DEPARTMENT OF ENVIRONMENTAL SCIENCE AND MANAGEMENT

School of Environmental Science
Bharathidasan University
Tiruchirappalli – 620 024

M Sc PROGRAM

In

Environmental Science and Sustainable Management

SYLLABUS

(Revised on 23-12-2024)

(For Students admitted from July 2025 Onwards)

BHARATHIDASAN UNIVERSITY, TIRUCHIRAPPALLI – 620 024.
CHOICE BASED CREDIT SYSTEM (CBCS)
Regulations
(For the PG MSc Environmental Science and Sustainable Management Programme)

1. Eligibility

i) For Admission

A candidate who is a graduate of this University or any recognized University in the main subject / subjects as given below against each or who has passed an examinations accepted by the Syndicate, as equivalent thereto. Provided that candidates who have qualified for the B.Sc./ B Tech/ BE shall also be eligible for MSc Environmental Science and Sustainable Management Programme

ii) For the Degree

The candidates shall have subsequently undergone the prescribed programme of study in a College affiliated to this University / Department of the University for not less than two academic years comprising 4 semesters, passed the examinations prescribed and fulfil such conditions as have been prescribed thereof.

2.Duration

The programme is for a period of two years. Each year shall consist of two semesters viz. Odd and Even semesters. Odd semesters shall be from June / July to October / November and Even semesters shall be from November / December to April / May. There shall be not less than 90 working days which shall comprise 450 teaching clock hours for each semester (exclusive of the days for the conduct of University end-semester examinations).

3.Courses in Programmes

The PG programme consists of a number of courses. The term 'course' is applied to indicate a logical part of the subject matter of the programme and is invariably equivalent to the subject matter of a "paper" in the conventional sense. The following are the various categories of the courses suggested for the PG programmes:

Core Courses and Core Choice courses (CC) 19+3, Elective Courses (EC) 3, Practical Courses (PP) 3, Non Major Elective (NME) 2, Value Added Courses 4 and a Project Work (PW) either as a part or for the whole fourth semester.

3.1 Non Major Elective and Extra Disciplinary Courses (ECs & NMEs)

Various Elective Courses is offered in the same Department for two semesters.

The Non Major Elective courses (NME) is open to all students irrespective of Science or Arts or Commerce Programmes. The Extra Disciplinary course should be availed by the student through Online Mode (MOOCs/ Swayam/ NPTEL) with at least courses with a minimum of 2 credits each by Credit Transfer mode.

3.2 Selection of students to the ECs & NMEs:

a. The Department Committee shall follow a selection procedure on a first come first served basis, fixing the maximum number of students, giving counselling to the students etc. to avoid overcrowding to particular course(s) at the expense of some other courses.

b. The failed candidates in one EC / NME are permitted to opt for another EC / NME Or they are permitted to continue with the same EC / NME.

c.. In respective of Online ECs relating to programmes like Software Technology, Cyber Technology, Computer Applications and Computer Science, theory and practical components can jointly constitute the course content.

The list of Core course and the elective course offered for the students of the department are given. The non major elective course for students of other department are also given herewith.

4. Project

Each candidate shall be required to take up a Project Work; submit Project Report at the end of the second year. The Head of the Department shall assign the Guide who in turn will suggest the Project Work to the student in the beginning of the second year. One typed copy of the Project Report shall be submitted to the University through the Head of the Department on or before the date fixed by the University. The Dissertation will be evaluated by Examiners. The candidate concerned will have to defend his project in a Viva-Voce examination.

5. Semesters

An academic year is divided into two semesters. In each semester, courses are offered in 15 teaching weeks and the remaining 5 weeks are to be utilized for conduct of examinations and evaluation purposes. Each week has 30 working hours spread over 5 / 6 days a week.

6. Credits

The term 'Credit' refers to the weightage given to a course, usually in relation to the Instructional hours assigned to it. For instance, a six-hour course is assigned four credits, four / five hour course is assigned three credits and two hour course is given two credits. However, in no instance the credits of a course can be greater than the hours allotted to it. The total minimum credits required for awarding M.Sc in Environmental Science and Management is 90. The details of credits for individual components and individual courses are given in Tables–1 & 2.

7. Course

Each Course is designed variously under lectures / tutorials / laboratory or field work / seminar / practical training / assignments / Industrial visit / term paper or report writing etc., to meet effective teaching and learning needs.

8. Examinations

i. There shall be examinations at the end of each semester, for odd semesters in the month of October/November; for even semesters in April/May.

ii. A candidate who does not pass the examination in any course(s) may be permitted to appear in such failed course(s) in the subsequent examinations to be held in October/November or April/May. However, candidates who have arrears in Practicals shall be permitted to appear for their arrears in Practical examination only along with Regular Practical examination in the respective semester.

iii. A candidate should get registered for the first semester examination. If registration is not possible owing to shortage of attendance beyond condonation limit/regulation prescribed or belated joining or on medical grounds, the candidates are permitted to move to the next semester. Such candidates shall re-do the missed semester after completion of the course.

iv. Viva-voce: Each candidate shall be required to appear for Viva-voce Examination in defence of the Project only.

v. For the Project Report, the maximum marks will be 80 percent and for the Viva-voce is 20 percent. vi. The results of all the examinations will be published through the department.

9. Condonation

Students must have 75% of attendance in each course for appearing the examination. Students who have 74% to 65% of attendance shall apply for condonation in the prescribed form with the prescribed fee. Students who have 64% to 50% of attendance shall apply for condonation in prescribed form with the prescribed fee along with the Medical Certificate. Students who have below 50% of attendance are not eligible to appear for the examination. They shall re-do the semester(s) after completion of the programme.

10. Question Paper Pattern

Part A

Ten Questions (No choice) 10 x 1 = 10 marks

Two Questions from each Unit
Of which five are Multiple Choice Questions
And five are of other categories

Part B

Five Questions out of Eight 5 x 4 = 20 marks
One Question compulsory from each Unit

Part C

Three Question out of Six 3 x 15 = 45 marks
Questions pertaining Case Studies/ Comprehensive
Questions/ Applications/ Logical Reasoning

11. Evaluation

The performance of a student in each Course is evaluated in terms of percentage of marks with a provision for conversion to grade points. Evaluation for each Course shall be done by a continuous internal assessment (CIA) by the Course teacher concerned as well as by an end semester examination and will be consolidated at the end of the semester.

The components for continuous internal assessment are:

Theory	Practical
2 tests : 15 Marks	Continuous performance : 20 Marks
Group Activity/Quiz : 5 Marks	Model Practical : 10 Marks
Assignments : 5 Marks	Record : 5 Marks
Total 25 Marks	Viva : 5 Marks
	Total 40 Marks

Attendance need not be taken as a component for continuous assessment, although the students should secure a minimum of 75% attendance in each semester. In addition to continuous evaluation component, the end semester examination, which will be a written-type examination of at least 3 hours duration, would also form an integral component of the evaluation. The ratio of marks allotted to continuous internal assessment and to end semester examination is 25:75. The evaluation of laboratory component, wherever applicable, will also be based on continuous internal assessment and on an end-semester practical examination with 40:60 ratio.

12. Passing Minimum

A candidate shall be declared to have passed in each course if he/she secures not less than 40% marks in the University Examinations (30 marks) and 40% marks in the CIA (10 marks) and not less than 50% in the aggregate, including CIA and University Examinations marks. **However, the program M.Sc Environmental Science and Sustainable Management requires 38 (U.E) +12 (C.I.A) marks to secure a minimum pass.** Candidates who have secured the pass marks in the end-semester Examination (U.E.) and in the CIA, but failed to secure the aggregate minimum pass mark (U.E. + C.I.A.) are allowed to secure aggregate minimum pass mark by appearing for University Examination only. Candidates who have failed in the Internal Assessment are permitted to appear for their Internal Assessment marks in the subsequent semesters (2 chances will be given) by writing the CIA tests and assignments.

A candidate shall be declared to have passed in the Project work if he/she gets not less than 40% in each of the Project Report and Viva-voce but not less than 50% in the aggregate of both the marks for Project Report and Viva-voce. A candidate who gets less than 40% in the Project must resubmit the Project Report. Such candidates need to defend the resubmitted Project at the Viva-voce within a month. A maximum of 2 chances will be given to the candidate.

13. Grading

Once the marks of the CIA and end-semester examinations for each of the courses are available, they will be added. The marks, thus obtained will then be graded as per the scheme provided in Table 3.

From the second semester onwards the total performance within a semester and continuous performance starting from the first semester are indicated respectively by **Grade Point Average (GPA)** and **Cumulative Grade Point Average (CGPA).**

These two are calculated by the following formulae

$$\textbf{GPA} = \frac{\sum_{i=1}^{n} C_i G_i}{\sum_{i=1}^{n} C_i}, \qquad \text{WAM (Weighted Average Marks)} = \frac{\sum_{i=1}^{n} C_i M_i}{\sum_{i=1}^{n} C_i}$$

where 'Ci ' is the Credit earned for the Course i in any semester ; 'Gi' is the Grade Point obtained by the student for the Course i and 'n' is the number of Courses passed in that semester.

CGPA = Average Grade Points of all the Courses passed starting from the first semester to the current semester.

14. Classification of Final Results

I. The classification of final results shall be based on the CGPA, as indicated in the table below.

II. For the purpose of Classification of Final Results, the candidates who earn the CGPA 9.00 and above shall be declared to have qualified for the Degree as "Outstanding". Similarly, the candidates who earn the CGPA between 8.00 and 8.99, 7.00 and 7.99, 6.00 and 6.99, and 5.00 and 5.99 shall be declared to have qualified for their Degree in the respective programmes as "Excellent", "Very Good", "Good", and "Above Average" respectively.

III. Absence from an examination shall not be taken as an attempt.

15. Conferment of the Master's Degree

A candidate shall be eligible for the conferment of the Degree only after he / she has earned the minimum required credits for the programme prescribed therefore (i.e. 90 credits).

Grading of the Courses

Marks Range	Grade Point	Corresponding Grade
90 and above	10	O
80 and above but below 90	9	A+
70 and above but below 80	8	A
60 and above but below 70	7	B+
50 and above but below 60	6	B
Below 50	N.A.	R.A.

Final Result

CGPA	Corresponding Grade	Classification of Final Results
9.00 and above	O	Outstanding
8.00 to 8.99	A+	Excellent
7.00 to 7.99	A	Very Good
6.00 to 6.99	B+	Good
5.00 to 5.99	B	Above Average
below 5.00	R.A.	Re-Appearance

Credit based weighted Mark System is to be adopted for individual semesters and cumulative semesters in the column 'Marks Secured' (for 100).

Table 1: Details on the number of courses and credits per course in MSc Environmental Science and Sustainable Management Programme
Core Courses (CC) 15, Elective Courses (EC) 4, Practical Courses (PP) 2, Non Major Elective (NME) 2, Value Added Courses 4 and a Project Work (PW)

S.No	Study Component	Number of Courses	Credits per course	Total Credits	Total weekly hours
1.	Core Course (CC)	12	4	48	6
2.	Practical Course (PP)	3	5	15	-
3.	Elective Course (EC)	3	3	9	4
4.	Project Work (IV Semester)	1	10	10	-
5.	Summer Internship	1	4	4	-
6.	Non Major Elective (NME) (II and III Semester)	2	2	4	3
				90	
7.	Value Added Course	4	2	8	3
	Total Credits			90 +8	
	Extra Credits that can be Earned				
8.	Extra Credit Course : MOOC /SWAYAM/NPTEL/Coursera	3	2	6	

PROGRAMME OUTCOMES	
PO1	This program is designed to develop comprehensive and deep knowledge of the field(s), in which the "one semester" thesis research is embedded.
PO2	The challenging, student-centered curriculum is research - based and technology - Oriented and provides a foundation for life - long learning.
PO3	The program caters to students' interest in different domains of biology – from classical to modern, including varied specializations.
PO4	Training in specialized domain of biology is intended to prepare students to become qualified graduates to address biology-related issues at national and international levels.
PO5	Biology being evidence-based, the program is grounded with an equal number of laboratory courses in the formal practices of observation, experimentation, testing hypotheses and interpretation.
PO6	Biology relies on applications of quantitative analysis and mathematical reasoning; therefore, the curriculum is designed to train the students to apply descriptive and inferential statistical methods, design and analyse diverse data set and understand the underlying probability in the calculations.
PO7	The program provides training to the students to develop their knowledge and skills to communicate appropriate scientific content, formatting and presentation of data through scientific seminars.
PO8	The program trains the students to understand the relationship between science and society, which enhances their vision to apply their knowledge in health systems, economic growth and sustainable environment.
PO9	The 10-credit research-oriented course engages in rigorous and original research that advances knowledge in their chosen field of study within the discipline.
PO10	Upon successful completion of the M.Sc. Environmental Science and Sustainable Management program with grade 9.0 and above (CGPA), the students shall be able to summarize the major, central tenets in their disciplines; this will provide ample chances for them to qualify for national eligibility tests and professional development gained will lead them to be successful in their careers in academia / industry.

PROGRAMME SPECIFIC OUTCOMES	
Upon completing the M.Sc. Environmental Science and Sustainable Management program, graduates will be equipped to:	
PSO1	Excel as management professionals specializing in corporate environmental management.
PSO2	Demonstrate expertise in effluent treatment and solid waste management
PSO3	Conduct comprehensive environmental audits, including energy audits, with specialized training.
PSO4	Serve as consultants for environmental impact assessment projects, combining theoretical knowledge with practical skills.
PSO5	Manage projects in urban and rural sectors focusing on environment, health, sanitation, and education.
PSO6	Establish entrepreneurial ventures, including NGOs, and promote environmental awareness and activism.
PSO7	Lead development and environmental projects, leveraging advanced tools and technologies.
PSO8	Provide skilled consultancy and project management in remote sensing and GIS applications for urban governance, health, forestry, biodiversity, and related fields.

