PERIYAR UNIVERSITY

Salem-636 011

(Reaccredited with 'A' Grade by the NAAC)

DEPARTMENT OF ENVIRONMENTAL SCIENCE

FIVE YEAR INTEGRATED

M.Sc. ENVIRONMENTAL SCIENCE

[Choice Based Credit System (CBCS)]

OBE SYLLABUS

(Effective from the academic year 2020-2021 and thereafter)

FIVE YEAR INTEGRATED M. Sc. ENVIRONMENTAL SCIENCE

OBE REGULATIONS AND SYLLABUS

(with effect from the academic year 2020-2021 onwards)

1. Preamble

Growing population and high standards of living put increasing pressure on our environment. Since the beginning of industrialization and urbanization, we have been facing increasing number of environmental challenges such as air, water and soil contamination, energy crisis, land degradation, deforestation, loss of biodiversity, global warming and climate change, etc., Considering the above issues, addressing environmental problems from a scientific perspective is utmost important for today's world. Hence, there is a need to develop the next generation graduates as skilled professionals in the multidisciplinary field of Environmental Science through the integrated degree programme to solve the global environmental issues.

2. General Graduate Attributes

1. ***Environmental Knowledge***

   Apply the basic knowledge of environmental components and its interactions and to conceptualize the domains towards environmental protection and to visualize the environmental management perspectives

2. ***Critical Thinking Skills***

   To critically analyze and evaluate the environment related issues and their sustainable management

3. ***Problem Solving Skills***

   Identify, analyze and assess the complex environmental issues and to apply the knowledge to solve the issues

4. ***Technical Skills***

   To acquire and equip with technical knowledge on critical environmental problems and to devise technical strategies for the betterment of the environment

5. ***Use of Modern Tools***

   To acquire the knowledge and working experience on modern tools in terms of instrumentation, softwares and research methods which can be used to assess the environmental quality

6. ***Research Skills***

   Improve the research-oriented skills by involving the basic, applied and field-based research works

7. ***Individual and Team Work***

   To develop the skills to work individually as well as a team in a proposed project work in order to manage the task

8. ***Project Management***

To manage and coordinate specific environmental work, tasks or projects and to apply specific principles and methodologies to carry out environmental projects

9. ***Societal and Environmental Concern***

To have appealing concern over the environment and its well-being, and to apply the acquired knowledge and skills for the societal upliftment and environmental protection

10. ***Environmental Management***

To improve to undertake and manage environment related works and to develop a leadership quality and capacity to manage a team for carrying out assigned tasks

11. ***Innovation and Entrepreneurship***

To apply the acquired skills and knowledge in the field of environmental science and to initiate small scale start-ups and upscale the process towards entrepreneurship

3. Programme Specific Qualification Attributes

- **Knowledge and understanding level (K1 and K2)**

Students will be able to understand the basic components of ecology and environment, chemistry of pollutants and their toxic effects, biodiversity and natural resources and their process for sustainable development.

- **Application level (K3)**

Students will be capable of applying microbes, plants and animals for potential environmental cleanup and green energy production, and to generate value-added products through waste recycling.

- **Analytical level (K4)**

Students will be able to analyze the environmental quality parameters and to address the issues of different environmental compartments.

- **Evaluation capability level (K5)**

Students can acquire the capability of evaluating the responsible factors for environmental related issues and can be able to apply the acquired knowledge in providing solutions.

- **Scientific or synthesis level (K6)**

Students will be able to synthesize or develop new processes, products and to formulate new scientific tools related to sustainable environmental management.

4. Vision

- Create and maintain excellence in Environmental Science and contribute knowledge and effort in bringing up rich posterity in environmental sustainability.

5. Programme Objectives and Outcomes

Programme Educational Objectives (PEOs)

Graduates of Integrated M.Sc. Environmental Science program will be

PEO1	Utilizing domain knowledge to understand the environment and to provide solutions for the development of society.
PEO2	Applying research and acquired skills with a rich set of communication and leadership skills to sustain in the environment.
PEO3	Expressing constant development in their specialized career through life-long learning, appreciating human values and ethics.

Programme Outcomes (PO)

After successful completion of the Five years Integrated M.Sc. Environmental Science Programme, the students are expected to have

PO1	Deep knowledge in natural resources, ecosystem and their biogeochemical processes, biodiversity, Geographic Information Systems (GIS) and their importance, various elements of climate change and environmental clearance procedures.
PO2	Good understating in toxicological properties of environmental pollutants and their impact on environment, environmental remediation bioprocess, occupational diseases, nanomaterials and their toxicity.
PO3	Capability in applying microbes, plants and animals for potential environmental cleanup and energy production, and to generate value added products through waste recycling and other sustainable environmental management practices.
PO4	Acquire more knowledge and proficiency in Environmental Impact Assessment, (EIA), pollution monitoring and management.
PO5	Skills in methods used for environmental cleanup, EIA process, GIS to monitor the environmental issues and critically analyzing the global climate change.
PO6	Expertise to become an environmental consultant / manager at local, regional and national level industry / institution /organizations.
PO7	Capability to become an entrepreneur in the field of EIA, GIS, waste management and waste recycling, natural product development, and environmental safety trainer.
PO8	Qualification to be employed as a researcher / scientist / faculty in Colleges / Universities / Government sectors / Research and Development organizations.

6. Candidate's eligibility for admission

Candidate who has passed in Higher Secondary Examinations with science subjects (Physics, Chemistry, Mathematics/ Biology/ Botany/ Zoology/ Agriculture/ Microbiology/ Computer Science or any other Life Science subjects or any other Examination as equivalent thereto under the Board of Higher Secondary Education, Government of Tamil Nadu / CBSE / ICSE or any other boards equivalent thereto shall be eligible for admission to Five years Integrated M.Sc. Degree Programme in Environmental Science.

7. Duration of the programme

The duration of the Integrated M.Sc. Environmental Science shall be over a period of **Five Years** from the commencement of the course. Undergraduate degree shall be awarded after successful completion of three years (up to VI Semester).

8. CBCS- Structure of the Programme

The programme structure comprises of two parts.

Course Component	No. of Courses	Hours of Learning	Marks	Credits
Part A (Credit Courses)				
Language Courses	4	5 h/ Week / Course	400	12
English Courses	4	5 h/ Week / Course	400	12
Core Courses	19	5 h/ Week / Course	1900	95
Allied Courses	4	4 h/ Week / Course	400	16
Elective Courses	4	4 h/ Week / Course	400	16
Non-Major Elective Courses	4	3 h/ Week / Course	400	10
Skill Based Elective Courses	6	3 h/ Week / Course	600	12
Practical Courses - Major	10	3 h/ Week / Course	1000	23
Practical Courses - Allied	4	3 h/ Week / Course	400	8
Research Projects	2	12 h & 30 h / week	300	14
Field Projects/Work	8	2 h/Week	400	8
Industrial Visits/Study Tour	1		50	2
Value Education/Yoga	1		100	2
Human Rights	1		100	
Environmental Studies (UGC mandatory course)	1	1 h / week / course	100	2
Sub Total	**76**		**6900**	**232**
Part B (Self-Learning Credit Courses)				
Online Courses (MOOC /SWAYAM)	4		400	8
Industry Oriented Courses (Certificate courses)	2		100	2
Total	**6**		**500**	**10**

9. Curriculum structure for each semester as per courses alignment

The curriculum for the Integrated M.Sc. Environmental Science Degree Programme shall comprise of the following courses according to the syllabus and books prescribed from time to time.

Part - I	Tamil / Other languages
Part - II	English
Part - III	1. Core Courses
	2. Allied Courses
	3. Major Elective Courses
	4. Research Projects
	5. Field Projects/Works
Part - IV	1. Non-Major Elective Courses
	2. Skill Based Elective Courses
	3. Industry Oriented Self-Learning Courses
	4. Environmental Studies (UGC mandatory course)
	5. SWAYAM/ MOOC Courses
	6. Value Education
	7. Human Rights
Part - V	Extension Activities (NSS / NCC / Sports / YRC and other co- and extracurricular activities offered under Part V)

Semester-wise Courses

Semester I		**Semester II**	
S.No.	**Courses**	**S.No.**	**Courses**
1	Language Part I - Paper 1	10	Language Part I - Paper 2
2	Language Part II - Paper 1	11	Language Part II - Paper 2
3	Major Core - Paper 1	12	Major Core - Paper 2
4	Major Core - Practical 1	13	Major Core - Practical 2
5	Allied I - Paper 1	14	Allied I - Paper 2
6	Allied I - Practical 1	15	Allied I - Practical 2
7	Field Project/Work 1	16	Field Project/Work 2
8	Value Education	17	Environmental Studies (UGC mandatory)
9	Environmental Studies (UGC mandatory)	18	Skill Based Elective Paper 1
Semester III		**Semester IV**	
19	Language Part I - Paper 3	28	Language Part I - Paper 4
20	Language Part II - Paper 3	29	Language Part II - Paper 4
21	Major Core - Paper 3	30	Major Core - Paper 4
22	Major Core - Practical 3	31	Major Core - Practical 4
23	Allied I - Paper 3	32	Allied I - Paper 4
24	Allied I - Practical 3	33	Allied I - Practical 4
25	Field Project/Work 3	34	Field Project/Work 4
26	Skill Based Elective Paper 2	35	Skill Based Elective Paper 3
27	Non-Major Elective Paper 1	36	Non-Major Elective Paper 2

Semester V		Semester VI	
S.No.	**Courses**	**S.No.**	**Courses**
37	Major Core - Paper 5	46	Major Core - Paper 8
38	Major Core - Paper 6	47	Major Core - Paper 9
39	Major Core - Paper 7	48	Major Core - Practical 7
40	Major Core - Practical 5	49	Major Core - Project 1
41	Major Core - Practical 6	50	Major Elective - Paper 2
42	Major Elective – Paper 1	51	Skill Based Elective Paper 5
43	Field Project/Work 5	52	SWAYAM/ MOOC Paper 2
44	Skill Based Elective Paper 4		
45	SWAYAM/ MOOC Paper 1		
Semester VII		**Semester VIII**	
53	Major Core - Paper 10	60	Major Core - Paper 13
54	Major Core - Paper 11	61	Major Core - Paper 14
55	Major Core - Paper 12	62	Major Core - Paper 15
56	Major Core - Practical 8	63	Major Core - Practical 9
57	Field Project/Work 6	64	Field Project/Work 7
58	Major Elective - Paper 3	65	Major Elective - Paper 4
59	Skill Based Elective Paper 6	66	Non-Major Elective Paper 3
		67	SWAYAM/ MOOC Paper 3
		68	Human Rights
Semester IX		**Semester X**	
69	Major Core - Paper 16	77	Major Core - Project 2
70	Major Core - Paper 17	78	Industrial Visits/Study Tour
71	Major Core - Paper 18		
72	Major Core - Paper 19		
73	Major Core - Practical 10		
74	Field Project/Work 8		
75	Non-Major Elective Paper 4		
76	SWAYAM/ MOOC Paper 4		

- Non-Major Elective Course (NMEC) can be chosen by the candidate from other Department courses offered in the University Departments.
- Skill Based Elective Course (SBEC) papers can be chosen by the candidates from the list of SBEC prescribed in this syllabus.
- SWAYAM/MOOC Courses can be chosen by the candidates from the list of courses offered by SWAYAM Portal during their specific semester of study.

List of Major Papers (Core / Elective / Skill Based Elective Courses / Practical Courses)

S. No.	Semester	Courses	Code
1	I	Earth Ecology and Environment	20UPEVS2C01
2	II	Environmental Chemistry	20UPEVS2C02
3	III	Environmental Microbiology	20UPEVS2C03
4	IV	Environmental Biochemistry and Toxicology	20UPEVS2C04
5	V	Biodiversity and Conservation	20UPEVS2C05
6	V	Environmental Pollution	20UPEVS2C06
7	V	Waste Management	20UPEVS2C07
8	VI	Energy and Environment	20UPEVS2C08
9	VI	Environmental Analysis and Techniques	20UPEVS2C09
10	VII	Natural Resources Management	20UPEVS2C10
11	VII	Environmental Impact Assessment	20UPEVS2C11
12	VII	Environmental Biotechnology	20UPEVS2C12
13	VIII	Climate Change and Current Issues	20UPEVS2C13
14	VIII	Environmental Geoinformatics	20UPEVS2C14
15	VIII	Pollution Control Strategies	20UPEVS2C15
16	IX	Environmental Safety and Health	20UPEVS2C16
17	IX	Research Methodology and Instrumentation	20UPEVS2C17
18	IX	Disaster Management	20UPEVS2C18
19	IX	Environmental Laws and Policies	20UPEVS2C19

S. No.	Semester	Core Elective Courses	Code
1	V / VI	Agroforestry and Silviculture	20UPEVS2E01
2		Biostatistics and Environmental Modelling	20UPEVS2E02
3		Cancer Biology and Environmental Carcinogens	20UPEVS2E03
4		Ecotourism	20UPEVS2E04
5		Marine Biotechnology	20UPEVS2E05
6	VII / VIII	Environmental Economics	20UPEVS2E06
7		Environmental Engineering	20UPEVS2E07
8		Environmental Nanoscience	20UPEVS2E08
9		Environmental Management System	20UPEVS2E09
10		Forest and Wildlife Management	20UPEVS2E10

S. No.	Semester	Core Practical Courses	Code
1	I	Core Practical -1	20UPEVS2P01
2	II	Core Practical -2	20UPEVS2P02
3	III	Core Practical -3	20UPEVS2P03
4	IV	Core Practical -4	20UPEVS2P04
5	V	Core Practical -5	20UPEVS2P05
6	V	Core Practical -6	20UPEVS2P06
7	VII	Core Practical -7	20UPEVS2P07
8	VIII	Core Practical -8	20UPEVS2P08
9	IX	Core Practical -9	20UPEVS2P09
10	X	Core Practical -10	20UPEVS2P10

S. No.	Semester	Field Project/Study	Code
1	I	Field Project/Study – Core Paper 1	20UPEVS2FS1
2	II	Field Project/Study – Core Paper 2	20UPEVS2FS2
3	III	Field Project/Study – Core Paper 3	20UPEVS2FS3
4	IV	Field Project/Study – Core Paper 4	20UPEVS2FS4
5	V	Field Project/Study – Core Paper 5	20UPEVS2FS5
6	VII	Field Project/Study – Core Paper 6	20UPEVS2FS6
7	VIII	Field Project/Study – Core Paper 7	20UPEVS2FS7
8	IX	Field Project/Study – Core Paper 8	20UPEVS2FS8

S. No.	Semester	Core Project / Industrial Visit	Code
1	I	Core Project 1	20UPEVS2PR1
2	II	Core Project 2	20UPEVS2PR2

S. No.	Semester	Allied Courses	Code
1	I	Chemistry - Paper 1 (Inorganic, Organic, Phy-1)	20UPEVS2A01
2	II	Chemistry - Paper 2 (Inorganic, Organic, Phy-2)	20UPEVS2A02
3	III	Biology - Paper 1 (Botany and Zoology)	20UPEVS2A03
4	IV	Biology - Paper 2 (Botany and Zoology)	20UPEVS2A04

S. No.	Semester	Allied Practical Courses	Code
1	I	Chemistry - Practical - 1	20UPEVS2AP1
2	II	Chemistry - Practical - 2	20UPEVS2AP2
3	III	Biology - Practical - 1	20UPEVS2AP3
4	IV	Biology - Practical - 2	20UPEVS2AP4

S. No.	Semester	Skill Based Elective Courses	Code
1	II,III, IV,V,VI VII	Aquaculture	20UPEVS2K01
2		Biocomposting	20UPEVS2K02
3		Biopesticides and Crop Protection	20UPEVS2K03
4		Bioremediation Techniques	20UPEVS2K04
5		Environmental Sanitation	20UPEVS2K05
6		Horticulture	20UPEVS2K06
7		Organic Farming Practices	20UPEVS2K07
8		Phytoremediation	20UPEVS2K08
9		Resources Recovery	20UPEVS2K09
10		Sludge Management	20UPEVS2K10

11. CBCS - Scheme of Examinations (Semester-wise structure)

S. No.	Part	Paper Type	Title of the Paper	Weekly Contact Hours	Credits	Internal Marks	Externa l Marks	Total Marks
SEMESTER – I								
1	I	Language	Tamil 1	5	3	25	75	100
2	II	English	English 1	5	3	25	75	100
3	III	Core - 1	Earth Ecology and Environment	5	5	25	75	100
4	III	Core Practical - 1	Practical - Core Paper 1	3	2	40	60	100
5	III	Allied - 1	Allied - Chemistry Paper 1	4	4	25	75	100
6	III	Allied Practical - 1	Practical - Allied Paper 1	3	2	40	60	100
7	III	Field Project - 1	Field Project/Work	2	1	25	25	50
8	IV	Value Education	Yoga	2	2	25	75	100
9	IV	UGC mandatory	Environmental Studies	1	-	-	-	-
			Sub Total	**30**	**22**	**230**	**520**	**750**
SEMESTER – II								
10	I	Language - 2	Tamil 2	5	3	25	75	100
11	II	English - 2	English 2	5	3	25	75	100
12	III	Core - 2	Environmental Chemistry	5	5	25	75	100
13	III	Core Practical - 2	Practical - Core Paper 2	3	2	40	60	100
14	III	Allied - 1	Allied – Chemistry Paper 2	4	4	25	75	100
15	III	Allied Practical- 2	Practical - Allied Paper 2	3	2	40	60	100
16	III	Field Project – 2	Field Project / Work 2	2	1	25	25	50
17	IV	UGC mandatory	Environmental Studies	1	2	25	75	100
18	IV	SBEC - 1	Skill Based Elective Course 1	2	2	25	75	100
			Sub Total	**30**	**24**	**255**	**595**	**850**
SEMESTER – III								
19	I	Language - 3	Tamil 3	5	3	25	75	100
20	II	English – 3	English 3	5	3	25	75	100
21	III	Core 3	Environmental Microbiology	5	5	25	75	100
22	III	Core Practical - 3	Practical - Core paper 3	3	2	40	60	100
23	III	Allied - 2	Allied – Biology Paper 1	4	4	25	75	100
24	III	Allied Practical -3	Practical - Allied Paper 3	3	2	40	60	100
25	III	Field Project - 3	Field Project /Work 3	1	1	25	25	50
26	IV	SBEC - 2	Skill Based Elective Course 2	2	2	25	75	100
27	IV	NMEC - 1	Non-Major Elective Course 1	2	2	25	75	100
			Sub Total	**30**	**24**	**255**	**595**	**850**
SEMESTER – IV								
28	I	Language - 4	Tamil 4	5	3	25	75	100
29	II	English - 4	English 4	5	3	25	75	100
30	III	Core - 4	Environmental Biochemistry and Toxicology	5	5	25	75	100
31	III	Core Practical - 4	Practical – Core Paper 4	3	2	40	60	100
32	III	Allied - 2	Allied – Biology Paper 2	4	4	25	75	100
33	III	Allied Practical - 4	Practical – Allied Paper 4	3	2	40	60	100
34	IV	Field Project - 4	Field Project / Work 4	1	1	25	25	50
35	IV	SBEC - 3	Skill Based Elective Course 3	2	2	25	75	100
36	IV	NMEC - 2	Non-Major Elective Course 2	2	2	25	75	100
			Sub Total	**30**	**24**	**255**	**595**	**850**

S. No.	Part	Paper Type	Title of the Paper	Weekly Contact Hours	Credits	Internal Marks	External Marks	Total Marks
SEMESTER – V								
37	III	Core -5	Biodiversity and Conservation	6	5	25	75	100
38	III	Core -6	Environmental Pollution	5	5	25	75	100
39	III	Core -7	Waste Management	6	5	25	75	100
40	III	Core Practical - 5	Practical Core - Papers 5 & 6	3	2	40	60	100
41	III	Core Practical - 6	Practical Core - Core Paper 7	3	2	40	60	100
42	III	Elective - 1	Elective 1	3	4	25	75	100
43	III	Field Project - 5	Field Project/Work 5	2	1	25	25	50
44	IV	MOOC - 1	MOOC 1	-	-	25	75	100
45	IV	SBEC - 4	Skill Based Elective Course 4	2	2	25	75	100
			Sub Total	**30**	**26**	**255**	**595**	**850**
SEMESTER – VI								
46	III	Core - 8	Energy and Environment	5	5	25	75	100
47	III	Core - 9	Environmental Analysis & Techniques	5	5	25	75	100
48	III	Core Practical-7	Practical - Core Papers 8 & 9	3	2	40	60	100
49	III	Core Project	Project	12	4	25	75	100
50	III	Elective - 2	Elective 2	3	4	25	75	100
51	IV	MOOC - 2	MOOC 2	-	-	25	75	100
52	IV	SBEC - 5	Skill Based Elective Course 5	2	2	25	75	100
			Sub Total	**30**	**22**	**190**	**510**	**700**
SEMESTER - VII								
53	III	Core - 10	Environmental Biotechnology	6	5	25	75	100
54	III	Core - 11	Environmental Impact Assessment	5	5	25	75	100
55	III	Core - 12	Natural Resources Management	5	5	25	75	100
56	III	Core Practical - 8	Core Practical - Core Papers 10,11&12	6	3	40	60	100
57	III	Field Project - 6	Field Project 6	2	1	25	25	50
58	III	Elective - 3	Elective 3	4	4	25	25	50
59	IV	SBEC - 6	Skill Based Elective Course 6	2	2	25	75	100
			Sub Total	**30**	**25**	**190**	**410**	**600**
SEMESTER – VIII								
60	III	Core - 13	Climate Change and Current Issues	5	5	25	75	100
61	III	Core - 14	Environmental Geoinformatics	5	5	25	75	100
62	III	Core - 15	Pollution Control Strategies	5	5	25	75	100
63	III	Elective - 4	Elective 4	4	4	25	75	100
64	III	Core Practical	Practical - Core Papers 13,14 & 15	6	3	40	60	100
65	III	Field Project - 7	Field Project 7	2	1	25	25	50
66	IV	NMEC - 3	Non-Major Elective 3	3	3	25	75	100
67	IV	MOOC - 3	MOOC 3			25	75	100
68	IV	UGC mandatory	Human Rights			25	75	100
			Sub Total	**30**	**26**	**215**	**535**	**850**

S. No.	Part	Paper Type	Title of the Paper	Weekly Contact Hours	Credits	Internal Marks	External Marks	Total Marks
SEMESTER – IX								
68	III	Core - 16	Environmental Safety and Health	5	5	25	75	100
69	III	Core - 17	Research Methodology and Instrumentation	5	5	25	75	100
70	III	Core - 18	Disaster Management	5	5	25	75	100
71	III	Core - 19	Environment Law and Policy	5	5	25	75	100
72	III	Core Practical	Practical-Core Papers 16,17 &18	5	3	40	60	100
73	III	Field Project - 8	Field Project 8	2	1	25	25	50
74	IV	NMEC - 4	Non-Major Elective 4	3	3	25	75	100
75	IV	MOOC - 4	MOOC 4		-	-	-	100
			Sub Total	**30**	**27**	**215**	**535**	**750**
SEMESTER - X								
76	III	Core Project Work	Project Work	**30**	10	50	150	200
77	III	Industrial Visits / Study Tour	Industrial Visits/Study Tour (VII –X Semesters)	-	2	-	50	50
			Sub Total	**30**	**12**	**50**	**200**	**250**
			Total		**232**			**7300**

12. Examinations

- Examinations are conducted at the end of every Semester.
- The examination for the Odd Semester (I, III, V, VII and IX) will be held in November/December and the Even Semester (II, IV, VI, VIII and X) will be held in the month of April/May of every academic year.
- Candidates failing in any subject (both theory, practical and skill) will be permitted to appear for such failed subjects in the same syllabus structure at subsequent examinations within next 5 years. Failing which, the candidate has to complete the course in the existing syllabus structure at the time of examination.
- The practical examinations for major and allied courses will be held at the end of each semester.

