SYLLABUS

Five-Year Integrated M.Sc. in Environmental Science and Technology

2025

SCHOOL OF ENVIRONMENTAL STUDIES

COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY

KOCHI - 682022

Contents

Program Outcomes

PO1: Demonstrate a comprehensive understanding of fundamental principles and concepts in basic sciences.

PO2: Analyze, evaluate, and synthesize complex scientific information and data using appropriate methods and techniques.

PO3: Apply scientific reasoning and critical thinking adeptly to recognize, assess, and resolve problems encountered in various scientific and technological contexts.

PO4: Utilize computing power, programming languages, and modern technologies proficiently to address scientific challenges, effectively integrating technological solutions into problem-solving processes.

PO5: Communicate scientific information effectively in written and verbal forms.

PO6: Achieve proficiency in using modern scientific tools and technologies for experimentation, data collection, analysis, and interpretation.

PO7: Adhere to ethical principles and practices in the conduct of scientific research and professional activities, and work collaboratively with others.

PO8: Engage in lifelong learning and professional development to enhance the knowledge and skills in basic sciences.

PO9: Embrace and practice constitutional values, including universal human values of truth, righteous conduct, peace, love, nonviolence, and scientific temper.

Program Specific Outcomes

PSO1 **Conservation and protection of the environment become the primary responsibility of students and they get moulded to be the future guardians of nature.**

PSO2 **Students get trained to use all the required tools and techniques for understanding the environment.**

PSO3 **Students can understand, think and evolve various strategies for management and conservation of the environment.**

PSO4 **Students become aware of the environmental disasters and they will be able to develop strategies to mitigate these issues.**

PSO5 **The learners will be able to become effective scientific communicators or collaborators in providing technical leadership to engage with the challenging environmental problems of local, national, and global nature.**

SCHEME

Faculty of Environmental Studies

SCHOOL OF ENVIRONMENTAL STUDIES [2025]

Five-Year Integrated M.Sc. in Environmental Science and Technology

L - Lecture, **T** - Tutorial, **P** - Practical Hours per week.

EST-Major-DSC: Core course for students Majoring in Environmental Science and Technology.

EST-Minor-DSC: Core course for students Minoring in Environmental Science and Technology.

EST-Minor-DSE: Elective course for students Minoring in Environmental Science and Technology.

EST-Disci-DSC: Core course offered to students who choose the discipline mentioned in Environmental Science and Technology.

EST-Disci-DSE: Elective course offered to students who choose the discipline mentioned in Environmental Science and Technology.

MDC: Multidisciplinary elective course offered to students whose Major or Minor pathways are different from Environmental Science and Technology.

AEC: Ability Enhancement Course (Languages).

VAC: Value Added Course.

SEC: Skill Enhancement Course.

Semester I

Semester Credits: 21 (AEC: 6, Major: 4, Minor: 8, MDC: 3);
Cumulative Credits: 21

Code	Course Name	Level	Course Type	Credit	L-T-P	Marks		
						CA	ESE	Total
25-815-0101	Environmental Chemistry	100	EST-Major-DSC, EST-Minor-DSC, EST-Disci-DSC	4	3-0-2	50	50	100
25-815-0102	Fundamentals of Ecology	100	EST-Minor-DSC	4	4-0-0	50	50	100
25-815-0103	Chemistry of the Environment	100	MDC	3	3-0-0	50	50	100

Semester II

Semester Credits: 21 (AEC: 6, Major: 4, Minor: 8, MDC: 3);
Cumulative Credits: 42

Code	Course Name	Level	Course Type	Credit	L-T-P	Marks		
						CA	ESE	Total
25-815-0201	Environmental Physics	100	EST-Major-DSC, EST-Minor-DSC, EST-Disci-DSC	4	4-0-0	50	50	100
25-815-0202	Environmental Pollution and Analysis	100	EST-Minor-DSC	4	4-0-0	50	50	100
25-815-0203	Occupational Environmental Health and Safety	100	EST-Minor-DSE	4	4-0-0	50	50	100

25-815-0204	Physical Processes in the Environment	100	MDC	3	3-0-0	50	50	100

Semester III

Semester Credits: 21 (Major: 4, Minor: 8, MDC: 3, VAC 6);
Cumulative Credits: 63

Code	Course Name	Level	Course Type	Credit	L-T-P	Marks		
						CA	ESE	Total
25-815-0301	Environmental Biology	200	EST-Major-DSC EST-Minor-DSC EST-Disci-DSE	4	3-0-2	50	50	100
25-815-0302	Bio Remediation	200	EST-Minor-DSC EST-Disci-DSE	4	4-0-0	50	50	100
25-815-0303	Natural Disasters and Management	200	EST-Minor-DSE	4	4-0-0	50	50	100
25-815-0304	Ecology and Conservation	200	MDC	3	3-0-0	50	50	100

Semester IV

Semester Credits: 22 (Major: 16, SEC: 3, VAC: 3);
Cumulative Credits: 85

Code	Course Name	Level	Course Type	Credit	L-T-P	Marks		
						CA	ESE	Total
25-815-0401	Methods in Environmental Analysis	200	EST-Major-DSC	4	3-0-2	50	50	100
25-815-0402	Introduction to Programming and Data handling	200	EST-Major-DSC	4	3-0-2	50	50	100
25-815-0403	Biodiversity and Conservation	200	EST-Major-DSC EST-Minor-DSE	4	4-0-0	50	50	100
25-815-0404	Environmental Pollution	200	EST-Major-DSC	4	3-0-2	50	50	100
25-815-0405	Water Quality monitoring and analysis	200	SEC	3	1-0-4	100		100

Semester V

Semester Credits: 23 (Major: 20, SEC: 3);
Cumulative Credits: 108

Code	Course Name	Level	Course Type	Credit	L-T-P	Marks		
						CA	ESE	Total
25-815-0501	Remote Sensing and GIS	300	EST-Major-DSC	4	3-0-2	50	50	100
25-815-0502	Environmental impact and risk assessment	300	EST-Major-DSC	4	4-0-0	50	50	100

25-815-0503	Environmetal Social Governance	300	EST-Major-DSC, EST-Minor-DSE	4	4-0-0	50	50	100
25-815-0504	Environmental Microbiology	300	EST-Major-DSC	4	3-0-2	50	50	100
25-815-L3EX	Elective (level 300 or above)	300	EST-Major-DSE	4	X-X-X	50	50	100
25-815-0505	Geo-informatics LAB	300	SEC	3	1-0-4	100		100

* **Students have to choose any two DSE courses from the given set of courses.**

Semester VI

Semester Credits: 23 (Major: 20, SEC: 3);
Cumulative Credits: 131

Code	Course Name	Level	Course Type	Credit	L-T-P	Marks		
						CA	ESE	Total
25-815-0601	Environmental Engineering Paper I	300	EST-Major-DSC	4	3-0-2	50	50	100
25-815-0602	Environmental Toxicology	300	EST-Major-DSC	4	3-0-2	50	50	100
25-815-0603	Environmental Policies and Law	300	EST-Major-DSC	4	4-0-0	50	50	100
25-815-L3EX	Elective 1 (level 300 or above)	300	EST-Major-DSE	4	X-X-X	50	50	100
25-815-L3EX	Elective 2 (level 300 or above)	300	EST-Major-DSE	4	X-X-X	50	50	100
25-815-0604	Advanced Applied Biology LAB	300	SEC	3	1-0-4	100		100

* **Students have to choose any two DSE courses from the given set of courses.**

Internship

Students have to complete an internship of 2 credits (60 Hours of work) before the completion of Semester 6.
Cumulative Credits: 133

Exit with 3-year UG Degree OR continue to 4th year.

List of Elective Courses with level 300

Code	Course Name	Level	Course Type	Credit	L-T-P	Marks		
						CA	ESE	Total
25-815-L3E1	Mathematical and Statistical Applications in Environmental Science.	300	EST-Major-DSE	4	3-2-0	50	50	100
25-815-L3E2	Fluid Mechanics	300	EST-Major-DSE	4	4-0-0	50	50	100

25-815-L3E3	Solid and Hazardous waste management	300	EST-Major-DSE, EST-Minor-DSE EST-Disci-DSE	4	4-0-0	50	50	100
25-815-L3E4	Industrial Ecology	300	EST-Major-DSE, EST-Minor-DSE	4	4-0-0	50	50	100
25-815-L3E5	Climate Change and Environment	300	EST-Major-DSE, EST-Minor-DSE	4	4-0-0	50	50	100
25-815-L3E6	Chemometrics and Good laboratory practices	300	EST-Major-DSE, EST-Minor-DSE	4	4-0-0	50	50	100
25-815-L3E7	Chemistry of Water and Waste Water Treatment	300	EST-Major-DSE	4	3-0-2	50	50	100

Semester VII

Semester Credits: 22
Cumulative Credits: 155.

Code	Course Name	Level	Course Type	Credit	L-T-P	Marks		
						CA	ESE	Total
25-815-0701	Environmental Engineering II	400	EST-Major-DSC	4	3-0-2	50	50	100
25-815-0702	Advance Applications of GIS	400	EST-Major-DSC	4	3-0-2	50	50	100
25-815-0703	Environmental Biotechnology	400	EST-Major-DSC	4	4-0-0	50	50	100
25-815-L4EX	Elective 1 (level 400 or above)	400	EST-Major-DSE	4	X-X-X	50	50	100
25-815-L4EX	Elective 2 (level 400 or above)	400	EST-Major-DSE	4	X-X-X	50	50	100
25-815-0705	Research Methodology & Scientific Communication	400	EST-Major-DSC	2	0-0-4	100		100

* **Students have to choose any one DSE course from the given set of courses.**

Semester VIII

Semester Credits: 22
Cumulative Credits: 177.

Code	Course Name	Level	Course Type	Credit	L-T-P	Marks		
						CA	ESE	Total
25-815-0801	Carbon Accounting And Reporting	500	EST-Major-DSC	4	3-0-2	50	50	100
25-815-L4EX	Elective 1 (level 400 or above)	400	EST-Major-DSE	4	X-X-X	50	50	100

25-815-L4EX	Elective 2 (level 400 or above)	400	EST-Major-DSE	4	X-X-X	50	50	100
25-815-L4EX	Elective 3 (level 400 or above)	400	EST-Major-DSE	4	X-X-X	50	50	100
25-815-0802	Research Project	500	EST-Major-DSC	12	0-4-16	100	100	200
25-815-0803	Mini Project	400	EST-Major-DSC	4	0-0-8	50	50	100
25-815-0804	Environmental Audit and Risk Management	400	EST-Major-DSE	2	1-0-2	100		100
25-815-0805	Environmental Material Science	400	EST-Major-DSE	2	1-0-2	100		100
25-815-0806	MOOC	400	EST-Major-DSE	2			100	100

Exit with 4-year UG Degree OR continue to 5^{th} year.

* **Students pursuing 4-year UG Honours Degree (with research) shall do the Research Project (808) instead of Mini Project (809) and any DSE course along with the DSC course to acquire the required credits. Students pursuing Honours without Research should do the Mini Project (809) and Three DSE courses along with the DSC course to acquire the required credits.**

List of Elective Courses with level 400

Code	Course Name	Level	Course Type	Credit	L-T-P	Marks		
						CA	ESE	Total
25-815-L4E1	Environmental Data Acquisition Methods	400	EST-Major-DSE	4	4-0-0	50	50	100
25-815-L4E2	Soil, Sediment and Air Analysis	400	EST-Major-DSE, EST-Minor-DSE	4	3-0-2	50	50	100
25-815-L4E3	Wastewater Treatment Technologies	400	EST-Major-DSE, EST-Minor-DSE	4	3-0-2	50	50	100
25-815-L4E4	Ecotoxicology and Biomonitoring	400	EST-Major-DSE, EST-Minor-DSE	4	3-0-2	50	50	100
25-815-L4E5	Environmental Modelling	400	EST-Major-DSE	4	3-0-2	50	50	100
25-815-L4E6	Applied Environmental Micro Biology	400	EST-Major-DSE, EST-Minor-DSE	4	3-0-2	50	50	100
25-815-L4E7	Applied Eco Toxicology	400	EST-Major-DSE	4	3-0-2	50	50	100
25-815-L4E8	Circular Economy And Resource Recovery	400	EST-Major-DSC, EST-Minor-DSE	4	3-0-2	50	50	100

Semester IX

Semester Credits: 22
Cumulative Credits: 199.

Code	Course Name	Level	Course Type	Credit	L-T-P	Marks		
						CA	ESE	Total
25-815-0901	Energy Efficiency and Sustainability	500	EST-Major-DSC	4	4-0-0	50	50	100

25-815-L5EX	Elective 1 (level 500 or above)	500	EST-Major-DSE	4	x-x-x	50	50	100
25-815-L5EX	Elective 2 (level 500 or above)	500	EST-Major-DSE	4	x-x-x	50	50	100
25-815-L5EX	Elective 3 (level 500 or above)	500	EST-Major-DSE	4	x-x-x	50	50	100
25-815-L5EX	Elective 4 (level 500 or above)	500	EST-Major-DSE	4	x-x-x	50	50	100
25-815-0908	MOOC	500	EST-Major-DSC	2				100

* **Students have to choose any three DSE courses from the given set of courses.**

List of Elective Courses with level 500

Code	Course Name	Level	Course Type	Credit	L-T-P	Marks		
						CA	ESE	Total
25-815-L5E1	Advanced Environmental Bio-Informatics	500	EST-Major-DSE	4	3-0-2	50	50	100
25-815-L5E2	Advanced Water Treatment Technologies	500	EST-Major-DSE	4	3-0-2	50	50	100
25-815-L5E3	Green Design & Management of Project area	500	EST-Major-DSE	4	3-0-2	50	50	100
25-815-L5E4	Environmental Data Modeling	500	EST-Major-DSE,	4	4-0-0	50	50	100
25-815-L5E5	Sustainable Development Principles And Practices	500	EST-Major-DSE	4	4-0-0	50	50	100
25-815-L5E6	Applications of Computational Methods	500	EST-Major-DSE	4	3-0-2	50	50	100

Semester X

Semester Credits: 22
Cumulative Credits: 221.

Code	Course Name	Level	Course Type	Credit	L-T-P	Marks		
						CA	ESE	Total
25-815-1001	Major Project	600	EST-Major-DSC	20	0-0-40	600		600
25-815-1002	MOOC*	500	EST-Major-DSC	2			100	100

*** **Regarding the Major Project the following directions may be followed:**

(a) The major project can be done within the department or in an external institution of National/International reputation. i.e. institutions like IISc Bangalore, Various IITs, IISERs, Central Universities, CSIR laboratories, NITs TIFR, Raman Research Institute, IIA, inter university centers like IUCAA, NPOL, ISRO, DRDO, IIEST, NGOs: TERI, IUCN, WWF, ATREE, industrial organizations, etc and any other equivalent institution.

(b) If a student wants to do his/her project in an external institution he/she has to find a supervisor from a nationally/internationally reputed institution like as mentioned above. A consent letter from the external supervisor should be produced to the Department Head/Coordinator of the batch. The consent letter can be considered by the Department council/Department Head and approval can be given to the student to pursue the project with the supervisor concerned.

(c) An internal faculty in charge must be assigned by the Department Council/Department Head to each student who is doing the project in other institutions/departments.

1. The internal faculty in charge will periodically monitor the progress of the students assigned to him/her.

(d) Continuous evaluation of the project must be done by the supervisor. In the case of projects done outside the department, this can be done either by the external supervisor alone or by the internal faculty in charge (in cases where the external supervisor is not able to produce an official evaluation statement) or by both the internal and external supervisors together.

(e) The department shall arrange a mid-term presentation for all students. This will form a part of the continuous evaluation.

(f) The students must submit a report at the end of the project, which is duly signed and recommended by the supervisor on or before the date stipulated by the Department. For projects done outside, the report must be duly signed by the external supervisor.

(g) The end-semester evaluation in the form of a presentation followed by viva based on the project will be done in the Department by a committee appointed by the Department Council/Department Head.

Online courses can be selected by the students from a set of courses approved by the Department Council. The Department can recommend courses from reputed platforms like Swayam (UGC), Coursera, CUSAT - MOOC etc. The following guidelines will be applicable to the online course.

(a) A sub-committee appointed by the Department council can approve a set of courses that the students in the Department can take. This will be based on considerations such as the length of a course, the relevance of its content to the program, etc. The list of approved courses will be notified to the students before the beginning of the semester. The students are allowed to choose a course from this approved set only.

(b) The credit given by the department for such a course will be two regardless of its duration.

(c) Students may register and complete the online course at their convenience during the semester but before the submission of the final project report.

(d) At the end of the course, the student should produce a valid document regarding the successful completion of the Course and stating his/her marks/grades. The Department Council will ascertain that the document produced is satisfactory and recommend awarding two credits for the course along with the marks/grades obtained.

(e) If a student fails a course, he/she may take the same or another approved course after informing the council.

LIST OF COURSES

Semester I

Code	Course Name	Level	Course Type	Credit
25-815-0101	Environmental Chemistry	100	EST-Major-DSC, EST-Minor-DSC, EST-Disci-DSC	4
25-815-0102	Fundamentals of Ecology	100	EST-Minor-DSC	4
25-815-0103	Chemistry of the Environment	100	MDC	3

Semester II

Code	Course Name	Level	Course Type	Credit
25-815-0201	Environmental Physics	100	EST-Major-DSC, EST-Minor-DSC, EST-Disci-DSC	4
25-815-0202	Environmental Pollution and Analysis	100	EST-Minor-DSC	4
25-815-0203	Occupational Environmental Health and Safety	100	EST-Minor-DSE	4
25-815-0204	Physical Processes in the Environment	100	MDC	3

Semester III

Code	Course Name	Level	Course Type	Credit
25-815-0301	Environmental Biology	200	EST-Major-DSC EST-Minor-DSC EST-Disci-DSE	4
25-815-0302	Bio Remediation	200	EST-Minor-DSC EST-Disci-DSE	4
25-815-0303	Natural Disasters and Management	200	EST-Minor-DSE	4
25-815-0304	Ecology and Conservation	200	MDC	3

Semester IV

Code	Course Name	Level	Course Type	Credit
25-815-0401	Methods in Environmental Analysis	200	EST-Major-DSC	4
25-815-0402	Introduction to Programming and Data handling	200	EST-Major-DSC	4
25-815-0403	Biodiversity and Conservation	200	EST-Major-DSC EST-Minor-DSE	4

25-815-0404	Environmental Pollution	200	EST-Major-DSC	4
25-815-0405	Water Quality monitoring and analysis	200	SEC	3

Semester V

Code	Course Name	Level	Course Type	Credit
25-815-0501	Remote Sensing and GIS	300	EST-Major-DSC	4
25-815-0502	Environmental impact and risk assessment	300	EST-Major-DSC	4
25-815-0503	Environmetal Social Governance	300	EST-Major-DSC, EST-Minor-DSE	4
25-815-0504	Environmental Microbiology	300	EST-Major-DSC	4
25-815-0505	Geo-informatics LAB	300	SEC	3

Semester VI

Code	Course Name	Level	Course Type	Credit
25-815-0601	Environmental Engineering Paper I	300	EST-Major-DSC	4
25-815-0602	Environmental Toxicology	300	EST-Major-DSC	4
25-815-0603	Environmental Policies and Law	300	EST-Major-DSC	4
25-815-0604	Advanced Applied Biology LAB	300	SEC	3

List of Elective Courses with level 300

Code	Course Name	Level	Course Type	Credit
25-815-L3E1	Mathematical and Statistical Applications in Environmental Science.	300	EST-Major-DSE	4
25-815-L3E2	Fluid Mechanics	300	EST-Major-DSE	4
25-815-L3E3	Solid and Hazardous waste management	300	EST-Major-DSE, EST-Minor-DSE EST-Disci-DSE	4
25-815-L3E4	Industrial Ecology	300	EST-Major-DSE, EST-Minor-DSE	4
25-815-L3E5	Climate Change and Environment	300	EST-Major-DSE, EST-Minor-DSE	4
25-815-L3E6	Chemometrics and Good laboratory practices	300	EST-Major-DSE, EST-Minor-DSE	4
25-815-L3E7	Chemistry of Water and Waste Water Treatment	300	EST-Major-DSE	4

Semester VII

Code	Course Name	Level	Course Type	Credit
25-815-0701	Environmental Engineering II	400	EST-Major-DSC	4
25-815-0702	Advance Applications of GIS	400	EST-Major-DSC	4
25-815-0703	Environmental Biotechnology	400	EST-Major-DSC	4
25-815-0705	Research Methodology & Scientific Communication	400	EST-Major-DSC	2

Semester VIII

Code	Course Name	Level	Course Type	Credit
25-815-0801	Carbon Accounting And Reporting	500	EST-Major-DSC	4
25-815-0802	Research Project	500	EST-Major-DSC	12
25-815-0803	Mini Project	400	EST-Major-DSC	4
25-815-0804	Environmental Audit and Risk Management	400	EST-Major-DSE	2
25-815-0805	Environmental Material Science	400	EST-Major-DSE	2

List of Elective Courses with level 400

Code	Course Name	Level	Course Type	Credit
25-815-L4E1	Environmental Data Acquisition Methods	400	EST-Major-DSE	4
25-815-L4E2	Soil, Sediment and Air Analysis	400	EST-Major-DSE, EST-Minor-DSE	4
25-815-L4E3	Wastewater Treatment Technologies	400	EST-Major-DSE, EST-Minor-DSE	4
25-815-L4E4	Ecotoxicology and Biomonitoring	400	EST-Major-DSE, EST-Minor-DSE	4
25-815-L4E5	Environmental Modelling	400	EST-Major-DSE	4
25-815-L4E6	Applied Environmental Micro Biology	400	EST-Major-DSE, EST-Minor-DSE	4
25-815-L4E7	Applied Eco Toxicology	400	EST-Major-DSE	4
25-815-L4E8	Circular Economy And Resource Recovery	400	EST-Major-DSC, EST-Minor-DSE	4

Semester IX

Code	Course Name	Level	Course Type	Credit
25-815-0901	Energy Efficiency and Sustainability	500	EST-Major-DSC	4

List of Elective Courses with level 500

Code	Course Name	Level	Course Type	Credit
25-815-L5E1	Advanced Environmental Bio-Informatics	500	EST-Major-DSE	4
25-815-L5E2	Advanced Water Treatment Technologies	500	EST-Major-DSE	4
25-815-L5E3	Green Design & Management of Project area	500	EST-Major-DSE	4
25-815-L5E4	Environmental Data Modeling	500	EST-Major-DSE,	4
25-815-L5E5	Sustainable Development Principles And Practices	500	EST-Major-DSE	4
25-815-L5E6	Applications of Computational Methods	500	EST-Major-DSE	4

SEMESTER X

Cource Code	Cource Title	Level	Course Type	Credits
25-815-1001	Major Project	600	EST-Major-DSC	20

SEMESTER I

25-815-0101: Environmental Chemistry

(**Credits : 4**)

Course Description:

Environmental chemistry is a broad and highly interdisciplinary field. Physico-chemical and biogeochemical phenomena in our environment are the core of the course- Environmental Chemistry. The course involves an interdisciplinary study of sources, various natural reactions, transport, effects and fates of chemical species in the soil, water and air environment. The course: Environmental Chemistry provides learners with both basic and advanced level knowledge on the chemistry of interactions occurring in natural environment with a special thrust on its theory and practices followed. Detailed teaching and discussion on chemistry of atmosphere, hydrosphere, geosphere, speciation of pollutants and environmental aspects of the biogeochemical processes is also highlighted.

Course Objectives:

The main objective of the course is to equip students with the knowledge of the chemical species and processes in the various spheres of the environment and the interactions to enable them to master to identify the specific issues and inter-relate them to the domain of environmental education to find suitable solutions to pollution hazards and protection. The students must be able to apply the focal concepts from multiple sub-disciplines of environmental chemistry, use technical and analytical skills to understand the level and effects of chemicals in environment such as air, water, soil, biota, assess the impact of chemical exposure on living systems and finally they will be equipped with full potential and capacity to emerge as competent environmental analytical chemists in the practising core areas and familiarise the sophisticated instruments in analytical chemistry. Ability to recognize the importance of environmental changes and understand various aspects of air, soil and water chemistry

Course Outcomes:

After successful completion of this course students should be able to:

CO1	have insight on fundamental characteristics of the various spheres (atmosphere, hydrosphere, geosphere, biosphere and anthrosphere) of the environment. Explain the sources, reactions, transport, effects and fates of pollutants in environment	Understand
CO2	describe the effects of human activity on air, water and soil quality	Understand
CO3	acquire experience in field studies related with monitoring of water, air and soil quality parameters	Apply

Assessment Pattern:

Category	**Assessment Methods**			**Examination**
	Test 1	**Test 2**	**Seminar**	
Understand	60	60	60	60

Apply	40	40	40	40

SYLLABUS

Unit I : Chemistry of Atmosphere

Definition and importance of atmosphere- Chemical Composition of unpolluted air at sea level- Thermal Stratification of the atmosphere and Chemical Speciation in its different layers- Chemical and photochemical reaction in the atmosphere. Reactions of atmospheric nitrogen, oxygen, ozone and water. Role of CO2 in the atmosphere. Composition of organic and inorganic particles-Reactions involving particles in the atmosphere. Introduction to anthropogenic changes in the atmosphere: Ozone layer depletion, Photochemical smog, acid rain

Module II : Chemistry of Hydrosphere

Definition of Hydrosphere-Importance of water-Distribution of water on the earth- Hydrological cycle-Characteristics of natural waters and processes that affect their composition-Structure of water- Unique properties of water and their environmental significance-Solubility of gases in water, Acid-base, redox and complexation reactions in water.

Module III : Chemistry of geosphere

Introduction-Definition of geosphere- Geochemical classification of elements, abundance of elements in earth crust. minerals and rocks and their properties- rock cycle- stages of weathering-physical, chemical and biological aspects of weathering-Ground water and the factors governing its chemical composition, soil formation, organic and inorganic components of soil-soil horizon and soil profile. Sediments, Clay minerals, physico-chemical properties of soil, soil types, ion exchange capacity and mineralogical controls.

Module IV: Biosphere and chemical processes

Definition of biosphere, Biotic and abiotic components, photosynthesis and respiration- carbon sequestration- formation, preservation and fate of organic matter in environment-Biogeochemical cycles of carbon, nitrogen, oxygen, phosphorous and sulphur.

Module V : Environmental chemical analysis

Analysis of Water Quality Parameters: Sampling, preservation, storage, pre-treatment and analytical methods (one each) for the measurement of the following parameters : colour, turbidity, electrical conductivity, acidity, alkalinity, hardness, DO, BOD, COD, pH, redox potential, chloride.

Analysis of Soils Quality Parameters: Sampling and storage, Pre-treatment, Determination of pH, Redox potential, electrical conductivuty, bulk density, specific gravity, soil texture, water content, total organic carbon.

References

1. Balaram Pani.; (2017). –Textbook of Environmental Chemistry, 2/e, ISBN:9789386768025, Pages : 594
2. Colin, B.; Michael, C.; (2012). –Environmental Chemistry. 5th Edition: ed W.H.Freeman & Co Ltd, ISBN: 9781464113499, pages: 736.
3. Stanley, E. M.; (2010). –Environmental Chemistry. 9th Edition, CRC Press, London.
4. James, E. G.; (2009). –Principles of Environmental Chemistry. Publisher: Jones & Bartlett; ISBN: 0763759392
5. Fifield, F.W.; (2000). –Environmental Analytical Chemistry. 2nd edition, Blackwell Publishers.
6. M. Lancaster, Green Chemistry: An Introductory Text, Royal Society of Chemistry, 2010.
7. S. C. Ameta, R. Ameta, Green Chemistry: Fundamentals and Applications, CRC Press
8. Carranzo, I. V. (2012). APHA, AWWA, WEF. "Standard Methods for examination of water and wastewater." Anales De Hidrología Médica, 5(2), 185–186.
9. Radojevic, M., & Bashkin, V. N. (2006). Practical environmental analysis. In The Royal Society of Chemistry eBooks.

25-815-0102: Fundamentals of Ecology

(Credits : 4)

Course Description:

This course provides an introduction to the fundamental principles of ecology, exploring the interactions between organisms and their environment. It covers key ecological concepts, including population dynamics, community interactions, ecosystem processes, and energy flow. The course also emphasizes the importance of biodiversity conservation and sustainable ecosystem management.

Course Objective:

1. Introduce fundamental ecological concepts.
2. Understand population dynamics and regulation.
3. Explore community interactions and succession.
4. Analyze ecosystem processes and energy flow.
5. Study biodiversity conservation and sustainability.

Course Outcomes:

After successfull completion of this course students should be able to:

CO1	Explain the fundamental concepts of ecology, including levels of ecological organization and environmental factors influencing ecosystems.	Understand
CO2	Understand population growth patterns, regulatory mechanisms, and ecological factors influencing species distribution.	Understand
CO3	Evaluate community interactions, ecological succession, and the role of species interactions in shaping ecosystems.	Analyze
CO4	Understand and Interpret ecosystem processes, including energy flow, food webs, and biogeochemical cycles, to understand ecosystem functioning.	Analyze
CO5	Assess biodiversity conservation strategies and their applications in sustainable ecosystem management and environmental protection.	Understand

Assessment Pattern:

Category	**Assessment Methods**			**Examination**
	Test 1	**Test 2**	**Seminar**	
Understand	30	30	30	30
Analyze	30	30	30	30
Apply	40	40	40	40

SYLLABUS

Module I : Introduction to Ecological Principles

Definition and scope of ecology, Historical development of ecological science, Autecology and synecology, Levels of ecological organization, Laws of limiting factors, Influence of physical factors – Light, temperature, water, and soil.

Module II : Population Ecology and Growth Dynamics

Attributes of populations – Density, natality, mortality, age distribution, Population growth models – Exponential and logistic growth, Concept of carrying capacity, Population regulation mechanisms, Life history strategies – r- and K-selection, Human population growth and its ecological implications.

Module III : Community Structure and Ecological Interactions

Community characteristics – Species richness, dominance, diversity, and abundance, Ecological succession – Types, processes, and mechanisms, Ecotones and edge effect, Community stratification and zonation, Ecological niche, Species interactions – Negative interactions (competition, predation, parasitism), Positive interactions (mutualism, commensalism, facilitation).

Module IV : Ecosystem Processes and Energy Flow

Structure and function of ecosystems, Energy flow – Food chains, food webs, and ecological pyramids, Biogeochemical cycles – Carbon, nitrogen, and phosphorus cycles, Types of ecosystems – Terrestrial (forests, grasslands) and aquatic (freshwater, marine), Ecosystem productivity – Primary and secondary productivity.

Module V : Conservation Ecology and Sustainable Management

Biodiversity – Types, values, and measurement, Major threats to biodiversity – Habitat loss, pollution, climate change, invasive species, Conservation strategies – In-situ and ex-situ approaches, Wildlife conservation and management, Role of ecology in sustainable development and ecosystem restoration.

References

1. Odum, E.P., & Barrett, G.W. (2005). Fundamentals of Ecology (5th Edition). Cengage Learning.
2. Smith, T.M., & Smith, R.L. (2020). Elements of Ecology (9th Edition). Pearson.
3. Begon, M., Townsend, C.R., & Harper, J.L. (2021). Ecology: From Individuals to Ecosystems (5th Edition). Wiley-Blackwell.
4. Molles, M.C. (2019). Ecology: Concepts and Applications (9th Edition). McGraw-Hill.
5. Chapman, J.L., & Reiss, M.J. (2005). Ecology: Principles and Applications (2nd Edition). Cambridge University Press.
6. Sharma, P.D. (2022). Ecology and Environment (15th Edition). Rastogi Publications.

25-815-0103: Chemistry of the Environment

(Credits : 3)

Course Description:

Environmental chemistry is a broad and highly interdisciplinary field. Physico-chemical and biogeochemical phenomena in our environment are the core of the Course- Environmental Chemistry. The course involves an interdisciplinary study of sources, various natural reactions, transport, effects and fates of chemical species in the soil, water and air environment. The course: Environmental Chemistry provides learners both basic and advanced level knowledge on the chemistry of interactions occurring in natural environments with a special thrust on its theory and practices followed. Detailed teaching and discussion on the chemistry of atmosphere, hydrosphere, geosphere, speciation of pollutants and environmental aspects of the biogeochemical processes is also highlighted.

Course Objectives:

The main objective of the course is to equip students with the knowledge of the chemical species and processes in the various spheres of the environment and the interactions to enable them to master to identify the specific issues and inter-relate them to the domain of environmental education to find suitable solutions to pollution hazards and protection. The students must be able to apply the focal concepts from multiple sub-disciplines of environmental chemistry, use technical and analytical skills to understand the level and effects of chemicals in the environment such as air, water, soil, biota, assess the impact of chemical exposure on living systems and finally they will be equipped with full potential and capacity to emerge as competent environmental analytical chemists in the practising core areas and familiarise the sophisticated instruments in analytical chemistry. Ability to recognize the importance of environmental changes and understand various aspects of air, soil and water chemistry

Course Outcomes:

After successful completion of this course students should be able to:

CO1	have insight on fundamental characteristics of the various spheres (atmosphere, hydrosphere, geosphere, biosphere and anthrosphere) of the environment. Explain the sources, reactions, transport, effects and fates of pollutants in environment	Understand
CO2	describe the effects of human activity on air, water and soil quality	Understand
CO3	acquire experience in field studies related with monitoring of water, air and soil quality parameters	Apply

Assessment Pattern:

Category	**Assessment Methods**			**Examination**
	Test 1	**Test 2**	**Seminar**	
Understand	60	60	60	60

Apply	40	40	40	40

SYLLABUS

Unit I : Chemistry of Atmosphere

Definition and importance of atmosphere- Chemical Composition of unpolluted air at sea level- Thermal Stratification of the atmosphere and Chemical Speciation in its different layers-Chemical and photochemical reaction in the atmosphere. Reactions of atmospheric nitrogen, oxygen, ozone and water. Role of CO2 in the atmosphere. Composition of organic and inorganic particles-Reactions involving particles in the atmosphere. Introduction to anthropogenic changes in the atmosphere: Ozone layer depletion, Photochemical smog, acid rain

Module II : Chemistry of Hydrosphere

Definition of Hydrosphere-Importance of water-Distribution of water on the earth- Hydrological cycle-Characteristics of natural waters and processes that affect their composition-Structure of water- Unique properties of water and their environmental significance-Solubility of gases in water, Acid-base, redox and complexation reactions in water.