M Sc Environmental Science and Sustainable Management

Course Structure

Semester	Course	Credit	Ins.Hrs/ Week	Exam hours	Marks		Total
					Int.	Extn	
I	CORE I	4	4	3	25	75	100
	CORE II	4	4	3	25	75	100
	CORE (CHOICE) III	4	4	3	25	75	100
	ELECTIVE I	3	3	3	25	75	100
	PRACTICAL I	5	8	3	40	60	100
II	CORE I V	4	4	3	25	75	100
	CORE V	4	4	3	25	75	100
	CORE(CHOICE)VI	4	4	3	25	75	100
	ELECTIVE II	3	3	3	25	75	100
	NON MAJOR ELECTIVE I	2	2	3	25	75	100
	PRACTICAL II	5	8	3	40	60	100
III	CORE VII	4	4	3	25	75	100
	CORE VIII	4	4	3	25	75	100
	CORE IX	4	4	3	25	75	100
	CORE (CHOICE) X	4	4	3	25	75	100
	ELECTIVE III	3	3	3	25	75	100
	NON MAJOR ELECTIVE II	2	2	3	25	75	100
	PRACTICAL III	5	8	3	40	60	100
IV	CORE XI	4	4	3	25	75	100
	CORE XII	4	4	3	25	75	100
	PW I	10	-	3	25	75	100
	SI I	4	-	3	25	75	100
		90					2200
Semester I	Value Added Course I	2	2	3	25	75	100
Semester II	Value Added Course II	2	2	3	25	75	100
Semester III	Value Added Course III	2	2	3	25	75	100
Semester IV	Value Added Course IV	2	2	3	25	75	100

BHARATHIDASAN UNIVERSITY, TIRUCHIRAPPALLI 620 024

M Sc Environmental Science and Sustainable Management

(Application to the candidates admitted from the academic year 2025 onwards)

S.No	Course Code	CORE/ ELECTIVE	List of Courses Offered under CBCS Total Credits 90 Title	Course Instruc.	Credits	Hours /Week	L Lecture	T Tutorial	P Practical
			Semester I						
1	25PGCC01	CORE I	Introduction to Environmental Development and Sustainability Science	RM	4	4	3	1	-
2	25PGCC02	CORE II	Remote Sensing and GIS for the Environment	MP	4	4	3	1	
3	25PGCC03	CORE (CHOICE) III	Environmental Pollution and Toxicology / Natural Resources Management	SN	4	4	3	1	-
4	25PGEC01	ELECTIVE I	Waste Management Strategies / Environmental and Occupational Epidemiology	MP	3	3	2	1	-
5	25PGPP01	PRACTICAL I	Practical – I (Environmental Quality Analysis)	RM	5	8	-	2	10
			Credits for Semester I		**20**				
			Semester II						
6	25PGCC04	CORE I V	Environmental Impact Assessment	RM	4	4	3	1	-
7	25PGCC05	CORE V	Environmental Law, Policies and Ethics	SN	4	4	3	1	-
8	25PGCC06	CORE(CHOICE)VI	Industrial Health and Safety / Environmental Informatics and Spatial Data Modelling	MP	4	4	3	1	-
9	25PGEC02	ELECTIVE II	Urban Environmental Sustainability: Issues and Strategies / Industrial Pollution, Management and Remediation	SN /MP	3	3	2	1	-
10	NME01	NME I	Non-Major Elective	MP	2	2	2	-	
11	25PGPP02	PRACTICAL II	Practical – II (Spatial Analysis and Modelling)	MP	5	8	-	2	10
			Credits for Semester II		**22**				
			Summer Internship		Evaluation in IV Semester				
			Semester III						
12	25PGCC07	CORE VII	Corporate Strategies for Environmental Management	RM	4	4	3	1	-
13	25PGCC08	CORE VIII	Microbial Techniques	SN	4	4	3	1	-
14	25PGCC09	CORE IX	Environmental Data Analytics and Research Methods	MP	4	4	3	1	-
15	25PGCC010	CORE (CHOICE) X	Environmental Social Governance / Sustainable Ecotourism	MP	4	6	4	2	-
16	25PGEC03	ELECTIVE III	Green Technologies and Energy Management / Climate Change, Mitigation, Adaptation and Resilience	SN	3	3	2	1	-
17	NME02	NME II	Non-Major Elective	RM	2	2	2	-	
18	25PGPP03	PRACTICAL III	Practical – III (Microbial Techniques)	SN	5	8	-	2	10
			Credits for Semester III		**26**				
			Semester IV						
19	25PGCC011	CORE XI	Global and National Environmental Issues (Self Study paper)	MP/RM/SN	4	4	3	1	-
20	25PGCC012	CORE XII	Ecosystem Services and Sustainable Management (Online Mode)	RM	4	4	3	1	-
21	25PGPW01	PW I	PROJECT WORK	MP/RM/SN	10	Cumulative credits for PW and Summer Internship -14			
22	25PGSI01	SI I	Summer Internship (Evaluation)	MP/RM/SN	4				
			Credits for Semester IV		**22**				
			TOTAL NUMBER OF CREDITS		**90**				
			VALUE ADDED COURSES						
1	25PGAC01	VACI	Value Added Course I		2	2	1	1	-
2	25PGAC02	VACII	Value Added Course II		2	2	1	1	-
3	25PGAC03	VACIII	Value Added Course III		2	2	1	1	-
4	25PGAC04	VACIV	Value Added Course IV		2	2	1	1	-
			TOTAL NUMBER OF CREDITS		**8**				
			EXTRA CREDIT COURSES						
1	Code given by course provider	Extra Credit Course	MOOC - course – I /SWAYAM/NPTEL/Coursera		2	-	-	-	-
2		Extra Credit Course	MOOC - course – II /SWAYAM/NPTEL/Coursera		2	-	-	-	-
3		Extra Credit Course	MOOC - course – III /SWAYAM/NPTEL/Coursera		2	-	-	-	-
			TOTAL NUMBER OF CREDITS		**6**				

SEMESTER I

CORE 1 : INTRODUCTION TO ENVIRONMENTAL DEVELOPMENT AND SUSTAINABILITY SCIENCE

Course Code: 25PGCC01

Course Objectives:

- To understand concepts and theories of planet earth evolution and its elemental composition
- To distinguish various spheres and layers within the earth and its salient features
- To acquire comprehensive knowledge on structure and functions of ecosystem
- To realize the core concepts of sustainability and sustainable development
- Discerning the trade-off between environment and society

* Lecture-L *Tutorial-T *Practical-P *Credit-C	L	T	P	C
Per Week	3	3	-	4

Course Outcomes:		KL
1.	Understand the fundamental theories of radiation and matter era	K1
2.	Crystalize various spheres of earth and its functional process	K3 & K4
3.	Elucidate the biosphere, biodiversity and the ecological process in the earth	K2 & K3
4.	Analyze the concept of sustainable development and the sustainability policy framework	K3 & K6
5.	Evaluate the implications of human centric interventions in sustainable development	K5 & K6

Knowledge level: Remember (K1); Understanding (K2); Perform (K3); Analyse (K4); Synthesize (K5); Evaluate (K6)

Mapping course outcomes with programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	L	M	L	L	M	L	L	M	M
CO2	S	L	M	L	M	M	L	L	M	M
CO3	S	M	M	M	S	M	M	M	M	S
CO4	S	L	M	S	M	M	M	M	M	S
CO5	S	M	M	M	S	M	M	M	S	S

Strong | Moderate | Low

Assessment Methods: Test-T, Seminar- S, Assignment- A, Discussion- D

	Modules	T	S	A	D
Module I **5 lectures**	Planet Earth: Formation of the Universe - Galaxies, Stars, Dark energy and dark matter, Planets, Sun and Earth - Earth layers - Core, Mantle, Crust Rocks, Minerals and Ores - Elemental abundance in each constituent. Origin of Life - Geological Periods - Proteozoic and Phanerozoic - Permian era - cretaceous era - Holocene to Anthropocene.	✓		✓	✓
Module II **6 lectures**	Biospheres: Atmosphere - layers, composition and significance. Solar energy and greenhouse effect. Atmospheric circulation. Hydrosphere: Hydrological cycle – Precipitation, Evapotranspiration, Infiltration, Surface flow, Fresh water, ground water, ocean currents - Lithosphere - rocks cycle and minerals, landforms and types, Weathering and soil forming process. Biosphere and Anthroposphere	✓			
Module III **6 lectures**	Ecosystems - Concept, Population, community, producers, flow of energy, food chains, tropic levels, energy and biomass. Tropical Forests: Evergreen, Deciduous Scrubs, Temperate Forest, Grasslands, Deserts, Marine ecosystem, Wetland ecosystem. Biodiversity: level, types, function, threats and conservation. Hotspots of Biodiversity, Human Impacts and Ecological foot prints. Biosphere reserves, wet lands, mangroves and coral reefs, protected area network in India	✓	✓		✓

Module IV **6 lectures**	Concepts of Sustainable Development: Development and Environment, Distribution of Wealth, Human capital and Natural Capital, Sustainable Development Concept - History and Evolution, Limits to Growth, Bruntland Period, Rio Declaration on Environment and Development, Agenda 21, Triple bottom line concept of sustainable development, Neo-liberalism and Environment, Millennium Development and Sustainable development goals	✓	✓		
Module V **5 lectures**	**Social and Ecological Dimensions of Sustainable Development:** Poverty driven development issues, inequality, conflict, and war, food security and crisis. Energy security - continuing use of fossil fuels, nuclear energy, wood fuels. Species and Ecosystems - extinction, trends, threats to the natural capital	✓			✓
Current Trends **2 lectures**	Advances in ……. : Recent concepts – Technological and Scientific developments – Real world cases/examples – Policy/Practice updates – Contradictions – World/Indian Scenario				✓
30 Lectures					

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- Miller, G.T. (1991). Environmental Science: sustaining the Earth, Thompson Brooks /Cole ,Belmont,CA

CORE 2 : REMOTE SENSING AND GIS FOR THE ENVRONMENT

Course Code: 25PGCC02

Course Objective: To help students understand the concept of remote sensing, GIS and GPS, by focusing on some of the underlying principles and to specially understand on how to use these tools to assess, estimate environmental changes and derive data from these sources.

* Lecture-L *Tutorial-T *Practical-P *Credit-C	L	T	P	C
Per Week	3	3	1	4

Course Outcomes:		KL
1.	Basic understanding of satellite remote sensing and how radiation interacts with environment and earth features.	K1
2.	Learning the methods of measurements and methods of image restoration and corrections	K2, K3
3.	Enrich the knowledge of mapping through GIS and to advantageously use it for environmental problem solving	K6
4.	Analyze different environmental data through GIS analysis methods	K5
5.	To effectively extract information from satellite data and couple GIS to derive more appropriate solutions	K5 &K6

Knowledge level: Remember (K1); Understanding (K2); Perform (K3); Analyse (K4); Synthesize (K5); Evaluate (K6)

Mapping course outcomes with programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	M	L	M	M	M	M	S	M
CO2	S	S	M	L	M	M	M	M	M	M
CO3	S	M	M	M	S	M	S	M	S	S
CO4	S	S	M	M	M	M	S	M	S	S
CO5	S	S	M	M	S	M	S	M	S	S
Strong			Moderate			Low				

Assessment Methods: Test-T, Seminar- S, Assignment- A, Discussion- D

	Modules	T	S	A	D
Module I **5 lectures**	History of remote sensing, Definition, concept and principle of Electromagnetic energy, Electromagnetic spectrum, Principles of Electro-magnetic Radiation, Physical properties and interaction of energy with Earth and Atmosphere, Spectral reflectance patterns and responses. Active and Passive Remote Sensing, Space programmes- Satellites and Sensors, Radar technology, Resolution of Images	✓		✓	✓
Module II **6 lectures**	Aerial photography - aerial cameras - photographic process, Elements of visual interpretation, Vertical and horizontal measurements, Data Acquisition, Source of Image degradation, Image rectification and restoration, Geometric and Radiometric corrections, UAV and Drone Based Technology- Case Studies	✓			
Module III **6 lectures**	GIS Basics: Concepts and Components, layers and features, Spatial data types, Digitisation, Data conversion,Raster data and Vector data structure, Introduction to GPS, GPS Satellite Constellation and Signals, GPS Measurements and instrumentation, Factors Influencing GPS Accuracy. Software for Remote sensing and GIS, Internet GIS, Interoperability and Open source GIS: Bhuvan portal, Quick Map Services	✓	✓		✓

Module IV **6 lectures**	Introduction to Maps and Map Projections: Types, Map Characteristics, Map Scale and effects, Spatial Data Analysis- Data attributes and spatial topology, Geographical datasets and data management, Vector Overlay Processes, Thematic Mapping, GIS analysis and queries, Data quality and errors, GIS map output, Real Time GIS, 3D GIS and Digital Twins, IoT and Dynamic Mapping, Crowdsourcing and Citizen Science, Volunteered Geographic Information (VGI), Google earth engine	✓	✓		
Module V **5 lectures**	Image pre-processing and correction methods, Image enhancement, Principal Component analysis, mosaic and subsets, Spatial filtering, Data merging, Digital image Classification & Advanced classification techniques, Change detection Analysis, Vegetation Indices	✓			✓
Current Trends **2 lectures**	Recent concepts – Latest Satellites launched, new Technological and Scientific developments –World/Indian Scenario- latest Applications- New Geomapping devices and Opensource software				✓
30 Lectures					

References:

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2. Sabins, Floyd F Jr ,*Remote Sensing: Principles and Interpretation, 2007,* W.H Freeman and Company, NY
3. Kang-tsung Chang, *Introduction to Geographic Information Systems*, 2006, Tata McGraw Hill Edition, New Delhi
4. James B Campbell, *Introduction to Remote Sensing,* 2007, The Guilford Press, 4th edition, NY, USA
5. John R Jensen*: Remote Sensing of the Environment: An Earth Resource Perspective* (2nd Edition), 1996, Prentice Hall Series in Geographic Information Science\
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7. Afonso Oliveira, Nuno Fachada, João P. Matos-Carvalho (2024). Data Science for Geographic Information Systems, (2024) 8th International Young Engineers Forum on Electrical and Computer Engineering (YEF-ECE), 1-7, IEEE, 2024
8. Hao Xu, Yuanbin Man, Mingyang Yang, Jichao Wu, Qi Zhang, Jing Wang (2023). Analytical Insight of Earth: A Cloud-Platform of Intelligent Computing for Geospatial Big Data
9. Dayna Nielson (2017) Geographic Information Systems (GIS): Techniques, Applications and Technologies, Nova Publications
10. Arvind W. Kiwelekar, Geetanjali S. Mahamunkar, Laxman D. Netak, Valmik B. Nikam (2020). Deep Learning Techniques for Geospatial Data Analysis Springer, Cham
11. Chandra P. Giri (2022), Remote Sensing in Mangroves Volume II, Mdpi AG Publishers

CORE (CHOICE) 3 : ENVIRONMENTAL POLLUTION AND TOXICOLOGY
Course Code: 25PGEC03

Course Objectives:

- Understand different types of environmental pollutants and its sources
- To study the industrial process and pollution sources of major red category
- To learn various met hods to assess and analyze environmental pollutants

* Lecture-L *Tutorial-T *Practical-P *Credit-C	L	T	P	C
Per Week	**3**	**1**	**0**	**4**

Course Outcomes:		KL
1.	Explain the sources, types, and pathways of environmental pollutants in air, water, soil, and biological systems.	K1, K2
2.	Utilize scientific methods and analytical tools to measure and monitor pollution levels.	K3
3.	Identify the effects of specific pollutants (e.g., endocrine disruptors, heavy metals) on humans and wildlife.	K4
4.	Conduct risk assessments for pollutants based on toxicity, exposure levels, and environmental persistence.	K6
5.	Recommend practical approaches for sustainable environmental management and pollution prevention and Advocate for inclusive and equitable pollution management strategies.	K5

Knowledge level: Remember (K1); Understanding (K2); Perform (K3); Analyse (K4); Synthesize (K5); Evaluate (K6)

Mapping course outcomes with programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	M	M	M	M	M	M	S	M
CO2	S	S	M	L	M	M	S	M	M	M
CO3	S	M	M	M	M	M	M	M	M	S
CO4	S	S	M	M	M	M	S	M	M	M
CO5	S	M	M	S	S	S	M	M	S	S
	Strong		Moderate		Low					

Assessment Methods: Test-T, Seminar- S, Assignment- A, Discussion- D

	Modules	T	S	A	D
Module I 5 lectures	Water Pollution: Physical and chemical properties of water, Pollution of water resources; Point and Nonpoint sources of pollution, Water Pollutants and their chemistry: solids and turbidity, alkalinity, acidity, salinity, hardness, nutrients, fluoride, heavy metals, organic pollutants – oxygen demanding wastes, (COD, BOD), Persistent organic pollutants in water (DDT, PCBs, PAHs, Dioxin), radio nuclides in the water, Ground water pollution, emerging water pollutants (Pharmaceuticals, antibiotics)	✓	✓	✓	✓
Module II 6 lectures	Air pollution: Particulate matter (inorganic and organic species in PM), gaseous Pollutants (CO, Sox, NOx), Ozone pollution and its atmospheric transformations, Primary air pollutants, Secondary air pollutants, Organic air pollutants, Hazardous Air Pollutants, Volatile organic pollutants, Global climate change; Green house gases emission and climate change, Acidic Deposition, Transboundary air pollution, Dust storm	✓	✓		
Module III 6 lectures	Soil pollution: Macro and micro pollutants in soil, heavy metals, radionuclides, agrochemical pollutants (fertilizers, pesticides, animal wastes), saline soils, industrial wastes (oil drilling, coal fired power plants, mining), Municipal solid wastes, Biomedical wastes, industrial sludge, atmospheric depositions in soils	✓	✓		✓
Module IV 6 lectures	Chemical properties of contaminants (Inorganic contaminant, Metals, Organic contaminants, PAH, PCB), Bioaccumulation and Biomagnification, Methods of transfer between environmental Phases. Bioavailability: Biological factors,	✓	✓		