Requirements for proceeding to subsequent semesters

- A candidate shall be permitted to appear for the University examinations for any semester (practical/theory) if he / she secures not less than 75% of attendance in the number of working days during the semester.
- Candidates shall register their names for the First semester examination after the admission in the PG courses.
- Candidates shall be permitted to proceed from the First Semester up to the Final Semester irrespective of their failure in any of the Semester Examination subject to the condition that the candidates should register for all the arrear subjects of earlier semesters along with current semester subjects.
- Candidates shall be eligible to proceed to the subsequent semester, only if they earn sufficient attendance as prescribed therefore by the Syndicate from time to time.

Provided in case of candidate earning less than 50% of attendance in any one of the semester due to any extraordinary circumstance such as medical grounds, such candidates who shall produce Medical Certificate issued by the Authorized Medical Attendant (AMA), duly certified by the Head of the Institution, shall be permitted to proceed to the next semester and to complete the course of study. Such candidate shall have to repeat the missed semester by rejoining after completion of final semester of the course, after paying the fee for the break of study as prescribed by the University from time to time.

13. Scheme for Evaluation and Attainment Rubrics

Evaluation will be done on a continuous basis and will be evaluated four times during the course work. The first evaluation will be in the 7th week, the second in the 11th week, third in the 16th week and the end - semester examination in the 19th week. Evaluation may be by objective type questions, short answers, essays or a combination of these, but the end semester examination is a University theory examination with prescribed question paper pattern.

Attainment Rubrics for Theory Courses

Internal *(Max. Marks - 25)*

Attendance	Seminar	Assignment	Internal/Cycle Test	Total
5	5	5	10	25

External (Max. Marks - 75)

Question Paper Pattern (Theory)

Section	Approaches	Mark Pattern	K Level
A	One Word (Answer all questions)	20 x 1 = 20 (Multiple Choice Questions)	K1, K2 K3, K4 K5, K6
B	100 to 200 words (Answer any three out of five questions)	3 x 5 = 15 (Analytical Type Questions)	
C	500 to 1000 words (Answer all five questions)	5 x 8 = 40 (Essay Type Questions)	

Attainment Rubrics for Lab Courses

Internal (Max. Marks - 40)

Attendance	Practical Test	Periodical Performance/Observation	Total Marks
5	25	10	40

External (Max. Marks - 60)

Major Experiment	Minor Experiment	Spotters	Record	Viva-Voce	Total Marks
20	15	15	5	5	60

Attainment Rubrics for Research Project

Internal (Max. Marks - 50)

	50 Marks

External (Max. Marks - 100)

Viva-Voce Presentation	25 Marks
Dissertation	75 Marks

14. Passing Minimum

- There shall be no passing minimum for internal marks.
  For external examination, passing minimum shall be of 50% (38 Marks out of 75 Marks) prescribed for the course.
- In the aggregate (External + Internal) the passing minimum shall be of 50% for each course / practical/ project and viva-voce.
- Grading shall be based on overall marks obtained (Internal + External) in the respective courses.

15. Classification of Successful Candidates

- Candidates who obtain 75% of the marks in the aggregate shall be declared to have passed the examination in **First Class with Distinction** provided they pass all the examinations prescribed for the course at the first appearance.

- Candidates who secure not less than 60% of the aggregate marks in the whole examination shall be declared to have passed the examination in **First Class.**

- All other successful candidates securing below 60% shall be declared to have passed in the **Second Class.**

16. Grading System

Evaluation of performance of students is based on ten-point scale grading system as given below.

Ten Point Scale			
Grade of Marks	**Grade points**	**Letter Grade**	**Description**
90-100	9.0-10.0	O	Outstanding
80-89	8.0-8.9	D+	Excellent
75-79	7.5-7.9	D	Distinction
70-74	7.0-7.4	A+	Very Good
60-69	6.0-6.9	A	Good
50-59	5.0-5.9	B	Average
00-49	0.0	U	Re-Appear
ABSENT	0.0	AAA	Absent

Core Courses

CORE COURSE – I

EARTH ECOLOGY AND ENVIRONMENT

Semester	Paper Code	Marks	Hours/Week	L	T	P	Credit
I	20UPEVS2C01	100	5	4	1	0	5

Course Objectives

The purpose of this course is to make the students to understand the basic information about the earth and environment. They will also learn about the interactions between the components of our environment, ecology and also about environmental issues and its sustainability.

Course Outcomes

On the successful completion of the course, students will be able to

CO1 Understand the principles, scope and components of the earth and environment

CO2 Know the basic concepts of ecology and ecosystems, factors and its interaction along with its succession processes

CO3 Understands the concept of biodiversity, its types, values and its conservation methods

CO4 Learns about various environmental issues and environmental sustainability.

CO5 Apply the knowledge of basic ecology in field studies.

CO6 Understands the interrelation between the earth environment and man

Mappings of course outcomes with programme outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	*							*
CO2	*			*	*		*	
CO3			*		*			
CO4			*					
CO5	*					*	*	
CO6	*			*		*		*

CORE COURSE – I

EARTH ECOLOGY AND ENVIRONMENT

UNIT I Earth and Environment Contact Hours 8

Definition, Principles and Scope of Environmental Science. Structure and composition of atmosphere, hydrosphere, lithosphere and biosphere. Earth as an eco-system. Interaction between Earth, Man and Environment (K1, K2, K3)

UNIT II Ecology Contact Hours 8

Scope, basic concepts in ecology, levels of ecology. Abiotic factors-Temperature, Light, Precipitation - Topographic and Edaphic Factors. Biotic Factors – Introduction to population ecology and community ecology – Ecological Interactions – Ecological Succession. (K1, K2, K3)

UNIT III Ecosystem Contact Hours 12

Ecosystem-Introduction, kinds- structure and function. Energy flow in ecosystem, food chain and food webs, pyramids of energy, biomass and numbers. Major ecosystems - pond, grassland, forest, desert, cropland etc. productivity of different ecosystems - primary productivity in terrestrial ecosystems, secondary productivity. Biogeochemical cycles in ecosystems-carbon, nitrogen, sulfur and phosphorous. (K1, K2, K3)

UNIT IV Biodiversity Contact Hours 12

Biodiversity and its conservation: Definition, types, importance of biodiversity and threats to biodiversity. Concept and basis of identification of 'Hotspots'; hotspots in India. Measures of biodiversity. Strategies for biodiversity conservation: in situ, ex situ and in vitro conservation. (K1, K2, K3)

UNIT V Environmental Issues and Awareness Contact Hours 10

Global Environmental Issues - Biodiversity loss, Climate change, Ozone layer depletion. Sea level rise. International efforts for environmental protection. National Action Plan on Climate Change. Sustainable Development Goals - 2030. (K4, K5, K6)

Text Books

1. Sharma P.D. (2017) Ecology and Environment. 13th Edition Rastogi Publications Ltd.
2. Rana S.V.S. (2009) Essentials of Ecology and Environmental Science. Prentice Hall Publishers Ltd.
3. Pratibha Singh, Anoop Singh & Piyush Malaviya (2009) Text Book of Environment & Ecology – Excel Publishers.

Reference Books

1. Singh J.S., Singh S.P. & Gupta S.R. (2014) Ecology, Environmental Science & Conservation S Chand Publishing Co
2. Sharma P.D. (2012) Environmental Biology. Deep and Deep Publications
3. Odum, E. P. & Barrett, G. W. (2005). Fundamentals of ecology. 5th ed. Belmont, CA: Thomson Brooks/Cole.

4. Pranav Kumar (2017) Fundamentals of Ecology and Environment. Second Edition Pathfinder Publications.
5. Madhab Chandra Dash (2018) Readings In Ecology And Environmental Science, Gen Next Publications.
6. Singh H.R. & Neeraj Kumar (2012). Ecology and Environmental Science, Vishal Publications

Web References

1. http://archive.mu.ac.in/myweb_test/M.A.Part%20-%20II%20-%20Paper%20VII.pdf
2. http://dspace.vpmthane.org:8080/jspui/bitstream/123456789/4202/1/FC%20Sem%202%20THE%20CONCEPT%20OF%20ECOLOGY%20AND%20ENVIRONMENT.pdf
3. https://shodhganga.inflibnet.ac.in/bitstream/10603/68238/6/06_chapter%201.pdf
4. http://rvskvv.net/images/Environmental-Science_23.04.2020.pdf
5. https://www.environmentalscience.org/ecology
6. http://environment-ecology.com/what-is-environment/669-environment.html
7. https://www.nationalgeographic.org/topics/resource-library-human-impacts-environment/?q=&page=1&per_page=25

Experiments for Practical Course

1. Biotic and Abiotic Component Assessment
2. Primary productivity of an aquatic ecosystem
3. Energy Transfer in an Ecosystem
4. Estimation of GPP and NPP
5. Field Survey and Sampling Methods
6. Ecological Data Collection
7. Ecological Data Interpretation and Presentation
8. Field Study Requirements

CORE COURSE – II

ENVIRONMENTAL CHEMISTRY

Semester	Paper Code	Marks	Hours/Week	L	T	P	Credit
II	20UPEVS2C02	100	5	4	1	0	5

Course Objectives

The purpose of this course is to develop an understand the basics of chemistry in relevance to environment and such as, solutions preparation, chemical reactions and their effects on the environment, to provide students with an understanding of the fundamental chemical processes occurred on environment.

Course Outcomes

On the successful completion of the course, students will be able to

CO1 Have knowledge of basic theories and problems of Environmental chemistry

CO2 Describe important chemical reactions and cyclic processes of chemical species in the atmosphere, hydrosphere and in lithosphere

CO3 Demonstrate knowledge of chemical principles of various fundamental environmental phenomena

CO4 Apply basic chemical concepts in understanding the behavior of pollutants

CO5 To analyze chemical processes involved in air, water and soil environmental problems

CO6 Know the different types of toxic and hazardous substances and analyze their toxicological information

Mappings of course outcomes with programme outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	*							*
CO2		*				*		
CO3		*				*		*
CO4		*						
CO5		*	*	*		*		*
CO6						*		*

CORE COURSE – II

ENVIRONMENTAL CHEMISTRY

UNIT I Fundamentals of Environmental Chemistry Contact Hours 12

Definition - Concept and Scope (K1 & K2)- Preparation of Standard Solutions – Molarity, Molality, Normality, Percent and PPM (mg/l) Solutions (K3 & K4)- Stoichiometry - Gibb's energy - Chemical Potential - Chemical Equilibria - Acid-base Reactions: pH and pOH and Buffer Solutions - Solubility and Solubility Product - Solubility of Gases in Water - The Carbonate System - Unsaturated and Saturated Hydrocarbons – Radionuclides (K3 & K4)

UNIT II Atmospheric Chemistry Contact Hours 10

Classification of Elements (K2 & K3) – Particles, Ions and Radicals (K2) - Formation of Inorganic and Organic Particulate Matter - Thermochemical and Photochemical Reactions in the Atmosphere - Oxygen and Ozone Chemistry - Chemistry of Air Pollutants (Oxides of Carbon, Nitrogen, Sulphur) (K4 & K5).

UNIT III Aquatic Chemistry Contact Hours 08

Formation of Water (K1) - Water Resources – Sources and Types (K1) - Hydrological Cycle - Unique Properties of Water (K2) - Role of Water in the Environment (K3)- Physical, Chemical and Biological Parameters of Water – Phenomenon of Eutrophication - Concept of DO, BOD, COD - Distribution of Chemical Species in Water - Types of reactions in various water bodies including marine environment (K4 & K5)

UNIT IV Soil Chemistry Contact Hours 10

Nature of soil – Formation and Types (K1 & K2)- Mechanical, Physical and Chemical Properties of Soil: Soil Structure, Texture (K3 & K4), Inorganic and organic components of soil, chemical properties of soil-saline. Acidic and alkaline soils (K5), Macro and Micronutrients, Humus and Organic Matter, C/N Ratio, Chemical reactions in soil (K3, K4 & K5)

UNIT V Pollutant Chemistry Contact Hours 10

Chemistry of Hydrocarbon Decay (K3)- Effects on Macro and Microorganisms (K4) – Surfactants - Cationic, anionic and non-ionic detergents, modified detergents (K1 & K5) - Pesticides: Classification, Degradation, Analysis - Pollution due to Pesticides – DDT and Endosulphan - Toxic effects of Heavy metals - Ar, Cd, Pb & Hg (K3, K4 & K5)

Text Books

1. De, A.K. (2007) Environmental Chemistry, Seventh Edition, New Age International Publishers.
2. Sharma, B.K. and Kaur, H. (1994) Environmental Chemistry, Goel Publishing House Ltd., Meerut, UP.
3. Balram Pani, (2007) Text Book of Environmental Chemistry, I.K. International Publishing House PVT. Ltd.
4. Girard J.E. (2015) Principles of Environmental Chemistry.
5. Rao, C.S. (2018) Environmental Pollution Control Engineering, 3rd Edition, New Age International (P) Ltd Publishers.

CORE COURSE – II

ENVIRONMENTAL CHEMISTRY

Reference Books

1. Manahan, S.E. (2009) Fundamentals of Environmental Chemistry, 9th Edition, Boca Raton: CRC Press LLC
2. Eugene, R. Weiner (2000) Applications of Environmental Chemistry, CRC Press, LLC
3. Ahluwalia, V.K. (2015) Environmental Pollution and health, The Energy and Resource Institute (TERI)
4. Vanloon. G.W. and Duffy S.J. (2011) Environmental Chemistry a global perspective, 3rd Edition, Oxford University Press
5. Ibanez, J. G., Hernandez-Esparza, M., Doria-Serrano, C., Fregoso-Infante, A., and Singh, M.M. (2007). Environmental Chemistry. Springer Press

Web References

1. http://www.nptel.ac.in/courses/122106030/Pdfs/3_1.pdf
2. http://www.crystal.med.upenn.edu/sharp-lab-pdfs/sharp_EncLifeSci.pdf
3. http://www.fao.org/docrep/field/003/AC172E/AC172E04.htm
4. http://www.essentialchemicalindustry.org/materials-and-applications/surfactants.html
5. http://agriinfo.in/?page=topic&superid=5&topicid=174
6. http://www.citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.800.8713&rep=rep1...pdf

CORE COURSE – III

ENVIRONMENTAL MICROBIOLOGY

Semester	Paper Code	Marks	Hours/Week	L	T	P	Credit
III	20UPEVS2C03	100	5	4	1	0	5

Course Objectives

To learn the basic knowledge about microbes, role of microbes and microbial interactions in the various environmental components. To understand the biogeochemical cycles prevailing in the environment, to enhance the skill on microbial analysis related to environment

Course Outcomes

On the successful completion of the course, students will be able to

CO1 Able to understand the significance of Microbiology and Microbiologists

CO2 Able to understand about microbes in environmental field and the role of microbes in soil fertility

CO3 Understand the biogeochemical cycles

CO4 Know about the impact of microbial air and water pollutants and their diseases

CO5 Apply the microbial processes to clean the environment.

CO6 To enhance the skill on microbial analysis of relevance to the environment

Mappings of course outcomes with programme outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	*							
CO2		*						
CO3		*						
CO4	*	*					*	
CO5		*				*		
CO6	*					*		

CORE COURSE – III

ENVIRONMENTAL MICROBIOLOGY

UNIT I **Introduction to Microbiology** Contact Hours 12

Introduction - History and Scope of Microbiology – Contributions of Antonie van Leeuwenhoek, Edward Jenner, Louis Pasteur, Robert Koch and Alexander Fleming - General characters of Bacteria, Fungi and Virus - Difference between Prokaryotes and Eukaryotes (K1, K2, K3)

UNIT II **Geo microbiology** Contact Hours 12

Soil microflora – Factors influencing the soil microflora – Role of microorganisms in soil fertility. Microbial interactions – Mutualism, Commensalism, Competition, Amensalism, Parasitism and Predation. Interaction between microbes and plants: Mycorrhizae (K1, K2, K3)

UNIT III **Biogeochemical Cycles** Contact Hours 10

Carbon cycle - Role of microbes in Carbon cycle - Nitrogen cycle - Mechanism of biological nitrogen fixation - Ammonification, Nitrification, Denitrification - Phosphorous cycle and Sulphur cycle (K1, K2, K3, K4)

UNIT IV **Air Borne and Water Borne Diseases** Contact Hours 12

Microbiology of air - Microbial air pollutants - Bioaerosols, Aero allergens – Airborne diseases, Symptoms and preventive measures - Water pollution: Sources and nature of pollutants in water – waterborne diseases, Symptoms and preventive measures (Cholera and Typhoid) (K3, K4, K5, K6)

UNIT V **Applied Microbiology** Contact Hours 12

Microbial conversion of solid waste to food (Mushroom), fuels (Biogas), Biodegradation of Lignin – Bioremediation: Types and its application – Bio deterioration of paper - Metal Corrosion (K3, K4, K5, K6)

Text Books

1. Pelczar, Chan and Kreig, (1982) Microbiology, McGraw Hill Book Co, New York
2. Dubey and Maheshwari, (1999) A text book of Microbiology, 1/e, Chand publications, New Delhi.
3. Mohapatra, P. K. (2008) Text Book of Environmental Microbiology, I K International Publishing House Limited

Reference Books

1. Prescott, Harvey, Klein, (2013) “Microbiology”, -McGraw Hill, Ninth Edition.
2. SubbaRao, N.S. (2004) Soil Microbiology.4th Edition, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
3. SubbaRao, N.S. (1995) Biofertilizers in Agriculture and Forestry.3rd Edition, Oxford and IBH Pub. Co. Pvt. Ltd., New Delhi.
4. Brock, T.D. Madigan, M.T. Martinko, J.M. and Parker, J. (1994) Biology of Microorganisms, VII Ed., Prentice-Hall, New Jersy, USA.

5. Ronald, M. Atlas and Richard Bartha, (1997) Microbial Ecology, 4/e, Benjamin Cummings Publishing company, USA.

Web References

1. www.microbialfuelcell.org
2. www.pollutionissues.com/A-Bo/Bioremediation.html
3. www.bioreactors.net
4. http://www.cpeo.org/techtree/ttdescript/biorec.htm
5. http://www.personal.psu.edu/jel5/biofilms/
6. www.rdp.cme.msu.edu

PRACTICALS

1. Good Microbiology laboratory practices: Laboratory safety (Dos and Don'ts),
2. To prepare basic liquid (Nutrient broth) and basic solid media (Nutrient Agar and Potato Dextrose Agar) for cultivation of bacteria and fungi.
3. To learn pure culture techniques used for isolation and purification of microorganisms
    a. Pour plate method
    b. Spread plate method
    c. Streak plate method
4. To perform different staining methods to study morphological and structural characteristics of bacteria and fungi
    a. Simple staining
    b. Gram Staining
    c. Fungal staining (Lacto-phenol cotton blue)
5. Enumeration of microbes from sewage, soil and air
6. Examination of Mycorrhizae - VAM

Reference Books

1. Ronald, M. Atlas et al., (1997) "Experimental Microbiology", Benjamin and Cummings Publication.
2. Cappuccino, J. G. and Sherman, N. (2002) "Microbiology: A Laboratory Manual", Addison Wesley.
3. Kannan,N. (1995) "Lab manual in Microbiology" , Panima publishers, New Delhi.
4. Gunasekaran, P. (2007) "Laboratory Manual in Microbiology", New Age International.

CORE COURSE - IV

ENVIRONMENTAL BIOCHEMISTRY AND TOXICOLOGY

Semester	Paper Code	Marks	Hours/Week	L	T	P	Credit
IV	20UPEVS2C04	100	5	4	1	0	5

Course Objectives

The purpose of this course is to focus on understanding the role of pollutants, xenobiotics in the natural environment and to understand the basics of environmental toxicology, cell biology and biochemistry and to characterize the adverse effects of chemical substances on ecosystems and humans.

Course Outcomes

On the successful completion of the course, students will be able to

CO1 Acquire broad knowledge in the field of environmental toxicology and biochemistry
CO2 Understand the basic principles, target organ toxicity and the toxicity of a select group of chemical compounds.
CO3 Synthesize and apply concepts from multiple sub-disciplines in environmental cell biology, biochemistry and toxicology.
CO4 Use technical and analytical skills to quantify the level of xenobiotics in environmental compartments
CO5 Understand the effects of xenobiotics on human health.
CO6 Understand relationships between chemical/drug exposure and their effects on physiological systems.
CO7 Acquire skills in toxicological bioassays.
CO8 Design strategies to study dose-response relationships

Mappings of course outcomes with programme outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1		*						
CO2		*						
CO3			*					
CO4			*					
CO5					*			
CO6				*				
CO7						*		
CO8								*

CORE COURSE - IV

ENVIRONMENTAL BIOCHEMISTRY AND TOXICOLOGY

UNIT I Basic Cell Biology Contact Hours 12

A brief history of cell biology, chemistry of the cell, Prokaryotic and Eukaryotic cell structure and intracellular organelles – Cell wall, membranes, nucleolus, endosomes, peroxisomes, mitochondria, endoplasmic reticulum, plant vacuoles, plastids, microbodies and chloroplast. Cell growth and division-Meiosis and Mitosis, genotypes and phenotypes, Cancer cell, stem cells and cloning (K1, K2)

UNIT II Environmental biochemistry Contact Hours 10

Basic chemistry of macromolecules: Carbohydrates, Amino acids, Proteins, Lipids and Nucleic acids of physiological significance. Structure and function of proteins and enzymes. Bioenergetics and metabolism of carbohydrates and lipids: Role of ATP; Glycolysis, Citric acid cycle, Glycogenesis, Glycogenolysis, Gluconeogenesis, lipid metabolism; Biosynthesis of cholesterol; Fatty acid oxidation; Electron transport chain and Oxidative phosphorylation. Metabolism of proteins and amino acids. Micronutrients: Vitamins and Minerals. Biochemistry of extracellular and intracellular communication: Membrane (K1, K2)

UNIT III Basics of Toxicology Contact Hours 10

Ecotoxicology: Biomarkers; Bioaccumulation; Biomagnification; Bioconcentration factor; Risk assessment; Effects on population and ecosystems; Toxicity of heavy metal (Pb, Cd, Hg and As). Cytotoxicity and Genotoxicity: Molecular mechanism of cell death; chromosomal aberration; sister chromatid exchanges; Micronucleus and Nuclear abnormalities; DNA damage and repair mechanism. Carcinogenesis: Classification of carcinogens; Metastasis and metabolism of chemical carcinogens; cancer risk evaluation; Brief outline of cancer therapy. Reproductive toxicology: Teratology; Reproductive toxicity; *In vitro* fertilization (K3, K4, K5)

UNIT IV Toxicity Testing and Bioassay Contact Hours 10

Toxicity assay: Acute and chronic toxicity; Dose - Response Relationship- Median lethal concentration (LD_{50} and LC_{50}); Sublethal concentration and safe concentration (NOEL, MATC); Whole Effluent Toxicity (WET) test; Bioassay - types, methodologies and application; Toxico Kinetics and toxicokinetic analysis (K5, K6)

UNIT V Xenobiotics Contact Hours 10

Concept of Xenobiotics: Toxic materials; Xenobiotic induced oxidative stress; Cell injury; Mode of action: Types of exposure, Absorption, Distribution, Metabolism and Excretion of toxicants (Phase I and Phase II reaction)

Text Books

1. Alberts B, Bray D, Hopkin K *et al.* (2009) Essential Cell Biology, 3rd edition.
2. Alberts B, Johmson A, Lewis J, Raff M, Roberts K and Walter P (2002) Molecular Biology of the Cell, Garland Science, New York.

