COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY

(Abstract)

Faculty of Environmental Studies - Revised Curriculum, Syllabus and Admission Criteria of M.Sc Environmental Science and Technology programme - Resolution of the Academic Council - Communicated - Orders issued.

ACADEMIC A SECTION

No.CUSAT/AC(A).A3/4192/2024 Dated,KOCHI-22,04.10.2024

Read:-Item No. I (d) (i - iii) of the minutes of the meeting of the Academic Council held on 30.04.2024

ORDER

The Academic Council considered along with the recommendations of it's standing committee, the Minutes of the Faculty of Environmental Studies held on 06.04.2024 and resolved to approve the following with modifications:

i. The revised Curriculum and Syllabus of M.Sc Environmental Science and Technology programme offered at the School of Environmental Studies with effect from 2024 admission (appended).

ii. The admission criteria of M.Sc Environmental Science and Technology programme w.e.f 2025 admission as follows:

1. **Physical Sciences**: Graduate in Chemistry with Physics and Mathematics as subsidiaries or graduate in Engineering (Civil/ Public Health/ Environmental) with 55% marks (50% in the case of SC/ST candidates) or graduate in Physics with Chemistry and Mathematics or graduates in Geology/ Earth Sciences with optional subjects in the qualifying examination and a valid rank in the Common Admission Test (CAT), conducted by the University
2. **Biological Sciences**: Graduate in Life Sciences/ Environmental Science/ Zoology/ Botany/ Microbiology/ Biotechnology with 55% marks (50% in the case of SC/ ST candidates) in optional subjects in the qualifying examination and a valid rank in the Common Admission Test (CAT), conducted by the University.

   Also resolved to approve the following TEST CODES for the conduct of CAT Examinations:

No;	Test Code	Subject
1	601	Biotechnology

2	604	Chemistry
3	607	Engineering Sciences
4	611	Life Sciences
5	613	Physics
6	609	Geology

iii. To maintain the intake of students to 30 seats for the Post Graduate Program M.Sc. Environmental Science and Technology from 2024 admissions onwards, offered at the School of Environmental Studies, CUSAT, Kochi- 682 022, in view of the global demand of the programme.

Orders are, therefore, issued accordingly.

Dr. Arun A U *

Registrar

To:

1. The Dean, Faculty of Environmental Studies
2. Chairperson, BoS under Faculty of Environmental Studies
3. The Director, School of Environmental Studies
4. All AR/DR Examination wing - with a request to forward to concerned sections
5. The Director, IQAC/ DoA
6. CIRM/Conference Sections
7. PS To VC/PVC;PA To Registrar/CE.

* This is a computer generated document. Hence no signature is required.

SYLLABUS

M.Sc. Environmental Science and Technology

[2024-2027]

SCHOOL OF ENVIRONMENTAL STUDIES

COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY

KOCHI - 682022

Contents

SCHEME

Faculty of Environmental Studies

SCHOOL OF ENVIRONMENTAL STUDIES [2024 – 2027]
M. Sc. Environmental Science & Technology

SEMESTER I

Couse Code	**Course Title**	**C/E**	**Credit**	**Internal Marks**	**External Marks**	**Total**
THEORY CORE						
24-360-0101	Environmental Biology	C	3	50	50	100
24-360-0102	Environmental Chemistry	C	3	50	50	100
24-360-0103	Environmental Physics	C	3	50	50	100
24-360-0104	Programming & Statistics	C	3	50	50	100
24-360-0105	Environmental Microbiology	C	3	50	50	100
THEORY ELECTIVE						
-	Elective I	E	2	50	50	100
-	Elective II	E	2	50	50	100
LAB CORE						
24-360-0110	Environmental Chemistry lab	C	2	50		50
24-360-0111	Environmental Microbiology lab	C	2	50		50
Total Credits	**Core -15; Elective - 04 Lab - 04**	**05C(T) 02E(T) 02C(L)**	23	450	350	800

NOTE: After the completion of the courses and examination of the SEMESTER I, students can join for industry bound- based INTERNSHIP in a recognized institute/ university/ organization/ industry/ government department/ in their home institution laboratory under the guidance of a research guide (certificate has to be issued by the head of the institution after the successful completion of the program).

SEMESTER II

Couse Code	Course Title	C/E	Credit	Internal Marks	External Marks	Total
THEORY CORE						
24-360-0201	Environmental Pollution	C	3	50	50	100
24-360-0202	Geo-informatics	C	3	50	50	100
24-360-0203	Environmental toxicology	C	3	50	50	100
24-360-0204	Environmental engineering	C	2	50	50	100
24-360-0205	Methods In Environmental Analysis	C	2	50	50	100
24-360-0206	Fluid Mechanics	C	2	50	50	100
THEORY ELECTIVE						
-	Elective I	E	2	50	50	100
-	Elective II [MOOC Course]	E	2	0	100	100
LAB CORE						
24-360-0213	Environmental engineering- lab	C	1	50		50
24-360-0214	Chemical and biological methods in environmental analysis –lab	C	2	50		50
24-360-0215	Environmental toxicology -lab	C	1	50		50
Total Credits	**Core -15; Elective -04 ; Lab -04**	**06C(T) 02E(T) 03C(L)**	23	500	450	950

NOTE: After the completion of the courses and examination of the SEMESTER II, students can join for an industry bound-based SKILL DEVELOPMENT PROGRAM in a recognized institute/ university/ organization/ industry/ government department/ in their home institution laboratory under the guidance of a research guide / scientist/ engineer/ technological personality (certificate has to be issued by the head of the institution on the successful completion of the program)