	Uptake of contaminants: different routes, Elimination of contaminants Toxicokinetics: Movement of chemicals through organism, properties of toxic compounds, Physiological effects of pollutants				
Module V 5 lectures	Molecular effects: protein response, Cell, tissue and organ damage, Molecular effects of contaminants: detoxification, DNA modification, Chromosome / Gene damage, Sublethal effects: reproduction, growth and development, Acute vs. chronic effects: , Dose-Response Relationships, Thresholds, LD50, NOAEL, and LOAEL, Population effects: dynamics, demography, Global movement of contaminants, Endocrine Disruptors and Carcinogens ,Persistent Organic pollutants and Risk assessment, Human risk assessment and epidemiology, Microplastics and Nanoplastics Pollution, PFAS (Per- and Polyfluoroalkyl Substances), Emerging Contaminants	✓			✓
Current Trends 2 lectures	Advances in Analytical Techniques, E waste and Toxicology, AI and machine learning in predicting the environmental fate of pollutants and their toxicity.		✓		✓
30 Lectures					

References

1. Understanding environmental Pollution, Second edition, Marquita K. Hill, Cambridge University Press, New Delhi 2004.
2. Environment and Pollution Science, I. L. Pepper etal, Elsevier press, 2006.
3. Environmental Chemistry, S. E. Manahan, Lewis Publishers, 2004
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5. Handbook of industrial and hazardous wastes treatment, Edited by L.K Wand et al, Marcel Dekker, New York
6. Chemistry of the environment, Bailey R. Aetal, Academic Press, 2005.
7. Basic Concepts of Environmental Chemistry, D.W. Connel, Lewis Publishers, Newyork, 1997
8. APHA (1992) Standard methods for the Examination of water and waste water. 18th edition. American Public Health Association, American Water Works Association and Environment Federation, Washington
9. Lorris G. Cockerham, Barbara S. Shane (1994) Basic Environmental Toxicology, CRC Press
10. Rose J (1998) Environmental Toxicology, Gordon and Breach Publications,
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12. Pim de Voogt, María Fernanda Cavieres, James B. Knaak, Annemarie P. van Wezel, Ronald S. Tjeerdema, Marco Vighi (2022) Book series, **Reviews of Environmental Contamination and Toxicology, Springer Publications**
13. Ming-Ho Yu, Humio Tsunoda, Masashi Tsunoda (2011) **Environmental ToxicologyBiological and Health Effects of Pollutants, Third Edition, CRC Press**
14. Pankaj Gupta, Amit Chanjta, Yogesh Mehta(2024) Environmental Toxicology By Copyright 2024, CRC Press
15. Esref Demir and Sam Kacew (2024) Environmental Toxicology and Human Health, MDPI

CORE (CHOICE) 3 : NATURAL RESOURCES MANAGEMENT
Course Code: 25PGEC03

Course Objectives:

- Gain foundational knowledge of renewable and non-renewable resources, their distribution, availability, and ecological significance.
- Examine approaches for the sustainable use and conservation of energy, water, forest, and biodiversity resources in the context of climate change and global development goals.
- Analyze national and international policies, laws, and institutional mechanisms that influence natural resource management.
- Develop the capacity to identify, analyze, and propose context-specific, interdisciplinary solutions to resource management challenges.

* Lecture-L *Tutorial-T *Practical-P *Credit-C	L	T	P	C
Per Week	3	1	0	4

Course Outcomes: At the end of the course, students will		KL
1.	Classify and assess the status and trends of various natural resources at local, national, and global scales.	K1, K3
2.	Analyze interlinkages between natural resources, ecosystems, human livelihoods, and development processes.	K2,K3
3.	Evaluate the effectiveness of sustainable resource management practices, including integrated approaches and community-based models.	K6
4.	Critically interpret legal, institutional, and policy frameworks related to natural resource governance.	K6
5.	Develop informed, interdisciplinary project proposals or strategies for addressing resource depletion, degradation, or mismanagement.	K4, K5

Knowledge level: Remember (K1); Understanding (K2); Perform (K3); Analyse (K4); Synthesize (K5); Evaluate (K6)

Mapping course outcomes with programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	M	S	S	M	S	S	S	S
CO2	S	M	M	S	S	S	S	M	S	S
CO3	S	S	M	S	S	S	S	M	S	S
CO4	M	L	M	S	M	S	M	L	M	S
CO5	S	M	M	S	S	S	S	S	S	S

Strong Moderate Low

Assessment Methods: Test-T, Seminar- S, Assignment- A, Discussion- D

	Modules	T	S	A	D
Module I 5 lectures	**Minerals and Water Resources:** Classification of energy resources: Renewable vs. non-renewable, fossil fuels, nuclear; Global and national trends: Energy demand, production, and consumption patterns; Sustainable energy solutions: Water resources: Types (surface, groundwater, wetlands); their distribution and ecological role and resource management Water-saving technologies: Rainwater harvesting, micro irrigation, recharge pit and check dams, desalination.	✓		✓	✓
Module II 6 lectures	**Forest Resources and Biodiversity Management:** Forest ecosystems: Types (tropical, temperate, boreal), structure, and ecological function; Biodiversity in forests: Genetic, species, and ecosystem diversity; role in ecological resilience; Carbon sequestration. Forest resource assessment: Inventory techniques, biomass estimation, productivity indices. Forest innovations: Precision forestry, forest carbon tracking, Forest carbon markets, deforestation drivers,	✓			

Module III 6 lectures	**Sustainable Resource Management Strategies:** Principles, institutional framework, case studies; Sustainable forestry practices: Certification, ecosystem-based management, low-impact logging; Community-based management: Participatory approaches, joint forest management (JFM), Economic valuation of resources: Market and non-market values, cost-benefit analysis in conservation,	✓	✓		✓
Module IV 6 lectures	**Resource Economics:** Economic classification of resources: renewable vs. non-renewable, Concepts of scarcity, opportunity cost, and externalities, The tragedy of the commons and common-pool resource dilemmas. Principles of supply, demand, and market equilibrium for natural resources. Economic efficiency and optimal resource allocation. Discounting and time preference in resource economics. **Renewable and Non-renewable Resource Economics**	✓	✓		
Module V 5 lectures	**Resource Conservation:** Definitions and scope: conservation vs. preservation. Importance: ecological stability, intergenerational equity, ecosystem services. Historical evolution of conservation movements (global and Indian perspectives). Contour farming, terracing, mulching, cover cropping, check dams, Watershed management and integrated approaches to water conservation.	✓			✓
Current Trends 2 lectures	Advances in ……. : Recent concepts – Technological and Scientific developments – Real world cases/examples – Policy/Practice updates – Contradictions – World/Indian Scenario				✓
30 Lectures					

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- Chris Armstrong *Global Justice and the Biodiversity Crisis: Conservation in a World of Inequality* Oxford University Press, 2024
- Kate Sherren, Gladman Thondhlana, & Douglas Jackson-Smith *Opening Windows: Embracing New Perspectives and Practices in Natural Resource Social Sciences* University Press of Colorado, 2024
- *Robin Wall Kimmerer,* The Serviceberry: An Economy of Abundance *Milkweed Editions, 2024*

ELECTIVE 1 : ENVIRONMENTAL AND OCCUPATIONAL EPIDEMIOLOGY
Course Code: 25PGEC01

Course Objectives:

- This course explores the theoretical foundations and methodological approaches in environmental and occupational epidemiology.
- It equips students with the ability to assess exposure-disease relationships, evaluate environmental and workplace hazards, and
- Appraises students to conduct interdisciplinary research with implications for public health policy and practice.

* Lecture-L *Tutorial-T *Practical-P *Credit-C	L	T	P	C
Per Week	3	1	0	4

Course Outcomes: Upon successful completion of this course, students will be able to:		KL
1.	Integrate epidemiologic principles with environmental and occupational health contexts	K1, K3
2.	Apply advanced study designs and exposure assessment tools to investigate disease etiology.	K2
3.	Analyze environmental and occupational data using statistical software.	K3
4.	Critically interpret research findings and synthesize evidence for public health action.	K4, K5
5.	Design interventions and policy recommendations for risk mitigation.	K6

Knowledge level: Remember (K1); Understanding (K2); Perform (K3); Analyse (K4); Synthesize (K5); Evaluate (K6)

Mapping course outcomes with programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	S	S	M	M	M	S	S
CO2	M	S	M	S	M	L	S	S	S	M
CO3	M	M	S	M	M	L	S	M	S	M
CO4	S	M	M	S	S	M	M	M	S	S
CO5	S	S	S	S	S	S	S	M	S	S
Strong			Moderate			Low				

Assessment Methods: Test-T, Seminar- S, Assignment- A, Discussion- D

	Modules	T	S	A	D
Module I 5 lectures	**Introduction**: History and evolution of the discipline, Core concepts: hazard, exposure, dose-response, latency, risk, The exposome and the eco-social framework, Determinants of environmental/occupational health disparities, Legal and ethical dimensions in exposure research	✓		✓	✓
Module II 6 lectures	**Advanced Exposure Science and Assessment:** Environmental exposure pathways: air, water, soil, food, radiation, noise, Occupational exposure scenarios and hazard profiling, Biological monitoring: sample collection, biomarkers, omics integration, Use of JEMs, time-motion studies, remote sensing and personal sensors, Indoor and ambient environmental assessments	✓			
Module III 6 lectures	**Study Design, Statistical Methods, and Causal Inference:** Advanced designs: nested case-control, case-crossover, time-series, panel studies, modeling complex exposures: mixtures, multipollutant models, cumulative exposures, Modeling latency and long-term exposure effects, Bias (healthy worker effect, surveillance bias), confounding, effect modification, and sensitivity analyses, Causal inference frameworks (Bradford Hill, counterfactuals, DAGs, G-methods)	✓	✓		✓
Module IV 6 lectures	**Health Outcomes and Mechanistic Pathways:** Major diseases linked to exposures: Respiratory: COPD, asthma, asbestosis, Cancer: occupational carcinogens (IARC Groups), environmental links, Neurological and developmental disorders (e.g., lead, pesticides), Cardiovascular, reproductive, and endocrine disruptions, Gene-environment and epigenetic interactions, Dose-	✓	✓		

	response modeling and threshold estimation				
Module V **5 lectures**	**Risk Assessment, Management, and Policy Translation:** Framework: Hazard identification, dose-response assessment, exposure assessment, risk characterization**,** Uncertainty analysis and probabilistic modelling**,** Regulatory frameworks: ILO, WHO, USEPA, REACH, CPCB, OSHA**,** Environmental and occupational surveillance systems (e.g., NOHS, PRTRs), Risk communication and public engagement	✓			✓
Current Trends **2 lectures**	Contemporary Challenges and Futures: Climate-sensitive exposures (e.g., vector-borne diseases, heat stress), planetary health, One Health frameworks, and global burden estimation using GBD and IHME tools.				✓
30 Lectures					

References:

1. Checkoway, H., Pearce, N., & Kriebel, D. 2004, *Research Methods in Occupational Epidemiology* (2nd Edition), Oxford University Press
2. Frumkin, H. (Ed.) 2016 *Environmental Health: From Global to Local* (3rd Edition), Jossey-Bass (Wiley)
3. Baker, D. & Nieuwenhuijsen, M. J. 2008, *Environmental Epidemiology: Study Methods and Application* Oxford University Press
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5. Friis, R. H., 2018, *Essentials of Environmental Health* (3rd Edition), Publisher: Jones & Bartlett Learning
6. LaDou, J. & Harrison, R. J. 2013, *Current Diagnosis & Treatment: Occupational & Environmental Medicine* (5th Edition), McGraw-Hill Education
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8. Boffetta, P., Nyberg, F. 2005, *Cancer Epidemiology and Prevention in the Workplace*, Springer
9. Schulte, P. A., & Hauser, J. E. , 2012, *The Use of Biomarkers in Occupational Health Risk Assessment*, Wiley-VCH
10. World Health Organization (WHO), *Environmental Health Criteria Series*, WHO Press Various Years

ELECTIVE 1 : WASTE MANAGEMENT STRATEGIES
Course Code: 25PGEC01

Course Objectives:

- Understand the nature, classification, and generation trends of various waste streams (municipal, industrial, hazardous, biomedical, electronic, etc.).
- Analyze the environmental and public health impacts of improper waste management.
- Introduce scientific and engineering principles for waste minimization, treatment, recycling, recovery, and safe disposal.
- Evaluate policy frameworks, standards, and global best practices in waste control and sustainable resource use.

* Lecture-L *Tutorial-T *Practical-P *Credit-C	L	T	P	C
Per Week	3	1	0	4

Course Outcomes: Upon successful completion of this course, students will be able to:		KL
1.	Classify different types of waste and assess their sources, properties, and impacts.	K1, K3
2.	Examine waste generation data and perform waste audits for control planning	K2,K4
3.	Design waste reduction and segregation strategies in line with 3Rs (Reduce, Reuse, Recycle).	K5
4.	Evaluate different waste treatment technologies (e.g., composting, incineration, landfilling, biomining).	K5
5.	Interpret national and international waste-related policies and compliance requirements.	K1

Knowledge level: Remember (K1); Understanding (K2); Perform (K3); Analyse (K4); Synthesize (K5); Evaluate (K6)

Mapping course outcomes with programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	M	M	M	L	S	M
CO2	M	S	S	S	M	M	M	M	S	M
CO3	S	S	M	S	S	S	S	M	S	S
CO4	M	S	M	M	M	M	S	M	S	M
CO5	S	M	M	S	M	S	M	L	M	S
Strong			Moderate			Low				

Assessment Methods: Test-T, Seminar- S, Assignment- A, Discussion- D

	Modules	T	S	A	D
Module I 5 lectures	Water and waste water treatment technologies – Effluent treatment technologies - Primary treatment methods - screening, aerators, communitors, grit chamber, equilization tank, coagulation, flocculation, designs of clariflocculators, flash mixers sedimentation, Filtration, rapid and slow sand filters, upflow aerobic filter process. Secondary treatment - Types of biological treatment, Activated sludge treatment, trickling filters, waste stabilization ponds, aerated lagoons, anaerobic digestors. Advanced treatment – reverse osmosis, ion exchange, biofilters, Zero liquid discharge	✓		✓	✓
Module II 6 lectures	Air Pollution control systems, design and height of chimneys- theory, plume behavior, wind rose model, Flue gas properties, different types of scrubbers in air pollution control, cyclone filters, Electro Static Precipitators, Vehicular emissions and control technologies, Respirable Dust Samplers, Particulate Matter Samplers (<10µm, <2.5µm, <1µm), catalytic converters, Fuel Borne Catalysts, Selective Catalytic Reduction, re-engining, particulate traps, CNG engines, BS IV and BS VI stage vehicles, indoor air pollution	✓			
Module III 6 lectures	Solid waste management, solid waste generation, characterization, minimization, collection, separation, treatment and disposal, classification of wastes, different methods of dispersal and disposal of solid wastes, landfill engineering; barrier	✓	✓		✓

	design and leachate management, incineration, pyrolysis, Secured/Scientific landfill, Soil and Groundwater contamination, Biological processes - composting, vermicomposting, anerobic digestion, organic waste convertor.				
Module IV **6 lectures**	Recycling of solid waste, linear and circular economy, biomedical wastes, e - waste, plastic and Glass disposal, recycling, Conversion products, recovery of materials and metals, cost benefit analysis, 3R /4R/5R concept, Biomining: Bioleaching vs. biosorption vs. bioprecipitation, specific waste streams: industrial flyash, mine tailing, industrial waste , packaging wastes,	✓	✓		
Module V **5 lectures**	Policies and initiatives: Swachh Bharat Mission (SBM) – Urban and Gramin, Extended Producer Responsibility (EPR) Framework, National Action Plan for Waste Management, Urban Local Body (ULB) Reforms & Smart Cities Mission, National Green Tribunal (NGT) Orders and Monitoring, GOBAR-Dhan Scheme (Galvanizing Organic Bio-Agro Resources), National Electric Mobility Mission & Battery Waste Management Rules, 2022, Waste to Energy (WTE) and Composting Policies, Start-up India and Entrepreneurship in Waste Sector, Mission LiFE India, Swachh Bharat Mission 2.0 : legacy waste elimination by 2026	✓			✓
Current Trends **2 lectures**	IoT-enabled bins, RFID tagging, and smart routing, bio-CNG plants, Producer Responsibility Organizations (PROs) active in e-waste collection and refurbishing, bioplastics, green jobs,				✓
30 Lectures					

References:

- Information Resources Management Association (IRMA)Waste Management: Concepts, Methodologies, Tools, and Applications 2019 IGI Global
- Ravindra K., Nandy T., Khanna P. 2023, Sustainable Waste Management: Policies, Strategies, and Technologies Springer
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- Sadhan Kumar Ghosh Circular Economy in Waste Management, Springer
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25PGPP01 : Practical I- Environmental Quality Analysis

Course Objectives

- To familiarize students with the national and international standards for air, water, and soil quality.
- To equip students with the ability to collect representative samples of air, water, and soil for analysis.
- To teach students the laboratory and field methods for analyzing pollutants and other parameters in environmental samples.
- To develop the ability to interpret analytical results and assess whether environmental standards are met, and to identify sources of pollution.

