Learner centered technique: Computer assisted learning & Individual project teaching

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	**50**
Continuous Evaluation	**50**
● **Test papers**	**20**
● **Tutorial with Seminar presentations/Discussions/Debate, etc.**	**20**
● **Assignment**	**10**

Sample questions to test outcomes.

1. What are the engineering properties of rocks? Comment on the effect of weathering on these properties.
2. Define Environmental Geology and explain its scope and importance in the context of environmental management.
3. Explain the role of geologists in environmental studies and briefly explain the need for environmental protection.
4. Discuss the different types of rocks and minerals, their formation processes, and environmental significance.
5. Differentiate between endogenic and exogenic geological agents, providing examples of each.

Course Title	BIODIVERSITY CONSERVATION
Semester	**Three**
Course Code	**KU03DSCEVS202**
Course Type	**Discipline-Specific Core**
Course Credit	**4**
Prerequisites	**Basics of Biology and Environmental Science**
Course Objectives	The course aims: ● To understand the concept and importance of biodiversity. ● To explore the different types of biodiversity and their distribution across ecosystems. ● To analyse the threats to biodiversity and the significance of conservation efforts. ● To study national and international biodiversity conservation strategies.

Modules	Content	Module Outcome
Module I Introduction to Biodiversity (15 hours)	**1.1 Concept of Biodiversity** Definition and types: Genetic, species, and ecosystem diversity - Levels of biodiversity (genetic, species, ecosystem) - Scope and significance of biodiversity - Indicators of biodiversity - Value of biodiversity: consumptive use, productive use, social, ethical, aesthetic and option values **1.2 Global Patterns of Biodiversity** Biodiversity hotspots - Major biomes and their biodiversity characteristics - Distribution of biodiversity in relation to climate, geography, and human impact - The mega-diversity countries of the world - Biogeographical classification of India. **1.3 Components of Biodiversity** Species diversity (species richness, evenness) - Ecosystem diversity (forest, marine, freshwater, etc.) - Genetic diversity (within and among species) - Alpha, Beta and Gamma Diversity	The student will be able to: ● Identify the basics of biodiversity - global, national and local levels ● Know the values of biodiversity ● Understand the components of biodiversity ● Identify the hotspots of biodiversity
Module II Threats to Biodiversity (15 hours)	**2.1 Human-induced Threats to Biodiversity** Habitat loss and fragmentation - Overexploitation (hunting, fishing, logging) - Pollution and its impact on biodiversity - Climate change and biodiversity - Invasive alien species. **2.2 Natural Threats to Biodiversity** Natural disasters (volcanic eruptions, earthquakes, floods) - Disease outbreaks in wildlife - Evolutionary changes and natural extinction events. **2.3 Emerging Threats and Challenges** Emerging zoonotic diseases - Anthropogenic pressures in biodiversity hotspots - Conservation challenges in urbanization and agriculture - Human-wildlife conflict - Endangered and endemic species of India - Extinction of species - Keystone species	● Identify and evaluate the various factors threatening biodiversity. ● Differentiate human-induced and natural threats to biodiversity. ● Recognize the emerging threats to biodiversity

Module III Biodiversity Conservation Strategies (25 hours)	**3.1 In-situ Conservation** Protected areas (National parks, Wildlife sanctuaries - concept and short description and importance of major national parks and wildlife sanctuaries of Kerala and India) - Biosphere reserves (concept and short description and importance of major reserves) and conservation corridors - Community reserves and sacred groves (Special reference to Kerala). **3.2 Ex-situ Conservation** Zoos, botanical gardens, and seed banks - Gene banks and cryopreservation - Aquaria - Biotechnology in conservation (e.g., cloning, genetic rescue) - National Bureau of Plant Genetic Resources (NBPGR) - National Bureau of Animal Genetic Resources (NBAGR) - Documenting traditional knowledge. **3.3 Sustainable Use of Biodiversity** Sustainable agriculture, forestry, and fisheries - Eco-tourism and its role in conservation - Certification programs (e.g., Fair Trade, organic certification). **3.4 Policy and Legal Framework for Biodiversity Conservation** National policies (e.g., National Biodiversity Action Plan of India) - International treaties (e.g., CBD, CITES, etc.) - Role of NGOs and local communities in conservation efforts. **3.5 People's Movement for Environmental Conservation** Bishnoi Movement - Chipko Movement - Narmada Bachao Andolan - Appiko Movement - Silent Valley Movement - Baliapal Movement. **3.6 Environmental Legislations** Definition - Need & purpose of environmental legislations - Legal provisions in Indian Constitution - Laws related to water, air & Forests and wildlife - General environmental laws.	● Evaluate and propose conservation strategies for the protection of biodiversity. ● Know the international conferences for biodiversity conservation**.** ● Recognize the NGOs and their roles in conservation of biodiversity ● Apply & analyze different international efforts for conservation of biodiversity. ● Analyze the values of sacred groves in conservation of biodiversity.
Module IV Case Studies and Future Directions in Biodiversity Conservation (20 hours)	**4.1 Case Studies on Successful Conservation Initiatives** Tiger conservation in India (Project Tiger) - Project Elephant - Amazon rainforest conservation efforts - Coral reef protection and restoration - Restoration of degraded ecosystems (e.g., reforestation). **4.2 Global and Local Biodiversity Conservation Challenges** Climate change impacts on biodiversity - Urbanization and biodiversity loss - Conflicts between development and conservation. **4.3 Future of Biodiversity Conservation** Role of technology in conservation (e.g., drones, satellite imagery) - Emerging global policies on	● Apply theoretical knowledge to real-world biodiversity conservation challenges through case studies and discussions on future directions. ● Able to recognize the role of technology in biodiversity conservation.

	biodiversity - The role of community-driven conservation.	
Module V Teacher Specific Module (5 Hours)	Areas of content, transaction, and evaluation are decided by the faculty.	
References	**Core compulsory reading** 1. Purohit, S. S., Agrawal, A. K., & Shammi, Q. J. (2007). *Environmental sciences: A new approach* (1st ed.). Agrobios (India). 2. Asthana, D. K., & Asthana, M. (2006). *A textbook of environmental studies* (1st ed.). S. Chand & Co. 3. Mandal, F. B., & Nandi, N. C. (2009). *Biodiversity: Concept conservation & Biofuture*. 4. Narasaiah, M. L. (2004). *Biodiversity and environment*. Discovery Publishing House. 5. Sharma, P. D. (2018). *Ecology and environment* (13th ed.). Rastogi Publications. 6. Santra, S. C. (2011). *Environmental science*. New Central Book Agency (P) Ltd. 7. Chapman, J. L., & Reiss, M. J. (1998). *Ecology: Principles and applications* (2nd ed.). Cambridge University Press. 8. Odum, E. P. (1971). *Fundamentals of ecology* (3rd ed.). W.B. Saunders Co. **Core suggested reading** 9. Trivedy, R. K. (2010). *Handbook of environmental laws, acts, guidelines, compliances, and standards* (3rd ed., Vols. 1–2). BS Publications. 10. Chaturvedi, R. G., & Chaturvedi, M. M. (1998). *Law on protection of environment and prevention of pollution (Central and States)* (1st ed.). The Law Book Co. (Pvt.) Ltd. 11. Trivedy, R. K., Goel, P. K., & Trisal, C. L. (1987). *Practical methods in ecology and environmental science* (Vol. 2). Enviro Media Publications. 12. Verma, P. S., & Agarwal, V. K. (2000). *Environmental biology: Principles of ecology* (10th ed.). S. Chand & Company Ltd.	

Course Outcomes	**CO1:** Comprehend the various forms and components of biodiversity. **CO2:** Analyse the factors influencing biodiversity distribution and richness. **CO3:** Assess the threats to biodiversity and their implications. **CO4:** Evaluate the different conservation strategies at global and local levels. **CO5:** Develop critical thinking about conservation policy and its challenges.

Teaching Learning Strategies	Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning (Video) Interactive Instruction: Active co-operative learning, Seminars, Group Assignments, Library work and Group discussion, Presentation by individual student/ Group representative Field work and field visits
Mode of Transaction	Face to face: Lecture method & Demonstration method Learner centered technique: Computer assisted learning & Individual project teaching

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	**50**
Continuous Evaluation	**50**
● **Test papers**	**20**
● **Tutorial with Seminar presentations/Discussions/Debate, etc.**	**20**
● **Assignment**	**10**

Sample questions to test outcomes.

1. Define biodiversity. Explain its different components with examples.
2. Analyze the role of international treaties like CITES and the Convention on Biological Diversity in global biodiversity conservation.
3. Evaluate the effectiveness of in-situ conservation strategies in protecting biodiversity.
4. What are the differences between in-situ and ex-situ conservation? Provide examples.
5. What role does sustainable agriculture play in biodiversity conservation?

Course Title	FUNDAMENTALS OF ENVIRONMENTAL CHEMISTRY
Semester	**Three**
Course Code	**KU03DSCEVS203**
Course Type	**Discipline-Specific Core**
Course Credit	**4**
Prerequisite	**Basics of Chemistry**
Course Objectives	The course aims ● To study the basics of environmental chemistry, chemical reactions involved in water and electrokinetic properties. ● To understand the meaning of environmental chemistry ● Explain key chemical concepts relevant to environmental systems. ● Analyse the chemistry behind atmospheric, aquatic, and soil pollution.

Modules	Content	Module Outcome
Module I Basic Principles of Environmental Chemistry (12 hours)	**1.1 Introduction to Environmental Chemistry** Definition, scope, and importance - Environmental segments: atmosphere, hydrosphere, lithosphere, biosphere. **1.2 Fundamental Chemical Concepts** Atomic structure, molecular orbitals, bonding types - Redox reactions, oxidation states in environmental contexts – Catalysis - Unsaturated and Saturated Hydrocarbons. **1.3 Chemical Stoichiometry and Solutions** Moles, normality, molarity, ppm, ppb - Preparation and dilution of solutions - Chemical Equilibria - Solubility products. **1.4 Acids, Bases and Buffers** pH scale, indicators, environmental buffering capacity - Carbonate and bicarbonate buffering systems. **1.5 Chemical Kinetics** Reaction rates and orders - Environmental relevance (e.g., ozone formation, pollutant degradation).	The student will be able to ● Identify the basics of Environmental chemistry ● Gain the knowledge on fundamental chemical concepts ● Recall the basics of stoichiometry & chemical kinetics ● Discuss the basic concept acids, bases and buffers.
Module II Transformation of Refractory Organic compounds in the Environment (13 hours)	**2.1. Soap & Synthetic Detergent (Surfactant)** Cationic, anionic and non-ionic detergents - Modified detergents **2.2. Pesticides and Fertilizers** Classification - Degradation and analysis of pesticides - Pollution due to pesticides - DDT, Endosulfan and its molecules - Types of synthetic fertilizers & its environmental effects. **2.3 Polychlorinated Biphenyls (PCB)** **2.4 Synthetic Polymers** Classification - Properties and applications - Special	● Analyze in detail about soaps and detergents. ● Identify the pollution caused by cleaning products.

	reference to PVC, Thermoplastics & thermosetting plastics - Advantages & disadvantages of synthetic polymers - Biodegradable & non-bio degradable polymers **2.5. Petroleum Products** Types of fuels – Paraffin – Petroleum byproducts	
Module III Chemistry of Atmosphere (25 hours)	**3.1 Structure and Composition of the Atmosphere** Vertical layers: Troposphere, Stratosphere, Mesosphere, Thermosphere, Exosphere - Composition of clean dry air (N_2, O_2, Ar, CO_2, trace gases) - Importance of trace gases and aerosols - Temperature inversions - Atmospheric lapse rate, Adiabatic lapse rate, wet and dry adiabatic lapse rate. **3.2 Photochemical Reactions in the Atmosphere** Basic principles of photochemistry: absorption of solar radiation, photodissociation - Formation of radicals (e.g., OH•, NO•) - Photochemical smog: formation, composition, and environmental impacts - Oxidizing and Reducing smog - Ecological effects. **3.3 Ozone Layer and Stratospheric Ozone Chemistry** Ozone-oxygen cycle (Chapman mechanism) - Role of UV radiation in ozone formation and breakdown - Ozone hole: causes (CFCs, NOx), consequences, and recovery efforts (Montreal Protocol) **3.4 Chemistry of Air Pollutants** Reactions of sulfur compounds ($SO_2 \rightarrow H_2SO_4$) - Reactions of nitrogen compounds ($NO \rightarrow NO_2 \rightarrow HNO_3$) - Chemistry of CO, hydrocarbons, and VOCs - Formation of secondary pollutants (PAN, tropospheric ozone). **3.5 Acid Rain Chemistry** Oxidation of SO_2 and NOx to sulfuric and nitric acids - Role of cloud chemistry and catalytic reactions - Environmental impacts on soil, water bodies, buildings, and health **3.6 Atmospheric Cleansing and Removal Processes** Wet deposition (rainout and washout) - Dry deposition (adsorption and settling) - Role of hydroxyl radical in natural cleansing mechanisms	● Discuss the basic structure & composition of atmosphere ● Analyze the different types of air pollutants, sources & its effects. ● Explain the fate of pollutants in the atmosphere ● Analyze the various reactions taking place in the atmosphere ● Estimate the harmful effects caused by air pollution.

Module IV Chemistry of Lithosphere and Hydrosphere (25 hours)	**4.1 Introduction to Lithosphere and Hydrosphere** Definition, extent, and significance of lithosphere and hydrosphere - Role in global biogeochemical cycles (C, N, P cycles) - Interactions between soil and water chemistry. **4.2 Composition of Natural Waters and Soils** Hydrosphere: Major and minor ions in freshwater: Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, HCO_3^{-}, SO_4^{2-}, Cl^{-}, NO_3^{-} - Trace elements in aquatic systems: Fe, Zn, Mn, Cu Lithosphere: Soil constituents: minerals, organic matter, pore water, and air - Types of soils and their chemical characteristics. **4.3 Water Chemistry and Pollution** Physical and chemical properties of water: pH, conductivity, turbidity, TDS - Key parameters: DO, BOD, COD, alkalinity, hardness - Redox reactions in water: aerobic vs anaerobic conditions - Chemical nature of water pollutants: heavy metals (Hg, Pb, Cd), nitrates, phosphates, pesticides - Eutrophication: causes, chemical mechanism, impacts **4.4 Soil Chemistry and Pollution** Soil pH, buffering, and redox potential - Nutrient cycles in soil: NPK chemistry, availability, and fixation - Soil contamination sources: agrochemicals, industrial effluents, waste leaching - Heavy metal interactions: adsorption, mobility, and toxicity - Chemical processes in soil pollution: chelation, ion exchange, complexation **4.5 Environmental Interactions and Remediation** Soil-water interactions: leaching, runoff, percolation - Fate and transport of pollutants in soils and water - Natural attenuation and chemical transformation processes - Basic chemical methods for remediation: liming, immobilization, phytoremediation, chemical oxidation	● Analyze the different types of water & soil pollutants, sources & its effects. ● Explain the fate of pollutants in lithosphere. ● Analyze the various reactions taking place in lithosphere and hydrosphere ● Estimate the harmful effects caused by soil pollution ● Explain the basic knowledge of water and its properties
Module V Teacher Specific Module (5 Hours)	Areas of content, transaction, and evaluation are decided by the faculty.	
References	**Core compulsory reading** 1. Manahan, S. E. (2017). *Environmental Chemistry* (10th ed.). Willard Grant Press. 2. Sharma, B. K. (2007). *Environmental Chemistry* (9th ed.). Goel Publishing House. 3. De, A. K. (2022). *Environmental Chemistry* (10th ed.). New Age International Publishers. 4. Bailey, R. A. (1993). *Chemistry of the Environment*. New York: Academic Press.	

	5. Tolgyessy, J. (1993). *Chemistry and Biology of Water, Air, and Soil*. Elsevier. 6. Gaur, E. K. (2019). *Textbook of Environmental Chemistry*. Sonali Publications. 7. Khopkar, S. M. (2023). *Basic Concepts of Analytical Chemistry*. New Age International Publishers. 8. Kaur, H. (2016). *Environmental Chemistry*. Meerut: Pragati Prakashan 9. VanLoon, G. W., & Duffy, S. J. (2000). *Environmental Chemistry: A Global Perspective*. Oxford University Press, USA. 10. Vogel, A. I., & Mendham, J. (2000). *Vogel's Textbook of Quantitative Chemical Analysis*. Longman. 11. Lipps, W. C., Braun-Howland, E. B., & Baxter, T. E. (2023). *Standard Methods for the Examination of Water and Wastewater*. APHA Press. **Core Suggested Reading** 12. Marr, I. L., & Cresser, M. S. (1983). *Environmental Chemical Analysis*. Blackie Academic & Professional. 13. Ahluwalia, V. K. (2020). *Environmental Chemistry* (2nd ed.). Ane Books Pvt. Ltd. 14. Harris, D. C. (1995). *Quantitative Chemical Analysis*. W. H. Freeman & Co Ltd. 15. Connell, D. W. (2005). *Basic Concepts of Environmental Chemistry* (2nd ed.). CRC Press.

Course Outcomes	**CO1:** Explain key chemical concepts relevant to environmental systems. **CO2**: Analyse the chemistry behind atmospheric, aquatic, and soil pollution. **CO3:** Analyze the fate of chemicals in the environment and suggest relevant interventions. **CO4:** Apply theoretical knowledge to environmental monitoring and pollution mitigation.

Teaching Learning Strategies	Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning (Video) Interactive Instruction: Active co-operative learning, Seminars, Group Assignments, Library work and Group discussion, Presentation by individual student/ Group representative Field work and field visits
Mode of Transaction	Face to face: Lecture method & Demonstration method Learner centered technique: Computer assisted learning & Individual project teaching

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	**50**
Continuous Evaluation	**50**
● **Test papers**	**20**
● **Tutorial with Seminar presentations/Discussions/Debate, etc.**	**20**
● **Assignment**	**10**

Sample questions to test outcomes.

1. Discuss the chemical transformations involved in acid rain formation.
2. Describe the composition and chemical properties of the troposphere.
3. Evaluate the environmental impact of nitrate and phosphate pollution in aquatic ecosystems.
4. Explain the sources and chemical behavior of fertilizers in soil.
5. Discuss the mobility and toxicity of heavy metals in the lithosphere.

Course Title	PRACTICAL IN ECOLOGY
Semester	**Three**
Course Code	**KU03DSCEVS204**
Course Type	**Discipline-Specific Core**
Course Credit	**4**
Prerequisite	**Basics in Biology**
Course Objectives	The course aims: • To learn ecological sampling methods for terrestrial and aquatic ecosystems. • To perform biodiversity and community structure assessments in varied habitats. • To use field instruments to record ecological and environmental parameters. • To understand habitat interactions, ecological zones, and species associations.

Modules	Content	Module Outcome
Module I Ecological Field Methods (20 Hours)	**1.1 Basics of Field Ecology** Definition, significance, ethics, and goals of field ecology - Site selection, equipment checklist, safety protocols **1.2 Vegetation Sampling Methods** Quadrat sampling: random, systematic, stratified - Transect techniques: line, belt, and point-centered quarter method - Plot size and shape determination **1.3 Faunal Survey Techniques** Direct methods: visual encounter, capture-recapture - Indirect methods: droppings, nests, tracks, call counts - Devices: pitfall trap, Sherman trap, mist nets, camera traps **1.4 Abiotic Parameter Monitoring** Soil: moisture, pH, texture, organic matter - Atmosphere: temperature, humidity, light intensity, wind speed - Instruments: hygrometer, lux meter, anemometer, soil thermometer	The student will be able to ● Describe the planning and execution of ecological field surveys. ● Apply correct sampling designs for plant and animal studies. ● Operate tools for faunal data collection and documentation. ● Accurately record and interpret abiotic variables.
Module II Vegetation Analysis and Biodiversity Assessment (20 Hours)	**2.1 Vegetation Data Analysis** Determination of minimum size of the quadrate for vegetation study - Frequency, density, abundance, basal area - Dominance and Importance Value Index (IVI) - Community composition metrics **2.2 Biodiversity Indices** Alpha diversity: Shannon-Weiner, Simpson's Index - Beta diversity: Whittaker's measure - Evenness and dominance measures **2.3 Species-Area Relationship & Rarefaction** Plot cumulative species count with area - Construct rarefaction curves from quadrat data **2.4 GPS-Aided Mapping** Use of handheld GPS devices - Waypoint mapping of	● Calculate community structure metrics. ● Apply ecological diversity formulae to field data. ● Graphically represent species-area and diversity trends. ● Use GPS for spatial data collection in ecology.

	transects and sample plots - Creating vegetation distribution maps	
Module III Aquatic Ecology Practicals (20 Hours)	**3.1 Aquatic Sampling Methods** Collection techniques for plankton, periphyton, nekton, benthos - Vertical and horizontal net tows - Sediment core collection for benthic studies **3.2 Aquatic Flora and Fauna Identification** Microscopic identification of phytoplankton and zooplankton - Quantitative and Qualitative Analysis of Phytoplankton & Zooplankton a. Lackey's Drop Method b. Hemocytometer Method Identification keys for aquatic insects and macroinvertebrates - Ecological significance of indicator species **3.3 Physicochemical Analysis of Water** pH, temperature, dissolved oxygen (DO), biochemical oxygen demand (BOD) - Conductivity, turbidity, nitrate, phosphate - Instruments: DO meter, colorimeter, Secchi disc **3.4 Aquatic Productivity and Biotic Indices** Primary productivity: Light-Dark bottle method - Chlorophyll estimation using acetone extraction	● Conduct plankton and benthos sampling efficiently. ● Identify aquatic organisms using lab techniques. ● Analyse key water quality parameters. ● Evaluate productivity and health of aquatic ecosystems.
Module IV Habitat Ecology and Community Interactions (20 Hours)	**4.1 Microhabitat Analysis** Soil-litter interactions, root zones, under-canopy environment - Edge vs core conditions in fragmented habitats - Use of quadrats for microhabitat species mapping **4.2 Community Zonation and Stratification** Vertical and horizontal stratification in forest, grassland, wetland - Zonation along elevation, moisture gradient - Case studies: mangrove zonation, altitudinal gradient **4.3 Trophic and Symbiotic Interactions** Observation and sketching of food chains and webs - Mutualism, parasitism, competition in local habitats - Ant-plant, mycorrhizal, pollinator associations **4.4 Ecological Case Studies and Field Visit** Conduct 1–2 field visits to forest, grassland, or aquatic ecosystem - Prepare ecological checklist of flora and fauna - Interaction with local communities/NGOs	● Analyse habitat heterogeneity through microhabitat studies. ● Identify patterns of zonation and community structure. ● Interpret trophic interactions through field observation. ● Gain holistic ecosystem understanding via field immersion.
References	**Core compulsory reading** 1. American Public Health Association, American Water Works Association, & Water Environment Federation. (2017). *Standard Methods for the Examination of Water and Wastewater* (23rd ed.). American Public Health Association. 2. United Nations Environment Programme (UNEP). (2002). *Global Environment Outlook* (GEO-3). Earthscan Publications Ltd. 3. Cotgreave, P., & Forseth, I. (2002). *Introductory Ecology*. Blackwell	

	Science. 4. Freedman, B. (1995). *Environmental Ecology: The Ecological Effects of Pollution, Disturbance, and Other Stresses*. Elsevier. 5. Odum, E. P., & Barrett, G. W. (2005). *Fundamentals of ecology* (5th ed.). Brooks/Cole. 6. Smith, R. L., & Smith, T. M. (2001). *Ecology & Field Biology*. Prentice Hall. **Core suggested reading** 7. Mishra, R. (1968). *Ecology Workbook*. Oxford & IBH. 8. Krebs, C.J. (2014). *Ecology: The Experimental Analysis of Distribution and Abundance*. Pearson. 9. Barbour, M.G., Burk, J.H., & Pitts, W.D. (1999). *Terrestrial Plant Ecology*. Benjamin Cummings. 10. Southwood, T.R.E. & Henderson, P.A. (2000). *Ecological Methods*. Wiley-Blackwell. 11. Dash, M.C. (2001). *Fundamentals of Ecology*. Tata McGraw-Hill.

Course Outcomes	**CO1:** Demonstrate field techniques for flora and fauna sampling. **CO2:** Calculate ecological indices and analyse community structure. **CO3:** Conduct aquatic surveys and evaluate water quality indicators. **CO4:** Understand habitat zonation and species interactions.

Teaching Learning Strategies	Experiential Learning: Field visits to forests, grasslands, aquatic ecosystems to understand natural habitats. Project-Based Learning: Students work in groups to conduct ecological surveys, biodiversity assessments, and data analysis. Inquiry-Based Learning: Students formulate hypotheses, conduct experiments (e.g., soil analysis, population study), and interpret data. Collaborative Learning: Group discussions and presentations on ecological topics and field results. Demonstration Method: Instructor-led demonstrations of instruments and experiments. Reflective Learning: Students maintain a field journal/lab notebook to document procedures, observations, and reflections.
Mode of Transaction	Face to face: Lecture method & Demonstration method Laboratory Work, Field-Based Learning, Hands-on Training Learner centered technique: Computer assisted learning & Individual project teaching

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	**50**
Continuous Evaluation	**50**
● **Test papers**	**20**
● **Tutorial with Seminar presentations/Discussions/Debate, etc.**	**20**
● **Assignment**	**10**

Sample questions to test outcomes.

1. How do you estimate primary productivity in a pond?
2. Describe the signs of mutualism observed in terrestrial habitats.
3. Calculate IVI of a grassland vegetation sample.
4. Compare Shannon and Simpson diversity indices from a field dataset.

SEMESTER IV

Course Title	**ADVANCED ENVIRONMENTAL CHEMISTRY**
Semester	**Four**
Course Code	**KU04DSCEVS205**
Course Type	**Discipline-Specific Core**
Course Credit	**4**
Prerequisite	**Knowledge in Environmental chemistry**
Course Objectives	The course aims ● To develop in-depth understanding of advanced chemical reactions in environmental contexts. ● To investigate pollutant dynamics using chemical principles and thermodynamics. ● To study emerging and legacy pollutants through advanced aquatic, atmospheric, and soil chemistry. ● To apply advanced chemical knowledge for pollution control, environmental safety, and sustainability.

Modules	Content	Module Outcome
Module I Environmental Thermodynamics and Redox Chemistry (15 hours)	**1.1 Chemical Thermodynamics in the Environment** Thermodynamic systems and processes - Gibbs free energy, enthalpy, entropy in natural systems - Thermodynamic feasibility of environmental reactions (e.g., precipitation, volatilization) **1.2 Chemical Equilibria and Solubility** Law of mass action; equilibrium constants (Kc, Kp) - Solubility products and precipitation reactions - Influence of temperature, pressure, and ionic strength on equilibria **1.3 Redox Chemistry in Environmental Compartments** Redox couples in environmental media (Fe^{3+}/Fe^{2+}, Mn^{4+}/Mn^{2+}, NO_3^-/NH_4^+) - Electrochemical potential, Nernst equation - Redox potential (Eh) and its environmental significance **1.4 Kinetics of Environmental Reactions** Rate laws and reaction mechanisms - Factors affecting reaction rates: temperature, pH, catalysts - Environmental examples: ozone decomposition, metal oxidation, photodegradation	• Explain thermodynamic principles governing chemical equilibria in environmental systems. • Evaluate solubility and precipitation processes relevant to pollutant mobility. • Interpret redox reactions across environmental media and predict electron transfer processes. • Apply chemical kinetics to assess pollutant degradation rates in natural systems.
Module II Organic Pollutants and Toxicological Chemistry (20 hours)	**2.1 Classes and Sources of Organic Pollutants** Persistent Organic Pollutants (POPs): PCBs, DDT, PAHs - VOCs, microplastics, personal care products (PPCPs) - Industrial and domestic sources of organic pollution **2.2 Environmental Fate and Degradation of**	• Classify major organic pollutants and assess their sources and persistence. Evaluate

	Organics Abiotic degradation: photolysis, hydrolysis, oxidation - Biodegradation pathways: aerobic vs. anaerobic mechanisms - Transformation products and their environmental significance **2.3 Toxicological Chemistry of Environmental Contaminants** Toxicity endpoints: LC50, NOAEL, LOAEL - Concepts of bioavailability, bioaccumulation, and biomagnification - Molecular interactions: enzyme inhibition, oxidative stress, endocrine disruption **2.4 Chemical Speciation and Risk Assessment** Speciation of metals (e.g., arsenic, chromium, mercury) - Role of pH and redox in mobility and toxicity - Basic principles of chemical risk assessment and hazard classification	transformation pathways and chemical degradation of organic contaminants. • Interpret the toxicological effects of chemical contaminants based on dose-response principles. • Assess chemical speciation and its implications for pollutant toxicity and risk.
Module III Advanced Aquatic and Marine Chemistry (20 hours)	**3.1 Complexation and Buffer Systems in Aquatic Systems** Stability constants, ligand exchange reactions - Natural ligands (e.g., humic/fulvic acids, EDTA) - Buffer systems: carbonate, phosphate, ammonia buffers **3.2 Colloidal and Surface Chemistry in Water** Properties and behaviour of colloids in aquatic environments - Coagulation–flocculation mechanisms (e.g., $FeCl_3$, alum) - Role of colloids in metal transport and pollutant adsorption **3.3 Estuarine and Marine Chemistry** Salinity, stratification, and mixing in estuaries - Redox clines and chemical speciation at interfaces - Sediment–water interactions and contaminant release **3.4 Marine Pollution Chemistry** Oil chemistry and dispersants - Emerging marine pollutants: microplastics, antifouling agents - Chemical impacts of nutrient enrichment and hypoxia	• Demonstrate understanding of chemical equilibria and buffer systems in natural waters. • Evaluate colloidal behaviour and surface chemistry in water treatment and contaminant transport. • Analyse the chemistry of estuarine and marine systems, including redox interfaces and salinity effects. • Investigate the chemical characteristics and environmental effects of marine pollutants.
Module IV Soil Chemistry and Advanced Atmospheric Processes (20 hours)	**4.1 Soil Chemical Composition and Reactions** Minerals, clays, oxides, and organic matter - Soil pH, CEC, and buffering capacity - Ion exchange reactions and adsorption–desorption **4.2 Heavy Metal Chemistry in Soil** Forms of metals in soil: exchangeable, bound, residual - Factors affecting mobility and toxicity: pH, redox, organic matter - Phytotoxicity and metal complexation	• Analyse soil chemical composition and reactions affecting nutrient and pollutant dynamics. • Interpret the mobility and

	4.3 Advanced Atmospheric Chemistry Radical chemistry (HO•, RO•, NO_3•) and photochemical cycles - VOC–NOx interactions, ozone formation and breakdown - Secondary organic aerosol (SOA) formation and health effects **4.4 Climate-Relevant Atmospheric Chemistry** Chemistry of greenhouse gases: CO_2, CH_4, N_2O, SF_6 - Role of aerosols in cloud formation and radiative forcing - Geoengineering chemicals: sulphate aerosols, iron fertilization	toxicity of heavy metals in soil environments. • Explain atmospheric photochemistry and radical-driven transformation of air pollutants. • Evaluate chemical processes affecting global biogeochemical cycles and climate-related atmospheric changes.
Module V Teacher Specific Module (5 Hours)	Areas of content, transaction, and evaluation are decided by the faculty.	
References	**Core compulsory reading** 1. De, A. K. (2022). *Environmental chemistry* (10th ed.). New Age International Publishers. 2. Manahan, S. E. (2017). *Environmental chemistry* (10th ed.). CRC Press. 3. Sharma, B. K. (2007). *Environmental chemistry* (9th ed.). Goel Publishing House. 4. VanLoon, G. W., & Duffy, S. J. (2000). *Environmental chemistry: A global perspective* (2nd ed.). Oxford University Press. 5. Connell, D. W. (2005). *Basic concepts of environmental chemistry* (2nd ed.). CRC Press. 6. Lipps, W. C., Braun-Howland, E. B., & Baxter, T. E. (2023). *Standard methods for the examination of water and wastewater* (24th ed.). APHA Press. 7. Tolgyessy, J. (1993). *Chemistry and biology of water, air, and soil: Environmental aspects*. Elsevier. 8. Vogel, A. I., & Mendham, J. (2000). *Vogel's textbook of quantitative chemical analysis* (6th ed.). Prentice Hall. 9. Sawyer, C.N., McCarty, P.L., & Parkin, G.F. (2003). *Chemistry for Environmental Engineering and Science*. Tata McGraw-Hill. 10. Baird, C. (2012). *Environmental Chemistry* (5th ed.). W.H. Freeman. 11. Harrison, R.M. (2014). *Pollution: Causes, Effects, and Control* (5th ed.). The Royal Society of Chemistry. **Core suggested reading** 12. Ahluwalia, V. K. (2020). *Environmental chemistry* (2nd ed.). Ane Books Pvt. Ltd. 13. Gaur, E. K. (2019). *Textbook of environmental chemistry*. Sonali Publications. 14. Kaur, H. (2016). *Environmental chemistry*. Pragati Prakashan. 15. Khopkar, S. M. (2023). *Basic concepts of analytical chemistry* (4th ed.).	

	New Age International Publishers. 16. Marr, I. L., & Cresser, M. S. (1983). *Environmental chemical analysis*. Blackie Academic & Professional. 17. Harris, D. C. (1995). *Quantitative chemical analysis* (5th ed.). W. H. Freeman and Company.

Course Outcomes	**CO1:** Apply chemical thermodynamics and kinetics in understanding pollutant behaviour. **CO2:** Analyse fate and transformations of organic and inorganic pollutants. **CO3:** Evaluate marine and freshwater chemistry from a pollution and remediation perspective. **CO4:** Propose and assess chemical mechanisms for pollution abatement in soil and atmosphere.

Teaching Learning Strategies	Direct Instruction: Brainstorming Lecture, Explicit Teaching, E-learning (Video) Interactive Instruction: Active co-operative learning, Seminars, Group Assignments, Library work and Group discussion, Presentation by individual students/Group representative Field work and field visits
Mode of Transaction	Face to face: Lecture method & Demonstration method Learner centered technique: Computer assisted learning & Individual project teaching

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	**50**
Continuous Evaluation	**50**
● **Test papers**	**20**
● **Tutorial with Seminar presentations/Discussions/Debate, etc.**	**20**
● **Assignment**	**10**

Sample questions to test outcomes.

1. Explain the Gibbs free energy concept and apply it to environmental redox reactions.
2. Describe the photochemical degradation pathway of a persistent organic pollutant.
3. Evaluate the chemical fate and environmental risks of microplastics in marine ecosystems.
4. Analyse how soil chemistry influences the mobility and bioavailability of heavy metals.

Course Title	BASICS OF HYDROLOGY
Semester	Four
Course Code	KU04DSCEVS206
Course Type	Discipline-Specific Core
Course Credit	4
Pre- Requisites	Basic Science, Environmental Science, Hydrology
Course Objectives	The course aims ● To study occurrence movement and distribution of water that is a prime resource for development of a civilization ● To know diverse methods of collecting the hydrological information, which is essential, to understand surface and groundwater hydrology ● To know the basic principles and movement of groundwater and surface water and properties of groundwater and surface water flow ● To promote the awareness of the life-long learning and to introduce them professional ethics and codes of professional practice in water management

Modules	Content	Module Outcome
Module I Introduction to Hydrology (15 hours)	**1.1 Definition, Scope, and Branches of Hydrology** Definition of hydrology and related terms - Role of hydrology in environmental science and engineering - Branches: Surface hydrology, groundwater hydrology, chemical hydrology, eco-hydrology, isotope hydrology, hydrogeology, hydro-informatics, and hydrometeorology. **1.2 Hydrological Cycle** Detailed description of cycle components: precipitation, interception, infiltration, percolation, runoff, evaporation, transpiration - Water budget and mass balance concept. **1.3 Precipitation** Forms: Rain, snow, hail, dew, frost - Types: Convective, orographic, cyclonic precipitation - Spatial and temporal distribution. **1.4 Measurement of Precipitation** Instruments: Non-recording (Standard rain gauge) and recording rain gauges (Tipping bucket, weighing gauge) - Measurement errors and correction. **1.5 Infiltration** Process and factors affecting infiltration (soil texture, vegetation, moisture content) - Infiltration capacity, infiltration rate, and measurement using double ring infiltrometer - Horton's equation for infiltration. **1.6 Surface Runoff** Concept and types (Hortonian, saturation excess) - Runoff generation mechanisms - Hydrograph basics: components, shape, and interpretation.	The student will be able to: ● Define hydrology and explain its importance. ● Understand precipitation types, measurement, and influencing factors. ● Explain infiltration mechanisms and measurement techniques. ● Differentiate between runoff types and their hydrological significance.

