UNIVERSITY OF CALICUT
Entrance examination for admission to Ph. [D] programme in Environmental Science- 2023
(Model Question Paper)

Time: 2 Hours **Max Marks 100**

Tag this question paper along with the answer sheets of Part II

PART I

Attempt **all** questions. Put a √ mark for correct answer.

Multiple choice questions. All questions carry 1 mark each. No negative marks.

01. In meteorology, the word insolation refers to:
[A] a well-constructed, energy-efficient home
[B] the solar constant
[C] incoming solar radiation
[D] an increase in solar output

02. The data which have already been collected by someone are called:
[A] Raw data
[B] Secondary data
[C] Array data
[D] Ficticious data

03. Carbon foot print is:
[A] The amount of carbon dioxide released into the atmosphere
[B] The amount of carbon stored within a living thing
[C] The total amount of circulating carbon in the biosphere
[D] A way to make accurate tracing of the animal tracks.

04. Which of the type of forest is most widespread in India
[A] Tropical Deciduous Forests
[B] Tropical evergreen Forests
[C] Temperate Forests
[D] Shola Forests

05. To test null hypothesis, a researcher uses:
[A] Correlation
[B] ANOVA
[C] Regression
[D] factorial analysis

06. The first step of research is:
[A] Selecting a problem
[B] Searching a problem
[C] Finding a problem

[D] Identifying a problem

07. To conserve coral reefs the Govt of India declared one of the following as a Marine National Park
[A] Gulf of Kutch
[B] Lakshadweep Islands
[C] Gulf of Mannar
[D] Andaman Islands

08. The bacteria responsible for deposition of iron oxide in water pipes is
[A] *Gallionella*
[B] *Klebseilla*
[C] *Thermococcus*
[D] *Helicobacter*

09. The following statistical test is used to ascertain whether there is significant difference between the variances of two sets of observations:
[A] T-test
[B] F-test
[C] Chi square test
[D] Regression

10. Research problem is selected from the stand point of:
[A] Researcher's interest
[B] Financial support
[C] Social relevance
[D] Availability of relevant literature

11. Atmospheric radioactive window permits thermal radiation of which wavelength to leave the earth?
[A] 4.3 to 9.3 µm
[B] 9.5 to 10.6 µm
[C] 7 to 12 µm
[D] 7.3 to 10.3 µm

12. Which one is called non-probability sampling?
[A] Quota sampling
[B] Cluster sampling
[C] Systematic sampling
[D] Stratified random sampling

13. Gutenberg discontinuity is found at the depth of:
[A] 333 km
[B] 700 km
[C] 1500 km
[D] 2900 km

14. ISO 14040 is related to
[A] Environmental audit

[B] Energy audit
[C] Cost benefit analysis
[D] Life cycle analysis

15. What are the conditions in which Type-I error occurs?
[A] The null hypotheses get accepted even if it is false
[B] The null hypotheses get rejected even if it is true
[C] Both the null hypotheses as well as alternative hypotheses are rejected
[D] None of the above

16. What is a hypothesis in research?
[A] A conclusion drawn from data analysis
[B] A summary of research findings
[C] A measurement of data accuracy
[D] A statement of predicted relationship between variables

17. Snow blindness is caused due to
[A] Ultra-violet radiations
[B] Excessive flux of visible radiations
[C] Infra-red radiations
[D] Microwave radiations

18. Which among the following chronic lung disease commonly known as ‘black lung disease’, leads to reduced life expectancy in coal-miners?
[A] Pneumoconiosis
[B] Progressive Massive Fibrosis
[C] Mesothelioma
[D] Collier’s Asthma

19. For a normal distribution the skewness is
[A] 1
[B] 0
[C] 1/2
[D] 2

20. What is the purpose of a research proposal?
[A]To present research findings
[B]To provide a rationale for the study
[C]To establish causality
[D]To guide the data collection process

21. The ‘thickness’ of Stratospheric Ozone layer is measured in:
[A] Sieverts
[B] Dobson units
[C] Melson units
[D] Beaufort Scale

22.What is a research design?
[A] A plan for data analysis
[B] A method for data collection

[C] A statistical technique
[D] A framework for conducting research

23. Geostrophic wind occurs when pressure gradient force balances:
[A] Coriolis force
[B] Frictional force
[C] Centripetal force
[D] Coriolis and frictional force together

24. Which of the following species in the atmosphere is called atmospheric detergent?
[A] Chlorine radical
[B] Hydroxyl radical
[C] Methyl radical
[D] Ozone radical

25. What is the appropriate statistical analysis for comparing means between two groups?
[A] Chi-squared test
[B] Analysis of variance (ANOV[A]
[C] Regression analysis
[D] T-test

26.What is the purpose of statistical analysis in research?
[A]To summarize research findings
[B]To collect primary data
[C]To draw conclusion from data
[D]To develop research hypotheses

27. The tendency of biological systems to resist change and to remain in a state of equilibrium is called:
[A] Homeostasis
[B] Feedback mechanism
[C] Ecological efficiency
[D] Carrying capacity

28. What is a random sample in research?
[A] A sample that is selected by chance
[B] A sample that is selected based on specific criteria
[C] A sample that is selected from population in a systematic way
[D] A sample that is selected based on convenience

29. According to WHO, maximum permissible level of chlorides in drinking water is?
[A] 100 mg/L
[B] 250 mg/L
[C] 600 mg/L
[D] 800 mg/L

30. Variety of different species, genetic variability among individuals within each species and variety of ecosystems constitute the so called
[A] Species diversity
[B] Genetic diversity

[C] Biological diversity
[D] Ecological diversity

31. What is a case study in research?
[A] A survey of a large population
[B] An in-depth investigation of a single individual or group
[C] An experimental design that tests a hypothesis
[D] An analysis of existing statistical data

32. Which of the following is a measure of central tendency in statistics?
[A] Standard Deviation
[B] Correlation Coefficient
[C] Mean
[D] Chi-square test

33. Baba Amte was the leader of
[A] Appiko Movement
[B] Chipko Movement
[C] Narmada Bachao Andolan
[D] Tehri Dam Movement

34. What is mode in descriptive data analysis?
[A] The value that appears most frequently in a dataset
[B] The average of a dataset
[C] The middle value of a dataset
[D] The difference between the highest and lowest values in a dataset

35. What is bias in research methodology?
[A] A measure of central tendency
[B] A measure of variability
[C] A systematic error in data collection
[D] A random error in data collection

36. An earthquake is rated as ‘major’ if its magnitude in Richter scale is in the range of
[A] 4.0 – 4.9
[B] 7.0 – 7.9
[C] 6.0 – 6.9
[D] 5.0 – 5.9

37. A research plan:
[A] Should be detailed
[B] Should be given to others for review and comments
[C] Sets out the rationale for a research study
[D] All of the above

38. An image, perception or concept that is capable of measurement is called_____
[A] Scale.
[B] Hypothesis.
[C] Type.
[D] Variable

39. Walkley and Black rapid titration method is used for the determination of:
[A] Organic carbon content of soil
[B] Nitrate content of soil
[C] Phosphate content of soil
[D] Fluoride content of soil

40.What is the purpose of a literature review in research?
[A]To identify the research gaps
[B]To summarize research findings
[C]To collect primary data
[D] To analyse data

41. In turbidity analysis, formazin is used:
[A] To stabilize the samples
[B] To preserve the samples
[C] To make turbidity standards
[D] To remove colour interferences

42. The rate of variation of population [N] with time [t] represented by equation $dN/dt = \gamma N$, follows
[A] J-shaped curve
[B] S-shaped curve
[C] Z-shaped curve
[D] Parabolic curve

43. In the process of conducting research 'Formulation of Hypothesis" is followed by
[A] Statement of Objectives
[B] Analysis of Data
[C] Selection of Research Tools
[D] Collection of Data

44. The amount of organic matter present at a given time per unit area is called
[A] Standing crop
[B] Standing quality
[C] Carbon content
[D] Carbon footprint

45. The Environment [Protection] Act of India was enacted in which year?
[A] 1974
[B] 1977
[C] 1980
[D] 1986

46. A formal document that presents the research objectives, design of achieving these objectives, and the expected outcomes/deliverables of the study is called:
[A] Research design
[B] Research proposal
[C] Research hypothesis
[D] Research report

47. Survey is a _____ study?
[A] Descriptive
[B] Fact finding
[C] Analytical
[D] Systematic

48. Which of the following is inter-tidal zone between land and open sea?
[A] Benthic zone
[B] Pelagic zone
[C] Neritic zone
[D] Littoral

49. In EIA, the methodology which works from a list of project activities to establish cause condition - effect relationship is known as:
[A] Checklist
[B] Overlays
[C] Networks
[D] Matrices

50. Questionnaire is filled by:
[A] Respondent
[B] Everybody
[C] Enumerator
[D] None of the above

50 x 1 = 50 marks

PART II

Attempt **all** questions. Each question carries **5** marks each.

51. Explain the thermal profile of the atmosphere with a suitable diagram.
52. Give an account of the types of biotic interactions in nature, citing examples.
53. Write a brief note on renewable energy sources.
54. Briefly explain about noise pollution, citing causes, consequences and management measures.
55. Explain the applications of remote sensing and GIS in environmental management.
56. Propose an Environmental Impact Assessment (EIA) protocol for a hydroelectric project.
57. Give an account on the various types of plagiarism and plagiarism check softwares.
58. Suggest methods for the conservation of any two RET plant species.
59. Suggest various monitoring techniques used in assessing the toxicological impact of chemicals on biological systems.
60. Elucidate various methods of solid waste management.

10 x 5 = 50 marks

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UNIVERSITY OF CALICUT

Abstract

General and Academic IV - Faculty of Science - Scheme and Syllabus of MSc Environmental Sciences Programme under CCSS PG Regulations 2022 (University Teaching Departments) with effect from 2022 Admission - Implemented-Orders Issued.

G & A - IV - J

U.O.No. 16245/2022/Admn Dated, Calicut University.P.O, 25.08.2022

Read:-1. U.O.No. 8481/2022/Admn, dated, 11.04.2022
2. Minutes of the meeting of the Board of Studies in Environmental Science & Water Management held on 03.08.2022
3. Approval of the Dean, Faculty of Science dated 18.08.2022
4.Orders of the Vice Chancellor in the file of even no. dated 21.08.2022

ORDER

1. The Regulations under Choice-based Credit Semester System for Post Graduate Programmes (CCSS-PG -2022) of all Teaching Departments / Schools of the University of Calicut w.e.f 2022 admission has been implemented in the University of Calicut, vide paper read (1) above.
2. The meeting of the Board of Studies in Environmental Science & Water Management held on 03.08.2022 has approved the Scheme and Syllabus of MSc Environmental Sciences programme in tune with new CCSS PG Regulation implemented with effect from 2022 Admission, vide paper read (2) above.
3. The Dean, Faculty of Science and the Vice Chancellor have approved the Scheme and Syllabus of MSc Environmental Sciences programme in tune with new CCSS PG Regulation implemented with effect from 2022 Admission, subject to ratification by the Academic Council, vide paper read (3) & (4) respectively.
4. The Scheme and Syllabus of MSc Environmental Sciences Programme in accordance with CCSS PG Regulations 2022 (University Teaching Departments), is therefore implemented in the University with effect from 2022 Admission, subject to ratification by the Academic Council.
5. Orders are issued accordingly. (Syllabus appended)

Ajitha P.P

Joint Registrar

To

The HoD, Department of Botany
Copy to: PS to VC/PA to PVC/ PA to Registrar/PA to CE/JCE I/JCE V/DoA/EX and EG Sections/GA I F/CHMK Library/Information Centres/SF/DF/FC

Forwarded / By Order

Section Officer

UNIVERSITY OF CALICUT
DEPARTMENT OF ENVIRONMENTAL SCIENCES

Learning Outcome-based Curriculum Framework (LOCF)
for

M.Sc. Programme in Environmental Sciences

(effective from 2022 admission)

University of Calicut
Department of Environmental Sciences

LOCF FOR

M. Sc. Programme in Environmental Sciences (CCSS)

(effective from 2022 admissions)

About the Department

The Department of Environmental Sciences started functioning in the University of Calicut, subsequent to a resolution of the Syndicate in 2008. The Post Graduate programme (M.Sc.) in Environmental Sciences started in 2015. This interdisciplinary programme is under Choice based Credit Semester System (CCSS) of the University. Present intake to this four-semester programme is 20. The department also reserves vacancies to other Indian and foreign nationals.

Candidates with a Degree in any Science Subject from the University of Calicut or any other University, recognized by the University of Calicut with a minimum of 50% marks can apply for admission to M. Sc. programme in Environmental Sciences. Admission to the programme is through an entrance examination conducted by the University or its representative bodies, annually.

Vision and Mission

Vision

A nationally acclaimed teaching and research institution, catering to the aspirations of all segments of the society on matters concerning environment and sustainable living.

Mission

To provide quality education and research outputs on matters pertinent to the environment through national norms and international collaborations.

To develop human resources capable of undertaking conservation, awareness and advocacy initiatives on natural resources, in the wake of increasing global environmental issues.

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University of Calicut
Department of Environmental Sciences

LOCF for M.Sc. Programme in Environmental Sciences (CCSS)

(effective from 2022 admissions)

Program Educational Objectives (PEOs)	
The M.Sc. programme in Environmental Sciences outlines various achievements that the students can attain after graduation.	
PO1	The courses have been designed to benefit all science graduates from interdisciplinary areas to have an in-depth knowledge on Environmental Sciences and its practical applications.
PO2	The courses have been designed to empower the students to take up various professions, including teaching at different levels, research jobs in scientific institutions, managerial positions in policy making institutions and industries and above all, spokespersons of environmental conservation and management.
PO3	The courses are designed to inculcate a thorough knowledge on various physical processes associated with the earth, the nature and composition of domains associated with the earth like lithosphere, hydrosphere, atmosphere, biosphere and their inter-relationships. Emphasis was also given to issues like resource depletion and pollution and the application of various conservation and technology-based interventions to combat such issues. Emphasis was also given to natural disasters and their management measures.
PO4	All the courses in this programme are designed to equip the students for CSIR / UGC / ICAR - SET / NET / GATE / JRF / ARS examinations and other competitive examinations conducted by UPSC / SSC / KPSC and similar recognized organizations. The project work envisaged in the syllabus will help the students to submit innovative research proposals and to receive grants-in aid for various research programmes.

Program Specific Outcomes (PSOs)	
After the successful completion of M.Sc. program in Environmental Sciences, the students are expected to have:	
PSO1	Knowledge about earth and its functioning, evolution of various domains and the nature and magnitude of their interrelationships. To have a better understanding of solar energy and its manifestations in sustaining various physical, chemical and biological processes on earth. To have an analytical perspective on resource depletion and pollution associated with various environmental domains.
PSO2	Understanding of the water resources associated with the earth and their estimation using technological means like remote sensing and geographical information systems. Also understanding of the microbial systems associated with various environmental domains and the interventions of biotechnological and other engineering approaches in environmental management.
PSO3	Acquire skills on the use of tools, techniques and monitoring methods in assessing various issues related to the environment. The topics of biodiversity and conservation will address the current issues and challenges associated with bio resource conservation. Environmental toxicology provides insight on the source, route and impacts of various toxicants on biological systems. The selection of an open elective course will help the students to have an understanding of a specified course from a wide range of courses having socio-economic or scientific linkages to the environment.
PSO4	Elucidate the socio-economic and legal aspects of resource utilization, conservation and management through courses like Environmental Economics and Environmental Law. A wide range of elective courses will help the students to have a better understanding of areas like Environmental Disaster Management, Environment planning policies and management, Current Environmental issues in India, Wildlife and Avian Biology, Natural resources: Conservation and Management, Green Chemistry, Global Climate Change and Mitigation.
PSO5	Elucidate the priority areas requiring research and to formulate action plans for resource conservation and management through output-oriented project work.

Program Outcomes (POs)	
On successful completion of the M. Sc. Programme in Environmental Sciences, the students will be able to:	
PO1	Attain a higher level of scientific knowledge on earth, its domains, interrelationships and energy transfer process.
PO2	Understand various issues associated with the environment and their management measures.
PO3	Understand the contributions of areas like microbiology, biotechnology, engineering, remote sensing and GIS in environmental management and resource conservation.
PO4	Learn about the toxicological impacts of chemicals on biological systems and their monitoring techniques. Also, knowledge on biodiversity, various threats to biodiversity and their management measures
PO5	Attain a higher level of knowledge on the socio-economic and legal aspects of resource conservation and management.
PO6	Improve their ability to undertake research studies on priority areas and to develop strategies for effective environmental management.

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Salient features

Name of the programme:	M.Sc. Environmental Sciences
Course Code:	FSCESMSC
Duration:	04 semesters (2 years)
Pattern:	CCSS

Core Courses

Core courses are the compulsory courses designed to meet the core requirement of providing a basic understanding of the discipline. Core courses can be both theory (3 credits) and practical (2 credits).