	Modules
Module I	**Introduction to Environmental Quality Analysis** • Overview of environmental pollutants (air, water, soil, noise) • Methods of sampling and analysis • Overview of standards and regulations (e.g., EPA, WHO)
Module II	**Air Quality Monitoring and Analysis** • Collection of air samples using different techniques (e.g., passive samplers, pumps), • Choosing sampling location • Determining concentrations of gaseous air pollutants (e.g., CO, NOx, SO2, particulate matter) • Use of equipment such as gas analyzers, particulate samplers, and air quality monitoring stations • Interpretation of air quality data and comparison with standards • Air Quality Index
Module III	**Water Quality Testing** • **Physical Parameters**: Temperature, turbidity, color, and conductivity • **Chemical Parameters**: pH, EC(µs), TDS(mg/l), Hardness(mg/l), Calcium Hardness (mg/l), Calcium (mg/l), Mg (mg/l), PH Alkalinity, Acidity, CO3 (mg/l), HCO3 (mg/l), Potassium(K) (mg/l), Sodium(Na) (mg/l), Chloride (mg/l), DO (mg/l), BOD (mg/l), COD (mg/l), Phosphate (mg/l), Nitrate (mg/l), Sulphate (mg/l), Iron (Fe) (mg/l), Fluoride (F) (mg/l), • Sampling techniques (grab, composite, and automated) • Use of instruments like spectrophotometers, titration methods, and colorimeters
Module IV	**Soil Quality Analysis** • Determining soil properties pH, EC, Organic carbon, Na, K, Ca, mg, CEC, SAR. • Micronutrients Toxic Metals- Heavy metals analysis in soil • Nutrient content (nitrogen, phosphorus, potassium) • Soil sampling and preparation techniques • Soil contamination testing (e.g., pesticides, metals)

Course Outcomes

- Analyze environmental samples using standard protocols to assess water, air, and soil quality parameters.
- Apply appropriate sampling techniques and laboratory methods for measuring key indicators such as pH, turbidity, BOD, COD, TDS, and particulate matter.
- Interpret experimental data to evaluate environmental pollution levels and identify potential sources of contamination.
- Demonstrate proficiency in using analytical instruments such as spectrophotometers, gas analyzers, and flame photometers for environmental monitoring.
- Correlate laboratory findings with environmental standards (e.g., CPCB, WHO) to assess compliance and inform mitigation strategies.


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SEMESTER II

CORE 4 : ENVIRONMENTAL IMPACT ASSESSMENT
Course Code: 25PGCC04

Course Objective:

- To understand the principles of environmental impact assessment and its evolution.
- To learn various steps and processes for environmental clearance of projects in India
- To identify potential hazards, quantify associated risks using various methods
- To understand the tools in environmental modeling for applications in EIA and Risk assessment

* Lecture-L *Tutorial-T *Practical-P *Credit-C	L	T	P	C
Per Week	3	1	-	4

Course Outcomes:		KL
1.	Students gain an understanding of how environmental impact assessment is conducted	K1
2.	Perform EIA tools in the engineering project management decision-making process	K2 & K3
3.	Proficient to analyse an environmental impact assessment, review and critically analyze an environmental impact statement	K4, K6
4.	Applying mathematical models for environmental impact prediction	K4 & K5
5.	Capable of evaluating environmental impact assessment of development projects	K4 & K6

Knowledge level: Remember (K1); Understanding (K2); Perform (K3); Analyse (K4); Synthesize (K5); Evaluate (K6)

Mapping course outcomes with programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	M	S	S	M	M	L	S	S
CO2	M	M	S	S	M	M	S	M	S	M
CO3	S	L	M	S	S	M	M	L	M	S
CO4	M	M	S	M	M	L	S	M	S	M
CO5	S	M	M	S	S	S	S	M	S	S

Strong | Moderate | Low

Assessment Methods: Test-T, Seminar- S, Assignment- A, Discussion- D

	Modules	T	S	A	D
Module I 5 lectures	Introduction to EIA, Concept of EIA, Evolution of EIA, EIA practice in India, EIA Notifications 1992, 1994, 1997, 2009 and 2016of MoEF, Coastal Regulation Zone Notifications, Project Screening in EIA, Nodal agencies and central and state, Defining and Examining Scope, Objectives and Alternatives in EIA Projects, Project Planning and processes, Baseline information, Impact prediction, decision making	✓		✓	✓
Module II 6 lectures	Types of EIA, Rapid ElA, Comprehensive EIA, Strategic EIA, Data Collection, Ecological Impacts, Environmental Impacts (Air, water, Land Noise), Socioeconomic and cultural Impacts, Health impacts, Prediction of Impacts; Methodologies (Checklists, Matrices, Networks, Overlays and GIS, Cost Benefit analysis, OGC tools, Environmental Management Plan (EMP).	✓			
Module III 6 lectures	Preparing and Writing of Environmental Impact Statements (EIS), Computer aided techniques, Reviewing EIA/EIS, Use of EIA in Public participation and decision making, EIA in Sustainable development. EIA case studies: Mining projects, Hydroelectric projects, Nuclear power projects, Thermal power projects, Refineries, Cement, Metallurgy.	✓	✓		✓
Module IV 6 lectures	Environmental Risk Assessment and Management, azard Identification, Hazard Characterization. Risk Assessment, Risk Screening & Prioritization, Qualitative Risk Assessment. Risk Management. Human Health Risk Assessment, Exposure Assessment, Dose-Response Predictions. Ecological	✓	✓		

	Risk Assessment, Problem Identification, Risk Analysis, Risk Characterization, Social aspects of risk.				
Module V **5 lectures**	Modeling tools in risk assessment. Modeling and simulation, Modeling Principles and Programming, Introduction to Stella and spreadsheet modeling. MATLAB, Specific Environmental models, Gausian model, Modelling pollution concentration in lake and stream Models. Air quality and emission dispersion models. Computerized models of urban land use, transportation and environment in the development. Simple climate change models. Using *R studio* in models. Machine Learning approaches in EIA	✓			✓
Current Trends **2 lectures**	Enhancing the quality of EIAs in sensitive areas, Environmentally-Extended Input-Output (EEIO) Analyses, Simulation-based integrated assessment models, such as E3ME-FTT-GENIE				✓
30 Lectures					

References

- Environmental Impact Assessment, A. K. Shrivastava, APH Publishing Corporation, New Delhi, 2003
- Environmental Impact Assessment, S. A. Abbasi and D. S. Arya, Discovery Publishing House New Delhi, 2004
- A Hand book of Environmental Impact Assessment, V.S. Kukarni, S.N. Kaul, R.K. Trivedi, Scientific Publishers, Jodhpur, 2002
- A Handbook of Environment Impact Assessmentbooks.google.co.in › books
- R.K. Trivedy, V.S. Kulkarni, S.N. Kaul (2019) A Handbook of Environment Impact Assessment. Scientific Publishers
- Perspectives on Strategic Environmental Assessment, Edited Maria Rosario, Lewis Publishers, USA, 2000.
- Kevin Hanna (2022) Routledge Handbook of Environmental Impact Assessment, Taylar & Francis Publishers

CORE 5 : ENVIRONMENTAL LAW, POLICIES AND ETHICS
COURSE CODE: 25PGCC05

Course Objectives:

Ethical foundation is a prerequisite for environment policy formulation. This paper introduces the basics of environmental ethics and theories. Environmental policies in India, global policy interventions are the focus of this course. Students learn the formulation, instruments strategies and implementation of environmental policies.

* Lecture-L *Tutorial-T *Practical-P *Credit-C	L	T	P	C
Per Week	3	1	0	4

Course Outcomes: At the end of the course, the students will be able to		KL
1.	Demonstrate in-depth knowledge of national and international environmental laws, treaties, and regulations, including their historical development and contemporary relevance.	K1
2.	Critically evaluate the effectiveness of environmental policy frameworks in addressing complex ecological challenges such as climate change, biodiversity loss, and pollution.	K2 & K3
3.	Integrate ethical theories and frameworks into the analysis of environmental dilemmas, ensuring that decisions reflect sustainability, equity, and justice.	K4
4.	Formulate innovative and sustainable policy recommendations to address environmental challenges while balancing economic, social, and ecological considerations.	K5
5.	Assess and ensure compliance with environmental laws and ethical standards in real-world case studies, focusing on corporate, governmental, and community responsibilities.	K6

Knowledge level: Remember (K1); Understanding (K2); Perform (K3); Analyse (K4); Synthesize (K5); Evaluate (K6)

Mapping course outcomes with programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	L	M	S	M	M	M	L	M	S
CO2	M	L	L	M	S	M	M	L	M	S
CO3	M	L	L	M	M	S	M	L	M	S
CO4	S	L	M	M	S	S	S	L	M	S
CO5	S	M	S	S	S	M	M	L	S	S
Strong			Moderate			Low				

Assessment Methods: Test-T, Seminar- S, Assignment- A, Discussion- D

	Modules	T	S	A	D
Module I 5 lectures	Ethics - Concepts - Ethical theories - consequential theory - deontological theory - virtue ethics - situation ethics - feminist ethics - Illustration cases - DPGs - Biopiracy – GMO – Stem cell research. Environment and constitution of India - Environmental legislature Machinery - Constitutional Status of Environment - Duty to Protect Environment.	✓		✓	
Module II 6 lectures	Laws on Water Pollution Control - Powers of Central and State Pollution Control Boards - Prevention and Control of Water Pollution - Closure or Stoppage of Water and Electricity Supply - Citizen Suit Provision - Power of Central Government to Supersede the Central Board - Power of State Government to Supersede the State Board.	✓	✓	✓	
Module III 6 lectures	Laws on Air Pollution Control - Powers and Functions of Boards - Air Pollution Control Areas - pollution control strategies - Prohibition of Emission of Air Pollutants	✓	✓	✓	✓
Module IV 6 lectures	Environment (Protection) Act 1986 - Powers of Central Government - Legal Regulation of Hazardous Substance - Hazardous Wastes (Management and Handing) Rules 1989 - The Natural Environment Tribunal Act 1995 - Legal Measures to Control Noise Pollution - solid waste management and handling	✓	✓	✓	✓

	rules-2000. Bio-medical wastes (Management and Handling) Rules 1999 - Coastal Regulation Zone Notification-1991.				
Module V 5 lectures	International Environmental conventions - Montreal Protocol - Earth Summit - Agenda 21 - Biodiversity Act, 2002 - Kyoto Protocol - Copenhagen Summit 2009 - Millennium Development Goals - Basel convention. Paris Agreement, Global Climate Action Plan, Review of NAAP and SAAP	✓		✓	✓
Current Trends 2 lectures	Enhanced Environmental Regulations, Climate Change Litigations, Recognition of the Right to a Healthy Environment, Re evaluation of Land Acquisition Laws				✓
30 Lectures					

References

- Gurdip Singh, 2005. 'Environmental Law in India', Macmillan India Ltd, New Delhi – 2.
- BalaKrishnamoorthy, 2005. Environmental Management, Prentice Hall of India Private Limited, New Delhi.
- S.K. Agarwal, 1997. Environmental Issues and themes, APH Publishing Corporation, New Delhi.
- John O Neil. R. Kerry Turner and Ian J. Batemaned ed., 2001. Environmental Ethics and philosophy, An Elgar Reference collection, USA.

CORE (CHOICE) 6: INDUSTRIAL SAFETY AND HEALTH

COURSE CODE: 25PGCC06 (Formerly Industrial Pollution and Waste Management)

Course Objectives: To understand hazards and hazardous and hazardous materials in occupational environment, learn about the methods to monitor the wastes, sources and control them. To understand the human exposure routes to toxic substances and materials and to know about various surveillance programs to manage hazards

* Lecture-L *Tutorial-T *Practical-P *Credit-C	L	T	P	C
Per Week	3	1	0	4

Course Outcomes:		KL
1.	Demonstrate a comprehensive understanding of industrial health hazards, safety practices, and safety regulations	K1
2.	Identify common occupational health risks and their impact on workers' health and productivity.	K2 & K3
3.	Conduct qualitative and quantitative risk assessments for various industrial operations.	K4
4.	Implement and manage safety management systems (SMS) and programs to ensure compliance with safety standards and regulations (OSHA, ISO 45001).	K5
5.	Design and manage waste management systems to meet environmental and legal requirements	K6

Knowledge level: Remember (K1); Understanding (K2); Perform (K3); Analyse (K4); Synthesize (K5); Evaluate (K6)

Mapping course outcomes with programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	M	M	S	M	M	L	M	S
CO2	S	L	M	L	S	M	M	L	M	S
CO3	M	M	S	M	S	M	S	L	S	M
CO4	S	M	S	S	S	M	S	L	S	S
CO5	M	S	M	M	S	M	M	M	S	M
Strong			Moderate			Low				

Assessment Methods: Test-T, Seminar- S, Assignment- A, Discussion- D

	Modules	T	S	A	D
Module I 5 lectures	**Industrial Safety Management** History of Safety movement in India and abroad – Evolution of modern safety concept-legal, Humanitarian, economic and social considerations – Definition of accident, Incident, Injury, Hazards, Unsafe act/ Condition, Accident prevention- Legislations in Safety & Health – The Factories Act & relevant state rules- Tamil Nadu Safety Officers Rules - Role of safety committee - Safety policy, budgeting for safety, Hazard identification and risk assessment techniques, Overview of Bureau of Indian standards in Safety,	✓			✓
Module II 6 lectures	**Safety education, training, and employee participation-** Importance of training, identification of training needs, training methods, program and training evaluation - Internal and external Training, seminars, conferences, Induction Training, Toolbox talks, E-Learning tools Role of government agencies and Industry forums in safety training - Importance of employee participation - Role of trade unions in Safety, Health and Environment - Organizing suggestions and evaluation of feedback system - Safety competitions - Modern methods of Safety Promotion - awards, competitions, celebrations, safety posters, safety displays, safety pledge, safety incentive scheme, safety campaign.	✓	✓	✓	

Module III **6 lectures**	**Fire safety -** Fire properties of solid, liquid and gases - fire spread - toxicity of products of combustion - combustion characteristic- flash point, fire point, ignition temperature, LFL, UFL, flame propagation.– properties of explosive, propellent.– vapour clouds – flash fire – jet fires – pool fires – unconfined vapour cloud explosion, shock waves - auto-ignition – boiling liquid expanding vapour explosion – case studies – Flixborough, Mexico disaster, Bhopal disaster, Piper Alpha, and Bombay Victoria dock ship explosions. **Sources of ignition** – fire triangle – principles of fire extinguishing – active and passive fire protection systems – various classes of fires – Types of fire extinguishers – – hydrant pipes – hoses – monitors – fire drills **Industrial fire protection systems** Sprinkler-hydrants-stand pipes– alarm and detection systems. Other suppression systems – CO2 system, foam system, dry chemical powder (DCP) system, halon system, Inergen, FM200, Disaster Management - Onsite & off site Emergency plan	✓	✓	✓	✓
Module IV **6 lectures**	**Accident Prevention, Investigation and Reporting -** Theories of accident causation, Direct and Indirect cost analysis, Principles of Accident Prevention, reportable and non-reportable accidents, reporting to statutory authorities - accident investigation methodology, Recommended practices for compiling and measuring work injury – Calculation of accident indices, frequency rate, severity rate as per IS 3786	✓	✓	✓	
Module V **5 lectures**	**Occupational Health** – Physical Hazards - Noise, Vibration. Ionizing radiation, non-ionizing radiations, heat stress - Chemical Hazards - Recognition of chemical hazards-dust, fumes, mist, vapour, fog, gases, types, concentration- Biological and ergonomical hazards- Classification of Bio-hazardous agents – examples, bacterial agents, viral agents, fungal, parasitic agents, infectious diseases-Ergonomics and human factors engineering - Work Related Musculoskeletal Disorders – Carpal Tunnel Syndrome CTS- Tendon pain disorders of the neck- back injuries. **Employee health program** Pre-employment and post-employment medical examinations – occupational related diseases, levels of prevention of diseases, notifiable occupational diseases such as silicosis, asbestosis, pneumoconiosis, siderosis, anthracosis, aluminosis and anthrax, Man as a system component – allocation of functions – Industrial toxicology, local, systemic and chronic effects, temporary and cumulative effects, carcinogens entry into human systems -stress – strain – fatigue – rest pauses – shift work – personal hygiene.	✓		✓	✓
Current Trends **2 lectures**	**Industrial Exposure**: Hands-on experience with safety equipment and simulation of industrial scenarios. **Industry Internship**: Exposure to real-world industrial safety practices. Independent research on a relevant topic in industrial safety and hazard management.				✓
30 Lectures					