Reference Books

1. Buchanan BB, Gruissem W and Jones RL (2002) Biochemistry and Molecular Biology of Plants, ASPB, USA.

CORE COURSE - IV

ENVIRONMENTAL BIOCHEMISTRY AND TOXICOLOGY

2. Cooper GM and Hausman RE (2013) The Cell: A Molecular Approach, 6th edition, Sinauer Associates, Sunderland, MA, USA.
3. David L. Nelson, Michael M. Cox (2004) Lehninger Principles of Biochemistry (1970) by Albert L. Lehninger Published April 23rd 2004 by W. H. Freeman (first published).
4. Gerald Karp (2002) Cell and Molecular Biology: Concepts and Experiments, 7th Edition.
5. Klaassen, Curtis D; Casarett, Louis J; Doull, John, (2013) Casarett and Doull's toxicology: the basic science of poisons (8th Edition) McGraw Hill Publishers.
6. Ted A. Loomis, A. Wallace Hayes. Loomis's Essentials of Toxicology (1996) 4th Edition, Academic Press Publishers.
7. Sharma PD, Rastogi and Lamporary (1994) Environmental Biology and Toxicology, Rajpal and Sons Publishing, New Delhi.
8. Ted A Simon. Environmental Risk Assessment: A Toxicological Approach (2014) CRC Press publications.
9. Loganathan, S., Murugan, T. (2017) Pesticide-Mediated Toxicity in Modern Agricultural Practices, Sustainable Agriculture towards Food Security, 359-373.

Web References

1. https://academic.oup.com/toxsci/article/120/suppl_1/S49/1616424
2. https://www.hindawi.com/journals/bmri/2017/4627872/
3. https://iubmb.onlinelibrary.wiley.com/doi/pdf/10.1016/0307-4412(81)90131-X
4. https://webstor.srmist.edu.in/web_assets/srm_mainsite/files/downloads/Introduction_To_Biochemistry.pdf

Practicals - Environmental Biochemistry and Toxicology

1. Estimation of metals in soil, plants and animal tissue.
2. Estimation of reducing sugars in toxic waste.
3. Estimation of protein from toxic waste.
4. Case studies on environmental effects of pesticides.
5. Modeling of pollutant dispersion.
6. Toxico-genomic and pharmaco-genomic evaluation of pollutants.
7. Isolated Cell Preparations
8. Protein Determination
9. Extraction of Enzymes
10. Electrophoresis

References:

1. Environmental Toxicology set of 3 volumes- Peter Gomes
2. Aquatic Environment and Toxicology-Pawan Kumar Bhart
3. Toxicology: Principles and Methods-Second Revised Edition - M A Subramanian SS Siddiqui, GU Ahmmad, S Loganathan. Cells. Transport, 2014.

CORE COURSE – V

BIODIVERSITY AND CONSERVATION

Semester	Paper Code	Marks	Hours/Week	L	T	P	Credit
V	20UPEVS2C05	100	5	4	1	0	5

Course Objectives

The purpose of this course is to gain an understanding of the value of biodiversity and drivers of its loss; current efforts to conserve biodiversity on global, national and local scales; practical issues with local conservation and organizations, policies and programmes for sustainable management of bioresources.

Course Outcomes

On the successful completion of the course, students will be able to

CO1 Understand the relationship between biodiversity and ecosystem functions

CO2 Understand the direct and indirect values of biodiversity resources and their bioprospecting opportunities

CO3 Outline the main reasons for decline and threats to biodiversity worldwide and understand the need for local action to address the global loss of biodiversity

CO4 Evaluate the pros and cons of species introductions and reintroductions

CO5 Understand the various *in situ* and *ex situ* conservation measures and make critical judgments on the conflict between conservation and development

CO6 Know more knowledge about the recent policies and programmes for sustainable management of bioresources and apply the rules and recommendations related to environmental protection

Mappings of course outcomes with programme outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	*					*	*	*
CO2	*					*	*	*
CO3	*			*	*	*	*	*
CO4	*					*	*	*
CO5	*			*	*	*	*	*
CO6	*			*		*	*	*

CORE COURSE – V

BIODIVERSITY AND CONSERVATION

UNIT I Introduction Contact Hours 08

Types of Biodiversity: Species, Genetic and Ecosystem diversity – Alpha, beta, and gamma diversity (K1 & K2) – Biodiversity and ecosystem function (K4 & K5) – Megadiversity zones and Biodiversity Hot Spots in India (K2 & K3) – Endangered and endemic species of flora and fauna in India (K1 & K2) - Ecologically Sensitive Areas (ESA) in India (K4 & K5) - Values of Biodiversity (K4 & K5)

UNIT II Threats to Biodiversity Contact Hours 12

Biodiversity threats under Anthropocene era: Habitat loss, fragmentation and degradation – Pollution - Overexploitation (K2, K4 & K5) – IUCN Threat Categories – Red Data Book (K2 & K4) – Climate change on species extinction - Causes and Impacts of Invasive species to biodiversity (K2, K3, K4 & K5) - Human-Animal conflict with special reference to elephants (K3, K4 , K5 & K6)

UNIT III Conservation Strategies Contact Hours 14

In situ conservation: Afforestation, Social Forestry, Agro-forestry, Zoos, Biosphere Reserves, National Parks, Sanctuaries, Protected Area Network, Sacred Groves and Sthalavrikshas (K1, K2 & K3) – *Ex situ conservation*: Botanical gardens, Cryopreservation, Gene Bank, Seed Bank, Pollen Bank, Sperm Bank, cDNA Bank (K1, K2 & K3) - Status and protection of species in National and International levels (K3 & K4)

UNIT IV Sustainable Management of Bioresources Contact Hours 12

Biodiversity Prospecting - Examples of biopiracy and bioprospecting (K2 & K5) - National Biodiversity Authority (NBA) – Functions of State Biodiversity Board (SBB) and Biodiversity Management Committee's (BMC) – People's Biodiversity Register (PBR) (K3, K4, K5 & K6) – International Organizations and biodiversity conservation: Role of CITES, IUCN and Convention on Biological Diversity (CBD) in biodiversity conservation (K2, K3 & K4) – WWF-India for priority and threatened species conservation (K3, K4 & K5)

UNIT V Policies, Programmes and Acts for Conservation Contact Hours 10

Salient features of Biological Diversity Act 2002 (K2 & K3) - Policies implemented by MoEF & CC for biodiversity conservation - Monitoring the Illegal Killing of Elephants (MIKE) programme - UNESCO Man and Biosphere Programme (MAB) (K3 & K5) - Nagoya Protocol on Access and Benefit-Sharing – Cartagena Protocol on Biosafety (K3) - SAWEN Network to combat illegal wildlife trade – Ramsar Strategic Plan 2016-2024 for wetland conservation (K4 & K5)

Text Books

1. Eugene P. Odum and Gary W. Barrett. (2004) Fundamentals of Ecology (5th Edition) Brooks/Cole Publishers.
2. Krishnamurthy KV (2003) An Advanced Textbook on Biodiversity – Principles and Practice, Oxford and IBH Publishing, New Delhi.

CORE COURSE – V

BIODIVERSITY AND CONSERVATION

Reference Books

1. Alonso A. Aguirre and Raman Sukumar (2017) Tropical Conservation. Perspectives on Local and Global Priorities, Oxford University Press, USA
2. Chaudhuri AB and Sarkar DD (2003) Megadiversity Conservation, Flora, Fauna and Medicinal Plants of India's Hot Spots. Daya Publishing House, New Delhi.
3. Dadhich LK and Sharma AP (2002) Biodiversity –Strategies for Conservation, APH Publishing Corporation, New Delhi.
4. Kapoor L and Usha S (2020) Biodiversity and Conservation: India's Panoramic View. In: Roy N., Roychoudhury S., Nautiyal S., Agarwal S., Baksi S. (eds) Socio-economic and Eco-biological Dimensions in Resource use and Conservation. Environmental Science and Engineering. Springer, Cham. https://doi.org/10.1007/978-3-030-32463-6_16
5. Muthuchelian K (2013) Glimpses of Animal Biodiversity, Astral International (P) Ltd., New Delhi.
6. Muthuchelian K (2013) Uyir Virimam (Tamil), Pranisha Pathippagam, Madurai.
7. Muthuchelian K (2016) Bioinformatics, Barcoding and Benefit Sharing in Biodiversity Educationist Press, New Delhi.
8. Richard Frankham, Jonathan D Ballou and David A. Briscoe (2010) Introduction to Conservation Genetics, Second edition, Cambridge University Press, UK.
9. William V. Holt, Janine L. Brown and Pierre Comizzoli (2014) Reproductive Sciences in Animal Conservation. Progress and Prospects, Springer, New York.

Journal articles

1. Ghosh-Harihar M, An R, Athreya R et al. (2019) Protected areas and biodiversity conservation in India. *Biological Conservation* 237: 114-124
2. Behera MD, Behera SK & Sharma S (2019) Recent advances in biodiversity and climate change studies in India. *Biodiversity and Conservation* 28: 1943-1951.

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1. www.iucn.org
2. www.cites.org
3. www.cbd.int
4. www.wri.org
5. http://www.sawen.org
6. http://www.ramsar.org/sites/default/files/hb2_5ed_strategic_plan_ 2016_24_e.pdf
7. https://www.thegef.org/topics/biodiversity
8. https://www.cbd.int/gspc/strategy.shtml
9. https://www.zsl.org/sites/default/files/LPR%202020%20Full%20report.pdf
10. http://www3.weforum.org/docs/WEF_New_Nature_Economy_Report_2020.pdf

Experiments for Practical Course

1. Taxonomic identification of plant and animal diversity in the University campus
2. To calculate density, frequency and abundance of plant species in grassland using quadrat method.

CORE COURSE – VI

ENVIRONMENTAL POLLUTION

Semester	Paper Code	Marks	Hours/Week	L	T	P	Credit
V	20UPEVS2C06	100	5	4	1	0	5

Course Objectives

The purpose of this course is to gain awareness of environmental pollution and its types, sources, effects & monitoring techniques, and to understand the fundamental principles governing the interactions between transport of pollutants in the environment.

Course Outcomes

On the successful completion of the course, students will be able to

CO1 Learn about the air, water and soil pollutants, sources and its types

CO2 Have clear understanding on the air, water, noise and radiation standards and its techniques

CO3 To understand the type impacts on environment from each of the pollutant

CO4 To acquire skills in assessing environmental impacts through a multidisciplinary approach

CO5 Apply relevant monitoring, skills and modern engineering tools to identify the environmental pollutants

Mappings of course outcomes with programme outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1		*						
CO2				*				
CO3		*		*				
CO4		*	*	*				*
CO5		*		*				*

CORE COURSE – VI

ENVIRONMENTAL POLLUTION

UNIT I Air Pollution Contact Hours 10

Air pollution - Natural and anthropogenic sources of pollution (K1 & K2) – Types of Air pollutants (K3) – History of air pollution (air pollution episode, global and India) (K3) - Effects of air pollution on environment (K3) Meteorology based transport and diffusion of pollutants - Behavior of pollutants in the atmosphere (K4)– Effects on environment - Air pollution standards (K4)- Air pollution index (K5) - Methods of monitoring, sampling and control of air pollution (K4, K5 & K6).

UNIT II Water Pollution Contact Hours 10

Water pollution – Types, and sources (K2 & K3) – Toxicology of water pollutants (Trace metals and organic substances) - Eutrophication (K4), Physico-chemical and bacteriological sampling techniques (K3 & K4)- Water quality and standards. Ground water pollution & marine pollution – sources (K3 & K4) – Ecological and Economic impacts of water pollution (K3 & K4)- Control of water pollution (K5)- Water harvesting techniques (K5).

UNIT III Soil Pollution Contact Hours 10

Soil Pollution- Sources (industrial, domestic and agricultural) & types of contaminants (pesticides, heavy metals and others) (K1 to K4) –Process that contribute degradation of soil quality (erosion, physical and chemical degradation) (K4) – Detrimental effects of soil pollutants on flora, fauna and ground water (K4) - Soil minerals and its importance's (K4)– Soil quality parameters (K4)– Soil sampling methods, devices and soil pollution control methods (K5).

UNIT IV Noise Pollution Contact Hours 10

Noise Pollution: Definition (K1), sources (K2), sound pressure level (K2), decibels, intensity, duration, pitch (K3), noise-monitoring-sound level meter, noise indices (K4). Noise exposure levels and effects on humans and animals (K4). Permissible standards (CPCB standards) (K4).

UNIT V Thermal & Radioactive Pollution Contact Hours 10

Thermal pollution- Sources (K2), Effects on aquatic environment and control measures (K4). Radioactive Pollution: Definition (K1), radioactivity (K2). Biological effects of radiation and ecosystem (K4). Radiation exposure standards (K4), radiation monitoring devices (K5).

Text Books

1. Avinash Chauhan (2020) Environmental Pollution and Management. IK International Publishers Ltd
2. Mark Brusseau, Ian Pepper, Charles Gerba (2019) Environmental and Pollution Science, 3rd Edition, Academic Press
3. Shafi, S.M (2005) Environmental Pollution. Atlantic Publishers and Distributors.

4. Khopkar, S. M (2005) Environmental Pollution Monitoring and Control, New Age International (P) Ltd Publishers.
5. Rao CS (2018) Environmental Pollution Control Engineering, 3rd Edition, New Age International (P) Ltd Publishers.

Reference Books

1. Jeffrey Peirce J, Aarne Vesilind P, Ruth Weiner (1997) Environmental Pollution and Control, 4th Edition, Butterworth-Heinemann
2. Roy M Harrison (2000) Pollution: Causes, Effects and Control, 4th Edition, The Royal Society of Chemistry
3. Ahluwalia, V K (2015) Environmental Pollution and health, The Energy and Resource Institute (TERI)
4. Daniel Vallero (2014) Fundamental of Air Pollution, 5th Edition, Academic Press
5. Agarwal S K (2009) Water Pollution, A P H Publishing Corporation

Web References

1. https://www.unicef.org/publications/files/UNICEF_Clear_the_Air_for_Children_30_Oct_2016.pdf
2. https://www.nile-center.com/uploads/RQZG7BCW4DGXNSZ.pdf
3. https://www.researchgate.net/publication/321289637_WATER_POLLUTION-SOURCESEFFECTS_AND_CONTROL
4. http://yadda.icm.edu.pl/yadda/element/bwmeta1.element.agro-0c6457fb-fa78-4aa1-9eca-5f4483681a90/c/ILNS-3-2014-1-6.pdf
5. http://osou.ac.in/eresources/Soil%20Pollution.pdf
6. https://www.researchgate.net/publication/289281444_Soil_pollution_Causes_effects_and_control
7. https://www.nios.ac.in/media/documents/313courseE/L36.pdf
8. https://www.conserve-energy-future.com/radioactive-pollution-causes-effects-solutions.php
9. https://www.researchgate.net/publication/319329633_Noise_Pollution_Human_Health_A_Review
10. https://ec.europa.eu/environment//europeangreencapital/wp-content/uploads/2011/05/EGCNantesUKChap7-F.pdf

Experiments for Practical Course

1. Air Pollution Monitoring Techniques – SPM, Gaseous Pollutants.
2. Measurement of noise at different locations.
3. Soil sampling techniques and devices
4. Analysis of Water Quality parameters, DO, BOD, COD and pH.

CORE COURSE – VII

WASTE MANAGEMENT

Semester	Paper Code	Marks	Hours/Week	L	T	P	Credit
V	20UPEVS2C07	100	5	4	1	0	5

Course Objectives

The purpose of this course is to understand the problems of different kinds of wastes and understand the proper collection, segregation and reduction methods for municipal waste, biomedical waste, hazardous waste, e-waste, industrial waste etc., To identify waste nature and proper disposal methods for each type of wastes and identify the energy producing wastes and recovery of the energy from the wastes using different techniques

Course Outcomes

On the successful completion of the course, students will be able to

CO1 Understand health and environmental issues related to solid waste management; Select the appropriate method for solid waste collection, transportation, redistribution and disposal

CO2 Understand industrial specific wastes and their efficient management

CO3 Understand engineering, financial and technical options for waste management and wealth from waste management techniques

CO4 Describe methods of disposal of hazardous solid waste

CO5 Understand the energy recovery and industrial specific treatment techniques

Mappings of course outcomes with programme outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1		*	*					
CO2		*					*	
CO3			*			*	*	
CO4		*				*	*	*
CO5				*		*	*	

CORE COURSE – VII

WASTE MANAGEMENT

UNIT I Municipal waste Management Contact Hours 12

Wastes – Introduction, Definition, Sources and Classification (K1 & K2); Municipal Solid Wastes – Source, Types, Per Capita Generation, Global Scenario Wastes (K3); Collection and Transportation Methods, Waste Processing and Material Recovery (TMRF), (K4) Effects of Municipal Solid Wastes on Environment. Disposal Methods (Landfill, Composting, Burning, Incineration, Pyrolysis, Anaerobic Digestion) (K5 & K6)

UNIT II Hazardous Waste Management Contact Hours 10

Hazardous waste – Introduction (K1 & K2), Characteristics (K3), Classification of Hazardous Waste (Industrial, Hospital and Domestic) – Labeling and Handling of Hazardous Solid Wastes (Segregation, Recovery of Hazardous Waste Substances) (K3 & K4) - Hazardous Wastes Disposal Techniques (K5).

UNIT III Biomedical Waste Management Contact Hours 8

Biomedical Wastes: Sources, Types of Biomedical Wastes (K1 & K2), Impacts of Biomedical Wastes on Environment (K3 & K4) – Labeling and transport (K4), Control Measures and disposal of biomedical wastes (K5).

UNIT IV Plastic, Radioactive & e-waste Management Contact Hours 12

Plastic Wastes: Sources, Types (K1 & K2), Facts & Figures of Plastic Waste Scenarios in National & International (K37 K4), Effects of Plastic Wastes on Environment, Control Measures of Plastic Wastes (K5 & K6). Radioactive Wastes: Sources, Types (K1 & K2), Effects (K3), Control and Disposal Methods (K4 & K5). E-wastes: Sources, Types of e-wastes (K2) – Impacts of e-wastes on Environment (K3) - Control and disposal methods of e-wastes (K4).

UNIT V Energy Recovery from Wastes Contact Hours 8

Vermicomposting, mushroom cultivation, fly ash bricks, biogas; Microbial fuel cell - Production of methane, ethanol, electricity; Industrial specific waste management techniques (K3, K4 & K5).

Text Books

1. Kinnaman, T.C and Takeuchi, K. (2014). Handbook on Waste Management, Edward Elgar Publishing, UK.
2. Ramesha Chandrappa and Jeff Brown, (2012). Solid Waste Management: Principles and Practice, Springer Science and Business Media Publishers.
3. Bhide and Sundaresan (2000) Solid Waste Management in Developing Countries – Indian National Scientific Documentation Center, New Delh
4. Basarkar Shishir, (2009) Hospital Waste Management: A Guide for Self-Assessment and Review, JAYPEEDIGITAL
5. Surendra Kumar (2009) Solid waste management, Northern Book Centre

CORE COURSE – VII

WASTE MANAGEMENT

Reference Books

1. Hieronymi, C.K, R. Kahhat, and Williams, E. (2012) E-waste Management: From Waste to Resource. Routledge Taylor Francis Group Publishers.
2. Lagrega, M.D, Buckingham, P.L and Evans, J.V. (2001) Hazardous Waste Management, McGraw Hill Int. Ed. New York.
3. Lie, D.H.F and Liptak B.G (2000) Hazardous Wastes and Solid Wastes, Lewis publishers, New York
4. John Pitchel (2014) Waste Management Practices, Municipal, Hazardous, and Industrial, 2nd Edition, CRC Press
5. Subramanian MN (2019) Plastic Waste Management Processing and Disposal, 2nd Edition, Scrivener Publishing.

Web References

1. http://www.cpeo.org/techtree/ttdescript/pyrols.htm
2. www.satavic.org/vermicomposting.htm
3. http://web.mit.edu/urbanupgrading/urbanenvironment/sectors/solid-waste-landfills.html
4. www.cement.org/waste/wt_apps_radioactive.asp
5. www.ipma.co.in/recycle.asp
6. linkinghub.elsevier.com/retrieve/pii/S026974910600042X
7. https://www.researchgate.net/publication/42339862_Biomedical_waste_management_An_overview
8. https://aces.nmsu.edu/pubs/_g/G314.pdf
9. http://cbs.teriin.org/pdf/Waste_Management_Handbook.pdf
10. https://www.eawag.ch/fileadmin/Domain1/Abteilungen/sandec/E-Learning/Moocs/Solid_Waste/W2/Solid_waste_management_UNEP_2005.pdf

Experiments for Practical Course

1. Segregation of wastes.
2. Composting techniques of wastes
3. Energy recovery from wastes – methane production
4. Waste utilization techniques for value added products – fly ash bricks, mushroom beds, coir bricks.

CORE COURSE – VIII

ENERGY AND ENVIRONMENT

Semester	Paper Code	Marks	Hours/Week	L	T	P	Credit
VI	20UPEVS2C08	100	5	4	1	0	5

Course Objectives

The purpose of this course is to understand the various forms of conventional and non-conventional energy resources and effective utilization of their resources. Further, to explore the knowledge pertaining to various biological energy resources and their feedstocks, conversion technologies and conservation practices.

Course Outcomes

On the successful completion of the course, students will be able to

CO1 Understand the different types of energy sources

CO2 Explore the knowledge in the interrelationship with energy-environment-sustainable development

CO3 Understand the global fossil fuels energy resources utilization and their impact on environment and economy and need for coal phase out scenario

CO4 Identify the alternative source of energy including nuclear energy resources

CO5 Explore more knowledge related to various renewable energy resources in India

CO6 Understand the existing novel technologies used for energy conservation in an efficient manner

CO7 Identify the suitable technologies for green buildings in terms of energy conservation and energy audit for sustainable environmental management

CO8 Understand the recent initiatives and policy framework by different organizations and MNRE, MoEF&CC and other Ministries

Mappings of course outcomes with programme outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	*					*	*	*
CO2	*		*		*	*	*	*
CO3	*		*		*	*	*	*
CO4	*		*		*	*	*	*
CO5	*		*		*	*	*	*
CO6	*		*		*	*	*	*
CO7	*		*		*	*	*	*
CO8	*		*		*	*	*	*

CORE COURSE – VIII

ENERGY AND ENVIRONMENT

UNIT I Energy sources Contact Hours 10

Introduction to nexus between Energy, Environment and Sustainable Development (K1 & K2) - Potential and perspectives of various energy sources in India (K3 & K4) - Classification of energy resources - Conventional and Non-conventional, Renewable and Non- renewable energy (K1, K2, K3 & K4) – Environmental implications of energy resources (K4 & K5)

UNIT II Non-renewable Energy Sources Contact Hours 12

Fossil fuels (Coal, petroleum, LPG and natural gas) – Composition and Classification of coal, crude oil and natural gas – Consumption and demands of coal, crude oil and natural gas – Environmental and economic impacts of fossil fuel consumption (K3 & K4) – Global coal phase out scenario (K4, K5 & K6) - Nuclear energy – fission and fusion (K1 & K2)

UNIT III Renewable Energy Sources Contact Hours 14

Solar, wind, geothermal, hydel and tidal energy sources (K1 & K2) - *Ocean Thermal Energy Conversion (OTEC)*: Principle and generation (K3 & K4) – Global energy consumption pattern – Applications of solar and wind energy - Present scenario and recent initiatives of renewable energy sources in India (K4, K5 & K6)

UNIT IV Waste to Energy Contact Hours 10

Bioenergy - Biomass energy as an energy source - Characteristics of biomass (K1 & K2) - Energy plantations - Biomass conversion technologies (K3 & K4) - *Types of biofuels*: Biodiesel, bioethanol, biogas, biohydrogen - Importance, production, technologies and applications (K4, K5 & K6) - India's Bioenergy Policy (K3 & K4)

UNIT V Energy Conservation Contact Hours 08

Energy conservation – Principles and approach (K1 & K2) - Energy conservation in buildings - Green buildings - Solar passive architecture, eco-housing (K3, K4, K5 & K6) - Energy audit (K4 & K5) - National and International norms (K2)

Text Books

1. Anuja Dahiya (2015) Bioenergy - Biomass to Biofuels. Academic Press, UK.
2. Balasubramanian Viswanathan (2017) Energy Sources. Fundamentals of Chemical Conversion Processes and Applications. Elsevier, Netherlands.
3. Bansal NK (2014) Non-Conventional Energy Resources, Vikas Publishing House Pvt Ltd., New Delhi.
4. Bhatia SC and Gupta RK (2018) Textbook of Renewable Energy. Woodhead Publishing India Private Limited, New Delhi.
5. Mehmet Kanoglu, Yunus A. Cengel, John M. Cimbala (2019) Fundamentals and Applications of Renewable Energy. McGraw-Hill Education.
6. Sawhney GS (2012) Non-Conventional Energy Resources, PHI Learning Private Limited, New Delhi.