Ability Enhancement Course (AEC)

An Ability Enhancement Course (ESW 1A 01 - Environmental Research Methodology) for 2 credits is offered during the first semester of the PG program by the Department.

Professional Competency Course (PCC)

Professional Competency course (ESW 2A 02) - Environmental Analytical Techniques and Instrumentation) for 2 credits is offered with an aim to provide hands-on training to develop technical skills and proficiencies in handling high-end instruments to carry out future research programs. The course is offered during the second semester of the PG program by the Department.

Open Elective Courses

Open elective courses (4 credits) are offered in the third semester of the program. An open elective course is chosen generally from a less related or unrelated discipline to enhance the general exposure outside the main discipline. The students pursuing M.Sc. Environmental Sciences have to opt for Open Elective courses offered by other Departments based on their interest. The scope of the Open Elective Courses is to effectively enhance horizontal mobility across diverse disciplines.

Discipline-Specific Elective Courses

Discipline-Specific Elective courses are offered by the Department to enhance the flexibility of selection of an area of specialization from a pool of courses. These courses are considered specialized or advanced with respect to M.Sc. Environmental Sciences program and provide extensive exposure in the areas chosen. A total of 07 Elective Courses are offered by the Department, of which a student has to complete two courses from the chosen area in the fourth semester of the program.

Dissertation

The topic of the dissertation may be chosen from an area of one of the elective courses opted in the 4th semester.

Evaluation and Grading

Calicut University Regulations for Choice-based Credit Semester System for Postgraduate Programmes of Teaching Departments / Schools of the University of Calicut (CCSS PG Regulations 2022) are to be followed for internal and external evaluation and grading.

The evaluation scheme for each course (paper) shall contain two parts a) continuous (internal) evaluation b) end semester evaluation. 50% weight shall be given to the continuous (internal) evaluation. The remaining 50% weight shall be for the end semester examination / evaluation.

Continuous (internal) evaluation: The internal evaluation shall be based on a predetermined transparent system involving periodic written tests, viva-voce, seminars and attendance in respect of theory courses and based on written tests, viva-voce and lab skill / records in respect of practical courses, as detailed below.

Internal evaluation

Sl. No.	Theory paper	Marks	Sl. No	Practical paper	Marks
a	*Attendance	5	a	Lab skill / quality of records	10
b	Seminar	5	b	Practical test	30
c	Assignment	5	c	Viva voce	10
d	Test paper	30			
e	Viva voce / Field work	5			
	Total	50		Total	50

* Attendance: 90% and above: 5 marks; 80-89%: 3 marks; 75-79%: 1 mark: below 75%: nil

End Semester Examination and Evaluation:

The End Semester examination in theory courses is to be conducted with question papers set by the examiners (internal / external). The evaluation of the answer scripts shall be done by the teacher offering the course and an expert (internal / external) based on a well-defined scheme of valuation framed by them. No separate minimum is required for internal evaluation for a pass, but a minimum 40% is required for each course in the end semester examination and evaluation.

The End Semester practical examination shall be conducted and evaluated by two or more examiners nominated by the Department Council.

The valuation scheme for Project/Dissertation: The valuation shall be jointly done by the supervisor of the project in the department and an External / Internal Expert from the approved panel, based on a well-defined scheme of valuation framed by them. The following break-up is suggested for the valuation. The concerned Department Council / BoS may decide on alternative break-up, if required, specific to the discipline of study.

The break-up suggested for project evaluation

Sl. No.	Particulars	Weightage (%)
01	Review of literature and formulation of research problem / objective	20
02	Methods and description of the techniques used	15
03	Analysis and discussion of results	30
04	Presentation of the report, organization, linguistics style, references etc.	15
05	Viva voce examination based on the project work / dissertation	20
	Total	100

Examiners

The internal examiners of each semester shall be the teachers who actually imparted instruction in that particular semester. The external examiners shall be selected from a panel of examiners approved by the Departmental Council / other academic bodies for each semester.

Plan of question papers for external examinations

Theory

Core & Elective Courses:

Part A: One essay-type questions of 8 marks to be answered out of two questions (1x8 = 8 marks).
Part B: Eight short answer questions of 4 marks each to be answered out of ten questions (8x4 = 32 marks).
Part C: Ten short answer questions of 1 mark each to be answered out of twelve questions (10x1 = 10 marks).

Practicals

The Board of examiners for practical examinations of I to IV semesters shall decide the plan of question papers. The break-up of marks for the external examinations of practical courses will be as follows:
practical examination - 40 marks; records / submission/viva - 10 marks.

Record of Practical Work

A certified record of practical work done by the student should be submitted at the time of each practical examination.

Duration of examinations

The duration for each theory and practical examination shall be three hours.

There will be two compulsory courses - Ability Enhancement Course (AEC) & Professional Competency Course (PCC) each with 2 credits, and these courses are to be done within the first two semesters. The credits will not be counted for computing the overall SGPA/CGPA of the student. The concerned department shall conduct examinations for these courses and shall intimate /upload the results of the same to the University on the stipulated date during the III Semester. The student has to obtain only minimum pass requirements (40%) in these two courses. The Department Council will decide the evaluation criteria for the Ability Enhancement Course and the Professional Competency Course.

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University of Calicut

M. Sc. Programme in Environmental Sciences (CCSS)

(effective from 2022 admissions)

Course structure, credits, mark distribution and scheme of evaluation

Semester	Course No.	Name of the Course	Credits	Continuous evaluation Internal (50%)	End Semester Evaluation (50%)	Total
I semester	ESW 1C 01	Physical processes in the environment	3	50	50	100
	ESW 1C 02	Fundamentals of ecology and environment	3	50	50	100
	ESW 1C 03	Energy and environment	3	50	50	100
	ESW 1C 04	Environmental pollution and Pollution Abatement	3	50	50	100
	ESW 1C 05	Practical I #	2	50	50	100
	ESW 1C 06	Practical II #	2	50	50	100
	ESW 1A 01	Ability Enhancement Course - Environmental Research Methodology Ø	2	100	-	100
Total			16			600
II semester	ESW 2C 07	Fundamentals of Environmental Engineering	3	50	50	100
	ESW 2C 08	Environmental Microbiology and Biotechnology	3	50	50	100
	ESW 2C 09	Hydrology and Water Resource Management	3	50	50	100
	ESW 2C 10	Remote Sensing and GIS	3	50	50	100
	ESW 2C 11	Practical III #	2	50	50	100
	ESW 2C 12	Practical IV #	2	50	50	100
	ESW 2A 02	Professional Competency course – Environmental Analytical Techniques & Instrumentation Ø	2	100	-	100
Total			16			600

Semester	Course No.	Name of the Course	Credits	Continuous evaluation Internal (50%)	End Semester Evaluation (50%)	Total
III semester (Two electives in which one is open elective)	ESW 3C 13	Environmental Assessment tools and monitoring methods.	3	50	50	100
	ESW 3C 14	Environmental Toxicology and Occupational Health Hazards.	3	50	50	100
	ESW 3C 15	Biodiversity and Conservation	3	50	50	100
	Open elective ESW 3E 01	Open elective course * (offered by other departments)	4	50	50	100
	ESW 3E 02	Elective 1**	4	50	50	100
	ESW 3E 03	Elective 2**				
	ESW 3E 04	Elective 3**				
	ESW 3C 16	Practical V #	2	50	50	100
	ESW 3C 17	Practical VI #	2	50	50	100
Total			21			700
IV semester (Two electives)	ESW 4C 18	Environmental Law	4	50	50	100
	ESW 4C 19	Environmental Economics	4	50	50	100
	ESW 4E 01	Elective 1 ©	4 + 4	50	50	100 + 100
	ESW 4E 02	Elective 2 ©				
	ESW 4E 03	Elective 3 ©				
	ESW 4E 04	Elective 4 ©				
	ESW 4P 01	Project / Dissertation	8	-	Dissertation 160 Viva 40	200
Total			24		500	600
Grand Total	Credits		77			
	Marks					2500

\# Practical I, II, III and IV will be conducted along with the second semester examination and V and VI along with IV semester examination.

***** One open elective in III semester

****** One elective in III semester from the list of 3 courses

© Two electives in IV semester from the list of 4 courses

Ø Credits earned for ESW 1A 01 and ESW 2A 02 will not be counted for CGPA

Open Elective course offered by the Department in the III semester

Sl. No.	Course code	Course title	Credits	Internal evaluation	External evaluation	Total
1	ESW 3E 01	Environment Management and Sustainable Development Goals	4	50%	50%	100

Elective courses offered by the Department in the III semester

Sl. No	Course code	Course title	Theory / Practical	Credits
01	ESW 3E 02	Current Environmental issues in India	Theory	4
02	ESW 3E 03	Wildlife and Avian Biology	Theory	4
03	ESW 3E 04	Global Climate Change and Mitigation	Theory	4

Electives offered by the Department in the IV semester

Sl. No	Course code	Course title	Theory / Practical	Credits
01	ESW 4E 01	Environmental Disaster Management	Theory	4
02	ESW 4E 02	Environment planning policies and management	Theory	4
03	ESW 4E 03	Natural resources: Conservation and Management	Theory	4
04	ESW 4E 04	Green Chemistry	Theory	4

There shall be provisions for the addition or deletion of elective courses to be offered, if necessary, in subsequent years of admission, subject to approval by the departmental council and other statutory academic bodies concerned. In the fourth semester, there will be two core and two elective (theory) courses. Each student in the fourth semester is required to submit a dissertation in one of the areas of elective courses chosen. Project / Dissertation work can be undertaken in the department of Environmental Sciences or in other departments of the University or in other recognized research institutions, with proper intimation.

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M. Sc. Programme in Environmental Sciences (CCSS)

CORE / ELECTIVE SUBJECTS – COURSE CONTENTS

SEMESTER I

ESW 1C 01

Physical Processes in the Environment

Course Objectives:
The main objectives of this course are: ● To enable the students to gain knowledge on sun earth systems and the phenomena that occur in the physical system of the earth and its associated environments ● To apply knowledge about the general circulation of the atmosphere and the ocean and the interactions followed by oceanic currents ● To have a knowledge on thermodynamics ● To have an understanding of the clouds, their types and the methods of their formations. The basic information gained from this core paper can be utilized by the students to know more about the weather and climate and the climatic disturbances happening today. ● To obtain knowledge about various systems in our environment and the formations of rocks and the concept of plate tectonics and continental drift

Expected Course Outcomes:		
On the successful completion of the course, the student will be able to:		
1	Describe the basics of earth systems, its processes, hydrology and basic concept of hydrology, sun earth system and general circulations of the atmosphere.	K1
2	Compare the plate tectonic processes and resultant features.	K2
3	Develop the ability to independently undertake research work on various domains and associated systems of our environment.	K3
4	Analyze the interrelationship between various spheres (Atmosphere, Lithosphere and Hydrosphere) of the Earth and the general circulation within these spheres.	K4
5	Evaluate the climate changes, their variability and the causes of climate change.	K5
6	Appraise the different geo-scientific approaches for a sustainable environment and attain higher competence and multidisciplinary project experience within selected topics related to the sun and earth system.	K5
K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate		

Module I:
Sun-Earth System: planetary motion and seasons; Solar radiation - global distribution, effect of atmosphere - scattering, absorption and reflection, greenhouse effect.
Earth Systems: Earth's geological history and development and evolution of the earth systems; Gaia Hypothesis; Introductions to various systems - Atmosphere, Hydrosphere, Lithosphere, Biosphere and their linkages. Properties and Structure of the Earth: crust, mantle, core, earth's magnetic field.

Module II:
Atmosphere and atmospheric circulation: Thermodynamics, Atmospheric stability: Composition of dry air and atmospheric water vapor content; Potential temperature, virtual temperature, isothermal and adiabatic processes; Stable, unstable and neutral equilibriums, Inversions; Atmospheric boundary layer- depth, structure, diurnal variations and their significance in pollutant dispersion. Structure of atmosphere and atmospheric circulation; General circulation of the atmosphere and Indian monsoons; General circulation of Oceans; Winds and surface circulation, causes of ocean currents, characteristics of convergence, divergence, upwelling and sinking of ocean waters; Deep-sea circulation, Thermohaline conveyor belt.

Module III:
Clouds and precipitation: Cloud formation and classification, aerosols, condensation and ice nuclei, droplet growth - curvature and solute effects, precipitation mechanisms; Weather and climate - Climatic zones, continental & maritime climates; Climate change and variability, Natural and anthropogenic causes of climate change, El Nino and ENSO events.

Module IV:
Introduction to Rocks: Types of Rocks: igneous, metamorphic and sedimentary Major Rock types- Origin and composition– The rock cycle: Geological Structures: folds, faults and joints: Disintegration of rocks: Weathering: Types of weathering, Formation of Soil, Soil profile: Concept of plate tectonics and continental drift; Geological time-scales

Module V:
Groundwater: Hydrological Cycle-Aquifers – types and properties, water table and Groundwater movement. Ground water recharge-recharge areas-discharge areas. Sustainable groundwater development and management

Suggested Readings:

1. Barry, R. G. and Chorley, R. J. (1997), Atmosphere, Weather and Climate (6th Edition), Methuen, London.
2. Fred, G. B. (1998), Environmental Geology - Principles and Practice, Blackwell Science Publishers, New Jersey, USA.
3. Subramaniam, V. (2002), Text Book of Environmental Science, Narosa Publishing House, New Delhi.
4. Andrew, D. W and Stanley, T. (2004), Environmental Hydrology (2nd Edition), Lewis Publishers, Boca Raton, FL.
5. John, M. and Mike, U. (2006). The Atmosphere and Ocean - A Physical Introduction (3rd Edition), Neil Wells, John Wiley & Sons, NY.
6. Mike, R. L. and Marta, P. (2006), Physical Processes in Earth and Environmental Sciences, Blackwell publishers, New Jersey.
7. Saxena, H. M. (2006) Environmental Studies, Rawat Publications, Bengaluru, India.
8. Roger, D. M. and Lawrence, R. W. (2007), Environmental Disasters, Natural Recovery and

Human Responses, Cambridge.
9. David, H. and Tim, S. (2010), Earth Environments - Past, Present and Future, Wiley-Blackwell, New Jersey.
10. Peter, S., Kenneth, A. and Kenneth A. (2012), Fundamentals of the Physical Environment, Rutledge, USA.

ESW 1C 02
Fundamentals of Ecology and Environment

Course objectives:
The main objectives of this course are: ● To enable the students to understand the fundamental and applied aspects of Environmental science. ● To expose the students, especially from non-biology backgrounds to the various aspects of ecosystem structure and functions.

Expected Course Outcome:		
The Course enables the students to:		
1.	Explain the concepts of ecology and environment	K1
2.	Outline the concept of ecosystem and nutrient flow of elements between organisms and the environment.	K2
3.	Relate the structural and functional aspects of a population as an ecological unit	K3
4.	Categorize the interactions within a biological community and the changes within the community over a period of time.	K4
5	Evaluate the processes within heterogeneous ecosystems	K5
6	Develop skills in applied aspects of ecology and analyze the factors of population growth and regulation.	K6
K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create		

Module I:

Fundamentals of Environmental Science - Definition, Scope and Importance of Environmental Science; Multidisciplinary nature of environmental Science; Need of Environmental awareness; Ecology, Interrelationship of ecology with other disciplines.

Module II:

Components of the Environment:
a) The atmosphere or the air: Layers of Atmosphere, Composition of air; importance of atmosphere, meteorological conditions and air circulation.
b) The hydrosphere or water: Importance of water, distribution of water at global, national and state

level. Hydrological cycle.
c) Lithosphere or the rock and the soil: Elementary composition of rocks in the earth crust. Types of rocks; Process of soil formation: Physical weathering, Chemical and biological weathering of rocks; Role of soil in shaping the biosphere.

Module III:
Environmental Factors (a) Climatic Factors - Light, Temperature of Air (atmospheric temperature), Rainfall (precipitation), Humidity of air, atmosphere (gases and wind), fire. (b) Topographic Factors: height of mountains, direction of mountains and valleys, steepness of slope and exposure of slope (c) Edaphic factors: Soil - soil formation, soil profile, soil erosion, soil conservation (d) Biotic factors: Intraspecific interactions; Interspecific interactions: Neutralism, Commensalism, Mutualism, Proto cooperation, Parasitism, Predation.

Module IV:
Ecosystem Definition; Components of ecosystem; Abiotic components: Light, Temperature, Pressure, Water, Wind, Soil; Biotic components; Energy flow in an ecosystem: Primary production, Secondary production; Food chain: Grazing food chain, Detritus food chain; Ecological pyramids: Pyramid of number, Pyramid of biomass, Pyramid of energy; Food web; Ecological indicators. Biogeochemical cycles: a) Gaseous cycles: Oxygen cycle, Carbon cycle and Nitrogen cycle. b) Sedimentary cycles: Phosphorus cycle, Sulfur cycle.