Module III : Chemistry of geosphere

Introduction-Definition of geosphere- Geochemical classification of elements, abundance of elements in earth crust. minerals and rocks and their properties- rock cycle- stages of weathering-physical, chemical and biological aspects of weathering-Ground water and the factors governing its chemical composition, soil formation, organic and inorganic components of soil-soil horizon and soil profile. Sediments, Clay minerals, physico-chemical properties of soil, soil types, ion exchange capacity and mineralogical controls.

Module IV: Biosphere and chemical processes

Definition of biosphere, Biotic and abiotic components, photosynthesis and respiration- carbon sequestration- formation, preservation and fate of organic matter in environment-Biogeochemical cycles of carbon, nitrogen, oxygen, phosphorous and sulphur.

Module V : Environmental chemical analysis

Anthrosphere: Definition, components of the anthrosphere, technology and the environment, effects of anthrosphere on earth, integration of the anthrosphere into the total environment, principles of green chemistry, sustainable development goals. Techniques for Green House Gas (GHG) reduction, Emissions carbon capture and storage (CCS) technologies, Green chemistry for bioremediation, Green technology for energy generation.

References

1. Balaram Pani.; (2017). –Textbook of Environmental Chemistry, 2/e, ISBN:9789386768025, Pages : 594
2. Colin, B.; Michael, C.; (2012). –Environmental Chemistry. 5th Edition: ed W.H.Freeman & Co Ltd, ISBN: 9781464113499, pages: 736.

3. Stanley, E. M.; (2010). –Environmental Chemistry. 9th Edition, CRC Press, London.
4. James, E. G.; (2009). –Principles of Environmental Chemistry. Publisher: Jones & Bartlett; ISBN: 0763759392
5. Fifield, F.W.; (2000). –Environmental Analytical Chemistry. 2nd edition, Blackwell Publishers.
6. M. Lancaster, Green Chemistry: An Introductory Text, Royal Society of Chemistry, 2010.
7. S. C. Ameta, R. Ameta, Green Chemistry: Fundamentals and Applications, CRC Press

SEMESTER II

25-815-0201: Environmental Physics

(**Credits : 4**)

Course Description:

The essential realisation that physical environment provides the main background for all human activity on Earth, is the core of the subject. Physical systems create, maintain, and modify all features that constitute Earth's surface. A core objective of this course is to unravel the complexity of the Earth System by dissecting its critical components – the atmosphere which envelops our planet and influences weather and climate; the hydrosphere which encompasses all water bodies, playing a key role in climatic regulation; the lithosphere which forms the solid earth beneath our feet, hosting geological processes and interactions. By examining these components, students will not only understand them in isolation but also appreciate how they interconnect and impact each other. Students will delve into the mechanisms that drive these components – from solar radiation's effect on the atmosphere to the deep currents stirring in the oceans, from the slow drift of continental plates to the rapid response of climate systems to anthropogenic changes. The interplay between natural variability and human-induced changes is key to understanding current environmental challenges and forecasting future scenarios. By integrating knowledge across disciplines, students will emerge with a nuanced understanding of how the Earth System works as a cohesive unit and how it can be studied to address some of the most pressing environmental issues facing our planet today.

Course Objectives:

The primary aim of this course is to gain a comprehensive understanding of the Earth's diverse physical systems and the intricate relationships between the Earth and the Sun, which significantly influence the Earth's environmental conditions. Additionally, it seeks to explore how these physical processes sculpt the Earth's surface features. This course delves into the complex and ever-changing interactions within the Earth System, with a particular focus on the key elements of earth sciences, atmospheric dynamics, oceanography, geoelogy, and the impacts of climate change. This includes an exploration of various interactions, thermodynamics, atmospheric stability, cloud formation and precipitation patterns, hydrological cycles, and the fundamental structure and composition of the Earth. Through an in-depth examination of the forces that drive the Earth's atmosphere, water cycle, solid earth, and their interactions, students will embark on a journey to thoroughly understand the climate system. This foundation will help students to understand the basic concepts of Earth's environmental and climatic conditions.

Course Outcomes:

After successful completion of this course students should be able to:

CO1	Understand Earth-Sun interactions and how solar radiation affects climate and weather.	Understand
CO2	Learn about atmospheric composition, structure, and basic thermodynamics.	Understand
CO3	Course Objective: Understand forces on air, wind systems, and major weather phenomena.	Analyze
CO4	Understand ocean and lithosphere processes and their climate impact.	Analyze

Assessment Pattern:

Category	Assessment Methods			Examination
	Test 1	Test 2	Test3	
Understand	70	70	70	70
Analyze	30	30	30	30

SYLLABUS

Module I : Laws of Physics, Sun-Earth System

Basic Laws of: Motion, Thermodynamics, and Radiation. Basics of energy transfer: radiation, conduction, convection. Radiation: Solar radiation, Terrestrial radiation, Seasons. Global distribution of solar radiation. Earth's albedo, greenhouse effect, and global warming.

Module II : Atmospheric structure, thermodynamics

Air composition, pressure, temperature, and humidity. Layers of the atmosphere. Atmospheric stability - basic temperature processes, lapse rates, stability types, and inversions, Basics of cloud formation and weather, Precipitation mechanisms.

Module III : Forces, force balances and weather systems

Principal forces acting on air masses: gravity, Coriolis effect, friction. Basic cyclones and anticyclones. Global and local winds. Overview of El Niño, La Niña, monsoon, and tropical cyclones, Land and Sea breeze.

Module IV : Oceanography and Geological Processes

Ocean currents, Ekman transport, Upwelling and sinking of ocean water. Earth's structure: crust, mantle, core. Rock cycle, Plate tectonics. Introduction to floods, earthquakes, volcanoes, and landslides.

References

1. C. Donald Ahrens, Robert Henson (2021) Meteorology Today: An Introduction to Weather, Climate, and the Environment, 13th Edition, Cengage, Boston.
2. Dennis L. Hartmann (2016) Global Physical Climatology, 2nd Edition, Elsevier Science.
3. John M. Wallace, Peter V. Hobbs (2006) Atmospheric Science, An Introductory Survey, 2nd Edition, Elsevier Science.
4. Alan P. Trujillo, Harold V. Thurman (2020) Essentials of Oceanography, 13th Edition, Pearson.
5. Roger G. Barry, Richard J Chorley (2010) Atmosphere, Weather and Climate, 9th Edition, Taylor & Francis, 2010.
6. Roland B. Stull (1988) An Introduction to Boundary Layer Meteorology, Springer.
7. C. Nick Hewitt, Andrea V. Jackson (2020) Atmospheric Science for Environmental Scientists, John Wiley & Sons.
8. Houghton, John. Global Warming (5th edition). Cambridge University Press, United Kingdom. 2015.

25-815-0202: Environmental Pollution and Analysis

(**Credits : 4**)

Course Description:

This course offers a foundational understanding of environmental pollution, covering air, water, soil, and noise pollution. It explores pollutant types, sources, impacts, and basic control methods. Students learn pollution analysis techniques, including environmental sampling and instrumentation. Emphasis is placed on regulatory standards, environmental laws, and sustainable pollution management practices. The course equips students with essential knowledge and skills to assess and address environmental pollution effectively.

Course Objective:

- To introduce students to the basic concepts of environmental pollution.
- To understand the sources, types, and effects of various pollutants.
- To learn basic techniques for pollution monitoring and analysis.
- To explore fundamental pollution control measures and regulatory frameworks.

Course Outcomes:

After successfull completion of this course students should be able to:

CO1	Understand the fundamental concepts of environmental pollution and its impact.	Understand
CO2	Develop basic analytical skills for environmental monitoring.	Analyse
CO3	Conduct simple laboratory and field-based pollution assessment experiments.	Apply
CO4	Interpret environmental data and reports.	Apply
CO5	Gain awareness of environmental policies and sustainable practices.	Understand

Assessment Pattern:

Category	**Assessment Methods**			**Examination**
	Test 1	**Test 2**	**Seminar**	
Understand	40	40	40	40
Apply	30	30	30	30
Analyze	30	30	30	30

SYLLABUS

Module I : Introduction to Environmental Pollution

Definition, scope, and importance of pollution studies; Types of pollution: Air, water, soil, noise, and radioactive pollution; Major sources and classification of pollutants; Global and local environmental pollution issues; Concept of pollutant transport and dispersion

Module II : Air and Water Pollution

Primary and secondary air pollutants; Effects of air pollution on health, climate, and ecosystems; Introduction to water pollution and major pollutants (organic, inorganic, microbial, thermal); Concept of

Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), and water quality parameters; Basic treatment methods for air and water pollution

Module III : Soil and Noise Pollution

Causes and consequences of soil pollution; Soil contamination by heavy metals, pesticides, and industrial wastes; Noise pollution: sources, measurement, and health effects; Noise pollution control measures and regulatory standards; Introduction to solid waste management and hazardous waste disposal

Module IV : Environmental Pollution Analysis Techniques

Basics of environmental sampling and analysis; Principles of air, water, and soil quality monitoring; Instruments used in pollution analysis (e.g., pH meter, spectrophotometer, gas analyzer); Overview of environmental laws and pollution control regulations (CPCB, WHO guidelines); Sustainable solutions for pollution reduction

References

1. Cunningham, W.P., & Cunningham, M.A. – Environmental Science: A Global Concern (McGraw-Hill, 2017)
2. Rao, M.N. & Rao, H.V.N. – Air Pollution (Tata McGraw-Hill, 2017)
3. Sharma, B.K. – Environmental Chemistry (Goel Publishing House, 2015)
4. Henry, J.G. & Heinke, G.W. – Environmental Science and Engineering (Pearson, 2006)
5. Peavy, H.S., Rowe, D.R., & Tchobanoglous, G. – Environmental Engineering (McGraw-Hill, 2013)
6. Manahan, S.E. – Environmental Chemistry (CRC Press, 2017)
7. Misra, K.C. – Environmental Pollution (S. Chand, 2010)

Journals & Online Resources:

a Central Pollution Control Board (CPCB) Reports – https://cpcb.nic.in

b United Nations Sustainable Development Goals (SDGs) – https://sdgs.un.org

c Science of the Total Environment (Elsevier)

d Environmental Monitoring and Assessment (Springer)

25-815-0203: Occupational Environmental Health and Safety

(**Credits : 4**)

Course Description:

This course explores the dynamic relationship between the environment and human health, integrating key concepts from environmental science, public health, toxicology, and occupational safety. Students will examine how air, water, soil, and socio-cultural factors influence individual and public health, as well as the epidemiological trends associated with communicable and non-communicable diseases. The course also delves into the classification and impact of environmental toxicants, principles of occupational health and hygiene, and safety systems essential for maintaining a healthy workplace. Emphasis is placed on practical strategies for hazard identification, risk mitigation, and fostering a safe and sustainable environment both in public and occupational settings.

Course Objective:

- Understand the fundamental concepts of environmental and public health, and the interplay between environmental quality and human well-being.
- Identify key environmental factors and lifestyle choices that influence health outcomes.
- Describe the types, causes, and prevention methods for both communicable and non-communicable diseases.
- Analyze environmental toxicants, their sources, transport mechanisms, toxic effects, and processes such as biomagnification and biotransformation.
- Explain the principles of occupational health, human exposure pathways, and control measures for workplace hazards.
- Evaluate safety system designs, emergency preparedness, and the implementation of risk-reduction practices in various work environments.

Course Outcomes:

After successful completion of this course students should be able to:

CO1	Identify the local and global occupational health and sustainability issues and their importance	Understand
CO2	Recognize health hazards associated with hazardous wastes, chemicals and other harmful substances which can pollute the immediate environment and cause health problems for people.	Understand
CO3	Illustrate methods used in epidemiology and toxicology to assess environmental exposures and hazards.	Apply
CO4	Identify the common work-related diseases and accidents in occupational setting	Apply
CO5	Describe methods of prevention and control of occupational health diseases, accidents/emergencies and other hazards	Apply

Assessment Pattern:

Category	**Assessment Methods**			**Examination**
	Test 1	**Test 2**	**Seminar**	
Understand	60	60	60	60
Apply	40	40	40	40

SYLLABUS

Module I :

Environmental Health - World Health organization (WHO) - concepts of environmental and public health. Human-environment interaction. Understanding linkages between Environment and Public Health: Effect of quality of air, water and soil on health. Perspective on Individual health: Nutritional, socio-cultural and developmental aspects, Dietary diversity for good health; Human developmental indices for public health.

Module II :

Need for good health- factors affecting health. Types of diseases - deficiency, infection, pollution diseases- allergies, respiratory, cardiovascular, and cancer Personal hygiene- food - balanced diet. Food habits and cleanliness, food adulterants, avoiding smoking, drugs and alcohol. Communicable diseases: Mode of transmission -epidemic and endemic diseases. Infectious diseases: Role of sanitation and poverty case studies on TB, diarrhoea, malaria, viral diseases. Non-communicable diseases: Role of Lifestyle and built environment. Diabetes and Hypertension. Epidemiology: Application of statistical methods to medical records in the study of health problems of human population in a given environment. Treatment of variation, with demographic, vital statistics and epidemiological data.

Module III :

Classification of toxicants in environment - natural and anthropogenic, their distribution, transport, and fate in the environment: Types of Toxicity- Acute, Subacute and Chronic effects of Toxicants. Dose-Response Relationship -LC50, LD50, EC50. Toxicity of Environmental pollutants: Toxicity of Persistent Organic Pollutants (POPs)– pesticides, insecticides, polychlorinated biphenyls, polychlorinated dibenzo-p-dioxins, polychlorinated dibenzofurans. Toxicity of heavy metals: Chromium, cadmium, mercury, arsenic, lead, iron. Biohazards: Radioactive substances, fluorides and carbon monoxide. Routes of Entry: Inhalation, Absorption, Ingestion, Injection. Biodistribution, Biomagnification and Biotransformation and excretion of toxic agents.

Module IV :

Occupational Health and Hygiene: Definition of the term occupational health and hygiene - Categories of health hazards – Exposure pathways and human responses to hazardous and toxic substances - Advantages and limitations of environmental monitoring and occupational exposure limits - Hierarchy of control measures for occupational health risks - Role of personal protective equipment and the selection criteria - Effects on humans - control methods and reduction strategies for noise, radiation and excessive stress.

Module V :

Workplace Safety and Safety Systems: Features of Satisfactory and Safe design of work premises – good housekeeping - lighting and colour, Ventilation and Heat Control – Electrical Safety – Fire Safety – Safe Systems of work for manual handling operations – Machine guarding – Working at different levels – Process and System Safety.

References

1. Morgan, M.T. (2003). Environmental Health. (3rd ed.). Belmont, CA: Wadsworth/Thomason Learning.
2. Frumkin H, editor. (2016). Environmental Health: From Global to Local. 3rd ed. San Francisco, CA: Jossey-Bass
3. Robert H. Friis (2012). Essentials of Environmental Health – second edition. Jones & Bartlett Learning

4. David Baker (2012), Essentials of Toxicology for Health Protection: A handbook for field professionals, 2nd Edition, OUP UK.
5. Blumenthal, D. S., and Ruttenber, A. J. (1995). Introduction to environmental health. Second Edition. New York: Springer
6. Mistry K U (2022), Fundamentals of Industrial Safety and Health Vol 1 & 2, Shyamaraj Global Commerce.

25-815-0204: Physical Processes in the Environment

(Credits : 3)

Course Description:

The essential realisation that physical environment provides the main background for all human activity on Earth, is the core of the subject. Physical systems create, maintain, and modify all features that constitute Earth's surface. A core objective of this course is to unravel the complexity of the Earth System by dissecting its critical components – the atmosphere which envelops our planet and influences weather and climate; the hydrosphere which encompasses all water bodies, playing a key role in climatic regulation; the lithosphere which forms the solid earth beneath our feet, hosting geological processes and interactions. By examining these components, students will not only understand them in isolation but also appreciate how they interconnect and impact each other. Students will delve into the mechanisms that drive these components – from solar radiation's effect on the atmosphere to the deep currents stirring in the oceans, from the slow drift of continental plates to the rapid response of climate systems to anthropogenic changes. The interplay between natural variability and human-induced changes is key to understanding current environmental challenges and forecasting future scenarios. By integrating knowledge across disciplines, students will emerge with a nuanced understanding of how the Earth System works as a cohesive unit and how it can be studied to address some of the most pressing environmental issues facing our planet today.

Course Objectives:

The primary aim of this course is to gain a comprehensive understanding of the Earth's diverse physical systems and the intricate relationships between the Earth and the Sun, which significantly influence the Earth's environmental conditions. Additionally, it seeks to explore how these physical processes sculpt the Earth's surface features. This course delves into the complex and ever-changing interactions within the Earth System, with a particular focus on the key elements of earth sciences, atmospheric dynamics, oceanography, geoelogy, and the impacts of climate change. This includes an exploration of various interactions, thermodynamics, atmospheric stability, cloud formation and precipitation patterns, hydrological cycles, and the fundamental structure and composition of the Earth. Through an in-depth examination of the forces that drive the Earth's atmosphere, water cycle, solid earth, and their interactions, students will embark on a journey to thoroughly understand the climate system. This foundation will help students to understand the basic concepts of Earth's environmental and climatic conditions.

Course Outcomes:

After successful completion of this course students should be able to:

CO1	Understand Earth-Sun interactions and how solar radiation affects climate and weather.	Understand
CO2	Learn about atmospheric composition, structure, and basic thermodynamics.	Understand
CO3	Course Objective: Understand forces on air, wind systems, and major weather phenomena.	Analyze
CO4	Understand ocean and lithosphere processes and their climate impact.	Analyze

Assessment Pattern:

Category	Assessment Methods			Examination
	Test 1	Test 2	Test3	
Understand	70	70	70	70
Analyze	30	30	30	30

SYLLABUS

Module I : Laws of Physics, Sun-Earth System

Basic Laws of: Motion, Thermodynamics, and Radiation. Basics of energy transfer: radiation, conduction, convection. Radiation: Solar radiation, Terrestrial radiation, Seasons. Global distribution of solar radiation. Earth's albedo, greenhouse effect, and global warming.

Module II : Atmospheric structure, thermodynamics

Air composition, pressure, temperature, and humidity. Layers of the atmosphere. Atmospheric stability - basic temperature processes, lapse rates, stability types, and inversions, Basics of cloud formation and weather, Precipitation mechanisms.

Module III : Forces, force balances and weather systems

Principal forces acting on air masses: gravity, Coriolis effect, friction. Basic cyclones and anticyclones. Global and local winds. Overview of El Niño, La Niña, monsoon, and tropical cyclones, Land and Sea breeze.

Module IV : Oceanography and Geological Processes

Ocean currents, Ekman transport, Upwelling and sinking of ocean water. Earth's structure: crust, mantle, core. Rock cycle, Plate tectonics. Introduction to floods, earthquakes, volcanoes, and landslides.

References

1. C. Donald Ahrens, Robert Henson (2021) Meteorology Today: An Introduction to Weather, Climate, and the Environment, 13th Edition, Cengage, Boston.
2. Dennis L. Hartmann (2016) Global Physical Climatology, 2nd Edition, Elsevier Science.
3. John M. Wallace, Peter V. Hobbs (2006) Atmospheric Science, An Introductory Survey, 2nd Edition, Elsevier Science.
4. Alan P. Trujillo, Harold V. Thurman (2020) Essentials of Oceanography, 13th Edition, Pearson.
5. Roger G. Barry, Richard J Chorley (2010) Atmosphere, Weather and Climate, 9th Edition, Taylor & Francis, 2010.
6. Roland B. Stull (1988) An Introduction to Boundary Layer Meteorology, Springer.
7. C. Nick Hewitt, Andrea V. Jackson (2020) Atmospheric Science for Environmental Scientists, John Wiley & Sons.
8. Houghton, John. Global Warming (5th edition). Cambridge University Press, United Kingdom. 2015.

SEMESTER III

25-815-0301: Environmental Biology

(**Credits : 4**)

Course Description:

Environmental biology, focuses on the study of living organisms and their interactions with the environment. It explores how organisms adapt to and influence their surroundings, and the impact of environmental factors on their behavior, physiology, and evolution. By studying the intricate relationships between organisms and their environment, environmental biology plays a crucial role in promoting sustainable practices and preserving the Earth's delicate ecosystems.

Course Objectives:

- Understand Foundations of Ecology
- Explore Population Dynamics
- Examine Community Dynamics
- Understand the Functioning of Ecosystem
- Understand and apply Ecology to Conservation

Course Outcomes:

After successfull completion of this course students should be able to:

CO1	Understand the historical development and fundamental concepts of ecology	Understand
CO2	To Analyze population characteristics and dynamics, to assess the roles of species in community ecology and population balance.	Analyse
CO3	To analyze the processes of succession, To understand their structure, stability, and resilience.	Analyze
CO4	To Understand energy flows, nutrient cycling, and landscape connectivity, to assess ecosystem functioning and health	Understand
CO5	Understand principles of conservation biology to analyze threats to biodiversity, evaluate ecosystem services, and implement restoration	Understand

Assessment Pattern:

Category	**Assessment Methods**			**Examination**
	Test 1	**Test 2**	**Test3**	
Understand	60	60	60	60
Apply	40	40	40	40

SYLLABUS

Module I : Foundations of Ecology

Definition, Historic development in ecological sciences, Level of ecological organization, Speciation, Ecological niche, Geographic Ecology- Distribution of organisms, factors influencing geographic patterns and importance of Biogeography, Biological invasions.

Module II : Population Dynamics

Characteristics of population, concept of carrying capacity, population growth and regulations, population fluctuations, dispersion and metapopulation, concept of r & k species; key stone species community

ecology. Abundance in time and space, factors influencing growth and decline, Population regulation and balance of nature

Module III : Community Dynamics

Community Dynamics: Succession and biodiversity, Food Webs and trophic interactions, Disturbance ecology and resilience. Species Interaction: Negative interactions (competition, predation, parasitism), Positive interactions (mutualism, commensalism), Implications for community structure and stability

Module IV : Ecosystem functioning

Ecosystem Ecology: energy flows and production, Nutrient cycling and biogeochemical processes, Landscape ecology and connectivity. Harvesting populations and Pest control: Sustainable harvesting practices, Pest control strategies and ecological impacts, Balancing human needs with ecosystem health.

Module V : Applied Ecology and conservation

Principles of conservation biology, Threats to biodiversity. Ecosystem services, Ecosystem Health and Human Impact, Human Impacts on ecosystem and conservation biology, Restoration ecology, Real world examples of ecological principles in action, Case studies in ecosystem management and restoration, Integrating ecological knowledge into decision making processes.

References

1. Molles, Manuel C., and Teresa Tibbets. Ecology: concepts and applications. New York: McGraw-Hill, 2002.
2. Begon, Michael, Martin Mortimer, and David J. Thompson. Population ecology: a unified study of animals and plants. John Wiley & Sons, 2009.
3. Verhoef, Herman A., and Peter J. Morin, eds. Community ecology: processes, models, and applications. Oxford University Press, 2010.
4. Raffaelli, David G., and Christopher LJ Frid, eds. Ecosystem ecology: a new synthesis. Cambridge University Press, 2010.
5. Van Dyke, Fred. Conservation biology: foundations, concepts, applications. Springer Science & Business Media, 2008.

25-815-0302: Bioremediation

(**Credits : 4**)

Course Description:

With the rising population of the world and daily life demands supplied through industries and modern industrialized agricultural systems, the need for preservation of ecosystems is increasingly revealed. The repeated occurrence of the calamities such as wars, earthquakes, and tsunamis are additional reasons that necessitate further attention to the cleaning of the polluted and/disrupted ecosystems. One of the most economical and stable approaches to cope with this vital task is the use of the techniques developed through progresses in an interdisciplinary science, bioremediation. Bioremediation as a branch of environmental biotechnology takes advantage of various living organisms including bacteria, fungi, algae, and plants in order to remediate the contaminated ecosystems.

Course Objective:

The purpose of this course is to introduce the underlying biogeochemical concepts pertinent to remediation of soil and groundwater, and describe how systems can be successfully engineered to support/promote remediation with an emphasis on bioremediation. Bioremediation is an increasingly utilized remediation technology that employs biological agents (microorganisms and plants) to treat hazardous contaminants in soil, and water; can lead to the permanent removal of contaminants from the environment; and may be inexpensive when compared to conventional techniques. It is a highly multidisciplinary, evolving technology that encompasses microbiology; chemical, civil, and environmental engineering; and environmental, soil, and analytical chemistry,

Course Outcomes:

After successfull completion of this course students should be able to:

CO1	learn about Bioremediation as an emerging clean up technology; Its advantages and disadvantages; types of bioremediation and its future prospects.	Remember
CO2	Describe the use of microbes and plants in biodegradation and biotransformation. Learn about bio treatability studies. Understand the principles of various physical and chemical remediation technologies and relate selection of these technologies to the properties of contaminants. Determine what is needed for site characterization, explain the relevance to selection of appropriate remediation strategies and determine when bioremediation is an appropriate technology and its advantages and limitations. Have knowledge of the impacts of contaminant characteristics to bioremediation process and describe the biodegradation of specific contaminants such as linear alkanes, BTEXs, PAHs, and chlorinated compounds such as PCE and PCBs.	Apply
CO3	Understand the metal microbe interaction and their degradation potential. Explain the application of microorganisms for remediation of oil spills and clean-up of marine and estuary systems; enhancing oil recovery etc.	Understand

CO4	Learn about the need for biotechnological intervention in the remediation of soil, subsurface and underground water system. Explain various in-situ and ex-situ treatment methods and their applications. Describe the interactions between contaminants, soil and presence of a NAPL phase, water and microorganisms and explain how these impact the fate of the contaminant and its bioavailability for biodegradation.	Understand
CO5	Learn Phytoremediation techniques and understand various cellular mechanism of contaminant uptake and detoxification.	Understand

Assessment Pattern:

Category	**Assessment Methods**			**Examination**
	Test 1	**Test 2**	**Seminar**	
Remember	10	10	10	10
Understand	70	70	70	70
Apply	20	20	20	20

SYLLABUS

Module I : Introduction to Bioremediation

An emerging clean-up technology; Bioremediation as an option to treat contaminated soils and ground water. Advantages and disadvantages of bioremediation compared to non-biological processes; bioremediation feasibility studies; microbial site characterization; laboratory bio treatability studies and protocols; bioremediation monitoring and evaluation; types of bioremediation; intrinsic and accelerated bioremediation; case studies; future prospects for bioremediation.

Module II : Bioremediation, Biotransformation and Biodegradation

Use of microbes (bacteria and fungi) and plants in biodegradation and Biotransformation. microbial metabolism - factors affecting microbial activity (choice of electron acceptor, toxicity of pollutant, C/N/P ratio, co-substrates, soil humidity, pH and temperature); In situ and Ex situ bioremediation; mineralization vs. partial degradation; Biodegradation - Factors affecting process of biodegradation; Methods in determining biodegradability; Contaminant availability for biodegradation; Bioremediation of VOCs. Biodegradation of specific contaminants (e.g. diesel fuel, polychlorinated biphenyls, dyestuffs, aromatic and polyaromatic hydrocarbons). Xenobiotics; Persistence and biomagnification of xenobiotic molecules; Microbial interactions with xenobiotics; Bioremediation of plastic waste.

Module III : Heavy metal and oil spill bioremediation

Sources of heavy metal pollution; Microbial interactions with inorganic pollutants - Microbial metal resistance; Microbial transformation; Accumulation and concentration of metals; Biosorption - Biotechnology and heavy metal pollution; Oil field microbiology; Improved oil recovery; Biotechnology and oil spills; Bioremediation in marine and estuarine systems: factors affecting bioremediation; need for introducing microbial cultures; bioremediation in coastal zone, oil spills.

Module IV : Contaminated soil and groundwater remediation

Contaminated soil remediation options; Containment systems; In-situ treatment systems: Pump-and-treat systems, Percolation, Bioventing, Air sparging or biosparging, Bioslurping; Ex-situ treatment

systems: Land farming, Compost piles, Biopile, Ex situ slurry techniques; Factors affecting bioremediation; Microbial constrains; Chemical constrains; Environmental constrains; Biostimulation; Bioaugmentation; Monitored natural attenuation.

Module V : Phytoremediation

Phytoremediation approaches; technical considerations; types of phytoremediation; factors influencing phytoremediation; translocation; enzymatic transformation; cellular mechanism of heavy metals detoxification and tolerance; cell wall and root exudates; phytochelates; metallothioneins; vascular compartmentalization; phytoremediation – novel transgenic approach; case studies; current research status; advantages and disadvantages of phytoremediation.

References

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2. John T. Cookson, (1995), Bioremediation engineering: design and application, McGraw-Hill, ISBN: 0070126143, 9780070126145.
3. Ronald M. Atlas, (2005), Bioremediation: applied microbial solutions for real-world environmental cleanup, ASM press, University of Michigan, ISBN: 1555812392, 9781555812393.
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6. Andrea Leeson, (2001), Natural attenuation of environmental contaminants, Battelle Press, University of Michigan, ISBN: 1574771124, 9781574771121.
7. Martin Alexander, (1999), Biodegradation and Bioremediation, (second edition), Acad. Press, 0120498618, 9780120498611.
8. Eve Riser-Roberts, (2010), Remediation of Petroleum Contaminated Soils: Biological, Physical, and Chemical processes, CRC Press, Lewis Publishers, ISBN: 0-87371-858-5.
9. David Sheehan, (2010), Bioremediation Protocols, Humana Press, ISBN: 1617370363, 9781617370366.
10. Lily Y. Young, (1995), Microbial transformation and degradation of toxic organic chemicals, Wiley-Liss, University of Michigan, ISBN: 0471521094, 9780471521099.
11. Ghulam Rasul Chaudhry, (2010), Biological degradation and bioremediation of toxic chemicals, Timber Press (OR), ISBN: 1604692049, 9781604692044
12. Bernd Beek, (2001), Biodegradation and persistence, Springer, University of Virginia, ISBN: 3540625763, 9783540625766 .
13. Biremediation of Wastes and Environmental Laws – (2010) by P.C. Trivedi.
14. Approaches in Bioremediation – (2018) Editors: Prasad, Ram, Aranda, Elisabet (Eds.), Springer, ISBN 978-3-030-02369-0.
15. Biodegradation and Bioremediation. (2017), by William Chang (Editor), Syrawood Publishing House, ISBN-10: 1682864529; ISBN-13: 978-1682864524.
16. Bioremediation: Applications for Environmental Protection and Management (2018) Varjani, S. J. (Ed), Agarwal, A. K. (Ed), Gnansounou, E. (Ed), Gurunathan, B. (Ed).
17. Bioremediation Technology for Plastic Waste (2019) Shahnawaz, M., Sangale, M. K., Ade, A. B.

25-815-0303: Natural Disasters and Management

(Credits : 4)

Course Description:

Natural disasters pose significant challenges to human society and environmental systems. This course provides comprehensive understanding of various natural disasters, their causes, impacts, and management strategies using modern geospatial technologies. This course offers a comprehensive overview of natural disaster management, focusing on the classification, characteristics, and impacts of various disasters, including geological, hydro-meteorological, and biological events. Students will explore methodologies for disaster monitoring, risk analysis, and vulnerability assessment, alongside emergency response planning and coordination strategies. The course also emphasizes post-disaster recovery and mitigation, highlighting rehabilitation strategies and community resilience. By integrating technology and examining case studies, participants will gain practical skills to effectively address and manage the challenges posed by natural disasters. This course prepares students to contribute to disaster preparedness, response, and recovery efforts in various settings, enhancing their ability to make informed decisions in high-pressure situations.

Course Objective:

This course provides advanced understanding of natural disasters and their management using geospatial technologies. Starting with detailed disaster classification and characteristics, it progresses through comprehensive risk assessment and vulnerability analysis. This comprehensive course explores the complexities of natural disasters through four key modules. In Module 1, students will gain insights into the classification and characteristics of various disasters, including geological, hydro-meteorological, and biological events, while examining global disaster patterns and their impacts. Module 2 focuses on disaster monitoring, risk analysis, and vulnerability assessment, emphasizing methodologies for damage assessment, data collection, and advanced mapping techniques. The third module addresses emergency response and management, covering planning protocols, evacuation strategies, and coordination of relief efforts. Finally, Module 4 delves into post-disaster recovery and mitigation, highlighting rehabilitation strategies, community resilience, and the integration of technology in disaster management. Through case studies and practical applications, students will develop a holistic understanding of disaster management, preparing them to effectively respond to and mitigate the effects of natural disasters in diverse contexts.

Course Outcomes:

After successfull completion of this course students should be able to:

CO1	Understand and analyze fundamental concepts of natural disasters and their classification	Understand, Analyze
CO2	Develop comprehensive skills in risk analysis and vulnerability assessment	Apply, Analyze
CO3	Master emergency response planning and post-disaster management strategies	Apply, Analyze
CO4	Analyze the implementation of disaster management solutions using modern technology	Apply, Analyze

Assessment Pattern:

Category	Assessment Methods			Examination
	Test 1	Test 2	Seminar	
Understand	40	40	40	40
Apply	40	40	40	40
Analyze	20	20	20	20

SYLLABUS

Module 1: Introduction to Natural Disasters

Classification and characteristics of natural disasters, Geological disasters: earthquakes, volcanoes, landslides, Tsunami, Hydro-meteorological disasters: floods, cyclones, droughts, Biological disasters: epidemics, pest attacks, Climate change and disaster trends, Global disaster patterns and impact analysis

Module 2: Disaster Monitoring, Risk Analysis and Vulnerability Assessment

Damage assessment methodologies, Data collection protocols and analysis frameworks, Comprehensive risk mapping and modeling, Advanced vulnerability analysis frameworks, GIS and spatial analysis in risk assessment, Multi-hazard zonation techniques, Prediction and forecasting methods, Socio-economic vulnerability assessment, Environmental impact analysis, Critical infrastructure vulnerability.