SEMESTER III: FIVE SPECIALISATIONS

- **STREAM I: Water Science and Technology**
- **STREAM II: Carbon Emission Control Systems**
- **STREAM III: Environmental Data Acquisition and Analysis**
- **STREAM IV: Waste Management and Resource Recovery**
- **STREAM V: Environmental Sustainability and Governance**

Couse Code	Course Title	C/E	Credit	Internal Marks	External Marks	Total
THEORY - CORE						
24-360-0301	Environmental Impact and Risk Assessment	C	3	50	50	100
24-360-0302	Biodiversity and Conservation	C	2	50	50	100
24-360-0303	Chemistry of Water And Wastewater Treatment	C	2	50	50	100
THEORY - SPECIAL ELECTIVE FOR SELECTED STREAM						
24-360-03XX	Special Elective I	E	3	50	50	100
24-360-03XX	Special Elective II	E	3	50	50	100
24-360-03XX	Special Elective III	E	3	50	50	100
LAB - CORE						
24-360-0320	Advanced Applied Biology Lab: Integrated Approaches to Biodiversity, Carbon Capture, and Wastewater Contaminant Toxicity Assessment	C	2	50		50
24-360-0323	Mini Project/ Practical/ Field study (in the area of specialisation)	E	3	50		50
Total Credits	**Core -7; Elective -09; Lab-05**	**03C(T) 03E(T) 02C(L)**	21	400	300	700

Note: In this Semester students can take any one of the specialisation from the following list of specialisations offered.

- **STREAM I : Water Science and Technology**
- **STREAM II : Carbon Emission Control Systems**
- **STREAM III : Environmental Data Acquisition and Analysis**
- **STREAM IV : Waste Management and Resource Recovery**
- **STREAM V : Environmental Sustainability and Governance**

THEORY -SPECIAL ELECTIVES FOR SELECTED STREAMS

Special Electives for Stream I : Water Science and Technology

Couse Code	Course Title	C/E	Credit	Internal Marks	External Marks	Total
24-360-0304	Water Science, Quality Monitoring, And Interpretation	E	3	50	50	100
24-360-0305	Wastewater Treatment Technologies	E	3	50	50	100
24-360-0306	Advanced Water Treatment Technologies	E	3	50	50	100

Special Electives for Stream II : Carbon Emission Control Systems

Couse Code	Course Title	C/E	Credit	Internal Marks	External Marks	Total
24-360-0307	Foundations For Carbon Management	E	3	50	50	100
24-360-0308	Carbon Capture And Storage	E	3	50	50	100
24-360-0309	Carbon Accounting And Reporting	E	3	50	50	100

Special Electives for Stream III : Environmental Data Acquisition and Analysis

Couse Code	Course Title	C/E	Credit	Internal Marks	External Marks	Total
24-360-0310	Environmental Data Acquisition Methods	E	3	50	50	100
24-360-0311	Environmental Data Modeling	E	3	50	50	100
24-360-0312	Environmental Monitoring, Analytical Instruments And Sensors	E	3	50	50	100

Special Electives for Stream IV : Waste Management and Resource Recovery

Couse Code	Course Title	C/E	Credit	Internal Marks	External Marks	Total
24-360-0313	Waste Management Principles And Practices	E	3	50	50	100
24-360-0314	Circular Economy And Resource Recovery	E	3	50	50	100
24-360-0315	Waste Management - Laboratory Techniques And Field/Site Visit	E	3	50	50	100

Special Electives for Stream V : Environmental Sustainability and Governance

Couse Code	Course Title	C/E	Credit	Internal Marks	External Marks	Total
24-360-0316	Environmental Sustainability Governance	E	3	50	50	100
24-360-0317	Sustainable Development-Principles And Practices	E	3	50	50	100
24-360-0319	Green Design And Management Of Project Areas	E	3	50	50	100

*** **Note:** Streams will be offered in a semester subjected to availability.

SEMESTER IV

Couse Code	Course Title	C/E	Credit	Marks
PROJECT WORK				
24-360-0401	Final Semester Project Work	C	14	
	Interim Report ii			50
	Presentation [Internal]			100
	Project Dissertation [External]			150
24-360-0402	Viva Voce [Internal]	C	2	50
Total Credits	**Core -16**	**2C**	16	350

DISTRIBUTION OF CREDITS SEMESTERWISE

SEMESTER	Course Code	Credits C/E/L	Credits (total)	Credits (max)	Marks
Semester I	(24-360-0101)-(24-360-0111)	15/4/4	23	24	800
Semester II	(24-360-0201)-(24-360-0215)	15/4/3	23	24	950
Semester III	(24-360-0301)-(24-360-0323)	7/9/5	21	24	700
Semester IV	Project & Viva	16/0/0	16	16	350

Skill Development Programme in Environmental Science & Technology - AREAS

1. Waste management technologies
2. Water, wastewater and air quality assessment and monitoring
3. Environment Impact assessment
4. Environmental Biotechnology
5. Environmental Toxicology
6. Biodiversity Conservation
7. Geographical Information System
8. Carbon sequestration technologies
9. Bio-resource management
10. Instrumentation in environmental management

Note : –

1. **INTERNSHIP/ SKILL DEVELOPMENT PROGRAME** for two months during summer vacation in industries/ institutions after SEMESTER II Examination, before the start of SEMESTER III.
2. Candidates must submit interim report of the project at mid-term which will be evaluated as part of the internal assessment as **PROJECT- INTERIM REPORT.**

INTERDEPARTMENTAL ELECTIVE- IDE OFFERED BY SCHOOL OF ENVIRONMENTAL STUDIES DURING 2024-2027.