Module V:
Population Ecology and Community Ecology: Population characteristics- Population growth and its dynamics; natality, mortality, growth patterns; Age distribution, Malthus theory; Community structure, Species diversity, Ecological dominance, Ecotone, Edge effect, Ecological equivalence, Succession and Climax; Ecological adaptations.

Suggested Readings:

1. Odum, E. P. (1971), Fundamentals of Ecology, W B Saunders Company, Philadelphia.
2. Odum, E. P. and Barrett, G. W. (2005), Fundamentals of Ecology, Belmont, CA: Thomson Brooks/Cole, USA.
3. Krebs, C. J. (1989), Ecological Methodology, Harper Collins Pub. New York.
4. Robert, L. S. (1990), Ecology and Field Biology, Harper Collins Pub, New York.
5. Michael, P. (1990). Ecological Methods for Laboratory and Field Investigations, Tata McGraw Hill Publishing Company Limited, New Delhi.
6. Chapman, J. L. and Reiss, M. J. (1992), Ecology-Principles and Applications, Cambridge University Press, New York.
7. Brewer, R. (1994). The Science of Ecology, Saunders College Publishing, New York.
8. Mukherjee, B. (1996), Environmental Biology, Tata McGraw- Hill Pub. Co. Ltd, New Delhi.
9. Colin, R., Townsend, Michael, B. and John, L. H. (2012), Essentials of Ecology, third Edn, Blackwell Science Publishers, New Jersey, USA.
10. Singh, J.S., Singh, S.P. and Gupta, S.R. (2008), Ecology, Environment & Resource Conservation, Anamaya Publications, New Delhi.

ESW 1C 03

Energy and Environment

Course objectives:		
The main objectives of this course are: ● To equip students with the necessary knowledge and skills in the areas of Energy and Environment. ● To develop human resources, which can cater to the rising demands from the public and private sectors for environmental managers in the field of energy, environment and sustainability.		
Expected Course Outcome:		
The Course enables the students to:		
1.	List different energy sources and their environmental impacts	K1
2	Outline conventional and renewable energy technologies and their application	K2
3.	Explain broad comprehension of alternative fuels, bioenergy and their production methodologies	K2
4.	Classify different types of renewable energy sources available in India; to assess their potential at present and in future.	K3
5	Examine the environmental impact of energy production and the relationship between energy production, consumption and climate change.	K4
6	Assess the consequences of the existing pattern of energy consumption.	K5
7	Develop innovative and creative solutions to various energy and environmental problems.	K6
8	Plan to conduct a suitable energy audit for different kinds of energy users.	K6
K1 - Remember; **K2**- Understand; **K3**-Evaluate; **K4**-Apply; **K5**-Analyze; **K6** - Create		

Module I:

Energy basics: Laws of thermodynamics; Forms and types of energy; Energy resources classification - perpetual, renewable and non - renewable; conventional and non- conventional; secondary energy sources; sun as source of energy, nature of its radiation, thermal dynamics of earth system, solar constant, distribution of solar radiation across various atmospheric levels, ecologically important radiations, energy flow in Ecosystems.

Module II:

Non-renewable energy resources: Coal, oil, natural gas, heavy radioactive elements; formation of fossil fuels in the geological time scale, India's non- renewable energy reserves and usage pattern; world's energy reserves and consumption; Non-renewable energy usage and limitations, role of fossil fuels in modern economy, Environmental impacts of fossil fuels exploitation and utilization.

Module III:
Renewable energy resources: Biomass, wind, hydroelectric, ocean, geothermal; Secondary energy resources - electricity, hydrogen; Alternate energy resources; Renewable energy usage, limitations and scope; modern techniques for energy resource recovery using microbes, solar collectors, photovoltaics, solar ponds, nuclear-fission and fusion, Magneto- Hydrodynamic Power (MHD) and biomass gasification.

Module IV:
Nuclear energy generation and environmental safety: radioactivity from nuclear reactors, fuel processing and radioactive waste, hazards related to power plants, dose from environment and nuclear radiations, pathways analysis and dose assessment, radioactivity risk assessment, criterion for safe exposure.

Module V:
Energy production and impacts on environment: degradation of air, water and land; Important multipurpose power projects and environmental issues in India; Energy use pattern in different parts of the world and its impact on the environment; energy utilization in urban and rural contexts; Sustainable energy management, problems and solutions; Energy audit, Energy crisis and challenges of energy transformation; Energy conservation measures for sustainable development.

Suggested Readings:

1. Walters, C. (1986), Adaptive Management of Renewable Resources, Macmillan Publishing Company, New York.
2. John, C., Sawhill, H. and Richard, C. (1986), Energy Conservation: Successes and Failures, Brookings Institution Press, Washington DC.
3. Widell, J. W., Weir, A. D. (1986), Renewable Energy Resources, E & F N Spon Limited, London.
4. Goldemberg, J., Johansson, T. B., Reddy, A. K. N. and Williams, R. H. (1988), Energy for Sustainable World, Wiley Eastern Ltd, New Delhi.
5. Joan, S. (1992), Getting to Know About Energy: In School and Society, Falmer Press, London.
6. IDRC (1993), AGENDA 21: Green Paths to the Future, International Development Research Centre, Ottawa.
7. Gilbert, M. M. (1997), Introduction to Environmental Engineering and Science (2nd Edition), Prentice Hall, New Jersey, USA.
8. Mittal, K. M. (1997). Non - conventional Energy Systems: Principles, progress and prospects. Wheeler Publications, Chennai.
9. Falmer, P., Elliot, D. (2003), Energy, Society and Environment, Technology for a Sustainable Future, Rutledge, USA.
10. Robert A. R. and Jack P. K. (2005), Energy and the Environment, Wiley Eastern Ltd, New Delhi.

ESW 1C 04
Environmental pollution and pollution abatement

Course objectives:		
The main objectives of this course are: ● To equip the students with an understanding of the chemistry of the tropospheric and stratospheric processes. ● To educate the students on pollution of water, air and soil, impacts of pollution and control measures. ● To focus on the chemical processes influencing the composition and chemical speciation of different spheres of the Earth System i.e Atmosphere, hydrosphere and lithosphere. ● To develop an understanding of chemicals and their effects on the environment, to gain an understanding of the fundamental chemical processes that are central to a range of important environmental problems and to utilize this knowledge in making critical evaluations of these problems.		
Expected Course Outcome:		
The Course enables the students to:		
1	List the sources, types of water, air, and soil pollution and impacts.	K1
2	Compare the sources and types of pollutants.	K2
3	Examine the causes of global warming, ozone depletion, enhanced emissions and urban air pollution.	K3
4	Examine the pollution caused by various industries and the processing and disposal of wastes.	K4
5	Assess the regulatory aspects of pollution control.	K5
6	Plan, interpret and evaluate numerical and graphical data relevant to environmental pollution.	K6
7	Design protocols for reducing the unwanted emissions to the environment and remediation of already polluted systems.	K6
K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create		

Module I:

Environmental pollution: Introduction to pollution - physical, chemical and biological; Radiation balance of the earth, Chemical species and particulates present in the atmosphere-ions, radicals, particles, reactions in atmosphere, radio nuclides, Electromagnetic radiations, Electro-smog, El Nino phenomenon and its effect.

Module II:
Air Pollution –Definition and Sources - Natural and anthropogenic; Types of Pollutants-Primary and Secondary. Acid rain, Smog- Photochemical and Classical; Ozone depletion; Factors affecting air pollution, Transport and diffusion of pollutants. Indoor air pollution – Types and sources of pollutants. Effects of pollutants on human beings, plants, animals, materials and on climate. Identification of aeroallergens. Air-borne diseases and allergies. Air pollution control.

Module III:
Water Pollution - Types -surface and groundwater; Surface water pollution-Sources – point and nonpoint, Types of pollutants – chemical, physical and biological; Chemical pollutants – inorganic (metals and other elements) and organic (POPs);Nutrients and Eutrophication, Organic matter - sources and degradation; Biological pollutants, Microbial pollution, Groundwater pollution - sources and types of pollutants, Geological and anthropogenic pollutants in groundwater – Arsenic, Fluoride, Saline water intrusion etc. Movements of contaminants in groundwater, Coastal and Marine pollution - Oil spills, Thermal pollution, Impacts of water pollution. Heavy metals and other POPs in aquatic systems - cycling and interactions, Fate and transport of pollutants- factors affecting, Global oceanic transport of pollutants, Management of point and nonpoint sources of water pollution, water pollution control, Role of State and Central Pollution Control Boards.

Module IV:
Soil/sediment Pollution – sources and types, soil as a pollutant, Soil quality parameters-Physico-chemical parameters of soil quality, factors affecting pollutants in the sediments – texture, pH, redox potential, organic carbon etc. Soil pollution control. Industrial waste effluents and heavy metals, their interactions with soil components. Soil microorganisms and their functions, Degradation of different insecticides, fungicides and weedicides in soil. Different kinds of synthetic fertilizers (N, P & K) and their interactions with different components of soil. Soil pollution control

Module V:
Solid wastes: definition, types, source, categories, generation rates; Indian and International scenario; Waste management approaches (collection, segregation and transport of solid wastes); Environmental impacts of wastes; recycling of wastes and waste minimization techniques; solid waste processing technologies, Emerging contaminants –definition, types and sources; Sources and health impacts of POPS, PCCDS, Dioxins, PCBs etc. Plastics pollution in the freshwater and marine ecosystems Natural disasters and Pollution

Module VI:

Physical Pollution: Noise Pollution and control: Characteristics of noise, sources, Effects of noise, Standards, Measurement and control; Radioactive Pollution: Radioactivity in the environment, Radioactive Pollution: Radionuclides- sources, types of radiation, Radioactive fallout, Ecological risks from radiation, effects on humans, exposure standards. Control measures: radioactive waste treatment. Light pollution: Characteristics, Sources, Effects and control

Suggested Readings:

1. Abbasi, S. A. (1998), Environmental Pollution and its Control, Coent International, Pondicherry, India.
2. Shaw, I. C. and Chadwick, J. (1997), Principles of Environmental Toxicology, Taylor & Francis Ltd., Bengaluru, India.
3. Gilbert M. M. (1997), Introduction to Environmental Engineering and Science (2nd Edition), Prentice Hall, New Jersey, USA.
4. Connell, D. W. (1997), Basic Concepts of Environmental Chemistry, Lewis Publishers, New York.
5. Freeman, H. M. (1998), Standard Book of Hazardous Waste Treatment and Disposal, McGraw Hill, New York.
6. David, H. F. and Bela, G. L. (2000), Air Pollution, Lewis Publishers, Boca Raton, FL.
7. Robert, U., Ayres, Leslie, A. (2002), A Handbook of Industrial Ecology, Edward Elgar Publishing Limited, Cheltenham, UK.
8. Mirsal, I. A. (2004), Soil Pollution, Springer Publications, New York.

9. Marquita, K. H. (2004), Understanding Environmental Pollution (Second edition), Cambridge University Press, New York.
10. Manahan, S. E. (2004), Environmental Chemistry, Lewis Publishers, New York.
11. Lawrence, K. W., Yung-Tse, H., Howard, H. L., Constantine, Y., Kathleen, H. L. (2005), Handbook of Industrial and Hazardous Wastes Treatment (Second Edition), Marcal Dekker Inc., New York.
12. Crittenden, J. C. et al (2005), Water Treatment - Principles and Design (Second Edition), John Wiley & Sons, New York.
13. Bailey, R. A. et al (2005), Chemistry of the Environment, Academic Press, Cambridge, UK.
14. Shilpa, S., Verma, H. N., Bhargava, S. K. (2006), Air Pollution and Its Impact on Plant Growth, New India Publishing Agency, New Delhi.
15. Ira, S. R. (2008), Principles and Practices of Toxicology in Public Health, Jones and Barlett Publications, Massachusetts, USA.

ESW 1C 05 (Practical – I)
Suggested Laboratory Exercises

Course Objectives:

The main objectives of this course are:

- To understand the sampling and preservation process for water collection and analysis.
- To understand the water quality parameters (physical, chemical and biological parameters) and the process of its estimation
- To estimate heavy metals in water samples using instrumental methods
- Assessment of microbiological, algae or phytoplankton/zooplankton diversity in water
- Students will gain knowledge on Drainage Basin Analysis and Collection and testing of groundwater quality.

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	Find out methods adequate for the collection of water samples for analysis.	K1
2	Compare the quality of water in physicochemical and bacteriological terms.	K2
3	Introduce new and innovative methods for water quality assessment.	K3
4	Analyze heavy metals in water samples using instrumental methods	K4
5	Evaluate various metrics used in water quality assessment.	K5
6	Formulate an inventory of the fundamental aspects of water quality and the comparison of water quality parameters.	K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

1. Methods of sampling and preservation of water.
2. Physico-chemical analysis of water - colour, temperature, turbidity, conductivity, salinity, pH, free carbon dioxide, alkalinity, acidity, Dissolved Oxygen (DO), BOD, COD, TS, TDS,

TSS, total hardness, calcium, magnesium, chloride, iron and manganese (colorimetric method), nitrate, nitrite and total nitrogen, phosphate, sulfate, oil and grease, detergents and other parameters determining water quality.

3. Estimation of Na and K in water using Flame Photometry.
4. Estimation of Fluoride and Arsenic content in water using analytical / instrumental methods.
5. Analysis of heavy metals (As, Hg, Pb, Cd etc.) in water using instrumental methods.
6. Estimation of microbiology of water (Coliforms and other Pathogenic groups) using standard methods.
7. Assessment of micro algal / phytoplankton / zooplankton diversity associated with water and estimation of their numerical strength using standard methods.
8. Drainage Basin Analysis - Generation of drainage density and drainage frequency maps.
9. Collection and testing of ground water quality.
10. Inclusion of other innovative methods other than those listed above in the area of water quality assessment.

ESW 1C 06 (Practical – II)

Suggested Laboratory Exercises

Course Objectives:

The main objectives of this course are:

- To introduce students to the quantitative and qualitative attributes of soils and associated life.
- To make students familiar with meteorological data collection and analysis

Expected Course Outcomes:

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

1	Find out methods adequate for the collection of rocks and soil	K1
2	Outline the methods for the sampling of air and water	K2
3	Apply innovative methods for the assessment of biodiversity	K3
4	Examine, segregate and analyze solid waste	K4
5	Evaluate the quality of water, soil and air samples collected	K5
6	Design strategies for the treatment of domestic water	K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

1. Collection and morphological analysis of rock types.
2. Methods of sampling and storage of soil / sediment.
3. Determination of physical and chemical properties of Soil; Analysis of pH, N, P, K, TOC, CEC, Fertility value, Soil moisture, Soil texture, Porosity, Bulk Density, Elasticity and Permeability – Infiltration rate.
4. Sieve analysis of sediments, pipette analysis, pebble classification.
5. Analysis of pesticide content in soil / sediment samples (instrumental methods)

6. Estimation of soil biota using standard methods.
7. Air quality – Analysis of Suspended Particulate Matter, Analysis of gaseous components like oxides of carbon, nitrogen, sulfur etc. in ambient air.
8. Assessment of wind velocity; Wind rose analysis
9. Collection of meteorological data and its analysis; Climatograph
10. Assessment of population / community structure using various sampling methods.
11. Estimation of frequency, Density, Abundance, IVI etc. using standard methods.
12. Assessment of biotic interactions like Neutralism, Commensalism, Mutualism, Proto cooperation, Parasitism, Predation etc.
13. Assessment of primary and secondary production in aquatic and terrestrial ecosystems.
14. Evaluation of communities and assessment of diversity indices.
15. Segregation and analysis of solid waste.

ESW 1A 01

Environmental Research Methodology (Ability Enhancement Course)

Course objectives:

The main objectives of this course are:

- To introduce students to quantitative and qualitative methods for conducting meaningful inquiry and research. They will gain an overview of research intent and design, methodology and technique, format and presentation, and data management and analysis, informed by commonly used statistical methods.

- The course will provide an overview of the important concepts of research design, data collection, statistical and interpretative analysis, and final report presentation.

Expected Course Outcome:

The Course enables the students to:

1.	List out various research methodologies that enable students to carry out research	K1
2	Outline a preliminary research design for projects in their subject matter areas	K2
3	Explain how literature survey and compilation of bibliography helps in research	K2
4	Disseminate the knowledge of research output to the society	k3
5	Assess the new research with that of the earlier know-how on the subject concerned.	k4
6	Prioritize various safety measures while doing research work	k5
7	Plan,Collect, analyze and report data using standard formats	K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Module I:

Concepts of Research: Basic concepts of research - Meaning, Objectives, Motivation and Approaches. Types of Research (Descriptive/Analytical, Applied/ Fundamental, qualitative/Quantitative, Conceptual/Empirical, Serendipity, Research methods versus Methodology, Research and scientific method. Research Process.