Module II: Evaporation, Evapotranspiration, and Surface Water Hydrology (25 hours)	**2.1 Evaporation** Definition and importance in hydrological cycle - Factors influencing evaporation (temperature, humidity, wind, solar radiation) - Evaporation from free water surfaces - Measurement of Evaporation: Pan evaporation method, Types of pans (Class A pan), procedures, and correction factors. **2.2 Transpiration** Process of water loss through plant stomata - Factors influencing transpiration. **2.3 Evapotranspiration (ET)** Combined water loss by evaporation and transpiration - Potential evapotranspiration (PET) vs. actual evapotranspiration (AET). **2.4 Watershed and Catchment Hydrology** Definition and characteristics: area, shape, drainage density, bifurcation ratio - Watershed delineation and significance. **2.5 Streamflow and River Discharge** Definition, factors influencing streamflow - Methods for streamflow measurement: velocity-area method, current meters, and stage-discharge relationships - Rating curve development. **2.6 Hydrographs** Components - Types: Instantaneous unit hydrograph, storm hydrograph - Hydrograph analysis for flood forecasting - Causes of floods and characteristics of flood hydrographs - Peak discharge, lag time, time to peak. **2.7 Runoff Estimation Methods** Rational method: formula and application for small catchments - Soil Conservation Service Curve Number (SCS-CN) method: concept and steps.	● Understand physical processes of evaporation and transpiration. ● Measure evaporation and estimate evapotranspiration using standard methods. ● Understand watershed characteristics and hydrological processes. ● Analyse streamflow data and hydrographs. ● Estimate runoff and understand flood hydrograph dynamics.
Module III: Groundwater Hydrology (20 hours)	**3.1 Groundwater Basics** Definition and importance in hydrology - Porosity, permeability, and specific yield. **3.2 Aquifers** Types: Unconfined, confined, perched, and artesian aquifers - Aquifer properties: transmissivity, storativity. **3.3 Darcy's Law and Groundwater Flow** Statement and derivation of Darcy's law - Application to groundwater flow calculations - Steady and unsteady flow concepts. **3.4 Measurement of Groundwater Levels** Well construction and types (dug wells, tube wells, bore wells) - Use of piezometers and observation wells - Water table and potentiometric surface - groundwater depth (aquifer test), conductivity, infiltration (infiltrometer), soil moisture (soil	● Explain groundwater occurrence and movement principles. ● Identify aquifer types and their properties. ● Measure groundwater levels and quality parameters. ● Discuss groundwater recharge, contamination, and sustainable management.

	moisture meter, gravimetric method, capacitance probe, Time domain reflectometer, Tensiometer). Geophysical investigation – resistivity and seismic method – application of remote sensing. **3.5 Groundwater Recharge and Discharge** Natural recharge mechanisms (infiltration, seepage) - Artificial recharge techniques - Groundwater discharge into springs, rivers, and wells. **3.6 Groundwater Contamination and Management** Sources of contamination (industrial, agricultural, domestic) - Effects on water quality - Groundwater management: conservation, regulation, pollution control.	
Module IV: Water Management Practices (15 hours)	**4.1 Wetland Management** Wetland Conservation - Importance of wetlands for hydrological balance and biodiversity - Wetland types: natural and artificial (ponds, marshes, swamps) - Wetland restoration techniques and community-based management. **4.2 Rainwater Harvesting and In-situ Water Conservation** Rainfall Pits and Rainwater Harvesting: Objectives and need for rainwater harvesting (RWH) - Types: rooftop RWH, percolation pits, recharge wells, trenches. Contour Bunding: Definition and working principle **4.3 Irrigation Techniques** Drip Irrigation: Components and layout - Advantages: water use efficiency, root-zone delivery - Limitations and maintenance. Channel Irrigation: Gravity-based surface irrigation - Lining of channels and water losses (seepage, evaporation) - Suitability for different crops and terrains. **4.4 Agricultural Water Use and Precision Farming** Irrigation Water Management - Crop water requirements (CWR), irrigation scheduling - Water use efficiency (WUE) and water productivity - Monitoring tools: tensiometers, soil moisture sensors. Precision Farming - Concept and principles: site-specific crop management - Use of GIS, GPS, and remote sensing in water management.	● Explain the principles and importance of wetland management. ● Demonstrate knowledge of various in-situ and ex-situ water conservation techniques. ● Understand modern and traditional irrigation systems and their role in sustainable water use. ● Analyse agricultural water management approaches, including precision farming.
Module V: Teacher Specific Module (5 Hours)	Areas of content, transaction, and evaluation are decided by the faculty.	
References	**Core compulsory reading** 1. Das, M. M., & Saikia, M. D. (2018). *Hydrology*. PHI Learning Private	

	Limited. 2. Chow, V. T. (1964). *Handbook of Applied Hydrology: A Compendium of Water-resources Technology*. McGraw-Hill Companies. 3. Charlu, T. G. K., & Datta, D. K. (1982). *Groundwater development in India*. Rural Electrification Corporation. 4. Reddy, P. J. R. (2011). *A Textbook of Hydrology*. Laxmi Publications. 5. Raghunath, H. M. (2022). *Engineering Hydrology: Principles, Analysis, Design*. New Age International Private Limited. 6. Chow, V. T., Maidment, D. R., & Mays, L. W. (1988). *Applied Hydrology*. McGraw-Hill Science, Engineering & Mathematics. 7. Subramanya, K. (2009). *Engineering Hydrology* (3rd ed.). McGraw-Hill Education. 8. IS 4986 (2002) Measurement of Rainfall. 9. IS 5973 (1998) Pan Evaporimeter. **Core suggested reading** 10. Todd, D. K., & Mays, L. W. (2004). *Groundwater Hydrology*. John Wiley & Sons. 11. Valdiya, K. S. (1987). *Environmental Geology, Indian Context*. McGraw-Hill Publishing Company 12. Raghunath, H. M. (2006). *Hydrology: Principles, Analysis and Design*. Wiley Eastern. 13. Linsley, R. K., Kohler, M. A., & Paulhus, J. L. H. (1975). *Hydrology for Engineers* (2nd ed.). McGraw-Hill. 14. Nash, P. (2010). *Hydrology and Water Resources*. Routledge.

Course Outcomes	**CO1:** Describe the components of the hydrological cycle and measure key parameters like precipitation and infiltration. **CO2:** Calculate evaporation and evapotranspiration using different empirical and analytical approaches. **CO3:** Analyse surface water flow, stream hydrographs, and estimate runoff using hydrological methods. **CO4:** Understand groundwater occurrence, flow principles, aquifer types, and methods for groundwater measurement and management.

Teaching Learning Strategies	Direct Instruction: Brainstorming Lecture, Explicit Teaching, E-learning (Video) Interactive Instruction: Active co-operative learning, Seminars, Group Assignments, Library work and Group discussion, Presentation by individual students/Group representative Field work and field visits
Mode of Transaction	Face to face: Lecture method & Demonstration method Learner centered technique: Computer assisted learning & Individual project teaching

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	**50**
Continuous Evaluation	**50**
● **Test papers**	**20**

● **Tutorial with Seminar presentations/Discussions/Debate, etc.**	**20**
● **Assignment**	**10**

Sample questions to test outcomes

1. What are the branches of hydrology?
2. Explain the hydrological cycle using a suitable diagram
3. Briefly explain statistical analysis in hydrology
4. Differentiate drip irrigation and channel irrigation
5. Elaborate methods of water management practices

Course Title	ENERGY AND ENVIRONMENT
Semester	**Four**
Course Code	**KU04DSCEVS207**
Course Type	**Discipline-Specific Core**
Course Credit	**4**
Pre- Requisites	**Knowledge in Environmental Science**
Course Objectives	The course aims • To introduce the fundamentals of energy types, flow, and transformation in environmental systems. • To explore conventional and non-conventional energy resources and their environmental impacts. • To understand energy policies, technologies, and their role in sustainable development. • To analyse energy conservation strategies and global energy issues in the context of climate change.

Modules	Content	Module Outcome
Module I Fundamentals of Energy and Environment (15 hours)	**1.1. Definition and Classification of Energy** Renewable vs. non-renewable energy - Primary and secondary energy. **1.2. Energy Units and Conversions** Energy use metrics. **1.3. Energy Flow in Ecosystems** Solar radiation - Food chains - Trophic levels - Ecological pyramids. **1.4. Thermodynamic Principles** First and Second Laws of Thermodynamics - Application in environmental systems. **1.5. Global and Indian Energy Scenario** Consumption patterns - Sectoral distribution - Energy access - Social inequalities related to energy production, distribution, and use.	The student will be able to: ● Describe various forms, classifications, and units of energy. ● Explain energy flow and efficiency in ecological systems. ● Apply thermodynamic principles to environmental contexts. ● Analyse energy demand and supply trends globally and in India.
Module II Conventional Energy Sources (20 hours)	**2.1. Fossil Fuels** Formation – Reserves - Extraction technologies - Energy content - Petroleum refining - Coal combustion - Natural gas processing - Gross-calorific value and net-calorific value. **2.2 Nuclear Energy** Fission and fusion - Types of reactors - Uranium cycle **2.3 Environmental Impacts** GHG emissions - Air pollution - Thermal pollution - Nuclear waste disposal **2.4 Case Studies** Indian coal-fired plants - Chernobyl and Fukushima	● Identify sources and energy content of conventional energy resources. ● Explain processes and technologies used in fossil fuel energy extraction. ● Discuss safety and environmental concerns of nuclear energy.

	disasters - Three Mile Island	
Module III Renewable Energy Sources (25 hours)	**3.1. Solar Energy** Principles of solar radiation and applications - Photovoltaic cells, solar collectors, solar ponds - Solar heating/cooling technique, solar distillation and drying, photovoltaic energy conversion - Solar thermal systems - Environmental impact of solar power - Physics of the sun - The solar constant - Extraterrestrial and terrestrial solar radiation - Solar radiation on tilted surface - Instruments for measuring solar radiation and sunshine - Solar radiation data - Applications of solar energy in India. **3.2. Wind Energy** Wind dynamics - Turbine technology - Grid integration - Onshore and offshore wind farms - Avian and wildlife interactions. **3.3. Hydropower** Types of dams - Turbine operations - Micro-hydro systems. **3.4. Biomass and Biogas** Feedstock types - Anaerobic digestion - Rural energy models. **3.5. Emerging Renewable Sources** Geothermal Energy & Ocean Energy: Types of wells, methods of harnessing the energy, potential in India. Principles utilization, setting of OTEC plants, thermodynamic cycles. Tidal and wave energy: Potential and conversion techniques, mini-hydel power plants, and their economics. Hydrogen fuel	● Compare different types of renewable energy sources. ● Understand the design and working of renewable energy technologies. ● Assess benefits and limitations of renewable energy systems. ● Evaluate emerging renewable technologies for feasibility and scalability.
Module IV Energy Planning, Policy, and Conservation (15 hours)	**4.1. Energy Efficiency and Conservation** Efficient appliances - Building insulation - Green buildings - Smart grids **4.2. Energy Policies** National energy policy (India) - SDG 7 (Affordable and Clean Energy) - NAPCC (National Action Plan on Climate Change) - PAT (Perform, Achieve and Trade) **4.3. Energy and Climate Change** GHG emissions from various sectors - Carbon footprint - Life-cycle analysis - Urban heat island effect - Radiative forcing - Impacts of large-scale exploitation of energy resources. **4.4. Role of individuals and communities** Behavioural changes - Local initiatives - Case studies on community-driven energy solutions.	● Apply conservation techniques across sectors. ● Interpret national and global energy policy frameworks. ● Understand the link between energy production/consumption and climate change. ● Promote individual and collective responsibility in sustainable energy use.

Module V Teacher Specific Module (5 Hours)	Areas of content, transaction, and evaluation are decided by the faculty.	
References	**Core compulsory reading** 1. Ramana, P. V., & Srinivas, S. N. (1997). *Biomass energy systems: Proceedings of the international conference, 26–27 February 1996*. Tata Energy Research Institute. 2. Eastop, T. D., & Croft, D. R. (1990). *Energy efficiency: For engineers and technologists*. Longman Publishing Group. 3. Turner, W. C., & Doty, S. (2009). *Energy management handbook* (7th ed.). Fairmont Press. 4. Murphy, W. R. (2007). *Energy management*. Elsevier. 5. Smith, C. B. (2007). *Energy management principles*. Pergamon. 6. Rao, C. S. (2015). *Environment pollution control engineering* (2nd ed.). New Age International. 7. Rai, G. D. (2003). *Non-conventional energy sources*. Khanna Publishers. 8. Twidell, J., & Weir, T. (2006). *Renewable energy resources*. Taylor & Francis. 9. Joseph, B. (2006). *Environmental studies*. Tata McGraw-Hill. 10. Mittal, K. M. (1997). *Non-conventional energy systems: Principles, progress and prospects*. Wheeler Publications. **Core suggested reading** 11. Tata Energy Research Institute. (1998). *Looking back to think ahead: Green India 2047*. TERI. 12. McKinney, M., & Schoch, R. M. (1998). *Environmental sciences: Systems and solutions*. Jones & Bartlett Publishers. 13. Miller, G. T. (2006). *Environmental science: Working with Earth*. Thomson. 14. Tata Energy Research Institute. (1997). *TERI energy data directory & year book (TEDDY)*. TERI. 15. Wright, R. T. (2008). *Environmental science: Towards a sustainable future*. Prentice Hall.	

Course Outcomes	**CO1:** Explain the science of energy flow in ecosystems and anthropogenic systems. **CO2:** Differentiate between various energy resources, their applications, and limitations. **CO3:** Assess the environmental and socio-economic impacts of energy generation and consumption. **CO4:** Propose sustainable energy solutions using conservation and policy tools.

Teaching Learning Strategies	Direct Instruction: Brainstorming Lecture, Explicit Teaching, E-learning (Video) Interactive Instruction: Active co-operative learning, Seminars, Group Assignments, Library work and Group discussion, Presentation by individual students/Group representative Field work and field visits
Mode of Transaction	Face to face: Lecture method & Demonstration method Learner-centered technique: Computer assisted learning & Individual project teaching

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	**50**
Continuous Evaluation	**50**
● **Test papers**	**20**
● **Tutorial with Seminar presentations/Discussions/Debate, etc.**	**20**
● **Assignment**	**10**

Sample questions to test outcomes

1. Define renewable and non-renewable energy with two examples each.
2. Compare and contrast fossil fuel and nuclear energy in terms of efficiency and pollution.
3. Explain India's energy policy and its integration with climate action.
4. What are the advantages of biogas over fossil fuels?
5. Analyse the lifecycle emissions of wind vs. coal-based power plants.

Course Title	ENVIRONMENTAL CHEMISTRY PRACTICAL I
Semester	**Four**
Course code	**KU04DSCEVS208**
Course type	**Discipline-Specific Core**
Course Credit	**4**
Pre-requisites	**Theoretical knowledge in Environmental Chemistry**
Course Objectives	The course aim • To develop practical skills in the analysis of environmental samples including water, soil, and air. • To familiarize students with standard laboratory procedures and instrumental techniques used in environmental chemistry. • To train students in the interpretation and analysis of environmental chemical data. • To ensure safe laboratory practices and enhance problem-solving skills through hands-on experience.

Modules	Content	Module Outcome
Module I Determination of various Physico - chemical properties of Water (25 hours)	1.1. Determination of pH 1.2. Determination of conductivity 1.3. Determination of D.O 1.4. Determination of total solids (Gravimetry) 1.5. Determination of total dissolved solids (Gravimetry) 1.6. Determination of total suspended solids (Gravimetry) 1.7. Determination of chlorides 1.8. Estimation of iron (Colorimetry) 1.9. Estimation of Hardness, Calcium and Magnesium 1.10. Chemical oxygen demand 1.11. Biological oxygen demand	The students will be able to: • Know the basic principles of the analysis of water, air, soil quality parameters
Module II Determination of various Physico - chemical properties of Water (20 hours)	2.1. Estimation of fluoride 2.2. Estimation of phosphate 2.3. Estimation of Nitrate & Nitrite 2.4. Estimation of Sodium & Potassium (Flame photometry) 2.5. Estimation of pesticides using TLC / paper chromatography 2.6. Estimation Acidity and Alkalinity.	• Analyse the Physico-chemical parameters of water
Module III Determination of various Physico - chemical properties of Soil Analysis (20 hours)	**3.1.** Determination of soil pH 3.2. Determination of soil moisture content 3.3. Estimation of soil chloride 3.4. Determination of TOC 3.5. Determination of Ca^{2+} & Mg^{2+} 3.6. Determination of food adulterant **3.7.** Organic Carbon, Soil Texture	• Assess Physico-chemical parameters of soil
Module IV Air Quality	**4.1. Air Quality Analysis** (Demonstration only) a) Particulate matter	• Perform various pollution monitoring

&Noise Quality Analysis (15 hours)	b) NO_x c) SO_x d) Pollen grains. **4.2. Noise Quality Analysis** (Demonstration only)	techniques
References	**Core compulsory reading** 1. Palleros, D. R. (2001). *Experimental organic chemistry*. John Wiley & Sons. 2. Furniss, B. S., Hannaford, A. J., Smith, P. W. G., & Tatchell, A. R. (1994). *Vogel's textbook of practical organic chemistry*. Longman Singapore Publishers. 3. Jeffery, G. H., Bassett, J., Mendham, J., & Denny, R. C. (1996). *Vogel's textbook of quantitative chemical analysis* (5th ed.). Longman Singapore Publishers. 4. Kolthoff, I. M., Sandell, E. B., Meites, L., & Brunauer, S. (1980). *Quantitative chemical analysis*. Macmillan.	

Course Outcomes	**CO1:** To develop skill in water analysis **CO2:** To develop skill in soil analysis **CO3:** To develop skill in air analysis **CO4:** To develop skill in pollution analysis

Teaching Learning Strategies	Direct Instruction: Brainstorming Lecture, Explicit Teaching, E-learning (Video) Interactive Instruction: Active co-operative learning, Seminars, Group Assignments, Library work and Group discussion, Presentation by individual students/Group representative Field work and field visits
Mode of Transaction	Face to face: Lecture method & Demonstration method Learner centered technique: Computer assisted learning & Individual project teaching

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	**50**
Continuous Evaluation	**50**
● **Test papers**	**20**
● **Tutorial with Seminar presentations/Discussions/Debate, etc.**	**20**
● **Assignment**	**10**

Sample questions to test outcomes

1. Analyse the water sample and calculate the amount of chloride in the sample.
2. Write the principle and procedure of determination of hardness.

SEMESTER V

Course Title	ENVIRONMENTAL TOXICOLOGY
Semester	**Five**
Course Code	**KU05DSCEVS301**
Course Type	**Discipline-Specific Core**
Course Credit	**4**
Prerequisite	**Knowledge in Environmental Science**
Course Objectives	The course aims ● To introduce the fundamental principles and scope of environmental toxicology. ● To understand the sources, types, and behaviour of environmental toxicants. ● To study the effects of toxicants on organisms and ecosystems. ● To examine the principles of risk assessment, toxicological testing, and regulatory frameworks.

Modules	Content	Module Outcome
Module I Fundamentals of Environmental Toxicology (15 hours)	**1.1 Introduction to Environmental Toxicology:** Definition, scope, and historical development - Branches of toxicology - Importance of toxicology - Principles of toxicology **1.2 Classification of Toxicants** Organic, inorganic, biological, radioactive - Entry into the environment, cycles and residence time - point and non-point sources. **1.3 Dose-Response Relationship** Concept of dose – Threshold - LD50, ED50, NOEL, LOEL. **1.4 Factors Influencing Toxicity** Age, sex, genetics, exposure duration, synergism, antagonism - Toxic effects due to a combination of chemicals. **1.5 Environmental Fate of Toxicants** Transport, transformation, and degradation in air, water, soil.	The student will be able to: ● Understand the foundational concepts and scope of environmental toxicology. ● Identify and classify environmental toxicants and their sources. ● Analyse dose-response relationships and their implications in toxicology. ● Assess factors that influence the behaviour and impact of toxicants.
Module II Mechanisms of Toxicity and Toxicokinetics (20 hours)	**2.1 Toxicokinetics** Absorption, Distribution, Metabolism, and Excretion (ADME) of toxicants. **2.2 Biotransformation** Phase I and Phase II reactions - Role of liver enzymes. **2.3 Mechanisms of Toxic Action** Enzyme inhibition - Oxidative stress - Receptor-mediated toxicity. **2.4 Organ Toxicity** Hepatotoxicity – Nephrotoxicity – Neurotoxicity -	● Explain how toxicants enter and move through biological systems. ● Understand biotransformation pathways and detoxification mechanisms. ● Describe toxic

	Reproductive and developmental toxicity. **2.5 Biomarkers of Exposure and Effect** Introduction to Biomarkers - Definition and classification of biomarkers - Biomarkers of exposure - Biomarkers of effect - Biomarkers of susceptibility - Importance of biomarkers in environmental toxicology - Applications in environmental health monitoring.	effects at organ and cellular levels. ● Apply knowledge of biomarkers in environmental monitoring.
Module III Ecotoxicology and Environmental Impact (20 hours)	**3.1 Ecotoxicology** Definitions - Levels of biological organization - Direct vs. indirect effects. **3.2 Bioaccumulation, Bioconcentration and Biomagnification.** Mechanisms of bioaccumulation - Mechanism of bioconcentration - Biomagnification process - Influencing factors - Ecological and health impacts. **3.1 Toxicity Testing** In vitro and In vivo toxicity test - Acute, sub-chronic, chronic tests - test organisms - LC50, EC50. **3.2 Microbial and Plant Toxicology** Effects on soil microbes, algae, phytotoxicity. 3.3 **Case Studies** Xenobiotics - Heavy metals (Lead, Mercury, Cadmium) - Pesticides (DDT, organophosphates) - Plastics.	● Understand the interactions between toxicants and ecosystems. ● Evaluate ecological risks from pollutants using bioaccumulation and biomagnification data. ● Interpret results of standard ecotoxicological testing procedures. ● Analyse real-world case studies of environmental contamination.
Module IV Environmental Risk Assessment and Regulations (20 hours)	**4.1 Environmental Risk Assessment (ERA)** Hazard identification - Exposure assessment - Risk characterization. **4.2 Toxicity Indices and Thresholds** ADI - RfD - Hazard quotient - Safety factors. **4.3 Toxicological Guidelines and Frameworks** WHO, EPA, CPCB, BIS. **4.4 Regulation of Environmental Toxicants** Laws related to air, water, soil pollution and hazardous waste. **4.5 Role of International Protocols** Stockholm Convention - Basel Convention - REACH.	● Develop environmental risk assessment models based on toxicological data. ● Apply toxicity indices to evaluate pollutant risks. ● Interpret environmental guidelines and legal standards. ● Understand international efforts in regulating toxicants.
Module V Teacher Specific Module (5 Hours)	Areas of content, transaction, and evaluation are decided by the faculty.	

References	**Core compulsory reading** 1. Pandey, K. (2005). *Fundamentals of toxicology*. New Central Book Agency. 2. Sharma, P. D. (1997–1998). *Environmental biology and toxicology*. 3. Gupta, P. K. (n.d.). *Modern toxicology*. New Central Book Agency. 4. Butler, G. C. (n.d.). *Principles of ecotoxicology*. 5. Duffus, H. J. (n.d.). *Environmental toxicology*. 6. Shukla, J. P., & Pandey, K. (n.d.). *Elements of toxicology*. Radha Publishers. 7. Rand, G. M., & Petrocelli, S. R. (n.d.). *Fundamentals of aquatic toxicology*. Hemisphere Publishing Corporation. **Core suggested reading** 8. Cockerham, L. G., & Shane, B. S. (n.d.). *Basic environmental toxicology*. CRC Press. 9. Kalia, M., & Sood, A. (n.d.). *Food preservation and processing*. Kalyani Publishers. 10. Hobbs, B. C., & Roberts, D. (1993). *Food poisoning and food hygiene* (6th ed.). Edward Arnold Publishers. 11. Pandey, K., Shukla, J. P., & Trivedi (Eds.). (2009). *Fundamentals of toxicology*. New Central Book Agency.

Course Outcomes	**CO1:** Explain the sources, classification, and environmental behaviour of toxicants. **CO2:** Analyse the mechanisms of toxicity at molecular, organismal, and ecosystem levels. **CO3:** Evaluate the bioaccumulation, biomagnification, and ecological risks of various pollutants. **CO4:** Interpret toxicological data and apply regulatory guidelines to environmental health problems.

Teaching Learning Strategies	Direct Instruction: Brainstorming Lecture, Explicit Teaching, E-learning (Video) Interactive Instruction: Active co-operative learning, Seminars, Group Assignments, Library work and Group discussion, Presentation by individual students/Group representative Field work and field visits
Mode of Transaction	Face to face: Lecture method & Demonstration method Learner-centered technique: Computer-assisted learning & Individual project teaching

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	**50**
Continuous Evaluation	**50**
● **Test papers**	**20**
● **Tutorial with Seminar presentations/Discussions/Debate, etc.**	**20**
● **Assignment**	**10**

Sample questions to test outcomes

1. Explain the importance of environmental toxicology
2. Illustrate the ingestion type of exposure with suitable examples
3. Comment on historical perspective of toxicity studies
4. Briefly explain the importance of metabolism in toxicity.
5. What is dose?

Course Title	ATMOSPHERIC SCIENCE AND METEOROLOGY
Semester	**Five**
Course Code	**KU05DSCEVS302**
Course Type	**Discipline-Specific Core**
Course Credit	**4**
Pre-Requisites	**Environmental Science/Atmospheric Science/Basic Science**
Course Objectives	The course aims ● To introduce fundamental concepts of atmospheric science ● To develop an understanding of atmospheric thermodynamics and dynamics ● To understand the meteorological and climatic phenomena ● To introduce techniques for atmospheric monitoring and modeling ● To foster climate modeling and prediction skills ● To equip students with practical and research skills

Modules	Content	Module Outcome
Module I Fundamentals of Atmospheric Science (20 hours)	**1.1 Structure and composition of the atmosphere** Layers of the atmosphere – Troposphere, Stratosphere, Mesosphere, Thermosphere, Exosphere Composition of the atmosphere – permanent & variable gases, aerosols Role of the atmosphere in sustaining life **1.2 Atmospheric Dynamics and Energy Balance** Solar radiation and Earth's energy budget Greenhouse effect and radiative forcing Heat transfer processes (conduction, convection, radiation) Seasonal variations and latitudinal energy distribution **1.3 General Circulation and Wind Systems** Coriolis effect and atmospheric motion Hadley, Ferrel, and Polar cells Trade winds, jet streams, and planetary waves Atmospheric stability and lapse rate	The student will be able to • Know about the fundamentals of atmospheric science • Identify the basics of dynamics of atmosphere • Recognize the circulation and wind systems • Gain knowledge on atmospheric role on sustaining life
Module II Fundamentals of Meteorology (20 hours)	**2.1 Fundamentals of Meteorology** Radiation Balance and Laws, Wind Belts, Monsoon, Climate. **2.2 Atmospheric Thermodynamics** Hydrostatic equilibrium and Hydrostatic equation, variation of pressure with height, geopotential, Tropical convection. **2.3 Atmospheric Electricity** Cloud Physics. Observation Techniques of the Atmospheric Properties. **2.4 Fundamental Equations** Pressure, gravity, centripetal and Coriolis forces, continuity equation in Cartesian and isobaric coordinates, Scale analysis, inertial flow, geostrophic and gradient winds, thermal wind, vorticity.	● Gain knowledge on fundamentals of meteorology. ● Know thermodynamics of atmosphere. ● Gain knowledge on cloud physics. ● Familiarize with fundamental equations related to meteorology.

	2.5 Atmospheric Turbulence Baroclinic instability, Atmospheric Waves.	
Module III Tropical Meteorology (20 hours)	**3.1 Meteorological Parameters and Weather Elements** Temperature, pressure, humidity, wind, and precipitation Instruments for weather measurement (thermometer, barometer, anemometer, hygrometer, rain gauge) Weather maps, isobars, and weather chart interpretation **3.2 Tropical Meteorology** Trade wind inversion, ITCZ, monsoon trough tropical cyclones, their structure and development theory, monsoon depressions. **3.3 Climate Variability and Forcings** Madden-Julian oscillation (MJO), ENSO, QBO (quasi-biennial oscillation) and sunspot cycles.	● Describe meteorological parameters. ● Differentiate climate variability and climate forcings ● Gain knowledge on tropical meteorology
Module IV Atmospheric Monitoring and Modeling (20 hours)	**4.1. Introduction to Atmospheric Models** Concept of numerical weather prediction (NWP) Governing equations of atmospheric motion (Navier-Stokes, thermodynamic equations) Types of models (deterministic vs. ensemble models) **4.2 Meteorological Modelling** Meteorological data collection (ground stations, balloons, aircraft) Satellite-based remote sensing in atmospheric science Weather forecasting techniques and models **4.3 Climate Modelling and Prediction** Synoptic weather forecasting, prediction of weather elements such as rain, maximum and minimum temperature and fog. Data Assimilation. Introduction to General Circulation Models (GCMs) Regional Climate Models (RCMs) and their applications Limitations and uncertainties in climate modeling	● Gain knowledge on atmospheric models. ● Illustrate equations of atmospheric motion. ● Recognize the difference between meteorological modelling and climate modelling ● Describe weather forecasting techniques and models. ● Recognize the limitations in climate modeling.
Module V Teacher Specific Module (5 Hours)	Areas of content, transaction, and evaluation are decided by the faculty.	
References	**Core compulsory reading** 1. Wallace, J. M., & Hobbs, P. V. (2006). *Atmospheric Science: An Introductory Survey* (2nd ed.). Academic Press. 2. Holton, J. R. (2004). *An Introduction to Dynamic Meteorology* (4th ed.). Elsevier. 3. Bohren, C., & Albrecht, B. (2023). *Atmospheric Thermodynamics* (2nd ed.). Oxford University Press.	

	4. Fedorovich, E., Rotunno, R., & Stevens, B. (2004). *Atmospheric Turbulence and Mesoscale Meteorology*. In Cambridge University Press eBooks. 5. Jacobson, M. Z. (2005). *Fundamentals of Atmospheric Modeling* (2nd ed.). Cambridge University Press. 6. Khouider, B. (2019). *Models for Tropical Climate Dynamics: Waves, Clouds, and Precipitation*. Springer. **Core suggested reading** 1. Lutgens, F. K., & Tarbuck, E. J. (2019). *The Atmosphere: An Introduction to Meteorology* (14th ed.). Pearson. 2. Laing, A., & Evans, J. L. (2011). *Introduction to Tropical Meteorology* (2nd ed.). The COMET Program. 3. Sokhi, R. S., Baklanov, A., & Schlünzen, K. H. (Eds.). (2018). *Mesoscale Modelling for Meteorological and Air Pollution Applications*. Anthem Press. 4. Stainforth, D. (2022). *Predicting Our Climate Future: What We Know, What We Don't Know, and What We Can't Know*. Oxford University Press.

Course Outcomes	**CO1:** Develop knowledge and critical understanding of Atmospheric Structure & Composition **CO2:** Interpret the fundamental equations of atmospheric science and meteorology, and their role in weather systems **CO3:** Understand the principles behind climate models and prediction techniques **CO4:** Develop Skills in Climate Prediction & Future Projections **CO5:** Utilize numerical and statistical models for weather forecasting and environmental assessment

Teaching Learning Strategies	Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning (Video) Interactive Instruction: Active co-operative learning, Seminars, Group Assignments, Library work and Group discussion, Presentation by individual student/ Group representative Field work and field visits
Mode of Transaction	Face to face: Lecture method & Demonstration method Learner centered technique: Computer assisted learning & Individual project teaching

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	**50**
Continuous Evaluation	**50**
• **Test papers**	**20**
• **Tutorial with Seminar presentations/Discussions/Debate, etc.**	**20**
• **Assignment**	**10**

Sample questions to test outcomes.

1. Explain the composition of the atmosphere and its significance in sustaining life on Earth.
2. Differentiate between climate variability and climate forcings with examples.
3. What are the major components of climate models, and how do they differ from weather models?
4. What are the different types of atmospheric models? Compare deterministic and ensemble models.

Course Title	ENVIRONMENTAL MICROBIOLOGY
Semester	**Five**
Course Code	**KU05DSCEVS303**
Course Type	**Discipline-Specific Core**
Course Credit	**4**
Prerequisite	**Environmental Microbiology, Environmental Science**
Course Objectives	The Course aims ● To understand the history and basics of microbiology ● To learn about microbial diversity in the environmental matrix ● To study the importance of microbes in the field of environmental microbiology ● To understand the biodegradation and its importance ● To know about recent advances in bioremediation techniques

Modules	Content	Module Outcome
Module I Introduction to Environmental Microbiology (20 hours)	**1.1 Introduction to Environmental Microbiology** Scope and relevance - Classification and diversity of microorganisms (bacteria, archaea, fungi, algae, protozoa, viruses) - Methods in microbial taxonomy and identification **1.2 Microbial Ecology** Microbial habitats: soil, water, air - Microbial interactions (symbiosis, commensalism, competition, predation, parasitism) - Biofilms and quorum sensing **1.3 Microbial Growth and Nutrition** Growth curves and kinetics - Factors influencing microbial growth - Nutritional types and requirements **1.4 Microbial Techniques** Culture techniques - Microscopy and staining methods - Molecular tools for microbial analysis (PCR, DNA fingerprinting, metagenomics – basics) **1.5 Application** Antibiotic sensitivity testing - Serological methods - Phage typing - Protein analysis - Comparison of nucleotide sequences.	The student will be able to: ● Explain the diversity and classification of microorganisms. ● Analyse microbial relationships in different environments. ● Apply basic microbiological techniques for environmental analysis. ● Interpret microbial interactions through ecological principles.
Module II Environmental Microbiology II (15 hours)	**2.1 Microbial Role in Biogeochemical Cycles** Carbon, nitrogen, sulphur, and phosphorus cycles - Methanogenesis and nitrification. **2.2 Microbial Pollution and Pathogens** Waterborne pathogens and indicators - Airborne microorganisms - Microbial contaminants in soil and food **2.3 Biodegradation and Bioremediation** Microbial degradation of hydrocarbons, pesticides, and plastics - In-situ and ex-situ bioremediation - Genetically modified microbes in bioremediation. **2.4 Microbial Monitoring and Biosensors** Microbial biosensors - Microbial indicators in water	● Evaluate microbial contributions to nutrient cycling. ● Identify major microbial pollutants and their health implications. ● Describe microbial processes in pollutant degradation.

	and soil pollution - Microbiological standards for potable water.	● Use microbiological tools for environmental monitoring.
Module III Introduction to Environmental Biotechnology (15 hours)	**3.1 Introduction to Environmental Biotechnology** Environmental Biotechnology - Principles, scope and development, Role of biotechnology in Environmental Protection. Genetic Engineering - Principles of genetic engineering - Application of genetic engineering - Benefits and hazards - The ethical and social implications of genetic engineering - Recombinant DNA technology. **3.2 Biotechnology in Waste Management** Composting and vermicomposting - Biogas and biofuel production - Microbial degradation of solid waste. **3.3 Biofertilizers and Biopesticides** Nitrogen-fixers, phosphate solubilizers, mycorrhizae - Microbial bio-pesticides and mode of action - Integrated Pest Management (IPM). **3.4 Biotechnology in Agriculture** Genetically Modified Organisms - Transgenic crops and environmental impact - Biosafety regulations and ethical concerns - Tissue culture: Techniques and its applications.	● Illustrate the scope and principles of environmental biotechnology. ● Evaluate biotechnological methods in waste conversion. ● Apply knowledge of biofertilizers and biopesticides in sustainable agriculture. ● Assess environmental impacts of GMOs and related biosafety issues.
Module IV Emerging trends in Environment Biotechnology (25 hours)	**4.1 Bioreactors and Fermentation Technology** Types of bioreactors (batch, continuous, fed-batch) - Downstream processing - Microbial consortia in reactors. **4.2 Biotechnology in Pollution Control** Biotreatment of industrial effluents (Paper industries, Textile Industries, Petrochemical Industries, Leather Industries and Mining Industries) - Biofiltration and bio scrubbers - Constructed wetlands and phytoremediation. **4.3 Biotechnology in Resource Recovery** Bioleaching and biomining - Bioplastics production - Recovery of metals and nutrients. **4.4 Emerging Technologies** Synthetic biology – Nanobiotechnology - CRISPR in environmental applications.	● Design and interpret bioreactor operations. ● Demonstrate biotechnological solutions for pollution control. ● Analyse resource recovery techniques using biotechnology. ● Explore recent advances in environmental biotechnology.
Module V Teacher Specific Module (5 Hours)	Areas of content, transaction, and evaluation are decided by the faculty.	
References	**Core compulsory reading**	

	1. Prescott, L. M., Harley, J. P., & Klein, D. A. (n.d.). *Microbiology* (7th ed.). 2. Sharma, K. (2010). *Manual of microbiology: Tools and techniques* (2nd ed.). Ane Books. 3. Pelczar, M. J., Chan, E. C. S., & Krieg, N. R. (n.d.). *Microbiology* (8th ed.). 4. Soper, R. (n.d.). *Biological science* (3rd ed.). Cambridge University Press. 5. Bhatia, S. C. (n.d.). *Handbook of environmental biotechnology* (Vol. 1). Atlantic Publishers. 6. Agarwal, S. K. (n.d.). *Advances in environmental biotechnology*. 7. Evans, G. M., & Furlong, I. C. (n.d.). *Environmental biotechnology: Theory and application*. 8. Sobti, R. C., & Pachauri, S. S. (n.d.). *Essentials of biotechnology*. 9. Hanspeter, W. (n.d.). *Methods in biotechnology*. 10. Sharma, S. K. (2008). *Manual of microbiology*. Ane Books. **Core suggested reading** 12. Indu, S., & Thakur, T. (2006). *Environmental biotechnology*. I.K. International. 13. Ulhas, K. P., & Muskan, K. (2009). *Essentials of biotechnology*. I.K. International. 14. Hari, S. (2017). *Environmental microbiology*. Crescent Publishing. 15. Varnam, H. A. (2000). *Environmental microbiology*. Manson Publishing.