Module 3: Emergency Response and Management

Emergency response planning and protocols, Advanced evacuation strategies, Resource allocation and management systems, Communication systems in disaster management, Search and rescue operations, Relief coordination and management, International disaster response mechanisms

Module 4: Post-Disaster Recovery, Mitigation and Technology Integration

Post-disaster needs assessment, Recovery planning and implementation, Rehabilitation strategies, Building codes and standards, Insurance and financial mechanisms, Community resilience building, Sustainable reconstruction approaches, Mobile applications in disaster management, Social media in disaster communication, Emerging technologies and future trends, Case studies and best practices

References

1. Smith, K. (2013). Environmental Hazards: Assessing Risk and Reducing Disaster. United Kingdom: Routledge.
2. Coppola, D. P. (2015). Introduction to international disaster management. Butterworth-Heinemann.
3. Van Westen, C. (2013). Remote sensing and GIS for natural hazards assessment and disaster risk management. In Elsevier eBooks
4. Abbott, P. L. (2023). Natural disasters. McGraw Hill.
5. Tomaszewski, B. (2020). Geographic Information Systems (GIS) for disaster management. In Routledge eBooks. https://doi.org/10.4324/9781351034869.
6. UNDRR, 2023. Global Assessment Report on Disaster Risk Reduction.
7. World Bank, 2022. Disaster Recovery Framework Guide

25-815-0304: Ecology and Conservation

(Credits : 3)

Course Description:

Environmental biology, focuses on the study of living organisms and their interactions with the environment. It explores how organisms adapt to and influence their surroundings, and the impact of environmental factors on their behavior, physiology, and evolution. By studying the intricate relationships between organisms and their environment, environmental biology plays a crucial role in promoting sustainable practices and preserving the Earth's delicate ecosystems.

Course Objectives:

- Understand Foundations of Ecology
- Explore Population Dynamics
- Examine Community Dynamics
- Understand the Functioning of Ecosystem
- Understand and apply Ecology to Conservation

Course Outcomes:

After successfull completion of this course students should be able to:

CO1	Understand the historical development and fundamental concepts of ecology	Understand
CO2	To Analyze population characteristics and dynamics, to assess the roles of species in community ecology and population balance.	Analyse
CO3	To analyze the processes of succession, To understand their structure, stability, and resilience.	Analyze
CO4	To Understand energy flows, nutrient cycling, and landscape connectivity, to assess ecosystem functioning and health	Understand
CO5	Understand principles of conservation biology to analyze threats to biodiversity, evaluate ecosystem services, and implement restoration	Understand

Assessment Pattern:

Category	**Assessment Methods**			**Examination**
	Test 1	**Test 2**	**Test3**	
Understand	60	60	60	60
Apply	40	40	40	40

SYLLABUS

Module I : Foundations of Ecology

Definition, Historic development in ecological sciences, Level of ecological organization, Speciation, Ecological niche, Geographic Ecology- Distribution of organisms, factors influencing geographic patterns and importance of Biogeography, Biological invasions.

Module II : Population Dynamics

Characteristics of population, concept of carrying capacity, population growth and regulations, population fluctuations, dispersion and metapopulation, concept of r & k species; key stone species community

ecology. Abundance in time and space, factors influencing growth and decline, Population regulation and balance of nature

Module III : Community Dynamics

Community Dynamics: Succession and biodiversity, Food Webs and trophic interactions, Disturbance ecology and resilience. Species Interaction: Negative interactions (competition, predation, parasitism), Positive interactions (mutualism, commensalism), Implications for community structure and stability

Module IV : Ecosystem functioning

Ecosystem Ecology: energy flows and production, Nutrient cycling and biogeochemical processes, Landscape ecology and connectivity. Harvesting populations and Pest control: Sustainable harvesting practices, Pest control strategies and ecological impacts, Balancing human needs with ecosystem health.

Module V : Applied Ecology and conservation

Principles of conservation biology, Threats to biodiversity. Ecosystem services, Ecosystem Health and Human Impact, Human Impacts on ecosystem and conservation biology, Restoration ecology, Real world examples of ecological principles in action, Case studies in ecosystem management and restoration, Integrating ecological knowledge into decision making processes.

References

1. Molles, Manuel C., and Teresa Tibbets. Ecology: concepts and applications. New York: McGraw-Hill, 2002.
2. Begon, Michael, Martin Mortimer, and David J. Thompson. Population ecology: a unified study of animals and plants. John Wiley & Sons, 2009.
3. Verhoef, Herman A., and Peter J. Morin, eds. Community ecology: processes, models, and applications. Oxford University Press, 2010.
4. Raffaelli, David G., and Christopher LJ Frid, eds. Ecosystem ecology: a new synthesis. Cambridge University Press, 2010.
5. Van Dyke, Fred. Conservation biology: foundations, concepts, applications. Springer Science & Business Media, 2008.

SEMESTER IV

25-815-0401: Methods in Environmental Analysis

(**Credits : 4**)

Course Description:

Reliable and accurate measurement of extremely small quantities of chemical species in various compartments of the environment is essential to trace their sources, reactions, transport, effects and fates. Students majoring in Environmental Science need grounding in instrumental analysis as much as traditional Chemistry majors do, but their backgrounds and needs may be quite different.

Course Objectives:

Students majoring in environmental sciences need a foundation in measurement techniques used in the field. Sophisticated instrumental methods of analysis is an essential component of environmental monitoring and assessment and provide enough information to judge the environmental quality. The course will provide in depth knowledge on the various sophisticated analytical instruments used in the laboratory for environmental chemical analysis and arrange students hands on training of various analytical instruments.

Course Outcomes:

After successfull completion of this course students should be able to:

CO1	Theoretical concepts on atomic spectroscopy, molecular spectroscopy and chromatography techniques	Understand
CO2	Instrumentation and application of analytical techniques	Understand
CO3	Sample preparation and operation of the instrument	Apply
CO4	Interpretation of data	Analyse

Assessment Pattern:

Category	**Assessment Methods**			**Examination**
	Test 1	**Test 2**	**Seminar**	
Understand	25	25	25	25
Apply	25	25	25	25
Analyze	25	25	25	25

SYLLABUS

Module I : Atomic Spectroscopy

Atomic Absorption Spectrometry (AAS): Theory, instrumentation and applications of flame AAS, Thermal AAS, Cold Vapour AAS, Interferences in AAS. Atomic Emission Spectrometry: Theory, Instrumentation and applications of Flame photometry, Flame Emission Spectrometry, Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES) and ICP/MS.

Module II : Molecular Spectroscopy

UV Visible Molecular Absorption Spectrometry: Theory, Instrumentation and applications. Infra-red Spectrometry: Theory, instrumentation and applications, Nuclear Magnetic Resonance (NMR) Spectroscopy: Theory, instrumentation and applications. Mass Spectrometry (MS): Theory, instrumentation and applications

Module III : Fundamentals of Chromatography

Introduction to chromatographic separations: General description, stationary phase and mobile phase,

distribution coefficient, capacity factor, chromatogram, retention time, migration rates of solutes, zone broadening, column efficiency, optimization of column performance, applications of chromatography. Theory and applications of Partition chromatography, Adsorption chromatography, Ion-exchange chromatography, Size-exclusion chromatography, Thin-layer chromatography(TLC).

Module IV : Chromatographic Instruments
Gas Chromatography: Principle of Gas - Liquid Chromatography (GLC), Instruments for GLC, Columns and stationery phases, detectors, applications. Gas chromatography mass spectrometry, Liquid chromatography (LC): High-Performance Liquid Chromatography (HPLC) - Theory, instrumentation and applications.

Module V : Instrumental Analysis and Interpretation of Test Results
UV-Visible Spectrophotometer- Sample preparation testing, Interpretation of the data and reporting of the results for selected compounds, fluoride, nitrite, nitrate, ammonia, silicate, phosphate, Sulphate, Nitrite, and Iron.

AAS- Atomic Absorption Spectrometer - Sample preparation testing, Interpretation of the data and reporting of the results for selected compounds (Cu, Mg, Mn, Cr, Fe, Zn).

HPLC- High Performance Liquid Chromatography - Sample preparation testing, Interpretation of the data and reporting of the results for selected compounds (Pyridine, mefnamic acid, Caffeine samples).

ICP-MS - Trace metal analysis - Sample Preparation testing, Interpretation of the data and reporting of the results for metals.

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References

1. Harris, D. C.; (2015). “Quantitative Chemical Analysis”. 9th Edition
2. Christian, G.D.; Purnendu, K.; Sandy Dasgupta.; Kevin, A. S.; (2014). Analytical Chemistry. 7th edition , ISBN 978-0-470-88757-8
3. Douglas, A.; Skoog, F.; James, H.; Stanley, R. C.; (2009). “Instrumental Analysis”. 3rd Indian Reprint, Brooks/Cole, a part of Cengage Learning.
4. Mendam, J.; Denny, R.C.; Barnes J.D.; Thomas, J.K.; (2007). “Vogel’s text book of Quantitative Chemical Analysis”. 5th impression, Dorling Kindersley (India) Pvt. Ltd.
5. Andrew, D. E.; Lenore, S.; Glesceri.; Eugene W. R.; Arnold E.; Greenberg.; (Eds) (2005). “Standards Methods for the Examination of Water and Wastewater Analysis”. 21st Edition, APHA. Washington DC.
6. Roger N. R.; (2002). “Introduction to Environmental Analysis”, John Wiley & Sons Ltd., Chichester.
7. Donald, L. P.; Gary, M. L.; George, S. K.; (2001). “Introduction to Spectroscopy”. 3rd Edition, Harcourt College Publishers.
8. Harvey, D. (2000). Modern analytical chemistry. McGraw Hill.

25-815-0402: Introduction to Programming and Data handling

(**Credits : 4**)

Course Description:

This course serves as an introduction to the fundamental concepts of programming and data handling within the context of environmental science. As technology becomes increasingly integral to environmental research and monitoring, proficiency in programming languages and data analysis tools is essential for scientists in this field. This course is designed to equip students with the foundational skills necessary to harness the power of programming for data manipulation, analysis, and visualization in environmental science applications.

Course Objectives:

The main objective of this course is to provide students a basic understanding the principles of computers and computer programming. They should readily use the object-oriented programming and apply various data types and control sequences. Students should be capable of doing statistical analysis and data analysis on environmental data sets.

Course Outcomes:

After successfull completion of this course students should be able to:

CO1	Discuss the basics of programming and interfacing in computer programming.	Understand
CO2	Interpret the various data types and operations in programming.	Apply
CO3	Execute codes using modules and functions in object-oriented programming.	Apply
CO4	Operate the fundamental statistical analysis on environmental data sets.	Apply
CO5	Examine basic data analysis and visualisation of environmental data.	Analyze

Assessment Pattern:

Category	**Assessment Methods**			**Examination**
	Test 1	**Test 2**	**Seminar**	
Remember	20	10	20	10
Understand	40	40	30	40
Apply	40	30	40	40
Analyze	0	20	20	10

SYLLABUS

Module I : Introduction to programming

Basic principles of computers; Relations between computers and programs; Compilers and Interpreters; History of Programming languages; Concepts of programming; Steps involved in developing a program; Object-oriented programming; Introduction to Python Programming; Installing Python; Different methods of using Python; inputs and outputs

Module II : Data types and control structures

Operators; Data types; variables; expressions; statements; assignment statements; strings and string operations; Control structures- conditional and decision making- loops;

Module III : Modules and Functions

Standard Modules; Libraries; Pandas-NumPy-SciPy; Packages; Create a module; Function parameters; Variable arguments; Scope of Function-Documentation; Create a Function;

Module IV : Data Handling and Visualization

File handling; Reading from file; Writing to file; Data structures- Array- List-Dictionary; Error processing; Exceptions; visualistion with Matplotlib

Module V : Statistical Analysis

Python statistic libraries; Descreiptive Statistics- Central tendency-Varibility-Correlation; Visualisation; Axes; DataFrames; Histograms; Pie Charts;Box Plots; Bar Charts; XY Plots

References

1. Martin C. Brown, "Python: The Complete Reference", 2018, Mc Graw Hill
2. Allen Downey, "Think Python: How to Think Like a Computer Scientist", 2016, Green Tea Press, Needham, Massachusetts
3. Charles R Severance, "Python for Everybody Exploring Data Using Pythons 3", 2017, PythonLearn
4. Allen B. Downey, "Think Stats: Exploratory Data Analysis in Python", 2014, Green Tea Press, Needham, Massachusetts
5. For installation and basic codes: www.python.org
6. For Python Tutorials : https://www.w3schools.com/python/

25-815-0403: Biodiversity and Conservation

(**Credits : 4**)

Course Description:

The course is designed to equip students with the knowledge and skills necessary to address the complex challenges of biodiversity conservation, both globally and within the context of India.

Course Objective:

To understand the fundamental concepts and types of biodiversity and to evaluate the economic and philosophical values of biodiversity. To analyze the role and effectiveness of conservation strategies and techniques and to identify and assess the major threats to biodiversity at local and global scales. To examine the biodiversity of India and its conservation policies and laws.

Course Outcomes:

After successfull completion of this course students should be able to:

CO1	Ability to define and classify different aspects of biodiversity.	Understand
CO2	Capacity to analyze the economic and philosophical dimensions of biodiversity.	Analyse
CO3	Understand and analyze the conservation strategies.	Analyze
CO4	Competence in analyzing and addressing threats to biodiversity.	Analyse
CO5	Understanding of India's biodiversity richness and conservation efforts, with insights into future directions.	Understand

Assessment Pattern:

Category	**Assessment Methods**			**Examination**
	Test 1	**Test 2**	**Seminar**	
Understand	60	60	60	60
Analyze	40	40	40	40

SYLLABUS

Module I : Introduction to Biodiversity

Definition and Basic concepts of biodiversity, types and importance of biodiversity. Species diversity, measuring species diversity, Genetic diversity, Ecosystem diversity: Ecosystems- structure and functions, Types of ecosystems, ecosystem services, energy flow in ecosystems, energy flow models, species interactions, food chains and food webs, keystone species. Biodiversity Worldwide.

Module II : The Value of Biodiversity

Ecological and environmental economics, cost-benefit analysis. Values of biodiversity - direct use value, indirect use value, non-use value, option value, existence value, intrinsic values, ethical values of biodiversity, amenity values. Economic valuation measures: market-based valuation, non-market based valuation. Deep Ecology

Module III : Conservation of Biodiversity

Definition and basic concepts, role and importance of protected areas, population dynamics, extinction

rates and habitat loss, Protected areas and conservation reserves, species based conservation, ecosystem based conservation, community based conservation, Bioprospecting, Threatened species in India, Biodiversity hotspots, Techniques of conservation – in situ conservation, ex situ conservation, in vitro conservation. International conservation agreements and treaties, restoration ecology, sustainable development: definition, principle, goals. International/National policies and conservation strategies; role of MAB, IUCN, Intellectual property rights-TRIPS, CBD,CITES role of Indigenous knowledge systems (IKS).

Module IV : Threats to biodiversity

Biodiversity loss: principle and impacts on ecosystem, habitat loss and fragmentation: edge effects, invasive species: definition and characteristics, examples, GMOs and conservation. Overexploitation: case studies. Environmental pollution and degradation, global climate change, human population growth and impact, legal protection of species, managing protected areas. Endangered and threatened flora and fauna of India.

Module V : Biodiversity of India

Biodiversity hotspots and endemic species in India, distribution of species, Importance of wetlands in India, Faunal and floral diversity, Protected areas – biosphere reserves, National parks, wild life sanctuaries; Sacred groves in India, Biodiversity conservation policies and laws in India: The wildlife (Protection) Act, 1972, The National Forest policy 1988, The Biological Diversity Act 2002. National Biodiversity Action Plan, Emerging Trends and Future Directions. Biodiversity Worldwide.

References

1. Gaston, Kevin J., and John I. Spicer. Biodiversity: an introduction. John Wiley & Sons, 2013.
2. Van Dyke, Fred. Conservation biology: foundations, concepts, applications. Springer Science & Business Media, 2008.
3. Goldstein, Eli. Introduction to Environmental Economics: By Nick Hanley, Jason F. Shogren and Ben White (Oxford University Press, 2001
4. Sessions, George. Deep ecology for the twenty-first century. (1995).
5. Leelakrishnan, P. Environmental law in India, (2008).
6. Williams, Claire G. Introduction to Conservation Genetics- Cambridge University Press, 2002.
7. Newman, Jonathan A. Climate change biology. Cabi, 2011.

25-815-0404: Environmental Pollution

(**Credits : 4**)

Course Description:

This course provides an in-depth exploration of major environmental pollution types—air, water, soil, and noise—alongside emerging contaminants and sustainable management strategies. Students will gain a comprehensive understanding of pollution sources, impacts on human and ecological health, monitoring methods, and advanced control technologies. Emphasis is placed on real-world applications through case studies on industrial emissions, river pollution, and soil remediation.

The course also examines critical global challenges, including microplastics and pharmaceutical pollutants, with focused discussions on relevant regional research (e.g., steroid hormones in South Indian water bodies). Students will be introduced to key environmental management tools such as Environmental Impact Assessment (EIA), risk assessment, and global policy frameworks, including the Sustainable Development Goals (SDGs). By integrating scientific, technological, and regulatory perspectives, the course prepares learners to address contemporary pollution issues and develop sustainable solutions for environmental protection.

Course Objective:

1. To understand the sources, types, and effects of pollution on the environment.
2. To analyse the mechanisms of pollutant dispersion and environmental impacts.
3. To explore monitoring, assessment, and mitigation strategies for pollution control.
4. To introduce legal frameworks, policies, and sustainable approaches to pollution management.

Course Outcomes:

After successfull completion of this course students should be able to:

CO1	Apply environmental science principles to analyze pollution issues.	Apply
CO2	Develop solutions for pollution control using scientific and technological approaches.	Analyse
CO3	Conduct field and laboratory experiments to assess environmental pollution.	Apply
CO4	Understand the environmental policies and regulatory frameworks.	Understand
CO5	Communicate scientific findings effectively through reports and presentations.	Apply

Assessment Methods

- Assignments & Case Studies (20%)
- Mid-Term Examination (30%)
- Final Examination (40%)
- Field/Laboratory Work & Report Submission (10%)

SYLLABUS

Module I : AIR POLLUTION

Topics Covered: Sources and classification of air pollutants; Effects of air pollution on human health, ecosystems, and climate change; Air quality standards and monitoring techniques; Dispersion of air

pollutants and modelling approaches; Control technologies for gaseous and particulate pollutants ; Case studies on industrial and vehicular pollution

Module II : WATER POLLUTION

Topics Covered: Sources and types of water pollution (organic, inorganic, microbial, thermal, radioactive); Impact of water pollution on aquatic ecosystems and human health; Water quality parameters and assessment techniques; Advanced wastewater treatment technologies; Case studies on river pollution and waterborne diseases

Module III : SOIL AND NOISE POLLUTION

Topics Covered: Soil contamination: sources, transport mechanisms, and impacts; Soil remediation technologies (bioremediation, phytoremediation, chemical treatments); Noise pollution: sources, measurement, and health effects; Noise pollution control measures and regulations

Module IV : RADIO ACTIVE POLLUTION

Definition of radio active pollution, Sources, types of radiation, effects on environment, human health effects. radio active pollution-case studies.

Module V : EMERGING POLLUTANTS AND ENVIRONMENTAL MANAGEMENT

Topics Covered: Emerging contaminants (micro plastics, pharmaceuticals, endocrine disruptors); Case study: Steroid hormones in water bodies (relevant to South India research); Environmental Impact Assessment (EIA) and risk assessment; Policies, laws, and global frameworks (SDGs, UNEP, CPCB regulations); Circular economy and sustainable solutions for pollution control

Textbooks:

1. Cunningham, W.P., & Cunningham, M.A. – Environmental Science: A Global Concern (McGraw-Hill, 2017)
2. Peavy, H.S., Rowe, D.R., & Tchobanoglous, G. – Environmental Engineering (McGraw-Hill, 2013)
3. M.N. Rao & H.V.N. Rao – Air Pollution (Tata McGraw-Hill, 2017)
4. R.S. Khoiyangbam & Navindu Gupta – Textbook of Environmental Studies (University Press, 2018)
5. S.P. Mahajan – Pollution Control in Process Industries (Tata McGraw-Hill, 2018)

Supplementary Readings:

1. Odum, E.P. & Barrett, G.W. – Fundamentals of Ecology (Thomson Brooks/Cole, 2005)
2. Manahan, S.E. – Environmental Chemistry (CRC Press, 2017)
3. Sharma, B.K. – Environmental Chemistry (Goel Publishing House, 2015)
4. Misra, K.C. – Environmental Pollution (S. Chand, 2010)
5. J.G. Henry & G.W. Heinke – Environmental Science and Engineering (Pearson, 2006)

Journals & Online Resources:

1. Environmental Science & Technology (American Chemical Society)
2. Water Research (Elsevier)
3. Journal of Hazardous Materials (Elsevier)
4. Science of the Total Environment (Elsevier)
5. Central Pollution Control Board (CPCB) Reports – https://cpcb.nic.in
6. United Nations Sustainable Development Goals (SDGs) – https://sdgs.un.org

Additional Learning Activities:

- Case Study: Analysis of environmental pollution case studies from India and abroad

- Field Visit: Industrial pollution monitoring site, wastewater treatment plants, air quality monitoring stations
- Lab Work: Water and air quality analysis, noise level measurement, soil pollution assessment
- Seminar/Presentation: Emerging pollutants and their effects on ecosystems

25-815-0405: Water Quality monitoring and analysis

(Credits : 3)

Course Description:

This course in Water Science, Quality Monitoring, and Interpretation offers a comprehensive study of water science and its environmental significance. It covers the hydrosphere, hydrological cycle, distribution of water, and characteristics of natural waters. Students learn about pollution types and water pollutants, including toxicity testing methods. This course includes analysis of water and wastewater, covering sampling, preservation, and analytical methods for physical, chemical, and biological parameters. Students interpret water quality data, including the distribution of total solids and dissolved solids, and learn about water quality indices and statistical methods. Advanced topics include remote sensing applications, real-time monitoring systems, data analysis, and ecological and toxicological risk assessment. Practical applications cover case studies, plant visits, and designing monitoring programs. Students gain hands-on experience in fieldwork and apply environmental toxicology to address toxic contaminants in water.

Course Objective:

The course aims to provide students with a comprehensive understanding of water science, quality monitoring, and interpretation, covering the hydrosphere, hydrological cycle, water distribution, natural water characteristics, pollution types, water pollutants, and toxicity testing methods. It includes analysis of water and wastewater, interpretation of water quality data, advanced topics such as remote sensing applications and ecological and toxicological risk assessment, and practical applications like case studies and plant visits for hands-on experience. .

Course Outcomes:

After successfull completion of this course students should be able to:

CO1	Understand the fundamental principles of water science, including the hydrosphere, hydrological cycle, and the distribution of water on Earth.	Understand
CO2	Analyze different types of pollution in the hydrosphere, and assess the nature and types of water pollutants, including their impacts and toxicity testing methods.	Analyse
CO3	Apply various techniques for the analysis of water and wastewater, including sampling, preservation, and analytical methods for physical, chemical, and biological parameters.	Apply
CO4	Evaluate water quality data, including the interpretation of total solids, dissolved solids, and the use of water quality indices and statistical methods.	Evaluate
CO5	Apply advanced concepts in water quality monitoring, such as remote sensing applications, real-time monitoring systems, data analysis, and ecological and toxicological risk assessment.	Apply

Assessment Pattern:

Category	Assessment Methods			Examination
	Test 1	Test 2	Seminar	
Understand	40	40	40	40
Apply	20	20	20	20
Analyze	20	20	20	20
Evaluate	20	20	20	20

SYLLABUS

Module I : Foundations of Water Science

Introduction to Water Science, Hydrosphere-Importance of water-Distribution of water on the earth- Hydrological cycle-Characteristics of natural waters and processes that affect their composition-structure of water-Unique properties of water and their environmental significance, Basic concepts of pollution in the Hydrosphere: Introduction, Nature and types of water pollutants, Elemental and organic pollutants.

Module II : Water Quality Parameters Analysis

Analysis of Water and Wastewater: Sampling, preservation, storage, pre-treatment and analytical methods, Physical Parameters of Water Quality (Temperature, Turbidity), Chemical Parameters (pH, Dissolved Oxygen), Biological Parameters (Bacteria, Algae), Toxicity Testing Methods for Water Quality Parameters,

Module III :Interpretation of Water Quality Data

TS and DS distribution, DO, COD fractions, concept and tests, fractions of N, P, TOC, DOC, BDOC, and NBDOC, the rationale in setting aesthetic and toxicity criteria), Water Quality Index and sample calculations. Water quality analysis, data profile, and interpretation- water quality indices. Statistical methods for stratum-based analysis of field samples- wastewater, surface water, and groundwater.

Module IV : Advanced Water Quality Monitoring

Advanced Sampling Techniques, Remote Sensing Applications in Water Quality Monitoring, Real-time Monitoring Systems, Data Analysis and Interpretation Techniques, Ecological and toxicological Risk Assessment in Water Monitoring

Module V : Practical Applications in Water Science

Case Studies in Water Quality Management, Water Treatment Plant Visits, Designing Water Quality Monitoring Programs, Fieldwork and Hands-on Experience in Water Science, Mitigation Strategies and Real-world applications of environmental toxicology in water science for Toxic Contaminants

References

1. Mahan, S.E., 2022. Environmental chemistry. CRC press.
2. Rice, E.W., Bridgewater, L. and American Public Health Association eds., 2012. Standard methods for the examination of water and wastewater (Vol. 10). Washington, DC: American public health association.
3. Grasshoff, K., Kremling, K. and Ehrhardt, M. eds., 2009. Methods of seawater analysis. John Wiley & Sons.
4. Roger, N.; Reeve.; (2002). “Introduction to Environmental Analysis”. Published by John Wiley & Sons Ltd, Chichester.
5. Fifield, F.W.; (2000). “Environmental Analytical Chemistry”. 2nd edition, Blackwell Publishers.

SEMESTER V

25-815-0501: Remote Sensing and GIS

(**Credits : 4**)

Course Description:

In today's world, technologies in geomatics play a vital role in achieving sustainable development and efficiently managing resources such as land, water, air, and the socio-economic environment. The combination of Geographic Information Systems (GIS) and Remote Sensing technology is particularly powerful, allowing for the integration of diverse databases onto a unified geospatial platform for comprehensive viewing and analysis. Geoinformatics and environmental science leverage these tools, including GIS, remote sensing, and spatial analysis, to tackle environmental issues more effectively. By utilizing these technologies, geoinformatics enables the collection, analysis, and visualization of spatial data, deepening our understanding of the Earth's systems and how they interact. This synergy allows environmental scientists to accurately monitor environmental changes, assess natural resources, plan for sustainable development, and implement conservation strategies. Remote sensing is especially important, offering up-to-date and detailed observations of the Earth's surface from afar, which aids in evaluating various phenomena such as climate change, deforestation, and pollution. Together, these fields provide insightful strategies for resource management and addressing environmental problems with improved precision and effectiveness. This introductory course covers the theories and practices of Remote Sensing Technology, Geographic Information Technology, and Global Positioning Technology, alongside the application of Geomatics Science in environmental management.

Course Objectives:

This course offers a thorough introduction to the fundamental principles and practical applications of Remote Sensing, Geographic Information Systems (GIS), and Cartography and Surveying Techniques. Starting with the basics of remote sensing, it progresses to detailed image processing techniques for data analysis and interpretation. This includes an exploration of essentials of GIS, from components and data management to spatial analysis and applications, before concluding with foundational cartography concepts and modern surveying methods. Designed to equip students with both theoretical understanding and practical skills, this course prepares participants for effective application in environmental management, geographical analysis, and beyond, bridging technology and real-world challenges.

Course Outcomes:

After successfull completion of this course students should be able to:

CO1	Gain knowledge of the principles and concepts of Remote Sensing and its applications.	Understand, Apply
CO2	Acquire knowledge on analysing and interpreting remote sensing data through visual interpretation and image processing techniques.	Apply, Analyse
CO3	Understand GIS fundamentals, data management, and spatial analysis.	Understand, Apply
CO4	Explore cartography, focusing on map making and GPS technology.	Understand, Apply

Assessment Pattern:

Category	Assessment Methods			Examination
	Test 1	Test 2	Test3	
Understand	40	40	40	40
Apply	40	40	40	40
Analyze	20	20	20	20

SYLLABUS

Module 1: Introduction to Remote Sensing

Basic concepts and processes, Remote Sensing System Classification, Sensor and Platforms, Sensor parameters, Resolution, Spectral Bands, Interaction of Energy, RS Satellites, RS Applications.

Module 2: Basics of Image Processing

Data Analysis and Interpretations, Visual Interpretation, Photoelements, Steps in image interpretation, Elements of Image Interpretation, Basics of Digital Image Processing, Image Rectifications and Corrections, Image enhancement, Image Classification.

Module 3: Introduction to GIS

Components of GIS, GIS data base, Spatial features, Data structure and Models, GIS Data Inputting and Outputting, Georeferencing, Basics of Spatial analysis, Vector and Raster Data Manipulation, Surface Modelling, Terrain Models, Interpolation, Geocoding, Network Analysis, Digital Terrain Models, Data Storage, GIS Applications

Module 4: Basics of Cartography

Basic concepts, Map scale, Map classification, Map elements, Geographical co-ordinates, Map Projections, Geodetic Datum, Topology, Global Position System. Survey, GPS survey and DGPS survey.

References

1. Lillisand, T., Kiefer, R. W., and Chipman, J., 2015.Remote Sensing and Image Interpretation, 7th Ed. Wiley, New York.
2. Joseph, G. and Jeganathan, C. 2018. Fundamentals of Remote Sensing. 3rd Ed. Univ. Press, Hyderabad.
3. Jenson, J.R. 2016. Introductory Digital Image Processing: A Remote Sensing Perspective, Pearson Education.
4. Jenson, J.R. 2009. Remote Sensing of the Environment: An Earth Resource Perspective 2nd Ed. Pearson Education.
5. Stan Aronoff,1989. Geographic Information Systems: A Management Perspective, WDL Publ. Ottawa, Canada.
6. Kang Tsung Chang, 2006. Introduction to Geographic Information Systems McGraw-Hill.
7. Xuan Zhu 2016 GIS for Environmental Applications - A practical approach, Routledge
8. Lavender, S., and Lavender, A., 2023. Practical Handbook of Remote Sensing, Routledge

25-815-0502: Environmental impact and risk assessment

(**Credits : 4**)

Course Description:

This course offers a comprehensive understanding of Environmental Impact Assessment (EIA) as a vital tool for sustainable development and environmental decision-making. It explores the historical evolution, legal frameworks, and methodologies involved in EIA, with a focus on India's regulatory system. Students will learn the complete EIA process—including screening, scoping, impact prediction, public hearings, and mitigation strategies—while gaining familiarity with tools like matrices, models, and expert systems.

The course also emphasizes socio-economic impact assessment, environmental management planning, and the role of ethics and quality in reporting. Practical applications are reinforced through case studies from diverse sectors such as mining, power generation, construction, and hazardous waste management. The final module delves into environmental risk assessment, covering hazard identification, exposure assessment, risk characterization, and emergency preparedness using tools like HAZOP, FMEA, and fault tree analysis. This interdisciplinary course equips students with the skills to evaluate environmental impacts and manage risks associated with developmental projects.

Course Objective:

- Understand the historical, legal, and procedural foundations of Environmental Impact Assessment, particularly in the Indian context.
- Apply tools such as checklists, matrices, and models for identifying and predicting environmental impacts across air, water, soil, noise, and biological domains.
- Conduct socio-economic impact assessments and formulate effective Environmental Management Plans (EMPs) with appropriate monitoring and mitigation strategies.
- Analyze real-world case studies to understand the application of EIA in various industrial and infrastructure projects.
- Perform environmental risk assessments using standard methodologies such as HAZOP, FMEA, and fault/event tree analyses.
- Design comprehensive risk management and emergency preparedness plans to minimize and address environmental hazards.
- Develop professional EIA documentation and recognize the importance of ethical standards and quality control in environmental reporting.

Course Outcomes:

After successfull completion of this course students should be able to:

CO1	Understand the necessity to study the impacts and risks that will be caused by projects or industries and the methods to overcome these impacts	Understand
CO2	Describe the legal requirements of environmental and risk assessment for projects	Understand
CO3	Prepare terms of reference for environmental impact and socioeconomic impact for any developmental project	Apply
CO4	Prepare environmental management plan and risk mitigation plan by considering environmental aspects, impacts and potential hazards respectively for any project	Apply

Assessment Pattern:

Category	**Assessment Methods**			**Examination**
	Test 1	**Test 2**	**Test3**	
Remember	10	10	10	
Understand	50	50	50	60
Apply	40	40	40	40

SYLLABUS

Module I : Fundamentals of EIA:

Historical development of Environmental Impact Assessment (EIA). Environmental Clearance- EIA in project cycle. legal and regulatory aspects in India – types and limitations of EIA –EIA process-screening – scoping - terms of reference in EIA- setting – analysis - mitigation. Cross sectoral issues –public hearing in EIA- EIA consultant accreditation.

Module II : Impact Identification and Prediction

Matrices – networks – checklists – cost benefit analysis – analysis of alternatives – expert systems in EIA. prediction tools for EIA – mathematical modeling for impact prediction – assessment of impacts – air – water – soil – noise – biological — cumulative impact assessment -Cost Benefit Analysis-Analysis of Alternative-Software Packages for EIA and Expert Systems in EIA.

Module III : Socio-Economic Impact Assessment and Environment Management Plan

Socio-economic impact assessment - relationship between social impacts and change in community and institutional arrangements. Factors and methodologies- individual and family level impacts. Communities in transition-rehabilitation Environmental management plan - preparation, implementation and review – mitigation and rehabilitation plans – policy and guidelines for planning and monitoring programmes – post project audit – documentation of EIA findings – ethical and quality aspects of environmental impact assessment

Module IV : Case Studies

Mining, power plants, cement plants, highways, petroleum refining industry, storage & handling of hazardous chemicals, common hazardous waste facilities, CETPs, CMSWMF, building and construction projects.

Module V : Risk Assessment

Environmental risk assessment framework-Hazard identification -Dose Response Evaluation – Exposure

Assessment – Exposure Factors, Tools for Environmental Risk Assessment– HAZOP and FEMA methods – Event tree, fault tree and MCACA - Risk Characterization Risk communication - Emergency Preparedness Plans –Design of risk management programs.