Module II:

Research Formulation - Observation and Facts, Prediction and explanation, Induction, Deduction. Defining and formulating the research problem, Selecting the problem and necessity of defining the problem. Literature review - Importance of literature reviewing in defining a problem, Critical literature review, Identifying gap areas from literature review. Hypothesis - Null and alternate hypothesis and testing of hypothesis.

Module III:

Research Design - Basic principles, Meaning, Need and features of good design, important concepts. Types of research designs. Development of a research plan - Exploration, Description, Diagnosis, Experimentation, determining experimental and sample designs. Important experimental designs.

Module IV:

Sampling: Definition, purpose, principles and advantages of sampling. Unit of sampling, population: techniques, characteristics of good samples, Sampling errors and ways to reduce them.

Module V:

Data Collection Experiments and surveys, Data collection techniques, collection of primary data, data through questionnaires, data through schedules, secondary data, selection of appropriate method for data collection, case study method.

Module VI:

Scientific Documentation and Communication: Research report writing (Thesis and dissertations, Research articles, Oral communications). Project proposal writing Presentation techniques - Assignment, Seminar, Debate, Workshop, Colloquium, Conference Abstract, synopsis, summary. Referencing methods. Ethics in reporting research: data errors and plagiarism. Checking documents for plagiarism.

Module VII:

Information Science, Extension and Ethics: Sources of Information - Primary and secondary sources. Library - books, journals, periodicals, reference sources, abstracting and indexing sources, Reviews, Monographs, Patents. Internet -Search engines and software, online libraries, e-Books, Encyclopedia, Institutional Websites. Intellectual Property Rights - Copyright, Designs, Patents, Trademarks, Geographical indications. Safety and precaution - ISO standards for safety, Lab protocols, Lab animal use, care and welfare, animal houses, radiation hazards. Extension: Lab to Field, Extension communication, Extension tools. Bioethics: Laws in India, Working with man and animals, Consent, Animal Ethical Committees and Constitution.

Suggested Readings:

1. Ahuja, R. (2001), Research Methods, Rawat Publication, Jaipur.
2. Earl, R. B. (2010), The Basics of Social Research, Wadsworth Publishing, California, USA.
3. Denscobe, M. (2017). The Good Research Guide for Small Scale Social Research Projects,

Viva Books, New Delhi.
4. Devendra, T. (2009), Research Methodology in Social Science, Deep & Deep Publications, New Delhi.
5. Gurumani, N. (2006), Research Methodology for Biological Sciences, MJP Publishers, Chennai.
6. Holmes, D. (2010), Research Methods for the Biosciences, Oxford, New York.
7. Kothari, C. R. (2014), Research Methodology-Methods and Techniques, New Age, Kerala.
8. Levin, R., Rubin, D. S, (2008), Statistics for Management, Dorling Kindersley Pvt. Ltd., Noida, India.
9. Mohankumar, P. S. (2001). Handbook on Research Methodology, Right Publishers, Kudanechoor, Kerala.
10. Narwal S. S. D. and Singh, J. P. (2004), Research Methods in Plant Science, Allelopathy Vol. 1. (Soil Analysis) Scientific Publishers, Jodhpur, India.

Semester – II
ESW 2C 07 – Fundamentals of Environmental Engineering

Course objectives:

- The course aims to inculcate the students with the advanced knowledge on various pollution events associated with water, soil and air. The course also emphasizes other pollution issues related to solid waste, noise and radiation.
- The course gives a detailed insight on the principles and practices of various engineering techniques related to the reduction of emissions to air, land and water and thereby pollution control.
- The course also helps in elucidating various emission standards which are determinants in assessing the efficiency of treatment systems.

Expected Course Outcome:

The Course enables the students to:

1	Identify the significance of environmental engineering and allied disciplines in sorting out the issues related to resource depletion and pollution.	K1
2	Discuss the principles and practices of various engineering tools and techniques in sorting out issues related to water pollution.	K2
3	Prepare an inventory on various methods employed in solid waste management and the extent of progress.	K3
4	Analyze the existing issues and find sustainable alternative methods for air pollution management	K4
5	Recommend various innovative methods of solid waste management	K5
6	Develop innovative methods of control of physical pollutants from the environment.	K6

K1 -Knowledge; **K2**-Understand; **K3**- Apply; **K4**-Analyze; **K5** - Evaluate; **K6**- create

Module I:

Introduction to Environmental Engineering: Concepts, characteristics of environmental engineering, civil engineering and environmental engineering, ecological principles and environmental

engineering, public and environmental health; ethics in environmental engineering; concepts of industrial ecology and its applicability in environmental engineering.

Module II:
Environmental engineering and water pollution: Sources of water pollution, pollutant dynamics in environment, aquatic ecology, self-purification; measurement of water pollution, water quality parameters, water pollution treatment (primary, secondary and tertiary, constructed wetlands), reduction, reuse and recycling techniques. Anaerobic, aerobic process, methanogenesis, bioreactors, cell and protein (enzyme) immobilization techniques; Treatment schemes for waste water, dairy, distillery, tannery, sugar, antibiotic industries;

Module III:
Environmental engineering and Solid waste: Solid waste characterization, dynamics of wastes in environment, management of solid waste (end of the pipeline techniques, management at the origin) and disposal of wastes; reduction, reuse and recycling techniques. Treatment methods (composting, incineration, pyrolysis, sanitary landfills); Waste disposal in landfills (site selection, design, and operation of sanitary landfills, secure landfills and landfill bioreactors); leachate and landfill gas management; landfill closure and post-closure environmental monitoring; landfill remediation). Legislation on management and handling of municipal solid wastes, bio-medical wastes and hazardous wastes, Vermi composting and vermi-technology.

Module IV:
Environmental engineering and air pollution: Air pollution characterization, pollutant dynamics in environment, management of air pollution (end of the pipeline techniques, management at the origin) and disposal of wastes; reduction, reuse and recycling techniques.

Module V:
Environmental engineering and physical pollution: Physical pollution (noise, radiation, light), pollutant dynamics in environment, management of physical pollution (end of the pipeline techniques, management at the origin) and control techniques.

Suggested Readings:

1. Gilbert, M. M. (1997), Introduction to Environmental Engineering and Science (2nd Edition), Prentice Hall, New Jersey, USA.
2. Brimicombe, A. (2003), GIS, Environmental Modeling and Engineering, Taylor & Francis, London.
3. Ruth, F. W. and Matthews, R. (2007), Environmental Engineering (4th Edition). Butterworth-Heinemann, Oxford, UK.
4. Butterworth, H., Glenn, O. S., Delmar D. F., William, J. E. and Richard K. F. (1992), Soil and Water Conservation Engineering, John Wiley & Sons, New York.
5. Vesilind, P. A. (1997), Introduction to Environmental Engineering, PWS Publishing Company, Boston.
6. Stanley, E. M. (1999), Industrial Ecology: Environmental Chemistry and Hazardous Waste (1st edition), CRC Press, Boca Raton, Florida.
7. Robert, U. A., Leslie, A. (2002). A Handbook of Industrial Ecology, Edward Elgar Publishing Limited, Massachusetts, USA.
8. George, T., Franklin, L., Burton and Stensel, H. D. (2003), Wastewater Engineering -

treatment and reuse (4th Edition), Metcalf & Eddy Inc., Tata McGraw Hill, New Delhi.

ESW 2C 08

Environmental Microbiology and Biotechnology

Course objectives:

- The course aims at imparting an understanding of the basic and applied aspects of environmental microbiology and providing a comprehensive insight into the importance of microbes as key players in various functions of the environment and also in waste degradation.
- The course on environmental biotechnology helps to educate the students on the recent concepts of biotechnology and its application on biological systems for the remediation of contaminated environments and eco-friendly processes. The Environmental Biotechnology course also introduces the student to the applications of biotechnology in environmental monitoring, waste management and pollution abatement, biodiversity conservation and bioenergy production.

Expected Course Outcome:

The Course enables the students to:

1	Describe the concepts of environmental microbiology and biotechnology and to list the importance of microbes in the environment	K1
2	Explain the significance of microbes in the bioremediation of environmental contaminants.	K2
3	Examine the use of microbes for wastewater treatment and other cleaner technologies	K3
4	Analyze the applications of environmental biotechnology in quality monitoring and pollution control	K4
5	Assess various industrial applications of biotechnology	K5
6	Prepare a plan on the innovative usages of microbiology in aspects related to agriculture and human health	K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Module I:

Scope and history of Environmental Microbiology: - characteristics, classification, identification and morphology of microorganisms. Microbial world: Bacteria, Archaea, Fungi, Algae, Virus, Protozoa. Identification of microorganisms – Direct microscopic examination, culture characteristics, biochemical and physiological properties, Antibiotic sensitivity testing, serological methods, Phage typing, protein analysis, comparison of nucleotide sequences.

Module II:

Environmental Microbiology: Physiological status of microorganisms in the environment. Organic substrate uses by microorganisms, Microbes in air, water and soil. Microorganisms in extreme

environments, Foreign derived microorganisms- Survival and fate, genetically engineered microorganisms- fate and effects.

The aquatic microorganisms. Nature of marine and freshwater environments, Biofilms and Microbial mats, Water and disease transmission, Microbial analysis of water quality.
The environment of soil microorganisms, Microbial diversity in soil, biogeochemical role of soil microorganisms. Biodegradation of herbicides and pesticides. Soil microorganisms associated with plants. Soil microorganism's interactions with the atmosphere, the role and importance of microbial ecosystems, biogeochemical transformation.

Module III:
Environment Biotechnology–Principles and scope, Role of biotechnology in Environmental Protection, biotechnology in industrial pollution control–Paper industries, Textile Industries, Petrochemical Industries, Leather Industries and Mining Industries.

Module IV:
Emerging trends in Environment Biotechnology – Agro – biotechnology – Bio- pesticides and Bio-fertilizers; Ecological Engineering-Aquatic macrophyte based wastewater treatment systems (AMATS)-constructed/artificial wetlands, Nutrient film techniques (NFT), Municipal solid waste management, Role of composting and vermicomposting; Biodegradable plastics – Biopolymers-PHBs and PHAs, Phyto – reactors-Plants used to produce genetically engineered products.

Module V:
Biotechnological Methods in Pollution Control – Air pollution control: Bio scrubbers, biofilters and membrane bioreactors. Bio-desulphurization of coal. Green belts. Bioremediation: Soil/ land contaminated with oil spills, and synthetic organic compounds (xenobiotics) such as PCBs, PAHs. Bioremediation technology, bioremediation of marine oil spills. Phytoremediation. Biosensors - Concept, principle, and development of biosensors. Biosensors for environmental monitoring - BOD, ammonia, and nitrite.

Suggested Readings:

1. Freeman, W. H. and Lynch, M. and Hobbie, J. E. (1988), Microorganisms in Action-Concepts and Applications of Microbial Ecology, Blackwell Scientific Publications, New Jersey, USA.
2. Claus, W. G. (1989), Understanding Microbes: A Laboratory TextBook for Microbiology, W. H. Freeman, New York.
3. Prescott, L. M., Harley, J. P. and Klien, D. A. (1993), Microbiology, WCB Publishers, Dubuque, Iowa, USA.
4. Pelczar, M. J., Reid, R. and Chan, E. C. S. (1996), Microbiology, Tata Mc-Graw Hill Publishing Co Ltd, New Delhi.
5. Abbasi, S. A. (1998), Environmental Pollution and its Control, Coent International, Pondicherry, India.
6. Abbasi, S. A. and Ramaswamy, E. V. (1999), Biotechnological Methods of Pollution Control, Universities Press India Ltd, Hyderabad.
7. Ogilvie, L. A., Hirsch, P. R. (2012), Microbial Ecological Theory: Current Perspectives, Caister Academic Press, Poole, UK.

ESW 2C 09

Hydrology and Water Resource Management

Course Objectives:		
The main objectives of this course are: ● The course introduces the students to hydrology, hydrological cycle, properties of water, types of water resources, ground water, their use and management. ● The course highlights the hydrological processes and inculcate the students with the knowledge of water resources conservation and management.		
Expected Course Outcomes:		
On the successful completion of the course, student will be able to:		
1	Identify the sources of water and prepare an inventory of water resources	K1
2	Outline the hydrological process in the environment.	K2
3	Examine the status of groundwater resources and their exploration	K3
4	Analyze the situation of floods and to estimate the flood frequency	K4
5	Evaluate the watershed management and water harvesting techniques	K5
6	Develop innovative techniques for wetland and forest management	K6
K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create		

Module I:

Introduction to hydrology: Definition, History of hydrology, Branches of hydrology - Chemical hydrology, Eco-hydrology, Hydrogeology, hydro-informatics, hydrometeorology, isotope hydrology, surface hydrology.

Module II:
The hydrologic cycle: Structure and properties of water, Inventory of Earth's water; different process of hydrologic cycle - precipitation, Canopy interception, snow melt, run off, subsurface flow, infiltration, evaporation, transpiration, sublimation, advection, condensation.

Module III:
Surface water resources: Drainage basin, Surface water hydrology - rainfall and surface runoff relationship, runoff, runoff characteristics, open channel flow; Statistical analysis in hydrology, Probable , Water balance.

Module IV:

Groundwater maximum precipitation, hydrograph, flow duration curve, Flood frequency analysis and estimation resources: Rock properties affecting groundwater, vertical distribution of groundwater, zone of saturation; Darcy's law -permeability, transmissivity and storage coefficient; Viscous character of groundwater flow; Geologic formations as aquifers, type of aquifers; Distribution of water - local, regional and global; Ground water exploration.

Module V:

Water resource management: Flood and floodplain management; Water-shed management, water harvesting and artificial recharge to ground water. Wetland and riparian management; forest management and water resources; Issues concerned with river linking in India**.**

Suggested Readings:

1. Aggarwal, A. (1991), Floods, Floodplains and Environmental Myths, Center for Science and Environment, New Delhi.
2. Andrew, D. W. and Stanley, T. (2004), Environmental Hydrology (2nd Edition), Lewis Publishers, Boca Raton, Florida.
3. Karanth, K. R. C. (1988), Ground Water: Exploration, Assessment and Development, Tata-McGraw Hill, New Delhi.
4. Mahajan, G. (1989), Evaluation and Development of Groundwater, Ashish Publishing House, New Delhi.
5. Rao, K. L. (1982), India's Water Wealth, Orient Longman, Delhi.
6. Subramaniam, V. (2002), Text Book of Environmental Science, Narosa Publishing House, Delhi.
7. Timothy, D. (2003), Fundamentals of Hydrology, Rutledge, Taylor and Francis Group, U.K.
8. Todd, D. K. (2004), Groundwater Hydrology, John Wiley & Sons Inc., New York.
9. Vijay, P. S. (1995), Environmental Hydrology, Kluwer Academic Publications, The Netherlands.
10. Wright, R. T. and Nebel, B. J. (2002), Environmental Science: Toward a Sustainable Future, Prentice Hall India Ltd, Delhi.

ESW 2C 10

REMOTE SENSING AND GIS

Course Objectives:
● This course provides students with an understanding of the basic concepts of remote sensing and Geographical Information Systems (GIS) techniques and the applications of these techniques in various disciplines of environmental sciences. ● The course is designed for students from diverse disciplines, who opt for a training on the use of remote sensing and GIS in environmental and natural resource analysis and management. ● The course focuses on the theories underlying basic processes in remote sensing, aerial and satellite remote sensing, photogrammetry, and sensors and digital image processing. Students will be taught with the processing of images from various sources.
Expected Course Outcomes:
On the successful completion of the course, student will be able to:

1	List the basics of mapping concepts and identify the significance of various satellite-based remote sensing products	K1
2	Examine and understand the data formats and data types in GIS	K2
3	Apply the spatial and non-spatial data using various methods	K3
4	Appraise the importance of spatial planning in environment management	K4
5	Gain experience in the applications of remote sensing and GIS to solve problems in the various branches of environmental sciences.	K5
6	Design methods to solve the environmental issues based on various spatial data products	K6
K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create		

Module I:

Fundamentals of GIS: History of GIS, definition, Functions, Components and organization of GIS. Maps and mapping concepts: Definition and classification, Types of Maps, Scales-Definition, types, representation and conversion (introduction only), Map conversions (Grids, Contours, Isobars, etc.), Measurements of area and distance (Square and Planimeter Methods), Topographical Maps, Cadastral maps, Toposheets (Interpretation and studies), Map projections- concept of projection and types of projection. Coordinate systems-Geographic and projected coordinate systems.

Module II:

Spatial Data models: Vector data model, Raster data Model and Triangulated Irregular Network (TIN) data model. Database theory- Functions, types (Hierarchical, Network, Relational, Object and Object-relational), Components of a database, Structured Query Language (SQL). Global Position System- components of GPS, application, Indian Regional Navigation Satellite System (IRNSS).