Course Outcomes	**CO1:** Familiarize the microbiological standards for water **CO2:** Compare microbial diversity among the environmental compartments **CO3:** Acquire knowledge on microbes' aid in containment's degradation **CO4:** Explore various updated methods of bio-remediation technique

Teaching Learning Strategies	Direct Instruction: Brainstorming Lecture, Explicit Teaching, E-learning (Video) Interactive Instruction: Active co-operative learning, Seminars, Group Assignments, Library work and Group discussion, Presentation by individual students/Group representative Field work and field visits
Mode of Transaction	Face to face: Lecture method & Demonstration method Learner centered technique: Computer assisted learning & Individual project teaching

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	**50**
Continuous Evaluation	**50**
● **Test papers**	**20**
● **Tutorial with Seminar presentations/Discussions/Debate, etc.**	**20**
● **Assignment**	**10**

Sample questions to test the outcome

1. Discuss the history and scope of environmental microbiology
2. What are the physical factors influencing the growth of aquatic microorganisms?
3. Discuss the role of bacteria in maintaining ecosystem health
4. Comment on the distribution of microorganisms in the aquatic environment.
5. Give a detailed account of the ecological importance of microorganisms.

Course Title	**PRACTICAL IN ENVIRONMENTAL MICROBIOLOGY**
Semester	**Five**
Course Code	**KU05DSCEVS304**
Course Type	**Discipline-Specific Core**
Course Credit	**4**
Prerequisite	**Knowledge in Environmental Microbiology**
Course Objectives	The course aims: ● To provide hands-on training in microbiological techniques relevant to environmental analysis. ● To develop skills in isolating, culturing, and identifying microorganisms from different environmental samples. ● To study microbial interactions and their roles in environmental processes. ● To apply microbiological techniques in assessing environmental quality and biodegradation.

Modules	Content	Module Outcome
Module I Fundamentals and Laboratory Techniques in Environmental Microbiology (15 hours)	**1. 1 Introduction** Laboratory safety - Aseptic techniques - Sterilization (dry heat, moist heat, filtration, chemical methods) **1.2 Preparation and Sterilization of Culture Media** Nutrient Agar - MacConkey Agar - Sabouraud Dextrose Agar, etc. **1.3 Cleaning and Sterilization of Glassware** **1.4 Use and Calibration of Microbiological Equipment** Autoclave - Laminar air flow - BOD incubator - Colony counter – Microscopy - Compound Microscope – Hemocytometer - Hot Air Oven - Water Bath - Filter Sterilization.	The student will be able to ● Understand and implement basic lab safety and aseptic procedures. ● Prepare and sterilize various culture media. ● Operate and maintain common microbiological instruments. ● Demonstrate good laboratory practices for handling microbes.
Module II (15 hours)	**2.1** Collection of air, water, and soil samples for microbiological analysis **2.2** Isolation of bacteria, fungi, and actinomycetes from soil and water **2.3** Observation under microscope and identification.	● Isolate and culture microorganisms from environmental sources. ● Use plating techniques for quantification and isolation of microbes. ● Recognize morphological characteristics under the microscope.
Module III Culture Media	**3.1 Bacterial Morphology** **3.2 Culture Media**	

Preparation (25 hours)	a. Medium for Microorganism Culture b. Preparation of Nutrient Broth c. Preparation of Nutrient Agar Plate d. Preparation of Agar Slants for the Preservation of Microorganisms e. Preparation of Potato Dextrose Agar (PDA) **3.3 Preparation of Bacterial Smear** a. Preparation of Bacterial Smear from Nutrient Broth b. Preparation of Bacterial Smear from Nutrient Agar **3.4 Inoculation & Culture Techniques:** a. Spread plate b. Pour plate c. Drop inoculation d. Streaking on plate **e.** Serial dilution method of estimation.	● Gain knowledge in basic microbiological equipment. ● Gain insight into the basics of microbiology from practical aspects. ● Gain skill for analyzing microbes
Module IV Microbial Isolation, Enumeration and Identification Techniques (20 hours)	**4.1. Staining Techniques and microscopic observation** a. Simple Staining of Bacteria b. Gram Staining of Bacteria c. Endospore Staining d. Negative Staining **4.2. Cultivation and enumeration of bacteriophages (Coliphages) from raw sewage**. (Demonstration only) **4.3. Assessment of water quality by total coliform and fecal coliform** **4.4. Most Probable Number (MPN) technique for Coliform analysis** **4.5. Sampling, isolation and enumeration of microorganisms in soil samples** a) THB Load of the Soil Sample by Pour Plate Method b) THB Load of the Soil Sample by Pour Plate Method **4.6. Detection of bacterial motility - Hanging drop method** **4.7. Biochemical test for characterization of bacteria** b) Catalase test c) Oxidation Fermentation Test **4.8. Isolation of Fungi**	● Gain insight into the staining techniques. ● Gain basic knowledge in sampling, isolation of bacteria
References	**Core compulsory reading** 1. American Public Health Association (APHA), American Water Works Association (AWWA), & Water Environment Federation (WEF). (2017). *Standard methods for the examination of water and wastewater* (23rd ed.). https://www.standardmethods.org 2. United Nations Environment Programme (UNEP). (2002). *Global environment outlook*. Earthscan Publications Ltd.	

	3. Cotgreave, P., & Forseth, I. (2002). *Introductory ecology*. Blackwell Science. 4. Freedman, B. (1995). *Environmental ecology*. Academic Press. 5. Odum, E. P. (1993). *Fundamentals of ecology*. 6. Odum, E. P., & Barrett, G. W. (1971). *Fundamentals of ecology* (Vol. 3). W.B. Saunders. 7. Smith, R. L. (1990). *Ecology and field biology*. HarperCollins Publishers. 8. Smith, R. L., & Smith, T. M. (1998). *Elements of ecology*. Addison Wesley Longman.
Course Outcomes	**CO1:** Perform microbiological sampling, culturing, and enumeration from soil, water, and air. **CO2:** Apply staining and microscopic techniques to identify microorganisms. **CO3:** Evaluate microbial roles in biogeochemical cycles, wastewater treatment, and bioremediation. **CO4:** Demonstrate laboratory safety, aseptic techniques, and data interpretation skills in microbiology.

Teaching Learning Strategies	Direct Instruction: Brainstorming Lecture, Explicit Teaching Interactive Instruction: Active co-operative learning, Library work and Group discussion, Hands on training Field visits
Mode of Transaction	Face to face: Lecture method & Demonstration method

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	**50**
Continuous Evaluation	**50**
● **Practical Examination**	**20**
● **Lab record**	**20**
● **Internal viva**	**10**

Sample Questions to test Outcomes

1. Identify given microorganisms.
2. Determine the minimum size of quadrate using the given data.
3. Write down the principle and procedure for the determination of transparency using a Secchi disc.

Course Title	CLIMATE CHANGE & ENVIRONMENTAL ETHICS
Semester	**Five**
Course Code	**KU05DSEEVS301**
Course Type	**Discipline-Specific Elective**
Course Credit	**4**
Prerequisite	**Knowledge in Environmental Science/Physics/Climate Change**
Course Objectives	The course aims ● To understand the science of climate change ● To analyze the impacts of climate change ● To explore mitigation and adaptation strategies to combat climate change ● To develop ethical and philosophical perspectives of climate change ● To assess climate policies and governance related to climate action ● To foster sustainable thinking and solutions

Modules	Content	Module Outcome
Module I Introduction to Climate Change (10 hours)	**1.1 Basics of Climate Science and Climate Change** Climate system: Components and interactions - Greenhouse gases and global warming - Climate change evidence and trends - Anthropogenic vs. natural climate variations **1.2 Science of Climate Change** Earth's energy balance and radiative forcing - Role of oceans and atmosphere in climate regulation - Feedback mechanisms (positive and negative) **1.3 Climate Models and Predictions** Climate modelling: Principles and types (GCMs, RCMs) - Uncertainties and limitations in climate predictions - Future scenarios: IPCC projections (RCPs, SSPs) **1.4 Tipping Points and Irreversible Changes** Permafrost thawing and methane release - Amazon rainforest dieback - Ocean circulation disruptions (AMOC weakening)	The student will be able to • Know about the fundamentals of climate science • Understand the science behind climate change • Describe climate models and predictions. • Recognize the tipping points of climate change. • Gain knowledge on the irreversible changes caused by climate change.
Module II Climate Change Impacts & Mitigation Potential (15 hours)	**2.1 Climate Change Impacts** Agriculture, coastal system, food supply and demand, biodiversity. **2.2. Land Degradation** Desertification, precipitation, polar ice melting and sea level rise. **2.3. Climate Change on Health** overview, food, biological and seasonal cycle, economy - Direct effect: health injuries, thermal stress, infectious, malnutrition, mental stress, drugs. **2.4 Mitigation Potentials** Energy sector, Transport sector, Industrial sector, Agricultural sector. **2.5 Bio-energy Options**	● Gain knowledge on impacts of climate change. ● Know the climate mitigation potential of various sectors. ● Familiarize with the bioenergy options to mitigate climate change.

	Hybrid fuel system, good cultivation habits, tree cover enhancement and policy regulation.	
Module III Environmental Ethics and Climate Change (20 hours)	**3.1 Introduction to Environmental Ethics** Definition and scope of environmental ethics - Key ethical theories (Utilitarianism, Deontology, Virtue Ethics) - Deep Ecology and Ecocentrism vs. Anthropocentrism **3.2 Ethical Dimensions of Climate Change** Climate justice: Responsibilities of developed vs. developing nations - Intergenerational equity and obligations to future generations - The moral responsibility of corporations and governments **3.3 Ethical Dilemmas in Climate Change** Balancing economic growth with environmental sustainability - Climate refugee crisis and human rights issues - Ethical implications of geoengineering and genetic modifications	● Gain knowledge on basics of environmental ethics. ● Describe how environmental ethics is related to climate change. ● Recognize the ethical dilemmas in climate change ● Gain knowledge on climate justice and human rights issues related to climate change.
Module IV Climate Change Policy and Governance (10 hours)	**4.1 International Climate Agreements** United Nations Framework Convention on Climate Change (UNFCCC) - Kyoto Protocol (1997): Successes and failures - Paris Agreement (2015): Goals, commitments, and challenges **4.2 National and Regional Policies** Role of governments in climate mitigation - Carbon pricing mechanisms (carbon tax, cap-and-trade) - Role of local governance and urban climate policies **4.3 Role of Civil Society and NGOs** Environmental activism and climate advocacy - Role of media in shaping climate discourse - Corporate social responsibility (CSR) and sustainability reporting **4.4 Role of Technology in Climate Solutions** Smart grids and energy storage innovations - AI and big data for climate monitoring - Ethical considerations in technological interventions	● Gain knowledge on international climate agreements. ● Illustrate equations of atmospheric motion. ● Recognize the national and regional policies related to climate mitigation. ● Describe the role of civil society and NGOs in climate mitigation and advocacy. ● Recognize the role of advanced technologies in climate solutions.
Module V Teacher Specific Module (5 Hours)	Areas of content, transaction, and evaluation are decided by the faculty.	
References	**Core compulsory reading** 1. Maslin, M. (2014). *Climate Change: A Very Short Introduction* (2nd ed.). Oxford University Press. 2. Neelin, J. D. (2011). *Climate Change and Climate Modeling*. Cambridge University Press.	

	3. Intergovernmental Panel on Climate Change (IPCC). (2022). *Climate Change 2022: Impacts, Adaptation, and Vulnerability*. Cambridge University Press. 4. Williston, B. (2022). *The Ethics of Climate Change: An Introduction* (2nd ed.). Routledge. **Core suggested reading** 5. Bates, C. (2022). *Earth's Tipping Points: Understanding Climate Change and Our Sustainable Future*. 6. McGuire, B. (2023). *The Point of No Return: How Close Are We to Irreversible Climate Change?*. Cambridge University Press. 7. International Energy Agency (IEA). (2023). *Energy Technology Perspectives 2023*. 8. World Intellectual Property Organization (WIPO). (2023). *Green Technology Book: Solutions for Climate Change Mitigation*. 9. Lee, W. L. (2022). *This Is Environmental Ethics: An Introduction*. Wiley-Blackwell. 10. Chancel, L. (2020). *Unsustainable Inequalities: Social Justice and the Environment*. Harvard University Press. 11. Rajamani, L., & Peel, J. (Eds.). (2021). *The Oxford Handbook of International Environmental Law* (2nd ed.). Oxford University Press. 12. Islam, M. N., & van Amstel, M. (Eds.). (2021). *India: Climate Change Impacts, Mitigation and Adaptation in Developing Countries*. Springer.

Course Outcomes	**CO1:** Develop knowledge on the fundamental principles of climate science and the factors influencing climate change. **CO2:** Identify and evaluate climate change mitigation and adaptation strategies. **CO3:** Apply ethical reasoning to climate change issues, including justice, sustainability, and policy-making. **CO4:** Develop and present well-structured arguments and solutions in climate-related discussions. **CO5:** Foster a sustainability mindset and promote environmentally ethical behaviors in everyday life.

Teaching Learning Strategies	Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning (Video) Interactive Instruction: Active co-operative learning, Seminars, Group Assignments, Library work and Group discussion, Presentation by individual student/ Group representative Field work and field visits
Mode of Transaction	Face to face: Lecture method & Demonstration method Learner centered technique: Computer assisted learning & Individual project teaching

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	**50**
Continuous Evaluation	**50**
• **Test papers**	**20**

• **Tutorial with Seminar presentations/Discussions/Debate, etc.**	**20**
• **Assignment**	**10**

Sample questions to test outcomes.

1. Explain the concept of "climate justice" and provide an example of how it applies to a developing country.
2. Differentiate between adaptation and mitigation strategies in climate change policy.
3. What is the precautionary principle in environmental ethics? Provide an example of its application in climate policies.
4. Discuss the moral responsibilities of developed countries toward developing nations in addressing climate change.

Course Title	AGRO-ECOLOGY
Semester	**Five**
Course Code	**KU05DSEEVS302**
Course Type	**Discipline-Specific Elective**
Course Credit	**4**
Pre Requisite	**Basic knowledge in Ecology**
Course Objectives	The course aims ● To understand the ecological principles that govern agricultural ecosystems. ● To examine the interactions between crops, soils, climate, and biota in agroecosystems. ● To evaluate sustainable agricultural practices from an ecological perspective. ● To develop skills to assess the environmental impacts of conventional and alternative farming systems.

Modules	Content	Module Outcome
Module I Introduction to Agro-Ecology and Agroecosystems (10 hours)	**1.1 Definition and Scope of Agroecology** History and evolution of agroecology - Agroecology vs. agronomy **1.2 Agroecosystem Concept** Components and characteristics - Inputs, outputs, feedback loops **1.3 Types of Agroecosystems** Traditional, industrial, and organic systems - Case studies from India and abroad **1.4 Ecological Interactions in Agroecosystems** Trophic structures - Energy flow and nutrient cycles	The students will be able to ● Understand the foundational concepts and evolution of agroecology. ● Describe the structure and functioning of agroecosystems. ● Identify differences among major types of agroecosystems. ● Analyze ecological interactions within farming systems.
Module II Soil, Water and Nutrient Dynamics in Agriculture (15 hours)	**2.1 Soil Ecology and Health** Soil organisms and biodiversity - Soil organic matter and fertility **2.2 Nutrient Cycling** Nitrogen, phosphorus, carbon cycles in agriculture - Role of cover crops and green manure **2.3 Water Use and Management** Irrigation methods and their ecological impacts - Rainwater harvesting and water conservation **2.4 Agroecological Soil and Water Management Practices** Mulching, composting, biochar - Conservation tillage and integrated watershed management	● Explain soil biotic and abiotic factors influencing productivity. ● Assess nutrient dynamics in agroecosystems. ● Evaluate water use efficiency and conservation in agriculture.

		● Apply agroecological techniques for improving soil and water health
Module III Biodiversity in Agroecosystems (15 hours)	**3.1 Role of Biodiversity in Agriculture** Genetic, species, and ecosystem diversity - Crop rotation, polyculture, and intercropping **3.2 Pollinators and Natural Pest Control** Beneficial insects and pollination services - Natural enemies and biocontrol agents **3.3 Agroforestry and Mixed Farming** Integration of trees, crops, and livestock - Ecological and economic benefits **3.4 Conservation of Agrobiodiversity** Seed banks, community seed systems - Traditional knowledge and farmer innovations	● Interpret the ecological roles of biodiversity in agriculture. ● Analyse practices that enhance biodiversity and ecosystem services. ● Identify strategies for pest and pollinator management through ecology. ● Evaluate agrobiodiversity conservation techniques.
Module IV Sustainable Agriculture and Climate Resilience (15 hours)	**4.1 Sustainable Agricultural Systems** Definition and principles of sustainable agriculture - Sustainable agricultural practices: Organic farming, permaculture, biodynamic farming - Ecological intensification **4.2 Agroecology and Climate Change** Climate-smart agriculture - Resilient crops and practices **4.3 Food Security and Socio-Economic Dimensions** Agroecology's role in food sovereignty - Participatory rural development **4.4 Policy and Governance for Agroecology** National and international agroecology policies - FAO, IPES-Food frameworks and SDGs	● Describe the principles and types of sustainable agriculture. ● Assess climate adaptation strategies through agroecological approaches. ● Examine the links between agroecology, food security, and equity. ● Analyse agroecology policies at national and global levels.
Module V Teacher Specific Module (5 Hours)	Areas of content, transaction, and evaluation are decided by the faculty.	
References	**Core compulsory reading** 1. Altieri, M. A. (1995). *Agroecology: The science of sustainable agriculture* (2nd ed.). CRC Press. 2. Gliessman, S. R. (2015). *Agroecology: The ecology of sustainable food systems* (3rd ed.). CRC Press.	

	3. Vandermeer, J. H. (2011). *The ecology of agroecosystems*. Jones & Bartlett Learning. 4. Uphoff, N. (Ed.). (2002). *Agroecological innovations: Increasing food production with participatory development*. Earthscan Publications. 5. Francis, C. A. (2009). *Agroecology: The ecology of food systems*. Journal of Sustainable Agriculture, 33(6), 669–670. 6. Pretty, J. N. (2008). *Agricultural sustainability: Concepts, principles and evidence*. Philosophical Transactions of the Royal Society B: Biological Sciences, 363(1491), 447–465. **Core suggested reading** 7. FAO. (2018). *The 10 elements of agroecology: Guiding the transition to sustainable food and agricultural systems*. Food and Agriculture Organization of the United Nations. 8. IPES-Food. (2016). *From uniformity to diversity: A paradigm shift from industrial agriculture to diversified agroecological systems*. International Panel of Experts on Sustainable Food Systems. 9. Nicholls, C. I., Altieri, M. A., & Vazquez, L. (2016). *Agroecology: Principles for the conversion and redesign of farming systems*. Agroecology and Sustainable Food Systems, 40(6), 1–22. 10. Wezel, A., Bellon, S., Doré, T., Francis, C., Vallod, D., & David, C. (2009). *Agroecology as a science, a movement and a practice: A review*. Agronomy for Sustainable Development, 29(4), 503–515. 11. Rosset, P. M., & Altieri, M. A. (2017). *Agroecology: Science and politics*. Practical Action Publishing.

Course Outcome	**CO1:** Analyse the structure and functioning of agroecosystems. **CO2:** Compare traditional and modern agricultural practices based on ecological principles. **CO3:** Evaluate the role of biodiversity, soil, and climate in sustainable agriculture. **CO4:** Recommend ecological approaches to enhance agricultural sustainability and resilience.

Teaching Learning Strategies	Direct Instruction: Brainstorming Lecture, Explicit Teaching, E-learning (Video) Interactive Instruction: Active co-operative learning, Seminars, Group Assignments, Library work and Group discussion, Presentation by individual students/Group representative Field work and field visits
Mode of Transaction	Face to face: Lecture method & Demonstration method Learner centered technique: Computer assisted learning & Individual project teaching

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	**50**
Continuous Evaluation	**50**
● **Test papers**	**20**

● **Tutorial with Seminar presentations/Discussions/Debate, etc.**	**20**
● **Assignment**	**10**

Sample questions to test outcomes

1. Define agroecology and distinguish it from conventional agronomy.
2. List the components of an agroecosystem.
3. Describe nutrient cycling in agroecosystems and explain how it can be enhanced using ecological principles.
4. Compare and contrast traditional and modern agricultural systems from an agroecological perspective.

Course Title	ECOTOURISM
Semester	Five
Course Code	KU05DSEEVS303
Course Type	Discipline-Specific Elective
Course Credit	4
Pre Requisite	Knowledge in Ecology
Course Objectives	The course aims • To provide foundational knowledge on the principles and practices of ecotourism. • To examine the relationship between biodiversity conservation and ecotourism. • To analyse the socio-economic and environmental impacts of ecotourism. • To develop skills for planning, managing, and promoting sustainable ecotourism initiatives.

Modules	Content	Module Outcome
Module I Introduction to Ecotourism (10 hours)	**1.1 Definition and Principles of Ecotourism** Distinction between tourism, nature-based tourism, and ecotourism - Core principles: conservation, communities, interpretation **1.2 Historical Development of Ecotourism** Evolution and global trends - Key international organizations (TIES, UNEP, WTO) **1.3 Types of Ecotourism** Wildlife tourism, cultural tourism, adventure tourism, rural tourism **1.4 Ecotourism Stakeholders** Role of government, NGOs, private sector, local communities	The students will be able to • Understand the evolution and definitions of ecotourism. • Identify key principles that guide ecotourism practices. • Differentiate among various types of ecotourism. • Recognize the roles of different stakeholders in ecotourism.
Module II Ecotourism and Environment (15 hours)	**2.1 Ecotourism and Biodiversity Conservation** Protected areas, national parks, biosphere reserves - Case studies: Kaziranga, Periyar, Sundarbans. **2.2 Impacts of Ecotourism on Environment** Positive and negative impacts - Carrying capacity and impact assessment. **2.3 Ecotourism and Climate Change** Carbon footprints, mitigation strategies - Sustainable transportation. **2.4 Eco-certification and Green Practices** Green tourism certification schemes - Best practices in eco-lodging and resource management.	• Analyse the relationship between ecotourism and biodiversity conservation. • Evaluate environmental impacts of ecotourism initiatives. • Understand the contribution of ecotourism to climate change

		mitigation. • Examine eco-certification schemes and sustainable tourism practices.
Module III Community Participation and Socio-Economic Dimensions (15 hours)	**3.1 Community-Based Ecotourism (CBET)** Participatory approaches, community benefits - Empowerment and equity **3.2 Cultural and Indigenous Tourism** Role of indigenous knowledge and traditions - Ethical issues in cultural tourism **3.3 Economic Benefits and Livelihood Generation** Employment, micro-enterprises, women's participation **3.4 Conflict and Displacement** Social issues, displacement, tourism gentrification	• Appreciate the role of communities in sustainable ecotourism. • Understand how ecotourism influences livelihoods and economic development. • Analyse ethical and cultural implications of ecotourism. • Identify and address social conflicts arising from ecotourism practices.
Module IV Planning, Policies, and Case Studies (15 hours)	**4.1 Ecotourism Planning and Development** Site selection, infrastructure, zoning - Tools: SWOT, EIA, stakeholder analysis **4.2 Ecotourism Policies and Legislation** National and international ecotourism policies - Ecotourism guidelines (India and global) **4.3 Successful Ecotourism Models** Global: Costa Rica, Kenya, Bhutan - India: Thenmala, Silent Valley, Ladakh **4.4 Future of Ecotourism** Technological innovations, digital ecotourism - Organizations and NGO's promoting ecotourism - Ecotourism and Sustainable Development - Challenges: overtourism, policy gaps, pandemics.	• Apply tools and techniques for ecotourism planning. • Interpret legal and policy frameworks related to ecotourism. • Examine successful ecotourism case studies from India and abroad. • Discuss the future prospects and challenges of ecotourism.
Module V Teacher Specific Module (5 Hours)	Areas of content, transaction, and evaluation are decided by the faculty.	
References	**Core compulsory reading** 1. Fennell, D. A. (2020). *Ecotourism* (5th ed.). Routledge. 2. Das, M., & Chatterjee, B. (2015). *Ecotourism: Principles, practices and policies*. ICFAI University Press. 3. Honey, M. (2008). *Ecotourism and sustainable development: Who owns paradise?* (2nd ed.). Island Press.	

	4. Ministry of Tourism, Government of India. (2008). *Ecotourism guidelines.* 5. Weaver, D. B. (2001). *The encyclopaedia of ecotourism*. CABI Publishing. 6. Buckley, R. (2009). *Ecotourism: Principles and practices*. CABI. **Core suggested reading** 7. Singh, S. (2002). *Ecotourism: Theory and practice*. I.K. International Publishing House. 8. Wearing, S., & Neil, J. (2009). *Ecotourism: Impacts, potentials and possibilities?* (2nd ed.). Butterworth-Heinemann. 9. Page, S. J., & Dowling, R. K. (2002). *Ecotourism*. Prentice Hall. 10. Newsome, D., Moore, S. A., & Dowling, R. K. (2012). *Natural area tourism: Ecology, impacts and management*. Channel View Publications. 11. United Nations Environment Programme (UNEP), & World Tourism Organization (UNWTO). (2005). *Making tourism more sustainable: A guide for policy makers*. UNEP and UNWTO. 12. Scheyvens, R. (1999). Ecotourism and the empowerment of local communities. *Tourism Management, 20*(2), 245–249.

Course Outcome	**CO1:** Define and differentiate ecotourism from other forms of tourism. **CO2:** Evaluate the role of ecotourism in conservation and local community development. **CO3:** Apply ecotourism principles to plan sustainable tourism models. **CO4:** Assess the challenges and policies related to ecotourism development in various regions.

Teaching Learning Strategies	Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning (Video) Interactive Instruction: Active co-operative learning, Seminars, Group Assignments, Library work and Group discussion, Presentation by individual student/ Group representative Field work and field visits
Mode of Transaction	Face to face: Lecture method & Demonstration method Learner centered technique: Computer assisted learning & Individual project teaching

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	**50**
Continuous Evaluation	**50**
● **Test papers**	**20**
● **Tutorial with Seminar presentations/Discussions/Debate, etc.**	**20**
● **Assignment**	**10**

Sample questions to test outcome

1. Differentiate between mass tourism and ecotourism.
2. Explain the concept of carrying capacity in ecotourism sites.
3. Write a note on the role of eco-certification.
4. Explain the importance of planning in sustainable ecotourism development with suitable examples.
5. Evaluate the role of ecotourism in biodiversity conservation using Indian case studies.

SEMESTER VI

Course Title	RESEARCH METHODOLOGY
Semester	**Six**
Course Code	**KU06DSCEVS305**
Course Type	**Discipline-Specific Core**
Course Credit	**4**
Prerequisite	**Basics of Research**
Course Objectives	The Course aims ● To introduce fundamental statistical concepts used in biological and environmental sciences. ● To develop skills in summarizing, analysing, and interpreting statistical data. ● To familiarize students with environmental modelling techniques. ● To inculcate scientific research skills, including research design and methodology.

Modules	Content	Module Outcome
Module I Fundamentals of Statistics (10 hours)	**1.1 Introduction to Statistics** Definition and importance in environmental and biological sciences - Types: Descriptive and Inferential Statistics. **1.2 Data Types and Scales of Measurement** Qualitative vs Quantitative data - Attributes and Variables; Types of variables - Nominal, ordinal, interval, and ratio scales. **1.3 Data Collection and Classification** Sampling methods: Random, Stratified, Systematic, Cluster - Primary and secondary data sources - Frequency distribution and tabulation. **1.4 Graphical Representation** Bar diagrams, histograms, pie charts, frequency polygons - Box plots and scatter diagrams.	The student will be able to: ● Identify various data types and appropriate statistical tools. ● Design effective sampling strategies. ● Organize data using tables and graphical techniques. ● Recognize the role of statistics in environmental decision-making.
Module II Statistical Measures (20 hours)	**2.1 Measures of Central Tendency and Dispersion** Mean: Arithmetic mean, geometric mean and harmonic mean, Median, Mode - Definitions, merits, demerits, and applications. Range, Mean Deviation, Variance, Standard Deviation, Coefficient of Variation, Quartile Deviation. **2.2 Measures of Asymmetry and Relationship** Skewness and Kurtosis - Correlation and Regression - Pearson's and Spearman's correlation - Linear regression models - interpretation and significance. **2.3 Probability and Probability Distributions** Basic probability concepts - Classical and empirical probability - Laws of probability (addition and multiplication) - Probability distributions (Binomial	● Compute and interpret measures of central tendency and dispersion. ● Analyse relationships between environmental variables using correlation and regression techniques. ● Apply probability theory and understand key

	distribution, Poisson distribution, and Normal distribution) - Applications in environmental data analysis (Monte Carlo analysis). **2.4 Hypothesis Testing** Null and alternate hypotheses - Parametric and Non-Parametric Tests - Parametric Tests: t-test (one-sample, independent, paired samples), z-test, one-way and two-way ANOVA - Non-Parametric Tests: Chi-square test for independence and goodness-of-fit, Mann–Whitney U test, Kruskal–Wallis test, and Wilcoxon signed-rank test.	probability distributions relevant to environmental phenomena. • Distinguish between parametric and non-parametric tests and apply appropriate statistical tests for hypothesis testing.
Module III Environmental Modeling (25 hours)	**3.1 Introduction to Modelling** Purpose and types of models (deterministic, stochastic, empirical, mechanistic) **3.2 Model Construction and Validation** Conceptual models - Approaches to development of environmental models: Linear, Simple and Multiple Regression Models - Model calibration and validation **3.3 Types of Environmental Models** Population growth and interaction models (exponential, logistic) - Lotka- Volterra models, Leslie's matrix Model. Nutrient cycling models, energy flow models Dispersion models (air and water) - Point source stream pollution model, air quality model, thermal plume and dispersion models. **3.4 Use of Software Tools** Basic introduction to Excel, R, SPSS for modelling and analysis - Factor analysis - Cluster analysis - PCA - Graph Plotting.	• Describe the purpose and types of environmental models. • Build and validate simple environmental models. • Analyse population and pollution dynamics using mathematical models. • Apply software tools to simulate environmental processes.
Module IV Research Methodology (20 hours)	**4.1 Research Fundamentals** Definition and objectives of research - Types of research: Basic vs Applied, Quantitative vs Qualitative, Experimental vs Descriptive - Steps in the research process **4.2 Research Ethics and Plagiarism** Ethical considerations in environmental research - Informed consent, data integrity, publication ethics - Plagiarism: types, consequences, and tools for detection (Turnitin, Urkund) - Role of ethics committees and institutional review boards (IRBs) - Best practices/standards setting initiatives and guidelines: COPE, WAME, etc. **4.3 Research Design and Proposal Writing** Structure and content of a research proposal - Formulating objectives and hypotheses - Sampling methods, tools for data collection - Literature review: sources, databases (PubMed, Scopus, Google Scholar) **4.4 Data Analysis, ICT Applications & Scientific**	• Explain key concepts and classifications of research relevant to environmental science. • Understand and apply ethical principles, including plagiarism prevention, in research practices. • Prepare effective research proposals and conduct literature reviews using ICT tools. • Analyse, document, and present research

	Writing Use of ICT in research: Reference management tools (Zotero, Mendeley), Data analysis software (Excel, SPSS, R), Data visualization tools (Tableau, Origin) - Scientific writing: Structure of thesis/dissertation and scientific papers, Tables, graphs, and figure design, Citation and referencing styles (APA, MLA, Vancouver), Communicating research through posters and oral presentations - Modern research tools	findings using scientific writing and digital tools.
Module V Teacher Specific Module (5 Hours)	Areas of content, transaction, and evaluation are decided by the faculty.	
References	**Core compulsory reading** 1. Vittal, R. R. (1986). *Business mathematics and statistics*. Margham Publications. 2. Gupta, S. P. (1996). *Statistical methods*. Sultan Chand & Sons Publications. 3. Haynes, R. (1982). *Environmental science methods*. Chapman & Hall. 4. Khan, I. A., & Kanum, A. (1994). *Fundamentals of biostatistics*. Ukaaz Publications. 5. Kothari, C. R. (1996). *Quantitative techniques*. Vikas Publishing House Pvt. Ltd. 6. Miller, J. (1989). *Statistics for advanced level*. Cambridge University Press. 7. Snedecor, G. W., & Cochran, W. G. (1982). *Statistical methods*. Academic Press. 8. Bliss, G. I. (1970). *Statistics in biology* (Vols. I & II). McGraw-Hill Book Company. **Core suggested reading** 9. Wardlaw, A. C. (1985). *Practical statistics for experimental biologists*. Wiley. 10. Sharma, B. A. V., Prasad, D. R., & Satyanarayana, P. (1989). *Research methods in social sciences*. Sterling Publishers Pvt. Ltd. 11. Kothari, C. R. (1989). *Research methodology: Methods and techniques*. Wiley Eastern. 12. Venkatasubramanian, V. (1999). *Introduction to research methodology in agricultural and biological sciences*. New Century Book House (P) Ltd.	