References

1. 1. Morris, P., & Therivel, R. (2021). Environmental Impact Assessment: Theory and Practice (4th ed.). Routledge.
2. Glasson. J.; (2019). "Introduction To Environmental Impact Assessment" 5th Edition, Taylor and Francis.
3. Salim M,; Zobaidul, K.; (2018). "Evaluating Environmental and Social Impact Assessment in Developing Countries". Elsevier.
4. Dr. Y. R. M Rao.; Dr. N. S. Raman.; (2018). "Environmental Impact Assessment". Laxmi Publications Pvt Ltd,
5. Marsden, S., & Cordonier Segger, M.-C. (2017). Strategic Environmental Assessment in International and European Law: A Practitioner's Guide. Cambridge University Press
6. Anji, R M.; (2017). "Environmental Impact Assessment".Butterworth-Heinemann.
7. Abington: Routledge. Brown, K. 2015. Resilience, Development and Global Change. London:
8. Fischer, T., & Gagnon, A. (2017). The Practice of Strategic Environmental Assessment. Earthscan.
9. I.V. Murali Krishna and Valli Manickam (2016). Environment Management- a primer for industries. BS Publications.
10. Anjaneyulu, Y., & Singh, A. K. (2016). Environmental Impact Assessment: Practical Solutions to Recurrent Problems. Springer.
11. Eccleston, C. H. (2015). Environmental Impact Assessment: A Guide to Best Professional Practices. Wiley-Blackwell.
12. Routledge Glasson, J. and Therivel, R. 2013. Introduction To Environmental Impact Assessment.
13. Grumbine, R.E. and Pandit, M.K., 2013. Threats from India's Himalaya dams. Science, 339:36-37.
14. Petts, J., & Ferrett, T. I. (Eds.). (2012). Handbook of Environmental Impact Assessment. Wiley-Blackwell.
15. Pandit, M.K. and Grumbine, R.E., 2012. Potential effects of ongoing and proposed hydropower development on terrestrial biological diversity in the Indian Himalaya. Conservation Biology, 26: 1061-1071.
16. Glasson, J., Therivel, R., & Chadwick, A. (2012). Introduction to Environmental Impact Assessment.
17. Routledge Arthwal, R.R.; (2012). "Environmental Impact Assessment". New Age International Private Limited; 2nd Edition.
18. Blaikie, P., Cannon, T., Davis, I. and Wisner, B. 2003. At Risk: Natural Hazards, People's Vulnerability and Disasters(2nd Ed.).
19. Lawrence, D.P.; (2003). "Environmental Impact Assessment - Practical Solutions to recurrent problems", Wiley-Interscience, New Jersey,
20. Routledge. Morris. P. & Therivel. R., 2001,Methods of environmental impact assessment, 2 nd Ed. Spon Press, New York, With a chapter on GIS and EIA by A.R. Bachiller & G. Wood, p. 381-401.
21. Morris, P., & Therivel, R. (2001). Methods in Environmental Impact Assessment. Routledge.
22. Petts, J. 1999. Handbook Of Environmental Impact Assessment. Vol. 1, Blackwell Science.
23. Petts, J.; (1999). "Handbook of Environmental Impact Assessment", Vol., I and II, Blackwell Science, London,
24. Canter, L.W.; (1996). "Environmental Impact Assessment". McGraw Hill, New York

25-815-0503: Environmetal Social Governance

(Credits : 4)

Course Description:

This course explores Environmental, Social, and Governance (ESG) principles in business education, focusing on sustainability governance, corporate responsibility, and integrated reporting. It equips students with the knowledge to analyze ESG factors, implement sustainable practices, and understand the impact of corporate actions on society and the environment.

Course Objective:

- Understand the Principles of Environmental Sustainability Governance
- Evaluate Corporate Sustainability Practices
- Analyze Environment, Social, and Governance (ESG) Factors
- Implement Integrated Reporting and Assurance Practices
- Develop ESG Disclosure Strategies

Course Outcomes:

After successfull completion of this course students should be able to:

CO1	Understand Environmental Social Governance	Understand
CO2	Analyse Corporate Sustainability Practices	Analyse
CO3	Integrate ESG Factors in Business Operation	Apply
CO4	Apply Tools and Methodologies for ESG Reporting	Apply
CO5	Engage in ESG Disclosures and Sustainability Leadership	Apply

Assessment Pattern:

Category	**Assessment Methods**			**Examination**
	Test 1	**Test 2**	**Seminar**	
Understand	30	30	30	30
Apply	40	40	40	40
Analyze	30	30	30	30

SYLLABUS

Module I : Introduction to Environmental Sustainability Governance

Definition and scope of environmental sustainability governance, Key concepts: policy-making, regulation, enforcement, and stakeholder engagement. Environmental Policy Analysis, Principles of policy analysis and evaluation, Tools and methodologies for assessing environmental policies, Case studies of successful and unsuccessful policy initiatives

Module II: Corporate Sustainability:

Overview, Debates surrounding corporate sustainability. Triple Bottom Line– meaning and components. Responsible Investing: Impact Investing, Social Impact Investing, ESG Investing. Corporate Social

Responsibility (CSR): Meaning, history and evolution, drivers of CSR, Sustainable development and CSR. Moral and economic arguments for CSR.CSR in India Overview, Provisions of the Companies Act, 2013.Corporate Environmental Responsibility. CER Frame work.

Module III: Environment, Social and Governance:

Relationship between business activities and environmental issues, impact of climate risks on the financial system; climate related physical and transition risks to business; Circular economy; Clean and technological innovation, green and ESG-related products; the Blue Economy. Environmental reporting: Significance, methods for measuring and reporting on environmental impacts- Ecological footprints. Social Factors– Stakeholders, key social concepts including human capital, development, employment standards, health and safety; product liability/consumer protection: safety, quality, health and demographic risks, and data privacy and security; stakeholder opposition/controversial sourcing. Social reporting: Significance, methods for measuring and reporting on social impacts. Governance Factors-Board structure, diversity, effectiveness, and independence; executive remuneration, performance metrics, and Key Performance Indicators (KPIs); Reporting and Transparency; financial integrity and capital allocation; Business ethics.

Module IV: Integrated reporting, Assurance and Verification

Integrated reporting: Overview of integrated reporting and its benefits. Key components of an integrated report. Examples of integrated reports and best practices for preparing them. Assurance and verification: Overview of assurance and verification in sustainability reporting. Types of assurance and verification (internal audit, external assurance). Best practices for selecting and working with assurance providers.

Module V: ESG Disclosures

Drivers for sustainability disclosures: Investor interest, consumer interest and regulatory bodies. Engaging with stakeholders- Customers, suppliers, employees and investors. Collaborative initiatives- Industry associations and multi-stakeholder partnerships. ESG Frameworks: Meaning, need for ESG reporting, principle of materiality– International Frameworks: Environmental Performance Index (EPI); Global Reporting Initiative (GRI); Carbon Disclosure Project (CDP); Sustainability Accounting Standards Board (SASB); United Nations Global Compact; Task Force on Climate related Financial Disclosures (TCFD) and Science Based Targets (SBT). Securities Exchange Board of India (SEBI)- Business Responsibility and Sustainability Report (BRSR). Sustainability leadership: Case studies of different industries.

References

1. 1. Aras, G. “A handbook of corporate governance and social responsibility”. CRC Press, 2016
2. Garima Dadhich, Ravi Raj Atrey. “Demystifying ESG – A Comprehensive Guide for Environmental – Social- Governance Integration and Practice”, Taxmann Publications (P) Ltd., New Delhi, 2024.
3. Baxi, C. V., & Prasad, A. (Eds.). “Corporate social responsibility: Concepts and cases: The Indian experience”. Excel Books India, 2005.
4. Mallin, C. A. (Ed.). “Corporate social responsibility: A case study approach”. Edward Elgar Publishing, 2009.
5. Matos, P. “ESG and responsible institutional investing around the world: A critical review”, CFA Institute Research Foundation, 2020.
6. Mondal, S., & Das, G. “Business, sustainable development & other emerging issues”. Sheba Blake Publishing, 2021.
7. Nemoto, N., & Morgan, P. J. “Environmental, social, and governance investment: Opportunities and risks for Asia”. Asian Development Bank Institute, 2020.
8. Prabakaran, S. “Business ethics and corporate governance”. Excel Books India, 2010.

25-815-0504: Environmental Microbiology

(Credits : 4)

Course Description:

This course will introduce students to the field of environmental microbiology- study of microbes in natural environment, its fundamental aspects and basic principles. Course also will provide an insight to the molecular aspects of microbiology, types of microbes present in the environment and its structure, reproduction mechanism and pathological aspects. By the end of the course students can understand and explain the basic principles of instruments used in microbiology, molecular microbiological aspects, structure and functions of various microorganisms in the environment.

Course Objectives:

Course aims to introduce basic biology students to the world of microbes. Students will familiarize with different types of microbes present in the environment, to isolate those microbes, identify and characterize them. Course will cover the structure, reproduction, clinical manifestations, epidemiology and preventive measures of different pathogens present in theenvironment.

Course Outcomes:

After successfull completion of this course students should be able to:

CO1	Explain the basics of microbiological techniques, isolation techniques and microscopy	Remember, Understand
CO2	Discuss the concept and goal of molecular microbiology, gene structure and regulation in bacteria	Remember, Understand
CO3	Describe the structure, function, nutrition and its uptake in bacteria, fungi, protozoa and algae	Remember, Understand
CO4	Discuss the structure, properties and cultivation of pathogenic viruses	Remember, Understand
CO5	Describe the microbial interactions, nutrient cycling, factors affecting their growth and microbial ecology	Remember, Understand

Assessment Pattern:

Category	**Assessment Methods**			**Examination**
	Test 1	**Test 2**	**Seminar**	
Remember	30	40	30	40
Understand	70	60	70	60

SYLLABUS

Module I : Introduction to Microbiology

History and scope of microbiology; Different kinds of media for isolation and study of microor ganisms; Microbiological water and sediment samplers; Microscope and microscopy; Concept of pure cultures and methods of obtaining pure cultures; Control of microorganisms by physical and chemical agents-

definitions, the pattern of microbial death, conditions influencing the effectiveness of antimicrobial agents:

Module II :Bacteria, Fungi

Bacteria: Cell structure: size, shape and arrangements, cell organization- cell membranes, cy toplasmic matrix, nucleoid, cell wall, components external to the cell wall- Bacterial endospores Bacterial nutrition- Common nutrient requirements- requirement for carbon, hydrogen, oxygen, nitrogen, phosphorous and sulphur, nutritional types, requirements for growth factors; Nutrient up take- Bacterial growth- Growth curve, mathematics of growth, measurement of microbial growth, continu ous culture of microorganisms. Fungi: Basic concepts, distribution, importance, structure, nutrition and metabolism, reproduction, characteristics of fungal division and classification.

Module III: Protozoans and Microalgae

Protozoans: Basic concepts, distribution, importance, morphology, nutrition, encystment and excystment, locomotor yorganells, reproduction and classification. Algae: Basic concepts, distribution, structure, algal nutrition, algal reproduction, characteristics, classification.

Module IV: Viruses

Early development in virology; General properties of viruses; Cultivation of viruses; Structure of viruses; Bacteriophages-classification and replication. Viroids and prions; Virus vaccines and interferons.

Module V : Microorganisms Interaction and Microbial Ecology

Foundations of microbial ecology and microbial interactions- mutualism, cooperation, commensalisms, predation, parasitism, amensalism, competition, symbiosis in complex systems; Influence of environmental factors on growth- solute and water activity, pH, temperature, oxygen concentration, pressure, radiation; quorum sensing, and microbial populations; Microenvironment and niche, biofilm and microbial mats, microorganisms and ecosystems, microorganism movement between ecosystems.

References

1. Clark,D.P.;(2010). Molecular Biology .Elsevier Inc. Amsterdam.
2. Daniel, D. C. ;(2012). Environmental Science . 9th Edition Jones & Bartlett Learnng
3. Flint,S.J.;Enquist,L.W.;Racaniello,V.R.;Skalka,A.M.;(2009). Principles of Virology. (3rd Edition) ASM Press, Washington ,DC.
4. Fulekar,M.H.;(2010). EnvironmentalMicrobiology .SciencePublishersCRCPressTaylor & FrancisGroup.
5. Gerald,K.;(2010). CellBiology .6th Edition International Student Version John Wiley & Sons, Limited, Willey-Blackwell, USA.
6. Jeffrey, C.; Pommerville.; (2004). Alcamos Fundamentals of Microbiology .7th Edition Jones & BartlettPub lishers.
7. Prescott,L.M.;HareleyJ.P.;Klein,D.A.;(2005). Microbiology .(6thEdition).McGraw Hill Publishing Co.Ltd.
8. RainaM.M.;IanL.P.;Charles,P.G.;(2006). Environmental Microbiology Elsevier, Academic Press, San Diego, CA,USA

25-815-0505: Geo-informatics LAB

(**Credits : 3)**

Course Description:

This course provides practical skills and knowledge in Geographic Information Systems (GIS) and Remote Sensing, with a focus on environmental analysis and sustainability. Students will learn to process, analyze, and visualize spatial data to address key environmental challenges such as climate change, land-use planning, and biodiversity conservation. The program emphasizes environmental mapping techniques, teaching participants how to create high-quality maps using geospatial tools like QGIS, ArcGIS, and Google Earth Engine. Students will work with satellite imagery, raster and vector data, and integrate diverse datasets for effective environmental assessments. Practical field data collection methods form a key component of the course. This bridges field observations with digital geospatial analysis. A strong focus is placed on spatial analysis techniques for evaluating environmental impacts, modeling changes over time, and identifying patterns crucial for sustainable decision-making. Real-world case studies and projects provide opportunities to apply these skills to pressing environmental issues.

Course Objective:

By the end of the course, students will be well-equipped to conduct environmental assessments, create detailed maps, and analyze spatial data to support research, policy-making, and management efforts. It balances theory with hands-on practice, preparing learners for real-world applications. This course aims to

- Develop practical skills in GIS and Remote Sensing applications for environmental analysis
- Master environmental mapping techniques using geospatial tools
- Learn field data collection methods for environmental monitoring
- Gain hands-on experience with spatial analysis for environmental assessment

Course Outcomes:

After successfull completion of this course students should be able to:

CO1	Demonstrate proficiency in GIS software operations and spatial database management	Apply
CO2	Apply field techniques for environmental data collection and processing using GPS and remote sensing	Analyze
CO3	Create and analyze environmental maps for various applications	Analyze
CO4	Perform advanced spatial analysis and environmental impact assessments	Analyze

Assessment Pattern:

Category	Assessment Methods			Examination
	Test 1	Test 2	Seminar	
Understand	20	20	20	20
Apply	40	40	40	40
Analyze	40	40	40	40

SYLLABUS

Module I :

Introduction to GIS Software ; Data input and basic mapping ; Coordinate systems and projections ; Creating and editing spatial databases

Module II :

Environmental Data Collection and Processing ; GPS field data collection techniques ; Remote sensing data acquisition ; Data conversion and integration

Module III :

Environmental Mapping Techniques ; Land use/land cover mapping ; Watershed delineation ; Air pollution mapping ; Natural resource mapping ; Hazard zone mapping

Module IV :

Advanced Environmental Analysis ; Spatial regression analysis ; Network analysis for environmental studies ; Geo-statistical analysis ; Environmental impact assessment

Module V :

Environmental Data Visualisation ; Creating thematic maps ; Interactive visualisation techniques ; Dashboard creation ; Report generation and map layouts

References

1. Xuan Zhu 2016 GIS for Environmental Applications - A practical approach, Routledge
2. Stan Aronoff,1989. Geographic Information Systems: A Management Perspective, WDL Publ.
3. Kang Tsung Chang, 2006. Introduction to Geographic Information Systems McGraw-Hill
4. Lavender, S., and Lavender, A., 2023. Practical Handbook of Remote Sensing, Routledge

SEMESTER VI

25-815-0601: Environmental Engineering Paper I

(**Credits : 4**)

Course Description:

Engineers and scientists from a number of related disciplines have been involved in the development of an academic basis for the understanding and management of the environment. During the last few years, schools of engineering have made considerable progress towards bringing the principles drawn from the related academic disciplines together and unifying them under Environmental Engineering. This subject gives an overview of the scope of Environmental Engineering and the important aspects covered by this branch of engineering.

Course Objectives:

Environmental Engineering as a branch of engineering is concerned with protecting the environment from the potentially deleterious effects of human activity, protecting the human population from the adverse environmental factors, and improving environmental quality for human health and wellbeing. The objective is to give the students an introduction to the basic principles of Environmental Engineering, the major related activities like wastewater treatment, public water supply, air pollution control and solid waste management, and the role of environmental engineers in these activities.

Course Outcomes:

After successfull completion of this course students should be able to:

CO1	Explain the scope of Environmental Engineering, the various activities forming part of it and the role of an Environmental Engineer in environmental management programs	Understand
CO2	Illustrate the use of chemical engineering principles in Environmental Management systems.	Apply
CO3	Understand the process of conventional treatment of water and design of water treatment system.	Apply
CO4	Explain water distribution system and water supply in buildings	Understand
CO5	Interpret Plumbing, sanitary fittings and their requirements for a small building and large housing complexes	Understand

Assessment Pattern:

Category	**Assessment Methods**			**Examination**
	Test 1	**Test 2**	**Test3**	
Understand	30	30	30	30
Apply	40	40	40	40
Analyze	30	30	30	30

SYLLABUS

Module I :

Role of environmental Engineers. Basic engineering principles in environmental management. Chemical Engineering - Basic Laws, Units & Dimensions: Law of conservation of matter. Law of conservation of energy. Material balance and energy balance. Molal units. Molarity, Molality and Normality. Ideal-gas law. Dalton's Law. Avogadro's Hypothesis. Raoult's Law. Dimensions and dimensional formulas. Dimensionless equations and consistent units. Concept of dimensional analysis. Use of dimensional analysis in solving problems. Stoichiometric and composition relations. Concept of unit operations and unit processes. Fluid Flow – Newton's law of viscosity, Flow of fluid in a pipe. Velocity of flow, laminar flow and turbulent flow, Reynolds Number, Bernoulli's Equation and its applications, Equivalent lengths and pressure drop for flow through a pipe. Agitation and mixing – Purpose and Equipments. Transport of solids – Conveyors.

Module II :

Role of environmental Engineers. Basic engineering principles in environmental management. Chemical Engineering - Basic Laws, Units & Dimensions: Law of conservation of matter. Law of conservation of energy. Material balance and energy balance. Molal units. Molarity, Molality and Normality. Ideal-gas law. Dalton's Law. Avogadro's Hypothesis. Raoult's Law. Dimensions and dimensional formulas. Dimensionless equations and consistent units. Concept of dimensional analysis. Use of dimensional analysis in solving problems. Stoichiometric and composition relations. Concept of unit operations and unit processes. Fluid Flow – Newton's law of viscosity, Flow of fluid in a pipe. Velocity of flow, laminar flow and turbulent flow, Reynolds Number, Bernoulli's Equation and its applications, Equivalent lengths and pressure drop for flow through a pipe. Agitation and mixing – Purpose and Equipments. Transport of solids – Conveyors.

Module III :

Hydrological concepts – hydrological cycle – Sources of water – Intakes – types of intakes – infiltration galleries – infiltration well – storage reservoirs – types of wells – sanitary protection of wells. Quality of water - portable water and mineral water - contamination of water - sampling techniques - analysis of water - Bacteriological analysis- water borne diseases – water quality standards. Transportation of water – Hydraulics of pipe flow – pipes & its types – design of pipes – Joints – pipe appurtenances – pumps – types of pumps – selection of pumps.

Module IV :

Treatment of water- working principles of unit operations and unit process of water treatment, Purpose and its design features – screening – plain sedimentation – coagulation sedimentation – filtration – disinfection – water softening and desalination– Operation & Maintenance aspects. Removal of Iron and Manganese – Fluoridation and defluoridation– distribution of water – planning – Methods of distribution – Service Reservoirs – purpose – types – locations and height – Design aspects – requirements of good distribution system – layout of distribution system.

Module V :

Sewage and sullage. Sewerage systems. Different types/stages of sewage treatment at city level-Sewer line, gradients, manholes, inspection chambers. One pipe/ two pipe plumbing systems. Sewage treatment at campus/ building level -sewage treatment plants, septic tank, leach pits. Sustainable practices and systems. Storm water drains at city level. Types of pipes. Storm water gutter. Drainage systems in small building and large housing complexes. Roof drainage. Rain water harvesting and storage sumps. Sustainable practices and systems.

References

1. Salil K Ghosal, Shyamal K Sanyal, Siddhartha Datta, “Introduction to Chemical Engineering”, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2017.
2. David M Himmelblau, “Basic Principles and Calculations in Chemical Engineering”, Pearson Education, 2015.
3. Manual on “Sewerage and Sewage Treatment Systems Part A, Part B & Part C” CPHEEO, Ministry of Urban Development, Government of India, New Delhi, 2013.
4. Garg. S.K., "Water Supply Engineering", Khanna Publishers, Delhi, September 2008
5. Punmia B.C, Arun K. Jain, Ashok K.Jain, “Water supply Engineering” Lakshmi publication private limited, New Delhi, 2016.
6. G.M. Fair, J.C. Geyer and D. Okin, ’Water and Waste Water Engineering Volume II’, John Wiley and Sons, Inc. New York, 2010.
7. S.C. Rangwala, ’Water Supply and Sanitary Engineering’, Charotar Publishing House, 2016.

25-815-0602: Environmental Toxicology

(**Credits : 4**)

Course Description:

This course in Environmental Toxicology is designed to provide a comprehensive overview of key concepts and practical applications in the field. Students explore toxicology's history, scope, and evolution, dose-response relationships, and factors influencing toxicity. Students learn about toxicity testing methods, acute and chronic toxicity tests, environmental fate of contaminants and molecular biology applications in ecotoxicology. Students will gain practical knowledge and skills in toxicity assessment, biomarker analysis, and understanding the molecular mechanisms of toxicity. The course covers harmful effects classification of chemicals, genetic factors in chemical accumulation, and immune responses to toxic substances. Additionally, students study animal metabolism of toxic substances, including uptake, transport, and storage. By course end, students gain a solid foundation in assessing and managing the impact of toxic substances on the environment and living organisms, preparing them for careers in environmental science, toxicology, and related fields.

Course Objective:

The course aims to provide information on the scope and application of toxicological principles, measures, and factors. It also covers various standards for toxicology testing to assess environmental pollution. Students will learn about contaminants, their fate, toxicity in the environment, toxicity testing principles and statistical concepts, along with the environmental fate of contaminants and emerging issues. The course will also focus on applications in ecotoxicology, which is crucial for analyzing environmental pollution in the present scenario of toxic exposures.

Course Outcomes:

After successfull completion of this course students should be able to:

CO1	Understand the fundamental principles of environmental toxicology, including toxicant classification, dose-response relationships, and mechanisms of toxicity.	Understand
CO2	Analyze the impact of toxicants on biological systems by interpreting bioaccumulation, biomagnification, and species sensitivity distributions in ecotoxicological studies	Analyse
CO3	Critically evaluate environmental risk assessment methodologies, including hazard identification, exposure assessment, and risk characterization, to determine their effectiveness in managing environmental health risks	Evaluate
CO4	Demonstrate the application of environmental monitoring techniques, toxicity assays, and analytical tools for assessing environmental contamination and toxicological effects.	Apply
CO5	Implement remediation strategies such as bioremediation and regulatory frameworks for managing contaminated environments and mitigating toxicant impacts.	Apply

Assessment Pattern:

Category	Assessment Methods			Examination
	Test 1	Test 2	Seminar	
Understand	20	20	20	20
Apply	30	30	30	30
Analyze	30	30	30	30
Evaluate	20	20	20	20

SYLLABUS

Module I : Introduction to Environmental Toxicology

Overview of Toxicology- Definition and scope of toxicology, Historical developments in toxicology, Toxicants and their source- Types of toxicants, Natural vs anthropogenic source, Environmental distribution and fate. Basic Principles of Toxicology- Dose-response relationship, Threshold and non-threshold effects, LD50, LC50, EC50, NOEL, LOEL, Acute toxicity, chronic toxicity.

Module II : Mechanisms of toxicity

Routes of Exposure- Inhalation, ingestion, and dermal exposure, Factors affecting absorption and distribution. Mechanisms of action- Cellular and molecular mechanisms. Toxicokinetics and toxicodynamics- Absorption, distribution, metabolism, excretion (ADME) (phase 1 and phase II reactions). Biotransformation and detoxification mechanisms. Toxicity assays- Bioassay, types, methodologies and application.

Module III : Ecotoxicology

Species sensitivity distributions, Biomarkers and bioindicators, Bioavailability and bioaccumulation, Biomagnification, Bioconcentration factor, Population and community effects, Ecosystem-level impacts. Specific toxicant case studies- mercury bioaccumulation, neonicotinoid impacts, EDCs, microplastics.

Module IV : Environmental Risk assessment

Sampling and analytical methods- Environmental monitoring techniques. Hazard identification, exposure assessment, dose-response assessment, risk characterization, ecological risk assessment-Methods and approaches. Case studies of Environmental Disasters. Testing protocols and guidelines. Uncertainty in Risk Assessment, Modern approaches to risk assessment.

Module V : Remediation and Management of contaminated environments

Techniques for soil and water remediation, Bioremediation: principles and applications. Regulatory frameworks- Major environmental legislation Clean Water Act, TSCA), International agreements (Stockholm Convention, Minamata Convention). Global regulatory perspectives, Community engagement in contaminated site management.

References

1. Environmental toxicology; John H. Duffs, 1980, Edward Arnold Publishers, New Delhi.
2. Elements of toxicology; J. P Shukla and Pandey, Radha Publishers, New Delhi.

3. Effects and Dose- response Relationships of Toxic metals- Nordberg.G, Elsevier Scientific Publishing Co.,New York.
4. Modern Trends in Toxicology ; Boy land E.and Goulding R, Butter worth's , London.
5. Essentials of Toxicology (IV) ; Loomis T. A. and A. Wallace, Hayes Academic Press, London.
6. Harper's Biochemistry; Murray et al., Apple ton and Lange, (1998), Prentice Hall, London.
7. Basic Environmental Toxicology; L.G. Cockerham and B.S. Shane, (1994), CRC Press, Boca Raton, USA.
8. Environmental Toxicology and Chemistry; Donald G. Crosby, (1998), Oxford University Press, Boca Raton, USA.
9. Gerrit Schuurmann and Bernd Markert (1998). Ecotoxicology. Spektrum Akademischer Verlag Co-publication Heidelberg. Berlin.
10. Walker C.H. Hopkin S.P. Sibly R.M and Peakall D.B (2001). Principles of Ecotoxicology. Second Edition, Taylor & Francis, London.
11. Clive Thompson K. Kirit Wadhia and Andreas P. Loibner (2005). Environmental Toxicity Testing . Blackwell Publishing Ltd. CRC Press.
12. Foekema E.M. Th. Scholten M.C. Van Dokkum H.P . Kaag N.H.B.M and Jak R.G (2005).
13. Laura Robinson. Ian Thorn (2005). Toxicology and Ecotoxicology in chemical safety Assessment. Black well Publishing Ltd. CRC Press.
14. Karen E Stine. Thomas M. Brown (2006). Principles of Toxicology, Second Edition, Taylor & Francis Group. CRC Press.
15. Michael C Newman and William H Clements (2008). Ecotoxicology. Taylor & Francis Group. CRC Press.
16. Environmental Toxicology, an open online textbook (2023) By Sylvia Moes ; Kees van Gestel ; Gerco van Beek.

25-815-0603: Environmental Policies and Law

(**Credits : 4**)

Course Description:

This course outcomes and cognitive levels ensure that students not only gain knowledge of environmental policies and legislations but also develop the critical thinking and analytical skills required to evaluate, apply, and innovate solutions for current and future environmental challenges in India. It also sets the foundation for further exploration into more sector-specific environmental legislations and challenges in India, providing students with a comprehensive understanding of environmental policy and law in the Indian context.

Course Objective:

- To familiarize students with the evolution of environmental policies in India and critically analyze the implementation of policies and legislation in addressing environmental challenges in India.
- To understand the constitutional provisions and environmental rights in India.
- To understand the key environmental laws and regulations in India.
- To explore the sector specific environmental legislations in India and their challenges and application.

Course Outcomes:

After successfull completion of this course students should be able to:

CO1	Understand the evolution and importance of environmental policies and legislations in India. Students will gain a comprehensive understanding of the key environmental issues and policies that have shaped India's environmental legal framework.	Remember
CO2	Assess the role of international environmental frameworks and India's commitment to global environmental governance. Students will understand India's role in international environmental conventions and agreements like the Paris Agreement, Kyoto Protocol, etc.	Understand
CO3	Analyze the constitutional provisions and their impact on environmental protection in India. Students will be able to evaluate the role of constitutional principles and judicial activism in protecting environmental rights.	Evaluate
CO4	Examine and critically evaluate the major environmental laws and regulations in India. Students will be able to assess the effectiveness of various environmental laws such as the Environment Protection Act, Water and Air Pollution Acts, and more.	Evaluate

CO5	To explore the sector specific environmental legislations in India and their challenges and application. The learner will be able to apply the provisions of these laws to practical situations. They will also be able to compare different laws and determine how they address various aspects of environmental protection.	Apply

Assessment Pattern:

Category	Assessment Methods			Examination
	Test 1	Test 2	Seminar	
Remember	50			20
Understand	50	50		30
Apply			40	20
Evaluate		50	60	40

SYLLABUS

Module I : Introduction to Environmental Policies and Legislation

Evolution of Environmental Policies in India; The National Environment Policy, 2006; Role of Government in Environmental Protection - Key Environmental Institutions: MoEFCC, CPCB, SPCB, NGT; Environmental Policy Shifts and Global Influence - India's Global Commitment to the Environment: United Nations Conference on the Human Environment (Stockholm 1972), United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement (2015); The National Action Plan on Climate Change (NAPCC).

Module II : Constitutional Provisions and Environmental Rights

The Constitution of India and Environmental Protection - Fundamental rights: Article 21 (Right to Life and Personal Liberty), Directive Principles of State Policy (DPSP): Article 48A (Protection of Environment) and Article 51A(g) (Duty of citizens to protect and improve the environment); Judicial Activism in Environmental Protection - Landmark cases such as M.C. Mehta vs. Union of India, Vellore Citizens Welfare Forum vs. Union of India, and T.N. Godavarman Thirumulpad vs. Union of India, etc.

Module III : Environmental Laws in India

The Wildlife Protection Act, 1972; The Water (Prevention and Control of Pollution) Act, 1974; The Air (Prevention and Control of Pollution) Act, 1981; The Forest Conservation Act, 1980; The Environment Protection Act, 1986 – Rules and Notifications; The Public Liability Insurance Act, 1991; The Chemicals Weapons Convention Act, 2000; The Energy Conservation Act, 2001; The Biological Diversity Act, 2002; The Forest Rights Act, 2006 (FRA); The National Green Tribunal (NGT) Act, 2010.

Module IV : Sector-Specific Environmental Legislation

Construction and Demolition Waste Management Rules, 2016; Industrial Pollution Control – Legal framework, Heavy Industries (e.g., Steel, Cement, Power Plants), Textile and Dyeing Industry; Mining Sector Regulations - The Mines and Minerals (Development and Regulation) Act, 1957, The Forest (Conservation) Act, 1980; Agriculture and Pesticides Regulation - The Insecticides Act, 1968, National Policy for Farmers, 2007; Waste Management and Pollution Control in the Chemical and Pharmaceutical Industries - The Hazardous Waste (Management, Handling, and Trans-boundary Movement) Rules, 2016, The Biomedical Waste Management Rules, 2016, MSW (Management & Handling Rules, 2016,

Renewable Energy and Green Technologies - The National Action Plan on Climate Change (NAPCC), 2008, The Energy Conservation Act, 2001; Forest and Wildlife Protection – Legal framework, Forestry and Land use; Climate Change and Emission Regulations - The Carbon Credit Trading Scheme (India, 2023), The National Clean Development Mechanism (CDM) Strategy, Sector-Specific Application: Power and Manufacturing Sectors; Plastic Waste Management - The Plastic Waste Management Rules, 2016; Maritime and Coastal Regulation - The Coastal Regulation Zone (CRZ) Notification, 2011, The Merchant Shipping Act, 1958.

References

Books:

1. Environmental Law and Policy in India by Shyam Divan and Armin Rosencranz, Oxford University Press. 2001.
2. Indian Environmental Law by R.K. Pateriya, K.K. Law Agency. 2003.
3. “Indian Environmental Law” by R.K. Pateriya.
4. “Environmental Legislation in India” by M.C. Mehta.

Journals and Reports:

1. Environmental Reports by Ministry of Environment, Forests and Climate Change (MoEFCC).
2. Journal of Environmental Law and Policy.

25-815-0604: Advanced Applied Biology LAB

(Credits : 4)

Course Description:

This advanced laboratory course integrates principles of ecotoxicology with molecular biology and cell culture techniques. Students will gain hands-on experience in assessing the molecular and cellular effects of contaminants, providing a comprehensive understanding of ecotoxicological mechanisms. The course will cover advanced techniques such as genotoxicity assays, gene expression analysis, and cell culture-based toxicity testing.

Course Objective:

The objective of this course is to equip students with a comprehensive understanding of the molecular and cellular mechanisms of ecotoxicity. They gain practical skills in molecular biology techniques relevant to ecotoxicology and learn cell culture techniques for assessing the effects of contaminants on cell viability and function. The course aims to integrate molecular and cellular data with ecological endpoints for comprehensive ecotoxicological assessments and apply advanced ecotoxicological techniques to real-world environmental issues.

Course Outcomes:

After successfull completion of this course students should be able to:

CO1	Students will grasp the molecular and cellular mechanisms of ecotoxicity, including genotoxicity, gene expression changes and cytotoxicity by contaminants.	Understand
CO2	Analyze molecular and cellular data, interpreting genotoxicity assays, quantifying gene expression changes, and assessing cell viability and function	Analyse
CO3	Apply molecular biology techniques like PCR and gene expression analysis, along with cell culture methods, to assess contaminant effects.	Apply
CO4	Evaluate molecular and cellular data's significance, integrating it with ecological endpoints to understand broader contaminant exposure implications	Evaluate

Assessment Pattern:

Category	**Assessment Methods**			**Examination**
	Test 1	**Test 2**	**Seminar**	
Understand	20	20	20	20
Apply	30	30	30	30
Analyze	30	30	30	30
Evaluate	20	20	20	20

SYLLABUS

1. DNA Extraction and Quantification:
Students extract DNA from environmental samples, quantify it using spectrophotometry, and assess DNA quality.