Module III:

Remote Sensing: Introduction- Definition, History and Scope of Remote Sensing. Electromagnetic Spectrum, Sensors and Platforms, Types of platforms, scanners and data products. Photogrammetry- Definition and types (Aerial and terrestrial photographs), Method and equipment's used in Aerial Photo Interpretation. Indian Remote sensing Programs.

Module IV:

Image processing: Resolution (spatial, spectral, radiometric and temporal), Digital Image processing-Image correction (Radiometric correction, geometric correction and Image registration), Image rectification, Image enhancement (Radiometric enhancement, spatial enhancement and spectral enhancement). Digital Image classifications- Supervised classification and unsupervised classification.

Module V:

Application of GIS and Remote Sensing: Environmental change detection, Resource mapping and

management, disaster management. Web GIS- Open-source GIS platforms (Quantum GIS, GRASS GIS, SAGA GIS), Bhuvan, Google earth, Online data sources.

Suggested Readings:

1. Begni, G. and Richard, E. (2005), Remote Sensing: a Tool to Monitor and Assess Desertification, Les dossiers thématiques du CSFD, France.
2. Daplyn, P., Cropley, J., Treagust and Gordon, A. (1994). The use of Geographical Information Systems in Socio-economic Studies, The Natural Resources Institute, Central Avenue, Chatham, UK.
3. Donnay, J. P., Barnsley, M. J. and Longley, P. A. (2001), Remote Sensing and Urban Analysis, Taylor & Francis, London.
4. Franklin, S. E. (2001), Remote Sensing for Sustainable Forest Management, Lewis Pub, London.
5. Haynes, R. (1982), Environmental Science Methods, Chapman and Hall, London.
6. Heywood, I., Cornelius, S. and Carver, S. (1998). An Introduction to Geographical Information Systems. Pearson education Ltd., New Delhi.
7. Janwar, M. L. and Chouhan, T. S. (1998). Remote Sensing and Photogrammetry, Vijayan Prakashan, Jodhpur.
8. Jha, V. C. (2000), Geomorphology and Remote Sensing, ACB Publications, Calcutta.
9. Khan M. Z. A. (1998), Test Book on Practical Geography. Concept Pub. Co., New Delhi.
10. Khna, N. (1998), Quantitative methods in Geographical Research, Concept Pub Co. New Delhi.
11. Lillesand, T., Kiefer, R. W., & Chipman, J. (2015). Remote sensing and image interpretation. John Wiley & Sons.

ESW 2C 11 (Practical-III)

Suggested Laboratory Exercises

Course Objectives:		
● This course is designed to provide skills on various analytical techniques related to air, soil, water, wastewater and solid waste samples and their application in environmental sciences.. ● The course is expected to provide deep insight into the applications of microbiological techniques in estimating environmental samples.		
Expected Course Outcomes:		
On the successful completion of the course, student will be able to:		
1	Identify the basic principles involved in the analysis of water and air quality	K1

	parameters	
2	Understand the methods of analysis of physico-chemical parameters of air, water and soil samples	K2
3	Apply practical experiences in microbiology for the collection, culture and identification of microbes from heterogeneous environments.	K3
4	Analyze the quality of water in a potability point.	K4
5	Evaluate the functioning of various industrial processes and their effluent treatment systems	K5
K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate		

1. Analysis of waste water for major physico-chemical parameters.
2. Analysis of the impact of air pollutants on biological systems.
3. Analysis of the microbiology of ambient air.
4. Analysis of the physical properties of solid waste which include specific weight, moisture content, field capacity etc.
5. Analysis of chemical properties of solid waste (proximate analysis) like loss of moisture, volatile combustible matter, fixed carbon, ash, elemental analysis, energy content etc.
6. Basic techniques in microbiology, Sterilization techniques- use of autoclave and hot air oven for sterilization
7. Culture media preparations.
8. Isolation techniques: serial dilution, plating.
9. Identification of bacteria and fungi from environmental samples: physiological and biochemical methods.
10. Staining – Simple and Gram's, Spore staining, Negative staining
11. Microscopic counting of microbes using hemocytometer.
12. Measurement of microbes using ocular and stage micrometers.
13. Estimation of coliform bacteria in water by MPN method.
14. Estimation of microbial count in soil and water.
15. Enumeration and identification of microbes and determination of their motility
16. THB load of microorganisms in different environmental samples.
17. Determination of potability of water using coagulant demand, chlorine demand and residual chlorine.
18. Estimation of synthetic organic compounds (xenobiotics) in water and soil /sediment samples
19. Visit to an industry / plant having pollution control (air, water, soil) facilities and submission of a report.

ESW 2C 12 (Practical-IV)
Suggested Laboratory Exercises

Course objectives:
● The course is designed to provide practical knowledge and logical thinking on various analytical techniques used in environmental planning and policy making. ● The course is intended to provide significant topics used in Remote Sensing and GIS, covering resource analysis, identification of geomorphic and environmental features,

drainage and watershed evaluation, land use - land change analysis, map making and subsequent planning.

Expected Course Outcome:		
The Course enables the students to:		
1	Identify the types of rocks, minerals and other geomorphic features	K1
2	Understand the basic principles involved in map making, interpretation of maps and editing.	K2
3	Examine various data types and interpret them using RS / GIS	K3
4	Apply the Knowledge of RS/GIS techniques in environment management	K3
K1 - Remember; **K2** - Understand; **K3** - Apply		

1. Identification of rocks and minerals
2. Study of topographic maps – identification of scale, latitude and longitude,
3. Study of various geomorphic and environmental features in the maps
4. Interpretation of aerial photos using stereoscopes
5. Identification of various geomorphic and environmental features and the preparation of various thematic maps
6. Interpretation of satellite imageries
7. Brief description of the important geomorphic and environmental features
8. Preparation of photogeologic maps
9. Map digitization and analysis.
10. Working with GPS device
11. Creating Geodatabase
12. Editing spatial data
13. Editing attribute data
14. Image enhancement and filtering techniques
15. Image subset and image mosaic
16. Image classification
17. Map creation.
18. Drainage Basin Analysis - Generation of drainage density and drainage frequency maps.
19. Application of RS/GIS techniques in water resource management

ESW 2A 02
Environmental Analytical Techniques and instrumentation
(Professional competency course)

Course objectives:

- The course is designed to provide a clear knowledge on the applications of various analytical techniques used in environmental analysis.
- The course provides a better knowledge on the principles, instrumentation and working of various analytical instruments used in qualitative and quantitative environmental analysis, like microscopy, spectroscopy, electrochemical analysis, separation techniques such as chromatography, centrifugation etc.

Expected Course Outcome:		
The Course enables the students to:		
1	Identify the developments in the field of instrumentation for quantitative and qualitative analysis of environmental samples	K1
2	Understand the principle and the components and function of instruments in environmental engineering	K2
3	Examine the applications of different instruments like spectrophotometer, chromatography, centrifugation etc. in environmental sample analysis	K3
4	Identify the instruments to be used for analysis of environmental samples on specific occasions.	K4
5	Assess and estimate the Environmental samples by using different instrumental methods and interpretation of results.	K5
K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate		

Module I:

Analytical Techniques and Instrumentation - I

Gravimetric Methods - Principle and application of gravimetric methods in determination of total, dissolved, suspended, volatile and fixed solids present in water and waste water. Estimation of moisture content of soil, phytomass, compost and vermi-compost using moisture balance

Volumetric Methods - Importance of volumetric analysis. - Standardization of reagents using volumetric titrations

Electrochemical Methods - pH meters, Glass and reference electrodes - Ion selective electrodes- Electrical conductivity measurements: Conductivity Meters

Photometric methods- Principle and applications of colorimetry, Nephelometry and Turbidimetry – Spectrophotometry - Optical design of filter photometer, single beam spectrophotometer, double beam – UV – Visible – Spectrophotometer - Flame photometry (FP) - Atomic Absorption Spectrophotometry (AAS), Magnetic Resonance spectroscopy (NMR) - X-ray Fluorescence - X-ray Diffraction

Dosimetry - Geiger Muller Counter - Scintillation counter.

Module II:

Analytical Techniques and Instrumentation - II

Chromatography - Paper chromatography- Thin layer chromatography - Column chromatography - Gas liquid chromatography- GC-MS- High Performance Liquid Chromatography (HPLC)

Electrophoresis - Gel electrophoresis - Immuno-electrophoresis (ELISA, Blotting Techniques, RFLP, etc.)

Microscopy - Light microscope, Bright field, Dark field, Phase contrast and fluorescent microscope - Electron Microscopy - Transmission Electron Microscope (TEM) and Scanning Electron Microscopy (SEM)

Module III:

Flow Cytometry, Micrometry micro techniques - Fixation, Sectioning, Histological and histochemical staining

Module IV:

Centrifugation - Basic principles of sedimentation, Types of centrifuges, Analytical and Preparative centrifugation, Differential and density gradient centrifugation.

Suggested Readings:

1. Rump, H. H. and Krist, H. (1998), Laboratory Manual for the Water, Wastewater and Soil, VCH Publishers, New York.
2. Skoog, D. A. and Leary, J. J. (1992). Principles of Instrumental Analysis, 4th edn., Saunder's College Publishing, Fortworth, USA.
3. Stanley, E. M. (2004), Environmental Chemistry, CRC Press, Boca Raton, Florida.
4. Bour, E. J. (1982), Introduction to Chemical Instrumentation, 4th edition, Wiley and Sons, NY.
5. Christian, G. D. (2001), Analytical Chemistry, 5th edition, John Wiley and Sons Inc., India
6. Khopkar, S. M. (1993), Environmental Pollution analysis, Wiley Eastern Ltd., New Delhi.
7. Manahan, S. E. (2007), Environmental Chemistry, 7th edition, Lewis Publications, Florida, USA.
8. Manly, (2001) Statistics for Environmental Science and Management, Chapman and Hall / CRC Press, Boca Raton, FL, USA.
9. Vogel, A. I. (1998), Quantitative Analysis, 6th edition, Prentice Hall Inc., New Jersey, USA.
10. Willard, H. H., Merritt L. L. and Dean, J. A. (1976), Instrumental Methods of Analysis, 5th edition, Van Nostrand Reinhold.

Semester III

ESW 3C 13
Environmental Assessment Tools and Monitoring Methods

Course objectives:

The main objectives of this course are:

- To provide theoretical and as well as practical knowledge on the execution of environmental impact assessment and to formulate environmental management plans in compliance with the rules and regulations.
- Comprehend the impact of any developmental activity and its mitigation measures.
- To provide a clear knowledge on the principles, working and interpretation of results of various analytical techniques used in environmental analysis.
- To introduce statistical tools for ecological and environmental data analysis.

Expected Course Outcome:

The Course enables the students to:

1	Realize the role of EIA in decision making process	K1
2	Identify various impacts associated with the proposed development projects	K1
3	Understand the procedures for environmental clearances stipulated by national as well as international agencies	K2
4	To enable the students to understand the applied aspects of ecology i.e. Eco informatics	K3
5	Understand and apply the concepts of environmental audits and clean development initiatives.	K3
6	Able to demonstrate the applications of statistical techniques in various environmental data collection and processing.	K4

Course objectives:		
The main objectives of this course are: • To provide theoretical and as well as practical knowledge on the execution of environmental impact assessment and to formulate environmental management plans in compliance with the rules and regulations. • Comprehend the impact of any developmental activity and its mitigation measures. • To provide a clear knowledge on the principles, working and interpretation of results of various analytical techniques used in environmental analysis. • To introduce statistical tools for ecological and environmental data analysis.		
Expected Course Outcome:		
The Course enables the students to:		
1	Realize the role of EIA in decision making process	K1
2	Identify various impacts associated with the proposed development projects	K1
3	Understand the procedures for environmental clearances stipulated by national as well as international agencies	K2
4	To enable the students to understand the applied aspects of ecology i.e. Eco informatics	K3
5	Understand and apply the concepts of environmental audits and clean development initiatives.	K3
K1- Remember -; **K2**-Understand; **K3**- Apply; **K4**-Evaluate		

Module I:

Quantitative and qualitative depletion of environmental resources, Methods of resource analysis. Monitoring of environmental resources.

Module II:

Basics of Environment Impact Assessment (EIA) and Risk Assessment (RA): Concept of EIA, Evolution of EIA, EIA practice in India, EIA Notifications 1994, 1997 2009; Other related notifications; Project Screening in EIA, defining and examining scope, objectives and alternatives in EIA Projects, project planning and processes, baseline information, Impact prediction, decision making; cumulative impact assessments, strategic impact assessments.

Module III:

Types of EIA: Rapid EIA, comprehensive EIA, strategic EIA, data collection, ecological impacts, environmental impacts (Air, water, land and noise), socioeconomic and cultural impacts, health impacts, prediction of impacts; methodologies, cost benefit analysis, Environmental Management Plan (EMP).

Module IV:

Environmental Impact Statements: Preparation and contents of Environmental Impact Statements (EIS); Reviewing EIA/EIS; Use of EIA in public participation and decision making; EIA in sustainable development. EIA - case studies: mining projects, hydroelectric projects, nuclear power projects, thermal power projects, refineries etc.

Module V:

Fundamental Statistics: Introduction-Importance and limitation; Classification and tabulation of data; Graphical representation; Measures of central tendencies- mean median and mode; Measures

of dispersion- range, standard deviation and coefficient of variation; Moments, Skewness and Kurtosis; Limit theorems: Central limit theorem, Strong Law of large number, Weak Law of large number. Correlation and regression- Scatter diagrams-Karl Pearsons coefficient of correlation-Rank correlation-Linear and Curvilinear regressions; Probability- Basic probability and statistics, probability fundamentals, computation and laws of probability, fundamentals of inference; probability theory, sample space and events, axioms of probability, conditional probability, independent events, Bayes' formula; addition and multiplication theorems-Binomial, Poisson and normal distribution, Probit analysis (Graphic Method only); Testing of Hypothesis: Null and alternative hypothesis- Two types of error- Level of significance test based on t, z, Chi-square and analysis of Variance – one-way, two- way, three-way analysis(Computational only using softwares for data analysis like Excel, SPSS, Minitab and RModule)

Module VI:
Application of computers in statistics: Data analysis using packages-SPSS, Introduction to Database Management System (DBMS), Introduction to Internet, protocols, WWW, URL, Web Site, Web Browser, Web Server. Eco-informatics applications in Natural Resources Management, wildlife conservation and management, habitat suitability studies, habitat modeling.

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Suggested Readings:

1. Ludwig, J. A. and James F. R. (1988), Statistical Ecology, John Wiley & Sons, New York.
2. Gupta, S.P. (2004), Statistical Methods, Sultan Chand & Sons New Delhi.
3. Robert, R. S. and James, F. R. (1994), Biometry: The Principles and Practices of Statistics in Biological Research (3rd edition), W. H. Freeman, New York.
4. Zar, J. H. (1999), Biostatistical Analysis, Pearson Education, New Delhi.
5. Bowerman, B. L., Richard, T. O. and Michael, L. H. (2001), Business Statistics in Practice, McGraw-Hill Irwin, New York.
6. Harry, F and Steven, C. A. (1994), Statistics - Concepts and Applications, Cambridge, UK.
7. Frederick, E. C., Dudley, J. C. and Sidney, K. (1979), Applied General Statistics, Prentice Hall India, Delhi.
8. Richard, I. L. and David, S. R. (1997), Statistics for Management (7th Edition), Prentice Hall, New Jersey, USA.
9. Digby, P. G. N. and Kempton, R. A. (1991), Multivariate Analysis of Ecological Communities, Chapman and Hall, London.
10. Friedrich, R. (2005), Ecological Informatics - Scope, Techniques and Applications, Springer, New York.

ESW 3C 14

Environmental Toxicology and Occupational Health Hazards

Course objectives:
● The course aims at providing students with an advanced, multi-disciplinary and current understanding of the effects of chemicals on human and environmental health. ● To build up a sound understanding of the type of pollutants in the environment, their entry, movement, storage and transformation within the environment. ● To acquire knowledge of the impact of pollutants on various populations and the whole ecosystems. ● To analyze health and safety issues in the working as well as living environments and to recommend safety measures.