Course Outcomes	**CO1:** Apply fundamental statistical techniques in environmental science research. **CO2:** Use statistical software tools and methods for data analysis. **CO3:** Construct and interpret environmental models for prediction and simulation. **CO4:** Design, conduct, and report scientific research following ethical guidelines.

Teaching Learning Strategies	Direct Instruction: Brainstorming Lecture, Explicit Teaching, E-learning (Video) Interactive Instruction: Active co-operative learning, Seminars, Group Assignments, Library work and Group discussion, Presentation by individual students/Group representative Field work and field visits
Mode of Transaction	Face to face: Lecture method & Demonstration method Learner centered technique: Computer assisted learning & Individual project teaching

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	**50**
Continuous Evaluation	**50**
● **Test papers**	**20**
● **Tutorial with Seminar presentations/Discussions/Debate, etc.**	**20**
● **Assignment**	**10**

Sample questions to test outcomes

1. Differentiate between deterministic and stochastic models.
2. Briefly describe components of a scientific research proposal.
3. What is a null hypothesis?
4. Illustrate with examples: Pearson's correlation and regression.
5. Explain the concept of ANOVA and its application in environmental studies.

Course Title	ENVIRONMENTAL POLLUTION II
Semester	**Six**
Course Code	**KU06DSCEVS306**
Course Type	**Discipline-Specific Core**
Course Credit	**4**
Prerequisite	**Knowledge in Environmental Science**
Course Objectives	The course aims: • To provide an in-depth understanding of water, soil, noise, radioactive, and emerging pollutants beyond the basic concepts. • To explore pollution pathways, advanced pollutant dynamics, and site-specific impacts. • To critically evaluate modern remediation technologies and global pollution case studies. • To examine the risk assessment processes and environmental quality standards at national and international levels.

Modules	Content	Module Outcome
Module I Advanced Water Pollution and Management (20 hours)	**1.1 Hydrogeological Contamination** Contaminant transport in aquifers - Saltwater intrusion, arsenic and fluoride contamination. **1.2 Advanced Treatment Methods** Membrane filtration (RO, UF, NF) - Advanced Oxidation Processes (AOPs) - Electrocoagulation and nanotechnology applications. **1.3 Industrial Wastewater Management** CETPs, zero liquid discharge (ZLD) systems - Case studies: Tanneries, textile, pharma industries. **1.4 Transboundary Water Pollution** River and lake pollution across borders (Ganga-Brahmaputra).	The student will be able to: • Evaluate contaminant transport in groundwater systems. • Apply advanced treatment technologies in industrial wastewater management. • Analyze real-world industrial case studies and solutions. • Understand implications of transboundary water pollution.
Module II Soil Pollution and Land Degradation (20 hours)	**2.1 Soil Pollution from Emerging Sources** Landfills, mining, e-waste, and battery waste - Persistent organic pollutants (POPs), PAHs **2.2 Soil Quality Indicators** Biological indicators (microbial biomass, respiration) - Heavy metal speciation **2.3 Sustainable Soil Management** Soil amendments, composting, green manuring - Risk-based land use planning	• Recognize modern soil pollution sources and pathways. • Use biological and chemical indicators for pollution diagnosis.

	2.4 Environmental Forensics in Soil Pollution Source apportionment and pollutant fingerprinting	• Design sustainable and site-specific remediation strategies. • Apply environmental forensic tools to trace pollution sources.
Module III Pollution from Radiation, Noise, and Light (15 hours)	**3.1 Radiation Pollution** Environmental behaviour of radionuclides - Radon gas in indoor environments - Low-level radiation effects on DNA and ecosystems. **3.2 Nuclear Waste Management** Storage, vitrification, geological disposal - Indian scenario: BARC, Kalpakkam, Kaiga. **3.3 Urban Noise and Light Pollution** Noise mapping and modelling techniques - Ecological effects of artificial light at night (ALAN) - Mitigation strategies for urban landscapes.	• Evaluate the transport and bioaccumulation of radionuclides. • Analyse nuclear waste handling protocols in India. • Examine urban noise and light pollution through GIS and modelling. • Suggest mitigation strategies for non-traditional pollution forms.
Module IV Emerging Pollutants and Pollution Risk Assessment (20 hours)	**4.1 Emerging Pollutants** Endocrine-disrupting compounds (EDCs) - Microplastics, nano plastics, PFAS **4.2 Wastewater-Based Epidemiology (WBE)** Monitoring pharmaceuticals, drugs, viruses (e.g., COVID-19 tracing) **4.3 Pollution Risk and Health Impact Assessment** Hazard Quotient (HQ), Chronic Daily Intake (CDI) - Environmental burden of disease (EBD) **4.4 Global Frameworks and Future Challenges** Stockholm and Basel Conventions - Pollution trends under climate change scenarios	• Identify key emerging pollutants and their sources. • Interpret environmental and human health risks using scientific models. • Explore innovations like WBE for pollutant tracking. • Analyse global frameworks and future outlook on pollution control.
Module V Teacher Specific Module (5 Hours)	Areas of content, transaction, and evaluation are decided by the faculty.	
References	**Core compulsory reading** 1. Rao, C.S. (2018). *Environmental Pollution Control Engineering*. New Age International Publishers.	

	2. Manahan, S.E. (2017). *Environmental Chemistry*. CRC Press. 3. Peirce, J.J., Vesilind, P.A., & Weiner, R.F. (1997). *Environmental Pollution and Control*. Butterworth-Heinemann. 4. MoEFCC Reports (Annual): *Pollution Status & Management Strategies*. **Core suggested reading** 5. Schwarzenbach, R.P., Gschwend, P.M., & Imboden, D.M. (2016). *Environmental Organic Chemistry*. Wiley. 6. Klaassen, C.D. (2013). *Casarett and Doull's Toxicology*. McGraw-Hill. 7. WHO & UNEP Reports: *Emerging Chemical Risks & Global Pollution Outlook*. **8.** IAEA Publications on nuclear safety and radioactive waste.

Course Outcomes	**CO1:** Analyse and interpret complex pollution issues across various environmental compartments. **CO2:** Implement advanced pollutant detection and remediation technologies. **CO3:** Evaluate international and national pollution-related case studies and standards. **CO4:** Propose sustainable management strategies based on scientific data and policy.

Teaching Learning Strategies	Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning (Video) Interactive Instruction: Active co-operative learning, Seminars, Group Assignments, Library work and Group discussion, Presentation by individual student/ Group representative Field work and field visits
Mode of Transaction	Face to face: Lecture method & Demonstration method Learner centered technique: Computer assisted learning & Individual project teaching

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	**50**
Continuous Evaluation	**50**
● **Test papers**	**20**
● **Tutorial with Seminar presentations/Discussions/Debate, etc.**	**20**
● **Assignment**	**10**

Sample questions to test outcomes

1. Define light pollution and its ecological impacts.
2. What are PFAS, and why are they called "forever chemicals"?
3. Evaluate the impact of e-waste on soil pollution and suggest remedial techniques.
4. Explain how wastewater-based epidemiology helps in environmental monitoring.

Course Title	INSTRUMENTATION TECHNIQUES
Semester	**Six**
Course Code	**KU06DSCEVS307**
Course Type	**Discipline-Specific Core**
Course Credit	**4**
Prerequisites	**Basics of Science, Environmental Chemistry**
Course Objectives	The course aims ● To provide students with a comprehensive understanding of various instrumental techniques used for the analysis of environmental samples, including water, air, soil, and biota. ● To introduce and explain the principles, operation, and applications of key environmental instrumentation. ● To familiarize students with the calibration, maintenance, and troubleshooting of environmental instrumentation, ensuring accurate and reliable results in environmental monitoring. ● To emphasize the importance of instrumentation in environmental regulations, monitoring programs, and the assessment of environmental health and safety.

Modules	Content	Module Outcome
Module I Fundamentals of Instrumentation (15 hours)	**1.1 Basic Concepts** Sensitivity - Specificity - Accuracy - Precision - Detection limits - Calibration - Noise, and signal-to-noise ratio. Basic Terminology: Equivalent weight of acids and bases, normality, molarity, molality, specific weight, and buffer solution - Precision and accuracy. **1.2 Introduction to Environmental Instrumentation** Role and importance of instrumentation in environmental monitoring Units of measurement, standards, calibration, and traceability Basics of instrument maintenance and safety precautions **1.3 Sample Collection and Preservation** Techniques for air, water, soil, and biological samples. **1.4 Quality Assurance & Quality Control (QA/QC)** Calibration standards - Blanks - Replicates - Standard operating procedures (SOPs). **1.5 Data Analysis** Analytical error - Statistical treatment of data - Software in instrumentation. **1.6 Gravimetric and Volumetric Methods** Principles and applications of gravimetric methods with examples - Volumetric methods: Acidimetry and alkalimetry - Permanganometry - Dichrometry -	The students will be able to: ● Explain the fundamental terminology and units used in instrumentation. ● Perform proper environmental sample collection and preservation. ● Design QA/QC protocols for analytical labs. ● Analyse instrumentation data using statistical tools.

	Iodometry and Iodimetry - Argentometry - Complexometry, Colorimetry - Cerimetry(ferrous).	
Module II Spectroscopic Techniques (20 hours)	**2.1 UV-Visible Spectrophotometry** Principles - Instrumentation - Applications in water and soil analysis. **2.2 Atomic Absorption Spectroscopy (AAS)** Flame and graphite furnace methods - Analysis of heavy metals. **2.3 Inductively Coupled Plasma – Optical Emission Spectroscopy (ICP-OES)** and **ICP-MS** Principle - Instrumentation - Comparison with AAS - Applications: Multielement analysis and trace element determination. **2.4 Fluorescence and FTIR Spectroscopy** Molecular vibration theory - Sample preparation - Applications in air and soil analysis Principles and applications in detecting organic pollutants.	● Describe the principles of spectrophotometry and its environmental applications. ● Operate AAS and interpret results for metal analysis. ● Explain the advantages of ICP techniques for trace analysis. ● Apply FTIR and fluorescence spectroscopy for organic compound analysis.
Module III Chromatographic and Electrochemical Techniques (20 hours)	**3.1 Gas Chromatography (GC) and Gas Chromatography-Mass Spectrometry (GC-MS)** Instrumentation - Column types - Detectors - Environmental applications. **3.2 High Performance Liquid Chromatography (HPLC) and LC-MS** Principles - Mobile/stationary phases - Detectors. **3.3 Ion Chromatography (IC)** Analysis of anions and cations in water and soil. **3.4 Potentiometry, Conductometry, and Voltammetry** Electrochemical sensors in environmental monitoring - Redox process - Electrode and electrode potentials - Electrochemical cells - Potentiometry - Conductometry - Polarography - Principle, Half-wave potential, Ilkovic equation, and application. pH meter - glass and reference electrodes - Ion selective electrodes Nephelometry and turbidimetry - Sulphide determination.	● Describe and utilize GC and GC-MS for volatile organic compound analysis. ● Explain HPLC principles and identify its application in pesticide residue analysis. ● Employ IC for analysis of ionic species in environmental samples. ● Use electrochemical techniques in water quality assessment.

Module IV Microscopic, Thermal, and Advanced Techniques (20 hours)	**4.1 Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM)** Sample preparation - Imaging, and elemental mapping. **4.2 X-ray Techniques** Theory - Principles of working operation and application of solids and crystals - Crystalline structure and elemental composition analysis - Bravais lattices - Miller indices - X-ray production - X-ray diffraction - Bragg's law – PXRD - X-ray fluorescence - Nuclear Magnetic Resonance. **4.3 Thermogravimetric Analysis (TGA) and Differential Scanning Calorimetry (DSC)** Characterization of materials and waste. **4.4 Portable and On-Site Monitoring Instruments** Real-time air and water quality sensors (e.g., PM2.5, DO, turbidity meters) **4.5 Electrophoresis** Gel electrophoresis - Polymerase chain reaction. **4.6 Biosensors and bioreactors**	• Use SEM and TEM to analyse environmental particulate matter. • Apply XRD/XRF for characterization of environmental samples. • Interpret thermal behaviour of pollutants and materials through TGA and DSC.
Module V Teacher Specific Module (5 Hours)	Areas of content, transaction, and evaluation are decided by the faculty.	
References	**Core compulsory reading** 1. Skoog, D. A., & Leary, J. J. (1992). *Principles of instrumental analysis* (4th ed.). Saunder's College Publishing. 2. Suchla, G. (Ed.). (1987). *Vogel's qualitative inorganic chemistry*. ELBS. 3. Willard, H. H., Merritt, L. L., Dean, J. A., & Settle, F. A. (1986). *Instrumental methods of analysis* (Indian Reprint). CBS Publishers and Distributors. 4. Skoog, D. A., West, D. M., Holler, F. J., & Crouch, S. R. (2004). *Fundamentals of analytical chemistry* (8th ed.). Cengage Learning. 5. Watson, J. T. (1997). *Introduction to mass spectrometry* (3rd ed.). Lippincott-Raven Publishers. 6. Christian, G. D. (1994). *Analytical chemistry* (5th ed.). John Wiley & Sons. 7. Pavia, D. L., Lampman, G. M., Kriz, G. S., & Vyvyan, J. R. (2008). *Introduction to spectroscopy* (4th ed.). Cengage Learning. 8. Lakowicz, J. R. (2006). *Principles of fluorescence spectroscopy* (3rd ed.). Springer. 9. Nelms, S. (2005). *Inductively coupled plasma mass spectrometry handbook*. Blackwell Publishing. 10. Innis, M. A., Gelfand, D. H., Sninsky, J. J., & White, T. J. (Eds.). (1990). *PCR protocols: A guide to methods and applications*. Academic Press. 11. Kassim, T. A., & Vafai, K. (Eds.). (2007). *Air quality monitoring, assessment, and management*. Springer. 12. American Public Health Association (APHA). (1998). *Standard*	

	methods for the examination of water and wastewater (20th ed.). APHA. 13. McBride, M. B. (1994). *Environmental chemistry of soils*. Oxford University Press. **Core suggested reading** 14. Fulekar, M. H., & Pathak, B. (2013). *Bioinstrumentation*. I K International Publishing House. 15. Willard, H. H., Merritt, L. L., Dean, J. A., & Settle, F. A. (1998). *Instrumental methods of analysis* (7th ed.). Wordsworth. 16. Ewing, G. W. (1995). *Instrumental methods of chemical analysis* (5th ed.). McGraw-Hill. 17. Reeve, R. (2002). *Introduction to environmental analysis*. John Wiley & Sons. 18. Skoog, D. A., West, D. M., & Holler, F. J. (2001). *Fundamentals of analytical chemistry* (7th ed.). Harcourt Asia PTE Ltd. 19. American Public Health Association (APHA). (1998). *Standard methods for the examination of water and wastewater* (20th ed.). APHA. 20. Kim, Y., & Platt, U. (2008). *Advanced environmental monitoring*. Springer. 21. Artiola, J. F., Pepper, I. L., & Brusseau, M. L. (2004). *Environmental monitoring and characterization*. Elsevier. 22. Pavia, D. L., Lampman, G. M., Kriz, G. S., & Vyvyan, J. R. (2008). *Introduction to spectroscopy* (4th ed.). Cengage Learning. 23. Lakowicz, J. R. (2006). *Principles of fluorescence spectroscopy* (3rd ed.). Springer. 24. Nelms, S. (2005). *Inductively coupled plasma mass spectrometry handbook*. Blackwell Publishing. 25. Innis, M. A., Gelfand, D. H., Sninsky, J. J., & White, T. J. (Eds.). (1990). *PCR protocols: A guide to methods and applications*. Academic Press. 26. Kassim, T. A., & Vafai, K. (Eds.). (2007). *Air quality monitoring, assessment, and management*. Springer.

Course Outcomes	**CO1:** Explain the operational principles of various analytical instruments. **CO2:** Demonstrate the ability to analyse environmental samples using spectroscopic and chromatographic methods. **CO3:** Evaluate the strengths and limitations of instrumentation techniques in environmental analysis. **CO4:** Apply analytical techniques in field and laboratory-based environmental monitoring.

Teaching Learning Strategies	Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning (Video) Interactive Instruction: Active co-operative learning, Seminars, Group Assignments, Library work and Group discussion, Presentation by individual student/ Group representative Laboratory visit.
Mode of Transaction	Face to face: Lecture method & Demonstration method Learner centered technique: Computer assisted learning & Individual project teaching

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	**50**
Continuous Evaluation	**50**
● **Test papers**	**20**
● **Tutorial with Seminar presentations/Discussions/Debate, etc.**	**20**
● **Assignment**	**10**

Sample questions to test outcomes.

1. Explain the working principle of a gas chromatograph and discuss its application in detecting air pollutants.
2. What is the role of spectrophotometry in environmental analysis? Provide examples of how it is used to measure water quality parameters.
3. Discuss the advantages and limitations of using high-performance liquid chromatography (HPLC) for analyzing organic contaminants in water.
4. Describe the steps involved in preparing a sample for analysis by atomic absorption spectroscopy (AAS). How is it used to detect heavy metals in soil and water?
5. How does a mass spectrometer work, and why is it useful in the analysis of trace pollutants in the environment?

Course Title	GREEN TECHNOLOGY
Semester	**Six**
Course Code	**KU06DSEEVS304**
Course Type	**Discipline-Specific Elective**
Course Credit	**4**
Prerequisites	**Knowledge in Environmental Science and Basic Science**
Course Objectives	The course aims: ● To provide foundational knowledge of green technology and its role in sustainable development. ● To introduce emerging eco-friendly technologies across industrial, agricultural, and energy sectors. ● To analyse the socio-economic and environmental benefits of green innovations. ● To equip students with the skills to critically evaluate and promote green practices.

Modules	Content	Module Outcome
Module I Fundamentals of Green Technology (10 hours)	**1.1 Introduction to Green Technology** Definition, characteristics, and goals - Importance in global and local contexts - Green vs. conventional technologies. **1.2 Principles of Green Engineering and Green Chemistry** The 12 principles of green engineering - Prevention over treatment - Design for energy and material efficiency. 12 principles of green chemistry - Designing safer chemicals and processes - Real-world examples in pharmaceutical and chemical industries. **1.2 Sustainability Assessment Tools** Life Cycle Assessment (LCA): stages, tools (e.g., SimaPro, GaBi) - Carbon footprint and water footprint: calculation and tools - Eco-labelling and environmental product declarations (EPD). **1.4 Ethics and Environmental Responsibility** Environmental ethics and intergenerational equity - Ethical decision-making in technology deployment - Role of corporate environmental responsibility (CER).	The student will be able to ● Define and explain the key concepts of green technology. ● Analyse the role of green chemistry and engineering in environmental protection. ● Apply sustainability assessment tools like LCA and carbon footprint analysis. ● Integrate environmental ethics into technological decision-making.
Module II Green Energy and Sustainable Systems (15 hours)	**2.1 Emerging Clean Energy Innovations** Hydrogen fuel cells: working principle, applications - Algae-based biofuels - Ocean energy: wave and tidal power. **2.2 Energy Storage and Distribution Systems** Battery technologies (Li-ion, flow batteries) - Pumped hydro storage - Smart grids and decentralized energy systems. **2.3 Green and Sustainable Transportation**	● Evaluate the efficiency and applications of clean energy sources. ● Understand the integration of smart grids in green energy systems.

	Electric vehicles (EVs) and hybrid vehicles - Alternative fuels: CNG, LPG, hydrogen - Public transport planning and non-motorized transport. **2.4 Sustainable Architecture and Green Buildings** Principles of green building design - Building materials: fly ash bricks, bamboo, etc. - Green building certifications: LEED, GRIHA, BREEAM.	● Analyse green building standards and sustainable architecture practices.
Module III Green Technologies in Industry and Waste Management (15 hours)	**3.1 Cleaner Production Techniques** Process modification and raw material substitution - Energy efficiency and resource optimization. **3.2 Industrial Ecology and Symbiosis** Eco-industrial parks: concepts and examples - Waste-to-resource linkages among industries. **3.3 Waste Management Technologies** Solid waste management hierarchy: reduce, reuse, recycle - Anaerobic digestion, composting, incineration - Integrated waste management systems. **3.4 Biotechnological Solutions** Bioremediation: types (in situ, ex situ), microorganisms used - Phytoremediation: mechanisms and plant species - Microbial fuel cells (MFCs). **3.5 Green Nanotechnology and E-Waste Management** Eco-friendly nanomaterials and their synthesis - Applications of nanotechnology in environmental monitoring and clean-up - Extended producer responsibility (EPR).	● Understand the principles of cleaner production and sustainable industrial practices. ● Assess the role of biotechnology in waste treatment. ● Evaluate eco-design and nanotechnology applications in industries. ● Apply circular economy principles to real-world waste management systems.
Module IV Policies, Innovations and Future Perspectives in Green Technology (15 hours)	**4.1 Policy Frameworks and Regulatory Mechanisms** National green technology policies (India, USA, EU) - Role of regulatory bodies (CPCB, MoEFCC). **4.2 Global Initiatives and Agreements** UN Sustainable Development Goals (SDG 7, 12, 13) - United Nations Environment Programme (UNEP) - Paris Agreement and role of green tech in climate targets. **4.3 Green Entrepreneurship and Innovation** Start-ups in green sectors: renewable energy, waste recycling - Sustainable business models (B-corps, social enterprises) - Green product innovation and marketing. **4.4 Smart Technologies for Environmental Management** Role of Artificial Intelligence (AI) in environmental monitoring - Internet of Things (IoT) for smart grids, smart water, and smart agriculture - Blockchain in carbon credit and emission tracking. **4.5 Challenges and Future Prospects** Economic and policy barriers to green tech adoption	● Examine policy frameworks and global initiatives supporting green technology. ● Understand the potential of green entrepreneurship. ● Explore the integration of digital technologies in green practices. ● Critically analyse the limitations and future directions of green technologies.

	- Technological scalability and infrastructure needs - Future directions: carbon capture, solar fuels, synthetic biology.	
Module V Teacher Specific Module (5 Hours)	Areas of content, transaction, and evaluation are decided by the faculty.	
References	**Core compulsory reading** 1. Anastas, P.T., & Warner, J.C. (2000). *Green Chemistry: Theory and Practice*. Oxford University Press. 2. Clark, J.H., & Macquarrie, D.J. (2002). *Handbook of Green Chemistry and Technology*. Wiley-Blackwell. 3. Mukherjee, B. (2011). *Environmental Pollution and Control*. Silverline Publications. 4. Anastas, P. T., & Warner, J. C. (2000). *Green chemistry: Theory and practice*. Oxford University Press. 5. Clark, J. H., & Macquarrie, D. J. (2002). *Handbook of green chemistry and technology*. Wiley-Blackwell. 6. Allen, D. T., & Shonnard, D. R. (2001). *Green engineering: Environmentally conscious design of chemical processes*. Prentice Hall. 7. Mukherjee, B. (2011). *Environmental pollution and control*. Silverline Publications. 8. Tulsian, M. K., & Tulsian, P. C. (2020). *Green technologies: Concepts and practices*. Pearson Education India. 9. Desai, A. V. (Ed.). (1999). *Non-conventional energy*. New Age International. **Core suggested reading** 10. Rao, C.S. (2006). *Environmental Pollution Control Engineering*. New Age International. 11. Allen, D.T., & Shonnard, D.R. (2001). *Green Engineering: Environmentally Conscious Design of Chemical Processes*. Prentice Hall. 12. UNEP Reports on Green Economy and Sustainable Development. 13. IPCC and SDG implementation reports (latest editions). 14. Basu, P. (2018). *Biomass gasification, pyrolysis and torrefaction: Practical design and theory* (3rd ed.). Academic Press. 15. Gandhi, A., & Gundimeda, H. (2016). *Green growth and sustainable development*. Springer. 16. Holmberg, J., & Robèrt, K. H. (2000). Backcasting from non-overlapping sustainability principles - a framework for strategic planning. *International Journal of Sustainable Development and World Ecology, 7*(4), 291–308. 17. World Economic Forum. (2023). *Top 10 emerging technologies*.	

Course Outcomes	**CO1:** Understand and explain the principles and significance of green technology. **CO2:** Assess various green technologies and their applications in real-world environmental management. **CO3:** Critically evaluate the environmental, economic, and social impacts of adopting green technologies. **CO4:** Design or recommend appropriate green technologies for various sectors.

Teaching Learning Strategies	Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning (Video) Interactive Instruction: Active co-operative learning, Seminars, Group Assignments, Library work and Group discussion, Presentation by individual student/ Group representative Field work and field visits
Mode of Transaction	Face to face: Lecture method & Demonstration method Learner centered technique: Computer assisted learning & Individual project teaching

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	**50**
Continuous Evaluation	**50**
● **Test papers**	**20**
● **Tutorial with Seminar presentations/Discussions/Debate, etc.**	**20**
● **Assignment**	**10**

Sample questions to test outcomes.

1. Define green chemistry and list its key principles.
2. What is life cycle assessment (LCA)? Explain with an example.
3. Differentiate between linear and circular economy.
4. Evaluate the environmental and economic benefits of adopting green technologies in waste management.
5. Explain how smart cities can integrate green technologies for sustainable development.

Course Title	WETLAND ECOLOGY
Semester	Six
Course Code	KU06DSEEVS305
Course Type	Discipline-Specific Elective
Course Credit	4
Pre-requisites	Knowledge in Ecology
Course Objectives	The Course aims ● Understand the definition and types of wetlands ● Learn about the formation and development of wetlands ● Understand the structure and function of wetland ecosystems ● Learn about the importance of wetlands and the threats they face ● Develop skills in identifying and describing wetland ecosystems

Modules	Content	Module Outcome
Module I Wetland Ecosystems and Classification (10 hours)	**1.1 Introduction to Wetlands** Definitions (Ramsar Convention, USFWS, Cowardin System) - Global distribution of wetlands **1.2 Types of Wetlands** Natural wetlands: Marshes, swamps, bogs, fens - Coastal wetlands: Mangroves, estuaries, deltas - Constructed wetlands **1.3 Wetland Functions and Services** Hydrological regulation - Nutrient cycling and sediment trapping - Carbon sequestration - Habitat for biodiversity **1.4 Major Wetlands of India and the World** Ramsar sites - Case studies: Chilika, Loktak, Sundarbans, Keoladeo, etc.	The student will be able to • Differentiate among various wetland types and their global distribution. • Explain the ecological and socio-economic functions of wetlands. • Identify and describe major Ramsar wetlands of national and international importance. • Analyse wetland classification systems used globally.
Module II Wetland Hydrology, Soil and Biogeochemistry (15 hours)	**2.1 Wetland Hydrology** Water balance, hydroperiod, inflows and outflows - Role of vegetation in hydrology **2.2 Wetland Soils and Sediments** Anaerobic conditions, redox potential - Soil types, peat formation, nutrient availability **2.3 Biogeochemical Cycles in Wetlands** Carbon, nitrogen, phosphorus cycles - Role of microorganisms **2.4 Wetlands and Climate Change** Carbon sinks vs methane sources - Climate mitigation through wetland conservation	• Describe the hydrological processes controlling wetland function. • Interpret wetland soil characteristics and their ecological roles. • Evaluate nutrient dynamics and microbial roles in wetlands. • Assess the impact of

		wetlands on global carbon and climate systems.
Module III Wetland Biodiversity and Anthropogenic Impacts (15 hours)	**3.1 Wetland Biodiversity** Flora: Hydrophytes, macrophytes, mangroves - Fauna: Waterbirds, amphibians, reptiles, invertebrates, fish **3.2 Invasive Species in Wetlands** Case studies: Eichhornia, Salvinia, Prosopis **3.3 Anthropogenic Threats** Land-use change, pollution, eutrophication - Urban encroachment, infrastructure development **3.4 Wetland Degradation and Loss** Drivers and consequences - Fragmentation and loss of ecosystem services	• Identify key species and ecological roles of wetland biodiversity. • Analyse the effects of invasive species on wetland ecosystems. • Examine anthropogenic pressures on wetland health and integrity. • Propose conservation approaches for reducing biodiversity loss in wetlands.
Module IV Wetland Management, Restoration, and Policy (15 hours)	**4.1 Wetland Conservation and Management** In-situ and ex-situ conservation - Integrated wetland management approaches **4.2 Wetland Restoration Techniques** Hydrological restoration, vegetation replanting - Case studies from India and abroad **4.3 Policies, Laws, and Governance** Ramsar Convention, National Wetland Rules - CBD, Wetland (Conservation and Management) Rules, 2017 (India) **4.4 Remote Sensing and GIS Applications** Wetland mapping and monitoring - Tools and techniques for wetland assessment	• Develop integrated strategies for wetland conservation and sustainable use. • Apply techniques and tools for wetland restoration and monitoring. • Interpret legal and institutional frameworks for wetland protection. • Use geospatial technologies in wetland mapping and management.
Module V Teacher Specific Module (5 Hours)	Areas of content, transaction, and evaluation are decided by the faculty.	
References	**Core compulsory reading** 1. Mitsch, W. J., & Gosselink, J. G. (2015). *Wetlands* (5th ed.). Wiley. 2. Keddy, P. A. (2010). *Wetland ecology: Principles and conservation*. Cambridge University Press.	

	3. Ramsar Convention Secretariat. (2016). *An introduction to the Ramsar Convention on wetlands* (6th ed.). Ramsar Convention Secretariat. 4. Odum, E. P. (2004). *Fundamentals of ecology* (5th ed.). Brooks/Cole. 5. Vymazal, J. (2010). *Constructed wetlands for wastewater treatment*. Springer. **Core suggested reading** 6. Ramsar Convention Secretariat. (n.d.). *Ramsar Convention Secretariat publications*. Ramsar Convention Secretariat. 7. Ministry of Environment, Forest and Climate Change (MoEFCC), Government of India. (2017). *Wetland (Conservation and Management) Rules, 2017*.

Course Outcomes	**CO1:** Analyse the physical, chemical, and biological characteristics of different wetland ecosystems. **CO2:** Evaluate the roles of wetlands in biodiversity conservation and climate regulation. **CO3:** Assess human impacts and develop wetland conservation and management strategies. **CO4:** Apply remote sensing and GIS tools for wetland mapping, monitoring, and restoration planning.

Teaching Learning Strategies	Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning (Video) Interactive Instruction: Active co-operative learning, Seminars, Group Assignments, Library work and Group discussion, Presentation by individual student/ Group representative Field work and field visits
Mode of Transaction	Face to face: Lecture method & Demonstration method Learner centered technique: Computer assisted learning & Individual project teaching

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	**50**
Continuous Evaluation	**50**
● **Test papers**	**20**
● **Tutorial with Seminar presentations/Discussions/Debate, etc.**	**20**
● **Assignment**	**10**

Sample questions to test outcomes.

1. Explain about the different types of wetland ecosystems?
2. What is ecotourism and their impact on wetlands?
3. Explain the sustainable methods to utilize wetlands?
4. Explain the ecosystem restoration techniques?
5. What are the services provided by the wetlands?

Course Title	INTERNSHIP
Semester	**Six**
Course Code	**KU06INTEVS301**
Course Type	**Discipline-Specific Core**
Course Credit	**4**
Pre-Requisites	**Knowledge in Environmental Science and Environmental Chemistry**
Course Objectives	The course aims • To expose students to real-world environmental practices and professional work settings. • To provide practical experience in the field of environmental science, including laboratory techniques, environmental monitoring, impact assessment, sustainability audits, conservation, etc. • To enhance professional skills such as data collection, report writing, team collaboration, and environmental communication. • To bridge theoretical knowledge with hands-on experience in government, academic, industrial, or NGO settings.

Modules	Activity	Module Outcome
Internship Areas	Students can opt for internships in any of the following sectors: • Environmental Monitoring Laboratories • Pollution Control Boards • Environmental NGOs • Research Institutions (e.g., NEERI, TERI, etc.) • Industries with Environmental Departments • Wildlife Sanctuaries, Biodiversity Parks, and Forest Departments • Environmental Consultancy Firms • Urban Local Bodies/Municipal Corporations (for waste and water management)	The student will be able to • Develop a proposal or plan for internship activities with defined objectives. • Perform assigned duties responsibly and ethically in the host organization. • Interact effectively with professionals and participate in team-based tasks. • Draw conclusions and insights from practical exposure. • Prepare a structured and analytical internship report.
Course Outcome	**CO1:** Apply theoretical knowledge of environmental science in real-world situations. **CO2:** Demonstrate practical skills in environmental monitoring, sampling, analysis, or conservation. **CO3:** Communicate technical information effectively through written reports and oral presentations. **CO4:** Exhibit professional responsibility, ethics, and teamwork in a work environment. **CO5:** Analyze and reflect upon challenges, strategies, and outcomes in environmental projects.	

SEMESTER VII

Course Title	DISASTER MANAGEMENT
Semester	**Seven**
Course Code	**KU07DSCEVS401**
Course Type	**Discipline-Specific Core**
Course Credit	**4**
Prerequisite	**Knowledge in Environmental Science**
Course Objectives	The course aims ● To provide in-depth knowledge of natural and anthropogenic disasters and their environmental implications. ● To develop skills for disaster preparedness, mitigation, response, and recovery. ● To familiarize students with institutional frameworks, disaster policies, and risk management strategies. ● To integrate climate change perspectives into disaster risk reduction approaches.

Modules	Content	Module Outcome
Module I Introduction to Disaster Management (15 hours)	**1.1 Key Concepts and Definitions** Disaster, hazard, vulnerability, exposure, capacity, risk, crisis, emergencies, resilience - Disaster typologies: sudden onset vs. slow onset **1.2 Classification of Disasters** Natural: Meteorological disasters, geological disasters, biological disasters - Anthropogenic: Industrial accidents, nuclear disasters, oil spills, chemical leaks, accident-related disasters **1.3 Phases of Disaster Management** Pre disaster phase, actual disaster phase, post disaster phase - Mitigation, preparedness, response, recovery - Emergency response protocols **1.4 Environmental and Socio-economic Impacts** Biodiversity loss, soil erosion, water and air pollution, displacement, health impacts	The student will be able to: ● Define key concepts and principles of disaster management. ● Identify and classify types of disasters with examples. ● Evaluate the causes and impacts of environmental and human-induced disasters. ● Analyse the disaster management cycle and its phases.
Module II Natural Disasters and Risk Assessment (20 hours)	**2.1 Earthquakes and Tsunamis** Earthquake genesis: plate tectonics, seismic waves, fault zones, earthquake magnitude and intensity scales (Richter, Moment Magnitude Scale) - Earthquake impact assessment: building vulnerability, soil liquefaction, seismic retrofitting Tsunami generation: submarine earthquakes, landslides, volcanic eruptions - Tsunami early warning systems: DART buoys, wave modelling, evacuation protocols	● Explain geophysical, meteorological, and hydrological disaster mechanisms. ● Develop risk and vulnerability maps using geospatial tools.

	2.2 Hydrometeorological Hazards Floods: Causes (riverine, flash floods, urban flooding), hydrological cycle influence, flood hazard mapping, embankments and levees Cyclones: Tropical vs. extra-tropical cyclones, formation, naming conventions, cyclone shelters, cyclone warning centers (IMD, WMO) Droughts: Meteorological, agricultural, and hydrological droughts; monitoring (SPI, NDVI), government relief measures **2.3 Risk and Vulnerability Assessment Tools** Concepts of hazard, exposure, vulnerability, and capacity - Data collection for risk assessment: primary (surveys, field data) and secondary (census, remote sensing) - Hazard zonation and risk mapping using GIS (e.g., QGIS, ArcGIS) - Introduction to disaster modelling platforms: HAZUS, CAPRA, OpenQuake **2.4 Community-Based Disaster Risk Reduction (CBDRR)** Principles of community participation, stakeholder analysis - Participatory tools: PRA, transect walk, seasonal calendars, risk mapping - Indigenous knowledge systems in disaster management - Role of NGOs, SHGs, Panchayati Raj Institutions (PRIs) in local resilience planning	● Design and evaluate early warning systems. ● Implement community-based disaster risk reduction (CBDRR) plans.
Module III Anthropogenic Disasters and Policy Frameworks Tools of Disaster management (20 hours)	**3.1 Industrial and Technological Disasters** Chemical spills, nuclear disasters, oil spills, mining disasters - Case studies: Bhopal Gas Tragedy, Chernobyl, Fukushima - Safety regulations (OSHA, ISO 14001), industrial safety audits **3.2 Urban and Transport-Related Disasters** Urban fires, building collapse, bridge and flyover failures - Public health crises: epidemics and pandemics (COVID-19, Ebola, SARS) - Role of urban planning, building codes, and emergency medical services **3.3 Institutional Frameworks and Legislation in India** Disaster Management Act, 2005 - Institutional setup: NDMA, SDMAs, NIDM, NDRF, IMD - Role of central, state, and local governments **3.4 International Policies and Agreements** Hyogo and Sendai Frameworks - UNDRR, SDGs, Paris Agreement (climate change and disaster risk) - Cross-border cooperation and international humanitarian aid	● Investigate the root causes and outcomes of man-made disasters. ● Assess policy interventions and institutional frameworks in disaster management. ● Critique international conventions and guidelines related to disasters. ● Apply legal and ethical considerations in disaster management operations.