CORE COURSE – VIII

ENERGY AND ENVIRONMENT

Reference Books

1. David B. Rutledge (2020) Energy: Supply and Demand. Cambridge University Press, UK.
2. Ehrlich R (2013) Renewable Energy. A First Course. CRC Press, Boca Raton, USA.
3. Galanakis CM (2020) Biobased Products and Industries. Elsevier, Netherlands.
4. Jacobson MZ (2020) 100% Clean, Renewable Energy and Storage for Everything. Cambridge University Press, UK.
5. Mitra M and Nagchaudhuri A (2020) Practices and Perspectives in Sustainable Bioenergy. A Systems Thinking Approach. Springer Nature India Private Limited.
6. Nikolay Belyakov (2019) Sustainable Power Generation. Current Status, Future Challenges, and Perspectives. Academic Press, UK.
7. Pandey A, Larroche C, Dussap C-G, Gnansounou, Khanal SK and Ricke S (2019) Biofuels: Alternative Feedstocks and Conversion Processes for the Production of Liquid and Gaseous Biofuels. Academic Press, UK.
8. Simon CA (2020) Alternative Energy. Political, Economic and Social Feasibility. Second Edition, Rowman & Littlefield, USA.
9. Thomas L (2020) Coal Geology, Third Edition, Wiley.
10. Tyagi H, Chakraborty PR, Powar S and Agarwal AK (2020) Solar Energy. Systems, Challenges, and Opportunities. Springer Nature Singapore Pte Ltd.

Journal Articles

1. Alalwan HA, Alminshid AH and Aljaafari HA (2019). Promising evolution of biofuel generations. Subject review. *Renewable Energy Focus*, 28, 127-139.
2. Bhagea R, Bhoyroo V and Puchooa D (2019). Microalgae: the next best alternative to fossil fuels after biomass. A review. *Microbiology Research*, 10(1).
3. Gong J, Li C and Wasielewski MR (2019) Advances in solar energy conversion. *Chemical Society Reviews*, 48(7), 1862-1864.
4. Lu M and Lai JH (2019) Building energy: a review on consumptions, policies, rating schemes and standards. *Energy Procedia*, 158, 3633-3638.
5. Srivastava RK, Shetti NP, Reddy KR and Aminabhavi TM (2020). Biofuels, biodiesel and biohydrogen production using bioprocesses. A review. *Environmental Chemistry Letters*, 1-24.
6. Vargas SA, Esteves GRT, Maçaira PM, Bastos BQ, Oliveira FLC and Souza RC (2019). Wind power generation: A review and a research agenda. *Journal of Cleaner Production*, 218, 850-870.
7. Wang H, Lei Z, Zhang X, Zhou B and Peng J (2019). A review of deep learning for renewable energy forecasting. *Energy Conversion and Management*, 198, 111799.

Web References

1. https://www.iea.org/reports/global-energy-review-2020.
2. https://climateanalytics.org/media/report_coal_phase_out_2019.pdf
3. https://publications.jrc.ec.europa.eu/repository/bitstream/JRC111438/acd_in_metis_final.pdf
4. https://www.worldgbc.org/what-green-building
5. https://beeindia.gov.in/sites/default/files/ctools/TR-EnergyAudits.pdf

CORE COURSE – IX

ENVIRONMENTAL ANALYSIS AND TECHNIQUES

Semester	Paper Code	Marks	Hours/Week	L	T	P	Credit
VI	20UPEVS2C09	100	5	4	1	0	5

Course Objectives

The purpose of this course is to introduce knowledge and skills in analysis of environmental pollutants in environmental matrices, including extraction, sample preparation and instrumentations analysis, theory and techniques in quantitative and qualitative methods.

Course Outcomes

On the successful completion of the course, students will be able to

CO1 Understand the basics and requirement of environmental analysis

CO2 Understand the environmental quality parameters to be monitored and determined

CO3 Know the role of sample preparation in environmental analysis

CO4 Understand the instrumental techniques and methods of analysis

CO5 Use spectroscopic and chromatographic techniques to quantify various pollutants in environment

CO6 Collect, analyze, validate the instrumental data and conclude the analytical data.

CO7 Demonstrate the ability to communicate results effectively in written analytical reports

Mappings of course outcomes with programme outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	*							
CO2		*		*				
CO3	*	*						
CO4				*	*			
CO5			*	*		*		
CO6						*	*	
CO7						*	*	*

CORE COURSE – IX

ENVIRONMENTAL ANALYSIS AND TECHNIQUES

UNIT I Introduction to Environmental Analysis Contact Hours 8

Quality Control and Quality Assurance Program in Environmental Analysis - Qualitative and Quantitative Analysis - Internal and External Standards - Standards Data Collection - Analysis - Data Errors in Quantitative analysis, Precision and Accuracy in Measurement. Types of Samples and Analysis Methods. (K1,K2,K3)

UNIT II Water Quality Analysis Contact Hours 10

Physical Parameters - Colour - Temperature - Turbidity. Chemical Parameters - pH- Electrical Conductivity - Total Solids - Dissolved Oxygen - Total Alkalinity - Iron -Nitrate - Biochemical Oxygen Demand - Chemical Oxygen Demand. Biological Parameters - MPN (Most Probable Number) and MFT (Membrane Filter Techniques) - SPC (Standard Plate Count) - National Water and Wastewater Quality Standards. (K1,K2,K3)

UNIT III Soil Quality Analysis Contact Hours 6

Collection of Soil Samples - Physico - Chemical Analysis of Soil - Density - Specific gravity - Texture - pH - Electrical Conductivity - Chlorides - Nitrates - Phosphates - Organic Matter - Standard Soil Quality Standards. (K1,K2, K3, K4,K5)

UNIT IV Air Quality Analysis Contact Hours 8

Indoor Air Quality - Ambient Air Quality Parameters – Particulate Maters, Inorganic and Organic Air Pollutants - Air Sampling Methods - Air Quality Monitoring Equipments - Environmental Air Quality Standards. (K1,K2, K3)

UNIT V Analytical Techniques Contact Hours 12

pH meter - Electrical Conductivity Meter - Nephlometer - UV-Vis Spectrometer - High Pressure Liquid Chromatography (HPLC) - Gas Chromatography - Flame Photometer - Atomic Absorption Spectrometry - X-ray Diffraction - Sound Level Meter. (K1,K2, K3, K4,K5)

Text Books

1. Krishnan Kannan, K., 1997. Fundamentals of Environmental Pollution, S. Chand Company, New Delhi
2. Murali Krishna, K.V.S.G. (2015) Air Pollution and Control, University Science Press.
3. Dara, S.S., 2000. A Text book of Environmental Chemistry and Pollution Control. S. Chand Company, New Delhi.

Reference Books

1. Christian GD (2001), Analytical Chemistry, 5th edition, John Wiley and Sons Inc., India
2. Wilson, K, Walker, J (2010) Principles and Techniques of Biochemistry and Molecular Biology, 7th edition, Cambridge University Press.
3. Goel, P.K. (2006) Water Pollution Causes, Effects and Control, New Age International Publishers.
4. Sandell, E. B., and Ōnishi, H. (1978) Photometric determination of traces of metals, Wiley

5. Welz, B., and Sperling, M. (2008) Atomic Absorption Spectrometry, John Wiley & Sons.
6. Ed Metcalfe, Atomic absorption and emission spectroscopy, J. Wiley, 1987.

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1. https://www.statisticshowto.com/accuracy-and-precision/
2. http://reference.wolframcloud.com/language/guide/ScientificDataAnalysis.html
3. https://www.epa.gov/wqs-tech/water-quality-standards-handbook
4. http://cwc.gov.in/water_quality
5. http://www.fao.org/3/a-i0131e.pdf
5. https://www.intechopen.com/books/air-quality/methods-for-online-monitoring-of-air-pollution-concentration
6. https://www.iedunote.com/environmental-analysis
7. http://www.cpeo.org/techtree/ttdescript/msgc.htm
8. https://www.scu.edu.au/southern-cross-geoscience/research-facilities-and-resources-group/analytical-equipment/
9. http://www.sticindia.com/saif_instruments.html#ea

Experiments for Practical Course

1. Internal and External Standard Calibration using Standard Sample.
2. Accuracy and Precision analysis.
3. Determination of Chemical Oxygen Demand from wastewater.
4. Estimation of soil organic matter.
5. Determination of soil Nitrate and Phosphate Contents.
6. Air sampling using high volume Air sampler.
7. Quantification of PM_{10}/$PM_{2.5.}$
8. Analysis of Organic Pollutants using GC/GC-MS.
9. Quantification of water pollutants using HPLC.
10. Quantification of heavy metals using AAS / ICP/MS.

CORE COURSE – X

ENVIRONMENTAL BIOTECHNOLOGY

Semester	Paper Code	Marks	Hours/Week	L	T	P	Credit
VII	20UPEVS2C10	100	5	4	1	0	5

Course Objectives

The purpose of this course is to acquaint students with knowledge in environmental biotechnology for gene cloning, to acquire skills in bioremediation of environmental pollutants, to apply the skills in developing innovative biotechnological processes for waste conversion, resource recovery, and production of bioproducts bioresources.

Course Outcomes

On the successful completion of the course, students will be able to

CO1 Understand the principles and methods of DNA manipulation, gene cloning and PCR process

CO2 Understand the basic principles of bioremediation of environmental pollutants.

CO3 Explain the role of microbes in degradation of environmental pollutants

CO4 Acquire skills in manipulating the microbes for biodegradation of pollutants

CO5 Develop processes for waste bioconversion to value-added products.

CO6 Apply the process for recovery of resources from different wastes.

CO7 Become an entrepreneur/researcher in the areas of environmental biotechnology.

Mappings of course outcomes with programme outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	*							
CO2	*	*						
CO3			*					
CO4	*	*	*	*			*	
CO5		*				*		
CO6	*					*		
CO7		*					*	*

CORE COURSE – X

ENVIRONMENTAL BIOTECHNOLOGY

UNIT I Structure and DNA Modifying Enzymes Contact Hours 12

Introduction to Biotechnology - Organization of Bacterial Genome - Structure of DNA – Restriction Enzymes: Nomenclature - Classification - Restriction and Methylation - Type II Restriction Endonuclease - Use of Restriction Endonucleases - Restriction Mapping and its Applications - DNA Modifying Enzymes - Nucleases - Polymerases - DNA Ligases. (K1, K2, K3)

UNIT II Gene Cloning and PCR Techniques Contact Hours 10

Gene Cloning - Over view, Cloning vectors - Plasmids, phages and cosmids, phagemids, Ti plasmids and viral vectors M13 - Cloning strategies, cloning and selection of individual genes – PCR - Working principle, types and applications. Environmental genome. (K1, K2, K3)

UNIT III Environmental Applications Microbes Contact Hours 10

Use of microbes in environmental decontamination - Biodegradation - Biosorption - Biotransformation - Bioaugmentation - Biostimulation - Rhyzoremediation, Mycoremediation - Phycoremediation - Bioleaching and Biomining - MEOR - Bioremediation pollutants: Heavy metals, PAHs, VOCs - Bioindicators and biosensors for detection of pollution. (K1, K2, K3)

UNIT IV Biotechnology for Waste Treatment Contact Hours 10

Biotechnology for Waste Management - Sewage treatment - Activated Sludge Process - Anaerobic Treatment - Sludge stabilization - Aerobic Composting, Anaerobic Digestion, Biogas Production, Algal Cultivation: Nutrient Removal. Solid Waste Treatment - Biocomposting - Vermicomposting - Air Pollution Control - Bioscrubber, Biofilters. (K3, K4, K5, K6)

UNIT V Microbial Bioproducts Contact Hours 10

Microbial bioproducts for environmental cleanup - Microbial biomass - Biosorbents - Biosurfactants - Microbial enzymes: lignocellulases, lipases, dioxygenases - Bioflocculants - Bioplastics - Biofertilizers - Biopesticides - Microbial fuels: Bioethanol, Biobutanol, and Biohydrogen. (K4, K5, K6)

Text Books

1. Mohapatra, P.K. (2008) Text Book of Environmental Biotechnology. IK International Publishers Ltd
2. Thakur, I.K. (2013) Environmental Biotechnology: Basic Concepts and Applications. 2nd Edition.
3. Brown TA (1995) Gene cloning - A introduction - Chapman & Hall, London.

CORE COURSE – X

ENVIRONMENTAL BIOTECHNOLOGY

Reference Books

1. Alexander N. Glazer Hiroshi Nikaido (1995) Microbial Biotechnology, WH Freeman and Company, NY, USA.
2. Bernaral R. Glick and Jack J. Pastemak (1994) Molecular Biotechnology: Principles and Applications of Recombinant DNA, ASM Press. Washington, DC USA.
3. Brown, T.A. (1995) Gene cloning - A introduction - Chapman & Hall, London.
4. Glazer and Nikaido (1995) Microbial Biotechnology. WH Freeman & Co., New York.
5. Kreuzer and Massey (2001) rDNA & Biotechnology. A guide for Teachers, 2nd Edition, ASM Press, Washington DC, USA.
6. Old, R.W. and Primrose, S.B. (1994) Principles of Gene Manipulation. Blackwell Scientific Publications, Oxford, UK.
7. Primrose SB (1994) Molecular Biotechnology, 2nd edition, Blackwell Scientific Publications, UK.
8. Singh, D.P. and Dwivedi, S.K. (2005) Environmental Microbiology and Biotechnology. 1st Edition, New Age International (P) Ltd., Publishers, New Delhi.
9. Fulekar, M.H. (2010) Environmental Biotechnology, CRC Press.
10. Cheremisinoff, N.P. (1997) Biotechnology for Waste and Wastewater Treatment. Science direct.

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1. www.microbialfuelcell.org
2. www.pollutionissues.com/A-Bo/Bioremediation.html
3. www.bioreactors.net
4. http://enhs.umn.edu/current/5103/gm/harmful.html
5. www.wastewatertreatment.co.in/index.php
6. http://archive.industry.gov.au/Biotechnologyonline.gov.au/enviro/environment.html
7. https://preventioncdnndg.org/eco-quartier/biomethanization-2/
8. https://www.nrel.gov/workingwithus/learning.html
9. https://www.epa.gov/recycle/composting-home
10. https://www.epa.gov/remedytech/green-remediation-best-management-practices-bioremediation

Experiments for Practical Course

1. Isolation of Genomic DNA and Agarose Gel Electrophoresis.
2. DNA Restriction Analysis and Mapping.
3. PCR Amplification of Bacterial 16S rRNA gene.
4. Biodegradation of organic pollutants - Phenol, Synthetic Dyes.
5. Aerobic treatment of wastewater.
6. Sewage sludge conditioning and sludge dewatering.
7. Production of Biosurfactants.
8. Biocomposting of sewage sludge.
9. Production of Microbial enzymes - Cellulase / Protease / Lipase / Ligninases.
10. Production of Biofertilizer - Rhizobium, Azotobacter.

CORE COURSE – XI

ENVIRONMENTAL IMPACT ASSESSMENT

Semester	Paper Code	Marks	Hours/Week	L	T	P	Credit
VII	20UPEVS2C11	100	5	4	1	0	5

Course Objectives

The purpose of this course is to introduce the methodology of environmental impact assessment (EIA) as a vital tool for sound environmental management and decision-making and to provide an overview of the concepts, methods, issues and various forms and stages of the EIA process.

Course Outcomes

On the successful completion of the course, students will be able to

CO1 Explain the major principles and components of EIA processes

CO2 List and comply with the environmental clearance procedures in India

CO3 Understand about the methods used for EIA studies

CO4 Discuss the implications of current jurisdictional and institutional arrangements in relation to EIA

CO5 Communicate both orally and in written form the key aspects of EIA

CO6 Understand how to liaise with and the importance of stakeholders in the EIA process

CO7 Access different case studies/examples of EIA in practice

CO8 Summarize the EIA report with suitable environmental management plan

Mappings of course outcomes with programme outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	*			*	*	*	*	*
CO2	*			*	*	*	*	*
CO3	*			*	*	*	*	*
CO4	*			*	*	*	*	*
CO5	*			*	*	*	*	*
CO6	*			*	*	*	*	*
CO7	*			*	*	*	*	*
CO8	*			*	*	*	*	*

CORE COURSE – XI

ENVIRONMENTAL IMPACT ASSESSMENT

UNIT I Introduction to EIA Contact Hours 12

Definition – Principles of EIA – Short-term and Long-term objectives - Evolution of EIA worldwide and in India – *Types of EIA*: Rapid EIA, Comprehensive EIA and Strategic EIA - Projects subject to EIA (Category A, B1 and B2) – Steps in EIA process – Objectives of the Standard Terms of Reference (TOR) - Stages and time frame for obtaining Environmental Clearance from MoEF & CC according to EIA notification 2006 – Merits and Demerits of EIA (K1, K2 & K3) – Overview of EIA 2020 Draft (K4 & K5)

UNIT II EIA Methodologies Contact Hours 10

Assessment of impacts: Air, water, soil, noise, biological, social, cultural, economical, and environmental factors (K5 & K6) – *EIA Methodologies*: Adhoc Method – Checklist Approach – Matrix Methods – Network Methods – Overlay Method (K2, K3 & K4)

UNIT III Public Participation, Preparation and Review of EIA Report Contact Hours 10

Objectives of People's Participation - Advantages and Disadvantages of People's Participation - People's Participation Techniques: Public Hearing - Preparation and Review of EIA Report: EIA Reports Content - Basis and Criteria for Evaluation of EIA Reports and EIA (K2, K3 & K4)

UNIT IV EIA case studies for major development projects Contact Hours 08

Major Highways Projects - Airport - River valley Projects – Mining and quarrying - Thermal and Hydroelectric Power Projects - Cement Industries (K3, K4, K5 & K6)

UNIT V Environmental Management System Contact Hours 12

*Environmental Management System***:** Core elements of EMS - Benefits of EMS - Certification body assessments of EMS - Documentation for EMS – ISO 14001 standard – PDCA (Plan-Do-Check-Act) in ISO 14001 Certification – Corporate Social Responsibility (CSR) Plan in India (K4, K5 & K6)

Text Books

1. Canter LW (1996) Environmental Impact Assessment. McGraw Hill, New York.
2. EIA Manual (2001) Ministry of Environment, Forest and Climate Change, New Delhi.

Reference Books

1. Anjaneyulu Y and Valli Manickam (2007) Environmental Impact Assessment Methodologies, 2nd Edition, B.S. Publications (ISBN: 978-81-7800-144-9).
2. Bregman JI (1999) Environmental Impact Statements. Lewis Publishers, London.
3. Carroll B, Fothergill J, Murphy J & Turpin T (2019) Environmental Impact Assessment Handbook: A practical guide for planners, developers and communities. ICE Publishing.
4. Christopher S and Mark Y (2007) Environmental Management Systems, (third edition), Earthscan Publications, First South Asian Edition.

5. David LG and Stanley BD (2001) ISO 14000Environmental Management, Prentice Hall.
6. Eccleston CH (2000) Environmental Impact Assessment - A Comprehensive Guide to Project and Strategic Planning, John Wiley and Sons, NY.
7. Hart SL (2019) Improving impact assessment: Increasing the relevance and utilization of scientific and technical information. Routledge.
8. Peter Wathern (2015) Environmental Impact Assessment: Theory and Practice, Taylor & Francis, London
9. Singleton R, Castle, P and Sort, D (1999) Environmental Assessment, Thomas Telford Publishing, London.
10. Whitelaw K and Butterworth (1997) ISO 14001: Environmental System Handbook.

Journal articles

1. Chowdhury, N. (2014). Environmental impact assessment in India: Reviewing two decades of jurisprudence. IUCN Academy of Environmental Law eJournal, 5, 28-32.
2. Singh, G. G., Lerner, J., Mach, M., Murray, C. C., Ranieri, B., St- Laurent, G. P.... & Chan, K. M. (2020). Scientific shortcomings in environmental impact statements internationally. People and Nature, 2(2), 369-379.

Web References

1. http://environmentclearance.nic.in/
2. www.fao.org/docrep/V8350E/v8350e06.htm
3. http://www.moef.nic.in/division/eia-manual
4. http://www.moef.nic.in/circulars
5. https://www.adb.org/documents/adb-environmental-assessment-guidelines
6. http://environmentclearance.nic.in/writereaddata/Draft_EIA_2020.pdf
7. http://environmentclearance.nic.in/writereaddata/Form-1A/HomeLinks/GuidanceManual.htm

Experiments for Practical Course

1. Preparation of EIA report for environmental clearance (EC)
2. Preparation of checklists for EIA study

CORE COURSE – XII

NATURAL RESOURCES MANAGEMENT

Semester	Paper Code	Marks	Hours/Week	L	T	P	Credit
I	20UPEVS2C12	100	5	4	1	0	5

Course Objectives

The purpose of this course is a view of the nature of Earth's resources, particularly the nonrenewable resources, how and where they are generated, how they are extracted and used, and how these activities impact Earth's environment. It also addresses sustainability by looking into different ways of conservation of the natural resources and their management.

Course Outcomes

On the successful completion of the course, students will be able to

CO1 Understand the different types of natural resources and their significance in ecosystem

CO2 Extensive knowledge pertaining to the sustainable utilization of natural resources

CO3 Develop an objective view of the nature of Earth's resources, particularly the non-renewable resources

CO4 Explain how and where the Earth's resources are generated, how they are overexploited, and how these activities impact Earth's environment

CO5 Develop perspectives on sustainability by looking into different ways of conservation of the precious natural resources and their management

CO6 Understand the recent initiatives and policy framework by different organizations for sustainable resources management

CO7 Gain an overview of key concepts, theories and analytical frameworks related to natural resource governance

CO8 Carry out interdisciplinary research and evaluate various natural resource based interventions for its social, institutional, ecological and economic outcomes

Mappings of course outcomes with programme outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	*				*	*	*	*
CO2	*				*	*	*	*
CO3	*					*	*	*
CO4	*				*	*	*	*
CO5	*			*	*	*	*	*
CO6	*			*		*	*	*
CO7	*			*		*	*	*
CO8	*			*		*	*	*

CORE COURSE – XII

NATURAL RESOURCES MANAGEMENT

UNIT I Introduction Contact Hours 08

Natural resources – Classification, Concepts and approaches of natural resource conservation (K1 & K2) – Natural resources of India – Factors influencing resource availability (K1 & K2) - Overexploitation of natural resources - Earth overshoot Day (K3 & K4)

UNIT II Land Resources Management Contact Hours 12

Land degradation due to mining, exploration, industrialization, irrigation and natural disasters - Soil erosion – Land degradation in India (K1, K2, K3 & K4) – Salient features of CoP 14 UNCCD for land restoration - Land restoration for achieving the Sustainable Development Goals (K4 & K5) - *Soil Fertility and Nutrient Management*: Role of organic matter and its significance in soil quality – Diagnosis of soil nutrient deficiencies (K3, K4 & K5) – Sustainable agricultural practices (K5 & K6) - Wasteland development strategies – Ecological significance of wetland conservation (K4 & K5)

UNIT III Mineral Resources Management Contact Hours 12

Resources and reserves – Origin, distribution and uses of economic minerals (K1 & K2) - Exploration of mineral resources from oceans - Steps in mineral exploitation - Impact of exploitation of economic minerals on environment - Conservation of economic mineral resources (K3, K4 & K5)

UNIT IV Water Resources Management Contact Hours 14

Overutilization of surface and groundwater – Integrated water resource management (K2, K3 & K4) - Watershed management – Rain water harvesting (K5 & K6) – Conflicts of major river water disputes in India - Interlinking of rivers and river basin management – Restoration of lakes and Ganga and Yamuna River Action Plans (K3, K4 & K5) - Coastal zone management strategies - Ecological significance of mangroves, Coral reefs and its conservation (K4 & K5)

UNIT V Forest Resources Management Contact Hours 12

Significance for the conservation of forest resources – Major forest types in India and their characteristics (K1 & K2) - Timber extraction, mining, dams and their impacts on forest and tribal people – Key features in India State of Forest Report 2019 (K3, K4 & K5) - *Forest management tools*: Social forestry, Agro-forestry, Urban forestry and Community forestry - Eco development committees, Ecotourism and Management of grasslands (K4 & K5)

Text Books

1. Owen OS & Chiras DD (1995) Natural Resources Conservation. Prentice-Hall India, New Delhi.
2. Sarah Fehley (2011) Natural Resource Management, Oriental Enterprises, Dehradun, India.
3. Miller TG Jr. (1989) Environmental Science, Wadsworth Publishing Co.