Couse Code	Course Title	C/E	Credit	Internal Marks	External Marks	Total
SEMESTER I						
24-360-0112	Introduction to Environmental Studies	IDE	3	50	50	100
SEMESTER II						
24-360-0216	Natural Resource Management	IDE	3	50	50	100
24-360-0217	Intellectual Property Right, Biosafety and Bioethics	IDE	3	50	50	100
24-360-0219	Bio-nanotechnology	IDE	3	50	50	100
SEMESTER III						
24-360-0321	Energy Resources and Management	IDE	3	50	50	100
24-360-0322	Industrial Ecology	IDE	3	50	50	100

LIST OF COURSES

SEMESTER I

Couse Code	Course Title	Core/Elective	Credit
24-360-0101	ENVIRONMETAL BIOLOGY	Core	3
24-360-0102	ENVIRONMENTAL CHEMISTRY	Core	3
24-360-0103	ENVIRONMENTAL PHYSICS	Core	3
24-360-0104	PROGRAMMING & STATISTICS	Core	3
24-360-0105	ENVIRONMENTAL MICROBIOLOGY	Core	3
24-360-0106	CONTEMPORARY ENVIRONMENTAL ISSUES AND LAWS	Elective	2
24-360-0107	ENVIRONMENTAL MANAGEMENT AND LEGAL ASPECTS	Elective	2
24-360-0108	CHEMOMETRICS & GOOD LABORATORY PRACTICES	Elective	2
24-360-0109	ENERGY RESOURCES AND MANAGEMENT	Elective	2
24-360-0110	ENVIRONMENTAL CHEMISTRY LAB	Core LAB	2
24-360-0111	ENVIRONMENTAL MICROBIOLOGY LAB	Core LAB	2

SEMESTER II

Couse Code	Course Title	Core/Elective	Credit
24-360-0201	ENVIRONMENTAL POLLUTION	Core	3
24-360-0202	GEO-INFORMATICS	Core	3
24-360-0203	ENVIRONMENTAL TOXICOLOGY	Core	3
24-360-0204	ENVIRONMENTAL ENGINEERING	Core	2
24-360-0205	METHODS IN ENVIRONMENTAL ANALYSIS	Core	2
24-360-0206	FLUID MECHANICS	Core	2
24-360-0207	ENVIRONMENTAL BIOTECHNOLOGY & BIO REMEDIATION	Elective	2
24-360-0208	APPLIED MATHEMATICS & STATISTICS	Elective	2
24-360-0209	INDUSTRIAL ECOLOGY	Elective	2
24-360-0210	ENVIRONMENTAL MODELING	Elective	2
24-360-0211	APPLIED ENVIRONMENTAL MICROBIOLOGY	Elective	2
24-360-0212	CLIMATE CHANGE AND ENVIRONMENT	Elective	2
24-360-0213	ENVIRONMENTAL ENGINEERING- LAB	Core LAB	1
24-360-0214	CHEMICAL AND BIOLOGICAL METHODS IN ENVIRONMENTAL ANALYSIS –LAB	Core LAB	2
24-360-0215	ENVIRONMENTAL TOXICOLOGY -LAB	Core LAB	1

SEMESTER III

Couse Code	Course Title	Core/Elective	Credit
24-360-0301	ENVIRONMENTAL IMPACT AND RISK ASSESSMENT	Core	3
24-360-0302	BIODIVERSITY AND CONSERVATION	Core	2
24-360-0303	CHEMISTRY OF WATER AND WASTEWATER TREATMENT	Core	2
24-360-0304	WATER SCIENCE, QUALITY MONITORING, AND INTERPRETATION	Elective	3
24-360-0305	WASTEWATER TREATMENT TECHNOLOGIES	Elective	3
24-360-0306	ADVANCED WATER TREATMENT TECHNOLOGIES	Elective	3
24-360-0307	FOUNDATIONS FOR CARBON MANAGEMENT	Elective	3
24-360-0308	CARBON CAPTURE AND STORAGE	Elective	3
24-360-0309	CARBON ACCOUNTING AND REPORTING	Elective	3
24-360-0310	ENVIRONMENTAL DATA ACQUISITION METHODS	Elective	3
24-360-0311	ENVIRONMENTAL DATA MODELING	Elective	3
24-360-0312	ENVIRONMENTAL MONITORING, ANALYTICAL INSTRUMENTS AND SENSORS	Elective	3
24-360-0313	WASTE MANAGEMENT PRINCIPLES AND PRACTICES	Elective	3
24-360-0314	CIRCULAR ECONOMY AND RESOURCE RECOVERY	Elective	3
24-360-0315	WASTE MANAGEMENT - LABORATORY TECHNIQUES AND FIELD/SITE VISIT.	Elective	3
24-360-0316	ENVIRONMENTAL SUSTAINABILITY GOVERNANCE	Elective	3
24-360-0317	SUSTAINABLE DEVELOPMENT- PRINCIPLES AND PRACTICES	Elective	3
24-360-0319	GREEN DESIGN AND MANAGEMENT OF PROJECT AREAS	Elective	3
24-360-0320	ADVANCED APPLIED BIOLOGY LAB: INTEGRATED APPROACHES TO BIODIVERSITY, CARBON CAPTURE, AND WASTEWATER CONTAMINANT TOXICITY ASSESSMENT	Core LAB	2