Module IV Disaster Mitigation, Climate Change, and Sustainable Recovery (20 hours)	**4.1 Disaster Mitigation Strategies** Structural: levees, dams, retrofitting, cyclone shelters - Non-structural: education, insurance, early warning systems - Urban planning, hazard zoning, critical infrastructure resilience **4.2 Climate Change and Disaster Linkages** Climate-induced disasters: extreme weather, sea-level rise, glacial melt - Vulnerability mapping and modelling (CMIP, IPCC scenarios) - Integration of climate adaptation into disaster policies **4.3 Post-Disaster Recovery and Rehabilitation** Phases of recovery: immediate, medium-term, long-term - Sustainable housing, livelihood restoration - Mental health support, trauma care, psychosocial rehabilitation **4.4 Eco-DRR and Sustainable Development** Role of ecosystems in hazard mitigation: wetlands, forests, mangroves - Nature-based Solutions (NbS), green infrastructure - Incorporating traditional and indigenous knowledge systems - Disaster-resilient development and climate-smart DRR planning **4.5 International organizations, bodies, and Finance** International Association of Emergency Managers - Red cross/Red crescent - United Nations - World Bank - International Strategies and Functions **4.6 National Organizations** National Disaster Management of India - Emergency Management and Research Institute (EMRI) - National Remote Sensing Institute (NIRS)	● Propose effective mitigation strategies incorporating climate resilience. ● Design sustainable recovery and rehabilitation frameworks. ● Integrate ecosystem-based and nature-based solutions in DRR. ● Employ interdisciplinary tools for post-disaster development planning.
Module V Teacher Specific Module (5 Hours)	Areas of content, transaction, and evaluation are decided by the faculty.	
References	**Core compulsory reading** 1. Alexander, D. (2002). *Principles of emergency planning and management*. Oxford University Press. 2. Coppola, D. P. (2020). *Introduction to international disaster management* (4th ed.). Butterworth-Heinemann. 3. Gupta, H. K. (2003). *Disaster management*. University Press. 4. Government of India. (2005). *Disaster Management Act*. Ministry of Law and Justice. 5. United Nations Office for Disaster Risk Reduction (UNDRR). (2015). *Sendai framework for disaster risk reduction 2015–2030*. 6. Tyagi, A. (2007). *Environmental science*. Danika Publishing Company. 7. Khitoliya, R. K., & Venkatachalam, K. (1997). *Urban settlements and natural hazards*. In *Proceedings of Seminar on Natural Hazards in the Urban Habitat*, November, New Delhi. 8. Arora, R. (2012). *Natural calamities and disaster management*. Sonali	

	Publications. 9. Kumar, A. (2009). *Disaster management*. Sonali Publications. **Core suggested reading** 12. Sharma, V. K. (2001). *Disaster management*. National Centre for Disaster Management. 13. Carter, W. N. (2008). *Disaster management: A disaster manager's handbook.* Asian Development Bank. 14. Wisner, B., Blaikie, P., Cannon, T., & Davis, I. (2004). *At risk: Natural hazards, people's vulnerability and disasters* (2nd ed.). Routledge. 15. Singh, R. B. (2006). *Natural hazards and disaster management*. Rawat Publications. 16. Parida, P. K. (2017). *Disaster risk reduction in South Asia*. Springer.

Course Outcomes	**CO1:** Analyse and classify different types of disasters based on origin and impact. **CO2:** Apply risk and vulnerability assessment techniques in real-world disaster scenarios. **CO3:** Interpret legal frameworks, policies, and organizational structures for disaster governance. **CO4:** Design climate-resilient and sustainable mitigation and recovery strategies using Eco-DRR and interdisciplinary tools.

Teaching Learning Strategies	Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning (Video) Interactive Instruction: Active co-operative learning, Seminars, Group Assignments, Library work and Group discussion, Presentation by individual student/ Group representative Field work and field visits
Mode of Transaction	Face to face: Lecture method & Demonstration method Learner centered technique: Computer assisted learning & Individual project teaching

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	**50**
Continuous Evaluation	**50**
● **Test papers**	**20**
● **Tutorial with Seminar presentations/Discussions/Debate, etc.**	**20**
● **Assignment**	**10**

Sample questions to test outcomes

1. Define the term "disaster" and explain the disaster management cycle.
2. What is vulnerability assessment? Mention any two tools used
3. Discuss in detail the Sendai Framework for Disaster Risk Reduction and its relevance to India.
4. Write short notes on community-based disaster management.

Course Title	REMOTE SENSING AND GIS
Semester	Seven
Course Code	KU07DSCEVS402
Course Type	Discipline-Specific Core
Course Credit	4
Prerequisite	Knowledge in Environmental science
Course Objectives	The course aims • Understand the basic principles and techniques of remote sensing and GIS. • Analyse satellite imagery and interpret spatial data for environmental applications. • Apply GIS tools to solve environmental problems and aid in decision-making. • Integrate remote sensing and GIS technologies in environmental research and management.

Modules	Content	Module Outcome
Module I Fundamentals of Remote Sensing (15 hours)	**1.1 Introduction to Remote Sensing** Definition, history, and evolution - Importance in environmental science - Comparison with conventional data collection **1.2 Electromagnetic Radiation (EMR)** Nature and properties of EMR - Interaction of EMR with atmosphere and earth surface - Atmospheric windows and absorption bands **1.3 Remote Sensing Platforms** Types: ground-based, aerial, satellite - Orbital characteristics: geostationary vs polar orbit - Examples: Landsat, IRS, Sentinel, MODIS, Cartosat **1.4 Sensors and Imaging Systems** Types of sensors: optical, thermal, microwave - Scanning systems: whiskbroom vs pushbroom - Multispectral vs hyperspectral sensors **1.5 Image Characteristics and Resolutions** Spatial, spectral, temporal, and radiometric resolutions - Trade-offs between different resolutions **1.6 Data Acquisition and Preprocessing** Sources of satellite data (USGS, ISRO, ESA) - Radiometric and geometric corrections - Cloud masking, atmospheric correction, resampling techniques	The student will be able to: ● Explain the principles and history of remote sensing. ● Differentiate between various sensors and platforms. ● Understand the role of electromagnetic radiation in remote sensing. ● Perform basic preprocessing of remotely sensed data.

Module II Image Interpretation and Analysis (20 Hours)	**2.1 Basics of Image Interpretation** Elements: tone, texture, shape, size, pattern, shadow, site, association - Manual interpretation techniques using false color composites **2.2 Digital Image Processing Basics** Image display and enhancement - Contrast stretching, histogram equalization - Band combinations (e.g., NDVI, NDBI, NDWI) **2.3 Image Classification Techniques** Supervised vs unsupervised classification - Training data, signature generation - Maximum likelihood classifier, decision trees **2.4 Change Detection Techniques** Pre-classification and post-classification comparison - Temporal image analysis - Applications in deforestation, urban growth, etc. **2.5 Accuracy Assessment** Confusion matrix, kappa coefficient - Ground truth data collection (field survey, GPS) **2.6 Software and Tools** ERDAS Imagine, ENVI, SNAP - Introduction to Google Earth Engine	● Interpret satellite images using both visual and digital techniques. ● Classify land use/land cover using remote sensing software. ● Assess classification accuracy with reference data. ● Apply image analysis techniques to environmental scenarios.
Module III Fundamentals of Geographical Information System (20 Hours)	**3.1 GIS Concepts and Architecture** Definition, components: hardware, software, data, people, methods - Functions: input, storage, analysis, output **3.2 Spatial Data Models** Raster and vector data structures - Comparison of models and use cases - Data encoding and file formats (shapefiles, GeoTIFF, KML) **3.3 Attribute Data and Database Management** Attribute tables, data types - Database models: flat file, relational databases - Linking spatial and non-spatial data **3.4 Map Projections and Coordinate Systems** Geographic vs projected coordinate systems - Common projections: UTM, WGS84, Lambert - Datum transformation **3.5 Spatial Analysis Tools** Buffering, overlay analysis, spatial query - Reclassification, interpolation, proximity analysis - Network analysis (brief overview) **3.6 GIS Software and Applications** QGIS, ArcGIS: GUI overview, basic operation - Open-source GIS platforms and web GIS - Case studies in environmental applications	● Understand GIS structure, data models, and software. ● Digitize and manage spatial data effectively. ● Perform basic spatial analyses for environmental assessments. ● Apply georeferencing and projection systems in GIS projects.
Module IV Applications of Remote Sensing and	**4.1 Land Use / Land Cover (LULC) Mapping** Classification schemes (e.g., NRSC, USGS Anderson) -Multi-temporal analysis - Accuracy and thematic consistency	● Apply RS-GIS in environmental monitoring and EIA.

GIS in Environmental Science (20 Hours)	**4.2 Environmental Impact Assessment (EIA)** Use of GIS and RS in baseline studies - Environmental sensitivity mapping - Monitoring post-EIA compliance **4.3 Natural Resource Management** Forest cover monitoring, wetland mapping - Soil resource mapping, agricultural land analysis - Water resource inventory and watershed mapping **4.4 Biodiversity and Habitat Modelling** Habitat suitability modelling using MaxEnt, InVEST - Species distribution and corridor connectivity - Protected area monitoring **4.5 Disaster Management Applications** Flood mapping, drought assessment using NDVI - Forest fire detection using thermal sensors - Landslide susceptibility zonation **4.6 Climate Change and Urban Studies** Urban heat island detection - Temporal analysis of CO_2 sinks/sources - Monitoring glacial retreat and snow cover changes	● Analyse natural resources using geospatial tools. ● Develop GIS-based models for habitat and biodiversity studies. ● Integrate GIS and remote sensing data for disaster and climate management.
Module V Teacher Specific Module (5 Hours)	Areas of content, transaction, and evaluation are decided by the faculty.	
References	**Core compulsory reading** 1. Beiser, A. (n.d.). *Applied physics* (Schaum's outline series). McGraw-Hill Book Co. 2. Miller, A., Thompson, J. C., Peterson, R. E., & Haragan, D. R. (n.d.). *Elements of meteorology*. Charles E. Merrill Publishing Co. 3. Lutgens, F. K., & Tarbuck, E. J. (n.d.). *The atmosphere*. Prentice Hall Publications. 4. Sabins, F. F. (n.d.). *Remote sensing: Principles and interpretation*. W. H. Freeman and Co. 5. Schande, E. (n.d.). *Remote sensing for environmental sciences*. Springer-Verlag. 6. Barrett, E. C., & Curtis, L. F. (n.d.). *Introduction to environmental remote sensing*. Chapman and Hall. 7. Lutgens, F. K., & Tarbuck, E. J. (n.d.). *The atmosphere*. Prentice Hall Publications. 8. Barry, R. G., & Chorley, R. J. (1976). *Atmosphere, weather and climate*. The English Language Book Society. 9. Rama Sastry, A. A. (1984). *Weather and weather forecasting*. Publication Division, Ministry of Information and Broadcasting, Government of India. 10. Strahler, A. N., & Strahler, A. H. (1973). *Environmental geo-science*. Wiley International. 11. Tyrell, G. W. (1959). *Principles of petrology*. Methuen Publishing. 12. Lillesand, T. M., Kiefer, R. W., & Chipman, J. W. (2015). *Remote sensing and image interpretation* (7th ed.). Wiley.	

	13. Chang, K. T. (2018). *Introduction to geographic information systems* (9th ed.). McGraw-Hill Education. **Core suggested reading** 14. Jensen, J. R. (2007). *Remote sensing of the environment: An Earth resource perspective* (2nd ed.). Pearson Education. 15. Sabins, F. F. (2007). *Remote sensing: Principles and interpretation* (3rd ed.). Waveland Press. 16. Heywood, I., Cornelius, S., & Carver, S. (2011). *An introduction to geographical information systems* (4th ed.). Pearson Education Limited. 17. Burrough, P. A., & McDonnell, R. A. (1998). *Principles of geographical information systems* (2nd ed.). Oxford University Press. 18. Campbell, J. B., & Wynne, R. H. (2011). *Introduction to remote sensing* (5th ed.). Guilford Press. 19. Tomlinson, R. (2007). *Thinking about GIS: Geographic information system planning for managers* (4th ed.). Esri Press. 20. Joseph, G. (2005). *Fundamentals of remote sensing* (2nd ed.). University Press (India). 21. Longley, P. A., Goodchild, M. F., Maguire, D. J., & Rhind, D. W. (2015). *Geographic information science and systems* (4th ed.). Wiley.

Course Outcomes	**CO1:** Demonstrate theoretical and practical knowledge of remote sensing and GIS technologies. **CO2:** Process and interpret remotely sensed data for environmental monitoring. **CO3:** Develop and manage GIS databases for environmental analysis. **CO4:** Utilize remote sensing and GIS tools to solve real-world environmental challenges.

Teaching Learning Strategies	Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning (Video) Interactive Instruction: Active co-operative learning, Seminars, Group Assignments, Library work and Group discussion, Presentation by individual student/ Group representative Field work and field visits
Mode of Transaction	Face to face: Lecture method & Demonstration method Learner centered technique: Computer assisted learning & Individual project teaching

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	**50**
Continuous Evaluation	**50**
● **Test papers**	**20**
● **Tutorial with Seminar presentations/Discussions/Debate, etc.**	**20**
● **Assignment**	**10**

Sample questions to test outcomes.

1. Differentiate between active and passive remote sensing.
2. Define spatial resolution with examples.
3. Explain the principles of electromagnetic radiation and its application in remote sensing.
4. Describe the process of image preprocessing in satellite remote sensing.
5. Explain how remote sensing and GIS can be integrated for disaster management.

Course Title	**SUSTAINABLE DEVELOPMENT**
Semester	**Seven**
Course Code	**KU07DSCEVS403**
Course Type	**Discipline-Specific Core**
Course Credit	**4**
Prerequisite	**Knowledge in Environmental Science**
Course Objectives	The course aims ● To understand the principles and dimensions of sustainable development. ● To evaluate sustainable development goals (SDGs) and their application in various sectors. ● To develop skills to critically analyse sustainability indicators and policies. ● To promote interdisciplinary approaches in implementing sustainable practices and strategies.

Modules	Content	Module Outcome
Module I Foundations of Sustainable Development (15 hours)	**1.1 Introduction and Historical Context** Definition, concept, and need for sustainable development - Origin: Stockholm Conference (1972), Brundtland Report (1987), Rio Earth Summit (1992) **1.2 Dimensions of Sustainable Development** Environmental, economic, social, and cultural sustainability - Interconnectedness of the three pillars **1.3 Models and Approaches** Weak vs. strong sustainability - Sustainability science - Traditional knowledge systems and sustainability **1.4 Carrying Capacity and Ecological Footprint** Ecological footprint analysis - Biocapacity and overshoot	The students will be able to: ● Understand the historical development of the sustainable development concept. ● Distinguish between various sustainability dimensions and their interlinkages. ● Analyse sustainability models and their applicability. ● Evaluate ecological footprints and carrying capacity at different scales.
Module II Sustainable Development Goals (SDGs) and Global Frameworks (20 hours)	**2.1 United Nations Sustainable Development Goals (SDGs)** Introduction to 17 SDGs and 169 targets - Role of UN, national governments, and global organizations **2.2 SDG Integration in Policies** Policy and governance mechanisms - India's progress toward achieving SDGs **2.3 Indicators and Measurement** Sustainability indicators (Environmental Performance Index, HDI, GPI, etc.) - Monitoring tools and methods **2.4 International Conventions and Treaties**	● Identify and explain each of the 17 SDGs and their interrelations. ● Examine national and international efforts for SDG implementation. ● Use indicators and tools to measure sustainability progress.

	Agenda 21 - Rio+20 - Paris Agreement - Convention on Biological Diversity (CBD)	● Evaluate international treaties and conventions in the context of sustainable development.
Module III Sectoral Perspectives and Case Studies (20 hours)	**3.1 Sustainable Agriculture and Food Security** Principles of sustainable agriculture - Organic farming, permaculture, agroecology - Precision farming and water-use efficiency - Role of GMOs and biotechnology - Sustainable fisheries and aquaculture - Climate-resilient agriculture and food sovereignty **3.2 Sustainable Urban Development** Concepts: Smart cities, eco-cities, resilient cities - Green architecture and energy-efficient buildings - Public transportation and sustainable mobility - Urban waste and water management - Urban sprawl and sustainable land use planning **3.3 Sustainable Energy Systems** Global energy demand and environmental impacts - Renewable energy sources: solar, wind, hydro, biomass, geothermal - Energy efficiency and conservation technologies - Decentralized and off-grid energy systems - Energy policy frameworks and subsidies **3.4 Case Studies of Sustainable Practices** **India:** Sikkim – 100% organic agriculture, Solar parks in Rajasthan and Gujarat, Delhi Metro – Sustainable urban transport **Global:** Curitiba (Brazil) – Integrated urban planning, Germany's Energiewende (energy transition), Bhutan's Gross National Happiness and sustainability	● Evaluate sustainability issues in key sectors (agriculture, urban, and energy). ● Assess methods and technologies used in sustainable agriculture and urban planning. ● Critically analyse the role of renewable energy and conservation in sustainable development. ● Interpret and reflect on real-world sustainability case studies from India and globally.
Module IV Tools, Strategies and Challenges in Sustainable Development (20 hours)	**4.1 Sustainability Assessment Tools** Environmental Impact Assessment (EIA): Concepts, steps, public participation, limitations - Strategic Environmental Assessment (SEA): Policy and planning integration - Life Cycle Assessment (LCA): Cradle-to-grave approach, carbon and water footprints - Cost-Benefit Analysis (CBA): Environmental valuation, shadow pricing **4.2 Green Economy and Circular Economy** Definition and principles of a green economy - Circular economy models (e.g., 3Rs: Reduce, Reuse, Recycle) - Sustainable production and consumption - Waste-to-resource innovations - Challenges in transition: economic, policy, technological **4.3 Sustainable Livelihoods and Indigenous Knowledge**	● Apply environmental and sustainability assessment tools to real-world contexts. ● Understand the principles and applications of green and circular economies. ● Appreciate the role of traditional and community knowledge in

	Livelihood frameworks and ecosystem services - Role of traditional ecological knowledge (TEK) - Community-based natural resource management (CBNRM) - Biodiversity conservation through local governance - Participatory rural appraisal (PRA) and stakeholder involvement **4.4 Barriers and Ethical Challenges** Political, financial, and institutional constraints - Technological limitations and resistance to change - Intergenerational equity and environmental justice - Cultural ethics and development paradigms - Gender perspectives in sustainable development	sustainable practices. ● Identify and address barriers and ethical challenges in the implementation of sustainable development.
Module V Teacher Specific Module (5 Hours)	Areas of content, transaction, and evaluation are decided by the faculty.	
References	**Core compulsory readings** 1. United Nations. (2015). *Transforming our world: The 2030 agenda for sustainable development*. 2. World Commission on Environment and Development. (1987). *Our common future* (The Brundtland Report). Oxford University Press. 3. United Nations Environment Programme. (2019). *Global environment outlook – GEO-6: Healthy planet, healthy people*. Cambridge University Press. 4. NITI Aayog. (2023). *SDG India Index & dashboard 2023–24: Partnerships, action, and performance*. Government of India. **Core suggested readings** 5. Sachs, J. D. (2015). *The age of sustainable development*. Columbia University Press. 6. Lele, S. (1991). Sustainable development: A critical review. *World Development, 19*(6), 607–621. 7. Rogers, P. P., Jalal, K. F., & Boyd, J. A. (2008). *An introduction to sustainable development* (2nd ed.). Earthscan. 8. Swilling, M., & Annecke, E. (2012). *Just transitions: Explorations of sustainability in an unfair world*. UCT Press.	

Course Outcomes	**CO1:** Explain the concept, evolution, and importance of sustainable development. **CO2:** Analyse global and national sustainability strategies and frameworks, including SDGs. **CO3:** Evaluate sustainability indicators and tools for policy development. **CO4:** Apply sustainable development principles in planning and decision-making processes at local and global scales.

Teaching Learning Strategies	Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning (Video) Interactive Instruction: Active co-operative learning, Seminars, Group Assignments, Library work and Group discussion, Presentation by individual student/ Group representative

Mode of Transaction	Face to face: Lecture method & Demonstration method Learner centered technique: Computer assisted learning & Individual project teaching

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	**50**
Continuous Evaluation	**50**
● **Test papers**	**20**
● **Tutorial with Seminar presentations/Discussions/Debate, etc.**	**20**
● **Assignment**	**10**

Sample questions to test outcome

1. Write a note on the ecological footprint and its relevance.
2. List any five Sustainable Development Goals and briefly explain them.
3. What is the role of indigenous knowledge in promoting sustainability?
4. Discuss the role of sustainability indicators in monitoring environmental policies.
5. Evaluate the strategies adopted by India to achieve SDG targets with examples.

Course Title	OCCUPATIONAL HEALTH & SAFETY
Semester	**Seven**
Course Code	**KU07DSCEVS404**
Course Type	**Discipline-Specific Core**
Course Credit	**4**
Prerequisite	**Knowledge in Environmental Science**
Course Objectives	The course aims ● To understand the fundamental concepts and principles of occupational health and safety (OHS). ● To evaluate workplace hazards and implement control measures. ● To examine national and international frameworks related to OHS management systems. ● To develop practical skills in risk assessment, accident investigation, and safety auditing.

Modules	Content	Module Outcome
Module I Fundamentals of Occupational Health and Safety (15 hours)	**1.1 Concept and Evolution of OHS** Definitions: Occupational Health, Safety, Hygiene - Historical development: International & Indian perspective - Importance and interdisciplinary nature of OHS **1.2 Occupational Health Principles** Work-related diseases: pneumoconiosis, asbestosis, silicosis - Musculoskeletal disorders and repetitive strain injuries (RSI) - Hearing loss, heat stress, radiation exposure - Concepts of occupational medicine and hygiene **1.3 Ergonomics and Workplace Design** Physical ergonomics: workstation layout, tool design - Cognitive ergonomics: decision-making and human error - Organizational ergonomics: work schedules, shift design **1.4 Occupational Safety and Accident Prevention** Accident types: slips, trips, falls, cuts, machinery injuries - Safety signs, labels, PPE (Personal Protective Equipment) - Safety culture, hazard symbols, and color codes **1.5 OHS Stakeholders and Ethical Issues** Role of employers, employees, safety officers - Worker rights and responsibilities - Ethical practices in OHS, whistleblowing **1.6 OHS Legislation Overview** Overview of Factories Act 1948 and Indian laws - Introduction to international labour standards (ILO)	The student will be able to ● Describe the key concepts and historical development of OHS. ● Identify major occupational diseases and preventive strategies. ● Explain the ergonomic principles in workplace design. ● Evaluate roles and responsibilities in OHS management.
Module II Workplace Hazards and Risk Management	**2.1 Physical Hazards** Noise: sources, measurement, hearing conservation programs - Vibration: whole-body and hand-arm vibration - Radiation: ionizing and non-ionizing sources - Thermal stress: heat stroke, hypothermia,	● Categorize physical, chemical, and biological hazards in the workplace.

(20 hours)	temperature controls **2.2 Chemical Hazards** Types: gases, vapors, dusts, fumes, mists - Routes of exposure: inhalation, dermal, ingestion - Toxicology basics: dose-response, TLVs, PELs - Carcinogens and mutagens at workplace **2.3 Biological Hazards** Bacteria, viruses, fungi, allergens - Zoonotic diseases in workplaces (e.g., farms, labs) - Prevention: hygiene practices, vaccination, containment **2.4 Mechanical and Electrical Hazards** Machine guarding, rotating equipment - Lockout-tagout (LOTO) procedures - Electrical shock hazards, arc flashes, grounding **2.5 Psychosocial and Organizational Hazards** Workplace stress, bullying, burnout, fatigue - Workload imbalance, shift work, job insecurity - Strategies for promoting mental health **2.6 Hazard Identification and Risk Assessment** Methods: Job Hazard Analysis (JHA), Hazard and Operability (HAZOP) - Risk Matrix and Risk Prioritization - ALARP principle (As Low As Reasonably Practicable)	● Conduct risk assessments using standard methodologies. ● Analyse psychosocial and mechanical factors affecting health. ● Apply control measures based on hierarchy of hazard control.
Module III Occupational Health and Safety Management Systems (OHSMS) (20 hours)	**3.1 Introduction to OHSMS** Concepts and evolution of OHSMS - Importance of a structured safety management system **3.2 OHSMS Standards (ISO 45001, ILO-OSH 2001)** Structure, clauses, and documentation of ISO 45001 - ILO-OSH 2001 principles and guidelines - PDCA (Plan-Do-Check-Act) approach in safety systems **3.3 Regulatory Frameworks and Compliance** Indian Laws: Factories Act, Environment Protection Act, Boiler Act - OSHA standards (USA), EU directives - Environmental clearances and workplace health norms **3.4 Implementation of Safety Management Systems** Safety policy, objectives, roles, responsibilities - Employee training and participation - Communication and documentation requirements **3.5 OHS Performance Monitoring** KPIs for safety: incident frequency, severity rate - Safety scorecards, dashboards **3.6 Continuous Improvement in Safety** Auditing, corrective and preventive actions (CAPA)	● Explain the components and standards of OHSMS. ● Evaluate legal frameworks for occupational health and safety. ● Formulate workplace safety plans and policies. ● Monitor OHS performance through appropriate tools and indicators.

Module IV Accident Investigation, Emergency Planning and Safety Audits (20 hours)	**4.1 Accident Theories and Models** Domino theory, Swiss Cheese Model, Human Error Theory - Heinrich's Law and Bird's Triangle **4.2 Incident Reporting and Investigation** Types of incidents: near misses, first-aid cases, reportable accidents - Investigation techniques: Root Cause Analysis, 5 Whys, Fishbone Diagram - Documentation and reporting protocols **4.3 Emergency Preparedness and Response** Fire safety and evacuation procedures - Emergency response plans (ERPs) and mock drills - Spill control and chemical hazard emergency response - First aid, CPR, and medical emergency response **4.4 Safety Audits and Inspections** Types of audits: internal, external, compliance-based - Safety inspection checklists and protocols - Audit reporting and follow-up actions **4.5 Business Continuity and Crisis Management** Continuity planning after incidents - Roles of leadership and crisis communication	● Describe theoretical models for accident causation. ● Perform root cause analysis and suggest corrective actions. ● Design emergency preparedness plans for workplace scenarios. ● Conduct internal safety audits and recommend improvements.
Module V Teacher Specific Module (5 Hours)	Areas of content, transaction, and evaluation are decided by the faculty.	
References	**Core compulsory reading** 1. Khanna Publishers. (2006). *Health and environment management system*. Khanna Publishers. 2. James, P. (2019). *Handbook of industrial hazards and safety*. Clanrye International. 3. Grimaldi, J. V., & Simonds, R. H. (2001). *Safety management* (5th ed.). AITBS Publishers. 4. Asfahl, C. R. (2003). *Industrial safety and health management* (Subsequent ed.). Pearson Prentice Hall. 5. Blake, R. P. (2000). *Industrial safety* (1st ed.). Prentice Hall. **Core suggested reading** 6. Poonia, M. P., & Sharma, S. C. (2019). *Industrial safety and maintenance management* (1st ed.). Khanna Book Publishing. 7. Withers, J. (1988). *Major industrial hazards: Their appraisal and control*. Gower Publishing Ltd. 8. Rao, S. S., Jain, R. K., & Saluja, H. L. (1997). *Electrical safety, fire safety engineering and safety management* (2nd ed.). Khanna Publishers. 9. Das, A. K. (2020). *Principles of industrial safety management: Understanding the Ws of safety at work* (1st ed.). PHI Learning Pvt Ltd. 10. Deshmukh, L. M. (2017). *Industrial safety management* (New ed.). McGraw Hill Education.	

Course Outcomes	**CO1:** Identify various occupational hazards and apply preventive strategies. **CO2:** Analyse workplace environments using scientific methods for health risk evaluation. **CO3:** Develop and implement OHS management systems aligned with legal and regulatory frameworks. **CO4:** Conduct safety audits and formulate strategies for improving workplace safety.

Teaching Learning Strategies	Chalk and talk, PowerPoint presentations, discussions with examples, Experiential Learning, Participative Learning. Interactive Instruction: Active co-operative learning, Seminars, Group Assignments, Library work and Group discussion, Presentation by individual student/ Group representative. Field work and field visits
Mode of Transaction	Face-to-face: Lecture Sessions, Interactive Classroom Discussions. Learner-centered Case Studies and Real-life Incident Analysis, Demonstrations, and Hands-on Sessions (for PPE, fire safety equipment, etc.) Group Activities and Role Plays (for training simulations), Audio-Visual Presentations and Safety Videos, Guest Lectures from Industry Experts, Field Visits (to industrial sites or safety training centers, if applicable), Assignments and Presentations

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	**50**
Continuous Evaluation	**50**
● **Test papers**	**20**
● **Tutorial with Seminar presentations/Discussions/Debate, etc.**	**20**
● **Assignment**	**10**

Sample questions to test outcomes.

1. Define Occupational Health and Safety (OHS). Discuss its scope and significance in industrial environments.
2. What are the primary objectives and guiding principles of OHS?
3. Explain the relationship between workplace environment and worker health.
4. Differentiate between occupational health, occupational hygiene, and ergonomics.
5. Describe the levels of prevention for occupational-related diseases with examples.

Course Title	INDUSTRY PROCESSES AND POLLUTION
Semester	**Seven**
Course Code	**KU07DSEEVS401**
Course Type	**Discipline-Specific Elective**
Course Credit	**4**
Pre Requisite	**Knowledge in Environmental Science**
Course Objectives	The course aims: ● To provide in-depth knowledge of major industrial processes and their environmental implications. ● To understand the sources and characteristics of industrial pollution. ● To explore pollution prevention and waste minimization techniques in industries. ● To evaluate the environmental management practices and regulatory frameworks in industrial sectors.

Modules	Content	Module Outcome
Module I Industrial Processes and Environmental Impacts (10 hours)	**1.1 Industrial Classification and Overview** Classification of industries based on raw materials and processes: Agro-based, chemical, metallurgical, textile, cement, pharmaceutical, paper and pulp, food processing - Characteristics of small, medium, and large-scale industries - Industrial development trends and eco-industrial parks **1.2 Process Flow of Major Industries** Cement, thermal power, steel, paper and pulp, pharmaceuticals - Flow diagrams, unit operations, and material balance - Inputs (raw materials, water, energy), outputs (products, emissions) **1.3 Resource Use and Efficiency** Energy consumption and efficiency in industries - Water use patterns and conservation techniques - Lifecycle analysis and industrial resource footprint **1.4 Environmental Impacts of Industrialization** Emission of greenhouse gases and climate change contribution - Localized air, water, and land degradation - Biodiversity and ecosystem disruption due to industrial siting	The student will be able to: • Classify industries based on type, raw materials, and end-products. • Interpret industrial process flow charts and environmental aspects. • Analyse energy and water usage patterns in different industries. • Assess industrial sustainability and environmental footprints.
Module II Industrial Pollution – Types, Sources and Characteristics (15 Hours)	**2.1 Air Pollution from Industries** Sources: boilers, furnaces, incinerators, kilns - Pollutants: SO_2, NOx, CO, PM, VOCs, HAPs - Ambient air quality impacts, dispersion models **2.2 Water Pollution from Industrial Discharges** Industrial wastewater composition: COD, BOD, TDS, metals, organics - Major polluting industries: tanneries, textiles, distilleries - Case studies of river pollution (e.g., Ganga, Yamuna) **2.3 Solid and Hazardous Waste** Fly ash, red mud, slag, sludge, e-waste - Toxicity, persistence, leachability of industrial waste - Storage,	• Identify and classify different types of industrial pollutants • Analyse wastewater characteristics and potential impacts • Evaluate the generation and toxicity of industrial waste • Investigate non-

	handling, and disposal methods **2.4 Noise, Odour, and Thermal Pollution** Noise sources: compressors, turbines, cooling towers - Thermal discharges and impacts on aquatic systems - Industrial odours and olfactometry studies	conventional pollution like noise and odour
Module III Pollution Control Technologies and Cleaner Production (15 hours)	**3.1 Air Pollution Control Systems** Cyclone separators, bag filters, scrubbers, ESPs - Process modification and stack design - Performance efficiency and emission standards **3.2 Effluent Treatment and Zero Liquid Discharge** Primary, secondary, tertiary treatment stages - CETPs: Design, operation, monitoring - Sludge treatment, Zero Liquid Discharge (ZLD) **3.3 Solid Waste and Hazardous Waste Management** On-site segregation, storage, and incineration - Hazardous waste manifest and landfill design - Co-processing in cement kilns, pyrolysis **3.4 Cleaner Production and Waste Minimization** Source reduction, substitution, process optimization - Resource efficiency and circular economy	• Design air and water pollution control mechanisms • Operate and evaluate effluent and waste treatment units • Recommend waste reduction and recovery strategies • Implement cleaner production approaches in industrial practices
Module IV Emerging Industrial Innovations, Risk Assessment, and Best Practices (15 hours)	**4.1 Industrial Innovations for Pollution Prevention and Sustainability** Green and sustainable industrial technologies (e.g., low-emission furnaces, dry processing) - Role of Industry 4.0 (IoT, AI, automation) in pollution control - Industrial symbiosis and resource sharing - Adoption of environmental design and eco-labelling **4.2 Environmental Risk Assessment and Industrial Accidents** Risk identification, analysis, and mitigation in industries - Toxicological and ecological risk assessment models - Industrial disasters (e.g., Bhopal gas tragedy, Vizag LG polymer leak) - On-site emergency planning and off-site consequence modelling **4.3 Best Available Techniques (BAT) and International Practices** Concept of BAT in pollution prevention (EU IPPC Directive, BREF documents) - Sector-specific BATs: mining, tanning, petrochemicals, manufacturing - Technology benchmarking and performance indicators **4.4 Climate Change and Decarbonization in Industry** GHG emissions from industrial processes: cement, steel, chemicals - Carbon footprint accounting and life-cycle emissions - Carbon capture, utilization and storage (CCUS) - Decarbonization pathways and net-	• Identify and evaluate emerging technologies that reduce industrial pollution. • Conduct risk assessments and prepare emergency management plans for industrial sites. • Apply international best practices and BAT principles to Indian industries. • Analyse industrial contributions to climate change and propose mitigation strategies.

	zero targets in heavy industry	
Module V Teacher Specific Module (5 Hours)	Areas of content, transaction, and evaluation are decided by the faculty.	
References	**Core compulsory reading** 1. Rao, C. S. (2006). *Environmental Pollution Control Engineering*. New Age International. 2. Peavy, H. S., Rowe, D. R., & Tchobanoglous, G. (1985). *Environmental Engineering*. McGraw-Hill. 3. Metcalf & Eddy. (2003). *Wastewater Engineering: Treatment and Reuse*. Tata McGraw-Hill. 4. Sharma, B. K. (2022). *Environmental Chemistry*. Goel Publishing House. **Core suggested reading** 5. Freeman, H. M. (1995). *Industrial Pollution Prevention Handbook*. McGraw-Hill. 6. Bishop, P. L. (2000). *Pollution Prevention: Fundamentals and Practice*. McGraw-Hill. 7. National Productivity Council. *Cleaner Production Manual*. NPC India.	