2. Gene Expression Analysis:
Using RT-PCR, students analyze the expression of specific genes in response to contaminants in model organisms/cell lines, comparing them to control samples.

3. Cell Culture Maintenance and Techniques:
Students culture cell lines (eg. Fish, Mammalian), maintaining them under sterile conditions and applying basic cell culture techniques.

4. Linking Molecular and Cellular Responses to Ecological Effects:
Through case studies, students analyze how molecular and cellular responses to contaminants translate into ecological impacts.

5. Application of Molecular and Cellular Techniques in Environmental
Monitoring: Students apply molecular and cellular techniques to analyze environmental samples, identifying contaminants and assessing their effects.

References

1. Cell and Molecular Biology: Concepts and Experiments, Gerald Karp, Sixth Edition
2. Freshney's Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications by R. Ian Freshney, Eighth Edition
3. Molecular Cloning- A laboratory Manual, by Michael R Green and Joseph Sambrook, Fourth Edition.
4. Ted A. Loomis and A. Wallace Hayes., 1996. Essentials of Toxicology Fourth edition, Academic press, Inc. London.

List of Elective Courses with level 300

25-815-L3E1: Mathematical and Statistical Applications in Environmental Science.

(**Credits : 4**)

Course Description:

Environmental sciences and technology are rapidly expanding with an increased need for more quantitative analysis of the data. Mathematics, statistics and computers are becoming more important to the environmental science work force. The students are expected to appreciate the usefulness of differential and integral calculus, differential equations and statistical techniques to relate the mathematics of environmental science problems in their real life.

Course Objectives:

The main objective of this course is to provide student basic calculus and statistical skills to develop mathematical models for environmental sciences, to help analyse data, and to use mathematics software for solving environmental science problems. This course is an engaging introduction to differential and integral calculus, differential equations and statistical analysis for environmental sciences. The central themes of the course will be functions as mathematical models for life science problems, and determination and analysis of these functions by using differentiation and integration tools and computer software.

Course Outcomes:

After successfull completion of this course students should be able to:

CO1	Estimate the derivatives and integrals of moderate complexity involving polynomials, exponentials, and logarithms	Apply
CO2	Discuss the basic statistical methods to solve problems and ability to operate various statistical software packages	Understand
CO3	Describe various environmental models with basic functions: linear, polynomial, exponential, logarithmic, and trigonometry.	Understand
CO4	Apply methods from discrete and continuous dynamical systems to solve problems from environmental science.	Apply
CO5	Classify the trends in environmental data with analysing graphs and fitting trends	Apply

Assessment Pattern:

Category	**Assessment Methods**			**Examination**
	Test 1	**Test 2**	**Seminar**	
Remember	20	20	20	20
Understand	40	40	40	40
Apply	40	40	40	40

SYLLABUS

Module I: Environmental Data Analysis and Statistical Techniques

Collection, Classification, and Tabulation of Environmental Data; Frequency Tables; Diagrammatic and Graphical Representation: Bar Charts, Pie Charts, Histograms, Frequency Polygons, and Cumulative Frequency Curves; Measures of Central Tendency and Dispersion: Mean, Median, Mode, Range, Standard and Relative Deviation, Coefficient of Variation, Advanced Statistical Distributions: Skewness, Kurtosis, Confidence Limits, and Confidence Intervals, Application of Normal Distribution in Environmental Data Interpretation, Analysis of Variance (ANOVA) in Environmental Science: One-Way and Two-Way Classification, Probit Analysis and its Application in Toxicology and Environmental Risk Assessment

Module II: Probability, Correlation, and Hypothesis Testing

Accuracy, Precision, and Error Minimization in Environmental Data Collection, Statistical Testing: Z, t, F, and χ^2 in Environmental Hypothesis Testing, Correlation and Regression Analysis: Pearson's and Spearman's Coefficients, Regression Models, Curve Fitting Techniques for Environmental Trends and Anomaly Detection, Probability Theory: Exclusive and Independent Events, Addition and Multiplication Theorems, Dependent Events and Conditional Probability in Environmental Risk Assessment

Module III: Advanced Calculus and Optimization

Derivatives and Rates of Change: Conceptual and Computational Aspects; The Derivative as a Function-Advanced Differentiation Techniques, The Product, Quotient, and Chain Rules- Applications in Environmental Modeling, Exponential Growth and Decay, Mathematical Modeling in Environmental Systems, Linear Approximation and Taylor Series Expansion for Environmental Applications, Applications of Derivatives: Optimization in Ecological and Resource Management, Maximum and Minimum Values, Increasing and Decreasing Functions – Concavity and Graphing with Computational Tools, L'Hospital's Rule: Indeterminate Forms in Environmental Data Analysis, Optimization Problems in Environmental Science and Engineering

Module IV: Integral Calculus and Multivariable Functions

Integrals in Environmental Contexts: Areas, Distances, and Accumulated Changes, The Definite Integral and the Fundamental Theorem of Calculus, Integration Techniques: Substitution Rule, Integration by Parts, Applications: Area Between Curves, Environmental Data Averaging, Volume Computations, Multivariable Calculus: Functions of Several Variables, Partial Derivatives, and their Applications in Environmental Modeling, Gradient and Directional Derivatives: Impact on Environmental Gradients and Diffusion Processes

Module V: Differential Equations in Environmental Systems

Modeling with Differential Equations: Population Dynamics, Pollution Dispersion, and Climate Models, Phase Plots, Equilibria, and Stability Analysis, Direction Fields and Separable Equations in Environmental Time-Series Analysis, Systems of Differential Equations: Coupled Environmental and Ecological Systems, Phase Plane Analysis and Stability of Ecological Equilibria, Qualitative and Quantitative Approaches to Linear and Nonlinear Differential Equations, Applications in Hydrology, Climate Change, and Resource Management

References

1. Marvin, L. B.; Neal, B.; John, Q.; (2008). - Calculus for the Life Sciences‖, Pearson Custom Publishing.
2. James, S.; Troy D.; (2015). -Biocalculus: Calculus for the Life Sciences‖. Cengage Learning,
3. Barnett Vic.; (2003). Environmental Statistics: Methods and Applications‖. JohnWiley & Sons, NewYork.
4. Frank S. Budnick (2017), Applied Mathematics for Business, Economics and Social Sciences, McGraw Hill Education.
5. Carsten Dormann (2020), Environmental Data Analysis, Springer Cham,
6. Bryan F.J. Manly (2000), Statistics for Environmental Science and Management, CRC Press
7. Linfield C. Brown & Paul Mac Berthouex (2002), Statistics for Environmental Engineers, CRC.
8. W. E Boyce, R. C. & D. B. Meade (2017), Diprima, , Elementary Differential Equations and Boundary Value Problems, Wiley.
9. William E. Boyce & Richard C. DiPrima(2017), Elementary Differential Equations and Boundary Value Problems, Wiley.
10. Douglas C. Montgomery & George C. Runger, (2016), Applied Statistics and Probability for Engineers, Wiley.

25-815-L3E2: Fluid Mechanics

(**Credits : 4**)

Course Description:

The study of Fluid Mechanics is designed in the curriculum of M Sc. Environmental Science & Technology, to acquire the knowledge of the dynamics of fluid to learn the functioning of natural systems. Leaners can design reactors and create systems that work under mass, & energy balanced, as well as kinetically controlled conditions. Syllabus is structured to enable them to utilize course objectives achieved in the professional practice of the domain knowledge of Environmental Science & Technology in their future career to work as Environmental Expert/ Scientist or Faculty. Course is to identify, evaluate, apply, determine the performance and create engineering systems. Fluid Mechanics is the branch of physics discusses and deals the mechanics of liquids, gases and plasmas and the changes it bears under forces on them. It has vivid and wide applications in Environmental Science and Engineering. Fluid mechanics has sections (1) Fluid Statics- study of fluid at rest, (2) Fluid Dynamics- the study of the effect of forces on fluid motion. The methods for visualizing and analyzing fluid flow- calculations of mass flow, volume flow, description of viscous behavior, flow measurement, frictions, discharges, resistance to flow, pressure head calculations, links and connections in reactor operations and monitoring programs of natural flow systems are the practices followed in the study of environmental systems by this disciple. Fluid Mechanics is included in the program as a bridging course to connect the gap where science graduates lack the foundation of engineering and physics concepts for the realization of natural and created systems.

Course Objectives:

To expose the students to acquire the theory and practices of Fluid Mechanics and Calculations for the study of fluid systems on a solid basis, for learning Environmental Science and Technology courses, conducting laboratory practicals, study models and simulations to equip them leadership for creative decision making as lead scientists and engineers.

Course Outcomes:

After successfull completion of this course students should be able to:

CO1	Understand the importance of volume and mass flow, mass and energy balances, rate of accumulation, residence time, area-velocity calculations, force, pressure inter conversion of units and importance application of physical systems and parameters in environmental systems.	Understand
CO2	Basic aspects specific properties of fluid, their classification, Newtonian behavior, viscous and pressure forces in fluid dynamics are made strong to understand the situations where they are prominent	Understand
CO3	Practical application of Fluid Mechanics in relation with environmental engineering systems is achieved, based on the prominent fundamental rules. Measurement of flow and use of flow devices are become thorough.	Apply
CO4	More practical applications of Fluid Mechanics are attained -for evaluating the flow characteristics, resistance due to roughness and uses of diagrams for decision making and reporting.	Analyse

CO5	Evaluation of the extent of restrictions in pipe flow systems, calculation of head losses during distributions and settling velocity during sedimentation process in water, wastewater and natural flow systems.	Evaluate

Assessment Pattern:

Category	**Assessment Methods**			**Examination**
	Test 1	**Test 2**	**Seminar & Assignment**	
Remember	10	10	10	10
Understand	20	20	20	20
Apply	20	20	20	20
Analyze	20	20	20	20
Evaluate	30	30	30	30

SYLLABUS

Module I : Basic Computations

Volume and volume flow rate, mass and mass flow rate, velocity and area relations, rate of accumulation of mass, mass and energy balance concepts, calculation of area of cross section, surface area and volume of spheres, cylinders, pipes, channels, storage tanks and other bodies. Calculation of velocity, density, mass flow rate, volumetric flow rate, residence time in equipment and other parameters. Units of measurement and conversion factors. Properties of fluids. Temperature, pressure, specific gravity, density, specific volume, viscosity and other properties of fluids. Units of measurement and conversion factors.

Module II : Properties of Fluid

Absolute and relative density, specific weight, shear stress and viscosity. Newton‘s law of viscosity, viscosity units and their conversion factors. Kinematic viscosity, surface tension, capillarity, compressibility, bulk modulus of elasticity, velocity of propagation of sound and sample calculations. Fluid statics: Pressure, pressure in compressible fluids, forces on plane surfaces, center of pressure, absolute pressure, static and dynamic system, force, concept of hydraulic jack, piezometric surface and hydraulic grade line. Head, pressure head, elevation head, velocity head and sample calculations.

Module III : Energy equation and its applications

Bernoulli‘s equation and its practical applications, energy equation, energy line, kinetic energy, correction factor, power, liquid atomizer. Torricelli‘s law, measurement of flow rate: orifice meter, venturi meter, rotameter, pitot tube. Other devices like weirs and notches. Non-uniform flow: classification of flow, steady flow, uniform flow, and irrotational motion, Reynolds‘s number, Hagen- Poiseuille‘s law, friction head loss, minor head loss, and sample calculations.

Module IV : Turbulent flow

Fanning equation, critical Reynolds‘s number, pipe flow, smooth and rough pipes, velocity distribution, friction factor, friction factor chart and commercial pipes. Moody diagram, Resistance at bends and other restrictions, equivalent length and k-values. Pipe flow systems: Friction head, Darcy- Weisbach equation. Competing forces, gravity and friction, Stoke‘s law. Drag coefficient, Sphere Reynolds‘s number, settling velocity and sample calculation.

Module V : Pipe Flow Systems

Resistance at bends and other restrictions, equivalent length and k-values. Pipe flow systems: Friction head, Darcy-Weisbach equation. Competing forces, gravity and friction, Stoke’s law. Drag coefficient, Sphere Reynolds’s number, settling velocity and sample calculation.

References

1. Judd S and Stephenson T, Edr. (2005). Process Science and Engineering for Water and Wastewater Rreatment, Vol. 4, IWA Publishing , 2005, ISBN electronic: 9781780402895, DOI: https://doi.org/10.2166/9781780402895.
2. V S Achari (2024) Fluid Mechanics For Environmental Systems, Teaching Materials, School of Environmental Studies, Cochin University of Science & Technology, Kochi- 682 022.
3. Boon R. C and V. S. Achari (2001). Flow Mechanics and Sedimentation, Bridging Course 0.2 Study Material, School of Environmental Studies, Cochin University of Science and Technology, Cochin.
4. Kundu P. K. and Ira M. Cohen (2010). Fluid Mechanics, Fourth Edition, ,ISBN: 0123814006, 9780123814005, Academic Press, New Delhi.
5. Modi P. N and S. M. Seth (2019). Hydraulics and Fluid Mechanics including Hydraulic Mechanics (in SI Units), 22 nd Edition, ISBN, 13: 9788189401269 , Standard Book House, New Delhi.
6. Chin D. A. (2020). Water Resources Engineering, e- Text Book, 4 th Edition, ISBN -13-9780135357750, Pearson
7. Subrahmanya K. (2002). Theory and Applications of Fluid mechanics: Including Hydraulic Mechanics, ISBN: 9780074603697, Tata McGraw-Hill Publishing Company Limited, New Delhi.
8. Harry Von Huben (1995). Basic science concepts and applications(Principles and practices of water supply operations), second edition,ISBN 10: 0898677963 ISBN 13: 9780898677966 American Water Works Association,
9. Price J.K (1998). Applied Math for Wastewater Plant Operators, ISBN: 0877628092, 9780877628095, C R C Press.

25-815-L3E3: Solid and Hazardous waste management

(Credits : 4)

Course Description:

This course is designed to provide students with a comprehensive understanding of the various types of waste, their environmental impacts, and the strategies for managing them in a sustainable manner. As global populations grow and industrial activities expand, the production and management of solid and hazardous wastes are becoming increasingly critical issues for environmental protection and public health.

This course covers the principles and practices involved in the proper management of solid and hazardous waste from its generation to final disposal, including the processes of waste minimization, collection, transportation, treatment, and disposal. Students will gain insights into the regulatory frameworks governing waste management, along with the technological innovations used to reduce waste and recycle materials.

Course Objective:

This course work provides an in depth understanding of solid and hazardous waste characteristics and management. The students acquire proficiency in processing technologies and disposal methods for municipal solid waste and hazardous waste generated from a community.

Course Outcomes:

After successfull completion of this course students should be able to:

CO1	Explain the functional elements of municipal solid waste management system	Understand
CO2	Evaluate the various processing technologies for MSW	Apply
CO3	Analyse the various options for disposal of MSW	Analyze
CO4	Identify and classify the hazardous wastes	Understand
CO5	Choose the treatment, storage, and disposal options for hazardous waste	Apply
CO6	Suggest feasible remediation measures for the contaminated sites	Analyze

Assessment Pattern:

Category	**Assessment Methods**			**Examination**
	Test 1	**Test 2**	**Seminar**	
Understand	60	20		30
Apply	40	40	30	30
Analyze		40	70	40

SYLLABUS

Module I : Fundamentals of waste management

Types and sources of solid waste, non-hazardous and hazardous waste-Present scenario and need for solid and hazard waste management- Legislations on management and handling of solid wastes and hazardous waste - Elements of integrated waste management and roles of stakeholders - Financing and Public Private Participation for waste management.

Module II : .Municipal solid waste

Waste generation rates and variation in MSW waste sampling and characterization physical, chemical and biological properties of solid wastes- Source reduction of wastes- Recycling and Reuse-Handling storage and collection of MSW-Analysis of collection system-Optimization of collection routes-Need for transfer and transport – transfer station.

Module III : Processing Technologies

Waste processing – purposes of Processing-Material separation and processing technologies Biological conversion technologies-Chemical conversion technologies and thermal conversion technologies-Energy recovery from conversion products-Co- processing of solid waste.

Module IV : Disposal of municipal solid waste

Disposal in landfills – Types-Site selection criteria's-Design and operation of landfill-Leachate and landfill gas management-Land fill closure and environmental monitoring-Land fill remediation.

Non Hazardous industrial solid wastes

Recycling and reuse of solid wastes-Handling and disposal methodologies of high volume non-hazardous solid wastes.

Module V : Hazardous wastes

Identification, classification of Hazardous waste-Source and characterization of hazardous waste – TCLP tests-Storage, labelling and handling of hazardous wastes Hazardous waste manifests and transport-Waste minimization options-Hazardous waste technological options-Physical treatment methods and chemical treatment methods-Biological treatment methods. Handling and management of biomedical waste. Disposal of Hazardous waste: Hazardous waste landfills-Site selection Criteria-Design and Operation of Hazardous waste landfills-Remediation of H.W disposal sites.

References

Textbooks:

1. "Solid Waste Engineering" by William A. Worrell and David Reuter
2. "Waste Management Practices: Municipal, Hazardous, and Industrial" by John Pichtel
3. "Introduction to Waste Management" by J. Jeffrey Peirce
4. "Hazardous Waste Management" by G. M. Fair and J. C. Geyer
5. Bhide A.D and Sundaresan, B.B. "Solid Waste Management Collection, Processing and Disposal", 2001, ISBN 81-7525-282-0
6. George Tchobanoglous, Hilary Theisen and Samuel A, Vigil "Integrated Solid Waste Management", McGraw Hill Publishers, New York, 1993.
7. "Manual on Municipal Solid Waste Management", CPHEEO, Ministry of Urban Development, Government of India, New Delhi, 2000.
8. Vesilind P.A., Worrell W and Reinhart, Solid Waste Engineering, Thomson learning Inc., Singapore, 2002.

Journals and Articles:

1. Journal of Environmental Management
2. Waste Management Journal
3. "Assessment of Solid Waste Management Systems in Developing Countries"

Websites and Online Resources:

1. U.S. Environmental Protection Agency (EPA) – www.epa.gov/waste
2. World Health Organization (WHO) - Waste Management – www.who.int
3. Waste Management Association of Australia (WMAA) – www.wmaa.com.au
4. The World Bank - Solid Waste Management – www.worldbank.org

Reports and Publications:

1. “Global Waste Management Outlook” – United Nations Environment Programme (UNEP)
2. “Solid Waste Management in the World’s Cities” – UN-Habitat

25-815-L3E4: Industrial Ecology

(**Credits : 4**)

Course Description:

Industrial ecology is an interdisciplinary field that seeks to understand industrial systems as integrated components of larger environmental and societal systems. The course name comes from the idea that the analogy of natural systems should be used as an aid in understanding how to design sustainable industrial systems.The course will cover theoretical frameworks, methodological approaches, case studies, and emerging trends in industrial ecology.

Course Objectives:

To be conversant with the basic principles and techniques of Industrial Ecology- a paradigm that looks to natural systems for the new principles of design and operation of community and industrial systems. Through the examination of material and energy flows, lifecycle assessments, and systems thinking, students will explore strategies for sustainable industrial development and resource management.

Course Outcomes:

After successfull completion of this course students should be able to:

CO1	Understand the principles and concepts of industrial ecology	Understand
CO2	Analyze material and energy flows within industrial systems	Analyse
CO3	Apply lifecycle assessment (LCA) methodologies to evaluate the environmental impacts of products and processes	Apply
CO4	Explore strategies for sustainable industrial development and resource management	Evaluate
CO5	Critically assess case studies and real-world applications of industrial ecology, Engage in discussions on emerging trends and future directions in the field.	Evaluate

Assessment Pattern:

Category	**Assessment Methods**			**Examination**
	Test 1	**Test 2**	**Seminar**	
Understand	30	30	30	30
Apply	30	30	30	30
Analyze	20	20	20	20
Evaluate	20	20	20	20

SYLLABUS

Module I : Introduction to Industrial Ecology

Definition and principles, Historical development, Concept and strategies of sustainable environment, Master equation for the estimation of total environmental impact, Technological evolution, Analogy of biological ecology and industrial ecology. Interdisciplinary nature of industrial ecology.

Module II : Material Flow Analysis (MFA)

Basics of MFA, MFA in industrial systems, Case studies and applications, Energy Flow Analysis, Energy metabolism of industrial systems, Energy efficiency and conservation, Renewable energy integration. Industrial Symbiosis and Eco-industrial Parks - Concept and principles of industrial symbiosis, Case studies of eco-industrial parks, Benefits and challenges

Module III : Life Cycle Assessment.

Life Cycle Assessment (LCA) - Principles and methodology, Types of LCA (e.g., attributional, consequential), Case studies and LCA applications. Biomimicry/ Biomimetics, levels of biomimetics. Strategies of Industrial ecology- Material Substitution-De-materialization, Transmaterialization-examples – Reuse and recycling, Case studies, Typical constraints on reuse and recycling.

Module IV : Circular Economy

Circular Economy and Industrial Ecology- Circular economy principles, Synergies between circular economy and industrial ecology, Circular design and closed-loop systems. Ecolabel, Green washing. Circular business models, Future directions and challenges.

Module V : Policy and Governance for Industrial Ecology

Regulatory frameworks, Corporate sustainability initiatives, International agreements and standards, Design for environmental Practices, Environment product design. Case Studies and Applications- Analyzing real-world examples, Emerging Trends in Industrial Ecology, Advanced technologies.

References

1. Ayres, Robert U. A handbook of industrial ecology. 2002
2. Graedel, Thomas E., and Braden R. Allenby. Industrial ecology and sustainable engineering. 2010.
3. Manahan, Stanley E. Industrial ecology: environmental chemistry and hazardous waste. Routledge, 2017.
4. Mary, A. C. Environmental Life Cycle Assessment. Ed., McGraw - Hill, New York. 2010, ISBN-13: 978-0070150638
5. Ahmed, M. H. Principles of Environmental Economics and Sustainability: An Integrated Economic and Ecological Approach. 2012. Routledge publisher. ISBN 0415676908
6. Williams R.B. Greening the Economy, 2013. Taylor & Francis Ltd. ISBN: 9780415745505

25-815-L3E5: Climate Change and Environment

(**Credits : 4**)

Course Description:

Understanding earth's climate and the impact of climate change on the environment is critical for the existence of humans. Earth's climate is known to vary in the past due to both external and internal factors. However, the impact of humans in the earth system is significant and is changing the planet. The repercussions of these are critical and is projected to impact the long-term climate of the planet. Understanding the climate system and its components is key to understand the changes of earth's climate. The anthropogenic activities impact the climate through several ways such as the greenhouse gas (GHG) emissions, aerosols, land use/landcover changes, etc. The impact of such changes in the climate needs to be understood. The availability of historical climate datasets and the future climate change projections such as the Coupled Model Intercomparison Project (CMIP) will help us to understand how climate system responds to such perturbations. Also, one should understand the impact of climate change on the sustainability of human population on earth. The climate change policies and other methods such as geoengineering the climate for the adaptation and mitigation of climate change needs to be understood in order to understand the human response to control and contain the impacts of climate change. The content of the syllabus "Climate change and Environment" provides a comprehensive understanding of all these aspects by clearly deducing a basement in the initial teaching followed by advanced level topics in various aspects of climate, climate change, environmental impacts and various policies and methods proposed for climate change mitigation and adaptation.

Course Objective:

The primary aim of this course is to gain a comprehensive understanding of the fundamentals of climate and the components of the climate system, ensuring a solid foundation in the subject matter. This encompasses identifying the myriad reasons behind climate change, including both naturally occurring phenomena and those resulting from human activities. A significant aspect involves analysing the impacts of climate change on the environment, thereby highlighting the urgent need for informed action. Furthermore, it is essential to delve into the historical occurrences of climate change as well as to project future changes, which requires a detailed understanding of past and present climate data. Lastly, understanding and analysing policies and methods for mitigating and adapting to climate change are crucial. This includes exploring various strategies that have been proposed or implemented globally to address the challenges posed by climate change, thereby preparing individuals to contribute effectively to efforts aimed at curbing its effects.

Course Outcomes:

After successfull completion of this course students should be able to:

CO1	Discuss the climate and the relationship between different components of the climate system.	Understand
CO2	Describe the natural and anthropogenic reasons for earth's climate change	Apply
CO3	Understand the reasons for past climate change and future climate change projections.	Apply, Analyse
CO4	Analyse and interpret the impact of climate change on environment	Apply
CO5	Ability to analyse the impact and feasibility of climate change policies and climate intervention methods on earths future climate	Analyse

Assessment Pattern:

Category	Assessment Methods			Examination
	Test 1	Test 2	Test3	
Understand	40	40	40	40
Apply	40	40	40	40
Analyze	20	20	20	20

SYLLABUS

Module I : Introduction

Climate system and its components, Interactions between climate system components, Global energy balance, Radiative forcing, Heat storage and transport, Hydrological cycle, Carbon cycle.

Module II : Climate change

Timescale of climate variations, Internal variability, Natural causes of climate change, Climate forcing and climate response, Feedbacks, Greenhouse effect, Anthropogenic climate change, Greenhouse gas emissions, Land use changes, Aerosols.

Module III : Past and Future climate change scenarios

Climate modeling, Reconstructing past climates, Past climate scenarios, Future climate projections, Representative Concentration Pathways - Uncertainties, IPCC assessments.

Module IV : Impact of climate change on environment

Long-term changes, Climate change over the 21^{st} century, decadal predictions and projections, changes in modes of variability, changes in climate extremes, abrupt climate changes, regional patterns of climate change – Indian monsoon.

Module V : Climate change adaptation/mitigation

Strategies to avoid dangerous climate change, Stabilisation of emissions, Zero carbon future, Sustainable development, Energy and transport for the future, Climate conventions, Technological solutions – Geoengineering.

References

1. Intergovernmental Panel on Climate Change (IPCC). Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press, United Kingdom. 2022
2. Houghton, John. 2015. Global Warming (5th edition). Cambridge University Press, United Kingdom.
3. Hartmann, D. 2016. Global Physical Climatology (2nd Edition). Elsevier, Netherlands.
4. Henson, R. 2019. The Thinking Person's Guide to Climate Change (2nd Edition). American Meteorological Society, United States.
5. Goosse, H. 2015. Climate System Dynamics and Modelling. Cambridge University Press, United Kingdom.
6. McGuffie., K, Henderson-Sellers, 2014 A. The Climate Modelling Primer (4th edition). Wiley- Blackwell, United States.
7. Neelin, DJ. 2011. Climate Change and Climate Modeling. Cambridge University Press, United Kingdom.
8. Freedman, B. 2014. Global Environmental Change. Springer Netherlands, Dordrecht.
9. Harrison, R; Hester, R. 2014. Geoengineering of the climate system. Royal Society of Chemistry, United Kingdom.

25-815-L3E6: Chemometrics and Good laboratory practices

(**Credits : 4**)

Course Description:

Chemometrics is the science of extracting information from chemical systems by data-driven means. It is the science of measurement [Chemo metry: Chemo – in Latin meaning- Chemistry and Metry from metria in Greek- with meaning - action or process of measuring"]. Good Laboratory Practices (GLP) is mainly concerned with practicing of assuring the repeatability of scientific investigations. The course introduces the tools available to ensure the quality of analytical chemical measurements. It helps the students to learn about regulatory aspects of quality assurance and quality control followed in the professional practice of analytical chemistry in all domain of knowledge- specifically for those aims to become Environmental Science & Technology professionals. Chemometrics is inherently interdisciplinary course, using methods frequently employed in core data-analytic disciplines such as statistics, applied mathematics, and computer science, in order to address problems in environmental science, chemistry, biochemistry, medicine, biology and chemical engineering. The assurance of quality is guaranteed in a Laboratory by an additional quality assurance unit that is controlled by continuous inspections to maintain the principles of GLP. The course introduces the tools available to ensure the quality of analytical chemical measurement. Validation describes in general the assurance that an analytical procedure provides; reproducible and secure results that are required for the application intended. An analytical laboratory proves its effective quality services and test results by an approved system of practices by assurance systems through accreditation.

Course Objectives:

The course provides the learners basic and advanced knowledge on principle and practice of chemometrics to work in a Good Analytical Laboratory System. There systematic practices are followed as per standard operating procedures during chemical measurement/ analysis, and quality control. Finally, learners will be equipped with full potential and capacity to emerge as competent analytical chemists/ scientists and able to develop their laboratory into an accredited and certified one. The test results and certification procedures must bear authenticity for final decision making by statutory authorities and to be devoid of any disputes and hence to be accepted by all.

Course Outcomes:

After successfull completion of this course students should be able to:

CO1	Fundamental concepts of chemometrics, evolution of analytical chemistry, quality systems, design of analysis, safety aspects in while working in a laboratory.	Remember
CO2	Ethical handling of chemicals and hazardous wastes, chemical balances, buoyancy correction, calibration of measuring devices, Laboratory accreditation and certification.	Understand
CO3	Errors in determination, significant figures, uncertainty & its propagation, sample calculations, Statistics for chemists, normal distribution of data structure, confidence intervals and t tests, quality control, statistics involved chemical measurement.	Apply
CO4	Treatment of analytical data to identify suitable methods, variability among test results, Data, Q tests for bad Data, regression analysis, hypothesis testing, graphical methods using spread sheet/ Excel and Origin, case studies	Analyse

CO5	Instrumental data: generation, use of model equations, evaluation of constants and parameters applying chemometry and statistical methods, analytical inferences. Evaluation of a research problem applying the domain knowledge acquired.	Evaluate

Assessment Pattern:

Category	Assessment Methods			Examination
	Test 1	Test 2	Seminar & Assignments	
Remember	10	10	10	10
Understand	20	20	20	20
Apply	20	20	20	20
Analyze	20	20	20	20
Evaluate	30	30	30	30

SYLLABUS

Module I : Tool of the Trade

Concepts of chemometrics, evolution of analytical chemistry, quality systems, qualitative and quantitative analysis, measurement systems and units, design of analysis , Laboratory- safety aspects in design and while working. National Building Rule for laboratory and the specifications. Hazardous waste management and andling rules, Ethical handling of chemicals and hazardous operations-hazard displays. Disposal of chemical wastes in laboratories. Special cases of cyanide, Cr (VI), heavy metals, toxic solvents and chemicals, safety practices in the laboratory. Environmental Sampling Plan as EPA Protocols. Quality Assurance, Quality control. NABL, ISO, HACCP, FSSI and other accreditations for an analytical laboratory.

Module II : Quality Management System

Laboratory notebook and recording of operations. Significant figures, uncertainty and its propagation, Measuring devices- balances - care in weighing- mechanical & piezoelectric balances, preventing weighing errors-buoyancy correction. Burettes pipettes and volumetric glasswares. Calibration: calibration of pipette, standard deviation of pipetting. Standard deviation of pipette intervals. Making inventory of lab chemical consumption. Dilution/ Concentration operations. Laboratory fortified blank/ laboratory control standard, Laboratory fortified matrix, duplicate sample/ Laboratory fortified matrix duplicate., internal standards, surrogates and tracers, calibration, quality control calculations., Schwart's control charts, QC evaluation for small sample sizes, correction action, and quality assessment, laboratory comparison samples, , compliance audits, management review.

Module III : Metrology in Chemistry

Mass balances, chemical equations, energy calculations, chemical concentrations and molality, ppm, ppb, unit conversions. Significant figures in addition, subtraction, multiplication and division, logarithm and antilogarithm. Types of errors- systematic and random errors. Precision and accuracy. Propagation of uncertainty- addition & subtraction, multiplication & division, mixed operations. The real rule of significant figures. Graphs and coordinates linear interpolation techniques. Data quality, measurement of uncertainty, bias, bias and random variation, repeatability, reproducibility and sources of bias and variation, gage repeatability, and reproducibility, and the measurement capability study, uncertainty statements. sample calculations, Statistics for chemists, normal distribution of data structure, confidence intervals and t tests, quality control, statistics involved chemical measurement.

Module IV : Basic Elements and Tools of Statistical Analysis

Gaussian distribution, score mean value, standard deviation and normal distribution. Area determination, coefficient of variation, standard deviation of the mean, Student's test, confidence limit, Shewart chart, Q-test for lab data, regression analysis, ANOVA. Spread sheets-MS Excel for generating graphs. Basics of Origin and R for Data presentation and Graphical Simulations. Treatment of analytical data to identify suitable methods, variability among test results, Data, Q tests for bad Data, regression analysis, hypothesis testing, case studies – to practice graphical methods using spread sheet/Excel and Origin for reporting. Certification and reporting. Treatment of laboratory experiment data for scientific interpretations and for publications in international journals.

Module V : Instrumental Methods, Data Acquisition and Analysis

High value equipments, operations and data acquisition, extraction of results, use of model equations, evaluation of constants and parameters applying chemometry and statistical methods, analytical inferences. Evaluation of a research problem applying the domain knowledge acquired using primary data by applying chemo metric principles.