References

- Prof. Sunil S.Rao, R.K.Jain (2000) Industrial Safety, Health and Environment Management Systems 2024 KHANNA PUBLISHERS
- Dr K U Mistry (2022) FUNDAMENTALS OF INDUSTRIAL SAFETY AND HEALTH by Vol 1 Shyamaraj Global Commerce
- Rajan Nijhawan – 1st Edition (2024) Waste Management Law with Guidelines, ILBCO Publishers

- Hazardous Materials Classification Systems", In: *EPA Handbook of Chemical Hazard Analysis Procedures*; 1989; (301) 447-1068
- Air Monitoring" (chap. 7) from: NIOSH/OSHA/USCG/EPA; *Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities*

CORE (CHOICE) 6: ENVIRONMENTAL INFORMATICS AND SPATIAL DATA MODELLING

COURSE CODE: 25PGCC06

Course Objectives: To introduce the concept of Applied Informatics and supports methods and procedures of spatial information technologies which contribute to environmental data analysis and environmental protection

* Lecture-L *Tutorial-T *Practical-P *Credit-C	L	T	P	C
Per Week	3	1	0	4

Course Outcomes:		KL
1.	The course offers comprehensive and in-depth understanding of environmental linkages and to estimate the spatially aggregation of features in geographical and how it is measured	K1 , K2
2.	The students gain knowledge on descriptive, explanatory, and inferential analyses from spatial data.	K3, K4,
3.	The course is designed to help develop sustainable solutions that are consensus-oriented, risk-informed, scientifically-based and cost-effective	K5, K6
4.	Offers spatial analysis and modelling that can be implemented in different computing platforms for the varied environmental data.	K2, K5
5.	Students have improved understanding of environmental systems, and are able to perform interdisciplinary analyses that can inform decision making and policy	K5, K6

Knowledge level: Remember (K1); Understanding (K2); Perform (K3); Analyse (K4); Synthesize (K5); Evaluate (K6)

Mapping course outcomes with programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	L	L	M	M	M	S	M	S	M
CO2	M	L	M	S	M	M	S	S	S	M
CO3	M	L	S	S	M	M	S	M	S	M
CO4	M	L	M	M	M	M	S	S	S	M
CO5	M	M	M	M	S	M	M	S	S	M
Strong			Moderate				Low			

Assessment Methods: Test-T, Seminar- S, Assignment- A, Discussion- D

	Modules	T	S	A	D
Module I 5 lectures	Introduction to the environment as a system of linked, interactive components. Application of information science to environmental management. Skills and techniques required for collecting, collating, archiving, modeling, analyzing, visualizing, and communicating information in support of natural resource management. Numerical modeling of the environmental system, Modeling concepts – physical versus empirical models, distributed versus lumped models	✓			✓
Module II 6 lectures	Geospatial Analysis, analysis and modeling, map algebra, cost benefit analysis ,spatial interpolation and approximation Terrain Modeling and Analysis TIN, DEM and DSM, Flow tracing, Watershed Analysis and hydrological models, hierarchies feature extraction, landform mapping, Introduction to Modeling of Geospatial Processes, Trend Analysis	✓	✓	✓	
Module III 6 lectures	Introduction to environmental informatics , Topics of environmental informatics , Environmental objects , Characterisation of an environmental system , Environmental metadata , Environmental data analysis , Scales of operation of environmental data , Re-sampling of environmental data , Data Intensive Science and Importance of Environmental Taxonomy	✓	✓	✓	✓

Module IV **6 lectures**	Environmental simulation models , Modelling procedure , Types and classification of mathematical models , Process identification , An eutrophication simulator, Environmental decision support systems, Introduction , Decision support on a river basin scale , Working levels of a DSS , Applications of DSS, Models using STELLA, **Digital Earth and Big Data, GeoAI models and IoT**	✓	✓	✓	
Module V **5 lectures**	Applications of earth observations to Environmental Planning and Management , forestry, wildlife, environment and natural resources including water, land and atmosphere. Case Studies	✓		✓	✓
Current Trends **2 lectures**	Artificial intelligence and expert systems for environmental applications, Computer graphics and visualization for environmental decision support				✓
30 Lectures					

References:

- Singh, R.B, *Environmental Monitoring: Applications of Remote Sensing and GIS*, 1991, Geocartho International Centre, Hongkong
- Muralikrishna, I.V, *Remote Sensing and GIS for Environmental Planning*, 1994,Tata McGraw Hill, New Delhi
- Robert Scally,*GIS for Environmental Management*, 2006, ESRI press, USA
- Bettinger, Wing and Wing, *Geographic Information Systems: Applications in Forestry and Natural Resources Management*,2004, McGraw Hill, NY
- Fischer.M.M and Nijkamp, P. *Geographic Information Systems – Spatial Modeling and Policy Evaluation*, 1993, Springer Verlag, NY.
- Estes J.E , and Senger, L.W, *Remote Sensing Techniques for Environmental Analysis,*1994, Hamilton Publishers, NJ.
- Gunther, Oliver. (2001). Environmental Information Systems. Published by Springer
- Michener, William (2000). Ecological Data: Design, Management and Processing (Ecological Methods and Concepts) Published by Wiley-Blackwell; 1 edition (February 17, 2000)
- P. K. Paul, Amitava Choudhury, Arindam Biswas, Binod Kumar Singh (2022) **Environmental Informatics:** Challenges and Solutions, Springer Publications
- **Ahmed M. Eldosouky, Luan Thanh Pham, David Gomez-Ortiz, Saulo Oliveira, Ahmed Henaish, Frontiers Media SA (2024)** Advanced Methods for Interpreting Geological and Geophysical Data, Frontiers Book Series

ELECTIVE 2 : URBAN ENVIRONMENTAL SUSTAINABILITY: ISSUES AND STRATEGIES
Course Code: 25PGEC02

Course Objectives:

- To understand the critical environmental challenges associated with urbanization.
- To explore sustainable strategies for addressing urban environmental issues.
- To evaluate policy frameworks and innovative technologies for sustainable urban management.

* Lecture-L *Tutorial-T *Practical-P *Credit-C	L	T	P	C
Per Week	3	1	0	4

Course Outcomes:		KL
1.	Identify key environmental challenges in urban areas.	K1 , K2
2.	Analyze the impacts of urbanization on ecosystems and resources.	K3
3.	Evaluate strategies for sustainable urban management.	K6
4.	Examine the role of policies and governance in urban sustainability.	K2, K5
5.	Propose innovative solutions for sustainable urban development.	K5, K6

Knowledge level: Remember (K1); Understanding (K2); Perform (K3); Analyse (K4); Synthesize (K5); Evaluate (K6)

Mapping course outcomes with programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	L	L	M	S	M	M	M	S	S
CO2	M	L	M	M	S	M	M	M	S	S
CO3	M	L	M	S	S	M	S	M	S	S
CO4	S	L	M	S	M	M	M	L	M	S
CO5	S	M	M	M	S	S	S	M	S	S
Strong			Moderate			Low				

Assessment Methods: Test-T, Seminar- S, Assignment- A, Discussion- D

	Modules	T	S	A	D
Module I 5 lectures	**Introduction to Urban Environmental Issues:** Urbanization trends and their environmental implications. Key challenges: air pollution, water scarcity, waste management, and urban heat islands. Impacts of urban sprawl on biodiversity and green spaces.	✓		✓	✓
Module II 6 lectures	**Urban Resources and Ecosystem Services:** Water management in urban areas: Challenges and solutions. Energy consumption and renewable energy in cities. Role of urban green infrastructure in enhancing ecosystem services.	✓			
Module III 6 lectures	**Strategies for Sustainable Urban Development:** Sustainable urban planning and design principles. Smart cities and their role in resource efficiency. Circular economy approaches: Waste-to-resource models and zero-waste cities.	✓	✓		✓
Module IV 6 lectures	**Policy Frameworks and Governance:** Urban environmental policies at the national and global levels. Role of public-private partnerships in sustainable urban management. Community participation and citizen engagement in urban governance.	✓	✓		
Module V 5 lectures	**Technological Innovations for Urban Sustainability:** Role of GIS and remote sensing in urban environmental monitoring. Smart mobility and transportation solutions. Innovations in urban agriculture and vertical farming for food security.	✓			✓
Current Trends 2 lectures	**Current Contours *(Not for Final Exam, only for Discussion)*:**Urban resilience in the face of climate change and natural disasters. Urban carbon footprint: Measurement and reduction strategies. Case studies: Successful urban sustainability initiatives from around the world.				✓
30 Lectures					

References:

- UN-Habitat. (2020). *World cities report 2020: The value of sustainable urbanization*. United Nations.
- Newman, P., Beatley, T., & Boyer, H. (2017). *Resilient cities: Overcoming fossil fuel dependence*. Island Press.
- Girardet, H. (2015). *Creating regenerative cities*. Routledge.
- Alberti, M. (2016). *Cities that think like planets: Complexity, resilience, and innovation in environmental sustainability*. University of Washington Press.

ELECTIVE 2 : INDUSTRIAL POLLUTION, MANAGEMENT AND REMEDIATION
Course Code: 25PGEC02

Course Objectives:

- Understand the sources, types, and environmental impacts of industrial pollution (air, water, soil, and solid waste).
- Gain knowledge of pollutant behavior, fate, and toxicity in different environmental matrices.
- Explore conventional and advanced methods for industrial waste treatment and pollution control.
- Learn principles and applications of bioremediation, phytoremediation, and other eco-friendly remediation technologies.
- Develop critical thinking on environmental risk assessment and pollution monitoring.

* Lecture-L *Tutorial-T *Practical-P *Credit-C	L	T	P	C
Per Week	3	1	0	4

Course Outcomes:		KL
1.	Identify and classify different types of industrial pollutants and their sources.	K1
2.	Analyze the environmental and health impacts of industrial emissions and effluents.	K4
3.	Evaluate various pollution control and remediation technologies based on industry type.	K5
4.	Apply concepts of microbial and phytoremediation to real-world pollution scenarios.	K3
5.	Design and propose integrated remediation strategies for polluted industrial sites.	K6

Knowledge level: Remember (K1); Understanding (K2); Perform (K3); Analyse (K4); Synthesize (K5); Evaluate (K6)

Mapping course outcomes with programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	M	M	M	M	S	M
CO2	S	S	M	S	S	M	M	M	S	S
CO3	M	S	S	M	M	M	S	S	S	M
CO4	M	S	M	M	M	M	S	S	S	M
CO5	S	S	S	M	M	S	S	S	S	S
Strong			Moderate				Low			

Assessment Methods: Test-T, Seminar- S, Assignment- A, Discussion- D

	Modules	T	S	A	D
Module I 5 lectures	**Industrial Pollution and Hazards:** Introduction to basic terminologies: gas, vapour, fume and mist, hazard types -physical, chemical, biological; Industries and classification of industries and types of pollutants (organic, inorganic, heavy metals); Air, water, and soil pollution from industries (textiles, tanneries, pulp & paper, pharmaceuticals, oil refineries), Major industrial disasters –Chernobyl, Bhopal gas tragedy, Minamata disease, industrial wastewater issues in India	✓		✓	✓
Module II 6 lectures	**Exposure and Risk Assessment:** Hazardous material exposure, components of Hazard diamond and numbering system; four facets of Industrial Hygiene; importance of Certified safety professional, Risk assessment: hazard identification	✓			
Module III 6 lectures	**Principles of Chemoremediation:** Definitions and types, In situ and ex situ chemical remediation strategies, In Situ Chemical Oxidation (ISCO) and Reduction (ISCR), Stabilization, Solidification, and Chemical Immobilization, Cement-based stabilization, pH control, ion exchange, chelating agents, Integration with biological remediation (bio-enhanced ISCO).	✓	✓		✓
Module IV 6 lectures	**Introduction to Bioremediation Concepts:** Types of bioremediations: in situ vs. ex situ, Passive (intrinsic) vs. active (engineered) bioremediation, Factors affecting microbial remediation efficiency; Microbial Degradation of Hydrocarbons and carbamate and chlorinated pesticides: Aerobic and anaerobic	✓	✓		

	degradation pathways, Role of consortia and biofilms. Mechanisms: hydrolysis, oxidation, dechlorination, Key microbial species (Pseudomonas, Flavobacterium, etc.), Agricultural soil bioremediation techniques: key microbial species, biochar, composting				
Module V 5 lectures	**Phytoremediation and other emerging technologies:** Phytoextraction, phytostabilization, phytodegradation, rhizofiltration, Role of rhizosphere bacteria and mycorrhizae, Plants used in phytoremediation (e.g., *Brassica*, *Populus*, *Vetiver*), Enhancing phytoremediation via genetic modification, Constructed Wetlands, Biosorption, and Bioaugmentation, Emerging Technologies, Nanobioremediation: nanoparticles + microbes/plants, Microbial Fuel Cells (MFCs): simultaneous treatment and energy recovery, Genetically engineered microbes for pollutant specificity	✓			✓
Current Trends 2 lectures	**Current Contours *(Not for Final Exam, only for Discussion)*:** Recent concepts – Technological and Scientific developments – Real world cases/examples – Policy/Practice updates – Contradictions – World/Indian Scenario				✓
30 Lectures					

References:

- Schnoor, J.L. (2001). *Phytoremediation: Technology Overview Report*, U.S. Environmental Protection Agency (EPA), Groundwater Remediation Technologies Analysis Center,
- Pilon-Smits, E. (2020), *Phytoremediation: Methods and Reviews,* Humana Press (Springer Protocols – Methods in Molecular Biology)
- Prasad, M.N.V. (2007). *Phytoremediation: Role of Plants in Contaminated Site Management,* Springer
- Raskin, I. & Ensley, B.D. (1999). *Phytoremediation of Toxic Metals: Using Plants to Clean Up the Environment* Wiley-Interscience
- Siegrist, R.L., Crimi, M., Simpkin, T.J. (2011). i*n Situ Chemical Oxidation for Groundwater Remediation,* Springer
- Ferguson, C.C. (1999). *Chemical Fate and Transport in the Environment*, CRC Press
- Mahajan, S.P. (1985), *Pollution Control in Process Industries,* Tata McGraw-Hill
- Atlas, R.M. & Bartha, R. (1997), *Microbial Ecology: Fundamentals and Applications* (4th Edition), Benjamin Cummings
- Maier, R.M., Pepper, I.L., & Gerba, C.P. (2015), *Environmental Microbiology* (3rd Edition), Academic Press
- Singh, A., & Ward, O.P. (2004), *Biodegradation and Bioremediation,* Springer-Verlag Berlin Heidelberg
- Jain, R.K., et al. (2011), *Microorganisms in Environmental Management: Microbes and Environment,* Springer
- Singh, S.N., & Tripathi, R.D. (2007), *Environmental Bioremediation Technologies* Publisher: Springer
- Fulekar, M.H. (2010), *Bioremediation Technology: Recent Advances,* Springer

25PGPP02: PRACTICAL II: SPATIAL ANALYSIS AND MODELLING

Course Objectives:

1. Gain proficiency in remote sensing techniques for environmental and spatial analysis.
2. Develop hands-on skills in GIS software for data collection, analysis, and visualization.
3. Apply remote sensing and GIS tools to solve real-world problems in natural resource management, urban planning, and environmental monitoring.