SEMESTER IV

Couse Code	Course Title	Core/Elective	Credit
24-360-0401	Final Semester Project Work Interim Report ii Presentation [Internal] Project Dissertation [External]	Core	14
24-360-0402	Viva Voce [Internal]	Core	2

INTERDEPARTMENTAL ELECTIVES COURSES

Couse Code	Course Title	Core/Elective	Credit
24-360-0112	INTRODUCTION TO ENVIRONMENTAL STUDIES	Elective	3
24-360-0216	NATURAL RESOURCE MANAGEMENT	Elective	3
24-360-0217	INTELECTUAL PROPERTY RIGHT, BIOSAFETY AND BIOETHICS	Elective	3
24-360-0219	BIO-NANOTECHNOLOGY	Elective	3
24-360-0321	ENERGY RESOURCES AND MANAGEMENT	Elective	3
24-360-0322	INDUSTRIAL ECOLOGY	Elective	3

Program Outcomes

1. **Students will understand the basic concepts, fundamental principles, and scientific theories related to multi-disciplinarily scientific phenomena and their relevance.**
2. **Students will acquire the know-how to preserve the environment and work towards its sustainability.**
3. **Students will design, organise and conduct scientific research leading to environmental protection and contribute to developing sustainable technologies for societal benefit and better understanding of the environment.**
4. **Students will analyse the existing dynamism in the highly complex human-environmental systems.**
5. **Students will provide scientific advice for policy and decision-makers.**

Program Specific Outcomes

1. **Conservation and protection of the environment become the primary responsibility of students and they get moulded to be the future guardians of nature.**
2. **Students get trained to use all the required tools and techniques for understanding the environment.**
3. **Students can understand, think and evolve various strategies for management and conservation of the environment.**
4. **Students become aware of the environmental disasters and they will be able to develop strategies to mitigate these issues.**
5. **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.**

SEMESTER I

24-360-0101 ENVIRONMETAL BIOLOGY

(**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:

1. Understand Foundations of Ecology
2. Explore Population Dynamics
3. Examine Community Dynamics
4. Investigate Ecosystem Functioning
5. 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 Evaluate the processes of succession, To understand their structure, stability, and resilience.	Evaluate
CO4	To Examine energy flows, nutrient cycling, and landscape connectivity, to assess ecosystem functioning and health	Apply
CO5	Apply principles of conservation biology to analyze threats to biodiversity, evaluate ecosystem services, and implement restoration	Apply

CO → PO, PSO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	3						2	1		
CO2				3			1	2		
CO3			1					3		
CO4		3	2	2		2	3			1
CO5		3	3		1	3		2	1	2

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

Assessment Pattern:

Category	Assessment Methods			Examination
	Test 1	Test 2	Test 3	
Understand	20	20	20	30
Apply	40	50	40	40
Analyze	40	30	40	30

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.

24-360-0102 ENVIRONMENTAL CHEMISTRY

(**Credits : 3**)

Course Description:

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 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 practicing core areas and familiarise the sophisticated instruments in analytical chemistry.

Course Outcomes:

After successfull 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

CO → PO, PSO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	3	1		2		1	2	2		
CO2	2	2		3			3	1	3	
CO3		3	2	1	1	2			1	2

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

Assessment Pattern:

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

SYLLABUS

Module 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. Chemical processes for the formation of organic and inorganic particulate matter- Composition of organic and inorganic particles- Reactions involving particles in the atmosphere. Introduction to Anthropogenic Changes in the Atmosphere: Ozone layer depletion, Photochemical smog.

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. Oxygen demanding materials, Concept of BOD and COD

Module III : Chemistry of Lithosphere

Introduction-Definition of geosphere- nature of solids in the geosphere- kinds of minerals and rocks and their properties- rock cycle- stages of weathering-physical, chemical and biological aspects of weathering- sediments-clays-Ground water in the geosphere. Distribution of water in earth, hydrology and hydrogeology, major basins and groundwater provinces of India, Geological weathering reactions, erosion, transportation and deposition of sediments. Geochemical classification of elements, abundance of elements in earth crust. Biogeochemical cycles of carbon, nitrogen, oxygen, phosphorous and sulphur.

Module IV : Soil Chemistry

Soil: Definition and importance - soil formation- soil horizon and soil profile. Soil forming minerals and process of soil formation, Identification and characterization of clay minerals, Soil physical and chemical properties, soil types and climate control on soil formation, Cation exchange capacity and mineralogical controls. Composition and physiochemical properties of soil- Water, air, organic and inorganic components of soil

Module V : Environmental chemical analysis

Analysis of Air: Air sampling techniques and analytical methods for monitoring SO2, NOX, CO, H2S and Suspended Particulate Matter (SPM). Analysis of Water and Wastewater: 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, fluoride, nitrite, nitrate, ammonia, phosphate, silicate and Metals. Analysis of Soils: Sampling and storage, Pre-treatment, Extraction of organic contaminants, extraction of available ions-Dissolution technique for the determination of total metal concentration in soil- Determination of pH, Cation Exchange Capacity (CEC), total and available metal ions.