Expected Course Outcome:		
The Course enables the students to:		
1	Describe the types, sources and fates of chemicals in the environment	K1
2	Explain the mechanisms involved in the lethal effects of chemicals	K2
3	Illustrate the concept of toxicokinetics and toxicodynamics	K3
4	Analyze health and safety problems in the working as well as living environments and to recommend safety measures.	K4
5	Assess the concept of suitable applications and interpretations of ecotoxicity assays and tests.	K5
6	Estimate the risk for adverse effects of chemicals on different biological organization levels based on knowledge about the toxicity, degradability, and bioavailability of the chemical.	K5
7	Prioritize the different methods of hazard control through engineering control, administrative initiatives and protective equipments.	K5
8	Plan to manage various devices to ensure the protection, promotion and maintenance of the health of employees exposed to chemicals.	K6
K1 - Remember; **K2**- Understand; **K3**-Apply; **K4**-Evaluate; **K5**-Analyze; **K6** -Create		

Module I:

Ecotoxicology as a synthetic science: major classes of environmental pollutants - inorganic, heavy metals, organics, organometallics, radioactive isotopes, gasses; routes of entry into ecosystems - surface waters, land, atmosphere; long-range movement and global transport of pollutants; Fate of pollutants in ecosystems - biotransformation, bioaccumulation and biomagnification.

Module II:
Toxicity testing: Test organisms used in bioassays; Definition of toxicity, case studies (As, Hg problems); Concept of dosimetry - lethal, sublethal and chronic tests, dose response curves, LC50, MATC-NOEC, brief statistical methodology; toxicant effects - cellular, organismic, population and ecosystem-Level effects, global effects.

Module III:
Biochemical effects of environmental contaminants: environmental carcinogens, mutagens, asbestos, hormone mimics; Biomarkers and bioindicators; metabolic impacts; biochemical parameters - enzymes, metabolites, structural changes, toxic response of different tissues and organelles, tissue specificity.

Module IV:
Environmental health and safety: Concept of environment, health and safety; Diseases through pollution (Environmental contamination related diseases- Gastroenteritis, Hepatitis, allergies, respiratory diseases, food-borne diseases, vector borne diseases); Management to control diseases; Occupational health and safety considerations; biological monitoring (eg. BEI). Occupational hygiene, preventive measures; Occupational health and safety management systems, OHSAS – 18000.

Environmental health and human society, Health problems in different types of industries:

Construction, textile, steel, food processing, tanneries, cement, thermal and nuclear power plants, pharmaceuticals; Occupational health and safety considerations in waste treatment plants.

Module V:
Safety and health management: Occupational health hazards, Promoting safety, Safety and health training, Stress and safety; Ergonomics- Introduction, Definition, Objectives, Advantages; Ergonomics hazards, Musculoskeletal disorders and cumulative trauma disorders; Importance of industrial safety, role of safety department, Safety committee and function.

Module VI:
Environmental risk assessment and management: Perceived risks, real risks, hazard identification, hazard characterization, health risk assessment, risk management.

Suggested Readings:

1. Rowland, A. J. and Cooper, C. (1983), Environment and Health, Edward Arnold Publishers Ltd, London.
2. Encyclopedia of Occupational Health & Safety (Vol. 1 & 2, 3rd Revised Edition), (1983), International Labor Organization, Geneva, Switzerland.
3. Jain, R. K. and Rao, S. S. (2006), Industrial Safety, Health and Environment Management Systems, Khanna publishers, New Delhi.
4. Slote, L. (1987), Handbook of Occupational Safety and Health, John Willey and Sons, New York.
5. Hayes, A. W. (1988), Principles and Methods of Toxicology (2^{nd} edn.), Raven press, New York.
6. Stewart, C. P. and Stolman, A. (1960), Toxicology (Vol. I), Academic press, New York.
7. David A. W. and Pamela, W. (2002), Environmental Toxicology (1st edition), Cambridge Environmental Chemistry Series, Cambridge University Press, New York.
8. Newman, M. C., Lawrence C. A., and Unger M. A. (2002), Ecotoxicology: Fundamentals of Ecotoxicology (2nd Edition), CRC Press, Boca Raton, Florida.
9. Walker, C. H., Hopkin, S. P., Sibly, R. M. and Peakall, D. B. (2001), Principles of Ecotoxicology (2nd Edition), Taylor & Francis, London.
10. Moore, G. S. (2002), Living with the Earth: Concepts in Environmental Health Science (2nd Edition), Lewis publishers, Michigan.

ESW 3C 15

Biodiversity and Conservation

Course Objectives:

The main objectives of this course are:

- To gain knowledge on the fundamental principles of biodiversity and its conservation
- To understand the main threats to biological diversity and the ability to evaluate the effects of human influences such as habitat fragmentation, climate changes and invasive species on biodiversity
- To understand the relationships and conflicts between social development and conservation of ecosystems; as well as moral and ethical issues
- To analyze information generated from scientific investigations and use findings to address conservation and biodiversity issues.
- To analyze sustainable utilization and conservation.

Expected Course Outcomes:		
On the successful completion of the course, students will be able to:		
1	To outline different concepts of biodiversity and discuss spatial and temporal aspects of biodiversity.	K2
2	To outline the biodiversity and ecosystem services concepts and their relevance in the management of natural resources and thereby ensuring sustainable development	K2
3	Identify interactions among ecological and socio-cultural variables in the context of conservation issues.	K4
4	Appraise how different global impacts can interact to affect ecosystems and their service values.	K5
5	Ability to create socio-cultural dimensions and broad legal framework for the conservation of biodiversity.	K6
K2 - Understand; **K4** - Analyze; **K5** - Evaluate; **K6** - Create		

Module I:

Biodiversity - An introduction and Theories of Biodiversity, Species interactions and biodiversity, Biodiversity concepts and patterns: organic evolution through geological time scale; Microbial diversity, Plant diversity, Soil biodiversity; Levels of biodiversity: Community diversity (alpha, beta and gamma biodiversity), Gradients of biodiversity (latitudinal, insular).

Module II:

Biodiversity - scales: Ecosystems diversity - biomes, mangroves, coral reefs, wetlands and terrestrial diversity; Species diversity - richness and evenness; Genetic diversity: subspecies, breeds, race, varieties and forms; benefits from biodiversity - direct and indirect benefits, Ecosystems services, Bio-prospecting; Biodiversity hotspots and their characteristics

Module III:

Threats to Biodiversity: Habitat loss and fragmentation; disturbance and pollution; introduction of exotic species; extinction of species; human intervention and biodiversity loss: global environmental changes, land and water use changes; national and international programmes for biodiversity conservation; Endangered and Threatened species, IUCN, Red Data Book Biodiversity convention and biodiversity Act, IPRs.

Module IV:

Biodiversity conservation: Conservation movements - International and National; –Biodiversity hotspots, Conservation in South and Southeast Asia. National Conservation Action Plan, Landscape-level Conservation, Conservation Strategies. ecologically relevant parameters (viable population, minimum dynamic area, effective population size, metapopulations); reproductive parameters in conservation (breeding habitats, mating systems, inbreeding depression, genetic bottlenecks, genetic constraints); IUCN categories -endangered, threatened, vulnerable species; Red Data Book and related documentation; threatened plants and animals of India, ecosystems, people and traditional conservation mechanisms.

Module V:

Ex-situ / in-situ conservation: Botanical gardens, Zoos, Aquaria, Homestead garden; Herbarium; In-

vitro conservation – Germplasm and Gene bank; Tissue culture - Pollen and spore bank, DNA bank; Wildlife values and eco-tourism, wildlife distribution in India, problems in wildlife protection, organizations involved in conservation (WWF, WCU,CITES, TRAFFIC etc.), Wildlife Protection Act 1972; In-situ conservation: sanctuaries, biospheres reserves, national parks, sanctuaries and nature reserves, preservation plots.

Suggested Readings:

1. Daly, G. C. (1997), Nature's Services: Societal Dependence on Natural Ecosystems, Island Press, Washington D.C.
2. Dobson, A. P. (1996), Conservation and Biodiversity, Scientific American Library, New York.
3. Gaston, K. J. and Spicer, J. I. (1998), Biodiversity - An Introduction, Blackwell Science, London.
4. Groom, B. B. and Jenkins, M. (2000), Global Biodiversity: Earth's Living Resources in the 21st Century, World Conservation Press, Cambridge, UK.
5. IUCN (2004), Red List of Threatened Species - a Global Species Assessment, IUCN, Gland, Switzerland.
6. Loreau, M. and Inchausti, P. (2002), Biodiversity and Ecosystem Functioning: Synthesis and Perspectives, Oxford University Press, Oxford.
7. Primack, R. B. (2002), Essentials of Conservation Biology (3rd Edition), Sinauer Associates, Sunderland, SA.
8. Pawar, S. N., Patil, R. B., and Salunkhe, S. A., (2005), Environmental Movements in India: Strategies and Practices, Rawat Publications, Jaipur.
9. Wilson Edward O. (1993), Diversity of Life, Harvard University Press, Cambridge, MA.
10. Klee, G. A. (1991), Conservation of Natural Resources, Prentice Hall, New Jersey.

ESW 3E 02

Current Environmental Issues in India (Elective course)

Course objectives:		
● To develop an interdisciplinary approach towards sustainable development, keeping in mind environmental management. ● To gain knowledge about different environmental issues, their causes, effects and control technologies globally ● To critically analyze the extent of effects due to a dilapidated environment and chalk out strategies to mitigate them. ● To raise awareness about the processes and legal bindings related to pollution and the environment.		
Expected Course Outcome:		
The Course enables the students to:		
1.	introduce to the structure and composition of different spheres of environment and ecosystem and their functioning	K1
2	Understand the sources, sinks and effects of different environmental pollution issues	K2
3	Illustrate the major environmental challenges faced by the world, their causes, effects and mitigation measures.	K3

4	To analyze and evaluate the pollution control technologies to be applied for effective environmental management	K4
5	Evaluate the legal procedures, rules and regulations for the management of the environment.	K5
K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5**-Evaluate		

Module I:

Realms of Environment: Atmosphere, Hydrosphere, Lithosphere and Biosphere, Solar system, overview of natural resources; Environmental problems faced by India; Sustainable development, concepts, problems and perspectives.

Module II:
Weather and climate: climate science, thermal inversion, heat island; natural hazards: volcanoes, earthquake, tsunami, landslide, tornadoes, storms, hurricane and flood; coastal erosion; green-house gasses: global warming, acid rain, Enso, El-nino, La-nina; Climate change, treaties and conventions, impact of climate change on water resources and agriculture.

Module III:
Environment, forest and wildlife: Forests in India, forest cover and types of forests, deforestation, conservation of forest resources; Biodiversity, wild life, endangered and threatened species, Biosphere reserves, national parks and sanctuaries, wetlands, mangroves and coral reefs; Wildlife conservation in India, Illegal trade in wildlife – poaching; Recent measures for wildlife protection and conservation of national heritage - UNESCO's World Heritage list.

Module IV:
Social construction of environmental issues: anthropogenic pressures on natural resources, conflicts and negotiation; Benefit-cost approach to environmental problems; Institutional mode of environmental planning, policy formulation and strategies.
Module V:
Environmental movements: History, People's movement for environmental conservation in India - Bishnoi Movement, Chipko Movement, Narmada Bachao Andolan, Apikko movement, Silent Valley Movement, Baliyapal, drivers for environmental movement, popular movements and people's participation.

Suggested Readings:

1. Ramachandra, G. M., A. J. (2000), Varieties of Environmentalism, Oxford University Press, Delhi.
2. Ramachandra, G. (2000), The Unquiet Woods: Ecological Change and Peasant Resistance in the Himalaya, University of California Press, California.
3. Agarwal, S. K. (1997), Environmental Issues and Themes, APH Publishing Corporation, New Delhi.
4. Edward, S. W. and Jean G. S. (2004), Sustainable Strategic Management, M. E. Sharp Inc., Kerala.
5. Gangstad, E. O. (1990), Natural Resource Management of Water and Land. Van Norstrand Reinhold. New York.
6. William, E. Grant, Ellen K. Pedersen and Sandra L. Marin (2009), Ecology and Natural Resource Management, John Wiley & Sons Inc., New York.
7. Mitchell, B. (1997), Resource and Environmental Management, Addison Wesley Longman Ltd, Edinburgh.
8. Andrew, E. D. and Edward, A.P. (2006), The Science and Politics of Global Climate Change:

A Guide to the Debate. Cambridge University Press, New York.
9. Muller, R. N. and Donahue, R. L. (1996), Soils in Our Environment, Prentice Hall of India, Delhi.
10. Mackenzie, A. and Sonia, R.V. (2002), Ecology Instant Notes. Viva Books Private Limited, New Delhi.

ESW 3E 03

Wildlife and Avian Biology (Elective course)

Course objectives:		
● This Specific Paper is designed to acquaint students with varied aspects of Biology and taxonomy of certain wild species, and wildlife conservation, including its importance, major threats, and management of their habitats and populations. The emphasis will be on developing interest and invoking a sense of responsibility among students towards wildlife conservation. The course also explores different techniques, perspectives, and approaches to both identify and achieve wildlife management goals.		
Expected Course Outcome:		
The Course enables the students to:		
1	List the key factors for the loss of wildlife and important strategies for their *in situ* and *ex situ* conservation.	K1
2	Understand the management practices required to achieve a healthy ecosystem for wildlife population along with an emphasis on conservation and restoration.	K2
3	Comprehend the application of the principles of ecology and animal behavior to formulate strategies for the management of wildlife populations and their habitats.	K3
4	Examine wildlife diseases and the quarantine policies.	K4
K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze.		

Module I:

Wildlife and avian biology: Concepts, various taxa, domestic vs. wild, endemism, ecological, economic, ethical and other significance of wild species; vertebrates and invertebrates.

Module II:

Biology and Taxonomy of certain wild species: Amphibians, fishes and reptiles - brief taxonomy; Extinct, threatened, endangered and endemic species - Population status, distribution, feeding and breeding habits, major threats to their survival and conservational significance.

Module III:

Biology and Taxonomy of certain wild species: Aves - brief taxonomy; Extinct, threatened, endangered and endemic species; Population status, distribution, feeding and breeding habits, major threats to their survival and conservational significance.

Module IV:

Biology and taxonomy of certain wild species: Mammals - brief taxonomy; Extinct, threatened, endangered and endemic species; Population status, distribution, feeding and breeding habits, major threats to their survival and conservational significance. Methods for the survey and assessment of flora and fauna.

Module V:
Environmental Impact on Wildlife: Wildlife conservation and management; Anthropogenic pressures on wild fauna and flora; Habitat loss, Habitat fragmentation, industrialization, urbanization and other threats; extinctions (historical and recent); Risks faced by small populations, minimum viable population, population viability analysis, diagnosis of declines; Biodiversity hotspots, reserve design in theory and practice; Wildlife diseases and their management; Wildlife administration and legislation; Sanctuaries, national parks, biosphere reserves.

Suggested Readings:

1. William, S. J. (2000), The Conservation Handbook - Research, Management and Policy, Blackwell Science Publishers, New Jersey, USA.
2. Rajesh, G. (1992), Fundamentals of Wildlife Management, Justice Home, Allahabad, India.
3. Grzimek's Animal life Encyclopedia (1972), Vol. 1-13, Van Nostrand Reinhold Company, New York.
4. Giles, R. (1994), Wildlife Management Techniques (3rd Edition), Nataraj Publications, Dehra Dun.
5. Esmond, H. and Harris, J. (1997), Wildlife Conservation in Managed Woodlands and Forests. Basil Blackwell, Oxford, UK.
6. Sálim, A. and Ripley (1983), Handbook of Birds of India and Pakistan (2nd Edition), Oxford University Press, Bengaluru.
7. Prater, S. H. (1990), The Book of Indian Animals, BNHS/Oxford, UK.
8. Alfred, J. R. S., Das, A.K. and Sanyal, A.K. (1998), Faunal Diversity in India, ZSI Calcutta.
9. Daniel, J. C. (2002), The Book of Indian Reptiles and Amphibians, Oxford, UK.
10. Sálim, A. (2002), The Book of Indian Birds (revised edition), BNHS & Oxford University Press, New Delhi.

ESW 3E 04
Global Climate Change and Mitigation (Elective course)

Course Objectives:		
The main objectives of this course are: ● To enable the students to be aware of the importance of climate change, including the drivers, impacts and mitigation ● To obtain knowledge on various environmental conventions and summits. ● To obtain knowledge about the national and international agencies in climate change mitigation		
Expected Course Outcomes:		
On the successful completion of the course, student will be able to:		
1	Describe the basics of Climate Change and explain the changes and their impacts so far and predict the future changes	K1
2	Understand the causes of climate change and analyze the impacts of climate change	K2
3	Illustrate various climate change adaptation methods and take necessary action for	K3

	climate change mitigation	
4	Analyze and evaluate various technical and financial aids for climate change mitigation and adaptation	K4
K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze		

Module I:
Climate Change: Origin and evolution of the earth's atmosphere. Atmospheric Chemistry; Overview of key concepts – weather and climate; Climatic classification – Koppen's climatic classification; Climatic variability- temperature, rainfall, wind speed & direction. El-Nino, La Nino and their impacts. Effect of various anthropogenic activities on earth's atmosphere.

Module II:
Greenhouse Effect: Global warming and greenhouse effect – major greenhouse gasses, sources and sinks of greenhouse gasses; Urban Heat Islands; Ozone layer depletion, issues and advance research to protect the Ozone layer and consequences; ground level ozone and air pollution; sea level rise and its impact; Heat and cold waves.