	Modules
Module I	**Introduction to Remote Sensing and GIS** Basic cartography, Toposheet identification, Latitude/Longitude conversions, Installation and interface overview of software such as ArcGIS, QGIS, or ENVI. Accessing satellite imagery from platforms like Sentinel Hub, USGS Earth Explorer, or Copernicus, Preprocessing satellite images: Georeferencing, mosaicking, and clipping.
	Image Processing Techniques
Module II	**Image Enhancement**: Applying contrast stretching, histogram equalization, and spatial filtering techniques, Calculating vegetation indices such as NDVI, EVI, and SAVI. **Supervised and Unsupervised Classification**: Implementing image classification techniques to map land use/land cover (LULC). Accuracy assessment using ground truth data.
	GIS Data Handling and Analysis
Module III	**Digitization and Data Input**: Creating and editing shapefiles for points, lines, and polygons. Digitizing features like roads, rivers, and administrative boundaries.
Module IV	**Spatial Data Analysis**: Buffering, overlay analysis, and spatial joins. Network analysis for transportation or utility networks. **Raster Data Analysis**: Elevation and slope mapping using Digital Elevation Models (DEMs). Performing hydrological analysis (e.g., watershed delineation).
Module V	**Spatial Interpolation**: Applying Kriging, IDW, or Thiessen polygon methods to predict spatial patterns. Analyzing land cover change over time using multi-date satellite images. Publishing maps and layers on platforms like ArcGIS Online or Google Earth Engine. Creating interactive web maps using tools like Leaflet or Mapbox.
	Global Positioning System
Module VI	**GPS :** Operating and obtaining Signals in GPS. Collection of Latitude Longitude Values Terrain Mapping and integrating maps in GIS.

Course Outcomes

- Acquire and preprocess remote sensing data from various sources, including satellite and aerial imagery, using appropriate tools and techniques.
- Apply image enhancement, classification, and interpretation techniques to extract meaningful information from remotely sensed data.
- Perform spatial analysis and modeling using GIS software to solve complex real-world problems in environmental, urban, agricultural, and disaster management domains.
- Integrate remote sensing data with GIS layers to create thematic maps, analyze spatial patterns, and generate decision-support outputs.
- Demonstrate proficiency in using software such as ArcGIS, QGIS, ERDAS Imagine, or ENVI for processing and analyzing geospatial data.

SEMESTER III

CORE 7 : CORPORATE STRATEGIES FOR ENVIRONMENTAL MANAGEMENT

Course Code: 25PGCC07

Course Objectives:

- To understand the Structure, features and benefits of ISO Management system
- Correspondence between ISO 9001, ISO, 14001 and ISO 45001
- To apply the ISO 14000 protocol for EMS
- To evolve strategies for Corporate Social Responsibility (CSR)

* Lecture-L *Tutorial-T *Practical-P *Credit-C	L	T	P	C
Per Week	3	1		4

Course Outcomes:		KL
1.	Understand the impact of business operations on environmental quality	K1
2.	Conceptualize the environmental policy for an industry	K2, K3
3.	Perform and analyze tools such life cycle assessment, environmental audits, evaluation of environmental performance for environmental decision-making	K3, K4
4.	Develop plans and protocols to conduct ISO 45000 - health and safety management systems	K4, K5
5.	Students can evolve environmental-management principles to achieve continual improvement in a corporate organization	K4, K6

Knowledge level: Remember (K1); Understanding (K2); Perform (K3); Analyse (K4); Synthesize (K5); Evaluate (K6)

Mapping course outcomes with programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	M	M	M	M	M	M	S	S
CO2	S	L	M	S	M	M	M	L	M	S
CO3	M	M	S	S	M	M	S	M	S	M
CO4	S	M	S	M	M	M	S	M	M	S
CO5	S	M	M	M	M	S	S	M	S	S

Strong | Moderate | Low

Assessment Methods: Test-T, Seminar- S, Assignment- A, Discussion- D

	Modules	T	S	A	D
Module I 5 lectures	**ISO Standard** Introduction – Development of ISO standard – Structure and features of ISO standard – Benefits of certification-certification procedure – Overview of ISO 14001, ISO 45001, ISO 26000, ISO 20400, ISO 27101 and its interrelations	✓	✓	✓	✓
Module II 6 lectures	**ISO 14001 - Environmental management systems** - Environmental policy- Environmental aspects – impact analysis - Objectives, targets and programme(s)- Implementation and operation – Checking - Management review- Implementation plan, Registration, Importance of ISO 14000 to the Management. Guidelines for environmental management systems auditing - General principles, Managing audit programme - Audit activities, steps in audit, Audit plan. Competence of auditors.	✓			
Module III 6 lectures	**Environmental Auditing** - types of environmental auditing, audit protocol - environmental audit process - pre-audit activities - onsite auditory - post-audit activity - Concept of LCA: Overview assessment methodology, Procedure for life cycle framework, ISO 14040 (LCA), General principles of LCA - Inventory Analysis, Impact Analysis, Interpretation -Optimisation and product improvement Waste Management: Sale and recycle, liquid, air, and solid waste management - Environmental Reporting - Corporate Environmental Reports	✓	✓		✓

Module IV 6 lectures	ISO 45000 Environmental Health and Safety: Concept of safety, health and environment. Diseases through pollution Basis of occupational health, biological monitoring (e.g. BEI), Occupational Hygiene, Concept of First Aid, Preventive Measures. Occupational Health & Safety Management System	✓	✓		
Module V 5 lectures	**Corporate Social Responsibility**- Principles of Responsible Investment - Corporates and Environmental Protection – Legislations related with CSR- Companies (Corporate Social Responsibility Policy) Rules. Benefits of CSR - Brand Differentiation - Consumer Perspective - Risk management - Employee Retaining - Laws and Legislations - Ethical Consumerism - Social Awareness - Corporate Greenwashing	✓	✓		✓
Current Trends 2 lectures	Advances in ……. : Recent concepts – Technological and Scientific developments – Real world cases/examples – Policy/Practice updates – Contradictions – World/Indian Scenario				✓
30 Lectures					

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- Banerjee B (2009) Corporate Environmental Management. Prentice-Hall Of India Pvt.
- Kamlesh Pritwani (2016) Sustainability of Business in the Context of Environmental Management. TERI Press
- Forest L. Reinhadt, 2000, Down to Earth – Applying Business principles to Environmental Management, Harvard Business school press. Boston, Massachusetts.
- Mark Anthony Camilleri (2018) Corporate Sustainability, Social Responsibility and Environmental Management: An Introduction to Theory and Practice with Case Studies (CSR, Sustainability, Ethics & Governance), Springer
- Samuel O. Idowu, René Schmidpeter 2024 CSR, Sustainability, Ethics & Governance, Springer

CORE 8 : MICROBIAL TECHNIQUES
Course Code: 25PGCC08

Course Objectives:

1. To provide a deep understanding of core microbiological laboratory techniques.
2. To train students in the cultivation, enumeration, and preservation of microorganisms.
3. To introduce advanced tools and techniques for microbial analysis and identification.
4. To ensure safe and sterile handling of microbial cultures under different biosafety levels.
5. To promote critical thinking and hands-on skills through experimental microbiology.

* Lecture-L *Tutorial-T *Practical-P *Credit-C	L	T	P	C
Per Week	3	1	0	4

Course Outcomes:		KL
1.	Demonstrate advanced understanding of microbial structure, function, genetics, and taxonomy across diverse domains of life.	K1, K2
2.	Apply modern techniques in microbiology for microbial identification and analysis.	K2, K3
3.	Analyze microbial interactions with hosts, other microbes, and environments to understand pathogenesis, symbiosis, and ecological roles.	K4, K5
4.	Critically assess microbial interactions and their influence on environmental processes such as decomposition, nutrient cycling, and pollution mitigation.	K4, K5
5.	Apply microbiological principles to design strategies for bioremediation, wastewater treatment, and environmental monitoring.	K3, K6

Knowledge level: Remember (K1); Understanding (K2); Perform (K3); Analyse (K4); Synthesize (K5); Evaluate (K6)

Mapping course outcomes with programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	M	L	M	L	M	M	S	M
CO2	M	S	M	M	M	L	S	S	S	M
CO3	M	M	M	M	M	M	M	M	S	M
CO4	M	M	M	M	M	M	S	S	S	S
CO5	M	S	S	M	M	M	S	S	S	S
Strong			Moderate			Low				

Assessment Methods: Test-T, Seminar- S, Assignment- A, Discussion- D

	Modules	T	S	A	D
Module I **5 lectures**	**Basic Microbiological Techniques :** History and scope of microbiology - Sterilization techniques: physical methods -; Heat-dry, Incineration and moist heat, Tyndallization, Autoclave, Hot air oven, Laminar air flow, filtration-Seitz filter, Membrane filter. Radiation methods: Ionizing and non-ionizing radiations (UV Rays, Gamma Rays and cathode rays) - Chemical methods: Disinfectants (Phenol/Alcohol), Antiseptic (Iodine,/ hydrogen peroxide), Sanitizer (chlorine), Germicidal (Glutaraldehyde/octenidene), Microbicidal (Silver nitrate/streptomycin), Microbiostatic agents (Sodium azide/ penicillin). Preparation of culture media: Definition, classification and types- solid, semisolid, broth, Natural, semisynthetic, synthetic, differential and selective media, transport media, Nutrient agar (NA), nutrient broth, Potato dextrose agar (PDA), Yeast extract mannitol agar (YEMA), Sabourud's dextrose agar (SDA), Mac Conkey's agar (MA).	✓		✓	✓
Module II **6 lectures**	**Cultivation and Isolation Techniques** Growth requirements and conditions for various microbes - Batch, fed-batch, and continuous culture systems - Isolation techniques: streak plate, pour plate, spread plate, serial dilution - Pure culture techniques and colony morphology.	✓			

Module III **6 lectures**	**Microscopy and Staining** Principles and types of microscopy: bright field, dark field, phase contrast, fluorescence, electron microscopy (TEM, SEM) - Sample preparation for microscopy - Staining techniques: simple, differential (Gram, acid-fast), structural stains (spore, capsule, flagella) - Instruments: centrifuge, pH meter, Colony counter, Incubator (Principles, components and use)	✓	✓		✓
Module IV **6 lectures**	**Quantitative Microbial Techniques** Microbial growth kinetics and measurement - Viable and total count methods (CFU, turbidity, direct count using hemocytometer) - Most Probable Number (MPN) and membrane filtration techniques - Antibiotic sensitivity testing (disc diffusion, MIC, MBC)	✓	✓		
Module V **5 lectures**	**Ecological and Environmental Microbiology:** Microbe-microbe and microbe-host interactions (symbiosis, competition, cooperation), Decomposition and nutrient recycling, Microbial food webs and trophic interactions, Soil microbiomes and rhizosphere interactions, Aquatic microbiology (freshwater and marine) , Extremophiles and life in extreme environments, Biofilms and microbial mats, **Applied Environmental Microbiology:** Microbial roles in bioremediation and biodegradation, Wastewater treatment microbiology	✓			✓
Current Trends **2 lectures**	Role of extremophiles in environmental adaptations, Microbial applications in bioenergy production. Innovations in metagenomics for studying microbial communities				✓
30 Lectures					

References

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- General Microbiology: RY Stanier; McMillan Press.
- General Microbiology: Hans G Schiegel; Cambridge University Press.
- Textbook of Microbiology: Dubey and Maheshwari; S. Chand Co. Ltd.
- Cullimore D. R. (2010). Practical Atlas for Bacterial Identification. (2nd Edition). -Taylor &Francis.
- Collee J. G., Fraser A.G. Marmion B. P. and Simmons A. (1996). Mackie & McCartney Practical Medical Microbiology. (14th Edition). Elsevier, New Delhi.
- Michael T. Madigan, Kelly S. Bender, Daniel H. Buckley, W. Matthew Sattley, David A. Stahl , 2023, ***Brock Biology of Microorganisms ,*** 16th Edition , Pearson Publishers **ISBN:** 978-0-13-589151-1 (Hardcover)
- Raina M. Maier, Ian L. Pepper, Charles P. Gerba, 2015, ***Environmental Microbiology*** 3rd Edition Academic Press (an imprint of Elsevier) **ISBN:** 978-0-12-394626-3 (Hardcover)
- Ronald M. Atlas, Richard Bartha 1997, ***Microbial Ecology: Fundamentals and Applications,*** 4th , Benjamin Cummings, **ISBN:** 978-0-8053-4523-5 (Hardcover)

CORE 9: ENVIRONMENTAL DATA ANALYTICS AND RESEARCH METHODS

COURSE CODE: 25PGCC09 (Formerly Statistics and Numerical Methods / Research Methodology)

Course Objectives:

- Gain foundational skills in data handling, analysis, and interpretation using tools like Excel, R, or Python.
- Apply basic statistical methods to identify patterns and trends in environmental datasets.
- Create meaningful visualizations to communicate insights effectively and understand to solve real-world environmental problems using data analytics techniques.
- To educate the learners on statistical tools that could support data analysis pertaining to business situations

* Lecture-L *Tutorial-T *Practical-P *Credit-C	L	T	P	C
Per Week	**3**	**1**	**0**	**4**

Course Outcomes:		**KL**
1.	Demonstrate the ability to identify and access environmental datasets and preprocess raw environmental data to make it suitable for analysis, addressing issues like missing values, inconsistencies, and outliers.	K1 , K3, K4
2.	Apply fundamental statistical techniques to summarize environmental data, identify trends, and make evidence-based inferences.	K2 & K3
3.	Utilize exploratory data analytics techniques to uncover patterns, relationships, and anomalies in environmental datasets, enabling informed decision-making.	K4
4.	Gain proficiency in using data analysis tools such as Excel, Python (pandas, Matplotlib, Seaborn), or R (ggplot2, dplyr) for environmental analytics.	K3, K5
5.	Understand how environmental data analytics can be used to inform sustainable policies and practices, contributing to environmental conservation and management efforts.	K2, K6

Knowledge level: Remember (K1); Understanding (K2); Perform (K3); Analyse (K4); Synthesize (K5); Evaluate (K6)

Mapping course outcomes with programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	M	M	M	M	M	S	S	S	M
CO2	M	L	M	M	M	M	S	M	S	M
CO3	M	L	M	M	M	M	S	S	S	M
CO4	M	M	M	M	M	M	S	S	S	M
CO5	S	L	M	M	S	S	M	M	S	S
Strong			Moderate			Low				

Assessment Methods: Test-T, Seminar- S, Assignment- A, Discussion- D

	Modules	T	S	A	D
Module I 5 lectures	**Introduction to environmental data analytics**, Importance of data analytics in environmental decision-making, Types and sources of environmental data, datasets, introduction to basic programs(Excel, Python and R), Identifying patterns and anomalies in environmental data. Visualization in environmental data analysis	✓			✓
Module II 6 lectures	**Statistics:** Importance and Scope, Measures of Central tendency, Mean Weighted Arithmetic Mean, Geometric Mean and Harmonic Mean. Median and Mode, Measures of Quartiles, Deciles and Percentiles. Problems , **Applications of Mean, Median and Mode, Positional measures.** Measures of dispersion, Standard Deviation, Variance, Skewness, Kurtosis and Moment. Correlation, Types of correlation, Spearman Rank Correlation. Regression	✓	✓	✓	
Module III	**Probability**, Concepts and Definition, Rule of Probability, Baye's theorem and Expected value. Probability Distribution: Binomial, Poisson and Normal	✓	✓	✓	✓

6 lectures	distributions. Test of hypothesis and inferences, Setting of hypothesis, Type I and Type II error, Z-test, t-test, ANOVA and Chi-Square test Problems				
Module IV 6 lectures	**Research Process:** Generating Research Ideas, Developing a research project structure of a research proposal, Organising Survey and Interviews, Collection of Data - Sampling design and Techniques - Classification and Representation of Data (Graphical and Diagrammatic). Research Design - Deduction and Induction causality - Dialectical Materialism – Models - Research methods - historical, theoretical and empirical - case study - objectivity in research	✓	✓	✓	
Module V 5 lectures	Thesis, Research and Popular Article writing, short communications – Introduction, Literature Review, Discussion, format and writing, preparing tables, figures and reference lists (Microsoft Excel), importance of Scopus, h index and citations	✓		✓	✓
Current Trends 2 lectures	Ethical considerations in environmental data usage, Addressing uncertainties and biases in data, Communicating findings effectively to stakeholders. Publicly available datasets from government and non-governmental organizations (e.g., EPA, NOAA, WHO).				✓
30 Lectures					

References

- Statistical Methods by S.P. Gupta. Sultan chand& Sons New Delhi,2004.
- Numerical methods, Balaguruswamy E TMH Publications
- Introduction to Numerical analysis, Froberg C E Addison Wesley
- Vogel "Text book of Quantitative inorganic analysis (2004) Bencetts J Denney, R.C. Jeffery, G.H. and Mendham J. Longman Scientific and Technical U.K.
- Molecular cloning – a laboratory manual 3rd edition-Joseph same brook and David W Russell, Cold Spring Harbor Laboratory Press, New York.
- Daniel R. Montello and Paul Sutton 2006, An introduction to Scientific Research Methods in Geography, Sage Publication Inc.
- S.P. Gupta (2004) Statistical Methods, Sultan Chand and Sons, New Delhi
- Day, R.A. 1998. How to write and publish a Scientific paper 5th ed. Orynx Press Phoenix
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- Ralph R.B. Von Frese (2023) Basic Environmental Data Analysis for Scientists and Engineers Paperback , CRC press

CORE (CHOICE0 10: ENVIRONMENTAL SOCIAL GOVERNANCE

COURSE CODE: 25PGCC10

Course Objectives:

- Understand the foundations of ESG and its role in sustainable development.
- Explore environmental, social, and governance factors influencing organizations.
- Learn frameworks, regulations, and standards for ESG reporting and compliance.
- Explore the intersections of ESG with policy, global markets, and industry frameworks.