References

1. D. C. Harris (2015) Quantitative Chemical Analysis 9th Edition, ISBN-13-978-1464135385, W. H. Free man & Co, New York.
2. Christian, Gary D., Purnendu K. (Sandy) Dasgupta, Kevin A. Schug (2014) Analytical chemistry. Seventh edition , ISBN 978-0-470-88757-8
3. D. C. Harris (1995) Quantitative Chemical Analysis, Fourth Edition, ISBN 0-7167- 2508-8, W. H. Freeman & Co, New York.
4. B. W. Wenclawiak, M. Koch and E. Hadjicostas (Edrs) (2010) Quality Assurance in Analytical Chemistry-Training Teaching, Springer-Verlag.
5. R. Caulcutt and R. Boddy (1994) Statistics for Analytical Chemists, First Edition, ISBN 0412-23730-x, Chapman and Hall, London.
6. H. M. Walker and J. Lev (2010) Elementary Statistical Methods, ISBN 03-08- 1130-9, Third edition, Holt,Reinhard and Winston, Inc.
7. A. W. Hounslow (1995) Water Quality Data - Analysis and interpretation, Lewis Publishers, Boca Raton.
8. James M Miller and Jace C Miller(2010),Statistics and Chemometrics for Analytical Chemistry-6 th Edition, Ashford Colour Press Ltd., Gosport, UK.
9. APHA (2022) , Standard Methods For the Examination of Water and Wastewater, 24 th, Edition, American Public Health Association, ISBN: 978-0-87553-299-8.
10. Krishna B and Achari V. S (2024) Groundwater for drinking and industrial purposes: A study of water stability and human health risk assessment from black sand mineral rich coastal region of Kerala, India, Journal of Environmental Management 351 (2024) 119783,https://doi.org/10.1016/j.jenvman.2023.119783
11. Krishna, B., & Achari, V. S. (2023). Groundwater chemistry and entropy weighted water quality index of tsunami affected and ecologically sensitive coastal region of India. Heliyon, 9(10). https://doi.org/10.1016/j.heliyon.2023.e20431
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25-815-L3E7: Chemistry of Water and Waste Water Treatment

(**Credits : 4**)

Course Description:

Environmental chemistry, -theories, principles, practices and laboratory session followed through the preceding Courses and learning sessions of Semester I, II & III has to be implemented in solving the real problems existing in the society and industry as well as for the innovations. In this regard, this course is designed to orient the students to the cause and reasons of real problems related to water science & water processing to meet the statutory guidelines. With a major thrust on hydro geochemical properties, quality criteria, hydro analytical data interpretations and chemical principles followed in water & wastewater processing industries in various aspects and dimensions. Identification of water (ground water, surface water and wastewater) quality problems, testing, evaluating and innovating solutions. Technical report and document preparation based on the findings to meet professional and statutory obligations.

Course Objective:

Identification and assessment of water quality, interpretation of data, optimization of treatment procedures, reactor operation and modelling procedures, testing and evaluation of materials used in water process technology. Incite interest among the students for capacity building for novelty and innovations in the existing treatment systems they are exposed in their future professional field based on a strong foundation of environmental, analytical and applied chemistry for meeting the need of the public, industry and government statutory organizations. Students are trained and made competent to identify problems from industry and outside, originate project proposals with specific objectives, design of research study/consultancy, generation of pertinent results by standard analytical methods, interpretation of results, evaluation of the problem findings with statutory guidelines, creative ideas, start-ups in water segments, product development and entrepreneurship.

Course Outcomes:

After successfull completion of this course students should be able to:

CO1	Understand basics of water and wastewater chemistry, role of a hydro-analytical chemist, testing and analysis protocols and classification methods.	Remember
CO2	Water quality data analysis and interpretations for fixing the quality issues of the water treatment process industry with respect to source, process and product water.	Understand
CO3	Decision of the required treatment for solving the problem based the evaluation of the quality parameters and profile based on hydro geochemical perspective using the engineering principles.	Apply
CO4	Test ing and evaluation of water based on hydro analytical data and materials for tertiary treatment using principles of adsorption engineering and isotherm models.	Analyse
CO5	Additional higher level of deliberation of the technicality of hydro analytical issues of water processing industries through practices to come out with creating suggestions can be reported as publications in standard journals and documents to statutory organizations, industry, courts and governments.	Evaluate

Assessment Pattern:

Category	Assessment Methods			Examination
	Test 1	Test 2	Seminar & Assignment	
Remember	10	10	10	10
Understand	20	20	20	20
Apply	20	20	20	20
Analyze	20	20	20	20
Evaluate	30	30	30	30
Create	10	10	10	10

SYLLABUS

Module I : Water and Best Use

World water crisis, Sustainable development goals, World Water Development Reports (2024, 2025, & 2026) and problems addressed, Water Resources of India report – Dynamic Groundwater Resources of India, 2022. Safe Drinking water Regulation,Classification of water based on origin. Designated Best Use (DBU) based classifications. Analytical instrumentations and testing protocols for groundwater , drinking water and wastewater using TOC Analyser, AAS, HPLC, ICP-MS for determinations. Water Quality Data- interpretations and report writing as per CPCB, BIS & WHO standards. Water quality monitoring programs- reported case studies. River & Lake monitoring protocols and modeling procedures, soil column compartments.

Module II : Water Quality Parameters & Water Quality Indices

Historical development of Water and wastewater analysis, US- EPA Regulations, APHA Standards, Water Quality Guidelines- evolution as part of sanitary engineering. Classification of analysis, Parameters, TS and DS distribution, DO, COD fractions, concept and tests, fractions of N, P, TOC, DOC, BDOC and NBDOC, rationale in setting aesthetic and toxicity criteria), Water Quality index and sample calculations. Water quality analysis, data profile and interpretation, - water quality indices (WQI), sample calculations based on published data. Statistical methods for stratum based analysis of field samples- wastewater, surface water and groundwater. Analysis and interpretation of WQ parameters for drinking water, sewage water, effluents, fisheries and aquaculture, documentation & certification (practical training in water quality laboratory).

Module III : Water Type, Classification and Hydrogeochemistry

Aquatic ecosystem, DO uptake and saturation problems; - oxygen transfer by reaeration, analysis of DO sag, DO sag models and kinetics. Groundwater classification; analyses, hardness types, salinity, SAR, ion-exchange, reverse ion exchange, Hill –Piper – Trilinear plots, Durov Diagram, Schoeller Diagram. BIS and WHO standards of drinking water- analysis and finding solutions for quality improvement using field samples- dugwells, borewells, industries and public. Analysis and interpretation of water for irrigation indices- (SAR, Na %, MAR (magnesium hazard), Kelly's ratio, & permeability index, USSL & Wilcox Diagrams and its interpretations).

Module IV : Chemistry of Water Stabilization and Tertiary Treatments

Industrial suit abilities based on indices an overview. pE- pH diagrams and their applications, electrochemical aspects of corrosion, immunity, passivation and protection, corrosion chemistry of Fe, Cu, Pb and Zn, Aggressive Index, Langelier Saturation Index, Ryznar stability index, Caldwell - Lawrence Diagram- its application. Analysis of wastewater and effluent water of selected industries. Tertiary treatment techniques- adsorption methods, isotherm models and kinetics. Model adsorption reactor systems and optimizations, determination of model parameters-Freundlich, Langmuir, BET, D-R, John,

John- Sivanandan Achari isotherms. Determination of porosity and surface area of porous materials used in tertiary treatment reactor systems.

Module V : Chemistry of Corrosion, Heavy Metal Removal in Processing Industries & Health Risk Assessment

Electrochemical aspects of corrosion coupon test and electrochemical evaluation of corrosivity, Corrosion inhibition –chemical inhibitors, sacrificial anodes, impressed current techniques. Redox techniques-removal of iron, manganese and chromate. Removal of fluoride and phosphate. Treatment, monitoring and process optimisation, reporting, preparation of proposals and documentation- case studies. Assessment of Human Health and Cancer Risk based on heavy metal presence in water. Design of research study/consultancy, generation of pertinent results by standard analytical methods, interpretation of results. Identification of water utility based industrial proble, evaluation of the process status, cause findings with statutory guidelines, report writing. Innovative - creative ideas, start-ups in water segments, product development and entrepreneurship.

References

1. Chin, D. A.; (2000). —Water Resources Engineering‖. ISBN 0-201-35091-2, Prentice- Hall, New Jersey.
2. Tebbutt, T. H. Y.; (2004). —Priciples of water quality control‖. 6th Edition, ISBN 0 7506 3658 0, Buttorworth- Heinemann.
3. Metcaff and Eddy (2003). Waste Water Engineering, Fourth Edition, Tata McGraw-Hill, New Delhi.
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15. Achari V S, Scientific Study related Health & Safety of Residents Near BPCL-Kochi Refinery, Kerala, India- Study Report Submitted by Expert Committee, 15 February, 2021.

SEMESTER VII

25-815-0701: Environmental Engineering II

(**Credits : 4**)

Course Description:

In the previous course 'Environmental Engineering I', the students have been introduced to the subject of Environmental Engineering. In continuation of that, more information on this branch of engineering is presented in this subject. This inter-alia includes some of the basic laws and the unit operations of chemical engineering which find extensive use in environmental engineering. Details of the engineered systems for industrial wastewater treatment, air pollution control and solid waste management are also presented in this subject.

Course Objectives:

The objective of this subject is to familiarize the students in the basic laws and the unit operations in chemical engineering which would become useful in studying and solving environment-related problems. The various techniques employed and the working principles of equipments used for wastewater treatment, air pollution control and solid waste management will enable the students to select the appropriate technology and equipment for control of wastewater, air pollution and solid waste management problems.

Course Outcomes:

After successfull completion of this course students should be able to:

CO1	Classify the techniques and the equipments used for the physical, physico-chemical and biological treatment of wastewater.	Understand
CO2	Select suitable type of treatment system for treating domestic and industrial waste water	Apply
CO3	Examine the sources and types of air pollutants, the meteorological factors influencing the dispersion of air pollutants	Apply
CO4	Identify the methods and equipments used for control of particulate matter and gaseous contaminants	Apply
CO5	Identify the characteristics of municipal solid waste and hazardous wastes and the engineered systems used for the collection, transport, treatment and disposal of solid wastes and hazardous wastes	Apply

Assessment Pattern:

Category	**Assessment Methods**			**Examination**
	Test 1	**Test 2**	**Test3**	
Understand	30	30	30	30
Apply	40	40	40	40
Analyze	30	30	30	30

SYLLABUS

Module I :

Graphical Representation of an Environmental Engineering Process: Representation of an object by plan, elevation and end view. Methods for pictorial representation of a process – Block flow diagrams (BFD), Process flow diagrams (PFD), Piping & Instrumentation diagram (P&ID). Symbols for the representation of equipment, piping and instruments. Wastewater flow and its characteristics, Effect of oxygen-demanding wastes on rivers - DO sag curve, Streeter-Phelp's equation, Wastewater collection systems, Estimation and variation of wastewater flows. Equalization, Neutralization, Proportioning processes, Volume and strength reduction. Preliminary, primary, secondary and tertiary wastewater treatment processes. Theory and design considerations of screens, grit chambers, sedimentation, coagulation, flocculation.

Module II :

Wastewater Treatment Systems - overview of Primary, Secondary and Tertiary Treatments – Fundamentals of Biological Treatment, Microbial Metabolism, Evaluation of Bio-kinetic Parameters- Modeling Suspended Growth Treatment Process. Activated Sludge Process - Modifications, Biological Nitrification and Denitrification - Attached Growth Biological Treatment Systems -Trickling Filters - Rotating Biological Contactors – membrane bio-reactor- Sequencing Batch Reactor-Moving bed biofilm reactor (MBBR) - Waste Stabilization Ponds and Lagoons - Aerobic Pond, Facultative Pond, Anaerobic Ponds- Polishing Ponds, Aerated Lagoons. Anaerobic Processes – Process Fundamentals - Standard High Rate and Hybrid Reactors, Anaerobic Filters- Expanded /Fluidized Bed Reactors - Up flow Anaerobic Sludge Blanket Reactors - Sludge Digestion, Sludge Disposal. Advanced Treatment: Adsorptive removal, Membrane separation processes, Advanced oxidation processes.

Module III :

Air pollution sources and types of air pollutants. Air pollution meteorology: Atmospheric energy balance, environmental lapse rates and atmospheric stability, winds, wind profiles, plume behaviour, convective current, turbulence. Dispersion of air pollutants, Introduction to various air quality models – steady state, dynamic, continuous, discrete and empirical, Box model, Gaussian dispersion model, Prediction of effective stack height - physics of plume rise, Holland's equation, Briggs equation, modifications of Gaussian dispersion models, Air quality monitoring instruments, Indoor Air Pollution – Cause and Effects.

Module IV :

Reduction in the generation of particulate matter by process modification, good housekeeping, and other means. Prevention and reduction of emissions, cleaner production. Carbon sequestration techniques, Control of Particulate matter - settling chambers, cyclones, bag-filters, electrostatic precipitators, wet collectors. Air pollution control by absorption, adsorption, condensation, incineration, bio scrubbers, biofilters. Design considerations, case studies. Air pollution control devices, theory and design considerations. Control of gaseous pollutants – Absorption, Adsorption and Condensation – Principles and equipment. Control devices for vehicular emissions. Noise Pollution – effects of noise, measurement methods, Noise abatement and Control.

Module V :

Solid and hazardous wastes- definition, types, sources, and impact on environmental health. Elements of integrated waste management. Waste generation rates- characteristics- physical, chemical, biological properties, hazardous characteristics-TCLP test- Concepts of waste reduction, recycling and reuse. Handling and segregation of waste at source - Storage and collection of municipal solid wastes- Analysis of collection systems- Needs for transfer and transport- Development and implementation of material recovery facility- Storage, Labelling, handling and transport of hazardous waste. Thermochemical

treatment – Waste to energy processes, incineration, gasification and pyrolysis. Biochemical treatment – Aerobic composting, Anaerobic digestion. Disposal in landfills- Landfill classification- Site selection, design and operation of sanitary landfills, secure landfills and landfill bioreactors. Leachate and landfill gas management-landfill closure and environmental monitoring.

References

1. Rao, C.S., "Environmental Pollution Control Engineering". Wiley Eastern Limited, New Age International Limited, New Delhi, 2018.
2. Rao, M.N. & Dutta, A.K. "Wastewater Treatment", 3rd Edition, Oxford & IBH Publishing, 2020.
3. Metcalf & Eddy "Wastewater Engineering: Treatment & Reuse", Fourth edition, Tata Mc Graw Hill, 2014.
4. CPHEEO Manual on Sewerage & Sewage Treatment Published by Ministry of Urban Development, New – Delhi, 2013.
5. Arceivala Soli J. & Asolekar Shyam R., "Wastewater Treatment for Pollution Control and Reuse" McGraw Hill Publication, 2006.
6. Noel De Nevers, "Air pollution control Engineering", McGraw Hill International Edition, McGraw Hill Inc, New Delhi, 2000.
7. George Tchobanoglous, Hilary Theisen, Samuel A. Vigil. "Integrated Solid Waste Management: Engineering Principles and Management Issues", McGraw Hill Education, 2014.
8. Charles A. Wentz. "Hazardous waste management". Second edition, McGraw Hill International, 1995.

25-815-0702: Advance Applications of GIS

(**Credits : 4**)

Course Description:

Remote sensing and Geographic Information Systems (GIS) are powerful tools that allow us to gather, analyze, and interpret data related to the Earth's surface. While basic applications might involve simple mapping or monitoring land use, advanced applications extend these capabilities significantly. Advanced Applications of GIS explores specialized applications of Geographic Information Systems in environmental management, urban planning, and resource monitoring. This course builds upon basic GIS concepts to provide in-depth knowledge of practical applications across various sectors, emphasizing sustainable development and decision-making through advanced spatial analysis.

Course Objective:

The objective of this course is to provide students with an in-depth understanding of advanced Geographic Information Systems (GIS) applications across various sectors. By exploring complex spatial data analysis techniques, students will learn how to manipulate and visualize geographic data to solve real-world problems. The curriculum will cover advanced GIS methodologies, including geostatistics, spatial modeling, and remote sensing, enabling students to assess environmental impacts, urban planning, and resource management effectively. By the end of the course, participants will be equipped with the skills necessary to design and implement advanced GIS projects, critically evaluate spatial data, and communicate findings effectively to diverse audiences.

Course Outcomes:

After successfull completion of this course students should be able to:

CO1	Apply advanced GIS techniques for environmental monitoring and conservation	Apply
CO2	Implement GIS solutions for urban planning and disaster management	Analyze
CO3	Develop advanced spatial analysis models for resource management	Analyze
CO4	Execute specialized GIS applications in agriculture and public health	Analyze

Assessment Pattern:

Category	**Assessment Methods**			**Examination**
	Test 1	**Test 2**	**Seminar**	
Understand	20	20	20	20
Apply	40	40	40	40
Analyze	40	40	40	40

SYLLABUS

Module I : Environmental Monitoring, Biodiversity Conservation

Land Use Change Detection: Analyzing changes in land use patterns such as urbanization, deforestation, or agricultural expansion. Water Quality Monitoring, air quality monitoring, Climate Change Studies: monitoring climate changer indicators crucial for understanding climate change impacts. Atmospheric Analysis, Oceanographic Studies, Monitoring of environmental health and pollution, Habitat Mapping, Species Distribution, Conservation Planning.

Module II : Disaster Management, Urban planning

Natural Disaster Assessment. Earthquake Damage Assessment, Flood Modeling, Wildfire Monitoring, Risk Analysis, Emergency Response Planning, Urban heat island analysis, land use and land cover change detection, disaster risk assessment, urban sprawl monitoring, infrastructure development planning, urban green space analysis, noise pollution mapping.

Module III : Agriculture

Precision farming, soil quality mapping, irrigation management, crop monitoring, pest and disease monitoring, agricultural land suitability analysis, vegetation health assessment, water resource management, drought risk assessment, agricultural supply chain optimization.

Module IV : Natural Resource Management

Forest cover mapping, watershed management, mineral exploration, biodiversity conservation, wildlife habitat modeling, renewable energy site selection, soil erosion analysis, carbon sequestration estimation, groundwater recharge zone identification, wetland monitoring, deforestation tracking, land use planning, disaster risk management, environmental impact assessment, protected area planning.

References

1. Xuan Zhu (2016) GIS for Environmental Applications - A practical approach, Routledge
2. Liang, S., Li, X., & Wang, J. (2012). Advanced remote sensing: Terrestrial Information Extraction and Applications. Academic Press.
3. Kang Tsung Chang, (2006). Introduction to Geographic Information Systems McGraw-Hill
4. Lavender, S., and Lavender, A., (2023). Practical Handbook of Remote Sensing, Routledge
5. Tian, B. (2016). GIS Technology applications in environmental and earth sciences. CRC Press.
6. Awange, J. L., & Kiema, J. B. K. (2013). Environmental Geoinformatics: Monitoring and Management. Springer Science & Business Media.
7. Singh A. K. and Chopra U. K (2007) Geoinformatics applications in agriculture. New India Publishing.
8. Shekhar, S., and Kumar, D. (2023). Geoinformatics for sustainable urban development. Routledge Series on the Indian Ocean and Trans-Asia.
9. Pandey, P. C., and Sharma, L. K. (2021). Advances in remote sensing for natural resource monitoring. John Wiley & Sons.

25-815-0703: Environmental Biotechnology

(Credits : 4)

Course Description:

Environmental Biotechnology utilizes microorganisms to improve environmental quality. These improvements include treatment of contaminated waters and wastewaters, clean-up of industrial waste streams, and remediation of soils contaminated with hazardous and toxic chemicals. Environmental biotechnology is essential to society and truly important as a technical discipline. The proposed course is designed to summarize recent progress in the area of biotechnology with an emphasis on novel approaches that offer new insights into the environmental biotechnology. The potential applications of biological treatment and how they can be combined for greater benefits for solving environmental issues.

Course Objective:

The objectives of this course are to build upon postgraduate knowledge in the application of environmental biotechnology for pollution control; prevention; detection and monitoring of environmental pollutants in today's scenario.

Course Outcomes:

After successfull completion of this course students should be able to:

CO1	Will experience the scope and application of Environmental Biotechnology in today‘s scenario.	Remember
CO2	Describe biological methods of treatment of wastewater, Reactor design and removal of metals.	Understand
CO3	Understand how environmental biotechnology can be used to prevent pollution and assists the industries with cleaner production alternatives.	Understand
CO4	Apply the knowledge of biotechnological tools in the management of solid wastes; remedial measures for the improvement of agriculture and food production in an environmental friendly manner with live models and case studies	Apply
CO5	Understand how effectively biotechnological systems can be used for the detection and monitoring environmental pollutants and management of natural resources.	Understand

Assessment Pattern:

Category	**Assessment Methods**			**Examination**
	Test 1	**Test 2**	**Seminar**	
Remember	10	10	10	10
Understand	60	60	60	60
Apply	30	30	30	30

SYLLABUS

Module I : Environmental Biotechnology in pollution control

A Historical Perspective; Scope of Environmental Biotechnology; Wastewater biotreatment: Aerobic biotreatment; Anaerobic biotreatment; Advanced biotreatment – membrane technology; Molecular techniques in waste water treatment; Biotreatment of gaseous streams; Biofilms in treatment of wastewater; Biofilm development and biofilm Kinetics; Aerobic Biofilms; Bioreactors for waste water treatments; Reactors types and design; Reactors in series; Development and optimization of membrane bioreactor process for use in sanitary and industrial sewage treatment; Metals removal by microorganisms from wastewaters.

Module II : Environmental Biotechnology in pollution control

A Historical Perspective; Scope of Environmental Biotechnology; Wastewater biotreatment: Aerobic biotreatment; Anaerobic biotreatment; Advanced biotreatment – membrane technology; Molecular techniques in waste water treatment; Biotreatment of gaseous streams; Biofilms in treatment of wastewater; Biofilm development and biofilm Kinetics; Aerobic Biofilms; Bioreactors for waste water treatments; Reactors types and design; Reactors in series; Development and optimization of membrane bioreactor process for use in sanitary and industrial sewage treatment; Metals removal by microorganisms from wastewaters.

Module III : Environmental impacts on agriculture

Biodegradation of agricultural chemicals; GM crops and their impact on environment; Biological nitrogen fixation; Phosphate solubilization; Biofertilizers; Biological control of insect pests; Role of biopesticides/ insecticides; Biocontrol of plant pathogens; Integrated pest management-practical implementation. **Module IV :. Environmental biotechnology in pollution detection and monitoring**

Biosensors: structure and construction; biosensor components: biological elements and principle of detection; Biosensor types and its applications; Bio indicators and Biomarkers.

Module V : Biotechnology for management of resources

Need for management of resources; Role of environmental biotechnology in management of resources; Reclamation of wasteland; Biomass production; Biogas and biofuel production; Development of environmentally friendly processes such as integrated waste management.

References

1. M.H. Fulekar, (2010), Environmental Biotechnology, Taylor & Francis Group, ISBN: 1578085829, 9781578085828
2. Pankaj Kumar Jain, Vijai Kumar Gupta , Vivek Bajpai , (2011), Recent Advances in: Environmental Biotechnology, LAP Lambert Acad. Publ., ISBN: 3844306870, 9783844306873.
3. W. B. Vasantha Kandasamy, W. B. Vasantha Kandasamy, Florentin Smarandache, S. R. Kannan, S. Ramathilagam, (2010), Methods in Environmental Biotechnology for Environmentalists, American Research Press, ISBN: 1599730944, 9781599730943.
4. Dr Marandi, Reza Marandi, Ali Shaeri, (2009), Environmental Biotechnology, SBS Publishers &; Distributors, ISBN: 818974187X, 9788189741877.
5. Wan Azlina Ahmad, (2011), Bacteria in Environmental Biotechnology: The Malaysian Case Study-Analysis, Waste Utilization &; Wastewater Remediation, Nova Science Pub Incorporated, ISBN: 1617283509, 9781617283505.
6. Indu Shekhar Thakur, (2011), Environmental Biotechnology: Basic Concepts and Applications, Second Edition (revised), I.K. International Publishing House Pvt., Limited, ISBN: 9380578474, 9789380578477.

7. Hans- Joacdening and Josef Winter, (2005), Environmental Biotechnology – Concepts and Applications, Wiley – VCH, Verlag GmbH &; Co, KGaA, Weinhein, ISBN: 3-527-30585-8.

8. T. Satyanarayana, Bhavdish Narain Johri, Anil Prakash, (2012), Microorganisms in Environmental Management: Microbes and Environment, Springer Dordrecht, Heidelberg, London, New York, ISBN: 978-94-007-2228-6.

9. Industrial Composting - Environmental Engineering and facilities Management (2007). Eliot Epstein.

10. Biosensors : an Introduction (1997) Brian. R. Eggins; John Wiley &; Sons Ltd. 11) Environmental Biotechnology: Achievements, Opportunities and Challenges, Article · January 2010, Author Maria Gavrilescu.

25-815-0704: Research Methodology & Scientific Communication

(**Credits : 2**)

Course Description:

This course on Research Methodology and Scientific Communication aims to equip students with the essential skills and knowledge needed to conduct effective research and communicate scientific findings. Through a combination of theoretical knowledge and practical application, students will learn various research methods, data analysis techniques, and effective communication strategies.

Course Objective:

The course aims to provide information of the fundamental principles of research methodology, different research designs and their applicability to various fields. data using appropriate statistical techniques and effective scientific communication strategies for presenting research findings.

Course Outcomes:

After successfull completion of this course students should be able to:

CO1	Understand the key concepts of research methodology and its significance in scientific inquiry.	Understand
CO2	Evaluate various research methods and select the most appropriate design for their studies.	Evaluate
CO3	Analyze data using statistical software and interpret the results accurately	Analyze
CO4	Apply effective communication techniques to present research findings in written and oral formats.	Apply

SYLLABUS

Module I : Introduction to Research Methodology

Definition and Importance of Research, Types of Research- Basic (fundamental) Research, Applied research, Descriptive Research, Analytical Research, Exploratory Research, Explanatory Research, Correlation Research, Experimental Research, Survey Research, Case study Research, Qualitative vs. Quantitative, Research Ethics.

Module II : Research Design and Planning

Formulating Research Questions and Hypotheses, Types of Research design, Research validity and reliability, Sampling Techniques, Designing Experiments and Surveys

Module III : Data Collection and Analysis

Methods of Data Collection: Surveys, Experimental, Interviews, Observations. Introduction to Statistical Analysis. Using Software for Data Analysis (e.g., SPSS, R)

Module IV : Scientific Communication

Introduction to Scientific Communication, Writing a Scientific Paper- Structure of a Research Paper, Abstract and Summary, Introduction and Background, Methodology Section, Results and Discussion, Conclusion and Recommendations, Referencing and Citation Styles. Writing Research Proposals and Reports. Preparing a Research Presentations- Visual Aids and Posters. Communicating with Non-Scientific Audiences, Understanding the Peer Review Process. Ethics in Scientific Communication. Publishing in Scientific Journals. Open Access Publishing. Scientific Communication in the Digital Age. Networking and Collaborations in Science.

Module V : Advanced Topics in Research Methodology

Mixed Methods Research, Longitudinal vs. Cross-Sectional Studies, Current Trends in Research Methodology.

References

1. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches by John W. Creswell and J. David Creswell, Sage Pubns; 5th edition (2 January 2018).
2. The Craft of Research by Wayne C. Booth, Gregory G. Colomb, and Joseph M. Williams, University of Chicago Press; 4th edition (28 October 2016).
3. Scientific Writing and Communication: Papers, Proposals, and Presentations by Angelika H. Hofmann
4. Scientific Writing and Communication: Papers, Proposals, and Presentations by Angelika H. Hofmann, Oxford Univ Pr; 3rd edition (17 November 2016).
5. The Elements of Style by William Strunk Jr. and E.B. White, Fingerprint! Publishing (1 November 2020).
6. Research Methodology: Methods and Techniques by C.R. Kothari, New Age International Publishers; Fourth edition (1 September 2019).
7. Research Methodology: A Step-by-Step Guide for Beginners by Ranjit Kumar, SAGE Publications Pvt. Ltd; Fourth edition (7 March 2024).
8. Ethics in Research: A Handbook for Researchers by A. K. Gupta.

SEMESTER VIII

25-815-0801: Carbon Accounting And Reporting

(**Credits : 4**)

Course Description:

Carbon Accounting, a pivotal area of study and practice has become increasingly critical in the global efforts to address climate change and promote sustainability. In today's environmentally conscious landscape, understanding the intricacies of carbon accounting is not just an asset but a necessity. This course is designed for students aiming to carve a niche in sustainability, and anyone passionate about making a positive environmental impact. This curriculum delves deep into the core aspects of carbon accounting, starting from its fundamental principles to the multifaceted methods used in the calculation and reporting of carbon emissions. The course navigate through the essential frameworks and standards that guide carbon accounting practices worldwide, ensuring students to become well-versed in both the theoretical and practical aspects of the field. Additionally, they will explore the tools and technologies that are pivotal in accurately measuring and reporting greenhouse gas emissions. This knowledge is crucial for organizations aiming to achieve their sustainability goals and for individuals committed to contributing to broader environmental conservation efforts.

Course Objectives:

The primary objective of this Carbon Accounting course is to equip participants with a robust understanding of carbon accounting practices, an essential skill set in the current environmentally conscious business environment. Students will delve into the fundamental principles of carbon accounting, explore various methods for calculating and reporting carbon emissions, and become familiar with the critical frameworks and standards that govern these practices globally. The course aims to empower students with the knowledge and tools necessary to accurately measure, report, and ultimately reduce greenhouse gas emissions. Through comprehensive instruction and practical application, they will be prepared to implement effective carbon management strategies within their organizations or communities, contributing significantly to global sustainability efforts.

Course Outcomes:

After successful completion of this course students should be able to:

CO1	Understand the basics of carbon accounting, the carbon cycle, GHG emissions, and reporting mechanisms.	Understand
CO2	Master various methods like bottom-up/top-down approaches, life cycle assessments, enabling accurate carbon footprint analysis.	Analyse
CO3	Gain expertise in global/regional standards and reporting initiatives for practical application.	Apply
CO4	Explore essential tools for accurate calculation, reporting, and management of carbon emissions.	Apply

Assessment Pattern:

Category	**Assessment Methods**			**Examination**
	Test 1	**Test 2**	**Test 3**	
Understand	40	40	40	40
Apply	40	40	40	40
Analyze	20	20	20	20

SYLLABUS

Module I : Basic principles of carbon accounting

Climate change and the role of carbon accounting, Carbon cycle and GHG emissions, Mandatory and Voluntary reporting, Units of measurements, Components of carbon reporting – Inventorying Emissions – direct and indirect sources, Baselines and Targets, Data collection, Calculating emissions, Reporting and verification, Developing reduction strategies. Role of emission factors, Primary and secondary data, Concept of boundaries, Official inventories.

Module II : Carbon accounting methods

Bottom-up and Top-down approaches, Inventory approach, Activity-based accounting, Life cycle assessment, Economic Input-Output Life Cycle Assessment (EIO-LCA), Process-based LCA, Hybrid LCA, Scope-based accounting, Project-based accounting, Carbon footprint analysis, Carbon inventory, Marginal abatement cost curve, Carbon offsetting

Module III : Carbon Accounting Frameworks and Standards

Scope, Methodologies, Reporting requirements, Certification, Global vs regional standards, Global and Regional Standards- Greenhouse Gas Protocol, ISO 14064, Verified Carbon Standard (VCS). Reporting initiatives - Carbon Disclosure Project (CDP), Science Based Targets initiative (SBTi), Global reporting Initiative (GRI), The Task Force on Climate-related Financial Disclosures (TCFD)

Module IV : Reporting tools

Carbon Footprint Calculators - Global Footprint Network Footprint Calculator, The Nature Conservancy Carbon Footprint Calculator, Carbon Footprint Ltd's Carbon Footprint Calculator, EPA's Carbon Footprint Calculator, WWF Footprint Calculator, Life Cycle Assessment (LCA) Tools – SimaPro, GaBi Software, OpenLCA, Ecoinvent Database, ACVIR, Umberto NXT LCA, CMLCA (Chain Management by Life Cycle Assessment), Footprinter, PRE Consultants, Environmental Management Systems (EMS), Globally Harmonized System (GHS), Software - Intelex Environmental Management, Enablon, IsoMetrix, Quentic, Sphera, Gensuite, VelocityEHS, EHS Insight, Cority, Greenstone.

Activities

1. Comparison of international standards.
2. Methodologies for calculating direct and indirect GHG emissions - Case study analysis
3. Conducting a carbon footprint assessment: Data collection and analysis
4. Reviewing real-world carbon reports

References

1. Brohé, A. (2017, September 8). The Handbook of Carbon Accounting Routledge.
2. Franchetti, M. J., & Apul, D. (2012). Carbon Footprint Analysis. CRC Press.
3. Matthews, H. S., Hendrickson, C. T., & Weber, C. L. (2008). The Importance of Carbon Footprint Estimation Boundaries. Environmental Science & Technology, United States.
4. Muthu, S. S. (2021, January 15). LCA Based Carbon Footprint Assessment. Springer Nature.
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8. ISO 14064-1:2018. (2018). Greenhouse gases — Part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals. International Organization for Standardization, Switzerland.
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10. Frischknecht, R., & Jungbluth, N. (Eds.). (2007). Implementation of Life Cycle Impact Assessment Methods. Ecoinvent report No. 3, Swiss Centre for Life Cycle Inventories, Switzerland.
11. Darabaris, J. (2019, May 16). Corporate Environmental Management, Second Edition. CRC Press.

25-815-0802: Research Project

25-815-0803: Mini Project

25-815-0804: EMS and Environmental Audit

(Credits : 2)

Course Description:

This course introduces students to Environmental Management Systems (EMS) and Environmental Audits. It covers the principles, frameworks, implementation strategies, and auditing techniques for managing environmental impacts in organizations. Students will gain the knowledge and skills to assess and improve the environmental performance of organizations through EMS and audits.

Course Objective:

To equip students with the knowledge and practical skills necessary to understand, implement, and audit Environmental Management Systems (EMS) in organizations. By the end of the course, students will be prepared to contribute effectively to environmental management practices and auditing processes in organizations, helping them enhance sustainability and comply with regulatory standards

Course Outcomes:

After successfull completion of this course students should be able to:

CO1	Explain the major environmental concepts and issues confronting managers working in corporations, businesses, government, industries and non- profit groups	Understand
CO2	Describe the strategic and operational approaches to environmental management that can be taken by business and society	Understand
CO3	Explain the concept of regulatory compliance, recent technological changes, emergency management, health and safety management, global resource conservation and sustainable development	Understand
CO4	Apply the concept of environmental management systems and identify the actions needed to prepare for an ISO 14000 certification audit for any industry	Apply

Assessment Pattern:

Category	**Assessment Methods**			**Examination**
	Test 1	**Test 2**	**Test3**	
Understand	100	70	30	60
Apply		30	70	40

SYLLABUS

Module I : Introduction to Environmental Management System (EMS)

Definition and Importance of EMS; Key Concepts: Sustainability, Corporate Social Responsibility (CSR), and Green Business Practices; Overview of ISO 14001 and other EMS standards; The Benefits of EMS for Organizations and the Environment

Module II : EMS Frameworks and Standards.