Reference Books

1. Dutta A (2001) Biodiversity and Ecosystem Conservation. Kalyani Publisher, Kolkata.
2. Filho WL and Sumer V (2015) Sustainable Water Use and Management, Springer International Publishing, Switzerland.
3. Grebner DL, Bettinger P and Siry JP (2013) Introduction to Forestry and Natural Resources, Academic Press, UK.
4. Jha LK (1997) Natural Resource Management. APH Publishing Corporation, New Delhi.
5. Jhariya MK, Banerjee A, Meena RS, Yadav DK (2020) Sustainable Agriculture, Forest and

Environmental Management, Springer, Singapore.

6 Kumar HD (1995) Modern Concepts of Ecology. Vikas Publishing House (P) Ltd., New Delhi.

7 Larocque GR (2020) Ecological Forest Management Handbook, Taylor & Francis.

8 MaDicken KG and Vergora NT (1990) Agroforestry: Classification & Management. John Wiley & Sons, New York.

9 Nalini KS (1993) Environmental Resources and Management, Anmol Publications (P) Ltd., New Delhi.

10 Nautiyal S and Kaul AK (1999) Forest Biodiversity & its Conservation Practices in India.

11 Negi SS (1993) Biodiversity and its Conservation in India. Indus Publications, New Delhi.

12 Obi Reddy GP, Patil NG and Arun Chaturvedi (2017) Sustainable Management of Land Resources: An Indian Perspective, Apple Academic Press, Inc., USA.

13 Ramade F (1984) Ecology of Natural Resources, John Wiley & Sons Ltd.

14 Rana SVS (2003) Essentials of Ecology & Environmental Sciences. Prentice-Hall of India, New Delhi.

15 Raymond F and Dasmann (1984) Environmental Conservation. 5th edition, John Wiley & Sons, New York.

16 Sapru RK (1987) Environmental Management in India. Vol I & II. Ashish Publishing House, New Delhi.

17 Sharma VK (1985) Water Resources Planning and Management. Himalaya Publishing House, New Delhi.

18 Tewari DN (1994) Tropical Forestry in India. Int. Book Distributor, Dehra Dun.

19 Wang Y (2014) Encyclopedia of Natural Resources – Land - Volume I, CRC Press, USA.

Journal Articles

1 Islam, M., & Managi, S. (2019). Green growth and pro-environmental behavior: Sustainable resource management using natural capital accounting in India. *Resources, Conservation and Recycling*, 145, 126-138.

2 Jain, S. K. (2019). Water resources management in India–challenges and the way forward. Current Science, 117(4), 569-576.

3 Rahaman, M. M., & Varis, O. (2005). Integrated water resources management: evolution, prospects and future challenges. *Sustainability: Science, Practice and Policy*, 1(1), 15-21.

4 Rebound effects in agricultural land and soil management: Review and analytical framework Paul, C., Techen, A. K., Robinson, J. S., & Helming, K. (2019). Rebound effects in agricultural land and soil management: Review and analytical framework. *Journal of Cleaner Production*, 227, 1054-1067.

5 Roidt, M., & Avellán, T. (2019). Learning from integrated management approaches to implement the Nexus. Journal of Environmental Management, 237, 609-616.

6 Singh, A., Saha, D., & Tyagi, A. C. (2019). Emerging issues in water resources management: Challenges and prospects. In Water governance: Challenges and Prospects (pp. 1-23). Springer, Singapore.

7 Soni, A. K. (2019). Mining of Minerals and Groundwater in India. In: Groundwater-Resource Characterisation and Management Aspects. Intech Open.

Web References

1. http://www.icimod.org/?q=1258

2. mines.nic.in/imsector.html

3. www.rainwaterharvesting.org/happenings/wetland_conservation.htm

4. www.ecoworld.com/atmosphere/effects/organic-farming-in-india.html

5. www.agroforestry.net

CORE COURSE – XIII

CLIMATE CHANGE AND CURRENT ISSUES

Semester	Paper Code	Marks	Hours/Week	L	T	P	Credit
I	20UPEVS2C13	100	5	4	1	0	5

Course Objectives

The purpose of this course is to focus on improving understanding of the climate system and climate science and the impacts of climate change, mitigation and/or adaptation to climate change and related issues.

Course Outcomes

On the successful completion of the course, students will be able to

CO1 Understand the climate and climate change processes at local to global scales

CO2 Empower the students to think critically about climate science

CO3 Sources and impacts of climate change due to anthropogenic activities especially energy utilization

CO4 Understand the existing novel technologies used for measurement of climate change and weather forecasting

CO5 Understand the recent initiatives and policy framework by UNFCCC, IPCC, CoP, MoEF&CC and other Ministries

CO6 Evaluate the successes and failures of past National and International efforts to address climate change mitigation and adaptation

CO7 Know how decisions about carbon emissions and other human activities might impact future climate during Anthropocene era

CO8 Evaluate prospects for future management of climate change

Mappings of course outcomes with programme outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	*			*		*	*	*
CO2	*					*	*	*
CO3	*			*		*	*	*
CO4	*				*	*	*	*
CO5	*	*			*	*	*	*
CO6	*				*	*	*	*
CO7	*			*	*	*	*	*
CO8	*	*			*	*	*	*

CORE COURSE – XIII

CLIMATE CHANGE AND CURRENT ISSUES

UNIT I **Meteorological Elements for Climate Change** Contact Hours 10

Structure of atmosphere: Vertical structure of atmosphere - *Atmospheric stability*: Adiabatic process – Air Temperature, Humidity, *Condensation*: Dew and Frost, Fog, and clouds – *Clouds*: Classification of clouds - *Precipitation processes*: Collison and Co-alescence process and Ice-crystal or Bergeron process – Cloud seeding – Precipitation types (Rain, snow, Sleet and freezing rain, snow grains and snow pellets, hail) - *Air Pressure and Winds:* Atmospheric pressure – Forces that influence the wind (Pressure gradient force, Coriolis force, centripetal force, friction) (K1 & K2)

UNIT II **Atmospheric Circulation, Air masses and Fronts** Contact Hours 12

Atmospheric circulation: Hadley circulation – Intertropical Convergence Zone (ITCZ) – Jet streams - *Global wind patterns*: Trade winds, Westerlies and Polar Easterlies – *Thermal circulations*: Sea and land breezes, Mountain and valley breezes, Katabatic winds, Chinook (Foehn) winds, Santa Ana winds, Desert winds - *Air masses*: Classification and characteristics of air masses – Types of air masses – *Fronts*: Type of fronts: Stationary fronts, cold fronts, warm fronts, occluded fronts (K1 & K2)

UNIT III **Air Quality and Consequences of Climate Change** Contact Hours 12

Global Air Quality and CO_2 concentration scenario - Role of air pollutants in climate change – Sources of greenhouse gases: Coal burning, Transportation sectors (vehicle, railways, shipping and aviation) - Ozone depleting substances – Facts and figures of current global warming scenarios in the world – *Extreme events of climate change*: - El Niño, La Niña and El Niño Southern Oscillation (ENSO) – Recent extreme events in the world – Global consequences of El Niño – Impacts of climate change: Changes in the SW and NE monsoon patterns in India – Melting of ice glaciers and Sea levels - Water scarcity - Food security – Species extinction – Human health – Civil Wars and Migration – Global swarming: Locust plaque (K2, K3, K4& K5)

UNIT IV **Climate Classification, Measurement of Climate Change and Weather forecasting** Contact Hours 08

Classification of climate: Koppen's and Thornthwaite' scheme - *The measurement of climate change*: Tree rings, ice cores, ocean sediments, pollen records, Boreholes and other proxy measurements - *Weather forecasting tools*: AWIPS computer work station, Doppler radar data, metogram, satellites and weather forecasting – *Types of forecasts*: Nowcast, short-range forecasts, medium and long-range forecasts (K2, K3 & K4)

UNIT V **Global/National Action Plans to Combat Climate Change Issues** Contact Hours 08

Key steps taken by UNFCCC to combat climate change: Kyoto Protocol – Copenhagen Accord 2009 - Cancun Agreements 2010 to establish Green Climate Funds – Paris Climate Agreement 2015, Intended Nationally Determined Contribution (INDC) to cut greenhouse gas emissions at CoP 21 – Montreal Protocol for ODS, Kigali Amendment 2016 to phase out hydrofluorocarbons (HFC) – Green climate funds – Clean Development Mechanism (CDM) – Climate Change Information Network (CC:iNet) – National Action Plan on Climate Change (Eight missions) – Recent initiatives related to climate change adaptation and mitigation in India (K4 & K5)

Text Books

1 Donald Ahrens C and Robert Henson (2016) Meteorology Today: An Introduction to Weather, Climate, and the Environment. Eleventh Edition, Brooks/Cole, Cengage

Learning, USA.

2 Galvin JFP (2016) An Introduction to the Meteorology and Climate of the Tropics. John Wiley & Sons Ltd., UK.

Reference Books

1 Alberto Troccoli, Laurent Dubus and Sue Ellen Haupt (2014) Weather Matters for Energy. Springer, New York.

2 Cowie J (2007) Climate Change: Biological and Human Aspects, Cambridge University Press, UK. 32

3 Dogra N and Srivastava S (2012) Climate Change and Disease Dynamics in India, TERI, New Delhi.

4 Filho WL (2012) Climate Change and the Sustainable Use of Water Resources, Springer-Verlag, Berlin, Heidelberg.

5 Friel S (2019) Climate Change and the People's Health (Vol. 2). Small Books Big Ideas in Popul.

6 John Turner and Gareth J Marshall (2011) Climate Change in the Polar Regions. Cambridge University Press, UK.

7 Kala CP and Silori CS (2013) Biodiversity Communities and Climate Change, TERI, New Delhi.

8 Lawrence A. Palinkas (2020) Global Climate Change, Population Displacement, and Public Health. The Next Wave of Migration. Springer Nature Switzerland.

9 Newman J, Anand M, Henry H, Hunt S and Gedalof Z (2011) Climate Change Biology, CAB International, Cambridge, MA, USA.

10 Marselle MR, Stadler J, Korn H, Irvine KN & Bonn A (2019) Biodiversity and health in the face of climate change (p. 481). Springer Nature.

11 Parry M L (2019). Climate Change and World Agriculture. Routledge.

12 Quaschning VV (2019) Renewable Energy and Climate Change. John Wiley & Sons.

13 Ramesh Chandrappa, Sushil Gupta and Umesh Chandra Kulshrestha (2011) Coping with Climate Change. Principles and Asian Context. Springer-Verlag, Berlin.

Journal Articles

1 Figueres C. (2020). Paris taught me how to do what is necessary to combat climate change.

2 Solomon, C. G., & LaRocque, R. C. (2019). Climate change—a health emergency. *New England Journal of Medicine*, 380(3): 209-211.

3 Walsh, B. S., Parratt, S. R., Hoffmann, A. A., Atkinson, D., Snook, R. R., Bretman, A., & Price, T. A. (2019). The impact of climate change on fertility. *Trends in Ecology & Evolution* 34(3): 249-259.

Web References

1. http://www.un-redd.org/
2. http://unfccc.int/
3. https://www.ipcc.ch
4. https://www.co2.earth/
5. http://www.climatecentral.org/
6. http://climate.nasa.gov/
7. http://www.who.int/mediacentre/news/
8. http://aqicn.org/map/

Experiments for Practical Course

1. Collection of meteorological data from authenticated government websites and analyse the scenario
2. Analyse the air quality data in the city

CORE COURSE – XIV

ENVIRONMENTAL GEOINFORMATICS

Semester	Paper Code	Marks	Hours/Week	L	T	P	Credit
VIII	20UPEVS2C14	100	5	4	1	0	5

Course Objectives

The purpose of this course is to introduce the principles, processes and application of Remote sensing and GIS, and to impart practical knowledge on the use of environmental geoinformatics and its techniques for Environmental management.

Course Outcomes

On the successful completion of the course, students will be able to

CO1 Acquaint adequate knowledge on principles and basic concepts of environmental geoinformatics.

CO2 Understand the basic concepts of GIS and its mechanisms

CO3 Know the various types of GPS systems

CO4 Learns to interpret satellite images

CO5 Understand Image Classification Techniques, Image enhancement and interpretation methods

CO6 Use GPS for various environmental applications.

CO7 Able to apply the tools of remote sensing and GIS for environmental disaster management and conservation

Mappings of course outcomes with programme outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	*				*		*	
CO2				*				
CO3				*	*		*	*
CO4				*	*			*
CO5				*				*
CO6				*	*		*	*
CO7	*				*		*	

CORE COURSE – XIV

ENVIRONMENTAL GEOINFORMATICS

UNIT I Remote Sensing Contact Hours 8

Intoduction to Remote Sensing Principles of Remote Sensing and GIS – Components of Remote Sensing Electromagnetic Radiation, EMR Spectrum- Properties –Historical Perspectives of Remote Sensing in India (K1, K2)

UNIT II GIS Concepts Contact Hours 10

Introduction to Geographical Information Systems Components of GIS -: Data structures - vector and raster data. Conversion of Vector and Raster Data – Geo referencing, Digitization and data attributes -map data representation. (K5, K6)

UNIT III GPS Concepts Contact Hours 10

Introduction to GPS, Error Sources and Positioning, GPS Satellite Systems, Types of GPS machines and its applications for surveying and mapping Global Navigation Satellite System.(K1, K2, K3)

UNIT IV Image Interpretation and Analysis Contact Hours 12

Principles of visual Interpretation of aerial photos and satellite imagery Recognition Elements and Interpretation keys. Image Enhancement Techniques-Linear Non- linear Contrast Enhancement Filtering - Principles of Image Classification - Supervised Classification - Unsupervised Classification (K2, K5, K6)

UNIT V Application of Remote Sensing and GIS Contact Hours 10

Applications of remote sensing for land use/land cover, landscape mapping, vegetation analysis, climate change studies, flood, drought assessment desertification and water shed management. Application of GIS for environmental studies- surveying and mapping. Emerging new softwares for RS and GIS.(K4, K5, K6)

Text Books

1. Chouhan T S (2020). Geoinformatics – Fundamentals and Applications, Scientific Publishers.
2. George Joseph, (2003).Fundamentals of Remote Sensing, Universities press (India) Pvt Ltd., Hyderabad.
3. Burrough, P. P. & McDonnel, R. A. (1998). Principles of GIS.Oxford University Press.

Reference Books

1. Chang, K. T. (2006). Introduction to Geographic Information Systems. The McGraw-Hill Publishers
2. Michael N. Demers (2008) Fundamentals of Geographical Information Systems. John Wiley & Sons, Inc.
3. Jenson, J.R. (1996)..Introductory Digital Image Processing: Prentice Hall Series.
4. Joseph Awange & John Kiema (2013) Environmental Geoinformatics: Monitoring

and Management. Springer Publications.

5. Bhatta B (2008) Remote Sensing and GIS. Oxford Publications
6. Kang Tsung Chang (2019) Introduction to Geographical Information System. 9th Edition, Mc. Graw Hill Publishers
7. Anji Reddy M (2016) Geoinformatics for Environmental Management, BS Publications.
8. Xuan Shu. (2005) GIS for Environmental Applications: A practical approach 1st Edition, New Age International (P) Ltd., Publishers, New Delhi.

Web References

1. https://webapps.itc.utwente.nl/librarywww/papers_2009/general/principlesremotesensing.pdf
2. https://crisp.nus.edu.sg/~research/tutorial/intro.htm
3. https://learn.canvas.net/courses/464/pages/unit-6-dot-2-basic-principles
4. http://www.ai.soc.i.kyoto-u.ac.jp/field_en/english_textbook/RemoteSensing_1.pdf
5. http://www.creaf.cat/earth-observation/gis-and-remote-sensing-methodologies-and-applications
6. https://gisgeography.com/100-earth-remote-sensing-applications-uses/
7. https://dphu.org/uploads/attachements/books/books_4518_0.pdf

Experiments for Practical Course

1. Installation of Software
2. Toposheet and Satellite Imagery Acquisition
3. Georeferencing of toposheet/ Satellite Imagery
4. Digitization Techniques
5. Creation of Vector Layers
6. Raster Image Processing
7. Image Classification Techniques
8. Study Map Representation/ Creation

CORE COURSE – XV

POLLUTION CONTROL STRATEGIES

Semester	Paper Code	Marks	Hours/Week	L	T	P	Credit
VIII	20UPEVS2C15	100	5	4	1	0	5

Course Objectives

The purpose of this course is to gain awareness of environmental pollution, control and treatment technologies to understand the fundamental principles governing the treatment of pollutants in the environment.

Course Outcomes

On the successful completion of the course, students will be able to

CO1 To develop environmental scientists and engineers and sensitize them towards environmental issues

CO2 Get exposed good practice of technologies and options used to remediate reduce/eliminate pollution of the environment

CO3 Select methods for control, and prevention of pollution to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability

CO4 Apply relevant techniques, skills and modern engineering tools to solve the environmental problems

CO5 Evaluate process design criteria for different air treatment technologies and perform basic calculations

Mappings of course outcomes with programme outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	*	*	*	*	*	*	*	*
CO2		*				*		
CO3		*				*		*
CO4		*						
CO5		*	*	*		*		*

CORE COURSE – XV

POLLUTION CONTROL STRATEGIES

UNIT I Air Pollution Control & Treatment Contact Hours 12

Air Pollution Control Methods: Particulate matter (Settling Chamber, Cyclones, Fabric Filter, Electrostatic Precipitator and Wet Scrubbers) - Gaseous Pollutants (NOx, SO2, CO, CO2 and Hydrocarbons).

UNIT II Water Pollution Control & Treatment Contact Hours 12

Drinking Water – Filtration, Chlorination, Reverse Osmosis, Ozonation. Wastewater Treatment Methods: Primary Treatment (Screening, Grit Removal, Neutralization, Coagulation, Skimming, Sedimentation) - Secondary Treatment (Aerobic – Aeration, Activated Sludge Process, Trickling Filters, Biological Contact Filters, Rotating Filters, Oxidation Ponds; Anaerobic – Anaerobic Digestion, Septic Tanks, Lagoons) - Tertiary Treatments (Ozonation, Chlorination, Activated Carbon filtration, UV, Reverse Osmosis) -

UNIT III Soil Pollution Control & Treatment Contact Hours 10

Soil Pollution Control - Soil Remediation Techniques: In situ and Ex situ - Physical (Soil Covering, Excavation, Electrokinetic Remediation, Air Sparging, Encapsulation) - Chemical (Soil Washing, Solidification, Vitrification) - Biological (Bioremediation and Phytoremediation).

UNIT IV Radiation Pollution Control & Treatment Contact Hours 8

Radioactivity and Radiation – Radiation Units - Radiation sources – Radiation Protection – Time – Distance - Shielding – Exposure and Contamination - Controlled area – Collection, storage and disposal.

UNIT V Noise, Thermal Pollution Control & Treatment Contact Hours 8

Noise Control Measures -Greenbelt and Protective Instruments – Elimination – Substitution – Engineering Control – Administrative Controls – Personal Protective Equipment's – Selection of hearing protection device. Thermal Pollution –Cooling ponds – Cooling Towers – Beneficial use of waste heat.

Text Books

1. Khopkar, S. M (2005) Environmental Pollution Monitoring and Control, New Age International (P) Ltd Publishers.
2. Rao CS (2018) Environmental Pollution Control Engineering, 3rd Edition, New Age International (P) Ltd Publishers.
3. Avinash Chauhan (2020) Environmental Pollution and Management. IK International Publishers Ltd
4. Singal S P (2000) Noise Pollution and Control, Narosa Pub house
5. J. Jeffrey Peirce Ruth F. Weiner P. Aarne Vesilind (1997) Environmental Pollution Control, 4th Edition, Elsevier Science

CORE COURSE – XV

POLLUTION CONTROL STRATEGIES

Reference Books

1. Yung –Tse Hung, Lawrence K Wang and Nazih K Shammas (Eds.) (2012) Handbook of Environment and waste Management Vol. 1 Air and Water pollution Control, World Scientific Press
2. Yung –Tse Hung Lawrence K Wang and Nazih K Shammas (Eds.) (2014) Handbook of Environment and waste Management Vol. 2 Land and Groundwater pollution Control, World Scientific Press
3. Yung –Tse Hung, Lawrence K Wang and Nazih K Shammas (Eds.) (2020) Handbook of Environment and waste Management Vol. 3 Acid rain and Greenhouse gas pollution Control, World Scientific Press
4. Mary K. Theodore, Louis Theodore, (2010) Introduction to Environmental Management, CRC Press.

Web References

1. http://www.ilocis.org/documents/chpt55e.htm
2. http://www.bbau.ac.in/dept/UIET/Study%20Materials%20for%20TCE-0.pdf
3. https://www.jica.go.jp/jica-ri/IFIC_and_JBICI-Studies/english/publications/reports/study/topical/health/pdf/health_08.pdf
4. https://www.researchgate.net/publication/236179607_Strategies_for_Prevention_and_Control_of_Air_Pollution_in_India
5. https://iums.ac.ir/uploads/Air_Pollution_Control_Engineerin%D8%B8%E2%80%9E_95694.pdf
6. http://yadda.icm.edu.pl/yadda/element/bwmeta1.element.agro-0c6457fb-fa78-4aa1-9eca-5f4483681a90/c/ILNS-3-2014-1-6.pdf
7. https://shodhganga.inflibnet.ac.in/bitstream/10603/21577/8/ch-5.pdf
8. https://www.mdpi.com/1660-4601/15/8/1657/pdf
9. https://udghoshna.files.wordpress.com/2014/08/noise-pollution.pdf
10. https://www.researchgate.net/publication/300713847_Treatment_Methods_for_Radioactive_Wastes_and_Its_Electrochemical_Applications

Experiments for Practical Course

1. Measurement of SPM, SO_2, and NO_2 levels in the atmospheric air.
2. Measurement water quality parameters pH, acidity, alkalinity, coagulation, TSS and TDS
3. Measurement of noise levels in different locations

CORE COURSE - XVI

ENVIRONMENTAL HEALTH AND SAFETY

Semester	Paper Code	Marks	Hours/Week	L	T	P	Credit
IX	20UPEVS2C16	100	5	4	1	0	5

Course Objectives

Introduction to basic principles of environmental health and safety practices and creating awareness of public and occupational health and safety requirements associated with the environment. The purpose of this course is to understand the role of environmental health, protection, safety at work, occupational health and safety, compliance and best practices.

Course Outcomes

On the successful completion of the course, students will be able to

CO1 Knowledge in the concepts and scope, basic requirements for healthy environment, environmental quality, human exposure and health impact.