Module III:
Impacts of climate change-Physical systems (Glaciers, snow, ice and/or permafrost; Rivers, lakes, floods and/or drought; Coastal erosion and/or sea level effects), Biological systems- (Terrestrial ecosystems; aquatic ecosystems); Human and managed systems (Food production; Livelihoods, health and/or economics)

Module III:
Climate change and policy frameworks – History of international climate change policies. United Nation Framework Convention on climate change (UNFCCC) – Key provisions of the UNFCCC, its structure, The Kyoto protocol and its associated bodies. Overview of Conference of Parties (CoP). Main climate change negotiations evolved over the past years and highlights some key issues relevant to the future climate change regime.

Module IV:
Climate change adaptation and mitigation: The concept of climate change adaptation; Linkage between climate change adaptation and development. International adaptation initiatives and programs. Definitions of mitigation and an overview of emissions levels and mitigation targets per country. Integrated mitigation for development and planning through low emission development strategies. Climate Change and sustainable development.

Suggested Readings:

1. Dey A.K. 2005. Environmental Chemistry, V Ed., New Age International Publishers
2. Frederick K. Lutgens, Edward J. Tarbuck. 1995. The atmosphere: an introduction to meteorology. Prentice Hall publication.
3. IPCC. 2006. Guidelines for National Greenhouse gas Inventories. Published by the Institute for Global Environmental Strategies (IGES), Hayama, Japan on behalf of the IPCC.
4. John E. Oliver, John J. Hidore. 2002. Climatology: An Atmospheric Science, Second Edition. Prentice Hall publication.
5. John T. Hardy. 2003. Climate Change: Causes, Effects and Solution. John Wiley & Sons publications.
6. Jonathan I. Lunine, Cynthia J. Lunin. 1999. Earth: Evolution of a Habitable World. Cambridge University Press. Great Britain.
7. Nicholas Stern. 2008. The Economics of Climate Change: The Stern Review. Cambridge University Press. Great Britain.
8. Pal Arya.S. 1998. Air Pollution Meteorology and Dispersion. Oxford University Press

9. Agarwal K.M, Sikdar P.K. and Deb S.C. 2002. A text book of Environment – MacMiller India Ltd., Calcutta
10. Tyler Miller Jr. Living in the Environment – Principles, Connections and Solutions.
11. Botkin D.B. 1989. Changing the Global Environment, Academic Press, San Diago.

ESW 3C 16 (Practical – V)
Suggested Laboratory Exercises

Course Objectives:		
The main objectives of this course are to: ● To enable the students to understand and acquire practical knowledge on various toxicological and biochemical tests on biological specimens. ● The program envisages the importance of incorporating various statistical techniques in Environmental research and management.		
Expected Course Outcomes:		
On the successful completion of the course, the student will be able to:		
1	Identify different parameters for the estimation of environmental samples.	K1
2	Outline the toxicological assays required in the biological specimens	K2
3	Find out methods to conduct biochemical tests on biological samples	K3
4	Demonstrate the applications of statistical techniques in environmental data collection.	K4
5	Compose a comprehensive Environmental Impact Assessment report of any project site.	K6
K1 - Remember; **K2** - Understand; **K3** - Apply; **K4**-Analyze; **K6**-Create		

1. Toxicology tests (LC50)
2. Estimation of starch in biological specimens
3. Estimation of amino acids in biological specimens
4. Estimation of protein in biological specimens
5. Estimation of reducing and non-reducing sugars in biological specimens
6. Estimation of primary and secondary metabolites in biological specimens
7. Estimation of phenolic contents in biological specimens
8. Estimation of chlorophyll pigments in plant tissues
9. Analysis of heavy metals and pesticides in water, soil and biological specimens.
10. Comprehensive Environmental Impact Assessment of any project site.
11. Recent techniques in Environmental auditing/ budgeting.
12. Analysis of environmental data using selected statistical tools (Direct and computational)

ESW 3C 17 (Practical – VI)

Suggested Laboratory Exercises

Course Objectives:

The main objectives of this course are listed below.

- The program envisages applying knowledge on the identification of major fauna and flora of terrestrial, freshwater and marine ecosystems.
- To obtain knowledge on the identification of phytoplankton and zooplankton communities in freshwater and marine ecosystems and assessment of their primary productivities
- To obtain knowledge on the phytosociological interactions among individuals / groups within communities and estimation of various indices.
- To familiarize the mapping of disaster-prone areas and also to prepare management plans for disaster risk reduction.
- Enable students to undertake visits / field studies in industries / areas of environmental significance like Biosphere reserves, National parks, Wildlife sanctuaries, Ecotourism sites institutions / conservation areas and to submit a report on the same.

Expected Course Outcomes:

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

1	Identify the major fauna and flora of terrestrial, freshwater and marine ecosystems and their interactions.	K1
2	Outline the processes for the collection and identification of phytoplankton and zooplankton communities in freshwater, estuarine and marine ecosystems.	K2
3	Apply latest methods (Eg. Lacky's Drop Method and Sedgwick-Rafter Cell method) for the identification of phytoplankton and Zooplankton.	K3
4	Analyze the diversity of major fauna and flora of terrestrial, freshwater, estuarine and marine ecosystems.	K4
5	Assess the frequency, density, abundance and IVI of flora and fauna	K5
6	Understand the Mapping of disaster-prone areas and also to prepare a management plan for disaster risk reduction.	K6

K1 - Remember; **K2**- Understand; **K3**-Apply; **K4**-Evaluate; **K5**-Analyze; **K6** -Create

1. Identification of major fauna and flora of terrestrial, freshwater and marine ecosystems.
2. Identification of phytoplankton and zooplankton communities in freshwater and marine ecosystems.
3. Estimation of phytoplankton by Lacky's Drop Method.
4. Estimation of Zooplankton by Sedgwick-Rafter Cell method.
5. Estimation of primary productivity – Light and Dark bottle method and effects of depth and light on primary productivity.
6. Community study: Quadrat method for the estimation of frequency, density, abundance and IVI of flora and fauna; Studies by line / belt transect and other methods.
7. Estimation of species richness - Fish, Reptilian, Avian, Mammalian.
8. Assessment of various diversity indices.
9. Estimation of Similarity coefficients.
10. Mapping of disaster-prone areas and development of management plans
11. Students are required to undertake visits / arrange field studies in industries / research institutions / conservation areas (Biosphere reserves, national parks, wildlife sanctuaries, ecotourism sites) and heterogeneous ecosystems and to submit a report of the same.

Semester IV

ESW 4C 18

Environmental Law

Course objectives:		
● The course is designed to impart knowledge about Indian and International Environmental laws, regulations and policies. It helps the student understand the Powers of State and Central Governments, Legal Regulation of Hazardous Substances, Hazardous Wastes (Management and Handling) Rules, The Natural Environment Tribunal Act, Legal Measures to Control Noise Pollution, Solid waste management and handling rules; Biomedical wastes (Management and Handling) Rules; Coastal Regulation Zone act.		
Expected Course Outcome:		
The Course enables the students to:		
1.	List out the international conventions and laws for sustainable environment	K1
2	Compare and analyze the international sustainable development initiatives and reports	K2
3	Classify the features of laws related to environmental protection and pollution control	K3
4	Examine the development activities based on the Environmental Laws	K4
5	Evaluate the global action and governance for environmental protection	K5
6	Synthesize and plan strategies for environmental protection and d management	K6
K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create		

Module I:

Environmental ethics: concepts, ethical theories, consequential theory, deontological theory, virtue ethics, situation ethics, feminist ethics, Illustration cases, Bio-piracy, GMO, Stem cell research. Environment and constitution of India, Environmental legislature machinery, Constitutional status of environment, Duty to protect environment

Module II:

Major Indian environment / conservation related acts: Introduction to Water (Prevention and Control of Pollution) Act - 1974, Water (Prevention and Control of Pollution) Cess Act -1974, Wildlife (Protection) Act -1972, Forest (Conservation) Act -1980, Air (Prevention and Control of Pollution) Act -1981. The Environment (Protection) Act -1986, The Public Liability Insurance Act – 1991, Biological Diversity Act, 2002, Indian forest act 1927, National Forest Policy, 1988, The National Environment Tribunal Act - 1995.

Module III:

Laws on water and air pollution control: Powers of Central and State Pollution Control Boards, Prevention and control of Water Pollution, Closure or stoppage of water and electricity supply, Power of Central / State Governments to supersede the respective Central / State Boards; Air

Pollution Control Areas, pollution control strategies, Prohibition of Emission of Air Pollutants.

Module IV:
Environment (Protection) Act - 1986: Powers of Central Government, Legislations on management and handling of Municipal solid wastes, Biomedical wastes and Hazardous Wastes. Coastal Regulation Zone (CRZ) Notification 1991, 2011 and 2018. The Ozone Depleting Substances Rules,2000. Wetland Conservation and Management Rules 2017.

Module V:
International environmental treaties and conventions: Ramsar convention - 1971, Bonn convention - 1979, CBD - 1992, Montreal Protocol-1987, Basel convention - 1989, Kyoto Protocol-1997, Earth Summit - 1992, Agenda 21, Stockholm convention - 2001, Biodiversity Act - 2002, Copenhagen Summit - 2009, Minamata convention - 2013. Millennium Development Goals.

Suggested Readings:

1. Singh, G. (2005), Environmental Law in India, Macmillan India Ltd, New Delhi.
2. Krishnamoorthy, B. (2005), Environmental Management, Prentice Hall of India Private Limited, New Delhi.
3. Agarwal, S.K. (1997), Environmental Issues and themes, APH Publishing Corporation, New Delhi.
4. John, O. N., Turner, R. K. and Bateman, I. J. (2001), Environmental Ethics and Philosophy, An Elgar Reference collection, USA.
5. Trivedi, R. K. (2010), Handbook of Environmental Laws, Rules Guidelines, Compliances and Standards (Vol I and II), BPB Publications, New Delhi.
6. Jadhav, H. and Bhosale, V. M. (1995), Environmental Protection and Laws, Himalaya Publishing House, Delhi.

ESW 4C 19

Environmental Economics

Course objectives:		
● The course is structured to introduce the student to various aspects of environmental economics, auditing, management and policies. It provides the student with the theory and analytical tools to explore the economic dimensions of natural resources, and to understand how the environment is valued. The course helps the student to understand how to use natural resources efficiently and also explore various policies for possible solutions and ensure sustainable development. The students will also get an idea about Renewable resources - Growth curves - the rate of exploitation - open access and common property solutions - exhaustible resources -monopoly and the rate of extraction - ecosystem services – Institutional approaches to environmental problems.		
Expected Course Outcome:		
The Course enables the students to:		
1.	Introduce the necessity of natural and ecological resources conservation and their management in terms of economic values.	K1
2	Outline the concept and theories related to environmental economics.	K2

3	Understand the role of different bodies in controlling pollution	K2
4	Examine the recent initiatives and guidelines for environmental economics.	K3
5	Analyze the rate of environmental degradation with the economic development	K4
6	Justify the necessity of natural resource conservation and prioritize the decision-making in terms of resource valuation and conservation	K5
7	Plan the new field of environmental economics in a holistic approach toward a solution to environmental problems	K6
K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate, **K6** - Create		

Module I:

Introduction, World environmental history and economic development; Nature and scope, Principles of environmental economics; Interrelationship between economics, environment and ecology; Foundation of environmental economics; Nexus between Ecology and Economics - The Principle of Material Balance - Private versus Social Cost.

Module II:
Environmental Economics - Basics and trends, Environment and economy, environmental and economic growth, environmental and development. Basic concept of sustainable development, Measures for sustainable development. Main characteristics of environmental goods- Pure public goods, Mixed collective goods, public bads, externalities, consumption and demand, production and supply, Marginal analysis. Market and market failure, externalities – marginal social cost, marginal private cost, marginal external growth, cost and solution to externality. Principles of maximum social welfare - Pareto Criterion.

Module III:
Resource Economics: Economics of natural resources. Population growth and its impact on the environment; The concept of common property resources and issues in global environmental resource sharing; World trade and the environment – International trade, Intellectual Property rights.

Social CBA (Cost Benefit Analysis). Economic CBA, Environmental pollution- control, private cost and social cost; Application of CBA-Technology versus Environment - Coase Theorem - Simon Kuznets's inverted 'U' shaped curve.

Module IV:
Economics of Pollution Control - Environmental Impact Assessment - Evaluation of Project and Programme – Benefit / Cost Analysis - Contingent valuation method - Measurement of environmental damages - Valuing environmental benefits: Hedonic price approach - Ecological footprint approach, Systems approach.

Module V:
Renewable resources - Growth curves - the rate of exploitation - open access and common property solutions - exhaustible resources - monopoly and the rate of extraction - ecosystem services – Institutional approaches to environmental problems.

Suggested Readings:

1. Ramprasad, S. (2001), Ecology and Economics - an approach to sustainable Development, Oxford.
2. Adiseshiah, M. S. (1987), Economics of Environment, Lancer International, India

International Center, New Delhi.
3. Pearce D. W. and Kerry R. T. (1990), Economics of Natural Resources and the Environment, Harvester WheatSheaf, New York.
4. Seneca J. J. and Michael K. T. (1974), Environmental Economics, Prentice Hall, New Jersey.
5. Kerr J. M. K., Marothia, D., Katar, S., Ramasamy, C. and Bentley, R. W. (1997), National Resource Economics – Theory and Application in India, Oxford & IBH Publishing Co, New Delhi.
6. Charles, D (2000), Environmental Economics, Oxford University Press, New York.
7. David, P. and Moran, D. (1994), The Economic Value of Biodiversity, Earthscan Publications Ltd, London.

ESW 4E 01

Environmental Disaster Management (Elective course)

Course Objectives:

The main objectives of this course are:

To understand disasters, disaster management, Flood damage assessment, EIA, air pollution, management of vehicular pollution, site suitability analysis, Pollution monitoring, assessment, prediction and forecasting.

- To understand weather and climate phenomenon and also climate change and its treaties and conventions
- To understand the forest protection measures and management
- To gain an idea about different types of disasters and disaster management.
- To understand the concept, scope and tools for disaster management. Phases of disaster management. Major environmental problems and sustainable development.

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	Facilitate adequate knowledge about disaster management.	K1
2	Understand the structure and function of disaster management mechanism	K2
3	Introduce a new approach to disaster management.	K3
4	Analyze the current disaster management phases and action in our society	K4
5	Evaluate different disasters and disaster management strategies adopted in recent years.	K5
6	Plan, assess, predict and forecast disasters and develop disaster management strategies.	K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Module I:

Environmental Disasters: definition, types and classifications of Disasters, Characteristics. Causal factors and characteristics of disasters, Natural Disasters: Meteorological disasters, Geological disasters, biological disasters, Anthropogenic Disasters: Chemical, Industrial and Nuclear related Disasters, Accident-related Disasters

Module II:
Climate change and Disasters: Air pollution: sources and impacts, green-house gasses; global warming, acid rain, ENSO, EL NINO, LA NINA, Treaties and conventions for Climate change and Disaster Management - IPCC,

Module III: Disaster Management I: Introduction to key concepts, terminologies and their complexities (Hazard, vulnerability, Exposure, Risk, Crisis, emergencies, Vulnerability, Disasters, Resilience). Disaster management: Concept and scope of disaster management / emergency management; Phases of disaster management - Pre disaster phase, Actual disaster phase, Post disaster phase.Professional activities - Mitigation, preparedness, response, recovery, programme planning and management;

Module IV: Disaster Management II: Tools of disaster management - Forecasting and warning systems of disasters. Measurement of responses of disasters, Community reaction to disasters, Disaster management - Emergency Management Information Systems (EIMS). Disaster assistance - Technological assistance, Relief camps, Camp layout, Food requirement, Water needs, Sanitation and Security;

Module V: Disaster management in India: Background, National Disaster Management Act, 2005, National Policy on Disaster Management, 2009, The National Disaster Management Plan, 2016, Disaster Management Cycle in India. International Cooperation and Current developments**:** Global Frameworks for Disaster Risk Reduction, Partnerships with International Agencies, India's Leadership Initiatives, Bilateral Agreements with Countries. Disaster management in Kerala.

Suggested Readings:

1. Nyle, C. B. (1996), Nature and Properties of Soil. Collier Macmillan International Editions, New York.
2. John, H. (2004), Global Warming: Complete Briefing. 3rd Ed., Cambridge University Press, New York.
3. Nicholas, S. (2007), The Economics of Climate Change: The Stern Review. Cambridge University Press, New York.
4. Andrew, E. D. and Edward, A.P. (2006), The Science and Politics of Global Climate Change: A Guide to the Debate. Cambridge University Press. New York.
5. Muller, R. N. and Donahue, R. L. (1996), Soils in our environment, Prentice Hall India, Delhi.
6. Mackenzie, A. and Sonia, R.V. (2002), Ecology Instant Notes by Viva Books Private Limited, New Delhi.