ISO 14001:2015 Environmental Management System; Structure and Clauses of ISO 14001; Core Principles of EMS; Other Relevant Standards and Guidelines; ISO 14004, EMAS (Eco-Management and Audit Scheme); Integration of EMS with Other Management Systems (ISO 9001, ISO 45001); Environmental Policy and Objectives; Environmental Aspects and Impacts; Legal and Regulatory Compliance;

Module III : Implementation of EMS

Developing EMS Procedures and Controls; Roles and Responsibilities in EMS; Employee Training and Awareness; Document Control and Record Keeping; Internal Audits and Continuous Improvement.

Module IV : Environmental Auditing

Introduction to Environmental Auditing; the Role of Environmental Audits in EMS; Types of Environmental Audits; Environmental Audit Process - Pre-Audit Activities: Planning and Preparation; Conducting the Audit; Audit Findings and Reporting; Audit Tools and Techniques; Corrective and Preventive Actions; Certification and External Audits.

Module V : Case Studies and Practical Applications

Case Studies of Successful EMS Implementation; Common Challenges and Best Practices; Group Project: Environmental Audit of a Real-World Organization; Presentation and Discussion of Group Projects; EMS in Different Sectors; Future Trends in EMS and Environmental Audits

References

1. Sheldon, C. (2017). ISO 14001:2015 Environmental Management Systems: A Complete Guide to the ISO 14001 Standard. Publisher: Routledge.
2. Bennett, M., & James, P. (2000). Environmental Management Systems: An Implementation Guide for Business. Publisher: McGraw-Hill.
3. ISO (2015). ISO 14001:2015 Environmental Management Systems – Requirements with Guidance for Use. Publisher: International Organization for Standardization (ISO).

Supplementary Books and Guides:

1. Rosenbaum, W. A. (2017). Environmental Audit Handbook. Publisher: Wiley.
2. Kolk, A., & van Tulder, R. (2002). The Effectiveness of Voluntary Environmental Agreements: The Case of the Dutch Eco-Management and Audit Scheme (EMAS). Publisher: Business Strategy and the Environment.
3. Kammer, A. (2018). Environmental Auditing: A Tool for Sustainable Development. Publisher: Springer.

Standards and Guidelines:

1. ISO (2017). ISO 14004:2016 Environmental Management Systems – General Guidelines on Implementation. Publisher: International Organization for Standardization (ISO).
2. European Commission (2014). Eco-Management and Audit Scheme (EMAS). Publisher: European Union.
3. U.S. Environmental Protection Agency (EPA) (2021). Environmental Auditing: A Guide for Facility Management. Publisher: EPA. Articles and Research Papers:
4. Kibert, C. J. (2016). Sustainable Construction: Green Building Design and Delivery. Publisher: Wiley.
5. Sarkis, J., & Zhu, Q. (2018). Environmental and Sustainability Auditing in Global Supply Chains: A Review of Tools and Practices. Journal of Environmental Management, 203, 499–509.
6. Sweeney, E., & Koutsou, S. (2015). A Critical Review of Environmental Auditing Methodologies and Tools. Journal of Environmental Auditing, 16(2), 75–92.

Online Resources:

1. International Organization for Standardization (ISO). Official ISO 14001:2015 Page. www.iso.org
2. U.S. Environmental Protection Agency (EPA). Environmental Auditing Resource Center. www.epa.gov/compliance/auditing
3. Environmental Protection Agency (EPA) - Audit Protocols and Checklists. EPA Audit Protocols

List of Elective Courses with level 400

25-815-L4E1: Environmental Data Acquisition Methods

(**Credits: 4**)

Course Description:

This course introduces students to various methods and techniques used in acquiring environmental data. It covers the principles, instrumentation, analysis, data management, and field techniques necessary for collecting accurate and reliable data for environmental monitoring and research purposes. Topics include sampling strategies, measurement techniques, sensor technologies, data logging, quality assurance, and data interpretation. Practical applications and case studies will be integrated into the course to provide real-world context and hands-on experience.

Course Objective:

The main objective of this course is to provide students with a basic understanding of the importance of environmental data acquisition, monitoring and managing of environmental resources. They should identify different types of environmental data and the parameters they represent and gain proficiency in data logging techniques and equipment. Students should develop skills in quality assurance and quality control procedures for environmental data.

Course Outcomes:

After successful completion of this course, students should be able to:

CO1	Interpret the importance of accurate data in environmental monitoring and management.	Understand
CO2	Apply appropriate data acquisition methods to specific environmental monitoring scenarios.	Apply
CO3	Analyze collected environmental data to identify patterns and trends.	Analyse
CO4	Evaluate the reliability and validity of acquired data.	Analyse
CO5	Critically assess the quality and accuracy of environmental data collected through various methods.	Evaluate

Assessment Pattern:

Category	**Assessment Methods**			**Examination**
	Test 1	**Test 2**	**Seminar**	
Understand	30	30	20	20
Apply	40	30	40	40
Analyze	30	30	40	30
Evaluate		10		10

SYLLABUS

Module I : Introduction to Environmental Data

Importance of Environmental Data and Monitoring, Types of data - Biological, Chemical, Physical, Qualitative, Quantitative, Spatial and Temporal data, Remote Sensing data, Field collected data, Model Outputs. Key components - Data collection, Data processing, Trend identification, Anomaly detection, Visualisation and Interpretation.

Module II : Data Acquisition in Environmental Studies

Methods of Data Acquisition - Field data collection - Direct measurement, Sampling techniques, Surveys. Remote sensing data collection - Platform selection, Sensor selection, Data processing, Data interpretation, Environmental monitoring systems - Sensors, Data loggers, Communication systems, Data Management Software. Citizen science as a data source.

Module III : Environmental Data Analysis

Statistical Analysis - Identifying trends, Relationship assessment, Pattern recognition, Hypothesis testing, Time-series analysis. Geospatial Analysis - Spatial relationships, Mapping, Spatial Interpolation. Machine learning Techniques. Decision making and predictive modelling, Decision support.

Module IV : Environmental Data Management

Data quality control - Data collection, Validation, Verification, Data cleaning and documentation, Principles of data quality Quality assurance protocols, Handling missing and erroneous data, Data storage and retrieval - Databases and management, Best practices.

Module V : Advanced Topics in Environmental Data

Internet of Things (IoT), Big Data in Environmental Studies, Artificial Intelligence and Machine Learning Applications. Case studies.

References

1. Dormann, C. (2020, December 20). Environmental Data Analysis. Springer Nature.
2. Glasson, J., Therivel, R., & Chadwick, A. (2005, September 30). Introduction To Environmental Impact Assessment. Routledge.
3. Hauer, F. R., & Lamberti, G. (2011, April 27). Methods in Stream Ecology. Academic Press.
4. Lillesand, T., Kiefer, R. W., & Chipman, J. (2015, February 18). Remote Sensing and Image Interpretation. John Wiley & Sons.
5. Townend, J. (2013, April 30). Practical Statistics for Environmental and Biological Scientists. John Wiley & Sons.
6. Longley, Goodchild, Maguire (2015) "Geographic Information Systems and Science", Wiley, United States
7. Ray, J. M. (2014, January 1). Research Data Management. Purdue University Press.
8. Reid, G. (2021, November 16). Principles of Database Management. Murphy & Moore Publishing.
9. Lea, P. (2018, January 22). Internet of Things for Architects. Packt Publishing Ltd.
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25-815-L4E2: Soil, Sediment and Air Analysis

(**Credits: 4**)

Course Description:

Soils are the most characteristic feature of the terrestrial environment providing a means of physical support for all terrestrial organisms, plants, and animals. They also supply nutrients required by living organisms. Since plants grow on soil, and animals graze on it, nutrients and toxic pollutants in the soil may be transported through the food chain. Greater emphasis is placed on soil analysis due to the important roles oils play in the biogeochemical cycling of nutrients and pollutants, and their vital role as the medium on which food is grown. Aquatic sediments are final repositories of materials originating from natural and anthropogenic sources. Contaminants associated with aquatic sediments may be released under specific conditions into overlying waters and pose a hazard to aquatic life and human health. Therefore, the characterization of sediments and the identification of the quality and quantity of contaminants in the sediments are very important in the assessment of sediment quality, in predictions of the release of the sediment contaminants into water, and in the development of techniques for remediation of aquatic ecosystems. The quality of the air has been steadily deteriorating, giving rise to numerous cases of illness and even death. Analyzing air quality parameters is crucial for protecting public health, ensuring regulatory compliance, and understanding environmental impacts. It helps identify pollution sources, develop effective mitigation strategies, and support research into the effects of air pollution.

Course Objective:

The course provides students with the expertise to generate good-quality data from physical- chemical analysis and interpret the information produced in the analytical laboratory. The course will provide in-depth knowledge of the various analytical and basic instrumental methods used in the laboratory for environmental analysis. Use the skills and modern environmental science techniques and tools necessary for a successful career in the field.

Course Outcomes:

After successful completion of this course, students should be able to:

CO1	Learn principle and procedure of experiments	Understand
CO2	Design and conduct experiments, Expertise in environmental sample preparation, physico-chemical and instrumental methods of analysis	Apply
CO3	Analyze and interpret analytical data	Analyze

Assessment Pattern:

Category	Assessment Methods			Examination
	Test 1	Test 2	Seminar	
Understand	20	20	20	20
Apply	60	60	60	60
Analyze	20	20	20	20

SYLLABUS

Analysis of Physico-chemical Parameters in Soils and Sediments

1. Determination of moisture content
2. Determination of bulk density
3. Determination of specific gravity
4. Determination of pH
5. Determination of electrical conductivity
6. Determination of redox potential
7. Determination of texture
8. Determination of organic matter
9. Determination of cation exchange capacity
10. Determination of trace metal content
11. Analysis of sodium and potassium
12. Determination of nutrients: exchangeable ammonia, nitrite, nitrate, urea, and Kjeldahl nitrogen
13. Determination of phosphorus content

Analysis of Air Quality Parameters

1. Determination of sulfur dioxide (SO_2) in air samples
2. Estimation of nitrogen dioxide (NO_2) in air
3. Analysis of carbon monoxide (CO) in air samples
4. Analysis of ozone (O_3) in air samples
5. Determination of ammonia (NH_3) in air samples
6. Analysis of hydrogen chloride in air samples
7. Atmospheric aerosol: heavy metals and major constituents
8. Determination of suspended particulate matter (SPM) – SPM 2.5μm
9. Determination of suspended particulate matter (SPM) – SPM 10μm
10. Determination of the gross composition of SPM 2.5µm and SPM 10μm
11. Calculation of air quality index and its interpretation

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25-815-L4E3: Wastewater Treatment Technologies

(Credits : 4)

Course Description:

This course in Wastewater Treatment Technologies provides students with comprehensive knowledge of various treatment processes used in wastewater treatment plants. The course covers sources and characteristics of wastewater, volume reduction techniques, primary treatment processes like screening and sedimentation, and advanced biological treatment methods for nutrient removal. Students also learn about specialized processes such as anaerobic digestion for sludge treatment and tertiary treatment techniques like adsorption methods for removing residual contaminants. The course includes sludge conditioning, thickening, stabilization, and digestion processes, including aerobic and anaerobic digestion, and composting. Through theoretical knowledge and practical applications, students develop skills to design, operate, and maintain wastewater treatment systems effectively, preparing them for careers in water resource management, and related fields. The course emphasizes sustainability and environmental stewardship, ensuring graduates are equipped to address the challenges of wastewater treatment and contribute to sustainable water management practices.

Course Objective:

The Wastewater Treatment Technologies major aims to provide students with a thorough understanding of wastewater treatment processes. The students learn about wastewater sources, volume reduction, screening, flocculation, sedimentation, and filtration. Students also study biological treatment methods, including aerobic and anaerobic digestion, as well as specialized treatments for nutrient and contaminant removal. This program prepares students for careers in water resource management, focusing on sustainable water management practices.

Course Outcomes:

After successful completion of this course, students should be able to:

CO1	Understand the principles and processes of wastewater treatment, including collection, primary treatment, and biological and tertiary treatment methods.	Understand
CO2	Analyze the efficiency and effectiveness of various wastewater treatment technologies, such as sedimentation, filtration, and disinfection, in removing contaminants.	Analyse
CO3	Apply knowledge of microbial metabolism and growth to design and optimize biological treatment processes for wastewater.	Apply
CO4	Evaluate the performance of wastewater treatment systems and propose improvements based on environmental factors and treatment goals.	Evaluate
CO5	Demonstrate proficiency in handling and treating sludge, including conditioning, thickening, stabilization, and digestion processes.	Evaluate

Assessment Pattern:

Category	**Assessment Methods**			**Examination**
	Test 1	**Test 2**	**Seminar**	
Understand	40	40	40	40
Apply	20	20	20	20
Analyze	20	20	20	20
Evaluate	20	20	20	20

SYLLABUS

Module I : Collection and Primary Treatment

Sources of wastewater, characteristics, variations in quantity and quality, volume reduction, flow equalization. Screening, flocculation, concept of velocity gradient, sedimentation. Analysis of flocculent settling hindered settling and compression settling. Settling column and settling curves. Plate settlers and tube settlers. Components of a coagulation-sedimentation plant. Filtration. Slow and rapid gravity filters, pressure filters and vacuum filters. Floatation, Disinfection Methods.

Module II : Biological Treatment I

Generalized metabolic pathway of microbes. Energy transfer and Gibb's Free Energy. Energy metabolism of autotrophs and heterotrophs. Exponential growth rate, yield, Monod Equation. Rate of food utilization, rate of growth, yield, specific substrate utilization rate and endogenous decay rate constant. Energy and carbon source requirements. True growth yield. Effect of environmental factors on microbial growth.

Module III : Biological Treatment II

Aerobic suspended growth processes: Activated sludge process. Equation connecting mean cell residence time, hydraulic residence time, yield and endogenous decay rate constant. Volumetric loading rate. Food to micro-organism ratio. Aerated lagoons. Oxidation (stabilization) ponds. Special Treatment Methods - Removal of nitrogen, phosphorus, iron, manganese, chromium and mercury. Attached growth processes, trickling filter and bio-tower, Rotating Biological Contactors. Anaerobic processes. Anaerobic digestion processes: Suspended growth anaerobic filter, expanded bed and Up-flow Anaerobic Sludge Blanket (UASB) processes.

Module IV : Tertiary Treatment

Tertiary treatment techniques- adsorption methods, isotherm models and kinetics. Model adsorption reactor systems and optimizations, determination of model parameters- Freundlich, Langmuir, BET, D-R, John, John- Sivanandan Achari isotherms. Determination of porosity and surface area of porous materials used in tertiary treatment reactor systems.

Module V : Treatment and Handling of Sludge

Sludge conditioning and sludge thickening. Sludge stabilization. Anaerobic sludge digestion. Standard-rate digestion and high- rate digestion. Aerobic sludge digestion, composting.

References

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25-815-L4E4: Ecotoxicology and Biomonitoring

(Credits : 4)

Course Description:

This course provides an integrated approach to understanding ecotoxicology and biomonitoring, focusing on contaminant fate in ecosystems, effects on organisms, and methodologies to assess environmental health. The curriculum emphasizes practical applications of biomonitoring techniques, emerging technologies, and data analysis to evaluate ecosystem integrity and develop evidence-based environmental protection strategies. Students will explore both fundamental principles and cutting-edge approaches in environmental assessment.

Course Objective:

The course aims to provide information to understand the fundamental principles of ecotoxicology and biomonitoring. It covers appropriate methodologies to detect and quantify environmental pollutants. Students will learn to evaluate the effects of contaminants on organisms at different levels of biological organization. The course will also focus how to analyze biomonitoring data using current statistical and modelling approaches and help design monitoring programs to assess ecosystem health and environmental risk.

Course Outcomes:

After successful completion of this course students should be able to:

CO1	Understand the fundamentals of ecotoxicology and reflect on ecosystem health	Understand
CO2	Analyze relationships between contaminant levels and biological responses	Analyse
CO3	Critically evaluate appropriate biomonitoring methods for specific environmental contexts	Evaluate
CO4	Demonstrate the application of environmental DNA (eDNA) and other molecular techniques for species detection	Apply
CO5	Implement comprehensive biomonitoring programs for complex environmental scenarios	Apply

SYLLABUS

Module I : Fundamentals of Ecotoxicology

Principles of environmental toxicology and ecological effects, Contaminant sources, transport, and fate in ecosystems, Bioavailability, bioaccumulation, and biomagnification, Toxicokinetics and toxicodynamics, Dose-response relationships and threshold effects, Species sensitivity distributions and ecological risk assessment

Module II : Biomarkers and Biological Responses

Molecular, cellular, and physiological biomarkers, Omics approaches (genomics, proteomics, metabolomics),

Behavioral and reproductive endpoints, Population and community-level responses, Adverse outcome pathways (AOPs) in ecotoxicology, Biomarker validation and quality assurance.

Module III : Biomonitoring Methodologies

Traditional biomonitoring approaches and indicator species, Environmental DNA (eDNA) and metabarcoding techniques, Remote sensing and real-time monitoring systems, Passive sampling devices and biosensors, Emerging contaminants monitoring strategies

Module IV : Data Analysis and Interpretation

Sampling and analytical methods, Statistical methods for ecotoxicological data, Multivariate analysis of biomonitoring datasets, Machine learning applications in environmental assessment, Geographic information systems (GIS) in spatial analysis, Ecological modelling and predictive approaches, Weight-of-evidence frameworks and uncertainty analysis

Module V : Applications and Case Studies

Freshwater, marine, and terrestrial biomonitoring programs, Climate change interactions with contaminant effects, Multiple stressor assessments in complex ecosystems, Environmental justice and community-based monitoring, International monitoring networks and data harmonization, Translating monitoring results into regulatory action and policy.

References

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2. Elements of toxicology; J. P Shukla and Pandey, Radha Publishers, New Delhi.
3. Effects and Dose- response Relationships of Toxic metals- Nordberg.G, Elsevier Scientific Publishing Co.,New York.
4. Modern Trends in Toxicology ; Boy land E.and Goulding R, Butter worth‘s , London.
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25-815-L4E5: Environmental Modelling

(**Credits : 4**)

Course Description:

Study of complex environmental systems based on simple mathematical relationships forms the basis of environmental modelling. Mathematical Equations otherwise called models are the abstraction of reality, and can be used to find suitable solutions to the many of the problems we face today using the principle of Applied, Physical & Analytical Chemistry in the field of Environmental Engineering. Accordingly, environmental systems can be described in terms of the functioning principles of tank and tubular reactors. The concept of mass and energy balance and its significance for the description of common model systems such as tank and tubular reactors, river models, lake models, biological hazard rooms, structured model kinetics, monod kinetics, and biofilms will be introduced in this course supported by respective mathematical models. Course starts with simple models, familiarizing the students on the significance of stochiometric coefficients for common reactions and their simulations using tools like AQUASIM, for practice. Later on for the implementation of complex systems based on the experiences gained, to make probable predictions according to the selection of suitable models. Study and application of AQUASIM, theory and practice of AQUACHEM and application of ADSORPTION ENGG MODELS are also familiarised to predict the properties and functioning of various environmental and material systems.

Course Objectives:

To expose the students to acquire the theory and practices of mathematical models for the study of complex environmental systems and uses of simulation tools to solve environmental issues through material & energy saving, pollution & emission reduction, waste minimization and reactor optimizations. Study of selected environmental and material systems using simulation soft wares is achieved. Knowledge and skill will be utilised to generate experimental/ instrumental data, model predictions based on it, interpretations of the results and drawing inferences and conclusions are achieved.

Course Outcomes:

After successful completion of this course students should be able to:

CO1	Understand the importance of environmental modelling for describing a process, and mass balance relationships. Study of isotherm model for basic understanding.	Understand
CO2	Basic aspects of environmental modelling with examples are described, for the understanding of its significance for the study reactor systems.	Understand
CO3	Description of models for the study of complex systems- rivers, lakes, hazard rooms, Monod-kinetics and wastewater treatment systems. Isotherm models and their applications in environmental engineering.	Apply
CO4	Use of simulation tools , practice using them for model descriptions and interpretation of the model parameters, to define the functioning of the selected systems	Analyse
CO5	Application of selected models for prediction - Substance separation in a box network, Hazard room model for air circulation, and BET, D-R, John & John-Sivanandan Achari isotherm model for material characterization and efficiency	Evaluate

Assessment Pattern:

Category	Assessment Methods			Examination
	Test 1	Test 2	Seminar & Assignment	
Remember	10	10	10	10
Understand	20	20	20	20
Apply	20	20	20	20
Analyze	20	20	20	20
Evaluate	30	30	30	30

SYLLABUS

Module I : General Aspects of Modeling

Reactions and stochiometric coefficient, Modeling principle and role in environmental technology, model classification; deterministic, stochastic, steady state and dynamic models. Modelling procedure, simulation and other tools. Aquasim and other tools for modelling of aquatic systems. Reactors in a box network.

Module II : Mass balance Concept

Stochiometry matrix, tank reactor, lake and watersheds, river flow systems, continuous stirred tank reactor (CSTR), plug flow tubular reactor (PFTR), convective and diffusive flows. Formulation of α mass balance in terms of accumulation, convection, production, diffusion and interface mass transport. Diffusion, Importance of total and component mass balance. Modelling of biological hazard room, Air Filter Efficiency,Lake Model , Lake Pollution as a modelling problem.

Module III : Reactor Modeling

Chemical and biological reaction systems. Reactor operations. Reaction kinetics with regards to microbial growth, substrate uptake kinetics and inhibition structured kinetic models, Monod kinetics, biofilm models, respiration and oxygen uptake rates, mass transfer coefficient, external and internal mass transfer. Modelling of tubular plug flow reactor, surface diffusion, pore diffusion, monolayer coverage, and computation of surface area: BET, D-R, α s , BJH & John isotherm models. Evaluation of constants and parameters for reactor operations.

Module IV : Modeling of Aquatic Systems

File handling, model formulations, variables, and process and reactor compartments, advective-diffusive reactor. Application of software in simulation with models: Biochemical process in a batch reactor, Batch reactor operations, transport and substance separation in a box network, Modeling of First Order Kinetic Reaction, Psedo order reaction, Gas- Volume Reactor.

Module V : Simulations by Software

Activated Sludge Modeling (ASM), River Modeling, Lake Modeling using AQUASIM 2.0 (EAWAG-Aquatic Research Computer Program for the Identification and Simulation of Aquatic Systems). Evaluation of Hydrological parameters using AQUACHEM (software Version, 2014.2, Waterloo Hydrogeologic, Inc, Canada), analysis and interpretation of water quality data for research purposes and publications. Design of experiments, identification of research problems, data generation, model identification, implementation, evaluation of model parameters, process optimisation, reactor performance analysis, interpretation of results, documentation and research publication- analysis and writing.

References

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25-815-L4E6: Applied Environmental Microbiology

(**Credits : 4**)

Course Description:

Course aims to impart the students with basic principles of microbiology and their applications to humankind. Course will provide an insight of several water and vector borne diseases, their detection, enumeration, epidemiology, identification and management. Course also deals with microbial applications in the environment such as production of biofertilizers, their applications, microbial degradation of pesticides, petroleum hydrocarbons, their degradation mechanisms, bioleaching and biomining. Course will also introduce students to the basics of animal tissue culture techniques. By the end of the course students will able to understand various applications of microorganisms in the environment.

Course Objective:

Students will study various water borne and vector borne pathogens and its management in the environment. They will study the applications of microbiology in the environment such as biofertilizers, biopesticides etc. Course will also cover the petroleum microbiology and its applications. Students will also learn about various cell culture techniques and their applications.

Course Outcomes:

After successful completion of this course students should be able to:

CO1	Explain water & vector borne pathogens, clinical manifestations and its management	Apply
CO2	Discuss the classification, mechanism and control of biopesticide development and application of biofertilizers.	Understand
CO3	Describe the nature and fate of petroleum hydrocarbons & microbial mechanism of degradation	Understand
CO4	Discuss the mechanism of biocorrosion, bioleaching	Understand
CO5	Explain the cell culture techniques and its biomedical applications	Understand

SYLLABUS

Module I : Water and vector borne human pathogens

Coliforms as indicators of faecal pollution - Total coli forms, faecal coliforms and E.coli. Faecal streptococci enterococci groups; Water borne pathogenic bacteria - Salmonella, Shigella, Vibrio cholera, Yersinia enterocolitica, Leptospira, Listeria monocytogenes, Compylobacterjejuni; Enteric viruses; Pathogenic Fungi and protozoans in water and waste water; Vector-borne human viruses - Detection, Enumeration, isolation and identification and management.

Module II : Pesticide microbiology and Biofertilizers

Pesticide Microbiology: Classes of pesticides based on structure and mode of action; basic mechanisms

and microbes involved in the microbial degradation of pesticides; factors affecting pesticide degradation; impact of pesticides on microbial communities; Biopesticides - Microbial control of insect pests - Diversity - Viral, Bacterial, Fungal and Protozoan pathogens - isolation, propagation and application; Problems and prospects in biopesticide application. Biofertilizers: Biological nitrogen fixation - microorganisms involved, mechanisms of nitrogen fixation, nitrogenase, symbiotic and free living nitrogen fixers; Phosphate solubilizerfs; Mycorrhiza - Ectotrophic and Vascular; Development and application.

Module III : Petroleum Microbiology

Over view of petroleum hydrocarbons, basic mechanisms involved in petroleum hydrocarbon degradation, Microbial processes involved, fate of petroleum hydrocarbon in the sea, bioremediation of oil spills; Biosurfactants - producer microorganisms, composition and application - enhanced oil recovery and oil degradation.

Module IV : Microbial fouling and corrosion

Primary film/biofilm formation and microbial fouling of surfaces, microbes involved, structures affected, preventive measures; Biocorrosion - role of sulphur oxidizing, iron oxidizing and sulphate reducing bacteria; Control of Biofouling and biocorrosion. Microbial leaching and biomining: Bioleaching bacteria, leaching reactions, desulphurization of coal, biomining.

Module V : Biomedical techniques & applications.

History, definition of primary, deployed, established, suspended and anchor-dependent cell cultures; Tissue culture laboratory lay out, equipments, media and glassware's; Cell culture techniques - enzymatic desegregation and explants culture techniques, open and closed systems, sub culturing; In vitro transformations and established cell lines; preservation of cell lines; Biomedical application such as viral isolation and propagation, toxicology and production of secondary metabolites.

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25-815-L4E7: Applied Ecotoxicology

(**Credits : 4**)

Course Description:

This course provides a comprehensive understanding and application of molecular biology and cell culture applications in ecotoxicology, focusing on the impact of toxicants on ecosystems and human health. The course covers fundamental concepts and modules covering broad aspects of aquatic ecosystem health, terrestrial ecotoxicology, molecular biology, and cell culture applications in ecotoxicology. The course gives practical knowledge on assessing the sensitivity of ecological components and ecosystem towards environmental chemicals

Course Objective:

The course aims to explore the historical and current significance of ecotoxicology, identify toxicants and their impacts on ecosystems, analyze ecosystem sensitivity, and evaluate the effects of toxicants on aquatic and terrestrial environments. Students will also learn molecular biology and cell culture techniques, develop risk assessment skills, and apply knowledge through case studies and practical applications.

Course Outcomes:

After successfull completion of this course students should be able to:

CO1	Explain the Ecotoxicological principles of ecosystem for the prediction of toxicant effects on ecosystem	Understand
CO2	Apply knowledge to assess risks and mitigate toxicant effects	Apply
CO3	Analyze complex ecological scenarios using ecotoxicological concepts.	Analyse
CO4	Evaluate molecular biology and cell culture effectiveness in ecotoxicological impact assessment.	Evaluate
CO5	Apply innovative environmental management strategies based on CO3 and CO4.	Apply

Assessment Pattern:

Category	**Assessment Methods**			**Examination**
	Test 1	**Test 2**	**Seminar**	
Understand	40	40	40	40
Apply	20	20	20	20
Analyze	20	20	20	20
Evaluate	20	20	20	20

SYLLABUS

Module I : Fundamentals of ecotoxicology and toxicants in the environment

Historical and current need for ecotoxicological studies -ecotoxicology and ecosystem- sensitivity of ecosystem and ecotone concepts. Ecosystem structure, function, and ecotoxicological principles Toxicokinetics & toxicodynamics; bioaccumulation and bioavailability models. Prediction of ecological effects: Octanol-water partition coefficient, Henry's Law, water solubility. Classes of toxicants: Plant, microbial, anthropogenic, endocrine disruptors, free radicals, antioxidant defence

Module II : Aquatic ecosystem health and risk assessment

Aquatic toxicity testing: Prolonged and chronic toxicity, fish and algal bioassays. Environmental surveillance: Specimen banking, indicator populations, lacustrine community stress indicators. Food chain magnification, population toxicology, infectious disease-toxicant interactions. Risk assessment: Environmental epidemiology, modelling, ecological and human health risk assessment, legislative frameworks.

Module III : Terrestrial ecotoxicology and human health

Community responses to toxicants: Biotic indices, biological integrity, species turnover, key species roles. Air pollution ecotoxicology; heavy metal impacts on plants and animals. Ecological redundancy and resilience in contaminated terrestrial ecosystems. Toxic substances of clinical and forensic relevance: Alcohols, amphetamines, pesticides, metals, carbon monoxide, cyanide. Environmental monitoring techniques: Passive sampling, remote sensing applications

Module IV : Molecular Tools in Ecotoxicology

Introduction to Molecular Biology- Importance in ecotoxicology. Molecular biomarkers – DNA, protein biomarkers, genotoxicity tests. Genomics and Proteomics- Gene sequencing and analysis-Proteomics techniques. Molecular Techniques-PCR and its variants-DNA sequencing methods, genetic mutations, Gene Expression Analysis-Real-time PCR (qPCR), CRISPR/Cas9 Applications- Real-world applications of molecular biology in eco-toxicology. Computational ecotoxicology: QSAR modelling, machine learning in toxicity prediction

Module V : Cell and cell culture applications in ecotoxicology

Cellular response to toxicants: Entry pathways, bioaccumulation, biotransformation, detoxification. Cellular damage indicators: DNA damage, apoptosis, necrosis, carcinogenesis. Use of cellular materials as toxicological evidence. Cell culture applications: Cytotoxicity assays (MTT, LDH), case studies, and real-world applications.

References

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9. Cell and Molecular Biology: Concepts and Experiments, Gerald Karp, Sixth Edition
10. Freshney's Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications by R. Ian Freshney, Eighth Edition
11. Molecular Cloning- A laboratory Manual, by Michael R Green and Joseph Sambrook, Fourth Edition.
12. Hisham. K. Hamadeh, Cynthia A. Afshari (2004). Toxicogenomics Principles and applications. Wiley and Sons, Inc.
13. Environmental Toxicology and Toxicogenomics- Principles, Methods and Applications (2021). Xiaoping Pan and Baohong Zhang. Springer Science+Business Media, LLC, part of Springer Nature 2021

25-815-L4E8: Circular Economy And Resource Recovery

(**Credits : 4**)

Course Description:

The course's significant focus is understanding the circular economy concept and its role in resource recovery. Students will explore innovative approaches to waste management that prioritize the reuse, recycling, and repurposing of materials, contributing to a more sustainable and efficient utilization of resources. It also focuses on bio-waste composting and covers its definition, characteristics, and sourcing, emphasizing waste segregation and addressing challenges such as packaging. Special attention is given to food waste and various composting technologies, including anaerobic digestion for biogas production. Legislative considerations in waste management are also explored.

Course Objective:

- Define circular economy concerning waste management
- Describe the different policy instruments used in waste management and the role of industry and citizens.
- To provide theoretical knowledge to improve the skills in managing waste at management facility centre.
- To understand the waste management scenario, scientific and technological options to manage waste.
- Understand the role of each stakeholder involved in waste management.

Course Outcomes:

After successful completion of this course students should be able to:

CO1	Familiarize the relationship between waste management and circular economy.	Understand
CO2	Identify Policy instruments to be used in waste management and waste reduction.	Evaluate
CO3	Understanding how to establish and manage waste disposal facility centers.	Analyse
CO4	Understanding the waste management scenario and options to manage waste.	Analyse
CO5	Learn how to promote effective governance of waste among critical stakeholders.	Apply

Assessment Pattern:

Category	**Assessment Methods**			**Examination**
	Test 1	**Test 2**	**Test3**	
Understand	10	10	10	10
Apply	20	20	20	20
Analyze	40	40	40	40
Evaluate	30	30	30	30

SYLLABUS

Module I :Concept of waste and circular economy.

Circular economy definitions and principles- Waste management practices in India and abroad- Scientific approaches to waste management- Linkage between waste management and sustainable development goals- Changing scenarios and recycling trends in the waste market- Circular economy case studies and market linkages.

Module II : Policy instruments on waste management control.

Introduction; Regulatory instruments and enforcement matters; Economic instruments; Extended producer responsibility (EPR); Communicative instruments; Monitoring and reporting.

Module III : Entrepreneurship in waste management.

An Overview of Entrepreneurship - Factors Influencing Entrepreneurship, Classification of Entrepreneurs, Qualities of an Entrepreneur, Innovation & Entrepreneurship, IOT and AI Application in Waste Management; Entrepreneurial Opportunities in Waste Management Sector; Public Private Partnerships and Community Driven Waste Management.

Module IV :Waste Management as Project Management.

Technological options and innovation in waste management- Collective Alternative Management Systems (CAMS) and Competence Management Systems (CMS)-Nationally Appropriate Mitigation Actions (NAMAs) for waste management-Context-based approaches to waste management projects- Project management principles and methodologies- Costing, affordability, and market requirements in waste management projects- Program Evaluation and Review Technique (PERT) and Critical Path Method (CPM)- SWOT analysis and Gantt chart application in waste management projects- Demand management strategies such as contracting- sub-contracting, outsourcing, and insourcing- Risk analysis and management techniques in waste management projects- Hands-on exercises on Activity planning & scheduling tools including PERT/CPM using Microsoft Project/Project Libre.

Module V : Management of Urban Waste Services.

JNNURM and SWM - Concept – Objectives – Mission – Facilities and Role of JNNURM in SWM – Impact and services – Best examples and practices from Indian perspective; Financing of SWM projects – assessment of finance – Financial support of Central, State government and other financial institutions – Pricing of Municipal services – Cost recovery framework – SWM project evaluation techniques; Personal aspects - Protective measures – Hygienic and unhygienic practices – Welfare measures – Productivity of SWM staff and equipment's – Training – contents, mode and tools – Motivation – stress management – Non-alcoholic practices – Communication – Change management.