CO2 Knowledge of the Industrial pollution and chemical safety in public exposure from industrial sources, Hazards by industry major chemical contaminants at workplace. Industrial environmental accidents.

CO3 Knowledge of understand the Environmental Disease present study in Fluorosis and Allergies; Epidemiological issues.

CO4 Knowledge of understand course will equip student with basic knowledge on safety issue related with explosion, pollutant release in water and air, and to implement measure during outbreak of flu epidemic at work place.

CO5 Knowledge of understand of occupational Safety and Health. Principles and methods of occupational health, Health problem due to industrial dust, heat, chemicals, noise, toxic gases and metals, Health hazard in agriculture - Pesticides and environment, Pesticides and human health.

CO6 Disease ecology with special reference to vector and water borne diseases Genotoxicity and epigenetic approach Occupational toxicology and health Xenobiotics and endocrine disruption

Mappings of course outcomes with programme outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	*	*	*	*		*	*	
CO2		*	*		*			*
CO3	*	*	*		*		*	
CO4	*			*		*	*	*
CO5		*	*		*			
CO6	*	*	*	*	*	*	*	*

CORE COURSE - XVI

ENVIRONMENTAL HEALTH AND SAFETY

UNIT I **Environmental Health** Contact Hours 12

Environmental health criteria, Scope of International Programme on Chemical Safety (IPCS). Effects of mercury, lead, chromium, cadmium, arsenic and nitrate on human health. Water borne diseases; Prevention and protection of community health from water borne diseases. Air borne bio-allergens; present in the ambient air, seasonal changes, mode of dispersal, disease intensity and control (K1, K2)

UNIT II **Industrial Pollution and Chemical Safety** Contact Hours 10

Extent of industrial pollution, Public exposure from industrial sources, Hazards by industry, Major chemical contaminants at workplace, Industrial environmental accidents (K2, K3, K4)

UNIT III **Occupational hazards** Contact Hours 10

Health consequences of different occupations- Anthracosis, Silicosis, Asbestosis; Concept of stress, Stress related diseases, Stress management, Stress, strain and general adaptive syndrome; Industrial Environmental Psychology; Cardio-respiratory response during high altitude acclimatization; Effect of climate on performance, Pandemics. (K4, K5)

UNIT IV **Occupational Safety and Health** Contact Hours 10

Effects of Physical Environment on Accidents, Crime, Suicide and Diseases of Man: Effects of temperature, humidity, ionization, ultra violet radiation and acidity of air on skin, lungs, throat, nose, eye, nervous system. Effects of weather and climate on diseases, mental processes, working efficiency, traffic and industrial accidents, behaviour, suicide and suicide attempts, effect of thermal stress and altitude on the action of drug. (K4, K5, K6)

UNIT V **Environmental Health Management** Contact Hours 10

occupational health practice: investigation, monitoring, control, characteristics and hazards of radioactive materials, dispersion of radioactive materials, risk assessment techniques for accidental release of toxic and inflammable materials, hazard analysis, potential risk, conceivable release mechanisms and release rates, fire and explosion hazards and simplified models for their assessment, examples of occupational health hazards: nasal cancer, asbestosis, bronchitis, heart disease, occupational health services. (K4, K5, K6)

Text Books

1. Shaw, J. Chadwick (1998) Principles of Environmental Toxicology, Taylor& Francis Ltd
2. Annalee Yassi, Tord Kjellstr'om, Theo de Kok, Tee Guidotti (2001) Basic Environmental Health, Oxford University Press
3. Standard Methods for Examination of Water and Waste Water, American Public Health Association (APHA).

4. A comprehensive laboratory manual for Environmental Sciences and Engineering By P.R. Sreemahadevan Pillai. New Age International Publishers.
5. Chemical and biological methods for water pollution studies By R.K. Trivedi
6. Handbook of water and waste water analysis By S.K. Maiti. Soil and air analysis by S.K. Maiti.

Reference Books

1. Environmental Health - Monroe T. Morgan (2003).
2. Handbook of Environmental Health and Safety - Koren, H. (2002).
3. Institution of Occupational Safety and Health, United Kingdom- A Practical Guide, 1993.

Web References

1. www.ehs.ucsb.edu/
2. www.ifc.org/ehsguidelines
3. www.slintec.lk/wp-content/uploads/2011/08/HealthSafetyManual.pdf
4. https://www.ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/sustainability-at-ifc/policies-standards/ehs-guidelines
5. https://www.ncbi.nlm.nih.gov/books/NBK55873/

Practicals- Environmental Health and Safety

1. Population modeling using Leslie's matrix.
2. Case studies on environmental issues and human health: ozone, water resources.
3. Awareness studies on environmental disasters.
4. Basic Hygiene and safety standards.
5. Potable water quality assessment.
6. Study of environmental carcinogens.
7. Experiments on eco-toxicity, genotoxicity and cytotoxicity; In vitro toxicity assay.

References:

1. Global Environmental Issues - Ed. Frances Harris and Frances Harris
2. Global Environmental Issues - K. Jagamohan Reddy.
3. Global Environmental and Pollution Issues by Dr. Aaradhana Salpekar and Dr. Kadambari Sharma.

CORE COURSE – XVII

RESEARCH METHODOLOGY AND INSTRUMENTATION

Semester	Paper Code	Marks	Hours/Week	L	T	P	Credit
IX	20UPEVS2C17	100	5	4	1	0	5

Course Objectives

The purpose of this course is to acquaint students about various types of research methods, instruments and their working principles, data process, report generation and to train the students to handle various research instruments.

Course Outcomes

On the successful completion of the course, students will be able to

CO1 Know the types of research and scientific databases, report writing and plagiarism.

CO2 Chose the research that they want to carryout.

CO3 Identify and design their research problems.

CO4 Understand the principles of research methods and instruments required for their research experiments.

CO5 Apply their knowledge on instrumentation for environmental analysis, and field works and data collection.

CO6 Apply the Software's and Statistical analysis methods and Data interpretation.

Mappings of course outcomes with programme outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	*							
CO2							*	*
CO3				*				*
CO4					*			*
CO5					*		*	*
CO6	*			*		*	*	

CORE COURSE – XVII

RESEARCH METHODOLOGY AND INSTRUMENTATION

UNIT I Research Methods Contact Hours 8

Basics of Fundamental and Applied Research, Types, scope, hypothesis. (K1, K2) Concept of research articles, research papers, reviews, scientific popular articles; Components of a Research Article (title, author-line, address, abstract, summary, hypothesis, keywords, introduction, methodology, observations, discussion, conclusion, citing relevant work of others); Reference protocols; Copyright Act (in brief), Plagiarism, Cheating / academic frauds; process of reviewing; Concept of Impact factor; H-Index, i-10 index and SCI Impact factor for journals. (K1, K2, K3)

UNIT II Basic Analytical Equipments Contact Hours 8

Principle, Working mechanism and environmental applications of pH Meter, Conductivity meter, Nephlometer. (K1, K2, K3) Basic principles and applications of light and electron microscopes. Types, function and applications of centrifuges. (K4, K5) Principle, types and environmental application of elctrophoretic techniques and radio immune assay techniques. (K4,K5)

UNIT III Spectroscopy Methods Contact Hours 12

Principle and concept of chromatography- stationary phase, mobile phase, partition and adsorption, coefficients. (K1,K2,K3) Working principle, instrumentation and environmental applications of Thin layer and Ion exchange chromatography, HPLC, HPTLC, LC-MS, and GC-MS 9 (K4, K5, K6)

UNIT IV Chromatography & Mass Spectrometry Contact Hours 12

Principle and concept of chromatography- stationary phase, mobile phase, partition and adsorption, coefficients. (K1,K2,K3) Working principle, instrumentation and environmental applications of Thin layer and Ion exchange chromatography, HPLC, HPTLC, LC-MS, and GC-MS 9 (K4, K5, K6)

UNIT V Statistical Analyses Contact Hours 10

Statistical Analysis: Sampling Methods and Data Collection – Questionnaire Survey, Experiments and Field works. (K3, K4) Measures of central tendency: Mean, Median and Mode- Merits and demerits. Measures of dispersion: Range, Standard Deviation, Variance, Skewness and Kurtosis; Distribution- Normal, *t* test and *chisquare* test, Difference among means - ANOVA. (K3, K4, K5) Correlation and Regression - Linear and Multiple. Introduction to statistical Softwares (SPSS, R, MATLAB) (K3, K4, K5, K6)

Text Books

1. Rt Kumar, (2010.) Research Methodology: A Step-by-Step Guide for Beginners, SAGE Pub.
2. Gurumani, N. (2006). Research Methodology for Biological Science. MJP Publishers.

CORE COURSE – XVII

RESEARCH METHODOLOGY AND INSTRUMENTATION

Reference Books

1. Christian GD (2001), Analytical Chemistry, 5th edition, John Wiley and Sons Inc., India
2. Khopkar SM (1993) Environmental Pollution analysis, Wiley Eastern Ltd.
3. Manahan SE (2007) Environmental Chemistry, 7th edition, Lewis Publications, Florida, USA.
4. Banerjee PK (2004) *Introduction to Biostatistics*. S. Chand and Co., New Delhi.
5. Manly, Bryan FJ (2001) Statistics for Environmental Science and Management, Chapman and Hall / CRC Press, Boca Raton, FL, USA.
6. Skoog DA, Holler FJ and Nieman TA (1980) Principles of Instrumental Analysis –5th edition, Thomson Asia Pvt., Singapore.
7. Vogel AI (1998) Quantitative Analysis, 6th edition, Prentice Hall Inc., Willard HH, Merrit LL and Dean JA (1976) Instrumental Methods of Analysis, 5th edition, Van Nostrand Reinhold.
8. Rastogi VB (2007) Fundamentals of Biostatistics. Ane Books India, New Delhi.
9. Wilson, K, Walker, J (2010) Principles and Techniques of Biochemistry and Molecular Biology, 7th edition, Cambridge University Press.

Web References

1. https://www.bio.umass.edu/biology/forms/content/499e-research-methodology
2. www.computerhope.com/os.htm
3. http://www.fao.org/docrep/005/ac665e/ac665e05.htm#TopOfPage
4. http://www.rss.hku.hk/plagiarism/page2s.htm
5. https://esajournals.onlinelibrary.wiley.com/doi/full/10.1002/bes2.1258
6. www.fao.org/docrep/W7295E/w7295e08.htm
7. https://chemistrynotesblog.wordpress.com/seperation-techniques/introduction-to-separation-techniques-2/
8. https://www.epa.gov/sites/production/files/2015-05/documents/402-b-04-001b-14-final.pdf
9. https://en.wikibooks.org/wiki/Proteomics/Protein_Identification_-_Mass_Spectrometry/Types_Mass_Spectrometry

Experiments for Practical Course

1. Preparing a scientific report and plagiarism checking.
2. Measurement of Turbidity using Nephlometer.
3. Demonstration of ICP-MS and heavy metals analysis.
4. Nanomaterials characterization using XRD.
5. Quantification of organic pollutants using HPLC.
6. Quantification of organic pollutants using GC-MS.
7. Statistical Data Analysis – Mean, Standard Deviation, Standard Error
8. Statistical Data - Analysis of Variance (ANOVA)

CORE COURSE – XVIII

DISASTER MANAGEMENT

Semester	Paper Code	Marks	Hours/Week	L	T	P	Credit
IX	20UPEVS2C18	100	5	4	1	0	5

Course Objectives

The purpose of this course is to mainly focus on understanding the different types of hazards and their impacts and the techniques for preparing effective disaster management plan including recovery and rehabilitation.

Course Outcomes

On the successful completion of the course, students will be able to

CO1 Develop an understanding of the different types of hazards.
CO2 Understand the different disaster prone zones.
CO3 Develop a basic under understanding of prevention, mitigation, preparedness, response and recovery.
CO4 Understand the technological advancements for early warning system.
CO5 Develop the disaster assistance tools and disaster preparedness.
CO6 Understand the disaster relief and recovery measures.
CO7 Acquire knowledge for capacity building and institutional framework for disaster management.
CO8 Develop a basic understanding for the role of public and private partnerships.

Mappings of course outcomes with programme outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	*					*	*	*
CO2						*	*	*
CO3	*					*	*	*
CO4						*	*	*
CO5					*	*	*	*
CO6						*	*	*
CO7	*					*	*	*
CO8	*					*	*	*

CORE COURSE – XVIII

DISASTER MANAGEMENT

UNIT I Types of Disasters Contact Hours 08

Geological Disasters - Hydro-Meteorological Disasters - Biological Disasters - Technological Disasters - Intentional, Civil, and Political Hazards - Global Outlook on Disaster Science

UNIT II Geological Hazards Contact Hours 10

Earthquake: Origin of Earthquake, its magnitude and intensity - Earthquake prone zones in India - Effects of earthquake - Earthquake prediction & control. Volcanoes: Types of volcanic eruptions - Active volcanic belts in the world - Nature and magnitude of volcanic hazards - Prediction of volcanic eruptions - Mitigation of volcanic hazards. Mass movement hazards: Landslides and Snow avalanche hazards

UNIT III Hydrological and Meteorological Hazards Contact Hours 12

Hydrological Hazards - Floods: Flooded geographical land types – Flash flood - Flood management strategies - Regions of flood prone zones in India – Flood forecasting and warning. Droughts: Types of droughts – Drought assessment parameters: Drought indices (meteorological indices, hydrological indices and agriculture index) - Preventive measures and preparedness plan for drought mitigation. Meteorological hazards - Cyclones: Tropical cyclones & Local storms – Heat waves and cold waves

UNIT IV Disaster Management Cycle and Framework Contact Hours 12

Disaster Management Cycle – Pre-Disaster: Risk Mapping - Zonation and Microzonation - Prevention and Mitigation of Disasters - Early Warning System – Preparedness - Capacity Development – Awareness. During Disaster: Evacuation – Disaster Communication – Search and Rescue – Emergency Operation Centre – Incident Response System – Relief and Rehabilitation. Post-disaster: Damage and Needs Assessment - Restoration of Critical Infrastructure – Early Recovery – Reconstruction and Redevelopment

UNIT V Disaster Management in India Contact Hours 10

Disaster Management Act 2005 - National Guidelines and Plans on Disaster Management - Role of Government (local, state and national), Non-Government and Inter-Governmental Agencies: National Disaster Management Authority (NDMA) - NIDM (National Institute of Disaster Management) - State Disaster Management Authorities - National Disaster Response Force

Text Books

1. Donald Hyndman and David (2005) Hyndman Natural Hazards & Disasters, Cengage Learning.
2. Palanivel K, Saravanavel K and Gunasekaran S (2015) Disaster Management, Allied Publishers Pvt Ltd., New Delhi.

Reference Books

1. BimalKanti Paul (2011) Environmental Hazards and Disasters - Contexts, Perspectives and Management, John Wiley & Sons, UK.
2. Bryant Edwards (2005) Natural Hazards, Cambridge University Press, UK.
3. Carter Nick W (1991) Disaster Management: A Disaster Manager's Handbook, ADB Manila

4 Collins Larry R and Schneid Thomas D (2000) Disaster Management and Preparedness, Taylor and Francis.

5 Coppola DP (2011) Introduction to International Disaster Management, 2nd Edition, Elsevier Science (B/H), London.

6 Indrajit Pal and Rajib Shaw (2018) Disaster Risk Governance in India and Cross Cutting Issues, Springer Nature, Singapore.

7 Jack Pinkowski (2008) Disaster Management Handbook, CRC Press -Taylor & Francis Group.

8 Jha and Kumar M (2010) Natural and Anthropogenic Disasters; Vulnerability, Preparedness and Mitigation, Springer.

9 Joseph F. Gustin (2010) Disaster & Recovery Planning: A Guide for Facility Managers, 5th Edition, Taylor &Francis.

10 Musavi SHA (2020) Early Warning –based Multihazard and Disaster Management Systems. CRC Press, Boca Raton, USA.

11 Pandey RK (2020) Disaster Management in India. SAGE Publications.

12 Pradeep Sahni, Alka Dhameja and Uma Medury (2001) Disaster Mitigation: Experiences and Reflections, PHI Learning.

13 Sharma RK and Sharma G (2005) Natural Disaster, APH Publishing Corporation, New Delhi.

14 Srivastava PK, Singh SK, Mohanty UC and Murty T (2020) Techniques for Disaster Risk Management and Mitigation. John Wiley & Sons Inc., USA

15 Tomaszewski B (2020) Geographic Information Systems for Disaster Management. Taylor & Francis Limited.

Journal Articles

1 Du, Lei, Yingbin Feng, Li Yaning Tang, Wei Kang, and Wei Lu (2020). Networks in disaster emergency management: a systematic review. *Natural Hazards* 1-27.

2 Makwana, Nikunj (2019) Disaster and its impact on mental health: A narrative review. *Journal of Family Medicine and Primary Care* 8 (10): 3090.

3 Modgil, Sachin, Rohit Kumar Singh, and Cyril Foropon (2020). Quality management in humanitarian operations and disaster relief management: a review and future research directions. *Annals of Operations Research* 1-54.

4 Raikes J, Smith TF, Jacobson C and Baldwin C (2019). Pre-disaster planning and preparedness for floods and droughts: A systematic review. *International Journal of Disaster Risk Reduction* 38: 101207.

5 Seba, Abderazek, Nadia Nouali-Taboudjemat, Nadjib Badache, and Hamida Seba. (2019). A review on security challenges of wireless communications in disaster emergency response and crisis management situations. *Journal of Network and Computer Applications* 126: 150-161.

6 Shaluf IM and Said AM (2003). A review of disaster and crisis. *Disaster Prevention and Management*: An International Journal.

7 Torani, Sogand, Parisa Moradi Majd, Shahnam Sedigh Maroufi, Mohsen Dowlati, and Rahim Ali Sheikhi (2019). The importance of education on disasters and emergencies: A review article. *Journal of Education and Health Promotion* 8.

Web References

1. www.nidmindia.nic.in
2. http://www.cambridge.org
3. Web based course material on Disaster Management of the University of Wisconsin Disaster Management Center (http://epdweb.engr.wise.sedu/dmc)
4. http://www.worldbank.org/html/fpd/dmf/risk_managemnt.htm

CORE COURSE - XIX

ENVIRONMENTAL LAWS AND POLICIES

Semester	Paper Code	Marks	Hours/Week	L	T	P	Credit
IX	19UPEVS2C19	100	5	4	1	0	5

Course Objectives

The purpose of this course is to introduce the students to the vast field of Laws and Policies both at the national and international level relating to environment.

Course Outcomes

On the successful completion of the course, students will be able to

CO1 Understand environmental legislation and policies of national and international regime.
CO2 Have an insight into major acts and rules applicable for pollution control and natural resource conservation.
CO3 To develop the skills needed for interpreting laws, policies and judicial decisions about the environment.
CO4 Know regulations applicable to industries and other organizations with significant environmental aspects.
CO5 Apply the legislation concepts for solving the local environmental problems.
CO6 Get knowledge of the legal system operating in India.
CO7 Be in a position to prepare compliance reports for getting environmental clearance
CO8 Prepare the environmental management system for an organization.

Mappings of course outcomes with programme outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1				*		*		
CO2				*				
CO3						*		*
CO4				*		*		
CO5						*		
CO6							*	
CO7				*				*
C08						*		*

CORE COURSE - XIX

ENVIRONMENTAL LAWS AND POLICIES

UNIT I **Environmental Legislation** Contact Hours 12

Definition of environment and pollutants, central and state boards for the prevention and control of environmental pollution, powers and functions of pollution control boards, penalties and procedure, duties and responsibilities of citizens for environmental protection. (K1, K2)

UNIT II **Laws and Acts guarding** Contact Hours 10

Wildlife Protection Act 1972, The Water (Prevention and Control of Pollution) Act 1974. Prevention and Control of Air Pollution Act 1981, Forest Conservation Act 1981, Environment (protection) Act 1986, Hazardous waste (Management and Handling) Rules, 1989, Bio-Medical Waste (Management and Handling) Rules, 1998. Issues involved in enforcement of environmental legislation, public awareness, public interest litigations (PILs) and its role in control of environmental pollution in India. (K1, K2, K3)

UNIT III **Environmental Movement In India** Contact Hours 10

Movements related to Environment Sacredgroves, Bishnoi tradition, Chipko movement, Tehridam, Sardar Sarovar, Narmada dam, Almatti dam, Silent Valley. Supreme Court Cases – Ratlam Municipality, Ganga Action Plan, Taj Trapezium, Delhi CNG, Tamil Nadu Tanneries, Doon Valley, Span motels private limited case, Oleum gas case (K1, K2, K3)

UNIT IV **International Environmental Treaties and Conventions** Contact Hours 10

StockholmConferenceonHumanEnvironment,1972, Ramsar Convention on Wetlands 1971, Montreal Protocol, 1987, Basel Convention (1989,1992), Earth Summit at Rio de Janeiro 1992, Kyoto Protocol 1997, Earth Summit at Johannesburg 2002. Rotterdam Convention on Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade 21, Convention on Desertification 1996, Convention on Biodiversity & Cartagena Protocol on Bio safety (K1, K2, K5, K6)

UNIT V **Major Initiatives/Policies** Contact Hours 10

Issues involved in enforcement of environmental legislation, public awareness, public interest litigations (PILs) and its role in control of environmental pollution in India. (K4, K5, K6)

Text Books

1. Environmental Law in India (2000) P. Leelakrishnan Butterworths India Publishers.
2. Textbook on Environmental Law (2010) N. Maheshwara Swamy, Asia Law House Publishers.
3 Environmental administration & law – Paras Diwaa.
4 Environmental planning, policies & programs in India - K.D. Saxena.
5 Shyam Divan and Armin Rosencranz, 2005, Environmental Law and Policy in India, Oxford University Press, New Delhi, 2005.
6 Leelakrishnan. P, 2008, Environmental Law Case Book, Lexis Nexis, Butterworths.

7 Mohanty. S. K., 2011, Environment and Pollution Law, Universal Law Publishing Co.Pvt. Ltd.
8 Shastri S C, 2008, Environmental Law, (2nd Edn.), Eastern Book Company, Lucknow.
9 Singh Gurdip, 2004, Environmental Law in India, Mcmillan & Co.
10 Shantakumar S, 2005 Introduction to Environmental Law, (2nd Edn.), Wadhwa& Company, Nagpur.
11 Sahasranaman P B, 2008 Handbook of Environmental Law in India, Oxford University Press (India).

Reference Books

1. Gurudeep Singh (2005) Environmental Law in India, McMillan, New Delhi.
2. Shyam Diwan and Armin Rosencrany (2001) Environmental Law and Policy in India, Oxford University Press, New Delhi.
3. Singh G (1995) Environmental Law: International & National Perspectives.
4. Tamil Nadu Pollution Control Board (1999) Pollution Control Legislation Vol. I and II, Chennai.
5. Maheshwara Swamy, Textbook on Environmental Law, (2ndEdn.), Asia Law House, Hyderabad, 2008.
6. I.A. Khan, Environmental Law, **(**2ndEdn.), Central Law Agency, Allahabad, 2002.
7. D.K. Asthana and Meera Asthana, Environment Problems and Solutions, (2nd Edn.), S. Chand & Co. Ltd., New Delhi, 2001.
8. S. Shantakumar, Introduction to Environmental Law, (2ndEdn.), Wadhwa & Company, Nagpur, 2005.
9. S.C. Shastri, Environmental Law, (3rd Edn.), Eastern Book Company, Lucknow, 2008.

Web References

1. cpcb.nic.in/
2. www.tnpcb.gov.in/
3. www.thesummitbali.com/
4. envfor.nic.in/legis/legis.html
5. edugreen.teri.res.in/explore/laws.htm
6. envfor.nic.in/legis/crz/crznew.html
7. rti.gov.in/
9. www.ngosindia.com/resources/pil.php

Practicals - Environmental Laws and Policies

1. Case studies on effective utilization of environmental laws: oil refineries, petrochemical industry.
2. Comparative analysis of various mega building projects and its impact assessment.
3. Impact assessment of green belts.
4. Visits-sanctuaries, reserves
5. Pollution Control Board Visits and Reports.