* Lecture-L *Tutorial-T *Practical-P *Credit-C	L	T	P	C
Per Week	3	1	0	4

Course Outcomes:		KL
1.	Students will develop a deep understanding of ESG frameworks, principles, and their significance in promoting sustainable and ethical business practices.	K1 , K2
2.	Students will acquire skills to evaluate and measure organizational ESG performance, and effectively communicate findings through standardized reporting tools such as GRI, SASB, or TCFD frameworks.	K2 & K3, K4
3.	Students will learn to integrate ESG considerations into corporate strategies, decision-making processes, and operational practices to drive long-term value creation.	K4, K5
4.	Students will demonstrate knowledge of global and local ESG regulations, standards, and ethical considerations, ensuring organizational compliance and sustainability leadership.	K2, K5, K6
5.	Students will develop the ability to analyze complex ESG-related challenges, devise innovative solutions, and contribute to creating sustainable business and societal outcomes.	K3,K5,K6

Knowledge level: Remember (K1); Understanding (K2); Perform (K3); Analyse (K4); Synthesize (K5); Evaluate (K6)

Mapping course outcomes with programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	L	M	M	M	M	M	L	S	S
CO2	S	M	M	M	M	M	S	M	S	S
CO3	S	M	M	M	M	S	S	M	S	S
CO4	S	L	M	M	M	M	M	L	M	S
CO5	S	M	M	M	S	S	S	M	S	S
Strong			Moderate			Low				

Assessment Methods: Test-T, Seminar- S, Assignment- A, Discussion- D

	Modules	T	S	A	D
Module I 5 lectures	**Introduction to ESG** : Definition of ESG, Understanding ESG and its Importance, ESG's role in global sustainability and corporate responsibility, Trends in ESG investment and corporate adoption, Investors, consumers, policymakers, and community perspectives, ESG Stakeholders, Relationship between ESG and the UN Sustainable Development Goals (SDGs), Global drivers of ESG adoption: Economic, legal, and societal pressures	✓		✓	✓
Module II 6 lectures	**Environmental Factors:** Climate Change and Carbon Management, Climate risks and opportunities, Net-zero commitments and carbon accounting frameworks, Carbon markets, offsets, and trading, Resource Management and Biodiversity: Sustainable resource use (energy, water, materials), Impact of operations on biodiversity and ecosystems	✓	✓	✓	
Module III 6 lectures	**Social Factors:** Human Rights and Labor Practices, Diversity, equity, and inclusion (DEI), Supply chain ethics and labor standards, Community	✓	✓	✓	✓

	Impact and Social Responsibility, Corporate social responsibility (CSR) programs, Social license to operate and community engagement, DEI (Diversity, Equity, and Inclusion) metrics and strategies,				
Module IV 6 lectures	**Governance Factors:** Corporate Governance and Leadership, Transparency, accountability, and ethical leadership, Board diversity and decision-making structures, ESG Risk Management and Compliance, Anti-corruption policies, Risk assessment frameworks, Balancing profit with ESG priorities, Governance metrics and performance measurement	✓	✓	✓	
Module V 5 lectures	**ESG Frameworks and Reporting:** ESG Standards and Certifications, Overview of standards like GRI, SASB, TCFD, and CDP, Industry-specific ESG considerations, ESG Reporting and Metrics, Best practices for data collection and disclosure, Tools for ESG reporting, Business Responsibility & Sustainability Reporting (BRSR)	✓	✓	✓	✓
Current Trends 2 lectures	**ESG in Practice:** Case studies of companies leading in ESG integration, Challenges and lessons learned, Developing an ESG Strategy: Crafting actionable ESG strategies for businesses, Future trends and innovations in ESG				✓
30 Lectures					

References:

- *Principles of Sustainable Finance* (2018) by Dirk Schoenmaker and Willem Schramade, Oxford University Press
- *The ESG Handbook: The Guide for Investors* by Betsy Atkins 2019
- Industry ESG reports (e.g., BlackRock, MSCI ESG Ratings)
- UN SDGs, World Economic Forum ESG Resources
- Academic Journals: *Journal of Environmental Economics and Management*, *Corporate Governance: An International Review*
- Colin Read (2023) Understanding Sustainability Principles and Esg Policies: A Multidisciplinary Approach to Public and Corporate Responses to Climate Change Springer International Publishing , Palgrave MacMillan

CORE (CHOICE) 10 : SUSTAINABLE ECOTOURISM

COURSE CODE: 25PGCC10

Course Objectives:

- To know the concepts and purpose of Ecotourism
- To understand the components and resources for ecotourism
- Learn about the people participation in Ecotourism and identify the sustainable ecotourism strategies.

* Lecture-L *Tutorial-T *Practical-P *Credit-C	L	T	P	C
Per Week	3	1	0	4

Course Outcomes:		KL
1.	Students will demonstrate a comprehensive understanding of sustainable ecotourism principles and their alignment with environmental conservation, cultural preservation, and socio-economic development.	K1 , K2
2.	Students will Critically assess the environmental, cultural, and economic impacts of ecotourism activities and develop strategies to mitigate negative consequences while promoting sustainability.	K2, K3, K4
3.	Students will develop and implement ecotourism projects or strategies that integrate conservation goals, community engagement, and responsible resource management.	K5, K6
4.	Students will apply national and international policies, certifications, and governance frameworks to promote sustainable practices within ecotourism industries.	K3, K5
5.	Course will foster community involvement in ecotourism initiatives, ensuring that local stakeholders benefit equitably while preserving their cultural and ecological heritage	K5, K6

Knowledge level: Remember (K1); Understanding (K2); Perform (K3); Analyse (K4); Synthesize (K5); Evaluate (K6)

Mapping course outcomes with programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	L	M	L	S	M	M	M	S	S
CO2	S	M	M	M	S	M	S	M	S	S
CO3	S	M	M	M	S	S	S	S	S	S
CO4	M	L	M	S	M	M	M	M	M	S
CO5	S	L	L	M	S	S	M	M	M	S
Strong			Moderate			Low				

Assessment Methods: Test-T, Seminar- S, Assignment- A, Discussion- D

	Modules	T	S	A	D
Module I 5 lectures	Definition and Concept of ecotourism , Characteristics and Functions of Eco-Tourism, Types and Nature of ecotourism, Social and ecological impacts of tourism, Ecotourism and related sub-sectors of the tourism industry, Ecotourism criteria, Environmental Effects of Ecotourism, Quebec declaration on ecotourism,	✓			✓
Module II 6 lectures	Ecotourism Resources: Identifying, listing, and understanding ecotourism resource categories, (natural, built, and events) Protected Areas: Definition, categories and roles, Identifying and describing ecotourism products, Access to resources: Challenges	✓	✓	✓	
Module III 6 lectures	Components of ecotourism, Ecotourism and the environment, Ecotourism and conservation, Ecotourism and protected areas, Ecotourism and economic benefits, Effects, fiscal impacts: taxes, fees expenditure, Ecotourism and social benefits, Ecotourism and local community, Revenue sharing, Effects of the income distribution, Inflation, Ecotourism and education, Emphasis on	✓	✓	✓	✓

	Slow Travel, Nature-Positive Tourism, Ephemeral Escapes, sustainable tourism entrepreneurship				
Module IV 6 lectures	Community-based tourism, Community-based tourism management, Monitoring the success and impacts of community-based tourism, Ecotourism practices, Transportation, Facilities (reduce, replace, reuse, recycle), Services (types, activities, and code of ethics), Pro poor tourism, Community-Centric Experiences, Culinary Conservation	✓	✓	✓	
Module V 5 lectures	Best practice guidance, Certification, case studies of eco-friendly practices in the tourism industry, Ecotourism in the national/global context, Convention on Biological Diversity, Millennium Development Goals, Ecotourism-based/related employment, Scope and areas of employment, National and State tourism board	✓		✓	✓
Current Trends 2 lectures	Cultural preservation, local employment, and equitable benefit-sharing, Technological Advances, Impact of social media on Tourism, Educational 'Back-of-House' Tours				✓
30 Lectures					

References

- Buckley, R. (2003). *Case studies in ecotourism.* Cambridge: CABI.
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- Bulbeck, C. (2005). *Facing the wild : ecotourism, conservation, and animal encounters*. London: Earthscan.
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- Fennell, D.A. (1999). *Ecotourism: an introduction*. London: Routledge.
- Lindberg, K. and D.E. Hawkins. (eds). (1993). *Ecotourism: a guide for planners and managers.* North Benninton: The Ecotourism Society.
- Page, S.J. and R.K. Dowling. (2002). *Ecotourism*. New York: Prentice Hall.
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  Wei-Ta Fang , Arba'at Hassan , Max Horng (2023) , **Ecotourism,** Environment, Health, and Education, Springer Publications

ELECTIVE 3: GREEN TECHNOLOGIES AND ENERGY MANAGEMENT

COURSE CODE: 25PGEC03

Course Objectives:

- To introduce the emerging concept of green and eco-friendly technologies available in various fields ; the key players for environmental management in future.
- To impart knowledge of sustainable technologies and innovative practices that promote environmental conservation and resource efficiency, enabling students to address global environmental challenges effectively.
- To foster entrepreneurial mindsets and skills by equipping students with the tools, strategies, and ethical understanding necessary to create and manage eco-friendly businesses that drive sustainable development.

* Lecture-L *Tutorial-T *Practical-P *Credit-C	L	T	P	C
Per Week	3	1	0	4

Course Outcomes:		KL
1.	Students will demonstrate a comprehensive understanding of sustainable practices, green technologies, and their applications in addressing environmental challenges.	K1
2.	Students will develop innovative solutions and prototypes using green technologies to mitigate environmental degradation and promote sustainable development.	K2 & K5
3.	Students will acquire the skills to identify opportunities, create business plans, and manage eco-friendly startups or ventures that align with sustainability principles.	K3, K5
4.	Students will be able to assess the environmental, social, and economic impacts of green technologies and ecopreneurship initiatives.	K4,K6
5.	Students will gain knowledge of environmental policies, regulations, and ethical considerations, applying them to create responsible and scalable green businesses.	K2,K3,K6

Knowledge level: Remember (K1); Understanding (K2); Perform (K3); Analyse (K4); Synthesize (K5); Evaluate (K6)

Mapping course outcomes with programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	M	M	S	M	M	M	S	S
CO2	S	M	M	M	S	S	S	M	S	S
CO3	S	L	M	M	M	M	M	M	S	S
CO4	M	M	M	M	S	M	M	M	S	S
CO5	S	L	M	S	M	M	M	M	S	S
Strong			Moderate			Low				

Assessment Methods: Test-T, Seminar- S, Assignment- A, Discussion- D

	Modules	T	S	A	D
Module I 5 lectures	Emerging green technology: A new horizon for environmental clean-up –Introduction- bioremediation-different types of bioremediation - bacterial remediation - phyto-remediation - myco-remediation - Carbon sequestration. Characteristics of market system –Traditional Business model. Concept of Sustainable development; History of ecoprenurialism . Characteristics of Entrepreneur-Sustainable business model. Need for eco-preneurship	✓			✓
Module II 6 lectures	Sanitation - Types and overview of onsite sanitation –off site sanitation - Ecological Sanitation (Eco-san) – a new green technology - socio-economic and environmental approach to ecological sanitation - Challenges - Practical difficulties to implementing ecological sanitation in Urban and Rural areas. Eco-preneurship in Agricultural Science & technologies-Organic farming- organic formulations, urban agriculture,	✓	✓	✓	

	mushroom cultivation, Bee keeping ,Single cell protein ,terrace &herbal gardening, organic certification, Biofertilizer production, Nursery technology				
Module III 6 lectures	Eco-Cycle solutions - Concept, Definition, Zero Waste management- Environment friendly product design, Clean production, distribution, Consumer empowerment, Resource recovery, Producer responsibility, subsidies. Ecopreneurship in waste management –wealth from wastes - composting, vermicomposting , RDF, Earthship , paper recycling, fly ash bricks, animal feed from waste- Fermentation technique.	✓	✓	✓	✓
Module IV 6 lectures	Non renewable energy resources and climate change; renewable energy resources and sustainability; green energy technologies – solar, wind, hydro, OTEC, geothermal, biomass, biofuels- concept of waste to energy –fuel cell- hydrogen fuel -scope and opportunities. Eco-preneurship in Green energy technologies-solar technologies, Bio-energy -RDF, Bio methanation, Bio-diesel production, Fuel cell, improved chullah.	✓	✓	✓	
Module V 5 lectures	Concept of Green Building: Sustainability and Energy Efficiency, Green buildings and sustainable ratings, designs of green buildings – resource efficiency improvements, material and energy management, waste management, LEED certification. Policies & regulation: Micro financing –evolution of MF in India. MFIs-formal-semi formal and informal-NABARD-SIDBI, Association for Sarva Seva Farms(ASSEFA), Mitrabharati, SADHAN, SEVA, Swayam Krishi Sangam, Entrepreneurship Development of India, ADB. Client characteristic microfinance services. Indian Government Business loan schemes MSMEs.	✓		✓	✓
Current Trends 2 lectures	Advances in ……. : Recent concepts – Technological and Scientific developments – Real world cases/examples – Policy/Practice updates – Contradictions – World/Indian Scenario				✓
30 Lectures					

References

- Handbook of renewable energy technologies.2011.Ahmed F Banzal(Brunel University, (UK)Ramesh C Bansal (The University of Queensland, Australia)Eds world scientific publishing Co pvt.Ltd 876P
- "Toilets that Make Compost" Low-cost, sanitary toilets that produce valuable Compost for crops in an African context by peter Morgan, Stockholm Environmental Institute 2007.
- Bauer,M.Mösle,P and Schwarz,M.2010 Green Building – Guidebook for Sustainable Architecture, Springer-Verlag Berlin Heidelberg
- Designing for Zero Waste: Consumption, Technologies and the Built Environment , by Steffen Lehmann (Editor), Robert Crocker (Editor) , (Earthscan Book Series on Sustainable Design) 1st Ed, Routledge Publishers, 2012
- The Zero Waste Solution: Untrashing the Planet One Community at a Time by Paul Connett Ph.D. (Author), Jeremy Irons (Foreword), Chelsea Green Publishing (October 18, 2013)
- *Larson, Andrea 2000. Business Strategy and the Environment. pp. 304–317.*
- McDonough, William 2002. *Cradle to Cradle: Remaking the Way We Make Things*. New York: North Point Press. pp. 27–30.
- Pastakia, A. 2002. Assessing ecopreneurship in the context of a developing country. . *Greener Management International*, 93-108.
- Yunus, *et al*., 2006. Creating a world without poverty: Social business and the future of capitalism. New York: Public Affairs.