References

1. Annepu RK. 2012. Report on sustainable solid waste management in India. Wasteto- Energy Research and Technology Council (WTERT) 1-189. See http://swmindia.blogspot.in/.
2. Chandrashekar et.al. (2014), 'Factors that influence Entrepreneurship in India- an Exploratory Study', Conference proceedings by 7th Annual EUROMED Academy of Business Conference, Norway, https://s3.amazonaws.com/academia.edu.documents/35271901/euromed2014-book-of-proceedings-2014-10-13.
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8. Waste Management in India - Shifting Gears, Report by ASSOCHAM, PWC, March, 2017.
9. Wilson DC, Velis C, Cheeseman C. 2006. Role of informal sector recycling in waste management in developing countries. Habitat Int. 30, 797–808. (doi:10.1016/j.habitatint.2005.09.005)

SEMESTER IX

25-815-0901: Energy Efficiency and Sustainability

(**Credits : 4**)

Course Description:

This course provides a comprehensive study of energy efficiency and sustainable design principles in the context of building construction and operation. It introduces students to energy consumption patterns, end-use systems, and passive design strategies that optimize energy use in buildings. Emphasis is placed on energy conservation, green building principles, climate-responsive design, and the role of sustainable materials.

Students will gain insights into embodied energy, life cycle analysis, and the application of international and national energy codes, standards, and rating systems such as LEED, GRIHA, and BEE. The course further explores energy efficiency in thermal and electrical utilities, including HVAC, lighting, and steam systems, as well as concepts of cogeneration and waste heat recovery.

The final module equips students with practical skills in energy management and auditing, carbon footprint analysis, and energy action planning. Through a blend of technical, environmental, and financial perspectives, students will be prepared to develop and evaluate high-performance, energy-efficient, and sustainable building solutions.

Course Objectives:

- Understand energy use patterns in buildings and apply energy-saving strategies.
- Integrate passive and climate-responsive design principles.
- Evaluate materials using life cycle and embodied energy concepts.
- Apply energy codes and building rating systems.
- Identify and improve efficiency in building utility systems.
- Conduct energy audits and propose sustainable energy management solutions.

Course Outcomes:

After successful completion of this course students should be able to:

CO1	Understand the concepts and factors influencing green building concepts, systems and energy management.	Understand
CO2	Identify and compare existing energy codes, green building codes and green rating systems	Understand
CO3	Use low embodied energy industrial and building materials and cost-effective building technologies	Apply
CO4	Illustrate the factors to increase the efficiency of thermal and electrical equipment	Apply
CO5	Identify different types of energy audit, maximizing and optimizing system efficiency	Apply

Assessment Pattern:

Category	**Assessment Methods**			**Examination**
	Test 1	**Test 2**	**Test3**	
Understand	30	30	30	30
Apply	40	40	40	40
Analyze	30	30	30	30

SYLLABUS

Module I :
Energy Efficiency, Overview of energy efficiency (EE) in buildings and its benefits, Approach to EE in Buildings, Basics of energy systems in buildings interface of systems and envelope, overview on energy-consuming end uses, energy consumption patterns of different end-use for varying building typologies, energy consumption benchmarks in buildings. Concept of passive building design.

Module II :
Conservation of Energy, Energy Utilization in Buildings, Sustainable construction, Need of energy in buildings, Study of climate and its influence in building design for energy requirement, Principles of energy conscious design of buildings, typical features of green buildings, benefits of green buildings towards sustainable development, Environment and Resource concerned of building, Implementation strategies related to Integrative design Strategies. High-Performance Building Energy Design Strategy and Goal Settings Methods to reduce embodied energy in building materials, Energy efficiency in a green building.

Module III :
Primary and Secondary Energy, Embodied Energy, Role of Materials, Emission and pollution, Resources for Building Materials, Life Cycle Assessment, Life Cycle Costing, Key considerations regarding sustainable materials Building energy efficiency, Standards, codes and rating of buildings (international and national perspective) related to energy efficiency in commercial buildings. Calculation and documentation for compliance and rating. Envelope, HV AC, lighting, controls for code compliance. Rating systems for energy efficient buildings in India and other countries. Green building rating systems and certification such as LEED, GRIHA, ASOOCHAM GEM, BEE and ECBC.

Module IV :
Energy Efficiency in Thermal Utilities: Fuel and Combustion; Boiler; Steam system; Furnaces; Insulation and Refractories; Cogeneration; Waste Heat Recovery; Heat Exchangers; HV AC and refrigeration system; Compressed Air System Energy Efficiency in Electrical Utilities: Electrical Systems; Electrical Motors and variable speed drives; Pump and pumping systems, Fan and Blowers, Lighting systems; Power generating system; Energy Conservation in buildings.

Module V :
General Aspects of Energy Management & Energy Audit: Basics of Energy and its various forms; Overview of Energy Conservation and related policies; Material and Energy Balance; Energy Action Planning; Energy Monitoring and Targeting. Financial Management; Carbon Footprint Calculation Energy Audit: need, types, understanding the energy cost, audit instruments, detailed methodology, different phases, detailed audit report format,

References

1. Ministry of Power, Energy Conservation Building Code 2018, Revised Version, Bureau of Energy Efficiency,2018,
2. Architectural Energy Corporation, Building Envelope Stringency Analysis, International Institute for Energy Conservation, 2004
3. Indian Building Congress, Practical Handbook on Energy Conservation in Buildings, I st ed. Nabhi Publication, 2008.
4. Bhattacharyya, Subhes C. Energy economics: concepts, issues, markets and governance. Springer Science & Business Media, 2011.
5. Ashok V. Desai. Energy Demand - Analysis, Management and Conservation, Wiley Eastern Ltd., New Delhi.,1990, ISBN 9788122402025.
6. Albert Thumann. Handbook of Energy Audits. 9th edition, CRC press, 2012.
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8. K.S. Jagadish, B. U. Venkataramareddy, K. S. Nanjundarao. Alternative Building Materials and Technologies. New Age International, 2007.

List of Elective Courses with level 500

25-815-L5E1: Advanced Environmental Bio-Informatics

(**Credits : 4**)

Course Description:

This course connects environmental science with bioinformatics tools to help understand our natural world. You'll learn fundamental bioinformatics techniques like BLAST and DNA barcoding, along with specialized skills for analyzing environmental DNA and modeling ecosystems. Through hands-on projects, you'll gain practical experience in sequence analysis and environmental data interpretation that can be applied to real-world challenges like biodiversity assessment, pollution monitoring, and conservation.

Course Objective:

The course aims to master core bioinformatics tools including BLAST, sequence alignment, and phylogenetic analysis. The students learn techniques for DNA barcoding and metabarcoding for species identification and develop skills in ecological modeling using computational tools. Apply data science techniques to environmental genomic problems and design monitoring systems using biological data and bioinformatics approaches

Course Outcomes:

After successfull completion of this course students should be able to:

CO1	Understand core bioinformatics tools including BLAST, sequence alignment, and phylogenetic analysis	Understand
CO2	Analyze relationships between genetic diversity and environmental factors	Analyse
CO3	Critically evaluate biodiversity patterns using metabarcoding approaches	Evaluate
CO4	Apply DNA barcoding analysis for species identification	Apply
CO5	Apply basic bioinformatics workflow for examining the relationships between genetic diversity and environmental factors.	Apply

SYLLABUS

Module I : Fundamentals of Bioinformatics

Introduction to biological databases (NCBI, EMBL, UniProt), Sequence file formats and data handling, BLAST and sequence similarity searching, Sequence alignment (pairwise and multiple sequence alignment). Hands-on Activity: Using BLAST to identify unknown sequences Software: NCBI BLAST web interface, Geneious Prime, MUSCLE, Clustal Omega, EMBOSS Tools.

Module II : DNA Barcoding and Environmental Genomics

Principles of DNA barcoding and marker selection (COI, ITS, 16S rRNA), Environmental DNA (eDNA) sampling and processing methods, Metabarcoding approaches for community analysis, Quality control and chimera detection in environmental sequences. Hands-on Activity: DNA barcode analysis for species identification Software: QIIME2, USEARCH, VSEARCH, cutadapt, DADA2, Trimmomatic, FastQC.

Module III : Sequence Analysis and Phylogenetics

Sequence annotation and feature prediction, Building and interpreting phylogenetic trees, Molecular evolution and selection analysis, Metagenome assembly and binning. Hands-on Activity: Constructing phylogenetic trees from environmental sequences Software: MEGA, IQ-TREE, MrBayes, MAFFT, RAxML, FigTree, Geneious Prime, PAML

Module IV : Ecological Applications and Data Integration

Biodiversity assessment using metabarcoding, Functional prediction from environmental sequences, Integrating genomic data with environmental parameters, Network analysis of species interactions. Hands-on Activity: Analyzing metabarcoding data for biodiversity assessment Software: R (vegan, phyloseq, DESeq2 packages), Cytoscape, PICRUSt2, STAMP, MEGAN, Galaxy platform.

Module V : Advanced Tools and Emerging Technologies

Machine learning for environmental sequence classification, Whole genome analysis in environmental contexts, Long-read sequencing technologies for environmental applications, Data visualization techniques for environmental genomics Hands-on Activity: Design and implement a complete environmental bioinformatics workflow Software: Python (scikit-learn, TensorFlow, Biopython packages), Nanopore tools, Flye, Canu, R (ggplot2, Shiny), Tableau.

References

1. Pevsner, J. (2023). Bioinformatics and Functional Genomics (4th ed.). Wiley-Blackwell.
2. Wooley, J. C., & Ye, Y. (2022). Computational Methods for Next Generation Sequencing Data Analysis. Wiley.
3. Taberlet, P., Bonin, A., Zinger, L., & Coissac, E. (2018). Environmental DNA: For Biodiversity Research and Monitoring. Oxford University Press.
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6. Beckerman, A. P., & Petchey, O. L. (2022). Getting Started with R: An Introduction for Biologists (3rd ed.). Oxford University Press.
7. Buffalo, V. (2022). Bioinformatics Data Skills: Reproducible and Robust Research with Open Source Tools (2nd ed.). O'Reilly Media.
8. VanderPlas, J. (2022). Python Data Science Handbook (2nd ed.). O'Reilly Media.

Software Requirements and Resources

Essential Software

- Sequence Analysis: NCBI BLAST+, MUSCLE, MAFFT, Clustal Omega
- Phylogenetics: MEGA, IQ-TREE, FigTree, RAxML
- Metabarcoding: QIIME2, DADA2, VSEARCH
- Quality Control: FastQC, Trimmomatic, MultiQC
- Programming: R, Python (Anaconda distribution recommended)
- R Packages: Bioconductor, dplyr, vegan, phyloseq, ggplot2
- Python Packages: Biopython, pandas, NumPy, scikit-learn, matplotlib

Cloud Resources

- Galaxy platform (https://usegalaxy.org/)
- CIPRES Science Gateway for phylogenetic analyses
- XSEDE computing resources for intensive analyses
- Docker containers with pre-configured bioinformatics environments

Data Sources

- NCBI SRA (Sequence Read Archive)
- BOLD Systems (Barcode of Life Data Systems)
- GBIF (Global Biodiversity Information Facility)
- ENA (European Nucleotide Archive)
- MGnify (EBI Metagenomics)

25-815-L5E2: Advanced Water Treatment Technologies

(**Credits : 4**)

Course Description:

This course on Advanced Water Treatment Technologies offers students a detailed exploration of the processes vital for maintaining water quality. It starts with the basics, covering coagulation, flocculation, and disinfection, while also introducing key concepts in water quality and environmental toxicology. Moving on to advanced methods like membrane filtration and oxidation, the course highlights the importance of considering toxicity in treatment processes. The course also explores the basics of designing water treatment plants, ensuring they understand layout, equipment selection, and safety standards, with a focus on toxicological aspects. Additionally, they gain insights into operating and maintaining treatment systems, including monitoring, and managing toxic contaminants. By exploring cutting-edge innovations and case studies, students are equipped with a thorough understanding of water treatment, preparing them for rewarding careers in the water industry.

Course Objective:

The objective of Advanced Water Treatment Technologies is to provide students with a comprehensive understanding of the principles and practices essential for maintaining water quality. Starting with foundational concepts such as coagulation, flocculation, and disinfection, students will develop a solid grasp of basic water treatment processes. As the course progresses, students will delve into advanced methods including membrane filtration, oxidation, and ion exchange, emphasizing the importance of considering toxicity in treatment technologies. This course is designed to explore emerging technologies and case studies where the students will gain practical insights into innovative practices in water treatment.

Course Outcomes:

After successfull completion of this course students should be able to:

CO1	Understand the fundamental principles of water treatment processes, including coagulation, flocculation, sedimentation, filtration, and disinfection.	Understand
CO2	Analyze the application of advanced treatment methods such as membrane filtration, oxidation processes, ion exchange, and adsorption in water treatment.	Analyse
CO3	Apply knowledge of water treatment plant design, including considerations for layout, equipment selection, and hydraulic design, with a focus on safety and regulatory compliance	Apply
CO4	Evaluate the operation and maintenance strategies of treatment systems, including monitoring, upgrades, modernization, and managing toxic contaminants.	Evaluate
CO5	Apply innovative practices in water treatment, including emerging technologies, smart systems, and sustainable practices, through case studies and real-world projects.	Apply

Assessment Pattern:

Category	**Assessment Methods**			**Examination**
	Test 1	**Test 2**	**Seminar**	
Understand	40	40	40	40

Apply	20	20	20	20
Analyze	20	20	20	20
Evaluate	20	20	20	20

SYLLABUS

Module I : Advanced Treatment Methods

Membrane Filtration, Micro and ultra and nanofiltration, Reverse and forward osmosis, Electrodialysis, Advanced Oxidation Processes, Ion Exchange and Adsorption, Biological Treatment (Activated Sludge, MBR), Toxicity Considerations in Advanced Treatment Technologies

Module II : Water Treatment Plant Design

Design Considerations for Water Treatment Plants, Process Flow Diagrams and Equipment Selection, Plant Layout and Hydraulic Design, Toxicological Aspects in Plant Design, Safety and Regulatory Compliance

Module III :Operation and Maintenance of Treatment Systems

Plant Operation Strategies, Monitoring and Control Systems, Upgrades and Modernization of Treatment Facilities, Toxic Contaminant Management in Operation and Maintenance, Troubleshooting and Maintenance Practices of treatment systems, Municipal wastewater treatment, Industrial wastewater treatment.

Module IV : Innovations in Water Treatment and Integrated Water Resource Management

Emerging Technologies in Water Treatment, Smart Water Treatment Systems, Sustainable Practices in Water Treatment, Sustainable Innovations Addressing Toxicity, Case Studies on Innovative Water Treatment Projects, Importance of Water Conservation, Residential Water Conservation Practices, Agricultural Water Management Techniques, Industrial Water Efficiency Measures, Principles of Integrated Water Resource Management, Sustainable Development Goals and IWRM

References

1. Judd, S., 2010. The MBR book: principles and applications of membrane bioreactors for water and wastewater treatment. Elsevier.
2. Elshorbagy, W. and Chowdhury, R. eds., 2013. Water treatment. BoD–Books on Demand.
3. Worch, E., 2012. Adsorption technology in water treatment (Vol. 10). Berlin: de Gruyter.
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6. Li, N.N., Fane, A.G., Ho, W.W. and Matsuura, T. eds., 2011. Advanced membrane technology and applications. John Wiley & Sons.
7. Singh, R., 2014. Membrane technology and engineering for water purification: application, systems design and operation. Butterworth-Heinemann.
8. Figoli, A., Hoinkis, J. and Bundschuh, J. eds., 2016. Membrane technologies for water treatment: removal of toxic trace elements with emphasis on arsenic, fluoride and uranium. CRC Press.
9. Ismail, A.F. and Matsuura, T. eds., 2012. Sustainable membrane technology for energy, water, and environment. John Wiley & Sons.

25-815-L5E3: Green Design & Management of Project area

(**Credits : 4**)

Course Description:

As urban landscapes continue to expand, the need for integrating sustainable practices into the heart of urban planning and project management has never been more crucial for students. This course aims to equip students with the knowledge and skills necessary to make a significant positive impact on our cities and their future. Throughout this course, students will delve into the principles of green design, learning how to select sustainable materials, implement energy- efficient systems, and ensure that buildings not only serve their inhabitants but also enhance the natural environment. Strategies for effectively managing project areas will be explored, focusing on responsible land use, habitat preservation, and the creation of green spaces that promote biodiversity and provide urban dwellers with much-needed access to nature. Students will emerge with a comprehensive understanding of how to balance human requirements with environmental stewardship, employing innovation, collaboration, and foresighted planning. Through this course, students will be empowered to lead the way in creating cities that are not only environmentally friendly but also vibrant, resilient, and inclusive for all residents

Course Objective:

This course is designed to arm students with the knowledge and practical skills essential for driving sustainable urban development and pioneering green design initiatives. Structured around five key modules, the curriculum offers a deep dive into the fundamentals of green design, advanced building techniques, and strategic project management, ensuring a comprehensive understanding of sustainability from the ground up. Students will navigate through the complexities of sustainable materials selection, energy conservation, and water management, moving towards innovative solutions in green building and urban resilience against climate change. The course also emphasizes the critical role of community engagement and policy frameworks in fostering sustainable urban ecosystems

Course Outcomes:

After successfull completion of this course students should be able to:

CO1	Gain a comprehensive understanding of green design principles, sustainable material selection, and indoor environmental quality to apply in real-world scenarios.	Understand
CO2	Enhance project area management skills for efficient resource use and habitat preservation through land use planning, site selection, and landscape optimization.	Apply
CO3	Explore a range of green building techniques for energy efficiency and renewable energy integration.	Apply
CO4	Investigate sustainable urban development strategies focusing on transportation, green spaces, and climate resilience	Analyse

CO5	Acquire tools for monitoring and evaluating sustainability efforts through certification and performance evaluation practices	Evaluate

Assessment Pattern:

Category	Assessment Methods			Examination
	Test 1	Test 2	Seminar	
Understand	20	20	20	20
Apply	40	40	40	40
Analyze	20	20	20	20
Evaluate	20	20	20	20

SYLLABUS

Module I : Green Design Principles

Sustainable Materials – Material selection, Natural and renewable materials, Energy efficiency, Water conservation – efficiency of usage, recycling, water harvesting Waste reduction, Indoor environmental quality – ventilation, daylighting, indoor air quality, Thermal comfort, Acoustic comfort, Biophilic design.

Module II : Project Area Management

Land use planning - Assessment, Design and Regulation phases. Site selection and development - Location, Site characteristics, Utilities availability, Land ownership, Site assessment. Landscape and ecosystem management: Optimization of Land, Water and Natural resources - Zoning, Habitat preservation, Ecosystem health and restoration efforts, Environmental impact assessment – Scoping, Baseline data collection, Impact identification, Impact prediction, Mitigation measures, Monitoring plan, Sustainable infrastructure: Resource efficiency, Biodiversity conservation, Climate resilience, Social equity.

Module III : Green Building Techniques

Active and passive design strategies - Building orientation, Natural ventilation, Thermal mass, Insulation, Daylighting, Shading devices, Cool roofs, Earth Sheltering, Living walls, Rainwater harvesting, Wind turbines, Greywater recycling, Dynamic shading systems, High efficiency heating, Ventilation and Air Conditioning (HVAC) systems, Energy management systems, Renewable energy systems - Renewable energy integration.

Module IV : Sustainable Urban Development

Transportation – Walkability, Efficient public transportation, Cycling infrastructure, Electric vehicles. Green spaces and Biodiversity – Parks, Green Roofs, Vertical Gardens. Design principles - Role of Indigenous Flora and Fauna. Urban Agriculture –Environmental and Social benefits, Community Gardens, Rooftop gardens, Vertical farming, Permaculture Design Principles. Climate adaptation and resilience – Assessing Climate risks in urban planning, Sustainable Urban Design for Climate Adaptation, Heat Island Effect Mitigation Strategies, Community-based Adaptation and Social Resilience.

Module V : Monitoring and Evaluation

Green building certification, Environmental laws and regulations, Performance measurement – Key performance indicators, Monitoring and Evaluation, Life cycle assessment, Post- occupancy evaluation.

References

1. Keeler, M., & Vaidya, P. (2016). Fundamentals of Integrated Design for Sustainable Building. John Wiley & Sons.
2. Jane Silberstein M.A., M. A. Silberstein, Chris Maser (2019) Land-Use Planning for Sustainable Development. CRC Press.
3. Allwood, J., & Cullen, J. (2012). Sustainable Materials - with both eyes open. UIT Cambridge Limited.
4. Kellert, S. R., Heerwagen, J., & Mador, M. (2013). Biophilic Design. Wiley.
5. Kubba, S. (2016). Handbook of Green Building Design and Construction. Butterworth- Heinemann.
6. Silvius, G., Schipper, R., Planko, J., & Van Den Brink, J. (2017). Sustainability in Project Management. Routledge.
7. Dramstad, W., Olson, J. D., & Forman, R. T. (2013). Landscape Ecology Principles in Landscape Architecture and Land-Use Planning. Island Press.
8. Gajanan M. Sabnis (2012) Green Building with Concrete: Sustainable Design and Construction. CRC Press.
9. Godfrey Boyle (2012) Renewable Energy: Power for a Sustainable Future. Oxford University Press.
10. Wheeler, S. M., & Beatley, T. (2014). Sustainable Urban Development Reader. Routledge.
11. Larice, M., & Macdonald, E. (2013). The Urban Design Reader. Routledge.
12. Preiser, W., & Vischer, J. (2006). Assessing Building Performance. Routledge.

25-815-L5E4: Environmental Data Modeling

(Credits : 4)

Course Description:

Environmental data modeling is an essential aspect of understanding and managing environmental systems. This course introduces students to the fundamental principles, techniques, and tools used in environmental data modeling. Students will learn how to collect, analyze, visualize, and interpret environmental data using various modeling approaches. The course will cover topics such as spatial analysis, temporal analysis, statistical modeling, and predictive modeling in the context of environmental sciences.

Course Objective:

The prime objective of this course is to enrich students with the basic concepts and principles of environmental data modeling. They gain proficiency in collecting and per-processing environmental data and explore various spatial and temporal analysis techniques for environmental data. They learn different types of environmental data and their characteristics, statistical modeling techniques for environmental data analysis, and predictive modeling approaches. They should develop skills to apply environmental data modeling techniques to solve real-world environmental problems.

Course Outcomes:

After successfull completion of this course students should be able to:

CO1	Explain the importance of environmental data modeling in environmental science and management.	Understand
CO2	Apply statistical methods to analyze and interpret environmental datasets.	Apply
CO3	Develop models to predict environmental phenomena based on collected data	Apply
CO4	Compare and contrast different modeling approaches for specific environmental problems.	Analyse
CO5	Analyze model outputs and assess their accuracy and limitations.	Analyse

Assessment Pattern:

Category	**Assessment Methods**			**Examination**
	Test 1	**Test 2**	**Seminar**	
Understand	30	30	20	30
Apply	40	30	40	40
Analyze	30	40	40	30

Module I : Basics of Environmental Modelling

Types of environmental models - Statistical Models, GIS-based models, Ecological models, Climate models, Air Quality models, Water quality models.

Module II : Enviromental modelling Approaches

Statistical modelling - Linear regression - Generalised linear models, Time series analysis, Spatial analysis. Machine learning - Supervised learning, Unsupervised learning, Reinforcement Learning, Semi-supervised and Deep learning. Simulation modelling - parameters and scenarios.

Module III : Environmental Modelling Techniques

Key compoenents - Data collection, Processing, Model selection and development, Model evaluation, Refinement, Sensitivity analysis, Uncertainity analysis, Visualisation, Validation and Testing, Prediction and Analysis.

Module IV : Applications of Environmental Data Modelling

Climate Change Assessment, Air Quality Management, Water Quality MAnagement, Water resources management, Natural disaster prediction, Ecological conservation, Optimising resource allocation, Risk aseesment, Policy development, Urban planning, Case studies.

References

1. Holzbecher, E. (2012, January 10). Environmental Modeling. Springer Science & Business Media.
2. Schnoor, J. L. (1996, October 4). Environmental Modeling. Wiley-Interscience.
3. Kanevski, M., Pozdnukhov, A., & Timonin, V. (2009, June 9). Machine Learning for Spatial Environmental Data. EPFL Press.
4. Gray, W. G., & Gray, G. A. (2017, January 1). Introduction to Environmental Modeling. Cambridge University Press.
5. Barnsley, M. J. (2007). Environmental Modeling: A Practical Introduction. United States: Taylor & Francis.
6. Philip J. Rasch (2012) Climate Change Modeling Methodology: Selected Entries from the Encyclopedia of Sustainability Science and Technology. United States: Springer New York.
7. Olej, V., Ilona, O. L., & Krupka, J. (2010, November 30). Environmental Modeling for Sustainable Regional Development: System Approaches and Advanced Methods. IGI Global.
8. Smith, J., & Smith, P. (2007, January 18). Environmental Modelling. Oxford University Press.
9. Haining, R. P. (2003). Spatial Data Analysis: Theory and Practice. United Kingdom: Cambridge University Press.

25-815-L5E5: Sustainable Development Principles And Practices

(**Credits : 4**)

Course Description:

This course offers students a comprehensive understanding of the principles, practices, and challenges associated with sustainable development. Adopting a multidisciplinary approach, students will explore the environmental, social, and economic dimensions of sustainability. They will examine practical strategies for implementing sustainable practices across various sectors, including energy, transportation, agriculture, urban planning, and more. Through case studies, students will develop the knowledge and skills necessary to address pressing sustainability issues and promote positive change in their communities and beyond.

Course Objective:

Overall, this course will equip students with the knowledge, skills, and tools needed to address complex sustainability challenges and drive positive change across various sectors and scales. By understanding the interconnectedness of environmental, social, and economic systems, they will be better prepared to advocate for and implement sustainable practices that foster resilience, equity, and prosperity for present and future generations.

Course Outcomes:

After successfull completion of this course students should be able to:

CO1	Understand the concept of sustainable development and to explore the environmental, social, and economic dimensions of sustainability	Understand
CO2	Examine the role of various sectors in sustainability, including agriculture, water, Energy, transportation, urban planning, climate, tourism and conservation.	Evaluate
CO3	Analyze the challenges and barriers to achieving sustainability at local, Regional and global levels.	Analyse
CO4	Analyse the case studies and best practices in sustainable development from different regions and sectors and to Analyse the indicators of sus- Tainable development.	Analyse
CO5	Develop practical skills for implementing sustainable practices in various Contexts.	Apply

Assessment Pattern:

Category	**Assessment Methods**			**Examination**
	Test 1	**Test 2**	**Seminar**	
Understand	20	20	20	20
Apply	20	20	20	20

Analyze	40	40	40	40
Evaluate	20	20	20	20

SYLLABUS

Module I : Introduction to Sustainable Development

Definition of sustainable development; The three pillars of sustainability: Environmental, Economic, and Social; Historical evolution of sustainable development; Key frameworks: Brundtland Report (1987), Agenda 2030, and the SDGs; Global Environmental Challenges: Climate change and its impact on sustainable development, Biodiversity loss and ecosystem services, Natural resource depletion (water, energy, etc.), Pollution and waste management; Economic Aspects of Sustainability; Social Dimensions of Sustainable Development.

Module II: Policy, Governance, and Sustainable Development

International organizations and agreements (e.g., UN, WTO, Paris Agreement); National sustainability policies and frameworks; Governance for sustainable development: roles of government, businesses, and NGOs; Policy integration and mainstreaming sustainability; Sustainable Development Goals (SDGs): Introduction to the 17 SDGs and their targets; How the SDGs relate to the three pillars of sustainability; Measuring progress towards SDGs: Indicators and benchmarks; Localizing SDGs for specific contexts; Sustainable Development Practices in Agriculture and Food Systems; Energy for Sustainable Development.

Module III: Tools for Sustainable Development

Life Cycle Assessment (LCA); Sustainability indicators and metrics; Sustainable Development Goals (SDG) reporting tools; Sustainability certifications (e.g., LEED, ISO 14001). Engaging Communities in Sustainability Practices - Community-driven development and participation, Building local resilience and sustainability, Education and awareness for sustainable living, Case studies of community-led sustainability initiatives.

Module IV: Business and Sustainability

The role of businesses in achieving sustainability goals; Corporate Social Responsibility (CSR) and sustainability reporting; Sustainable supply chains and ethical sourcing; Green washing vs. genuine sustainability. Sustainable Urban Development and Green Cities - Sustainable urban planning and design, Urbanization and its impact on the environment, Green infrastructure and sustainable transportation, Case studies of sustainable cities (e.g., Copenhagen, Vancouver).

Module V: Future Trends and Innovations in Sustainable Development

Technological innovations for sustainability (e.g., clean tech, AI), The future of global sustainability governance, The role of youth and activism in driving change, Emerging trends: Bio-economy, circular economy, digital sustainability

References

Core Textbooks:

1 Brundtland, G. H. (1987). Our Common Future: The World Commission on Environment and Development. Oxford University Press.

2 Sachs, J. D. (2015). The Age of Sustainable Development. Columbia University Press.

3 Dyllick, T., & Hockerts, K. (2002). Beyond the Business Case for Corporate Sustainability. Business Strategy and the Environment, 11(2), 130–141.

Key Reports & Publications:

4 United Nations (UN) (2015). Transforming our World: The 2030 Agenda for Sustainable Development.

5 World Commission on Environment and Development (WCED) (1987). Our Common Future.

6 The Sustainable Development Goals Report (Annual Report by the UN)

Books on Sustainability in Practice:

7 Jackson, T. (2009). Prosperity without Growth: Economics for a Finite Planet. Earthscan.

8 Kates, R. W., Parris, T. M., & Leiserowitz, A. A. (2005). What is Sustainable Development? Goals, Indicators, Values, and Practice. Environment: Science and Policy for Sustainable Development, 47(3), 8-21.

9 Hawken, P., Lovins, A., & Lovins, L. H. (1999). Natural Capitalism: Creating the Next Industrial Revolution. Little, Brown, and Company.

Environmental Economics & Policy:

10 Pearce, D., Barbier, E., & Markandya, A. (1990). Sustainable Development: Economics and Environment in the Third World. Edward Elgar Publishing.

11 Baumol, W. J., & Oates, W. E. (2001). The Theory of Environmental Policy (2nd ed.). Cambridge University Press.

Case Studies and Practical Applications:

12 Elkington, J. (1997). Cannibals with Forks: The Triple Bottom Line of 21st Century Business. Capstone Publishing.

13 Sullivan, R. (2010). Sustainability in Business: A Global Perspective. Routledge.

Journal Articles:

14 Brockington, D., & Sullivan, S. (2003). Sustainable Development: A Critical Perspective. Development Policy Review, 21(4), 471–487.

15 Mebratu, D. (1998). Sustainability and Sustainable Development: Historical and Conceptual Review. Environment: Science and Policy for Sustainable Development, 40(1), 1-9.

Additional Resources:

16 United Nations Environment Programme (UNEP). (2020). The UN Environment Programme's Annual Report on Global Environmental Governance.

17 International Institute for Environment and Development (IIED). (2019). Sustainable Development Goals and Local Implementation.

25-815-L5E6: Applications of Computational Methods

(**Credits : 4**)

Course Description:

This course explores advanced applications of computational methods in addressing complex challenges within the field of environmental studies. Students get introduced to sophisticated computational techniques, modelling approaches, data analysis methods, and simulations. This course equips them with the skills necessary to tackle real-world environmental problems. Emphasis will be placed on case studies and problems that bridge the gap between theoretical knowledge and practical problem-solving

Course Objective:

By the end of this course, students will have gained advanced computational skills and a deep understanding of how these methods can be effectively applied to address complex environmental issues, preparing them for careers at the forefront of environmental research and innovation

Course Outcomes:

After successfull completion of this course students should be able to:

CO1	Discuss the basic concepts of Monte Carlo simulation	Understand
CO2	Solve the systems of linear equations in environmental science	Apply
CO3	Execute the regression analysis and curve fitting on real-world data.	Apply
CO4	Solve the differential equations of higher order.	Apply
CO5	Examine the power-series analysis of time series data sets in environmental science	Analyze

Assessment Pattern:

Category	**Assessment Methods**			**Examination**
	Test 1	**Test 2**	**Seminar**	
Remember	20	10	20	10
Understand	40	40	30	40
Apply	40	30	40	40
Analyze	0	20	20	10

SYLLABUS

Module I : Numerical Solution of a system of Equations

Linear Algebraic equations; Matrix population modelling; Elementary ideas on using matrix; Gauss Jordan elimination method; ; Gauss elimination method; Gauss-Jordan method to find inverse of a matrix.

Algorithm and Programmes for each method.

Module II : Numerical Solution of Differential Equations

Elementary ideas on differential equations; Solution of simple First order ODEs; Asymptotic behaviour; Numerical Solutions of ODEs; Euler method – Modified Euler method – Runge Kutta Method 4th order; adaptive step size R-K method; Solving higher order equations ; Concept of stability.

Algorithm and Programmes for each method.

Module III : Curve Fitting and Interpolation

Requirement of Curve fitting; Least -square method of fitting for linear, polynomial, power and exponetial; Introduction to interpolation; finite difference operators; Newton's forward interpolation method; backward interpolation method; divide difference method; Cubic spline method;

Algorithm and Programmes for each method.

Module IV : Power series analysis

Introduction, Frequency Distributions in One Variable; Fourier Series Analysis with Application to Periodic Step Function; Fast Fourier Transform; Application of FFT in time-series;

Algorithms and Programmes

Module V : Introduction to Monte Carlo Simulation

Introduction to Simulations - Buffon's needle problem – requirement of random numbers - Random number generators - Monte Carlo method. Basic use of random number for MC.

References

1. Numerical methods for scientific and Engineering computation M.K Jain,S.R.KIyengar, R.K. Jain, New Age International Publishers
2. Computer Oriented Numerical Methods, V. Rajaraman, PHI, 2004.
3. Numerical Methods, E. Balagurusami, Tata McGraw Hill, 2009.
4. Numerical Mathematical Analysis, J.B. Scarborough, 4PthP Edn, 1958
5. Explorations in Monte Carlo Methods Ronald W Shonkwiler and Franklin Mendivil , Springer
6. https://www.codesansar.com/numerical-methods/

SEMESTER X

25-815-1001: Major Project