Course Outcome	**CO1:** Analyse various industrial processes and identify major pollutants generated. **CO2:** Evaluate the impact of industrial pollution on the environment and human health. **CO3:** Recommend appropriate pollution control and waste management strategies. **CO4:** Interpret and apply environmental laws and management systems in industrial contexts.

Teaching Learning Strategies	Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning (Video) Interactive Instruction: Active co-operative learning, Seminars, Group Assignments, Library work and Group discussion, Presentation by individual student/ Group representative Field work and field visits
Mode of Transaction	Face to face: Lecture method & Demonstration method Learner centered technique: Computer assisted learning & Individual project teaching

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	**50**
Continuous Evaluation	**50**
● **Test papers**	**20**
● **Tutorial with Seminar presentations/Discussions/Debate, etc.**	**20**
● **Assignment**	**10**

Sample questions to test outcomes

1. Describe in detail the pollution control techniques in the cement industry.
2. Discuss the environmental impacts and mitigation strategies for the pulp and paper industry.
3. Explain the concept of ZLD and its application in textile industries.
4. Define the term "Cleaner Production" with an example.

Course Title	ENVIRONMENTAL, SOCIAL & GOVERNANCE (ESG)
Semester	**Seven**
Course Code	**KU07DSEEVS402**
Course Type	**Department-Specific Elective**
Course Credit	**4**
Prerequisite	**Knowledge in Environmental science**
Course Objectives	The course aims: ● To introduce the foundational concepts and global evolution of ESG and its relevance to sustainability science. ● To analyse how environmental, social, and governance dimensions influence corporate, governmental, and policy decisions. ● To provide practical knowledge on ESG frameworks, metrics, disclosures, and reporting standards. ● To foster critical thinking for evaluating ESG performance and ethical leadership in environmental governance.

Modules	Content	Module Outcome
Module I Foundations and Evolution of ESG (10 hours)	**1.1 Historical Evolution of ESG and Sustainable Development** Rise of environmental movements, CSR, and sustainability - From Corporate Social Responsibility (CSR) to ESG investing - Milestones: Brundtland Report, UNGC, SDGs. **1.2 Core Concepts and Pillars of ESG** Detailed study of Environmental, Social, and Governance pillars - Key principles, indicators, and ESG materiality matrix - Triple bottom line and stakeholder theory. **1.3 Global ESG Frameworks and Standards** UN Global Compact, GRI, SDGs, SASB, TCFD, CDP, PRI - ESG policies in the EU, USA, and emerging economies - Corporate ESG benchmarking and disclosure practices. **1.4 ESG Indices, Scores, and Rating Methodologies** MSCI ESG Ratings, Sustainalytics, Refinitiv ESG scores - Comparison of methodologies and their strengths/limitations - ESG performance as a metric in responsible investing.	The student will be able to: • Understand the historical context and key drivers of ESG. • Explain ESG frameworks and international commitments. • Differentiate among global ESG rating mechanisms. • Identify ESG risks and stakeholders.
Module II Environmental Dimension of ESG (15 hours)	**2.1 Climate Change and Carbon Management** GHG accounting protocols (Scopes 1, 2, 3) - Science-based targets, carbon neutrality, net-zero pathways - Emission trading systems and carbon markets. **2.2 Natural Resource Use and Efficiency** Water, energy, material footprints; resource intensity metrics - Circular economy, cradle-to-cradle approach, life cycle thinking - Eco-efficiency and green product design. **2.3 Pollution Control and Biodiversity**	• Apply carbon accounting and reduction frameworks. • Evaluate resource efficiency and circular economy practices. • Integrate biodiversity and

	Conservation ESG relevance in pollution reduction and biodiversity strategy - Green infrastructure, ecosystem services, and nature-based solutions - Environmental impact assessments and offsets. **2.4 Environmental Reporting and Transparency** GRI Environmental Indicators, TCFD environmental metrics - Environmental disclosures under SEBI-BRSR (India) - Corporate environmental audits and sustainability reports.	pollution control into ESG assessments. • Interpret and assess environmental disclosure practices.
Module III Social Responsibility and Human Capital (15 hours)	**3.1 Labor Rights, DEI, and Fair Practices** Freedom of association, fair wages, safe working conditions - Diversity, Equity, and Inclusion (DEI) policies in ESG - Child labor, forced labor, and ethical sourcing. **3.2 Community Engagement and Social Equity** Stakeholder engagement models and consultation practices - Social license to operate and inclusive growth - Indigenous rights and benefit-sharing frameworks. **3.3 Occupational Health and Employee Well-being** ISO 45001, workplace safety culture, and accident reporting - Employee mental health, flexible work arrangements, ergonomics - ESG metrics for health and satisfaction. **3.4 Social Performance Monitoring and Reporting** Social KPIs under GRI and SASB standards - Reporting on human rights and community impact - Social audits and third-party verification.	• Interpret social obligations under ESG and labor frameworks. • community impact and stakeholder expectations. • Assess health and well-being initiatives in ESG reporting. • Develop inclusive and equitable social strategies.
Module IV Governance and ESG Implementation (15 hours)	**4.1 Corporate Governance and Board Accountability** Board composition, independence, ESG expertise - Roles of audit, risk, and sustainability committees - Ethical leadership and fiduciary responsibilities. **4.2 Legal Frameworks and ESG Compliance** Indian CSR mandate, SEBI BRSR guidelines - EU Corporate Sustainability Reporting Directive (CSRD) - ESG-linked financial disclosures and penalties. **4.3 ESG Risk Management and Assurance** Risk identification, double materiality, ESG data quality - Internal controls, ESG audits, and assurance processes - Role of ESG ratings in investment risk analysis. **4.4 Challenges and Future of ESG** Greenwashing and credibility issues - ESG in emerging markets and developing economies - Future trends: integrated reporting, AI in ESG, sustainable finance.	• Apply ESG principles in ethical corporate governance. • Understand global and Indian ESG legal mandates. • Design frameworks for ESG assurance and reporting. • Analyse barriers and innovations in ESG implementation.

Module V Teacher Specific Module (5 hours)	Areas of content, transaction, and evaluation are decided by the faculty.	
References	**Core compulsory reading** 1. Global Reporting Initiative. (2021). *GRI standards*. 2. Securities and Exchange Board of India (SEBI). (2021). *Business Responsibility and Sustainability Reporting (BRSR) Framework.* 3. Task Force on Climate-related Financial Disclosures. (2021). *Recommendations of the Task Force on Climate-related Financial Disclosures*. 4. United Nations Global Compact. (2014). *Guide to corporate sustainability: Shaping a sustainable future*. 5. United Nations. (2015). *Transforming our world: The 2030 agenda for sustainable development*. 6. Principles for Responsible Investment. (2021). *Introduction to responsible investment: ESG integration*. **Core suggested reading** 7. Eccles, R. G., & Krzus, M. P. (2018). *The Nordic model: An analysis of leading practices in ESG disclosure*. Nordic Council of Ministers. 8. Khan, M. H. (2022). *ESG and sustainability: A comprehensive guide for investors and professionals*. Wiley. 9. Kotsantonis, S., Pinney, C., & Serafeim, G. (2016). ESG integration in investment management: Myths and realities. *Journal of Applied Corporate Finance*, 28(2), 10–16. 10. Bansal, P., & DesJardine, M. R. (2022). *Corporate sustainability: Managing risks and opportunities*. Cambridge University Press. 11. Ioannou, I., & Serafeim, G. (2017). The consequences of mandatory corporate sustainability reporting. In R. G. Eccles & M. P. Krzus (Eds.), *The Cambridge handbook of corporate law, corporate governance and sustainability* (pp. 402–428). Cambridge University Press.	

Course Outcomes	**CO1:** Demonstrate a comprehensive understanding of ESG components and their interdependencies. **CO2:** Analyse ESG risks and opportunities in various sectors and organizations. **CO3:** Apply ESG frameworks and standards to assess environmental and social performance. **CO4:** Propose ESG-driven strategies for sustainable development and corporate responsibility.

Teaching Learning Strategies	Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning (Video)Interactive Instruction: Active co-operative learning, Seminars, Group Assignments, Library work and Group discussion, Presentation by individual student/ Group representative Field work and field visits
Mode of Transaction	Face to face: Lecture method & Demonstration method Learner centered technique: Computer assisted learning & Individual project teaching

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	**50**
Continuous Evaluation	**50**
● **Test papers**	**20**
● **Tutorial with Seminar presentations/Discussions/Debate, etc.**	**20**
● **Assignment**	**10**

Sample questions to test outcomes.

1. What is the Total Economic Value (TEV) of an ecosystem?
2. Explain the Coase theorem and its significance in environmental economics.
3. Discuss various environmental valuation methods and their limitations.
4. Evaluate the role of tradable permits in pollution control using global examples.
5. Critically examine the effectiveness of India's National Environmental Policy (2006) in addressing ecological degradation.

Course Title	HUMAN RIGHTS AND ENVIRONMENTAL JUSTICE
Semester	**Seven**
Course Code	**KU07DSEEVS403**
Course Type	**Discipline-Specific Elective**
Course Credit	**4**
Prerequisite	**Knowledge in Environmental Science**
Course Objectives	The course aims: • To understand foundational concepts of human rights in environmental contexts. • To critically examine frameworks of environmental justice at local, national, and international levels. • To analyse the role of vulnerable and marginalized communities in environmental conflict and governance. • To assess legal, institutional, and policy mechanisms ensuring environmental justice and human rights.

Modules	Content	Module Outcome
Module I Introduction to Human Rights and Environment (10 hours)	**1.1 Conceptual and Historical Foundations** Origin and development of human rights - Civil, political, economic, social, and cultural rights - Generational classification of human rights (First, Second, Third Generation) **1.2 Environment as a Human Right** Right to a healthy environment - UN recognition and declarations (e.g., Stockholm 1972, Rio 1992) - Procedural rights: access to information, public participation, and justice **1.3 International Human Rights Instruments** UN Human Rights Council and Environmental Rights - Role of Special Rapporteur on Human Rights and Environment - Global human rights declarations (UDHR, ICCPR, ICESCR) and environmental relevance **1.3 Development, Environment, and Rights** Sustainable development and environmental rights - Balancing economic growth and ecological justice	The students will be able to: • Describe key human rights frameworks and their environmental implications. • Interpret how environmental issues intersect with civil and economic rights. • Analyse international human rights law relating to the environment. • Evaluate developmental conflicts from a human rights perspective.

Module II Environmental Justice: Concepts and Movements (15 hours)	**2.1 Foundations of Environmental Justice** Definitions and evolution - Principles and ethics of environmental justice - Distinction from environmental equity and sustainability **2.2 Environmental Injustices and Marginalization** Environmental racism and caste-based inequality - Gender and environmental exposure - Indigenous land rights and displacement **2.3 Environmental Justice Movements** Grassroots activism (e.g., Chipko, Narmada Bachao Andolan, Plachimada) - Climate justice movements (Fridays for Future, Greta Thunberg, Extinction Rebellion) - Role of NGOs and civil society **2.4 Global Environmental Justice Frameworks** EJ Atlas and case documentation - Global South vs. Global North struggles - Role of international organizations (GAIA, FOEI, UNEP EJ programs)	• Explain key concepts and ethics in environmental justice. • Identify socio-political patterns in environmental discrimination. • Assess contributions of social movements to EJ frameworks. • Compare environmental justice contexts across countries and cultures.
Module III Law, Policy and Institutions in Environmental Human Rights (15 hours)	**3.1 International Legal Instruments** Aarhus Convention (Access to Information, Public Participation) - Paris Agreement and Human Rights - UN Environmental Rule of Law Initiative **3.2 National Laws and Environmental Justice (India Focus)** Constitution of India (Article 21 and environmental rights) - Environmental Protection Act, 1986 - Forest Rights Act, 2006 and Environmental Impact Assessment (EIA) 2020 **3.3 Judicial Activism and Access to Environmental Justice** Public Interest Litigation (PIL) and landmark judgments - Role of National Green Tribunal (NGT) - Environmental jurisprudence and expansion of Article 21 **3.3 Institutional Mechanisms and Policy Gaps** Role of MoEFCC, CPCB, SPCBs - Gaps in implementation and environmental governance - Intersectionality in law and the need for inclusive policies	• Analyse key international environmental legal frameworks. • Evaluate national environmental laws from a human rights perspective. • Assess the role of judiciary and institutions in securing environmental justice. • Identify and critique gaps in existing legal and policy frameworks.
Module IV Contemporary Issues and Future Perspectives (15 hours)	**4.1 Climate Change and Environmental Justice** Climate refugees and relocation justice - Disproportionate impacts on vulnerable communities - Loss and damage discussions in climate treaties **4.2 Corporate Accountability and Environmental Ethics** Environmental crimes and ecological harm -CSR, ESG, and sustainability reporting **4.3 Environmental Justice in Urban and Rural Settings** Urban poor and slum dwellers facing pollution - Rural land degradation and water scarcity - Infrastructure	• Examine how climate change exacerbates environmental injustice. • Analyse corporate practices in relation to environmental human rights. • Evaluate justice-based issues in urban and rural

	development and displacement **4.4 Emerging Trends and Future of EJ** Technology and environmental monitoring for justice - Youth and digital EJ activism - Ecofeminism, intergenerational equity, and planetary justice	environmental governance. • Predict future directions of the environmental justice movement.
Module V Teacher Specific Module (5 hours)	Areas of content, transaction, and evaluation are decided by the faculty.	
References	**Core compulsory readings** 1. Boyd, D. R. (2012). *The Environmental Rights Revolution*. UBC Press. 2. Shiva, V. (2005). *Earth Democracy: Justice, Sustainability and Peace*. South End Press. 3. Guha, R. (2000). *Environmentalism: A Global History*. Longman. 4. Shanthakumar, S. (2017). *Introduction to Environmental Law*. LexisNexis. **Core suggested readings** 5. Schlosberg, D. (2007). *Defining Environmental Justice*. Oxford University Press. 6. Rajagopal, B. (2003). *International Law from Below: Development, Social Movements and Third World Resistance*. Cambridge University Press. 7. EJAtlas (www.ejatlas.org) – Global documentation of EJ conflicts 8. UN Reports on Human Rights and Environment 9. Indian Supreme Court Judgments on Environmental Rights	

Course Outcomes	**CO1:** Define and contextualize human rights within environmental discourses. **CO2:** Identify and evaluate issues of environmental injustice across regions and demographics. **CO3:** Interpret and critique national and international legal instruments related to environmental human rights. **CO4:** Develop informed, equitable, and justice-based environmental solutions and policy suggestions.

Teaching Learning Strategies	Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning (Video)Interactive Instruction: Active co-operative learning, Seminars, Group Assignments, Library work and Group discussion, Presentation by individual student/ Group representative Field work and field visits
Mode of Transaction	Face to face: Lecture method & Demonstration method Learner centered technique: Computer assisted learning & Individual project teaching

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	**50**
Continuous Evaluation	**50**
• **Test papers**	**20**

● **Tutorial with Seminar presentations/Discussions/Debate, etc.**	**20**
● **Assignment**	**10**

Sample questions to test outcomes

1. Explain the significance of the Aarhus Convention.
2. Write a note on the Chipko movement as an environmental justice struggle.
3. Discuss how human rights and environmental protection are interrelated.
4. Analyse the gender dimension in environmental justice conflicts.
5. Discuss the challenges of implementing environmental laws in ensuring justice for marginalized communities.

SEMESTER VIII

Course Title	**ENVIRONMENTAL ECONOMICS AND POLICY ANALYSIS**
Semester	**Eight**
Course Code	**KU08DSCEVS405**
Course Type	**Discipline-Specific Core**
Course Credit	**4**
Prerequisite	**Knowledge in Environmental science**
Course Objectives	The course aims ● To impart in-depth understanding of key concepts and frameworks in environmental economics. ● To explore the application of economic tools for environmental valuation and policy development. ● To evaluate national and global environmental governance structures and instruments. ● To develop critical thinking and analytical abilities in policy formulation and impact analysis.

Modules	Content	Module Outcome
Module I Foundations of Environmental Economics (15 hours)	**1.1 Principles of Economics Applied to Environment** Scarcity, utility, opportunity cost, supply-demand curves - Types of goods: private, public, common-pool, and club goods - Environmental externalities: positive and negative - Market equilibrium and efficiency **1.2 Environmental Externalities and Market Failures** Causes and consequences of market failure - External costs and benefits - Common property resources and "Tragedy of the Commons" - Public goods and free-rider problem **1.3 Welfare Economics and Environment** Pareto efficiency and compensation principle - Social welfare function - Equity-efficiency trade-offs in environmental decisions - Cost-effectiveness vs cost-benefit principles **1.4 Natural Resource Economics and Sustainability** Renewable vs non-renewable resources - Optimal extraction models (e.g., Hotelling's Rule) - Resource scarcity and the role of technology - Concepts of sustainability (weak vs strong)	The student will be able to: • Explain the relevance of economic principles in environmental management • Identify causes of market failure in environmental contexts • Evaluate trade-offs in social welfare and environmental equity • Apply models for resource allocation and sustainability
Module II Environmental Valuation and Economic Appraisal (20 hours)	**2.3 Understanding Environmental Values** Types of values: use (direct and indirect), non-use (option, existence, bequest) - Total Economic Value (TEV) framework - Need for valuation of ecosystem services - Examples of valuation in forests, water, air **2.2 Environmental Valuation Techniques**	• Categorize types of environmental values • Select appropriate valuation tools for specific case studies

	Revealed preference methods: travel cost, hedonic pricing - Stated preference methods: contingent valuation (CVM), choice experiments - Benefits transfer method - Pros and cons of each method **2.3 Cost-Benefit Analysis (CBA)** Steps: baseline setting, identification of costs and benefits - Discounting, Net Present Value (NPV), Internal Rate of Return (IRR) - Sensitivity analysis and uncertainty - Social discount rate debate **2.4 Ethical and Practical Issues in Valuation** Incommensurability of nature - Valuation of biodiversity and cultural values - Risk perception and valuation under uncertainty - Criticisms of monetization of nature	• Perform economic appraisals using CBA • Reflect critically on ethical issues in valuation
Module III Policy Instruments and Environmental Governance (20 hours)	**3.1 Economic Instruments in Environmental Policy** Overview: taxes, subsidies, deposit-refund systems - Pollution taxes (Pigouvian taxes), carbon taxes - Environmental subsidies and green incentives - Performance and limitations **3.2 Market-Based Instruments and Property Rights** Tradable pollution permits (cap-and-trade systems) - Examples: EU ETS, Clean Development Mechanism (CDM) - Role of property rights and Coase Theorem - Implementation challenges **3.3 Regulatory and Voluntary Instruments** Command-and-control regulations - Voluntary agreements and eco-labelling - Corporate social responsibility (CSR) and self-regulation - Behavioural economics and nudges **3.4 Institutional and Legal Frameworks** National and state environmental institutions - Environmental courts and tribunals - International institutions: UNEP, World Bank, GEF - Intergovernmental negotiation processes	• Distinguish between various policy instruments and their mechanisms • Evaluate case studies of market-based environmental governance • Understand legal and institutional roles in enforcement • Analyse policy effectiveness using economic reasoning
Module IV Policy Evaluation, National and Global Frameworks (20 hours)	**4.1 Environmental Policy Analysis Tools** Steps: problem definition, stakeholder analysis, options evaluation - Policy cycle and feedback loops - Indicators and monitoring frameworks - Multi-criteria decision analysis (MCDA) **4.2 Environmental Impact Assessment (EIA) and SEA** History and objectives of EIA - EIA process in India and globally - Strategic Environmental Assessment (SEA) vs EIA - Public participation and transparency **4.3 National Environmental Policies and Acts** India's National Environmental Policy (2006) - Key legislations: Air Act, Water Act, EPA, Forest Act, Wildlife Act - Role of MoEFCC, CPCB, SPCBs -	• Apply policy analysis frameworks to real-world problems • Evaluate EIA and SEA practices for effectiveness and inclusivity • Interpret India's policy tools in historical and legal context • Analyse international

	Gaps and overlaps in implementation **4.4 International Environmental Agreements and Frameworks** UNFCCC, Kyoto Protocol, Paris Agreement - Convention on Biological Diversity (CBD), Ramsar Convention - Sustainable Development Goals (SDGs) - Global environmental diplomacy and equity	agreements for their design and outcomes
Module V Teacher Specific Module (5 hours)	Areas of content, transaction, and evaluation are decided by the faculty.	
References	**Core compulsory reading** 12. Kolstad, Charles D. (2011). *Environmental Economics*. Oxford University Press. 13. Hanley, N., Shogren, J.F., & White, B. (2013). *Introduction to Environmental Economics*. Oxford University Press. 14. Pearce, D.W., & Turner, R.K. (1990). *Economics of Natural Resources and the Environment*. Harvester Wheatsheaf. **Core suggested reading** 15. Tietenberg, T. & Lewis, L. (2018). *Environmental and Natural Resource Economics*. Routledge. 16. Perman, R., Ma, Y., McGilvray, J., & Common, M. (2011). *Natural Resource and Environmental Economics*. Pearson. 17. Baumol, W.J., & Oates, W.E. (1988). *The Theory of Environmental Policy*. Cambridge University Press. 18. National Environmental Policy (2006), Government of India 19. Relevant IPCC Assessment Reports, UNFCCC documents	

Course Outcomes	**CO1:** Interpret and apply economic theories in the context of environmental issues. **CO2:** Quantify and evaluate environmental goods and services using economic tools. **CO3:** Analyse and assess the effectiveness of environmental policies and regulations. **CO4:** Synthesize economic data and policy documents to propose sustainable solutions.

Teaching Learning Strategies	Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning (Video)Interactive Instruction: Active co-operative learning, Seminars, Group Assignments, Library work and Group discussion, Presentation by individual student/ Group representative Field work and field visits
Mode of Transaction	Face to face: Lecture method & Demonstration method Learner centered technique: Computer assisted learning & Individual project teaching

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	**50**
Continuous Evaluation	**50**
● **Test papers**	**20**
● **Tutorial with Seminar presentations/Discussions/Debate, etc.**	**20**
● **Assignment**	**10**

Sample questions to test outcomes.

1. What is the Total Economic Value (TEV) of an ecosystem?
2. Explain the Coase theorem and its significance in environmental economics.
3. Discuss various environmental valuation methods and their limitations.
4. Evaluate the role of tradable permits in pollution control using global examples.
5. Critically examine the effectiveness of India's National Environmental Policy (2006) in addressing ecological degradation.

Course Title	ENVIRONMENTAL IMPACT ASSESSMENT
Semester	**Eight**
Course Code	**KU08DSCEVS406**
Course Type	**Discipline-Specific Core**
Course Credit	**4**
Prerequisite	**Knowledge in Environmental Science**
Course Objectives	The course aims ● To introduce the core principles, history, and evolution of Environmental Impact Assessment (EIA). ● To develop analytical capabilities in screening, scoping, impact prediction, and evaluation. ● To impart knowledge on legal, procedural, and participatory frameworks of EIA at national and international levels. ● To provide real-world insights through sector-specific case studies and environmental management planning.

Modules	Content	Module Outcome
Module I Introduction to Environmental Impact Assessment (15 hours)	1.1 Historical Evolution and Fundamentals of EIA Origin and evolution of EIA globally and in India - Definition, objectives and principles of EIA - Relationship between EIA and sustainable development 1.2 Stages and Types of EIA Pre-feasibility and feasibility studies - Types: Strategic EIA, Rapid EIA, Comprehensive EIA - Project cycle integration with EIA stages 1.3 EIA Legislation and Policies EIA Notification 2006 (India) and amendments - EPA 1986, Water Act 1974, Forest Conservation Act 1980 - Global treaties: Espoo Convention, Rio Summit (Agenda 21), UNCED 1.4 Institutional Framework and Stakeholder Involvement Roles of MoEFCC, CPCB, SPCBs, SEACs and EACs - Role of NGOs, industries, communities - Public consultation and public hearing processes	The student will be able to: • Describe the origins, need, and significance of EIA. • Identify the main stages and procedures in the EIA process. • Understand legal and institutional frameworks for EIA. • Explain the role of public participation and stakeholder engagement in EIA.
Module II Methods of Impact Identification, Prediction, and Evaluation (20 hours)	**2.1 Impact Identification Techniques** Ad hoc method - Checklist method (simple and descriptive) - Matrix methods: Leopold matrix, cross-impact matrices - Network diagrams and flow charts **2.2 Environmental Impact Prediction Tools** Air quality models (AERMOD, ISC3) - Water quality models (QUAL2K, WASP) - Noise prediction models (FHWA) - Ecological and health impact modelling **2.3 Impact Evaluation and Assessment** Ranking, weighting, and scoring techniques -	• Apply tools and methods for impact identification. • Use prediction models for environmental components. • Evaluate environmental impacts quantitatively and qualitatively. • Analyse

	Environmental indices and indicators - Overlay techniques using GIS/Remote Sensing **2.4 Risk and Cost-Benefit Analysis** Risk assessment: Hazard identification, exposure assessment - Risk characterization and management - Cost-benefit analysis: Tangible and intangible values - Environmental valuation methods (WTP, Hedonic pricing)	uncertainties, risks, and perform cost-benefit analyses.
Module III Environmental Management Plan, Auditing, and Monitoring (20 hours)	**3.1 Designing an Environmental Management Plan (EMP)** Concepts and scope of environmental Planning - Structure and content of EMP - Mitigation strategies for air, water, soil, biodiversity - Waste management and energy efficiency plans **3.2 Environmental Monitoring Programs** Baseline vs. continuous monitoring - Sampling techniques and indicator selection - Monitoring frequency and reporting formats **3.3 Environmental Auditing and Compliance** Types of audits: internal, third-party - Audit procedure, compliance tracking - Reporting formats and corrective action protocols **3.4 Integration with Sustainability and SDGs** Linking EMP with circular economy and green economy principles - Life cycle assessment (LCA) and EIA - Climate resilience and disaster risk reduction in EMPs	• Design structured Environmental Management Plans (EMPs). • Develop monitoring systems for different environmental components. • Evaluate post-approval audit and compliance strategies. • Integrate EIA with sustainability and circular economy goals.
Module IV Sectoral EIA, Case Studies, and Report Writing (20 hours)	**4.1 Sectoral Guidelines and Sector-specific EIA** EIA in mining, thermal power plants, hydro-projects - Infrastructure: highways, airports, SEZs - Waste disposal, chemical industries, tourism projects **4.2 National Case Studies** Sardar Sarovar Project - POSCO steel plant (land, forest rights, and clearance) - Delhi Metro (transportation and air quality benefits) - Mopa Airport Goa (biodiversity and stakeholder concerns) **4.3 International Case Studies** Exxon Valdez (oil spill and marine pollution) - Fukushima Nuclear Disaster - Three Gorges Dam (resettlement and ecological changes) **4.4 EIA Report Writing and Review Process** Structure of an EIA report - Common deficiencies and review criteria (Quality Review Checklist) - Public hearing documentation and Final EMP summary	• Apply EIA procedures to various development sectors. • Critically evaluate real-life EIA projects and reports. • Identify sector-specific challenges and solutions. • Learn formatting, technical writing, and review techniques for EIA reports.
Module V Teacher Specific Module (5 hours)	Areas of content, transaction, and evaluation are decided by the faculty.	

References	**Core compulsory reading** 1. Canter, L. W. (1996). *Environmental Impact Assessment*. McGraw Hill. 2. Glasson, J., Therivel, R., & Chadwick, A. (2012). *Introduction to Environmental Impact Assessment*. Routledge. 3. MoEF&CC (2006). *EIA Notification* and later amendments. 4. World Bank (1991). *Environmental Assessment Sourcebook* (Volumes I–III). **Core suggested reading** 5. Petts, J. (1999). *Handbook of Environmental Impact Assessment*. Blackwell Science. 6. Therivel, R. (2004). *Strategic Environmental Assessment in Action*. Earthscan. 7. UNEP (2002). *EIA Training Resource Manual*. 8. Jay, S. et al. (2007). "Environmental impact assessment: Retrospect and prospect." *Environmental Impact Assessment Review*.

Course Outcomes	**CO1:** Define and explain the theoretical framework, history, and legislative context of EIA. **CO2:** Demonstrate the ability to conduct impact identification, prediction, and mitigation using appropriate tools and methods. **CO3:** Design and evaluate Environmental Management Plans (EMPs) and monitoring systems. **CO4:** Critically review EIA reports and engage with sectoral applications and case studies.

Teaching Learning Strategies	Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning (Video) Interactive Instruction: Active co-operative learning, Seminars, Group Assignments, Library work and Group discussion, Presentation by individual student/ Group representative Field work and field visits
Mode of Transaction	Face to face: Lecture method & Demonstration method Learner centered technique: Computer assisted learning & Individual project teaching

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	**50**
Continuous Evaluation	**50**
● **Test papers**	**20**
● **Tutorial with Seminar presentations/Discussions/Debate, etc.**	**20**
● **Assignment**	**10**

Sample questions to test outcomes.

1. Define scoping and its role in EIA.
2. Differentiate between Rapid EIA and Comprehensive EIA.
3. Explain the structure and key components of an EMP using a sectoral example.
4. Evaluate the EIA of a major infrastructure project in India and its outcomes.

Course Title	**ENVIRONMENTAL ENGINEERING**
Semester	**Eight**
Course Code	**KU08DSCEVS407**
Course Type	**Discipline-Specific Core**
Course Credit	**4**
Prerequisite	**Knowledge in Environmental Science**
Course Objectives	The course aims ● To introduce the principles and applications of environmental engineering in pollution control. ● To impart scientific and technological knowledge in water, wastewater, air, and solid waste treatment systems. ● To train students to design, operate, and evaluate environmental infrastructure and treatment units. ● To enhance students' abilities to develop sustainable engineering solutions to environmental issues.

Modules	Content	Module Outcome
Module I Water Supply and Treatment Systems (15 hours)	**1.1 Sources of Water** Surface and groundwater characteristics - Source selection criteria - Groundwater recharge and contamination - Influence of catchment activities **1.2 Water Quality Parameters and Standards** Physical, chemical, biological characteristics - Drinking water standards (IS 10500, WHO) - Sampling, preservation, and analysis techniques **1.3 Water Treatment Processes** Preliminary: Screening, grit removal - Primary: Sedimentation, coagulation, flocculation - Secondary: Softening, Filtration (slow/rapid sand, pressure filters) - Disinfection: Chlorination, ozonation, UV radiation **1.4 Design of Water Supply and Distribution Systems** Intake structures - Pumping systems and pipelines - Distribution layouts: Dead-end, grid, ring systems - Leakage detection and NRW (Non-Revenue Water) control **1.5 Water Conservation and Reuse Technologies** Rainwater harvesting (RWH) systems - Greywater and blackwater reuse - Demand-side management and conservation strategies - Dual piping systems	The student will be able to: ● Identify and assess water sources and their quality. ● Describe the processes involved in potable water treatment. ● Design and evaluate water distribution networks. ● Implement water conservation and reuse techniques.
Module II Wastewater Engineering (20 hours)	**2.1 Characterization of Domestic and Industrial Wastewater** Flow rate estimation: Parameters: BOD, COD, TSS, TDS, nutrients, pathogens: Industrial wastewater pre-treatment needs **2.2 Primary Treatment Units** Screening and grit chambers - Primary sedimentation tanks - Oil and grease traps	● Analyse wastewater characteristics and treatment requirements. ● Design and evaluate primary and secondary

	2.3 Secondary Biological Treatment Nature and Kinetics of Biological Growth - Aerobic Process - Activated sludge process: Design, operation, sludge volume index - Oxidation ditches - Rotating biological contactors - Aerated lagoons and stabilization ponds Attached Growth System, Trickling Filters, High-rate anaerobic reactor - CSTR, up flow anaerobic filters – UAFS, UASB, expanded, fluidized Bed Reactors. **2.4 Tertiary and Advanced Wastewater Treatment** Nutrient (N, P) removal techniques - Membrane bioreactors, reverse osmosis, electrodialysis - Advanced oxidation processes (AOPs) **2.5 CETP & ZLD** Concept of Common Effluent Treatment Plants (CETP) - Wastewater recycling and zero liquid discharge. **2.6 Sludge Treatment and Disposal** Thickening, dewatering, digestion (anaerobic/aerobic) - Sludge drying beds, incineration - Safe disposal and reuse (biosolids application)	treatment systems. ● Explain advanced wastewater treatment and nutrient removal. ● Recommend appropriate sludge management practices.
Module III Air and Noise Pollution Control (20 hours)	**3.1 Air Pollutants: Classification and Effects** Gaseous and particulate pollutants - Photochemical smog, ozone depletion - Health, vegetation, material impacts **3.2 Air Pollution Meteorology and Dispersion Modelling** Lapse rate, stability, inversion - Gaussian plume model - Wind rose diagrams - Air quality standards - Air Sampling **3.3 Particulate Matter Control Technologies** Cyclone separators, wet scrubbers - Gravitational Settling Chamber - Centrifugal Collector – Scrubber - Fabric filters, electrostatic precipitators - Design considerations and efficiencies **3.4 Control of Gaseous Pollutants** Absorption (wet scrubbers) - Adsorption (activated carbon) - Combustion (thermal/catalytic) - Condensation methods **3.5 Noise Pollution: Assessment and Control** Sources: Industrial, transport, construction - Sound measurement (decibel, dB(A)) - Noise mapping, barriers, zoning regulations - Occupational health norms (OSHA guidelines)	● Understand types and sources of air and noise pollutants. ● Apply meteorological concepts to pollution dispersion modelling. ● Evaluate air pollution control equipment performance. ● Propose mitigation strategies for industrial and urban noise pollution.
Module IV Solid and Hazardous Waste	**4.1 Solid Waste Types and Characteristics** Municipal, biomedical, e-waste, industrial waste - Waste generation rates and composition - Segregation, recycling, life cycle analysis	● Classify and characterize various types of solid and hazardous waste.

Management (20 hours)	**4.2 Collection, Transport, and Storage Systems** Collection methods and routing - Transfer stations - Temporary storage and community bins **4.3 Processing and Disposal Technologies** Composting (aerobic/anaerobic), vermicomposting - Incineration (mass burn, RDF), pyrolysis - Landfilling: Sanitary design, leachate/gas management - Anaerobic digestion **4.4 Hazardous Waste Management** Classification (ignitability, reactivity, toxicity) - Listed hazardous waste - Treatment technologies (neutralization, immobilization) - TSDFs, risk assessment and transport regulations (Manifest System) - Hazardous waste rules - E-waste management **4.5 Biomedical Waste and Plastic Waste Management** Biomedical Waste Management: Classification - Categories of Biomedical Waste (Biomedical Wastes Rule, 1998) - Segregation - Treatment Methods Plastic Waste Management: Classification - Reduce, Reuse, Recycle and Recovery - Plastic Waste Management Rules, 2016. **4.6 Circular Economy and Resource Recovery** Waste-to-energy (WTE) systems - 3Rs (Reduce, Reuse, Recycle), Extended Producer Responsibility (EPR) - Material Recovery Facilities (MRFs)	● Design effective waste collection, transport, and disposal systems. ● Recommend appropriate treatment options for hazardous wastes. ● Integrate circular economy principles in sustainable waste management.
Module V Teacher Specific Module (5 hours)	Areas of content, transaction, and evaluation are decided by the faculty.	
References	**Core compulsory reading** 1. Peavy, H.S., Rowe, D.R., & Tchobanoglous, G. (2013). *Environmental Engineering*. McGraw-Hill. 2. Metcalf & Eddy (2014). *Wastewater Engineering: Treatment and Resource Recovery*, McGraw-Hill. 3. Masters, G.M., & Ela, W.P. (2008). *Introduction to Environmental Engineering and Science*, Pearson. 4. Nemerow, N.L. (2009). *Industrial Waste Treatment*, Elsevier. **Core suggested reading** 5. Kiely, G. (1997). *Environmental Engineering*, McGraw-Hill. 6. Henry, J.G. & Heinke, G.W. (2005). *Environmental Science and Engineering*, Pearson Education. 7. Mahajan, S.P. (1991). *Pollution Control in Process Industries*, Tata McGraw-Hill. 8. Crites, R., & Tchobanoglous, G. (2010). *Small and Decentralized Wastewater Management Systems*, McGraw-Hill.	