References

1. Balaram Pani.; (2017). –Textbook of Environmental Chemistry, 2/e, ISBN:9789386768025, Pages : 594
2. Popek, E.; (2017). –Sampling and Analysis of Environmental Chemical Pollutants, A Complete Guide. 2nd Edition, ISBN: 9780128032022, Elsevier.
3. Colin, B.; Michael, C.; (2012). –Environmental Chemistry. 5th Edition: ed W.H.Freeman & Co Ltd, ISBN: 9781464113499, pages: 736.
4. Stanley, E. M.; (2010). –Environmental Chemistry. 9th Edition, CRC Press, London.
5. James, E. G.; (2009). –Principles of Environmental Chemistry. Publisher: Jones & Bartlett; ISBN: 0763759392
6. John, H.; Seinfeld.; Spyros, N. P.; (2006). –Atmospheric Chemistry and Physics. 2nd edition, John Wiley.
7. Andrew, D. E.;, Lenore, S. G.; Eugene, W. R.; Arnold, E. G.; (Eds) (2005). –Standards Methods for the Examination of Water and Wastewater Analysis. 21st Edition, APHA, Washington DC.
8. Roger, N.; Reeve.; (2002). –Introduction to Environmental Analysis. Published by John Wiley & Sons Ltd, Chichester.
9. Fifield, F.W.; (2000). –Environmental Analytical Chemistry. 2nd edition, Blackwell Publishers.
10. Daniel, J. J.; (1999). –Introduction to Atmospheric Chemistry. Princeton University Press.
11. Harrison, R.M.; (1995). –Pollution: Causes, Effects and Control. The Royal Society of Chemistry, Cambridge.
12. . Peter, O. W.; (1976). –Analysis of Air Pollutants. John Wiley & Sons, New York

24-360-0103 ENVIRONMENTAL PHYSICS

(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.

Course Outcomes:

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

CO1	Gain a thorough insight into the Earth-Sun dynamics, focusing on how solar radiation shapes our climate, weather patterns, and energy distribution worldwide.	Understand

CO2	Acquire knowledge on atmospheric composition and structure, and the thermodynamic principles that govern weather patterns and the global energy balance.	Understand
CO3	Asses the concepts of atmospheric stability, cloud formation mechanisms, and the processes leading to various types of precipitation.	Understand, Analyse
CO4	Examine the natural and anthropogenic factors influencing climate change and variability in global and regional scales.	Understand, Analyse
CO5	Understanding of the processes in ocean and lithosphere, and their impacts on climate.	Understand

CO → PO, PSO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	3	1		1			3	1		
CO2	3	2		3			3			
CO3	2			2			2			
CO4	2	2		3			1		2	
CO5	2			3			2			

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

Assessment Pattern:

Category	**Assessment Methods**			**Examination**
	Test 1	**Test 2**	**Test 3**	
Understand	70	70	70	70
Analyze	30	30	30	30

SYLLABUS

Module I : Sun-Earth System

Solar radiation, Terrestrial radiation, Radiation laws, Seasons. Global distribution of solar radiation, Effect of atmosphere on solar radiation - Scattering, Absorption and Reflection, Earth's albedo, Greenhouse Effect, Global Warming.

Module II : Atmospheric Composition and Thermodynamics

Composition of dry air, Atmospheric water vapour content. Energy budget of the earth, Mean heat balance of the earth-atmosphere system, General circulation of the atmosphere, Forces and force balance, State and Structure of Atmosphere - Pressure, temperature, humidity, Vertical

thermal structure of the atmosphere. Potential temperature, virtual temperature, isothermal and adiabatic processes, dry and saturated adiabatic lapse rates.

Module III : Atmospheric Stability, Clouds and Precipitation

Stable, unstable and neutral equilibria. Inversions. Atmospheric Boundary Layer, Cloud formation and classification - Aerosols, condensation and ice nuclei, droplet growth - curvature and solute effects, precipitation mechanisms. Weather modification.

Module IV : Climate Variability and Climate Change

Weather and Climate - Climatic zones, Climate change, Natural changes and anthropogenic causes of climate change, Climate variability - El Nino, La Nina and ENSO events. Tropical Cyclones, Indian Monsoon, Thermal circulations and Local winds, Land and Sea breeze.

Module V : Oceanography and Geological Processes

General Circulation of Oceans - Winds and surface circulation - Characteristics of convergence, divergence, upwelling and sinking of ocean waters, Ekman spiral and Ekman transport. Vertical structure of oceans, Thermohaline conveyor belt. Crust, mantle, core, earth‘s magnetic field. Recycling of the Lithosphere - The rock cycle, weathering and erosion, sedimentation, metamorphism. Concept of plate tectonics and continental drift. Geological time-scales. Geological Hazards - Floods, Landslides, Earthquakes, Volcanism, Avalanche.

References

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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.

24-360-0104 PROGRAMMING AND STATISTICS

(**Credits : 3**)

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

CO → PO, PSO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	2		1				2	1		2
CO2	2		2				2	2		2
CO3	2		2	2	1		3	3	1	2
CO4	3	1	2	1			2	2	2	1
CO5	2	1	2	1		2	2	2	2	1

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

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/

24-360-0105 ENVIRONMENTAL MICROBIOLOGY

(**Credits : 3**)

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

CO → PO, PSO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	3		1				3	1		
CO2	3		2				3	2		
CO3	3		1				3	2		
CO4	3		3				3	3		
CO5	3	2	1	2			2	2		1

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

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 microorganisms; 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 : Fundamentals in molecular biology

Concepts and criteria of molecular microbiology. Detection and isolation of mutants, Gene structure; Regulation of gene activity in prokaryotes: Transcription, Translation - polypeptide synthesis, Feed back inhibition -, E coli lactose system and operon model, Attenuation, Global regulatory systems - catabolic repression. PCR variations - Nested PCR, Inverse PCR, Reverse -transcriptase PCR, Real time PCR; DNA sequencing - Sanger‘s chain termination method, Automated DNA sequencer, BLAST search algorithm, Construction of phylogenetic tree and Next generation sequencers; Whole genome shot gun sequencing; Metagenomics.