ESW 4E 02

Environmental Planning Policies and Management (Elective course)

Course Objectives:
The main objectives of this course are: ● To enable the students to acquire knowledge on the importance of environmental planning and management and quality standards. ● The program envisages applying knowledge about environmental policies and management principles and concepts, and also strategies for environmental planning and

management ● To obtain knowledge of various environmental conventions and summits. ● To obtain knowledge of the national and international agencies in environmental conservation.		
Expected Course Outcomes:		
On the successful completion of the course, student will be able to:		
1	Grasp the basic concept and principles of Environment management and Environment planning and also the students can realize the Environmental Auditing process**,** Environmental quality standards (ISO standards).	K1
2	The students can understand the Ecological aspects of EPM**,** Steps in environmental planning, Identification and formulation of strategies for EPM, and the students can practice environmental planning and management process for different sectors.	K2
3	Examine the major Environmental Conventions and Summits for sorting out environmental issues and their roles in environmental management from a global perspective.	K3
4	Analyze the role of NGOs' in EPM and know more about information, education and communication	K4
5	Recommend environmental planning and management strategies in managing disasters on a broader perspective	K5
K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5**-Evaluate		

Module 1:

Introduction - Basic principles of environment management, Environment planning and management, Environment management – tools and techniques - Environmental Audit**,** Environmental quality standards (ISO standards).

Environment Management Systems (EMS). Introduction to environmental quality models- input and output models, linear programming models of environmental quality management

Module II:

Environmental planning and management**:** Principles of EPM, Principles, concepts and scope of environmental planning, Ecological aspects of EPM**,** Steps in environmental planning, Identification and formulation of strategies of EPM, Environmental analysis and EPM, Physical planning in relation to environment and land-use classification**,** EPM fortown and urban lands**,** rural and agricultural lands**,** Lands reclaimed**,** Wetlands**,** Mining areas**,** Industrial areas**,** Transportation and urban planning.

Module III:

Environment Management Systems (EMS)

International standards for Environment Management, ISO 14000 Family Standards, Other Environment Standards -ISO 9001, ISO 14001, ISO 45001, ISO 50001, ISO 20121 etc., EMS in industries

Restoration of Ecosystems - Eco restoration- definition & history & significance, Degraded ecosystems – reasons – natural and anthropogenic, Restoration types – active and passive, Restoration process – pre-analysis, process and past monitoring, Global and regional initiatives of ecosystem restoration

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Module IV:
Environmental Conventions and Summits: -UNCED and its conventions on climate change, biodiversity, desertification, and tropical forests - Stockholm Convention, 1972 & Antarctica Convention; Ramsar Convention, Hague declaration-1989**,** Rio declaration 1992 and Agenda 21, Rio+5, Rio+10 and Rio+20. Earth Summit, Kyoto Protocol, Montreal Protocol, Manila Declaration, Global Environment Monitoring System (GEMS).

National and International Agencies for environmental management - UNEP, UNDP, WWF, UNCED, IUCN, GEF & WCN, Earth watch, other UN organizations, Co-operation on ozone layer, migratory species, wetlands, mangroves, oceans etc.

Module V:
Information, education and communication-Environmental education and awareness, information networks- ENVIS centers, INFOTERA etc. Role of NGOs in the implementation of environmental policies, communication and management, various national and international NGOs; Peoples Participation and various movements for environmental protection.

Suggested Readings:

1. World Commission on Environment and Development (1987), Our Common Future. World Bank: World Development Report (1992).
2. Christian, N. M. (2007), Environmental Planning and Management. Imperial College Press.
3. Edward, S. W., Jean G. S., (2004), Sustainable Strategic Management, M. E. Sharp Inc.
4. Gangstad, E.O. (1990), Natural Resource Management of Water and Land. Van Norstrand Reinhold. New York
5. William, E. G. et al. (2009), Ecology and Natural Resource Management.
6. Mitchell, B. (1997), Resource and Environmental Management, Addison Wesley Longman Ltd, Edinburgh.
7. Puma, B. K. (1994), Tourism Management: Problems and Prospects. Ashish Publishing House, New Delhi.
8. Ryding, S.O. (1994), Environmental Management hand book, IOS Press, Amsterdam.

ESW 4E 03

Natural Resources: Conservation and Management (Elective course)

Course objectives:		
● This course aims to equip students with the necessary knowledge and skills in the areas of natural resources. This course provides a broad overview of natural resources management. The interdisciplinary nature of this course allows students to learn about conservation, protection and management of a variety of natural resources. Principles and practices for sustainably managing natural resources i.e., soil, water, forests, and biodiversity are taught. The students can appreciate the importance of conservation strategies for a sustainable environment. This paper deals with sustainable management strategies for biological resources with particular reference to Kerala.		
Expected Course Outcome:		
The Course enables the students to:		
1	Able to name ecosystem services and the necessity of natural resource	K1

	conservation.	
2	Understand the importance of natural and ecological resources.	K2
3	Apply the laws of the ecosystem and the concept of carrying capacity to natural resource management.	K3
4	Categorize the areas of application of sustainable development in environmental management.	K4
5	Justify the use of non-renewable resources and the necessity of environmental safeguards for mineral resource use.	K5
6	Prioritize the causes of biodiversity loss and propose a conservation plan.	K5
7	Design a plan to implement successful eco-restoration of degraded natural systems.	K6
K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5**-Evaluate; **K6** - Create		

Module I:

Sustainable Management: Concepts and dimension, Theories and definitions, Sustainable Development: Strategies and Policies. Sustainable human development index, Sustainability pillars. Sustainable development goals and achievements. Role of environmental Planning and management in Sustainable Development.

Module II:

Natural resources: Definition, classification, types, concepts and approaches of natural resource conservation - Natural resources of India, Natural resources degradation - types and causes, loss of biodiversity, land degradation, deforestation, ecological and social impact of resource depletion.

Module III:

Soil (land) Resources Management: Distribution of Soil resources – Role of agricultural practices in soil degradation - Soil erosion – Soil fertility and nutrient management: Role of organic matter and its significance in soil quality – Diagnosis of soil nutrient deficiencies – Organic farming: Principles, benefits and methods of organic farming; Green manuring, Animal manures and composting - Wasteland development strategies.

Module IV:

Mineral Resources Management: Resources and reserves – Origin, distribution and uses of economic minerals - Exploration of mineral resources from oceans - Steps in mineral exploitation, Impact of exploitation of economic minerals on environment - Conservation of economic mineral resources. Management strategies.

Module V:

Water Resources Management: Integrated water resource management - Watershed management – Rain water harvesting – Interlinking of rivers and river basin management - Wetland conservation – Coastal zone management strategies - Ecological significance of mangroves, Coral reefs and its conservation, Management strategies.

Module VI:

Forest Resources Management: Significance for the conservation of forest resources – Distribution of forests, Wood production, Forest land use changes in India, Future demand of forest land, Carbon sequestration - Forest management tools: Social forestry, Agro-forestry and Urban forestry - Eco development committees, Ecotourism, Climate change reduction, Carbon trading and Management

of grasslands, Management strategies.

Module VII:
Management of Biological Resources: Biological Resource for health Management- Medicinal plants, Identification of problems and development of sustainable management strategies for biological resources with particular reference to Kerala.

Module VIII:
Social issues and the Environment Management: Basic concepts of Social and human interference, management of social environmental issues and urban problems related to energy; Resettlement, rehabilitation of people, its problems and concerns; Pollution impacts to environment (Climate change, global warming, acid rain, ozone depletion), nuclear accidents and holocaust, wasteland reclamation, consumerism and waste products, public awareness, population growth and family welfare programme, human rights, women and child welfare; Role of information technology in environmental conservation and management.

Suggested Readings:

1. Dutta, A. (2001), Biodiversity and Ecosystem Conservation, Kalyani Publishers, Kolkata.
2. Jha, L. K. (1997), Natural Resource Management, APH Publishing Corporation, New Delhi.
3. Kumar, H. D. (1995), Modern Concepts of Ecology, Vikas Publishing House (P) Ltd., New Delhi.
4. Dicken, K. G. M. & Vergora, N. T. (1990), Agroforestry: Classification & Management. John Wiley & Sons, New York.
5. Nalini, K. S. (1993), Environmental Resources and Management, Anmol Publications (P) Ltd., New Delhi.
6. Nautiyal, S. & Kaul, A. K. (1999), Forest Biodiversity & its Conservation Practices in India. Oriental Enterprises, DehraDun, India.
7. Sarah, F. (2011), Natural Resource Management, Oriental Enterprises, Dehradun, India.
8. Owen, O. S. & Chiras, D. D. (1995), Natural Resources Conservation, Prentice-Hall India, New Delhi.
9. Ian, N. (2009), Agroforestry for Natural Resource Management, CSIRO publishing, Oxford.

ESW 4E 04

Green Chemistry (Elective course)

Course objectives:		
● The course is designed to impart knowledge about industrial chemistry and applications of Green Chemistry. The program envisages principles of Green Chemistry, designs greener processes, Sustainable industrial chemistry, Emerging Green Technologies and Alternative Energy Sources. It is designed to get an idea about properties and fates of environmental contaminants and Improving manufacturing through green alternatives; economic perspectives on pollution prevention and minimization; Sustainability and recycling.		
Expected Course Outcome:		
The Course enables the students to:		
1.	Describe Green chemistry and sustainability which relates to problems of societal concern.	K1
2	Outline the knowledge of the relationship between science and technology	K2

	and societal issues in both focused and broad interdisciplinary contexts.	
3	Illustrate a process and identify parameters that make environmentally friendly/sustainable/green products.	K3
4	Compare and classify chemical/industrial processes based on their relative "greenness"	K4
5	Recommend Green technologies for waste management	K5
K1 -Understand; **K2**-remember; **K3**- Apply; **K4**-Evaluate; **K5**-Analyze		

Module I:
Introduction to Green Chemistry: The basics of sustainability, green chemistry and general chemistry; Chemical production (the old and new), Energy (Fossil fuel, batteries, bio-fuels, solar), Plastics (petroleum and biopolymers); The fate of chemicals in the environment: Pesticides, heavy metals, pharmaceuticals and personal care products; prevention of chemical accidents.

Module II:
Green Chemistry and Industrial Processes: Principles of Green Chemistry, Evaluating the effects of Chemistry, Waste: production, problems & prevention; Designing greener processes; Sustainable industrial chemistry; Renewable resources; Emerging Green Technologies & Alternative Energy Sources; Sustainable Industrial Chemistry- Bio-diesel.

Module III:
Pollution Prevention, Green Chemistry and Green Engineering: Introduction to concepts - Properties and fates of environmental contaminants - types of compounds and where they end up; Humans - Industrial activity and the environment; Types of pollutants produced by humans with case study; Improving, manufacturing though green alternatives; Economic perspectives on pollution prevention and minimization; Sustainability and recycling; Water - Sources of water pollution, types of contaminants, treatment techniques; Air - Sources of air pollution, acidic aerosols and the ozone hole, climate change and global warming. Energy - Types of energy sources and their environmental impact, treatment of energy, production waste and alternative energy sources; Agriculture - Pollution from fertilizers and pesticides; Impact on nature (wildlife and food supplies). - Green alternatives for fertilization and pest control**.**

Suggested Readings:

1. Ahuluwalia, V. K. (2013), Green Chemistry, Alpha Science International, Oxford, UK.
2. Ahuluwalia, V. K. and Kidwai, M. (2007), New Trends in Green Chemistry, Anamaya Publications, New Delhi.
3. Bhatia, S.C. (2006), Environmental Chemistry, CBS Publications, Mumbai, India.
4. Anil Kumar De (2007), Environmental Chemistry, New Age Publications, Kochi, India.
5. Bharucha, E. (2001), Text Book of Environmental Chemistry, Oxford & IBH, Delhi.
6. Ahuluwalia, V. K. and Sunita, M. (2008), Environmental Science, Ane Books Pvt. Ltd., New Delhi.
7. Misra, S. P. and Pandey, S. N. (2009), Essential Environmental Studies, Ane Books Pvt. Ltd., New Delhi.

ESW 4P 01

Project / Dissertation

Course Objectives:		
● The main objectives of this course are to enable the students to undertake project work in their areas of interest and to make them work independently. The course will provide an overview of the important concepts of research design, data collection, statistical and interpretative analysis, and final report presentation.		
Expected Course Outcomes:		
On the successful completion of the course, student will be able to:		
1	Gain an overview of research intent and design, methodology and technique, format and presentation, and data management	K1
2	Understand research ethics so as to contribute to application, advancement and impart knowledge in the field of Environmental science	K2
3	Design an objective for a project and undertake project work individually in their subject areas of interest	K3
4	Review and analyze research findings	K4
	K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze	

The student should undertake a Project / Dissertation work in the Department of Environmental Science of the University of Calicut or in an approved R & D institution outside, under the guidance of an authorized person, with prior permission from the Department / University. The research work undertaken by the student should be original, authentic and related to any field of Environmental Science. There will be an evaluation of the project work, by a committee, including subject expert from outside. The student has to undertake a viva-voce in connection with the evaluation of Project work / Dissertation.

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UNIVERSITY OF CALICUT
Department of Environmental Sciences

SYLLABUS OF OPEN ELECTIVE COURSE

Course Code: ESW 3E 01
Course Title: **ENVIRONMENT MANAGEMENT AND SUSTAINABLE DEVELOPMENT GOALS**
Credits: 04
Evaluation: Department of Environmental Sciences (50% internal and 50% external)
Total marks: 100

Course Objectives:
The main objectives of this course are: ● To enable the students to the importance of environmental management and conservation and sustainable development ● To provide the students with the theory and analytical tools to explore the economic dimensions of natural resources, auditing, management and policies and to understand how

the environment is to be valued sustainably. ● To make the students understand the use of natural resources efficiently and explore various policies for possible solutions, ensuring sustainable development		
Expected Course Outcomes:		
On the successful completion of the course, student will be able to:		
1	Identify the major environmental challenges faced globally, their causes, effects and mitigation measures.	K1
2	Understand the major conventions and summits for overcoming global environmental issues and the role of various governmental and non-governmental organizations in attaining sustainable development goals	K2
3	Examine the rules and regulations of environment management	K3
4	Analyze various global environmental issues and to critically comment on the causes and mitigation measures	K4
5	Evaluate environmental degradation in tune with economy and sustainable development	K5
6	Assess the setbacks in attaining sustainable development goals and to create strategies for the attainment of such goals	K6
K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create		

Module I:

Introduction to Sustainable Development: Glimpse into History and Current practices - Broad introduction to SD - its importance, need, impact and implications; definition, Principles, evolution of SD perspectives (MDGs AND SDGs) over the years; 1987 Brundtland Commission and outcome; UN summits and outcome. Ecosystem & Sustainability.

Module II:

Fundamentals of ecology - types of ecosystems & interrelationships, factors influencing sustainability of ecosystems, ecosystem restoration - developmental needs. Introduction to sustainability & its factors, requirements for sustainability: food security and agriculture, renewable resources - water and energy, non-renewable resources, sustainability conflicts. Integrated approach for resource protection and management.

Module III:

Dimensions to Sustainable Development - society, environment, culture and economy; current challenges - natural, political, socio-economic imbalance; sustainable development initiatives: global, regional, national, local; needs of present and future generation - political, economic and environmental. Status of Global and Indian environment.

Module IV:

Education for Environment and Sustainable Development: Environmental education, Education for Sustainable Development, Education for sustainable consumption, Eco – School, Role of NGOs in the implementation of environmental policies, communication and management, various national and international NGOs, People's Participation and various movements for environmental protection. Need and scope for evolving participatory, community based environmental

management strategies.

Module V:

Basic Principles of Environment Management, Environment Planning and Management, Environmental Audit, Environmental quality standards (ISO standards). Tool box for environmental management. An overview of Ecological footprints, Strategic Environmental Assessment (SEA), Ecological Economics.

Module VI:

Challenges of sustainable development: Sustainable development goals and achievements. Sustainability and development indicators, Gandhian model of sustainable development, Sustainable living and values. Strengthening institutions for sustainability; achieving sustainable development goals - bridging conflicts and the way forward. Case studies on sustainable development with special reference to India.

Suggested readings:

1. World Commission on Environment and Development (1987) Our Common Future
2. World Bank: World Development Report (1992)
3. Christian Ndubisi Madu (2007), Environmental Planning and Management. Imperial College Press.
4. Edward Stead W, Jean Garner Stead (2004), Sustainable Strategic Management, M E Sharp Inc
5. William E. Graw et al (2009) Ecology and Natural Resource Management
6. Ryding, S.O. (1994). Environmental Management hand book. *IOS Press,* Amsterdam

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