Elective Courses

ELECTIVE COURSE – I

AGROFORESTRY AND SILVICULTURE

Semester	Paper Code	Marks	Hours/Week	L	T	P	Credit
V / VII	20UPEVS2E01	100	3	3	0	0	3

Course Objectives

To impart knowledge on the concept of Agroforestry land use including diagnosis & design methodologies, to develop understanding of students about advance in Silviculture and Silvicultural practice, effect of Silvicultural practices on forest stand management and stand development, advances in coppice Silviculture.

Course Outcomes

On the successful completion of the course, students will be able to

CO1 To understand the need of Agroforestry and the involved biophysical processes
CO2 To study the roll of Agroforestry systems in soil fertility and nutrient cycling
CO3 To be aware of opportunities for employment and cash income through Agroforestry systems
CO4 Students can understand the plantations in different types of forest

Mappings of course outcomes with programme outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	*							
CO2			*					
CO3		*						
CO4	*			*			*	

SYLLABUS

UNIT I Introduction to Agroforestry Contact Hours 12

Agroforestry objectives, importance, potential and impediments in implementation. Land capability classification and land evaluation (K1, K2, K3)

UNIT II Advances in Agro forestry Contact Hours 12

Overview of global agro-forestry systems, shifting cultivation, taungya system, multiple and mixed cropping, alley cropping, shelter - belts and windbreaks, energy plantations and homestead gardens. Product in potential of different silvi-pasture system (K1, K2, K3)

ELECTIVE COURSE – I

AGROFORESTRY AND SILVICULTURE

UNIT III Basic principles in Silviculture Contact Hours 12

Philosophy of silviculture – Advance reproduction methods and their role in silviculture – Judging successful establishment; Analysis of active and passive site preparation – Silviculture with an ecosystem approach (K1, K2, K3, K4)

UNIT IV Silviculture practices in different types of forest Contact Hours 12

Advance Silvicultural practices in rain forest; Tropical forest; Subtropical forest, Temperate forest; Mechanization and role in Silviculture (K3, K4, K5, K6)

UNIT V Different techniques of Silviculture Contact Hours 10

Analysis of different techniques of silviculture in forest stand management, Technique for early stand development; Analysis of thinning methods and its impact on wood yield and quality; Stand protection and health management (K3, K4, K5, K6)

Text Books

1. Dwivedi, A.P. (1992) Agroforestry: Principles and Practices. Oxford & IBH.
2. Nair, P.K.R. Rai, M.R and Buck, L.E. (2004) New Vistas in Agroforestry. Kluwer
3. Nair, P.K.R. (1993) An Introduction to Agroforestry. Kluwer.
4. Ong, C.K and Huxley, P.K. (1996) Tree Crop Interactions – A Physiological Approach. ICRAF.
5. Thampan, P.K. (1993) Trees and Tree Farming. Peekay Tree Crops Development Foundation.
6. Young, A. (1997) Agroforestry for Soil Management. CABI
7. Dwivedi, A.P. (1992) Agroforestry: Principles and Practices. Oxford and IBH.
8. Dwivedi, A.P. (1993). A Text Book of Silviculture. International Book Distributors, Dehradun.

Reference Books

1. Evans, J. (1982) *Plantation Forestry in the Tropics*. Clarendon Press.
2. Ford, E.D. (1984). Nutrition of Plantation Forests. Academic Press.
3. Kadambi, K. (1993) Silviculture and Management of Teak. Vedams Books International.
4. Khanna, L.S. (1996) Principle and Practice of Silviculture. International Book Distributors.
5. Sairll, P.S. Evans, J. Auclair, D. and Flack, J. (1997) Plantation Silviculture in Europe. Oxford University Press.
6. Smith, D.M. Larson, B.C. Ketty, M.J. and Ashton, P.M.S. (1997) The Practices of Silviculture - Applied Forest Ecology. John Wiley & Sons.
7. Smith, D.M. (1980) The Practice of Silviculture. 8th Ed. USED.
8. Zobel, B.J. Wyk, G. and Stahlper, P. (1987) Growing Exotic Forests. John Wiley & Sons

ELECTIVE COURSE – II

BIOSTATISTICS AND ENVIRONMENTAL MODELING

Semester	Paper Code	Marks	Hours/Week	L	T	P	Credit
V / VI	20UPEVS1E02	100	3	3	0	0	3

Course Objectives

The purpose of this course is to equip students with basic knowledge in basic statistical and bio statistical methods. To be skilled in using various tools for statistical analyses, to introduce the concept of environmental modeling, its approaches, methods, to make them aware of the practical applications of biostatistics and environmental modeling.

Course Outcomes

On the successful completion of the course, students will be able to

CO1 Know the basic methods in Statistics and methods of data collection

CO2 Understand the basic principles of biostatistics and different types of tests

CO3 Enable to understand the different tools in biostatistics for various datasets

CO4 Learns the basic concept and principles of environmental modeling

CO5 Acquire the skills to apply the biostatistics and modeling methods for environmental studies.

CO6 Enhance the skills of presenting the statistically proven datasets

CO7 Equip to perform environmental models and concepts for different applications

Mappings of course outcomes with programme outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	*	*	*					
CO2		*	*					*
CO3								
CO4	*			*				*
CO5	*			*	*	*		
CO6	*			*	*	*	*	*
CO7	*				*	*	*	*

ELECTIVE COURSE – II

BIOSTATISTICS AND ENVIRONMENTAL MODELING

UNIT I **Basic Statistical Methods** Contact Hours 8

Elementary concept of statistics – Sampling Methods - Data Collection, Computation and Presentation, Calculation of mean, mode and standard deviation from field data, laboratory data – Data representation Methods. (K1, K2, K3)

UNIT II **Biostatistics Methods** Contact Hours 5

Measures of dispersion: Range, Standard Deviation, Variance, Skewness and Kurtosis; Distribution - Normal, t test and chisquare test, Difference among means - ANOVA. Correlation and Regression - Linear and Multiple. (K3, K4, K5)

UNIT III **Tools for Analysis** Contact Hours 7

Descriptive Statistics, Data Distribution Analysis – Parametric and Non-Parametric Tests- Introduction to SPSS, MATLAB, Biio Python and R Statistics (K3, K4)

UNIT IV **Environmental Modeling** Contact Hours 7

Approaches to development of environmental models; linear, simple and multiple regression models, validation and forecasting. Models of population growth and interactions: Lotka-Voltera model, Leslie's matrix model. Point Source Stream Pollution Model, Box Guassian Plume Model. (K4, K5)

UNIT V **Application of Environmental Modeling and Biostatistics** Contact Hours 7

Experimental Design for Environmental Modeling - Case Studies - Biostatistics - Significance in Data Presentation - Data Validation through Statistical Approaches. Statistical and Modeling Softwares - Commercial Use and Applications(K5, K6)

Text Books

1. Sharma A K (2005).Text Book of Biostatistics, DPH Mathematic Series, Discovery Publishing House
2. Smith J (2012). Environmental Modeling - An Introduction, Oxford University Press, UK.
3. Gray & Gray (2016). Introduction to Environmental Modeling Cambridge University Press

ELECTIVE COURSE – II

BIOSTATISTICS AND ENVIRONMENTAL MODELING

Reference Books

1. Jorgeson SE (1995). Handbook of Environmental and Ecological Modeling, Levis Publications, New York
2. Rosner B (2016) Fundamentals of Biostatistics, 8th Edition Cengage Learning, USA.
3. William G Gray (2018). Introduction to Environmental Modeling, Cambridge University Press UK.
4. Sundar Rao & Richard (2015) Introduction to Biostatistics and Research Methods 5th Edition, PHI Learning Publishers.
5. Chap T. Le & Lynn E. Eberly (2016) Introductory Biostatistics, 2nd Edition, John Wiley Publications
6. Mike J Barnsley, S.B. (2007) Environmental Modeling, A Practical Introduction, 1st Edition, Taylor & Francis Co., Publishers
7. Andrew Ford (2009) Modeling the Environment, 2nd Edition, Island Press Publications.

Web References

1. http://pages.stat.wisc.edu/~ifischer/Intro_Stat/Lecture_Notes/0_-_Preliminaries/0.2_-_Contents.pdf
2. http://www.statstutor.ac.uk/resources/uploaded/1introduction3.pdf
3. http://biostatcourse.fiu.edu/
4. http://www.fao.org/3/W7295E/w7295e08.htm
5. https://www.epa.gov/measurements-modeling/environmental-modeling
6. http://www.eolss.net/sample-chapters/c07/e4-20-03-01.pdf

CORE ELECTIVE COURSE

CANCER BIOLOGY

Semester	Paper Code	Marks	Hours/Week	L	T	P	Credit
V / VI	20UPEVS2E03	100	3	3	0	0	3

Course Objectives

The purpose of this course is to introduce the students to the vast field of Laws and Policies both at the national and international level relating to environment.

Course Outcomes

On the successful completion of the course, students will be able to

CO1 The course is mainly focus on understanding the role of chemicals in the natural environment and to characterize the adverse effects of chemical substances on the ecosystem and humans.

CO2 To understand the basic processes underlying the transformation of a normal cell to its malignant counterpart, and the consequences of malignant transformation on the cellular and organism level.

CO3 To Understand how the biological knowledge of cancer development is used in modern cancer treatment.

CO4 To Show knowledge and skills in laboratory techniques used in experimental cancer research, and demonstrate knowledge in cancer epidemiology, use basic epidemiological research methods and describe their importance.

Mappings of course outcomes with programme outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1				*		*		
CO2				*				
CO3						*		*
CO4				*		*		
CO5						*		
CO6							*	
CO7				*				*
C08						*		*

CORE ELECTIVE COURSE

CANCER BIOLOGY

UNIT I Fundamentals of Cancer Biology Contact Hours 12

Cancer cell: Introduction, cancer as a group of diseases, Overview of gene expression &chromosome structure. Tobacco carcinogens, their biomarkers and tobacco induced cancer. Overview of cell division, differentiation and death. Tumor heterogeneity and cancer cell plasticity. Oncogenes and tumor suppressors. Conversion of normal cells into cancer cells (K1, K2).

UNIT II Classification of cancer Contact Hours 10

Classification of cancer types: solid tumors, histopathological and immunohistochemical diagnosis. Molecular diagnosis. Molecular classification of cancer. Cancer treatment-laser, chemo and other Approaches (K1, K2, K3).

UNIT III Carcinogenesis Contact Hours 10

Historical developments, Classification of mutational changes at the chromosomal level and gene mutations, Chemical mutagens – Alkylating agents and others, Molecular mechanism of mutations. Effects on DNA, Induction and analysis of gene mutations in mammalian cell culture. Chemical carcinogens– Reaction and mechanism of action. Environmental hazards induced carcinogenesis and preventive measures (K3, K4).

UNIT IV Cell and Molecular Basis of Cancer Contact Hours 10

Molecular basis of carcinogenesis: cancer genes, oncogenes and their mutations, signal transduction pathways, ligands and receptors. Cell cycle and Apoptosis: Growth and proliferation, angiogenesis, invasion and metastasis, epigenetics, stem cells, apoptotic pathways, cell immortalization and tumorigenesis, genetic instability. Cancer genomics and proteomics (K4, K5, K6).

UNIT V Cancer epidemiology, etiology and drug discovery Contact Hours 10

Risk factors, prevention of cancer, cancer screening and treatment modalities. Cancer drug discovery and its applications in various types. Fundamentals of bioinformatics. Basis of anti-cancer drugs and pharmacokinetics (K4, K5, K6).

Text Books

1. Acton QA (2013) Issues in Radiation Biology and Toxicology Research, Scholarly Editions, Atlanta, GA, USA.
2. Baker D, Karalliedde L, Murray V, Maynard RL and Parkinson NHT (2012) Essentials of Toxicology for Health Protection – A handbook for field professionals, 2nd edition, Oxford University Press, UK.
3 Camacho C (2012) Molecular Oncology–Principles and Recent Advances, Bentham Books, USA.
4 Dietert RR (2010) Immunotoxicity Testing: Methods and Protocols, Humana Press, USA.
5 Dietert RR and Luebke RW (2012) Immunotoxicity, Immune Dysfunction, and Chronic Disease, Humana Press, USA.

6 Fowler B A (2013) Computational Toxicology – Methods and Applications for Risk Assessment, Academic Press, UK.
7 Gupta R S (2006) Toxicology of Organophosphate and Carbamate Compounds, Academic Press, UK.
8 Krieger RI and Hayes WJ (2010) Hayes' Hand book of Pesticide Toxicology, Elsevier, UK.
9 Lynch JJ (2012) Lippincott's Manual of Toxicology, Lippincott Williams & Wilkins, USA.
10 Manahan SE (2013) Fundamentals of Environmental Toxicology and Toxicological Chemistry –Sustainable Science, 4th edition, CRC Press, Boca Raton, FL, USA.
11 Matthiessen P (2013) Endocrine Disrupters–Hazard Testing and Assessment Methods, John Wiley & Sons, Inc.., NJ, USA.
12 Schober O and Riemann B (2013) Molecular Imaging in Oncology, Springer-Verlag, Berlin.
13 Siddiqui SS, Loganathan S, Krishnaswamy S, Faoro L, Jagadeeswaran R, Salgia R (2008) *C. elegans* as a model organism for in vivo screening in cancer: effects of human Met in lung cancer affect *C. elegans* vulva phenotypes. Cancer Biol. Ther.7 (6):856-863.
14 WexlerP,HakkinenPJ,KennedyJr.G,StossFW(2000)InformationResourcesin Toxicology, 3rd edition, Academic Press, UK.

Reference Books

1. Singh DK (2012) Pesticide Chemistry and Toxicology, Bentham Books, USA.
2. Mullen PW (2011) Immunotoxicology: A Current Perspective of Principles and Practice, Springer, London.
3. Spellman FR and Stoudt ML (2013) The Handbook of Environmental Health, Scarecrow Press Inc., MA, USA.

Web References

1. http://www.sanger.ac.uk/
2. http://www.wormbase.org/#01-23-6
3. http://www.reprotox.org
4. http://www.unomaha.edu/envirotox/
5. http://www.clintox.org/radsig.cfm
6. http://informahealthcare.com/doi/book/10.3109/9781420093100
7. www.tox.si/novice/zadnja-novice/103-toxicity-of-ionizing-radiaton
8. http://www.nccr-oncology.ch
9. ntp.niehs.nih.gov/ntp/Factsheets/WormToxFS06.pdf
10. ansc.umd.edu/labs/hamza/pub/Nass_Hamza%20CPTox_2007.pdf
11. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2580824/pdf/nihms-75488.pdf
12. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3428303/pdf/pone.0043577.pdf

ELECTIVE COURSE – IX

ECOTOURISM

Semester	Paper Code	Marks	Hours/Week	L	T	P	Credit
V / VI	20UPEVS2E04	100	3	3	0	0	3

Course Objectives

To understand the principles and importance of ecotourism, to learn the impacts and management practices of ecotourism, to know about the concept of ecotourism, development of ecotourism places.

Course Outcomes

On the successful completion of the course, students will be able to

CO1 Know the principles and concept of ecotourism
CO2 Able to understand the types and benefits of ecotourism
CO3 Know interesting places of ecotourism
CO4 Evaluate the impacts of ecotourism on the environment
CO5 To understand the different parts of ecotourism in India

Mappings of course outcomes with programme outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	*							
CO2		*						
CO3				*				
CO4	*		*				*	
CO5		*				*		

UNIT I Introduction to Ecotourism Contact Hours 12

Scope and definitions; Objectives of tourism; Significance of Tourism – Classification – Religious tourism – Cultural tourism – Heritage tourism – Monumental tourism – Adventure tourism – Mass tourism – Sustainable tourism – Consumptive & non consumptive tourism; implications of tourism (K1, K2, K3)

UNIT II Biodiversity of Ecotourism Contact Hours 12

Ecotourism – definition and characteristics features - Ecosystem & biodiversity support to local economy, conservation of biosphere, learning experience; Goals - social, economical and environmental (K1, K2,K3)

ELECTIVE COURSE – IX

ECOTOURISM

UNIT III Types of Ecotourism Contact Hours 10

Principles of Ecotourism: Types of Ecotourism – Objectives of Ecotourism – benefits of Ecotourism – trends affecting ecotourism (K1, K2, K3)

UNIT IV Impact of Ecotourism Contact Hours 10

Impact of Ecotourism: Economic impacts (fiscal impacts) – Types and degree of impacts from Ecotourism activities – Socio cultural impacts – Environmental impact (K3, K4, K5, K6)

UNIT V Different parts of Ecotourism Contact Hours 10

Ecotourism in India – India a land of pluralism: land, people, flora and fauna and climatic variations – Ecotourism in India – Different ecotourism spots - contrast from tropics to snow – ocean to mountain – desert to forest – Critical analysis of ecotourism in India with a case study (K3, K4, K5, K6)

Text Books

1. Dasman, R.F. (1968) Environmental Conservation: John Wiley and Sons, New York.
2. Mukherjee, N. (2008) Ecotourism and sustainable Development. Cybetech Publications, New Delhi.

Reference Books

1. Agarwal, A. N. (1980) Indian Agriculture, Vikas publishing House, New Delhi.
2. Weaver, D. B (2001) The Encyclopedia of Ecotourism, CABI, Publishing.
3. Sinha, P. C. (2003) Encyclopedia of Ecotourism, Vol-I, II & III, Anmol publications Pvt. Ltd, New Delhi.
4. Bhatia, A. K. (1978) Tourism in India, Sterling Publishers, New Delhi.

Web References

1. www.incredibleindia.org/newsite/cms_page.asp?pageid=994
2. www.nativescience.org/html/eco-tourism.html
3. www.wcsindia.org/
4. envfor.nic.in/divisions/9-10.pdf
5. http://www.ceeraindia.org/documents/lib_tabofcon_160300.htm

ELECTIVE COURSE – IX

MARINE BIOTECHNOLOGY

Semester	Paper Code	Marks	Hours/Week	L	T	P	Credit
V / VI	20UPEVS2E05	100	3	3	0	0	3

Course Objectives

To make the student understand the major components of marine environment, to enable the students with biomedicinal compounds from marine Bioresources, to enrich the students in areas of Probiotics and transgenic fish.

Course Outcomes

On the successful completion of the course, students will be able to

CO1 Awareness on the physical and chemical elements present in marine environment

CO2 Knowledge on the biodiversity of different organisms in marine environment

CO3 Understand the bioactive compounds of the marine resources

CO4 Application of marine organisms for production of antibiotics

CO5 Knowledge on Probiotics microbes to enhanced the aquaculture biotechnology

Mappings of course outcomes with programme outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	*							
CO2		*						
CO3			*					
CO4	*			*			*	
CO5		*				*		

UNIT I Introduction to Marine Biotechnology Contact Hours 12

Introduction of Marine Biotechnology - Definition, tools and application - Physical and chemical oceanography -Marine Environment - Deep Sea - Coral reef - Estuaries - Mangrove ecosystems - Diversity of Plankton- Phytoplankton - Zooplankton (K1, K2, K3)

ELECTIVE COURSE – IX

MARINE BIOTECHNOLOGY

UNIT II Ecology of Marine Biotechnology Contact Hours 12

Ecology of marine flora and fauna - Microscopic (Bacteria, Fungi, Microalgae) - Macroscopic (Sponge and fishes) - Marine Plants – Seaweeds - Sea grasses- Mangrove and their associate plants - Live feed culture Technology – Artemia – Rotifer - Microalgae (K1, K2, K3)

UNIT III Marine Microorganisms Contact Hours 12

Drugs from Marine organisms - Sponge - Coral- Seaweeds- Sea grasses- Mangrove - Drugs from Marine Microbes – Bacteria - Fungi – Actinomycetes - Drugs from marine microalgae Cyanobacteria - Blue green algae (K1, K2, K3)

UNIT IV Application of Marine Biotechnology Contact Hours 12

Biotechnological application of Marine Enzymes - Amylase, Protease, Lipase, Cellulases, from micro algal, Bacteria, Fungi, Actinomycetes - Marine Polysaccharides - Alginic acid - AgarAgar - Carrageen from marine seaweeds (K3, K4, K5, K6)

UNIT V Aquaculture Biotechnology Contact Hours 10

Aquaculture Biotechnology - Microbial disease- Vibriosis – Aeromonosis - Viral Disease WSSV (White Spot Syndrome Viral infection) - IHHNV (Infections Hypodermal and Hematopoietic Necrosis Virus) - Probiotics Microbe - Bacteria - Fungi used for Fin and Shell fish's production (K3, K4, K5, K6)

Text Books

1. Kim, S. K. (2015) "Hand book of Marine Biotechnology", Springer Dordrecht Heidelberg, London New York.
2. Lavens, P. and Sorgerloos, P. (1996) "Manual on the production and use of live food for aquaculture", Food and Agriculture Organization (FAO) of the United Nations, Rome.
3. Pillay, T.V.R. and Kutty, M.N. (2005) "Aquaculture Principles and Practices", Blackwell Publishing Asia Pvt. Ltd, Australia, Second Edition.

Reference Books

1. Hart, P.J.B. and Reynolds, J.D. (2004) "Hand Book of Fish biology and Fisheries - Fish Biology Vol-1," Blackwell Science Pvt. Ltd, USA.
2. Ravi Shankar, P. (2006) "Fish Biology and Ecology", University College of Science, Osmania University, Hyderabad.

ELECTIVE COURSE

ENVIRONMENTAL ECONOMICS

Semester	Paper Code	Marks	Hours/Week	L	T	P	Credit
VII / VIII	20UPEVS1E06	100	4	3	1	0	3

Course Objectives

The purpose of this course is to make the students to learn the basic concepts of environmental economics, and about micro and macroeconomics, to know about cost benefit analysis, economic benefits of environmental resources, to understand the valuation methods and economic analysis of environmental systems.