Module III :Bacteria, Fungi, Protozoans and Microalgae

Bacteria: Cell structure: size, shape and arrangements, cell organization - cell membranes, cytoplasmic matrix, nucleoid, cell wall, components external to the cell wall - capsule, slime layers and S - layers, pilli and fimbriae, flagella, motility and chemotaxix. 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- Passive diffusion and active transport, group translocation and ion uptake. Bacterial growth- Growth curve, mathematics of growth, measurement of microbial growth, continuous culture of microorganisms. Fungi: Basic concepts, distribution, importance, structure, nutrition and metabolism, reproduction, characteristics of fungal division and classification. Protozoans: Basic concepts, distribution, importance, morphology, nutrition, encystment and excystment, locomotor yorganells, reproduction and classification. Microalgae: Basic concepts, distribution, structure, algal nutrition, algal reproduction, characteristics, classification.

Module IV : Viruses

Early development in virology; General properties of viruses; Cultivation of viruses; Virus preparation; purification and assays; Structure of viruses; Bacteriophages -classification and replication. Viroids and prions; Viruses of fungi, algae and protozoans; 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; Microbial growth in natural environment- growth limitation by environmental factors, counting viable but non -cultivable cells, quorum sensing, and microbial populations; Nutrient cycling interactions - carbon cycle, sulphur cycle, nitrogen cycle, manganese cycle, microorganisms and metal toxicity; The physical environment - Microenvironment and niche, biofilm and microbial mats, microorganisms and ecosystems, microorganism movement between ecosystems.

References

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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.
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6. Jeffrey, C.; Pommerville.; (2004). Alcamos Fundamentals of Microbiology .7th Edition Jones & BartlettPublishers.
7. Prescott,L.M.;HareleyJ.P.;Klein,D.A.;(2005). Microbiology .(6thEdition).McGraw Hill Publishing Co.Ltd.
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24-360-0106 CONTEMPORARY ENVIRONMENTAL ISSUES AND LAWS

(Credits : 2)

Course Description:

Policy is the sum total of the values to which a person or a group of persons or institutions social, legal and governmental - consider as important in their relation with one another. Environmental policies have to be formulated in the credible of social morals and values - the public opinion representing the views of both the elite expert and lay public. A clear vision should be there reflecting all the conflicting values and the vision is called policy and the translation into legal frame work called law.

Course Objectives:

This course work provides an in-depth understanding of the vast field of Environmental law and policy and the study would be familiar with the overall legal regime of the country as well as international obligations. To impart knowledge on the policies, legislations, institutional framework and enforcement mechanism for environmental management in India.

Course Outcomes:

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

CO1	Describe the Indian Legal System and the fundamentals of Indian Constitution	Understand
CO2	Understand the philosophy, principles and environmental justice for pollution control	Understand
CO3	Apply the provision for legal control of industrial pollution by legislations	Apply
CO4	Give critic comment on environmental legal framework	Apply

CO → PO, PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3				3	1				
CO2	3	2	1		3	2		2	1	2
CO3	3	2	1		3	2		2	3	2
CO4	1	2		3	3	2	1	3	2	3

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

Assessment Pattern:

Category	Assessment Methods			Examination
	Test 1	Test 2	Seminar	
Remember	10	10	10	10
Understand	50	50	50	50
Apply	40	40	40	40

SYLLABUS

Module I : Contemporary Environmental Issues

Environmental Issues in India- Climate Change, Global Warming, Pollution and Deforestation. Solution for the environmental problems, Environmental governance in India- Issues and Challenges.

Module II : Fundamentals of Law and Legal system

Introduction to law - Different theories about law - Understanding legal system - Various organs of legal system -Indian Legal system - Law enforcement in India - Fundamentals of Indian constitution. Statutes, Rules and Notification - Fundamental rights, Article 48(A) and 51-A(g) - Writ petitions - Constitutional Remedies. Provision of constitution of India regarding environment (article 48 A & 58A), Environmental dispute redress bodies: (i) National Green Tribunal - composition and jurisdiction, (ii) Trial court- jurisdiction under the environmental legislations, and (iii) Executive Magistrate' s powers.

Module III : Philosophy, Principles, Environmental Justice and Pollution Control

An Introduction to Environmental policies and philosophies - Environment movements - Environmental principles - Precautionary - Polluter Pays - Concepts of Liabilities and Public Liability Insurance Act - MultiLateral protocols and agreements - Montreal, Kyoto and Rio - Right to Environment - A basic human Right - Constitutional law perspectives - Article 21 - Traditional common and criminal laws remedies for environmental protection - Law of Nuisance : Tort Law - Public Nuisance - Chapter XIV of Indian Penal Code - Section 133 of Cr.PC - Environmental Justice - PIL and Environmental Tribunals - National Environmental Appellate authority and Green Tribuna

Module IV : Environmental Protection Laws in India

Genesis of the act - Delegation of Powers - The Wildlife (Protection) Act, 1972, Water (Prevention And Control Of Pollution) Act, 1974,Water (Prevention And Control Of Pollution) Cess Act, 1974, Air (Prevention And Control Of Pollution) Act, 1977, Forest Conservation Act, 1980, Environmental Protection Act, 1986, Public Liability Insurance Act 1991, The ozone-depleting substances (regulation and control) rules, 2000, Noise Pollution (Regulation and Control) Rules, 2000 , The energy conservation act, 2001, Biological Diversity Act, 2002,The National Green Tribunal Act, 2010, Compensatory Afforestation Fund Act, 2016 - Rules and Notification - Environment Impact Assessment - Coastal Regulation Zone - Biodiversity laws - Waste Management Laws - Municipal Solid Waste, Bio Medical Waste, Hazardous Waste.