Course Outcomes	**CO1:** Understand and apply principles of water and wastewater engineering. **CO2:** Analyse and design systems for air and noise pollution control. **CO3:** Evaluate solid and hazardous waste management strategies. **CO4:** Integrate environmental engineering solutions with policy and sustainability frameworks.

Teaching Learning Strategies	Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning (Video) Interactive Instruction: Active co-operative learning, Seminars, Group Assignments, Library work and Group discussion, Presentation by individual student/ Group representative Laboratory visit.
Mode of Transaction	Face to face: Lecture method & Demonstration method Learner centered technique: Computer assisted learning & Individual project teaching

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Components	Marks
End Semester Evaluation	**50**
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● **Test papers**	**20**
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● **Assignment**	**10**

Sample questions to test outcomes.

1. Differentiate between grab and composite sampling in water analysis.
2. What are the components of a modern landfill?
3. State the role of activated carbon in gas pollution control.
4. Discuss the various stages in water treatment with diagrams.
5. Describe different methods of hazardous waste treatment and disposal.

Course Title	CARBON NEUTRALITY
Semester	**Eight**
Course Code	**KU08DSEEVS404**
Course Type	**Discipline-Specific Elective**
Course Credit	**4**
Prerequisite	**Knowledge in Environmental Science/Climate change**
Course Objectives	The course aims: • To provide a comprehensive understanding of carbon sources, sinks, and climate mechanisms. • To enable students to measure, assess, and interpret carbon footprints across systems. • To evaluate technologies and strategies aimed at achieving carbon neutrality. • To critically examine global, national, and institutional pathways and policies for net-zero targets.

Modules	Content	Module Outcome
Module I Climate Science and the Carbon Cycle (10 hours)	**1.1 Global Carbon Cycle and Biogeochemical Pathways** Carbon fluxes between atmosphere, biosphere, lithosphere, and hydrosphere - Human alterations and disruptions in natural cycles **1.2 Greenhouse Gases and Radiative Forcing** Properties of CO_2, CH_4, N_2O, F-gases - GWP, radiative forcing, and climate sensitivity **1.3 Carbon Budgets and Tipping Points** IPCC-defined carbon budgets (1.5°C/2°C thresholds) - Earth system feedbacks and potential tipping points **1.4 Anthropogenic Emissions and Sectoral Contributions** Sectoral emissions (transport, agriculture, energy, industry) - Trends and sources globally and in India **1.5 Climate Models and Projections** Basics of Earth System Models (ESMs) - IPCC SSPs, RCPs, and climate futures	The students will be able to: • Understand the science behind global warming and the role of carbon in climate regulation. • Interpret carbon cycle alterations due to anthropogenic influences. • Assess the relevance of carbon budgets for policy and practice. • Analyse sectoral emissions and climate response scenarios.
Module II Carbon Accounting and Footprint Analysis (15 hours)	**2.1 GHG Emission Accounting Frameworks** IPCC inventory guidelines, GHG Protocol (Scope 1, 2, 3) - ISO 14064/14067 for organizations and products **2.2 Tools and Techniques in Carbon Footprinting** Carbon calculators (CoolClimate, OpenLCA) - Emission factors, boundary setting, data quality **2.3 Life Cycle Assessment (LCA) and Embodied Carbon** Cradle-to-grave vs. cradle-to-gate analysis - Carbon intensity and product/service footprinting **2.4 Carbon Auditing and Reporting Standards** Institutional/Corporate audit procedures - GRI, CDP,	• Apply accounting standards to calculate organizational and product emissions. • Use tools for carbon footprinting and life cycle analysis. • Understand reporting obligations and voluntary disclosure mechanisms. • Evaluate carbon

	BRSR, ESG frameworks **2.5 Carbon Sequestration Measurement Methods** Estimating terrestrial and aquatic carbon sinks - Remote sensing, modelling, and MRV systems	sinks and offset validity.
Module III Decarbonization Technologies and Strategies (15 hours)	**3.1 Renewable Energy Systems for Net-Zero** Solar PV, wind, hydro, biomass, geothermal - Integration, intermittency, storage technologies **3.2 Energy Efficiency and Sustainable Infrastructure** Passive design, insulation, energy-efficient appliances - Smart grids and urban carbon reduction **3.3 Carbon Capture, Utilization and Storage (CCUS)** Pre-/post-combustion capture, direct air capture - Geological storage, mineralization, industrial reuse **3.4 Nature-based Solutions (NbS)** Forest regeneration, afforestation, blue carbon - Urban greening, agroforestry, biodiversity co-benefits **3.5 Carbon Offsetting Mechanisms and Markets** REDD+, carbon credits, VCM, permanence and leakage - Criticisms and ethical dimensions of offsetting	• Identify viable decarbonization options across sectors. • Evaluate technical and economic feasibility of carbon capture and renewables. • Understand the scope and limitation of nature-based solutions. • Critique offsetting schemes and carbon market mechanisms.
Module IV Policies, Governance, and Roadmaps for Carbon Neutrality (15 hours)	**International Frameworks and Agreements** UNFCCC, Paris Agreement, Glasgow Pact - Nationally Determined Contributions (NDCs) **National Carbon Neutrality Plans** India's net zero by 2070 roadmap - State-level SAPCCs and NAPCC missions **Corporate and Institutional Net-Zero Pledges** Science-Based Targets initiative (SBTi) - ESG governance, net-zero campuses **Carbon Pricing Instruments and Policy Tools** Emission trading systems (ETS), carbon taxes, subsidies - Voluntary vs. regulatory approaches **Equity, Justice and Implementation Challenges** Just transition, climate finance, loss and damage - Global North vs. South responsibilities	• Analyse the role of international policy in driving carbon neutrality. • Evaluate India's and other countries' national net-zero strategies. • Assess corporate contributions and accountability frameworks. • Identify equity challenges and propose inclusive policies.
Module V Teacher Specific Module (5 hours)	Areas of content, transaction, and evaluation are decided by the faculty.	
References	**Core compulsory reading** 1. IPCC Sixth Assessment Report (AR6, 2023) 2. UNFCCC Paris Agreement (2015) 3. MoEFCC (2022). *India's Long-Term Low Emissions Development*	

	Strategy 4. GHG Protocol Standards (https://ghgprotocol.org/) **Core suggested reading** 5. World Bank (2023). *State and Trends of Carbon Pricing* 6. IEA (2021). *Net Zero by 2050: Roadmap for Global Energy Sector* 7. Drawdown Project. *Solutions to Climate Change* 8. TERI. *Pathways for India's Carbon Neutrality* 9. UNEP (2023). *Emissions Gap Report*

Course Outcomes	**CO1:** Analyse the role of human activity in altering carbon dynamics and climate balance. **CO2:** Perform carbon audits and footprint assessments using standardized protocols. **CO3:** Evaluate decarbonization pathways including renewable energy, CCUS, and offsets. **CO4:** Critically appraise national and global carbon neutrality policies and implementation frameworks.

Teaching Learning Strategies	Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning (Video) Interactive Instruction: Active co-operative learning, Seminars, Group Assignments, Library work and Group discussion, Presentation by individual student/ Group representative Field work and field visits
Mode of Transaction	Face to face: Lecture method & Demonstration method Learner centered technique: Computer assisted learning & Individual project teaching

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	**50**
Continuous Evaluation	**50**
• **Test papers**	**20**
• **Tutorial with Seminar presentations/Discussions/Debate, etc.**	**20**
• **Assignment**	**10**

Sample questions to test outcomes.

1. Define Scope 1, 2, and 3 emissions with examples.
2. What is the Global Warming Potential (GWP) of methane?
3. Differentiate between carbon neutral and climate positive.
4. Evaluate India's roadmap to achieve net-zero emissions by 2070.
5. Compare and contrast various carbon offsetting mechanisms.

Course Title	RENEWABLE AND NON-RENEWABLE ENERGY
Semester	**Eight**
Course Code	**KU08DSEEVS405**
Course Type	**Discipline-Specific Elective**
Course Credit	**4**
Prerequisite	**Knowledge in Environmental Science**
Course Objectives	The course aims ● To enable deep understanding of various energy forms, classifications, and global energy challenges. ● To examine the extraction, use, and consequences of fossil and nuclear energy. ● To explore technologies, economics, and deployment of renewable energy systems. ● To assess policies, auditing, sustainability measures, and future energy transitions.

Modules	Content	Module Outcome
Module I Energy Fundamentals, Resources, and Environmental Impacts (10 hours)	**1.1 Basics of Energy Concepts** Definitions, units (Joule, kcal, TOE), energy density - Primary vs secondary energy - Law of conservation of energy - Thermodynamic concepts: entropy, exergy **1.2 Energy Flow and Conversion** Energy flow diagrams in ecosystems - Sankey diagrams - Energy transformations: electrical ↔ mechanical ↔ thermal - Concept of energy quality and degradation **1.3 Global & Indian Energy Trends** Global energy demand by region and sector - India's energy mix: fossil vs renewables - Per capita consumption, energy poverty - Energy access and equity **1.4 Classification and Characteristics of Energy Resources** Commercial vs non-commercial (wood, dung) - Renewable (solar, wind, hydro) vs non-renewable (coal, oil) - Local vs imported resources - Dispatchable vs non-dispatchable energy **1.5 Environmental and Social Impacts** Air and water pollution from energy use - Habitat disruption and biodiversity loss - Climate change and GHGs - Energy justice and community displacement	The student will be able to: • Understand energy systems and transformations. • Analyse country-specific energy use trends and transitions. • Evaluate energy classifications and access. • Assess the ecological and socio-political footprint of energy production.

Module II Nonrenewable Energy Resources: Technologies and Impacts (15 hours)	**2.1 Coal** Formation and types (anthracite, lignite) - Underground vs surface mining - Clean coal technologies (IGCC, CCS) - Fly ash management and mine reclamation **2.2 Petroleum and Natural Gas** Origin and occurrence - Exploration: seismic surveys, drilling - Refining (distillation, cracking) - Natural gas liquefaction (LNG) and pipelines - Methane hydrates: emerging frontier **2.3 Nuclear Energy** Fission process, uranium enrichment - Reactor types (PWR, BWR, fast breeders) - Spent fuel management and reprocessing - Radiation risks and international safety standards (IAEA, NRC) - Accidents: Chernobyl, Fukushima – causes and aftermath **2.4 Unconventional Fossil Fuels** Oil sands, oil shales, coal-bed methane - Hydraulic fracturing and induced seismicity - EROI (Energy Returned on Investment) comparison - Water-intensive technologies and waste disposal **2.5 Energy Security and Fossil Fuel Challenges** Peak oil concept - Fossil fuel subsidies and market volatility - Import dependency and geopolitical conflicts - Just Transition concepts	• Comprehend technical aspects of fossil fuel and nuclear energy. • Analyse risks and benefits of unconventional fossil fuels. • Evaluate challenges of waste management and accident control. • Critique fossil fuel dependence and energy security frameworks.
Module III Renewable Energy Technologies and Applications (15 hours)	**3.1 Solar Energy** Solar radiation measurement and global solar atlas - Solar PV: semiconductors, cell efficiency, I-V characteristics - CSP: parabolic trough, heliostats - Applications: rooftops, water heating, solar drying - Off-grid vs grid-connected systems **3.2 Wind Energy** Wind resource mapping and site assessment - Horizontal vs vertical axis turbines - Power curve, Betz limit, cut-in/cut-out speeds - Environmental impacts: bird mortality, noise - Wind-solar hybrid systems **3.3 Hydro and Ocean Energy** Hydropower types: storage, run-of-river, pumped storage - Ecological impacts of dams: fish migration, sedimentation - Ocean energy: tidal, wave, and Ocean Thermal Energy Conversion (OTEC) - Small hydro and micro-hydro applications **3.4 Bioenergy** Biomass sources: agricultural, forest residues, algae - Anaerobic digestion: biogas plants, slurry management - Biodiesel and bioethanol production - Advanced biofuels and algal biofuel technologies **3.5 Geothermal Energy and Integration of Renewables**	• Describe key principles and designs of renewable technologies. • Evaluate renewable energy potential and implementation barriers. • Analyse environmental trade-offs and sustainability metrics. • Integrate renewable systems into energy planning frameworks.

	High and low enthalpy resources - Flash steam and binary cycle plants - District heating systems - Issues: land subsidence, resource depletion - Grid integration challenges, variability solutions (batteries, demand response)	
Module IV Energy Efficiency, Policy, and Future Transitions (15 hours)	**4.1 Energy Efficiency and Conservation** Efficiency in lighting, motors, appliances - Passive design, insulation, building codes (ECBC) - Transport energy efficiency (EVs, public transport) - Industrial optimization techniques **4.2 Energy Auditing and Management** Energy audit types: preliminary, detailed - Energy accounting and performance indicators - Tools: power meters, thermal cameras, flue gas analysers **4.3 Policy, Legislation, and Governance** National Electricity Policy, Energy Conservation Act (2001) - Perform Achieve Trade (PAT) and Renewable Energy Certificates (RECs) - Climate finance and carbon markets - International frameworks: UNFCCC, Paris Agreement, SDG 7 **4.4 Sustainable Energy Planning and Modelling** Life cycle assessment (LCA) of energy systems - Energy-environment-economic (3E) modelling tools - Integrated energy planning for urban/rural areas - Circular economy approaches and decarbonization roadmaps **4.5 Future Energy Technologies** Hydrogen energy: fuel cells, electrolysers - Smart grids and digitalization of energy systems - Battery storage, pumped hydro, flywheels - AI and IoT in energy demand forecasting - Carbon capture, utilization, and storage (CCUS)	• Conduct and interpret energy audits in multiple sectors. • Analyse the role of national and global energy policies. • Apply sustainability assessment tools for energy planning. • Forecast trends and disruptive technologies for clean energy.
Module V Teacher Specific Module (5 hours)	Areas of content, transaction, and evaluation are decided by the faculty.	
References	**Core compulsory reading** 1. Rao, S. & Parulekar, B. B. (2005). *Energy Technology: Non-Conventional, Renewable and Conventional*. Khanna Publishers. 2. Twidell, J. & Weir, T. (2015). *Renewable Energy Resources*. Routledge. 3. MNRE, Govt. of India – Annual Reports, Solar Mission Documents 4. IEA (International Energy Agency) – *World Energy Outlook* **Core suggested reading** 5. Boyle, G. (2004). *Renewable Energy: Power for a Sustainable Future*. Oxford University Press. 6. Tester, J. W. et al. (2012). *Sustainable Energy: Choosing Among Options*. MIT Press. 7. Smil, V. (2017). *Energy and Civilization: A History*. MIT Press. 8. Goldemberg, J. (2012). *Energy: What Everyone Needs to Know*. Oxford	

	University Press.

Course Outcomes	**CO1:** Comprehend and compare types of energy resources with their implications. **CO2:** Analyse environmental impacts of energy production and usage. **CO3:** Assess renewable energy technologies and integration into policy frameworks. **CO4:** Apply auditing and planning tools to improve energy efficiency and sustainability.

Teaching Learning Strategies	Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning (Video) Interactive Instruction: Active co-operative learning, Seminars, Group Assignments, Library work and Group discussion, Presentation by individual student/ Group representative Field work and field visits
Mode of Transaction	Face to face: Lecture method & Demonstration method Learner centered technique: Computer assisted learning & Individual project teaching

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	**50**
Continuous Evaluation	**50**
● **Test papers**	**20**
● **Tutorial with Seminar presentations/Discussions/Debate, etc.**	**20**
● **Assignment**	**10**

Sample questions to test outcomes.

1. List the environmental concerns associated with shale gas extraction.
2. Explain the working of a parabolic trough in a solar thermal plant.
3. Compare the efficiency and emissions of coal vs natural gas power plants.
4. Discuss India's policy instruments promoting energy efficiency.
5. Analyse the effectiveness of PAT and REC mechanisms in India’s energy market.

Course Title	**NATURE-BASED SOLUTIONS FOR ENVIRONMENTAL CHALLENGES**
Semester	**Eight**
Course Code	**KU08DSEEVS406**
Course Type	**Discipline-Specific Elective**
Course Credit	**4**
Prerequisite	**Knowledge in Environmental Science**
Course Objectives	The course aims • To provide a conceptual and theoretical understanding of Nature-based Solutions (NbS) as ecological approaches to address environmental challenges. • To explore and assess the role of NbS in climate mitigation, adaptation, disaster risk reduction, and sustainable development. • To critically examine real-world applications of NbS across various ecosystems and sectors. • To analyse the governance, policy instruments, and financing frameworks that facilitate effective implementation of NbS.

Modules	Content	Module Outcome
Module I Theoretical Foundations of Nature-Based Solutions (10 hours)	**1.1 Conceptual Evolution of NbS** History and origin (IUCN, IPBES, UNEP perspectives) - Integration of NbS into ecosystem-based approaches and sustainability science - Definitions and typologies (restorative, protective, productive) **1.2 Principles and Standards for NbS** IUCN Global Standard for NbS: 8 principles and 28 criteria - Key attributes: adaptive design, multi-functionality, local context - Measurement indicators and tools for self-assessment **1.3 Classification and Typologies of NbS** Conservation-based (e.g., protected areas, buffer zones) - Restoration-based (e.g., rewilding, afforestation) - Infrastructure-based (e.g., green roofs, bioswales) - Hybrid and socio-ecological systems **1.4 Ecosystem Services and Natural Capital** Types: provisioning, regulating, supporting, cultural - Valuation approaches (TEEB, InVEST) - Interlinkages between ecosystem services and human wellbeing - Trade-offs in ecosystem services provisioning	The student will be able to: • Understand the historical and conceptual basis for NbS. • Distinguish types of NbS based on functionality and scale. • Interpret global principles and standards guiding NbS. • Assess how ecosystem services underpin NbS planning.

Module II Climate Change, Resilience, and Disaster Risk Reduction through NbS (15 hours)	**2.1 Climate Change Mitigation using NbS** Forest carbon sequestration and soil carbon sinks - Blue carbon ecosystems (mangroves, seagrass, salt marshes) - NbS within the REDD+ and NDC frameworks - Co-benefits: air quality, biodiversity, livelihoods **2.2 Climate Adaptation and Urban Resilience** Urban forests, green corridors, and urban wetlands - Nature-based cooling: green roofs, walls, shaded spaces - NbS in heat island mitigation and stormwater management - Sponge cities concept (e.g., China) **2.3 Disaster Risk Reduction (Eco-DRR)** Floodplain restoration, landslide risk reduction through reforestation - Coastal defence using mangroves, dunes, oyster reefs - NbS in cyclone buffering and drought resistance - Community-based disaster management linked to NbS **2.4 Monitoring and Evaluation of Climate-oriented NbS** Indicators: carbon capture, water storage, biodiversity gain - Geospatial tools and remote sensing for M&E - Climate resilience indices and NbS integration - Case comparisons (e.g., Netherlands, Bangladesh, Kerala)	● Explain the mitigation potential of NbS across ecosystems. ● Analyse urban NbS for heat, flooding, and air pollution challenges. ● Evaluate Eco-DRR strategies with global and Indian examples. ● Use metrics to assess performance of NbS in climate resilience.
Module III Sector-Specific Applications of NbS (15 hours)	**3.1 Water Management and Wetland Restoration** Constructed wetlands, bioswales, and riparian buffers - Groundwater recharge through rain gardens and vegetated basins - Natural floodplain management - River rejuvenation case studies **3.2 Sustainable Agriculture and Agro-Ecology** Agroforestry and silvopasture - Organic farming with ecological buffers - Pollinator conservation and habitat strips - Water-smart agriculture using NbS in drylands **3.3 Urban Green Infrastructure and NbS in Cities** Green roofs, living walls, pocket parks, biodiversity-friendly landscaping - Permeable surfaces for stormwater management - Smart cities and NbS integration in India (e.g., Pune, Bengaluru) - Nature-based mobility corridors (e.g., greenways) **3.4 Coastal and Marine NbS** Coral reef restoration, dune stabilization, seagrass replantation - Climate-resilient coastal zoning with NbS - Coastal livelihood restoration through NbS (e.g., seaweed, mangroves) - Integrated coastal zone management (ICZM) with NbS	● Apply NbS in water resource and agricultural sector challenges. ● Design urban NbS interventions using green infrastructure principles. ● Evaluate marine and coastal NbS for biodiversity and disaster resilience. ● Critically analyse sector-specific success stories and their scalability.

Module IV Policy, Governance, and Financing of NbS (15 hours)	**4.1 Policy Frameworks and Global Conventions** UNFCCC (REDD+, NDCs), CBD, SDG integration - IPBES and IPCC views on NbS - Nature-based targets in Global Biodiversity Framework - NbS in Indian national policy (e.g., GIM, SAPCCs) **4.2 Governance Models and Stakeholder Engagement** Polycentric and participatory governance - Role of local communities and indigenous knowledge - Cross-sectoral coordination and institutional arrangements - NbS in decentralized planning (e.g., Panchayati Raj) **4.3 Financing Nature-Based Solutions** Public funding mechanisms (CAMPA, NAPCC) - Green bonds, impact investing, payment for ecosystem services (PES) - Climate funds (GCF, Adaptation Fund) and NbS integration - Barriers to financing and strategies for scale-up **4.4 Implementation Tools and Mainstreaming Strategies** Legal and regulatory frameworks - Environmental impact assessments incorporating NbS - Private sector and CSR in NbS implementation - Mainstreaming NbS into infrastructure and development planning	● Examine international and national policy instruments for NbS. ● Assess governance mechanisms and the role of local communities. ● Evaluate financial strategies and emerging markets for NbS. ● Recommend tools for implementing and mainstreaming NbS.
Module V Teacher Specific Module (5 hours)	Areas of content, transaction, and evaluation are decided by the faculty.	
References	**Core compulsory reading** 1. IUCN (2020). *Global Standard for Nature-based Solutions*. 2. IPBES (2019). *Global Assessment Report on Biodiversity and Ecosystem Services*. 3. UNDRR (2021). *Words into Action Guidelines on Eco-DRR and NbS.* 4. UNEP (2021). *State of Finance for Nature.* 5. IPCC AR6 (2022). *Climate Change 2022: Impacts, Adaptation and Vulnerability*. 6. CBD (2020). *Global Biodiversity Outlook 5.* 7. MoEFCC (2015). *National Mission for a Green India.* 8. World Bank (2021). *Integrating Nature into Adaptation Planning.* 9. Abizaid, C. M. (Ed.). (2019). *Nature-based Solutions to Climate Change*. Springer. 10. Leal Filho, W. (Ed.). (2020). *Handbook of Nature-Based Solutions to Mitigation and Adaptation to Climate Change*. Springer. 11. Davis, A. P., & United States Environmental Protection Agency. (2019). *Green Infrastructure: A Guide for Municipalities*. EPA. 12. Society for Ecological Restoration. (2019). *Ecological Restoration: A Global Strategy*. SER. 13. Kumar, P. (Ed.). (2018). *The Economics of Ecosystems and*	

	Biodiversity. Routledge. 14. Sandholz, S. (2020). *Nature-Based Solutions for Urban Challenges*. Springer. 15. Petzold, J., & Schenk, S. (Eds.). (2020). *Climate Change and Nature-Based Solutions*. Springer. **Core suggested reading** 16. Eggermont, H. et al. (2015). *Nature-based Solutions: New Influence for Environmental Management and Research*. GAIA. 17. Raymond, C. et al. (2017). *A framework for assessing the co-benefits of nature-based solutions*. Ecosystem Services. 18. Chausson, A. et al. (2020). *Mapping the effectiveness of NbS for climate adaptation*. Global Change Biology. 19. Frantzeskaki, N. et al. (2019). *Nature-Based Solutions for Cities*. Elsevier. 20. Pauleit, S. et al. (2017). *Advancing Green Infrastructure through NbS*. Springer. 21. Nesshöver, C. et al. (2017). *The science-policy-practice interface of NbS*. Environmental Science & Policy. 22. Toxopeus, H. & Polzin, F. (2017). *Financing NbS: Policy insights*. Environmental Innovation and Societal Transitions.

Course Outcome	**CO1:** Describe and explain the conceptual framework and categories of NbS. **CO2:** Apply NbS to tackle environmental challenges such as climate change, water scarcity, and biodiversity loss. **CO3:** Critically analyse case studies of sectoral and place-based NbS implementation. **CO4:** Evaluate policy frameworks and governance mechanisms supporting NbS adoption at different scales.

Teaching Learning Strategies	Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning (Video)Interactive Instruction: Active co-operative learning, Seminars, Group Assignments, Library work and Group discussion, Presentation by individual student/ Group representative Field work and field visits
Mode of Transaction	Face to face: Lecture method & Demonstration method Learner centered technique: Computer assisted learning & Individual project teaching

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	**50**
Continuous Evaluation	**50**
● **Test papers**	**20**
● **Tutorial with Seminar presentations/Discussions/Debate, etc.**	**20**
● **Assignment**	**10**

Sample questions to test outcomes.

1. Define blue carbon and provide two examples.
2. What are sponge cities and how do they relate to NbS?
3. Briefly explain the role of indigenous knowledge in NbS.
4. Explain the financing challenges and solutions for scaling up NbS in developing nations.
5. Analyze the role of NbS in climate adaptation and disaster risk reduction with real-world examples.

Course Title	**AI IN ENVIRONMENTAL SCIENCE**
Semester	**Eight**
Course Code	**KU08DSEEVS407**
Course Type	**Discipline-Specific Elective**
Course Credit	**4**
Prerequisite	**Knowledge in Environmental Science and IT**
Course Objectives	The course aims • To introduce students to AI, ML, and DL fundamentals applicable to environmental science. • To equip learners with technical skills for environmental modelling and monitoring using AI. • To explore AI applications for risk assessment, environmental management, and sustainability. • To critically evaluate the limitations, ethical concerns, and future directions of AI in environmental systems.

Modules	Content	Module Outcome
Module I Foundations of Artificial Intelligence in Environmental Science (10 hours)	**1.1 Core Concepts of Artificial Intelligence** Definitions and historical development - Branches of AI: Symbolic AI vs. Statistical AI - Cognitive computing and environmental relevance - Overview of AI in Earth and Environmental Sciences **1.2 Machine Learning (ML) Fundamentals** Types of ML: Supervised, unsupervised, semi-supervised, reinforcement learning - Key algorithms: Linear regression, decision trees, SVM, k-means clustering - Feature selection and dimensionality reduction (PCA, t-SNE) - Performance metrics: accuracy, precision, recall, F1 score **1.3 Deep Learning (DL) and Neural Networks** Artificial Neural Networks (ANN): structure, training, activation functions - CNNs for satellite imagery and spatial data - RNNs for time-series prediction (e.g., rainfall, temperature) - Autoencoders and generative models in environmental applications **1.4 Programming Tools and Environments** Python-based tools: TensorFlow, Keras, PyTorch, Scikit-learn - AI model development pipeline: data preprocessing, training, validation - Use of Jupyter Notebooks and Google Colab for environmental data modeling - Introduction to AutoML and cloud-based AI services (Google Earth Engine, Azure AI)	The student will be able to: • Understand the foundational concepts of AI and ML. • Distinguish between different types of learning methods. • Comprehend the structure and function of neural networks. • Identify appropriate AI tools for environmental data analysis.

Module II AI in Environmental Monitoring and Modeling (15 hours)	**2.3 Air Quality Monitoring and Forecasting** Predicting Air Quality Index (AQI) using regression and DL models - Spatio-temporal pollution mapping with AI-GIS integration - Source apportionment using clustering techniques **2.2 Water Quality Analysis and Prediction** Modelling water quality indices (WQI) using ML/DL - Prediction of biochemical oxygen demand (BOD), pH, turbidity using regression models - AI in hydro informatics and sensor network optimization - Remote sensing for surface water monitoring and classification **2.3 Soil, Agriculture, and Land Use Classification** AI for precision agriculture: crop yield prediction, pest detection - Soil classification using SVM and deep CNN on hyperspectral data - Land use and land cover (LULC) mapping using satellite imagery - Integration with drones and smart farming technologies **2.4 Ecological Modelling and Biodiversity** Habitat suitability modelling using Random Forest and MaxEnt - Species distribution modelling using ML classifiers - Ecosystem change detection using time-series remote sensing and DL - Use of AI in conservation biology and biodiversity informatics	• Apply AI techniques in air, water, and soil quality monitoring. • Develop models for environmental variable prediction. • Interpret ecological patterns using AI tools. • Integrate remote sensing and GIS with AI for spatial analysis.
Module III AI for Environmental Risk Assessment and Management (15 hours)	**3.1 Natural Disaster Risk Prediction** Flood forecasting using RNNs and hydrological models - Wildfire prediction using CNN on satellite data and meteorological variables - Earthquake and landslide susceptibility mapping using ML techniques - AI for early warning systems and disaster dashboards **3.2 Climate Modelling and Trend Forecasting** Climate variable downscaling using deep learning - AI for GHG emissions prediction and scenario modelling - Climate anomaly detection using unsupervised learning - AI in climate vulnerability assessments and mitigation planning **3.3 Environmental Impact Assessment (EIA) Enhancement** AI-driven decision support systems for EIA processes - Predictive modelling of project impacts (e.g., pollution load, biodiversity loss) - Natural language processing (NLP) in EIA document analysis - Public sentiment analysis on development projects using AI **3.4 Waste and Resource Management** Image-based waste classification using CNNs - Smart bin systems and route optimization for collection - Predictive analytics for waste generation trends - AI applications in recycling, composting, and circular	• Employ AI in early warning and disaster risk reduction. • Forecast climate variables and assess future risks. • Use AI tools in EIA for better decision-making. • Enhance waste management through smart systems.

	economy	
Module IV Challenges, Ethics, and Future of AI in Environment (15 hours)	**4.1 Ethical, Legal, and Social Implications** Algorithmic bias and transparency in environmental decision-making - Data privacy and ownership concerns in environmental surveillance - Accountability and liability in AI-driven assessments - Environmental justice and equitable AI access **4.2 Technical Challenges and Model Limitations** Data quality, availability, and heterogeneity - Model interpretability (black-box problem) and overfitting - Uncertainty quantification and validation techniques **4.3 Sustainability of AI Systems** Environmental footprint of AI: energy and water use in model training - Green AI: Efficient models, hardware choices, energy-aware programming - Life-cycle assessment of AI infrastructure in environmental science - Sustainable digital twin ecosystems for climate resilience **4.4 Future Directions and Innovations** AI for citizen science and participatory sensing (e.g., eBird, iNaturalist) - AI in policy and governance: smart cities, pollution taxes, carbon credits - Digital twins for ecosystems and smart conservation areas - Interdisciplinary integration: AI with economics, law, and health in environmental management	• Evaluate ethical implications of AI applications in environmental fields. • Identify and mitigate limitations in AI-driven models. • Promote sustainable AI practices in environmental research. • Analyse emerging AI trends relevant to environmental governance.
Module V Teacher Specific Module (5 hours)	Areas of content, transaction, and evaluation are decided by the faculty.	
References	**Core compulsory reading** 1. Russell, S., & Norvig, P. (2020). *Artificial Intelligence: A Modern Approach*. 2. Goodfellow, I., Bengio, Y., & Courville, A. (2016). *Deep Learning*. 3. Mohanty, M. K., & Misra, S. (2021). *AI for Earth Observations*. Springer. 4. Das, H., & Tripathi, M. (2022). *AI and IoT in Environmental Sustainability*. CRC Press. 5. Zhang, Z. et al. (2022). *AI for Environmental Science*. Nature Reviews Earth & Environment. 6. Witten, I., Frank, E., & Hall, M. (2016). *Data Mining: Practical ML Tools and Techniques*. 7. Singh, R. & Mehta, M. (2023). *AI for Climate Action*. Elsevier. **Core suggested reading** 8. IPCC Reports (AI-relevant sections) 9. UNEP Reports on AI and the Environment 10. Official documentation: TensorFlow, Scikit-learn, PyTorch 11. ITU AI for Good Reports 12. World Bank or NITI Aayog publications on AI and sustainability	

Course Outcome	**CO1:** Demonstrate foundational and applied knowledge of AI in the context of environmental issues. **CO2:** Apply AI methods to analyse, predict, and interpret environmental phenomena. **CO3:** Design AI-integrated solutions for environmental monitoring, risk management, and sustainability. **CO4:** Critically assess AI-based approaches in terms of ethics, feasibility, and environmental impact.

Teaching Learning Strategies	Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning (Video)Interactive Instruction: Active co-operative learning, Seminars, Group Assignments, Library work and Group discussion, Presentation by individual student/ Group representative Field work and field visits
Mode of Transaction	Face to face: Lecture method & Demonstration method Learner centered technique: Computer assisted learning & Individual project teaching

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	**50**
Continuous Evaluation	**50**
● **Test papers**	**20**
● **Tutorial with Seminar presentations/Discussions/Debate, etc.**	**20**
● **Assignment**	**10**

Sample questions to test outcomes.

1. Define supervised learning and provide one environmental application.
2. How can AI assist in waste segregation at the municipal level?
3. List two ethical issues related to the use of AI in ecological conservation.
4. Discuss how AI can be used for flood prediction. Include a workflow with algorithms and data sources.
5. Critically analyse the challenges and sustainability issues associated with AI deployment in climate modelling.

Course Title	CAPSTONE PROJECT IN HONOURS WITH RESEARCH PROGRAMME
Semester	Eight
Course Code	KU08RPHEVS401
Course Type	Discipline-Specific Core
Course Credit	12
Prerequisites	Successful completion of core courses

Course Description

This course is the culmination of academic and research training imparted throughout the Five-Year Integrated Master's Programme in Environmental Science. Offered in Semester Eight, the Capstone Project enables students to independently conceptualize, design, and execute a research project that addresses a significant environmental issue. Emphasizing interdisciplinary inquiry, the project involves a comprehensive review of literature, formulation of research questions or hypotheses, data collection (field/lab-based), statistical or geospatial analysis, and scientific interpretation. Students are required to submit a dissertation and defend their findings in a formal presentation. The course aims to foster analytical thinking, problem-solving abilities, and academic writing skills essential for higher research or professional careers in environmental science.

Aim

The aim of this course is to enable students to apply interdisciplinary knowledge and research skills acquired during the programme to conduct independent, original research on contemporary environmental issues, thereby preparing them for higher studies, research, and professional careers in environmental science.

Objectives

1. **Foster independent research skills** by enabling students to plan and execute a research project from inception to completion.
2. **Promote interdisciplinary thinking** through the integration of concepts and methods from various branches of environmental science.
3. **Enhance analytical and technical competencies** in data collection, statistical analysis, GIS, and scientific interpretation.
4. **Develop scientific communication skills** through the preparation of a structured dissertation and oral presentation.
5. **Instill research ethics and professional responsibility** in dealing with environmental data, communities, and ecosystems.
6. **Prepare students for academic and professional advancement** by building a strong foundation in environmental research methodologies and project management.

Course Outcome	**CO1**: Formulate a clear and focused research question or hypothesis based on a critical review of environmental literature. **CO2**: Design and execute a methodologically sound research plan using appropriate field, laboratory, or computational tools. **CO3**: Analyse and interpret data using statistical, geospatial, or modelling techniques relevant to environmental science. **CO4**: Prepare a comprehensive scientific dissertation that effectively communicates research findings and adheres to academic standards. **CO5**: Present and defend research outcomes through effective oral and visual communication in a professional setting.