Course Outcomes

On the successful completion of the course, students will be able to

CO1 Understand the basic concept and principles of environmental economics

CO2 Learn the concept of micro and macroeconomics and its influential factors

CO3 Knows the cost benefit analysis of the environmental systems and its resources

CO4 Learn about the economic factors and cost benefits of natural resources

CO5 Acquire skills to valuate an environmental system and its regulations

CO6 Apply the knowledge of environmental economics valuation needs

CO7 Become an analyst in in the areas of environmental economics

Mappings of course outcomes with programme outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	*					*	*	*
CO2	*				*			
CO3			*	*				
CO4		*				*	*	
CO5	*				*			
CO6			*	*		*		*
CO7	*						*	*

ELECTIVE COURSE

ENVIRONMENTAL ECONOMICS

UNIT I Environmental Economics Contact Hours 8

Introduction to Environmental Economics – Central Themes, Ecology, Environment and its Economical Perspectives, Current State of Environment, Sustainable Development: Basic Issues, Concepts, Definitions Approaches, Rules and Indicators. (K1, K2))

UNIT II Micro and Macro Economics Contact Hours 5

Externality, Public goods, Asymmetric Information, Environmental problem as an Externality, Environmental Conservation as a Public Good, Concepts on Green National Income Sustainable Development - Weak notion - Strong Notion, Practising Sustainable Development. (K1,K2, K3)

UNIT III Cost-Benefit Analysis Contact Hours 7

Use of microbes in environmental decontamination - Biodegradation - Biosorption - Biotransformation - Bioaugmentation - Biostimulation - Rhyzoremediation, Mycoremediation - Phycoremediation - Bioleaching and Biomining - MEOR - Bioremediation pollutants: Heavy metals, PAHs, VOCs - Bioindicators and biosensors for detection of pollution. (K1, K2, K3)

UNIT IV Natural Resources Economy Contact Hours 7

Introduction to Damage and Benefit Estimation: Objections to CB Analysis Benefit "Routes" – A Brief Review, Demand shifts: Complementarity, Cost Shifts: Averting, Replacing or Curing Expenditure, Travel Cost and Its Relation to Environmental Quality, Hedonic Pricing, Direct Methods of Benefit Estimation. (K3, K4)

UNIT V Environmental valuation, and Enforcement Contact Hours 5

Theory of Environmental Valuation- Introduction to Methods of Valuation. Theory of Regulation and instruments of Regulation, Elements of a Monitoring and Enforcement System Economics of Monitoring and Enforcement, Major Laws and policies for enforcement. (K5,K6)

Text Books

1. Nick Hanley, Jason F. Shogren and Ben White (2013) Environmental Economics In Theory and Practice, MacMillan Press Ltd. Hampshire
2. Karpagam M (2019) Environmental Economics: A Textbook, Sterling Publishers
3. Rabindra N Bhattacharya (2002) Environmental Economics 1st Edition- Oxford Publishers

ELECTIVE COURSE

ENVIRONMENTAL ECONOMICS

Reference Books

1. Hanley, Shogren and White (1997), Environmental Economics in Theory and Practice, MacMillan India Ltd.
2. Hussen, Ahmed. M, (2000), Principles of Environmental Economics: Economics, Ecology and Public Policy, Routledge, New York. Kadekodi, Gopal K. (2004) Ed." Environment Economics in Practice. Oxford University Press, New York.
3. Kolstad D. Charles. (2004) Environmental Economics. Oxford University Press, UK.
4. Joshi MV (1995) Theories and Approaches of Environmental Economics, Atlantic Publishers.
5. Stephen Smith (2011) Environmental Economics: A Very Short Introduction, OUP Publishers UK.
6. Philip E Graves (2014) Environmental Economics, An Integrated Approach CRC Press, UK.
7. Alfred Endres (2010) Environmental Economics - Theory and Policy, Cambridge University Press

Web References

1. https://www.epa.gov/environmental-economics
2. https://www.pnas.org/content/116/12/5233
3. https://www.nber.org/papers/w18794.pdf
4. https://www.oas.org/dsd/publications/Unit/oea71e/ch05.htm
5. http://ietd.inflibnet.ac.in/bitstream/10603/194/6/15_chapter5.pdf

ELECTIVE COURSE – VII

ENVIRONMENTAL ENGINEERING

Semester	Paper Code	Marks	Hours/Week	L	T	P	Credit
VII / VIII	20UPEVS2E07	100	4	3	1	0	3

Course Objectives

The purpose of this course is to teach the students about the background of engineering principles, designs and methods to solve the environmental problems like wastewater treatment, sludge stabilization and biogas production, and to monitor environmental pollutants.

Course Outcomes

On the successful completion of the course, students will be able to

CO1 Understand the complex environmental issues use of various engineering strategies to apply to solve environmental issues

CO2 Understand the basic principles and methods of environmental engineering

CO3 Identify the suitable treatment methods for wastewater treatment and sludge stabilization

CO4 Understand the process of biogas production from sewage sludge.

CO5 Use their acquired knowledge to design the reactors for sewage and sludge treatment.

CO6 Monitor the environmental pollutants and control the treatment process

Mappings of course outcomes with programme outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	*							
CO2		*						
CO3			*	*				
CO4			*					
CO5							*	
CO6				*		*		*

ELECTIVE COURSE – VII

ENVIRONMENTAL ENGINEERING

UNIT I An Overview of Wastewater Treatment and Disposal Contact Hours 10

Environmental sanitation, wastewater - wastewater quantity and quality-characteristics - treatment required - preliminary, primary, secondary, and tertiary treatments - sedimentation - effluent disposal - chlorination - sludge stabilization - biosolids. (K1, K2) Sewer system - design of sewers, estimation of sewage flow, sewage collection, and odour control. (K3, K4)

UNIT II Pre and Primary Wastewater Treatment Plant Contact Hours 8

Principle and design of screening, equalization tank, grit chambers, rectangular and circular coagulation and flocculation tank, sedimentation tank. Chemically Enhanced Primary Treatment (CEPT) - Design for a Small Community level. (K2, K3, K5, K6)

UNIT III Aerobic Treatment of Wastewater Contact Hours 8

Principles and design of aerobic biological treatment of sewage - Activated sludge process, Oxidation Ditch, Aerobic lagoons, Trickling filters, Sequencing batch reactors, Fluidized-bed bioreactors - Nutrient removal and pathogen reduction. (K2, K3, K5, K6)

UNIT IV Anaerobic Treatment of Wastewater and Sludge Contact Hours 10

Design of facilities for anaerobic treatment of wastewater and sludge (K5) - Anaerobic digesters and septic tanks, Anaerobic filters, Upflow anaerobic sludge blanket reactor - Sludge thickening and digestion -Biogas production - Sludge dewatering process, Biosolids - drying and disposal. (K5, K6)

UNIT V Air Pollution and Control Equipments Contact Hours 8

Principle and design of minimum stack height - Settling chamber - Cyclone collector - Fabric filter and Electrostatic Precipitators (ESP) - Bioscrubbers. (K4, K5, K6)

Text Books

1. Venugopala Rao, P (2002) Textbook of Environmental Engineering PHI Learning Pvt. Ltd
2. Basak, N N (2017) Environmental Engineering Tata McGraw Hill Publishing Company
3. Weiner R F, Matthews R A (2003) Environmental Engineering 4th edition, Butterworth and Heinemann press

Reference Books

1. Air Pollution Control Technology Manual (1998) Overseas Environmental Cooperation Center, Japan
2. Anne Maczulak (2010) Environmental Engineering: Designing a Sustainable Future, Infobase Publishing, NY, USA
3. Louis Theodore (2008) Air Pollution Control Equipment Calculations, John Wiley & Sons, NJ, USA.

4. Mihelcic JR, Fry LM, Myre EA, Phillips L and Barkdoll BD (2009) Field Guide to Environmental Engineering for Development Workers - Water, Sanitation, and Indoor Air, American Society of Civil Engineers, USA
5. Pawlowski A, Dudzinska MR and Pawlowski L (2013) Environmental Engineering, CRC Press, Boca Raton, FL, USA
6. Mackenzie L. Davis, David A. Cornwell, (2014) Introduction to Environmental Engineering 5th edition, McGraw Hill.
7. Nelson DL (2016) Textbook of Environmental Engineering, CBS publishers
8. Dugal KN (2008) Element of Environmental Engineering, S Chand Publishing

Web References

1. www.microbialfuelcell.org
2. www.pollutionissues.com/A-Bo/Bioremediation.html
3. www.bioreactors.net
4. http://enhs.umn.edu/current/5103/gm/harmful.html
5. www.wastewatertreatment.co.in/index.php
6. http://archive.industry.gov.au/Biotechnologyonline.gov.au/enviro/environment.html
7. https://preventioncdnndg.org/eco-quartier/biomethanization-2/
8. https://www.nrel.gov/workingwithus/learning.html
9. https://www.epa.gov/recycle/composting-home
10. https://www.epa.gov/remedytech/green-remediation-best-management-practices-bioremediation

CORE COURSE – XI

ENVIRONMENTAL MANAGEMENT SYSTEM

Semester	Paper Code	Marks	Hours/Week	L	T	P	Credit
VII / VIII	20UPEVS2E08	100	4	3	1	0	3

Course Objectives

The aim of this course is to provide students with a broad understanding about Environmental Auditing (EA) and sustainable innovative strategies in Environmental Science.

Course Outcomes

On the successful completion of the course, students will be able to

CO1 Understand the major principles and components of EA processes

CO2 Describe the benefits of environmental auditing and how it fits with the wider environmental management responsibilities of an organization

CO3 Outline the role of an environmental audit within an organizations Environmental Management System (EMS)

CO4 Acquire basic skills to take up environmental auditing and lifecycle analysis at specific industries

CO5 Understand how to liaise with and the importance of stakeholders in the EA process

CO6 Access different case studies/examples of EA in practice

CO7 Summarize the EA report with suitable environmental management plan

CO8 Acquire various approaches for Environmentally Sustainable Product Innovation

Mappings of course outcomes with programme outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	*		*		*	*	*	*
CO2	*		*		*	*	*	*
CO3	*		*		*	*	*	*
CO4	*		*		*	*	*	*
CO5	*		*		*	*	*	*
CO6	*		*		*	*	*	*
CO7	*		*		*	*	*	*
CO8	*		*		*	*	*	*

CORE COURSE – XI

ENVIRONMENTAL MANAGEMENT SYSTEM

UNIT I Environmental Auditing Contact Hours 08

Environmental Auditing (EA) – Definition, Key concepts of EA - Objectives and Scope of EA - Types of EA: Liabilities Audit, Management Audit and Activities Audit - Principle elements of an Environmental Audit – Components of auditing – Advantages and disadvantages of internal and external environmental audit

UNIT II Audit Process Contact Hours 12

Major steps involved in auditing process: Pre-audit activities, Onsite audit process (material balance, waste flow, monitoring, field observations, draft report) and Post-audit activities – Environmental audit report and follow-up – Problems encountered during the audit – Environmental auditor competence

UNIT III Environmental Management System (EMS) Contact Hours 08

Core Elements of Environmental Management System: Plan, Do, Check, Act – PCDA Loops – Key features of ISO 14001 in EMS – Benefits of implementing an EMS

UNIT IV Life Cycle Assessment (LCA) Contact Hours 12

Stages in Life Cycle Assessment – Life Cycle Assessment: Cradle-to-Grave, Cradle-to-Gate, Cradle-to-Cradle, Life Cycle Energy Analysis – Life Cycle of Industrial Products – Phases of LCA Framework: Goal and Scope definitions, Life Cycle Inventory (LCI), Life Cycle Impact Assessment (LCIA) and Life Cycle Interpretation – Applications of LCA – Limitations of LCA

UNIT V Environmentally Sustainable Product Innovation Contact Hours 10

Sustainable Innovative Strategies in Environmental Science: Ecodesign or Design for Environment (DfE) – Product Design – Materials Management – Production Design: Cleaner Production Strategies - Eco-design Approaches for Developing Eco-friendly Products - Eco-labeling in India and other countries – Barriers to Cleaner Production Implementation

Text Books

1 Shrivastava AK (2003) Environment Auditing. APH Publisher, New Delhi.

2 Sarkar D, Datta R, Mukherjee A and Hannigan R (2016) An Integrated Approach to Environmental Management. John Wiley & Sons Inc., USA.

Reference Books

1 Buckley R (1991) Perspectives in Environmental management. Springer-Verlag Berlin Heidelberg.

2 Christopher S and Mark Y (2007) Environmental Management Systems, (third edition), Earthscan Publications, First South Asian Edition.

3 David LG and Stanley BD (2001) ISO 14000 Environmental Management, Prentice Hall.

4 Galanakis CM (2020) Innovation Strategies in Environmental Science. Elsevier, Netherlands.

5 Jain RK, Cui Z and Domen JK (2016) Environmental Impact of Mining and Mineral Processing. Management, Monitoring, and Auditing Strategies. Elsevier, UK.

6 Murali Krishna IV and Manickam V (2017) Environmental Management: Science and Engineering for Industry. Elsevier, UK.

7 Shanker K, Shankar R and Sindhwani R (2019) Advances in Industrial and Production Engineering. Springer Nature Singapore Pte Ltd.

8 Shen TT (1995) Industrial Pollution Prevention. Springer-Verlag Berlin Heidelberg.

9 Whitelaw K and Butterworth (1997) ISO 14001: Environmental System Handbook.

Journal articles

1 Aich A and Ghosh SK (2020). Framework for Auditing of Municipal Solid Waste Management System in India. In: Solid Waste Policies and Strategies: Issues, Challenges and Case Studies (pp. 85-99). Springer, Singapore.

2 Gupta S, Saksena S and Baris OF (2019). Environmental enforcement and compliance in developing countries: Evidence from India. *World Development*, 117, 313-327.

3 Wanyonyi, A. (2020). An Insight into the Emerging Issues, Challenges and Future Prospects in Environmental Audit. Challenges and Future Prospects in Environmental Audit (June 16, 2020).

Web References

1. http://www.gogreenmechanisms.com/service/environment-audit/
2. http://cpcbenvis.nic.in/scanned%20reports/PROBES%2050%20Guidelines%20for%20Environmental%20Audit.pdf
3. http://kb.icai.org/pdfs/PDFFile5b28e322df0fd2.63902464.pdf
4. https://www.sciencedirect.com/topics/engineering/ecodesign
5. https://www.sciencedirect.com/topics/earth-and-planetary-sciences/cleaner-production
6. https://www.gdrc.org/sustdev/concepts/02-c-prod.html
7. http://www.cprac.org/en/sustainable/production/cleaner
8. https://isoconsultantkuwait.com/2019/06/21/iso-140012015-environment-management-system/

CORE COURSE – IX

ENVIRONMENTAL NANOSCIENCE

Semester	Paper Code	Marks	Hours/Week	L	T	P	Credit
VII / VIII	20UPEVS2E08	100	4	3	1	0	3

Course Objectives

The aim of this course is to provide students with a broad understanding about Environmental Auditing (EA) and sustainable innovative strategies in Environmental Science.

Course Outcomes

On the successful completion of the course, students will be able to

CO1 Understand the background about on nanotechnology and its importance
CO2 Understand different types of nanomaterials and their use
CO3 Obtain knowledge on synthesis the nanomaterials by different methods
CO4 Acquire knowledge on characterization and properties of the nanomaterials
CO5 Understand the application nanomaterials for degradation of environmental pollutants
CO6 Apply knowledge and skills in nano remediation, and water purification
CO7 Understand the impact of nanomaterials on environment.

Mappings of course outcomes with programme outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1		*						
CO2		*						
CO3		*						
CO4			*					*
CO5			*		*			
CO6		*	*			*	*	*
CO7		*			*	*		

CORE COURSE – IX

ENVIRONMENTAL NANOSCIENCE

UNIT I Introduction to Nanotechnology Contact Hours 08

Introduction to Nanoscience and Nanotechnology - Nanoscale Properties - Electrical, Optical, Chemical - Engineered Nanomaterials - Carbon based nanomaterials (K1, K2) - Fullerins, Carbon Nanotubes; Metal based Nanomaterials - Metal and Metal oxide Nanoparticles; Dendrimers - Nanocomposites - Nonporous materials. (K1, K2)

UNIT II Synthesis of Nanomaterials Contact Hours 12

Introduction to synthesis of nanomaterials - Bottom-up approach - Top-down approach - Physical methods - ball milling, melt mixing, physical vapour deposition, sputter deposition, evaporation; Chemical methods - chemical reduction, sol-gel method, photochemical synthesis, electrochemical synthesis, emulsion synthesis, sonochemical methods, microwave assisted synthesis; Biological methods - Green synthesis of nanoparticles using Bacteria - Fungi -Actinomycetes- Plants and plant metabolites. (K1, K2, K3)

UNIT III Characterization of Nanomaterials Contact Hours 08

Nanomaterials characterization using Spectrometer - UV-Vis, FT-IR, Fluorescence Spectrophotometer, Raman Spectroscopy; Electron Microscopy - TEM, SEM, Cryo-SEM, Scanning Probe Microscopy (AFM, STM), Confocal Microscopy, Diffraction Techniques (XRD, Synchrotron). (K2, K3, K4)

UNIT IV Environmental Applications of Nanomaterials Contact Hours 12

Nanomaterials for environmental remediation – Nanoscale zero-valent iron (NZVI), Titanium dioxide nanoparticles - Bimetallic nanoparticles - Silver nanoparticles - Metal oxide nanoparticles - Nanoadsorbents - Nanocatalysts - Nanoflocculant. Degradation and transformation of environmental pollutants - Halogenated Organic Solvents, Persistent Organic Pollutants, PPCPs, dyes, explosives, toxic heavy metals - arsenic and chromium. Nanoremediation - Ground Water Remediation - Permeable Reactive Barrier - Air purification - Soil remediation. (K3, K4, K5, K6)

UNIT V Nanotoxicity and Environmental Impacts Contact Hours 10

Routes of nanomaterials into the water environment, Hazardous effects of nanomaterials on Human and Animal Health (K1, K2). Impacts of nanomaterials on environmental microbial community - bioaccumulation - cytotoxic - genotoxic - effects of engineered nanoparticles. (K4, K5)

Text Books

1. A Textbook of Nanoscience and Nanotechnology (2012) T. Pradeep. Tata McGraw-Hill Education (India).ISBN: 9781259007323.
2. Textbook of Nanoscience and Nanotechnology (2013). Murty, B.S., Shankar, P., Raj, B., Rath, B.B., Murday, J.

Reference Books

1. Pradeep, T. (2008) Nano: The Essentials - Understanding Nanoscience and Nanotechnology, Tata Mc. Graw Hill Professional.
2. Rao, C.N.R., Muller, A., Cheetham, A.K. (2004) The Chemistry of nanomaterials: Synthesis, Properties and Applications.

3. Niemeyer, C.M., Mirkin, C.A. (2004) Nanobiotechnology:Concepts, Applications and Perspectives, Wiley VCH.
4. Mirkin, C.A. Niemeyer, C.M. (2007) Nanobiotechnology - II more concepts and applications, Wiley VCH.
5. Z.hang, T.C., Hu, Z., Surampalli, R., Tyagi, R.D. Lai, K.C.K, Lao, I.Mc. (2009) Nanotechnologies for Water Environment Applications. American Society of Civil Engineers (ASCE) Publications.
6. Mark Wiesner, Jean-Yves Bottero (2007) Environmental Nanotechnology: Applications and Impacts of Nanomaterials, McGraw, Hill Professional.
7. Simeonova P.P, Opopol N, and Luster M.I. (2006) Nanotechnology - Toxicological Issues and Environmental Safety, Springer.
8. Poole, C.P. Jr .Owens, F.J. (2003) Introduction to Nano Technology Wiley India Pvt Ltd.

Web References

1. http://www.gogreenmechanisms.com/service/environment-audit/
2. http://cpcbenvis.nic.in/scanned%20reports/PROBES%2050%20Guidelines%20for%20Environmental%20Audit.pdf
3. http://kb.icai.org/pdfs/PDFFile5b28e322df0fd2.63902464.pdf
4. https://www.sciencedirect.com/topics/engineering/ecodesign
5. https://www.sciencedirect.com/topics/earth-and-planetary-sciences/cleaner-production
6. https://www.gdrc.org/sustdev/concepts/02-c-prod.html
7. http://www.cprac.org/en/sustainable/production/cleaner
8. https://isoconsultantkuwait.com/2019/06/21/iso-140012015-environment-management-system/

ELECTIVE COURSE – X

FOREST AND WILDLIFE MANAGEMENT

Semester	Paper Code	Marks	Hours/Week	L	T	P	Credit
VII / VIII	20IUPEVS2E10	100	4	3	1	0	3

Course Objectives

Introduce to the principles and concepts of conservation, to provide scientific knowledge on sustainable Management

Course Outcomes

On the successful completion of the course, students will be able to

CO1 The student completed this course can expect to have an adequate knowledge on importance of forest ecosystem

CO2 Students understand the different properties of soil

CO3 The students learn sound knowledge on impact of deforestation in ecosystems

CO4 Students can understand the laws of forest

CO5 Students learn the different wild life conservation and management

Mappings of course outcomes with programme outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	*							
CO2		*						
CO3			*					
CO4	*	*					*	
CO5				*		*		

UNIT I **Introduction to Forests Ecosystem** Contact Hours 12

Definition -- Forest Ecosystem - Forest community concepts - Succession - Primary productivity - Composition of forest types in India -Classification of India's Forests - Species composition association and diversity. Extent of forests in India and other countries - Role of forests - Factors of locality - climatic - edaphic - topographic - biotic - Interaction of Forests with the Environment. Recent trends in forestry development in the world. Exotics - Role of Exotic forest trees in India - Application of bio-technological methods in forestry (K1, K2, K3)

ELECTIVE COURSE – X

FOREST AND WILDLIFE MANAGEMENT

UNIT II Forest Soils Contact Hours 11

Classification - Factors affecting soil formation - Podzolization and laterization - Physical, Chemical and biological properties of Forest soils - Problem soils. Soil and water conservation measures. Watershed management - Concepts and methods - Forest treatments - Streamflow - Impact on water yield and quality Use of remote sensing techniques in forest survey (K1, K2, K3)

UNIT III Definition and objectives of forest mensuration Contact Hours 11

Measurement of diameter, girth, height and volume of Trees-Role of Forest Protection in Indian Forest-r Forest fire - Fire protection methods- Forest Policy - Necessity - Formulation of National Forest Policy - History of Forest development in India - Indian Forest Policy of 1894, 1952 and 1988- Role of ICFRE in Forest Research and Education - Forest laws - Necessity - General Principles - Indian Forest Act 1927, Forest Conservation Act 1980 (K1, K2, K3)

UNIT IV Introduction to Wildlife management Contact Hours 10

Ecology and biology of wildlife - Principles and techniques of management - Wildlife habitats - Census - Land tenure system - Major wildlife species in India and their broad study – Wild life health and management- Human and wild animal Conflict and Management-Wildlife Forensics - Overview, various forensic protocols for species Identification- Wildlife crime case studies (K3, K4, K5, K6)

UNIT V Wildlife conservation and management Contact Hours 10

Habitat management and conservation in India- Policy and legal measures – Sanctuaries, National parks and Biosphere reserves - Special projects for wildlife conservation. Project Tiger and Musk Deer Project. Wildlife corridors. MAB, Red Data Book, Category of threat, CITES Wildlife census, Purpose, techniques. Direct and indirect methods of population estimation. Role of scientific institution and NGOs in Wild Life Conservation - Wildlife (Protection) Act, 1972-Ecotourism (K3, K4, K5, K6)

Text Books

1. Avery, T.E. and Barkhart, H.E. (1983) Forest measurements. McGraw Hill Book Company, New York. 331 p.
2. Chaturvedi, A.N. and Khanna, L.S. (1994) Forest mensuration. International Book Distributor, Dehradun. 403 p.
3. FAO. (1981) Manual of forest inventory with special reference to mixed tropical forests, FAO. Forestry Paper 27.
4. Jerram, M.R.K. and Bourne, R. (1980) Elementary forest mensuration. Natraj Publication, Dehradun. 126 p.
5. Philip, M.S. (1998) Measuring trees and forests. CAB Publication, New York.
6. Dhyani, S.N. (1994) Wildlife management. Rawat Publication, Jaipur. 258 p.
7. Hosetti, B.B. (1997) Concepts in wildlife management. Daya Publishing House, Delhi.

ELECTIVE COURSE – X

FOREST AND WILDLIFE MANAGEMENT

Reference Books

1. Khan, T.I. and Al-Ajmi, D.N. (1999) Global biodiversity conservation measures, Pointer Publishers, Jaipur. 468 p.
2. Nautiyal, S. and Kaul, A.K. (1999) Forest biodiversity and its conservation practices in India. Oriental enterprise Dehradun, 337 p.
3. Ramakrishnan, P.S. (1992) Shifting agriculture and sustainable development. Man and Biosphere series. The Parthenon Publishing Group. 424 p.
4. Saharia, V.B. (1989) Wildlife law in India. Natraj Publication, Dehradun.
5. Sinha, P.C. (1998) Wildlife and forest conservation. Anmol Publishing Pvt.Ltd., New Delhi.
6. The World Resources Institute, 1990-91. Possible effects on global wanning on forests and range Iands World Resources; 1990-91. Oxford University Press, 1990. New York.

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1. www.gfc.state.ga.us/resources/publications/ForestsAndWildlife.pdf
2. woodlandstewardship.org/?page_id=1154
3. https://www.forestasyst.org/wildlife.html
4. gradestack.com/.../Management.../Forests-and-Wildlife/15038-2998-4773-study-wtw
5. https://www.bookstore.ksre.ksu.edu/pubs/MF2899.pdf