Module V : Environmental Responsibility

Corporate Social Responsibility and ISO, Carbon Neutrality - National Action Plan on Climate Change, Scheme of labeling of environmentally friendly products (ecomark). International Treaties and Protocols.

References

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5. Environmental Policy in India, Natalia Ciecierska-Holmes , Kirsten Jörgensen , Lana Laura Ollier , D. Raghunandan , Routledge; 1 edition, 2019
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15. Environmental issues in India; a reader - 2006 by Rangarajan
16. Understanding and solving environmental problems in the 21st century - 2002 by R. Costanza
17. Environmental administration & law - Paras Diwaa, 2002
18. Shyam Divyan and Armin Roseneranz -Environmental law and policy in India Oxford University Press, New Delhi, 2001
19. International environmental laws- Priya Ranjan Trivedi-1996
20. Environmental planning, policies & programs in India - K.D. Saxena.1993
21. Greger I. Megregor, -Environmental law and enforcement , Lewis Publishers, London, 1994

24-360-0107 ENVIRONMENTAL MANAGEMENT AND LEGAL ASPECTS

(**Credits : 2**)

Course Description:

Environmental Management System educates students to become environmental managers who not only understand all aspects of the environmental industry/or corporate but also have "new work skills", including skills in critical and analytical thinking, problem solving, project management, interpersonal relations and team work.

Course Objectives:

To impart an understanding of systems approach to Environmental Management as per ISO 14001 and skills for environmental performance in terms of legal compliance, pollution prevention and continual improvement.

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

CO → PO, PSO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	1	3			3	1	2	3		
CO2	2	3	1		3	2		3		
CO3	2	3	1		3	2		3		
CO4	1	3		3	3	2	1	3		

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

Assessment Pattern:

Category	**Assessment Methods**			**Examination**
	Test 1	**Test 2**	**Test 3**	
Remember	10	10	10	10
Understand	50	50	50	50
Apply	40	40	40	40

SYLLABUS

Module I : Foundations and Frameworks of Environmental Management Systems

The Context of Environmental Management: Sustainability and sustainable development; Relationship between business and Environment; Implementation of EMS - Barriers, obstacles in EMS; Opportunities in implementation of EMS. EMS Hierarchy: structure; Concept of Continual improvement; EMS model; Environmental policy and planning; Implementation and operation; Checking and Corrective action - Management Review; Application of EMS.

Module II : Environmental Audit

Definition of environmental audit; principle elements of an EA; components of auditing; audit process; guidelines for auditing; types of audit; risk audit techniques; EA report. Waste audit; example of audit: municipal solid waste management.

Module III : Environmental Accounting

Forms of environmental accounting; need of environmental accounting at corporate level; scope of Environmental accounting; valuation methods: market valuation of natural resources, maintenance valuation of environmental assets, contingent valuation of environmental services, environmentally adjusted economic aggregates; compilation of physical natural resource accounts; examples for forest accounts.

Module IV : Energy Management and Audit Types of energy audit, ten-step methodology for energy audit; audit phases: phase I - pre-audit phase activities, phase II - detailed energy audit activities; process flow diagram and list process steps: identify waste streams and obvious energy wastage, identification of energy conservation opportunities, classification of energy conservation measures, energy audit reporting format - fuel costs, power costs, plant energy performance, energy audit instruments, calculating energy and demand balances, energy audit for buildings.

Module V : ISO 9000, 14000 series and OHSAS 18001

EMS certification; emerging trends in management of environmental issues - life cycle assessment (LCA), Environmental Impact Assessment (EIA), Global Compact, Triple bottom line (TBL), ISO 14000 series; statutes of EMS in India; OHSAS 18001 standard.

References

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3. Environmental planning and management, Christian N Madu, Imperial college press, 2007
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10. Environment management systems: principles and practice, 1995,Hunt David
11. Environment management with Indian experience
12. Environment policy and development issues, vol 1, C V Rajasekhara 18.Environmental Management basics and Applied aspects of management of Ecological and Environmental systems, 2000, Biswarup Mukharjee
13. Environmental management : an Indian perspective, 2000, S N Chary and Vinod Vyasulu
14. Environmental management,2000, B Narayan
15. Environmental management , 2000, N K Uberoi
16. Environmental management for sustainable development, 2002, C J Barrow
17. Environmental management systems, 1991, B W Marguglio
18. Environmental management training, R G A Boland
19. Environmental Management a Primer for Industries, I V Murali krishna and Valli Manickam

24-360-0108 CHEMOMETRICS & GOOD LABORATORY PRACTICES

(Credits : 2)

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

CO → PO, PSO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	3						3	2		
CO2	3						3	2		
CO3	2						2	2		
CO4	2						2	2		
CO5	2		1				3	2		1

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

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.