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation (Viva Voce)	**50**
Continuous Evaluation	**50**
● **Methodology**	**20**
● **Proper execution**	**20**
● **Presentations/ (Mid Semester)**	**10**

SEMESTER IX

Course Title	NANOTECHNOLOGY FOR ENVIRONMENTAL APPLICATIONS
Semester	**Nine**
Course Code	**KU09DSCEVS501**
Course Type	**Discipline-Specific Core**
Course Credit	**4**
Prerequisite	**Knowledge in Environmental Science**
Course Objectives	The course aims: • To introduce the fundamental concepts of nanoscience and nanotechnology relevant to environmental systems. • To explore various synthesis methods and characterization techniques of nanomaterials used in environmental applications. • To examine the roles and mechanisms of nanomaterials in water purification, air pollution control, and soil remediation. • To enable students to critically assess real-world environmental applications of nanotechnology.

Modules	Content	Module Outcome
Module I Introduction to Nano (20 hours)	**1.1. Historical introduction** Bulk Vs Nano size - Concept of Nano and its evolution - Scientific revolution - Feynman's vision and its explanation. **1.2. Size-dependence of properties** Surface area to volume ratio and quantum size effects. **1.3. Classifications** Zero dimensional, one dimensional, two dimensional and three-dimensional nanomaterials - Metal nanoparticles - Semiconductor quantum dots **1.4. Nano porous materials** Mesoporous and micro porous materials. **1.5. Magnetic nanoparticles** Nano magnetism. **1.6. Carbon Nanostructures** Fullerene - Carbon nanotubes - Graphene nanostructures.	The student will be able to: • Identify the basics of nanotechnology • Describe the latest development in the area of Nanotechnology. • Know in detail about the classification of nanoparticles. • Recognize carbon nanostructures.
Module II Nanomaterials – Properties and Synthesis (20 hours)	**2.1. Nanomaterials and Properties** Metal Nanoparticles - Surface plasmon resonance - Semiconductor nanoparticles optical and electronic properties. Nano porous materials: Mesoporosity and micro porosity - Magic numbers - Mesoporous materials - Silica and titania and their applications. Self-assembled nanostructures. **2.2. Nanomaterials Synthesis** Top-down process: Lithography and High-energy balling - Bottom-up approach: Wet chemical routes, solution phase and vapor phase synthesis, sol-gel	• Identify the properties of nanoparticles. • Know about nano porous materials and their applications. • Gain idea about the synthesis methods of nanomaterials • Recognize semiconductor nanoparticles, their

	synthesis - Synthetic methods for metal and semiconductor nanoparticles - Template-based synthesis of mesoporous metal oxides - Synthesis of carbon nanotubes, fullerenes and graphene.	synthesis and importance.
Module III Nanomaterials Characterization (15 hours)	**3.1. Tools for Characterization of Nanomaterials** UV-Visible spectroscopy - X-Ray Diffraction (XRD) techniques - Electron microscopy: Scanning Electron and Transmission Electron Microscopy (SEM and TEM), Atomic Force Microscopy (AFM) techniques - BET surface area measurements.	• Identify the basics of characterization. • Gain knowledge on various tools used for the characterization of nanomaterials.
Module IV Environmental Applications of Nanomaterials (20 hours)	**4.1. Nanomaterials for water treatment** Photocatalysis - Degradation of textile industry wastes such as dyes - Removal of waste from water using semiconductor nanomaterials **4.2. Air purification** **4.3. Nanomaterials for antimicrobial coatings** **4.4. Medical Implants and Paints** **4.5. Superhydrophilicity** Self-cleaning applications **4.6. Dye sensitized solar cells** Electrochromic device applications.	• Analyse the environmental applications of nanomaterials • Gain knowledge about photo catalysis and degradation of industrial wastes using semiconductor nanomaterials. • Describe about dye sensitized solar cells and their applications.
Module V Teacher Specific Module (5 hours)	Areas of content, transaction, and evaluation are decided by the faculty.	
References	**Core compulsory reading** 1 Roco, M. C., & Bainbridge, W. S. (2001). *Societal implications of nanoscience and nanotechnology*. National Science Foundation. 2 The Royal Society & The Royal Academy of Engineering. (2004). *Nanoscience and nanotechnologies: Opportunities and uncertainties*. The Royal Society. 3 United States Environmental Protection Agency (EPA). (2007). *Nanotechnology white paper*. EPA 100/B-07/001. 4 Organisation for Economic Co-operation and Development (OECD). (2010). *Regulatory frameworks for nanotechnology in foods and medical products: Summary results of a survey*. OECD Publishing. 5 International Organization for Standardization (ISO). (n.d.). *ISO/TC 229 Nanotechnologies.* 6 Environmental Defense Fund. (2013). *Nanotechnology: Responsible stewardship of engineered nanomaterials*. 7 National Institute for Occupational Safety and Health (NIOSH). (2009). *Approaches to safe nanotechnology: Managing the health and safety concerns associated with engineered nanomaterials* (DHHS Publication No. 2009-125).	

	8 Nel, A. E., Xia, T., Mädler, L., & Li, N. (2006). Toxic potential of materials at the nanolevel. *Science, 311*(5761), 622–627. **Core suggested reading** 9 Schmid, G. (2004). *Nanoparticles: From theory to application*. Wiley-VCH. 10 Rao, C. N. R., Müller, A., & Cheetham, A. K. (Eds.). (2004). *The chemistry of nanomaterials: Synthesis, properties and applications* (Vol. 1 & 2). Wiley-VCH. 11 Bhushan, B. (2017). *Springer handbook of nanotechnology* (4th ed.). Springer. 12 Zhang, X. (2012). *Nanotechnology for water treatment and purification.* Springer. 13 Karn, B., Masciangioli, T., Zhang, W. X., Tsouris, C., & Lowry, G. V. (2009). *Nanotechnology and the environment*. CRC Press. 14 Wiesner, M. R., & Bottero, J. Y. (2007). *Environmental nanotechnology: Applications and impacts of nanomaterials*. McGraw-Hill. 15 Poole, C. P., Jr., & Owens, F. J. (2007). *Introduction to nanotechnology*. Wiley India. 16 Pradeep, T. (2007). *Nano: The essentials—Understanding nanoscience and nanotechnology*. Tata McGraw-Hill. 17 Klabunde, K. J. (Ed.). (2001). *Nanoscale materials in chemistry*. John Wiley & Sons. 18 Nalwa, H. S. (Ed.). (2002). *Nanostructured materials and nanotechnology*. Academic Press. 19 Vollath, D. (2008). *Nanomaterials: An introduction to synthesis, properties and applications*. Wiley-VCH. 20 Chattopadhyay, K. K., & Banerjee, A. N. (2009). *Introduction to nanoscience and nanotechnology*. PHI Learning Pvt. Ltd. 21 Ozin, G. A., Arsenault, A. C., & Cademartiri, L. (2009). *Nanochemistry: A chemical approach to nanomaterials*. Royal Society of Chemistry. 22 Atkins, P., & De Paula, J. (2006). *Atkins' physical chemistry* (8th ed.). W. H. Freeman and Company. 23 Skoog, D. A., Holler, F. J., & Crouch, S. R. (2007). *Principles of instrumental analysis* (6th ed.). Thomson Brooks/Cole.

Course Outcomes	**CO1:** Familiarize with advanced topics of nanotechnology and promote research-oriented mentality to solve environmental issues and problems such as water and air pollution using nanomaterials. **CO2:** The course contents will give ideas about the latest development in the area of Nanotechnology. **CO3:** This course prepares the student to acquire knowledge, skills and expertise on nanotechnology along with the integrated knowledge of all relevant disciplines. **CO4:** Apply the knowledge for Environmental and energy issue.

Teaching Learning Strategies	Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning (Video) Interactive Instruction: Active co-operative learning, Seminars, Group Assignments, Library work and Group discussion, Presentation by individual student/ Group representative

	Field work and field visits
Mode of Transaction	Face to face: Lecture method & Demonstration method Learner centered technique: Computer assisted learning & Individual project teaching

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	**50**
Continuous Evaluation	**50**
● **Test papers**	**20**
● **Tutorial with Seminar presentations/Discussions/Debate, etc.**	**20**
● **Assignment**	**10**

Sample questions to test outcomes

1. Explain the concept and evolution of nano.
2. Describe the classification of nanomaterials.
3. Briefly explain carbon nanostructures.
4. Explain the properties of nanomaterials.
5. Differentiate Top-down and Bottom-up approach in the synthesis of nanomaterials.
6. Write an essay on the environmental applications of nanomaterials.

Course Title	**SOLID WASTE MANAGEMENT**
Semester	**Nine**
Course Code	**KU09DSCEVS502**
Course Type	**Discipline-Specific Core**
Course Credit	**4**
Prerequisite	**Knowledge in Environmental Science**
Course Objectives	The course aims: • To understand the generation, composition, and classification of solid wastes from various sources. • To explore technological and scientific methods for collection, transportation, and treatment of solid waste. • To evaluate sustainable and integrated solid waste management approaches including reuse, recycling, composting, and energy recovery. • To analyse the environmental, social, economic, and legislative aspects related to solid waste management.

Modules	Content	Module Outcome
Module I Introduction to Solid Waste (15 hours)	**1.1 Classification and Sources of Solid Waste** Definition and classification: biodegradable, non-biodegradable, inert, recyclable, hazardous - Sources: municipal (domestic, commercial, institutional), industrial, biomedical, agricultural, e-waste, construction & demolition (C&D) - Differences between solid, liquid, and hazardous wastes - International waste classification standards (e.g., US EPA, Basel Convention) **1.2 Waste Generation Patterns and Influencing Factors** Socio-economic and cultural influences on waste generation - Demographic and seasonal variations - Per capita waste generation: methods and analysis - Urban vs rural waste generation trends **1.3 Physical, Chemical, and Biological Characteristics of Waste** Moisture content, density, calorific value, particle size - Chemical composition: organic content, ash, metals, nutrients - Biodegradability and bio-stabilization potential - Health hazards associated with unsegregated waste **1.4 Sampling, Characterization, and Quantification Techniques** Sampling design and representativeness - Laboratory and field characterization methods - Proximate and ultimate analysis - Tools for quantification: weighing, volumetric, statistical analysis	• Identify and classify different types of solid waste based on origin and characteristics. • Analyse generation trends, influencing factors, and composition of waste in different sectors. • Apply standard methods for sampling, quantification, and characterization of solid waste. • Evaluate the environmental and public health impacts of unscientific solid waste handling and disposal.

Module II Collection, Transport, and Storage of Solid Waste (20 hours)	**2.1 Waste Storage and Segregation at Source** Color-coded containers and bin standards (SWM Rules 2016) - Storage capacity planning and design - Decentralized storage vs. centralized storage - Community bins, household bins, and institutional bins **2.2 Primary and Secondary Collection Systems** Door-to-door collection models - Pushcarts, tricycles, compactor trucks - Frequency and scheduling - Informal sector involvement and their role in collection **2.3 Transfer Stations: Design and Operation** Criteria for site selection and layout planning - Equipment used: compactors, loaders, conveyors - Operational efficiency and environmental safeguards - Case studies from Indian cities **2.4 Transportation Mechanisms and Logistics Optimization** Vehicle types and specifications (open vs closed trucks) - Route planning using GIS tools - Load optimization and fleet management - Emission standards and fuel efficiency of transport fleets	• Design effective on-site storage and segregation systems suitable for urban and rural settings. • Assess and compare various collection methods and their efficiency in different socio-economic contexts. • Plan and optimize transfer stations and transportation logistics using environmental and cost criteria. • Recommend best practices and technologies for safe and hygienic solid waste handling and transport.
Module III Processing and Treatment Technologies (20 hours)	**3.1 Composting Techniques and Applications** Windrow composting, aerated static pile, in-vessel composting - Operational parameters: temperature, C:N ratio, moisture - Quality standards for compost (FCO standards) - Market and application of compost **3.2 Anaerobic Digestion and Biogas Generation** Digestion stages: hydrolysis, acidogenesis, methanogenesis - Types: single-stage and multi-stage digesters - Biogas purification and energy utilization - Digestate management **3.3 Thermal Treatment Technologies** Incineration: types, process, emission controls - Pyrolysis and gasification: temperature regimes and outputs - Comparison of thermal technologies - Environmental and economic concerns **3.4 Material Recovery, Recycling, and Emerging Processing Technologies** Recovery of plastics, metals, glass, paper - MRFs (Material Recovery Facilities): layout, operations - Emerging tech: plasma arc, hydrothermal carbonization - Circular economy models and innovations	• Describe and design composting and anaerobic digestion processes for organic solid waste. • Evaluate the operational principles and environmental implications of thermal treatment technologies. • Compare recycling and material recovery processes and their applicability to different waste streams. • Analyse emerging waste treatment technologies and assess their feasibility in different geographic and economic

		contexts.
Module IV Disposal, Policy Framework, and Sustainable Management (20 hours)	**4.1 Sanitary Landfilling: Design and Post-Closure** Types of landfills: controlled, engineered, bio-reactor - Site selection criteria: geology, hydrology, land use - Leachate collection and treatment systems - Post-closure care, monitoring, and land reuse **4.2 Legal, Regulatory, and Institutional Framework** Solid Waste Management Rules (2016), updates and amendments - Biomedical Waste Management Rules, E-Waste Rules, Plastic Waste Management Rules - Extended Producer Responsibility (EPR) mechanisms - Role of regulatory bodies: CPCB, SPCBs, ULBs **4.3 Integrated Solid Waste Management (ISWM) Approaches** Concept and components: 4Rs + Treatment + Disposal - Tools for decision-making: LCA, environmental audits - Decentralized vs. centralized systems **4.4 Public Participation, Education, and Behavioural Change** IEC (Information, Education, Communication) strategies - Role of NGOs, SHGs, resident welfare associations - Behavioural science in waste minimization - Tools: awareness campaigns, mobile apps, reward-based models	• Design scientifically sound sanitary landfill systems and post-closure care practices. • Interpret and apply key solid waste management regulations and policy instruments at national and international levels. • Integrate technical, legal, and community-based components into a sustainable ISWM framework. • Develop public engagement strategies and behavioural change models to improve waste management outcomes.
Module V Teacher Specific Module (5 hours)	Areas of content, transaction, and evaluation are decided by the faculty.	
References	**Core compulsory reading** 1. Tchobanoglous, G., Theisen, H., & Vigil, S. (1993). *Integrated solid waste management: Engineering principles and management issues*. McGraw-Hill. 2. Peavy, H. S., Rowe, D. R., & Tchobanoglous, G. (1985). *Environmental engineering*. McGraw-Hill. 3. Kreith, F., & Tchobanoglous, G. (2002). *Handbook of solid waste management* (2nd ed.). McGraw-Hill. 4. Sharma, S., & Shah, K. W. (2005). *Generation and disposal of solid waste in Hoshangabad*. Indian Journal of Environmental Protection, 25(10), 865–870. 5. Ministry of Environment, Forest and Climate Change (MoEFCC). (2016). *Solid Waste Management Rules, 2016*. Government of India. 6. United Nations Environment Programme. (2018). *Africa Waste Management Outlook*. UNEP. 7. Central Pollution Control Board (CPCB). (2021). *Annual report on implementation of solid waste management rules*. Ministry of Environment, Forest and Climate Change, Government of India.	

	8. World Bank. (2018). *What a waste 2.0: A global snapshot of solid waste management to 2050*. World Bank Publications. **Core suggested reading** 9. Wilson, D. C., Rodic, L., Scheinberg, A., Velis, C. A., & Alabaster, G. (2012). Comparative analysis of solid waste management in 20 cities. *Waste Management & Research*, 30(3), 237–254. 10. Hoornweg, D., & Bhada-Tata, P. (2012). *What a waste: A global review of solid waste management*. World Bank. 11. Agarwal, A., Singhmar, A., Kulshrestha, M., & Mittal, A. K. (2005). Municipal solid waste recycling and associated markets in Delhi, India. *Resources, Conservation and Recycling*, 44(1), 73–90. 12. Asnani, P. U. (2006). *Solid waste management*. India Infrastructure Report 2006, IDFC. 13. Kumar, S., Bhattacharyya, J. K., Vaidya, A. N., Chakrabarti, T., Devotta, S., & Akolkar, A. B. (2009). Assessment of the status of municipal solid waste management in metro cities, state capitals, class I cities, and class II towns in India: An insight. *Waste Management*, 29(2), 883–895. 14. Chattopadhyay, S., Dutta, A., & Ray, S. (2009). *Municipal solid waste management in Kolkata, India – A review*. *Waste Management*, 29(1), 470–478.

Course Outcomes	**CO1:** Classify various types and sources of solid waste and understand the factors influencing their generation and composition. **CO2:** Analyse and apply appropriate methods for collection, storage, transportation, and transfer of solid waste. **CO3:** Evaluate and compare various waste processing and treatment technologies including composting, anaerobic digestion, incineration, and recycling. **CO4:** Design sustainable solid waste management systems that incorporate legal, environmental, technological, and socio-economic considerations. **CO5:** Critically assess national and international solid waste management policies, regulations, and their practical implementation for achieving sustainable development goals (SDGs).

Teaching Learning Strategies	Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning (Video) Interactive Instruction: Active co-operative learning, Seminars, Group Assignments, Library work and Group discussion, Presentation by individual student/ Group representative Field work and field visits
Mode of Transaction	Face to face: Lecture method & Demonstration method Learner centered technique: Computer assisted learning & Individual project teaching

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	**50**
Continuous Evaluation	**50**

● **Test papers**	**20**
● **Tutorial with Seminar presentations/Discussions/Debate, etc.**	**20**
● **Assignment**	**10**

Sample Questions to test Outcomes

1. Explain the classification of solid wastes and discuss the major sources of municipal solid waste in urban India.
2. Define hazardous and non-hazardous waste with examples. How does their management differ?
3. Explain the importance of source segregation and describe color-coded bin systems.
4. Describe the stages of anaerobic digestion and factors affecting biogas yield.
5. Describe the concept of Integrated Solid Waste Management and its components.

Course Title	ENVIRONMENTAL MANAGEMENT AND ENVIRONMENTAL AUDIT
Semester	**Nine**
Course Code	**KU09DSCEVS503**
Course Type	**Discipline-Specific Core**
Course Credit	**4**
Prerequisite	**Knowledge in Environmental Science**
Course Objectives	The course aims ● To understand the fundamentals of environmental management ● To develop skills in environmental management systems ● To gain expertise in environmental auditing ● To analyze industry-specific environmental management and audit practices ● To develop practical skills for environmental compliance and corporate sustainability

Modules	Content	Module Outcome
Module I Fundamentals of Environmental Management (15 hours)	**1.1 Concepts and Evolution of Environmental Management** Definitions and key principles of environmental management - Historical development and milestones globally - Integration of environment in economic and social development - Emerging trends and future challenges **1.2 Environmental Governance and Legal Frameworks** Major international environmental agreements and conventions - National environmental laws and regulations: overview and implementation - Role of government agencies and regulatory bodies - Enforcement, compliance, and environmental litigation **1.3 Sectoral Environmental Management** Environmental issues in manufacturing and mining industries - Agricultural environmental impacts and management strategies - Urban environmental management: challenges and policies - Emerging industrial sectors and their environmental considerations **1.4 Tools and Techniques in Environmental Management** Cleaner production and eco-efficiency approaches - Environmental risk assessment and hazard identification - Resource use optimization: water, energy, materials - Environmental monitoring and reporting techniques	The student will be able to: ● Explain core environmental management concepts and historical development. ● Understand global and national environmental governance frameworks. ● Analyse sector-specific environmental management challenges. ● Identify key tools and approaches in environmental management.
Module II Environmental Auditing	**2.1 Introduction to Environmental Audit** Definition, purpose, and benefits of environmental audit - Types of audits: compliance, management	• Define and classify environmental audits.

(20 hours)	systems, functional, due diligence - Legal and regulatory requirements for auditing - Stakeholders and their roles in environmental audits **2.2 Planning and Conducting an Environmental Audit** Audit scope and objective setting - Developing audit checklists and protocols - Conducting site inspections and observations - Data collection methods: interviews, sampling, documentation review **2.3 Audit Tools and Techniques** Use of environmental performance indicators (EPIs) in audits - Analytical techniques for audit data evaluation - Application of GIS and remote sensing in audits - Software and digital tools for audit management **2.4 Audit Reporting and Follow-up Actions** Structuring and writing audit reports - Communication of findings to management and stakeholders - Developing corrective and preventive action plans - Monitoring audit recommendations and continuous improvement	● Design and execute environmental audit programs. ● Use auditing tools and techniques for data collection and analysis. ● Develop audit reports and recommend improvements for compliance and sustainability.
Module III Environmental Management Systems (EMS) (20 hours)	**3.1 Overview of EMS and Its Importance** EMS concepts, objectives, and benefits - Relationship between EMS and organizational sustainability goals - Components of an effective EMS - Challenges in EMS implementation **3.2 ISO 14001:2015 Standard** Structure and clauses of ISO 14001:2015 - Leadership commitment and policy development - Planning: risk-based thinking, objectives, and programs - Support: resources, competence, awareness, and communication **3.3 EMS Documentation and Implementation** Environmental policy, manuals, and procedures - Operational control and emergency preparedness - Training and awareness programs for EMS - Document control and record management **3.4 Monitoring, Measurement, and Continuous Improvement** Internal audits and management review processes - Corrective and preventive actions - Performance evaluation using indicators and benchmarks - Certification and re-certification processes	● Understand EMS structure and components. ● Interpret ISO 14001 standards and implementation process. ● Prepare EMS documentation and implement continual improvement processes. ● Evaluate EMS effectiveness and integrate with corporate strategies.

Module IV Environmental Performance and Sustainable Practices (20 hours)	**4.1 Environmental Performance Indicators (EPIs)** Types of EPIs: air, water, waste, energy, biodiversity - Data collection and validation techniques - Reporting frameworks: Global Reporting Initiative (GRI), CDP - Using EPIs for benchmarking and decision making **4.2 Waste Management and Pollution Prevention** Classification and sources of wastes - Waste minimization and segregation techniques - Pollution control technologies for air, water, and soil - Hazardous waste management and disposal methods **4.3 Sustainable Resource Management** Energy efficiency techniques and renewable energy options - Water conservation technologies and rainwater harvesting - Sustainable land use and biodiversity conservation - Life cycle assessment and product stewardship **4.4 Corporate Social Responsibility (CSR) and Environmental Ethics** CSR principles and environmental stewardship - Stakeholder engagement and communication - Ethical issues in environmental management - Reporting CSR initiatives and sustainability performance	● Analyse environmental performance indicators and metrics. ● Understand waste management and pollution control strategies. ● Integrate sustainability into business operations. ● Promote corporate social responsibility and environmental ethics.
Module V Teacher Specific Module (5 hours)	Areas of content, transaction, and evaluation are decided by the faculty.	
References	**Core compulsory reading** 1. Fath, B., & Jørgensen, S. E. (Eds.). (2020). *Environmental Management Handbook, Second Edition – Six Volume Set*. CRC Press. 2. Hyde, P., & Reeve, P. (2015). *Essentials of Environmental Management* (3rd ed.). Routledge. 3. Marguglio, B. (2016). *Environmental Management Systems*. CRC Press. 4. Greeno, J. L. (1987). *Environmental Auditing: Fundamentals and Techniques*. Center for Environmental Assurance, Arthur D. Little, Inc. 5. International Organization for Standardization. (2015). *ISO 14001:2015 – Environmental management systems – Requirements with guidance for use*. ISO. 6. Ministry of Environment, Forest and Climate Change. (2016). *Environmental management in India: Guidelines and strategies*. Government of India. 7. Sharma, R. C. (2016). *Sustainable development and environmental management*. PHI Learning Pvt. Ltd. **Core suggested reading** 8. Antweiler, W. (2014). *Elements of Environmental Management*. University of Toronto Press.	

	9. Rao, P. M., & Rao, P. S. B. (2025). *Environment Management and Audit*. Regal Publications. 10. Prasad, M. (2020). *Environmental Performance Auditing in the Public Sector: Enabling Sustainable Development*. Routledge. 11. Humphrey, N., & Hadley, M. (1995). *Environmental Auditing*. Wiley. 12. Barrow, C. J. (2006). *Environmental management for sustainable development* (2nd ed.). Routledge. 13. Whitelaw, K. (2017). *ISO 14001 environmental systems handbook* (4th ed.). Routledge. 14. Gupta, A. K. (2015). *Environmental management and sustainable development*. Daya Publishing House. 15. Russo, M. V., & Fouts, P. A. (2010). *Corporate environmental management: A study of business and sustainability*. Pearson Education.

Course Outcomes	**CO1:** Demonstrate knowledge of environmental management principles and legal frameworks. **CO2:** Analyse organizational environmental performance and design management strategies. **CO3:** Perform environmental audits and prepare detailed audit reports for corrective actions. **CO4:** Implement and maintain EMS including ISO 14001 standards in varied organizational contexts.

Teaching Learning Strategies	Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning (Video) Interactive Instruction: Active co-operative learning, Seminars, Group Assignments, Library work and Group discussion, Presentation by individual student/ Group representative Laboratory visit.
Mode of Transaction	Face to face: Lecture method & Demonstration method Learner centered technique: Computer assisted learning & Individual project teaching

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	**50**
Continuous Evaluation	**50**
● **Test papers**	**20**
● **Tutorial with Seminar presentations/Discussions/Debate, etc.**	**20**
● **Assignment**	**10**

Sample questions to test outcomes.

1. Define environmental audit and list its types.
2. Explain the role of environmental performance indicators in management.
3. Describe the components of an effective EMS documentation system.
4. Discuss the steps involved in planning and conducting an environmental audit in an industrial setting.

Course Title	ENVIRONMENTAL LAW AND POLICIES
Semester	**Nine**
Course Code	**KU09DSCEVS504**
Course Type	**Discipline-Specific Core**
Course Credit	**4**
Prerequisite	**Knowledge in Environmental Science**
Course Objectives	The course aims ● Understand the fundamental principles of environmental law ● Understand the role of institutions and mechanisms in environmental governance ● Develop a critical perspective on environmental issues ● Solve environmental problems using legal and policy frameworks

Modules	Content	Module Outcome
Module I Foundations of Environmental Law and Policy (10 hours)	**1.1 Historical Evolution of Environmental Law in India and Globally** Pre-1970s environmental regulations - Role of environmental movements (e.g., Chipko, Silent Valley) - Influence of Stockholm (1972), Rio (1992), and Johannesburg (2002) Declarations - Case laws that shaped environmental jurisprudence **1.2 Environmental Ethics and Legal Philosophy** Anthropocentrism vs. Ecocentrism - Deep ecology and ecofeminism - Environmental justice and equity - Rights of nature (Earth Jurisprudence) **1.3 Core Principles of Environmental Law** Precautionary Principle - Polluter Pays Principle - Public Trust Doctrine - Principle of Intergenerational Equity and Sustainable Development **1.4 Legal and Institutional Framework in India** Role of Judiciary (Supreme Court, High Courts, PILs) - Statutory institutions: MoEFCC, CPCB, SPCBs - Role of Attorney General and Green Benches - National Green Tribunal (NGT): Powers, jurisdiction, and case examples	The students will be able to: • Explain the foundational concepts and evolution of environmental law. • Interpret key legal principles applied in environmental jurisprudence. • Identify various sources and stakeholders in the legal framework. • Describe the structure and function of institutions involved in environmental law enforcement.
Module II National Environmental Legislations (15 hours)	**2.1 The Environment (Protection) Act, 1986** Legislative background post-Bhopal Gas Tragedy - Delegated legislation: rules and notifications - Role of central government in laying down standards - Environmental audit and penalties **2.2 Air and Water Pollution Control Laws** Key features of the Air Act, 1981 - Mechanism for monitoring and controlling emissions - Structure and powers of Central and State Pollution Control Boards - Water Act: "consent to operate," effluent standards, CETPs **2.3 Forest, Wildlife and Biodiversity Laws** Forest Conservation Act, 1980: clearance procedures and penalties - Wildlife Protection Act, 1972:	• Summarize major national environmental laws. • Analyse the regulatory and enforcement mechanisms in Indian environmental law. • Interpret provisions of specific acts and their practical applications. • Evaluate the

	schedules, sanctuaries, authorities - Biological Diversity Act, 2002: Access and Benefit Sharing (ABS), role of NBA, SBB, BMCs - Vanishing species and protected area management **2.4 Hazardous Waste and EIA Regulations** Hazardous Wastes Rules, 2016 - Biomedical Waste Rules, 2016 - EIA Notification 2006 and its amendments - Public hearing, environmental clearance, and recent controversies	effectiveness of national laws in achieving environmental protection.
Module III International Environmental Law and Agreements (15 hours)	**3.1 Evolution of International Environmental Law** Sources: treaties, conventions, customary law, general principles - Key institutions: UNEP, WTO, IPCC, IUCN - Soft law vs hard law - Role of NGOs and civil society in treaty development **3.2 Major Global Environmental Agreements** Montreal Protocol on ODS: mechanisms and success stories - UNFCCC, Kyoto Protocol: CDM, Joint Implementation, Emission Trading - Paris Agreement: NDCs, global stocktake, climate finance - Basel, Rotterdam, and Stockholm Conventions on hazardous substances **3.3 Biodiversity and Conservation Treaties** Convention on Biological Diversity (CBD) and Cartagena Protocol - Nagoya Protocol on Genetic Resources and ABS - CITES: trade in endangered species - Ramsar Convention on Wetlands **3.4 Global Environmental Governance and India's Commitments** UN SDGs and Agenda 2030 - India's Intended Nationally Determined Contributions (INDCs) - Transboundary pollution, marine protection, and desertification - Role of G20, BRICS, and South-South Cooperation	● Identify and explain key international treaties and legal instruments. ● Evaluate the effectiveness of MEAs in global environmental governance. ● Interpret India's role and obligations in international environmental law. ● Discuss transboundary issues and legal cooperation mechanisms.
Module IV Policy Instruments, Implementation, and Environmental Governance (15 hours)	**4.1 Types of Environmental Policy Instruments** Command and Control vs Market-based mechanisms - Environmental taxes, subsidies, tradable permits - Extended Producer Responsibility (EPR) - Voluntary instruments: ecolabels, green audits **4.2 National Environment Policy (NEP) 2006 and Institutional Implementation** NEP 2006: Vision, objectives, and strategies - Criticism and limitations - Interlinking with Five Year Plans and NAPCC - Role of Gram Sabhas and decentralization **4.3 Compliance Mechanisms and Public Participation** Right to Information (RTI) and environmental transparency - Environmental Impact Assessment (EIA) and Strategic EIA - Social Impact Assessments (SIA) - Role of public hearings, NGOs, and	● Distinguish between various policy instruments used for environmental protection. ● Analyse India's NEP and its implementation status. ● Describe mechanisms for governance, compliance, and public participation. ● Predict future trends and reforms in

	community litigation (PILs) **4.4 Contemporary Developments and Future Trends** Corporate Environmental Responsibility and ESG laws - Green Tribunal activism and emerging jurisprudence - Climate litigation: carbon majors and liability - AI, blockchain, and environmental compliance monitoring	environmental law and governance.
Module V Teacher Specific Module (5 hours)	Areas of content, transaction, and evaluation are decided by the faculty.	
References	**Core compulsory reading** 1. Divan, S., & Rosencranz, A. (2001). *Environmental law and policy in India* (2nd ed.). Oxford University Press. 2. Leelakrishnan, P. (2008). *Environmental law in India* (3rd ed.). LexisNexis Butterworths. 3. Sands, P., Peel, J., Fabra, A., & Mackenzie, R. (2018). *Principles of international environmental law* (4th ed.). Cambridge University Press. 4. Birnie, P., Boyle, A., & Redgwell, C. (2009). *International law and the environment* (3rd ed.). Oxford University Press. 5. Shyam Divan. (2020). *Environmental law: Cases and materials* (2nd ed.). LexisNexis. 6. Rajagopalan, R. (2005). *Environmental studies: From crisis to cure* (2nd ed.). Oxford University Press. 7. Ministry of Environment, Forest and Climate Change (MoEFCC), Government of India. (2006). *National environment policy, 2006*. 8. Central Pollution Control Board (CPCB). (2020). *Annual reports and environmental guidelines*. **Core suggested reading** 9. Kiss, A., & Shelton, D. (2007). *Guide to international environmental law*. Martinus Nijhoff Publishers. 10. Jayakumar, N. (2019). *Environmental law* (6th ed.). LexisNexis. 11. Rao, P. K. (2002). *The economics of environment and development*. Pearson Education. 12. Bartrip, P. W. J. (2000). *The history of pollution control in the UK: Nuisance law to environmental protection*. Oxford University Press. 13. United Nations Environment Programme (UNEP). (2012). *Training manual on international environmental law*.	

Course Outcomes	**CO1:** Explain key environmental laws and policy frameworks at the national and international levels. **CO2:** Analyse the effectiveness and limitations of existing environmental legislation. **CO3:** Apply legal principles in addressing real-world environmental issues. **CO4:** Evaluate the role of institutions and stakeholders in environmental governance.

Teaching Learning Strategies	Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning (Video) Interactive Instruction: Active co-operative learning, Seminars, Group Assignments, Library work and Group discussion, Presentation by individual student/ Group representative Field work and field visits
Mode of Transaction	Face to face: Lecture method & Demonstration method Learner centered technique: Computer assisted learning & Individual project teaching

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	**50**
Continuous Evaluation	**50**
● **Test papers**	**20**
● **Tutorial with Seminar presentations/Discussions/Debate, etc.**	**20**
● **Assignment**	**10**

Sample questions to test outcomes.

1. Explain the "Polluter Pays Principle" with examples.
2. Describe the structure and role of the National Green Tribunal (NGT).
3. State any two limitations of the Water (Prevention and Control of Pollution) Act, 1974.
4. Discuss the constitutional provisions for environmental protection in India.
5. Evaluate the role of international treaties in controlling climate change with special reference to the Kyoto Protocol.

SEMESTER X

Course Title	CAPSTONE RESEARCH PROGRAM
Semester	**Ten**
Course Code	**KU10RPHEVS501**
Course Type	**Discipline-Specific Core**
Course Credit	**20**
Prerequisites	**Successful completion of a 4-year Bachelor's Honours Degree in Environmental Science or an equivalent program in Environmental Science.**
Course Objectives	The course aims • Apply academic knowledge to address real-life environmental problems or projects. • Understand the operational structure, goals, and impact of environmental organizations. • Develop and refine technical, analytical, and communication skills in a professional setting. • Conduct structured reporting on field-based or organization-based learning. • Exhibit professional ethics, responsibility, and collaboration in multidisciplinary teams.

Course Description

The Capstone Research Program is a culminating academic and practical experience for final semester students of the Integrated Masters Programme in Environmental Science. This program mandates students to undergo a professional research/internship in a state, national, or internationally recognized organization engaged in environmental research, management, policy, sustainability, education, or technology.

This hands-on training aims to expose students to real-world environmental issues, professional work culture, and multidisciplinary problem-solving. Students are expected to produce a detailed research report, deliver a presentation, and appear for a viva voce examination to evaluate their understanding and learning outcomes from the internship experience.

Aim

- To provide students with practical experience and insights into professional environmental work.
- To help students integrate theoretical knowledge with field, laboratory, or policy applications.
- To build networks and enhance employability in the environmental sector.
- To promote critical thinking, communication, and project management skills.

Course Outcome	**CO1**: Demonstrate applied knowledge in environmental science through professional work. **CO2**: Analyze and evaluate institutional or organizational approaches to environmental issues. **CO3**: Produce a structured and well-documented internship report reflecting learning and contributions. **CO4**: Prepare a comprehensive scientific dissertation that effectively communicates research findings and adheres to academic standards. **CO5**: Showcase ethical conduct, punctuality, and teamwork during the internship tenure.

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation (Viva voce)	**50**
Continuous Evaluation	**50**
● **Methodology**	**20**
● **Proper execution**	**20**
● **Presentations/ (Mid Semester)**	**10**

Employability for the Programme

To become Environmentalist, Scientist, Teacher and Policy makers.

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