ELECTIVE 3 : CLIMATE CHANGE, MITIGATION, ADAPTATION AND RESILIENCE
Course Code: 25PGEC03

Course Objectives:

- To provide an in-depth understanding of the science behind climate change.
- To analyze the impacts of climate change on ecosystems, societies, and economies.
- To explore mitigation strategies and adaptation measures to combat climate change.

* Lecture-L *Tutorial-T *Practical-P *Credit-C	L	T	P	C
Per Week	**3**	**1**	**0**	**4**

Course Outcomes:		KL
1.	Explain the scientific basis and evidence for climate change.	K1, K2
2.	Analyze the effects of climate change on natural and human systems.	K2, K3
3.	Assess mitigation strategies for reducing greenhouse gas emissions.	K2, K4
4.	Evaluate policies and global frameworks for addressing climate change.	K5, K6
5.	Develop sustainable solutions and adaptation measures for resilience.	K5, K6

Knowledge level: Remember (K1); Understanding (K2); Perform (K3); Analyze (K4); Synthesize (K5); Evaluate (K6)

Mapping course outcomes with programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	L	M	M	M	M	M	L	S	M
CO2	S	M	M	M	S	M	M	M	S	S
CO3	S	M	M	M	S	S	S	M	S	S
CO4	S	L	M	S	M	M	M	M	M	S
CO5	S	M	M	M	S	S	S	M	S	S
Strong			Moderate			Low				

Assessment Methods: Test-T, Seminar- S, Assignment- A, Discussion- D

	Modules	T	S	A	D
Module I 5 lectures	**Introduction to Climate Change:** Climate change vs. climate variability. Greenhouse gases: Sources, sinks, and atmospheric dynamics. Evidence of climate change: Temperature trends, sea level rise, and glacial retreat.	✓		✓	✓
Module II 6 lectures	**Impacts of Climate Change:** Effects on ecosystems: Biodiversity loss, shifts in species distribution, and ecosystem services. Impacts on agriculture, water resources, and food security. Socio-economic impacts: Displacement, health risks, and economic vulnerabilities.	✓			
Module III 6 lectures	**Climate Change Mitigation:** Carbon sequestration: Biological and geological method Renewable energy sources: Solar, wind, and bioenergy technologies. Low-carbon technologies: Energy efficiency, carbon capture, and storage. Role of afforestation and reforestation in mitigation.	✓	✓		✓
Module IV 6 lectures	**Policy and Governance:** International frameworks: United Nations Framework Convention on Climate Change (UNFCCC), Kyoto Protocol, and Paris Agreement. National and regional climate policies and initiatives. Role of stakeholders: Governments, NGOs, and the private sector in mitigation efforts.	✓	✓		
Module V 5 lectures	**Adaptation and Resilience:** Adaptation strategies for agriculture, water, and coastal systems. Urban resilience: Green infrastructure and climate-smart urban planning. Indigenous knowledge and community-based adaptation approaches.	✓			✓
Current Trends 2 lectures	**Current Contours *(Not for Final Exam, only for Discussion)*** Geoengineering and its potential role in mitigating climate change. Climate finance mechanisms: Carbon markets and green bonds. Advances in climate modeling and prediction tools.				✓
30 Lectures					

References

1. Henson, R. (2011). *The rough guide to climate change* (3rd ed.). Rough Guides.
2. Orr, D. W. (2011). *Down to the wire: Confronting climate collapse*. Oxford University Press.
3. Edenhofer, O., Pichs-Madruga, R., Sokona, Y., et al. (Eds.). (2011). *Renewable energy sources and climate change mitigation: Special report of the Intergovernmental Panel on Climate Change*. Cambridge University Press.
4. Held, D., Nag, E.-M., & Roger, C. (2013). *Climate governance in the developing world*. Polity Press.

Suggested Online resources

1. United Nations Climate Change (UNFCCC). *Climate action and policies*. https://unfccc.int
2. **IPCC Reports:**
   Intergovernmental Panel on Climate Change (IPCC). (2023). *AR6 Synthesis Report: Climate*

25PGPP03: PRACTICAL II: MICROBIAL TECHNIQUES

Course Objectives:

- To provide hands-on training in microbiological techniques for environmental studies.
- To study the diversity and functions of microorganisms in different environmental settings.
- To develop skills for isolating, culturing, and identifying environmental microbes.

	Practical Modules
	• Principles and methods of sterilization, Direct microscopic observations of bacterial shape – cocci, rods, chains, fungal spores, mycelium, yeast budding, • Preparation of growth media: bacteria, fungi and actinomycetes • Pure culture technique: Streak plate, spread plate and pour plate methods. • Bacterial motility by hanging drop method. • Isolation and purification of bacteria and fungi • Staining methods: Simple, acid fast, Gram staining, spore, Capsule, Lactophenol cotton blue staining • Isolation of bacteria from soil and water samples • MPN test for coliforms in water samples

Course Outcomes

- Isolate, identify, and characterize microorganisms from diverse environmental and clinical samples using morphological, biochemical, and molecular methods.
- Perform and interpret microbial growth experiments, including growth curve analysis and factors affecting microbial growth.
- Apply microbiological techniques in environmental, food, medical, and industrial microbiology contexts.

LAB MANUAL RECOMMENDATIONS (OPTIONAL):

1. **Nester, E. W., Anderson, D. G., & Roberts, C. E. (2018).***Microbiology: A Human Perspective (9th Edition)*. McGraw Hill Education.
2. **Gunasekaran, P. (2007).***Laboratory Manual in Microbiology*. New Age International Publishers.


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SEMESTER IV

CORE 11 : GLOBAL AND NATIONAL ENVIRONMENTAL ISSUES

COURSE CODE: 25PGCC11 (Self Study paper)

Course Objectives:

This course introduces the three aspects of sustainability how transportation planning practices and management strategies affect these aspects. It aims to provide knowledge about current environmental and energy policies and contemporary transportation issues in India and worldwide.

* Lecture-L *Tutorial-T *Practical-P *Credit-C	L	T	P	C
Per Week	**3**	**1**	**0**	**4**

Course Outcomes: At the end of the course, the students will be able to		**KL**
1.	Critically assess the effectiveness of international agreements (e.g., Paris Agreement, Convention on Biological Diversity) and national policies in addressing pressing environmental challenges.	K1 , K6
2.	Examine the socio-economic and ecological consequences of environmental issues, considering disparities between developed and developing nations.	K2 & K3
3.	Propose innovative and practical solutions to environmental problems by integrating scientific, technological, policy-based, and community-centered approaches.	K4, K5
4.	Demonstrate the ability to advocate for sustainable development by applying environmental science knowledge to public debates, policymaking, and local community action.	K3, K6
5.	Identify and analyze the root causes, scope, and interconnections of global and national environmental issues, including climate change, deforestation, biodiversity loss, and water scarcity.	K2, K3, K6

Knowledge level: Remember (K1); Understanding (K2); Perform (K3); Analyse (K4); Synthesize (K5); Evaluate (K6)

Mapping course outcomes with programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	L	M	S	M	M	M	M	M	S
CO2	S	M	M	M	S	M	M	M	S	S
CO3	S	M	M	M	S	S	S	M	S	S
CO4	S	L	M	M	M	M	M	L	S	S
CO5	S	M	M	M	S	M	M	M	S	S
Strong			Moderate			Low				

Assessment Methods: Test-T, Seminar- S, Assignment- A, Discussion- D

	Modules	T	S	A	D
Module I 5 lectures	Realms of Environment: Atmosphere, hydrosphere, lithosphere and Biosphere. Solar system, the Earths origin, age and internal constitution. Geological timescale. Overview of natural resources- Environmental problems faced by India and the world. Sustainable development-problems and perspectives.	✓	✓	✓	
Module II 6 lectures	Weather and climate: climate science, thermal inversion, heat island, natural hazards: volcanoes, Earth quake, tsunami, land slide, tornadoes, storms, Hurricane and flood. Coastal erosion Air pollution:- sources and impacts, -Green house gases; global warming, acid rain, *ENSO:-el-Nino; la-Nina climate change: Treaties and convention-ICCC.*	✓	✓	✓	

Module III 6 lectures	Energy Crisis: dimension of Crisis, problems faced: Solution of the crisis power sector reforms, policy initiatives, energy conservation, CNG its advantages as a fuel. Delhi experience and controversy, problems faced and future outlook, alternate fuel technologies, nuclear fuel controversies- international agreements	✓	✓	✓	
Module IV 6 lectures	Environment, Forest and wildlife: Forests in India forest cover and types of forests, deforestation and conservation, biodiversity, wildlife-endangered and threatened species, Biosphere reserves, wet lands, mangroves and coral reefs, wildlife conservation in India,Illegal trade in wildlife-poaching. Recent measures for wildlife protection and conservation national heritage- UNESCO's World Heritage list.	✓	✓	✓	
Module V 5 lectures	Safety and Environment: Social construction of environmental issues-anthropogenic pressure-conflicts and negotiation. Benefit-cost approach to environmental problems. Institutional mode of environmental planning-policy formulation and strategies-popular movements and people's participation	✓	✓	✓	✓
Current Trends 2 lectures	Stagnation in International Environmental Diplomacy, Questioning the Efficacy of U.N. Summits, Emphasis on Integrated Environmental Solutions, Sustainable Urban Development, Recognition of Interconnected Environmental Challenges				✓
30 Lectures					

References

- Gurdip Singh, 2005. 'Environmental Law in India', Macmillan India Ltd, New Delhi – 2.
- BalaKrishnamoorthy, 2005. Environmental Management, Prentice Hall of India Private Limited, New Delhi.
- S.K. Agarwal, 1997. Environmental Issues and themes, APH Publishing Corporation, New Delhi.
- John O Neil. R. Kerry Turner and Ian J. Batemaned ed., 2001. Environmental Ethics and philosophy, An Elgar Reference collection, USA.
- Paul F. Ploutz (2011) Global Warming, **Publisher** Xlibris
- Eric Lonergan and Corinne Sawers *(2022)Supercharge Me: Net Zero Faster*

CORE 12 : ECOSYSTEM SERVICES AND SUSTAINABILITY
Course Code: 25PGCC12

Course Objective:

- To identify the complexity and role of ecosystem and natural capital
- To understand the concepts and categories of ecosystem fabric and services
- Learning the methods to quantify the services provided by the ecosystem services
- Applying the ecosystem services for environmental sustainability and policy changes

* Lecture-L *Tutorial-T *Practical-P *Credit-C	L	T	P	C
Per Week	4	1		4

Course Outcomes:		KL
1.	Realize how critical are the ecosystem services for the sustainable livelihood	K1 , K2
2.	Analyze the ecosystem changes and its implications on human sustenance	K2 , K3
3.	Quantify the ecosystem services using appropriate tools	K3 , K4
4.	Appraise the policies and programs for ecosystem conservation	K5, K6
5.	Evolve protocols and approaches to engage community participation in ecosystem conservation	K5

Knowledge level: Remember (K1); Understanding (K2); Perform (K3); Analyse (K4); Synthesize (K5); Evaluate (K6)

Mapping course outcomes with programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	L	M	M	S	M	M	M	S	S
CO2	S	M	M	M	S	M	M	M	S	S
CO3	S	S	M	M	M	S	S	M	S	M
CO4	S	L	M	S	M	M	M	M	M	S
CO5	S	L	L	M	S	S	M	M	M	S

Strong | Moderate | Low

Assessment Methods: Test-T, Seminar- S, Assignment- A, Discussion- D

	Modules	T	S	A	D
Module I 5 lectures	**Introduction to Ecosystem and its components:** Ecosystems - Biotic and Abiotic components- Various kinds of ecosystems - productivity of Ecosystems - Limiting factors in ecosystems - Population – Structure, Meta Population theory - demography and Growth -Community structure and interrelations -Energy flow in Ecosystems -Food chain, food web -Ecological pyramids	✓		✓	✓
Module II 6 lectures	**Ecosystems Services** Introduction - Over view of ecosystem services - Conceptual bases - Provisioning services: Food, Raw material, Fresh water and Medicinal resources - Regulatory services: Climate, Air quality, Water Management, Pollination and Biological control -Cultural services: Tourism and recreation – Global value of Ecosystem services	✓			
Module III 6 lectures	**Assessment of Ecosystem Services** Quantifying and Valuing Ecosystem service – Economic/Service indicators and value framework - TEEB Ecosystem Service Valuation Database Valuing Techniques- Total Economic Value - Direct use values , Indirect use values, Non use value; Direct market valuation, Indirect market valuation, Survey based valuation - **TESSA** – Market based and Non market approaches – Value Transfer method – Analysis - Interpretation and Decision Making – Case Studies	✓	✓		✓

Module IV 6 lectures	**Conservation of Ecosystem services** Ecosystems and sustainable human well-being – Threats to Ecosystem services – Human Impacts – Ecological foot prints - Conservation Policies and Programs – Global and Regional; MDG, SDG REDD+ - Indian Scenario – Environmental Protection Acts, Policies and Programs – Forest and Biodiversity protection programs – Ecological sensitive areas – Western Ghats and its ecologically sensitive area - India's National Action Plan on Climate Change	✓	✓		
Module V 5 lectures	**Recent Trends in Environmentally Sustainable Management** Participatory Management- PPP, Community Participation in Water Resource Management, Forest Resource Management, Energy Resource Management - Sustainable Agriculture – Organic Farming - Challenges in SD: Poverty, Decentralisation, Laws and Legislations, Ethical Consumerism, Social Awareness.	✓			✓
Current Trends 2 lectures	Advances in ……. : Recent concepts – Technological and Scientific developments – Real world cases/examples – Policy/Practice updates – Contradictions – World/Indian Scenario				✓
30 Lectures					

References

- Grunewald, Karsten, Bastian, Olaf (2015) Ecosystem Services – Concept, Methods and Case Studies, Springer Publications
- McCarthy, D. &Morling, P. (2014) A Guidance Manual for Assessing Ecosystem Services at
- Natura 2000 Sites. RoyalSociety for the Protection of Birds: Sandy,Bedfordshire.
- UNU/IAS Report (2003) Urban Ecosystems Analysis: Identifying Tools and Methods. United Nations University Institute of Advanced Studies (UNU/IAS), 5–53–67 Jingumae, Shibuya–ku, Tokyo, 150–8304, Japan
- Rachel A. Neugarten et al (2018) Tools for measuring, modelling, and valuing ecosystem services. Publisher IUCN, Gland, Switzerland

LIST OF NON MAJOR ELECTIVE COURSES

S.No	COURSE TITLE	CI
1.	PLASTIC POLLUTION AND ITS IMPACTS**	Dr.R.Mohanraj
2.	ENVIRONMENTAL STUDIES FOR COMPETITIVE EXAMS	Dr.N.D.Shrinithivihahshini
3.	BIODIVERSITY STUDIES: WALKS IN THE CAMPUS**	Dr.N.D.Shrinithivihahshini
4.	CLIMATE CHANGE AND ITS IMPACTS**	Dr.R.Mohanraj
5.	MOBILE APPS AND OPEN SOURCE TECHNOLOGY FOR GEO ENVIRONMENTAL STUDIES	Dr.M.Prashanthi Devi
6.	GEOAI AND IOT FOR SUSTAINABLE ENVIRONMENT AND INFRASTRUCTURE**	Dr.M.Prashanthi Devi

**** Post Approval**

LIST OF VALUE ADDED COURSES

S.No	COURSE TITLE	CI
1.	GREEN AUDIT **	Dr.R.Mohanraj
2.	ORGANIC FARMING	Dr.N.D.Shrinithivihahshini
3.	TERRACE GARDENING/ ADVANCES IN CONTAINER GARDENING	Dr.N.D.Shrinithivihahshini
4.	RURBANISATION: CONCEPTS FOR SUSTAINABLE LIVING**	Dr.M.Prashanthi Devi
5.	CARBON FOOTPRINT ASSESSMENT	Dr.N.D.Shrinithivihahshini

**** Post Approval**