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1. D. C. Harris (2015) Quantitative Chemical Analysis 9th Edition, ISBN-13-978-1464135385, W. H. Free man & Co, New York.
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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
12. Achari, V. S., Lopez, R. M., Rajalakshmi, A. S., Jayasree, S., Shibin, O. M., John, D., & Sekkar, V. (2021). Microporous carbon with highly dispersed nano-lanthanum oxide (La2O3) for enhanced adsorption of methylene blue. Separation and Purification Technology, 279, 119626.
13. Achari, V.S. (2005). Water Quality Assessment in the Tsunami Affected Coastal Areas of Kerala, 2005. The final report su)bmitted to Department of Science and Technology. DST Project No. SR/S4/Es-135-7.7/2005 dated 03-03-2005.

24-360-0109 ENERGY RESOURCES AND MANAGEMENT

(Credits : 2)

Course Description:

Energy is required for all life processes. Human energy consumption has grown steadily throughout human history. In the pre-industrial time, humans had modest energy requirements, mainly for food and fuel for fires to cook and keep warm. However, the energy requirement has grown tremendously in modern times. Energy resources refer to all forms of fuels which find applications in the development of the modern world. Heating, generation of electrical energy and energy conversion processes of all sorts, are the main function of fuels.

The primary energy sources include fossil energy (oil, coal and natural gas), nuclear energy, and renewable energy (wind, solar, geothermal and hydropower). The secondary energy source is from the conversion of primary sources such as electricity which flows through power lines and other transmission infrastructures. Fossil fuels have disadvantages as they are non-renewable and they cause several harmful effects on the environment. The need of exploiting renewable energy has become the top most priority in the modern world. At the same time a proper management strategy also needs to be worked out. The content of the syllabus —Energy Resource Management‖ 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 energy, its various ways of production, its uses and finally its management. The students will learn about energy production and utilization along with associated environmental management, regulatory and policy issues.

Course Objectives:

To impart a complete understanding of the basic characteristics of renewable sources of energy and related technologies. To identify new methods and technologies for effective utilisation of renewable energy resources. To deduce a complete protocol for the management of energy

Course Outcomes:

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

CO1	Discuss the relationship between energy usage and human development index, effect of energy services on productivity, health, education, safe water and communication	Understand
CO2	Describe the non renewable energy resources, its distribution, usage and environmental impacts	Understand
CO3	Provide with a solid foundation for developing the use of renewable energy systems	Understand
CO4	Analyse and interpret information related to renewable energy	Analyse
CO5	Ability to analyse the viability of energy conservation projects	Analyse

CO → PO, PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2			2		3	1		2
CO2	2	3			1		3	2		2
CO3	2	3	2				3			1
CO4	2				3		2		2	
CO5			3	2			2		3	

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

SYLLABUS

Module I : Introduction

Energy and Human development index, Sources of Energy, Renewable and non-renewable energy, Energy requirements and consumption pattern in the context of global, national and regional.

Module II : Non-renewable Energy Resources

Classification of Fossil fuels: Coal, Oil, Oil shale, Tar sands, Natural gas, Non-fossil fuels: Nuclear power, Ecological and social impacts of major thermal and nuclear power plants, Management of energy projects and its environmental impacts.

Module III : Renewable Energy Resources- and alternate fuels

Solar Energy: Technique for harvesting solar energy, direct utilization of solar energy by thermal conversion thermo-mechanical conversion, Photo-voltaic cells, indirect utilization through water power- Ocean Thermal Energy Conversion (OTEC), , Wind resources, Geothermal sources, Tidal energy and Ocean waves, biogas- recent advancements and upgradation technologies, fuel cell- storage and recent developments

Module IV : Energy conservation policies and acts

India‘s Energy and Climate Concerns: Schemes to promote energy conservation and energy efficiency - Standards and Labeling, Energy Conservation Building Codes (ECBC), National Mission for Enhanced Energy Efficiency (NMEEE).

Module V : Energy Management and Auditing - Demand Side Management (DSM) Scheme

Economic analysis in the Energy Management and Audit Programme, Energy audit; Phases in energy auditing; Energy bills; Energy rate schedules; Energy accounting; Energy audit report format; Case studies ; Green buildings

References

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2. The future Energy use , Hill, R., O‘Keef, P., and Snape, C. Earthscan publication Ltd. London, 1996
3. Environemntal Chemistry ,Colin Baird,. W.H.Freeman and Company, 1999
4. Looking back to think ahead: Green India 2047. Tata Energy Research Institute (TERI), 1998
5. Energy Conservation Guidebook, Dale R Patrick, Stephen W Fardo, 2ndEdition, CRC Press, 2014
6. Handbook of Energy Audits, Albert Thumann, 9thEdition, CRC Press, 2012
7. Energy Management Handbook,W.C. Turner, 6thEdition, CRC Press, 2006
8. Guide to Energy Management, Capehart B.L., Turner W.C., Kennedy W.J. 7thEdition, Fairmont Press,2011
9. Energy Conservation Guidebook , Patrick D.R., Fardo S.W., Richardson R.E., Fardo B.W., 3rd Edition, Fairmont Press, 2014

24-360-0110 ENVIRONMENTAL CHEMISTRY LAB

(Credits : 2)

Course Description:

Study of the environment requires reliable and accurate measurement of extremely small quantities of chemicals and the ability to determine if they are naturally occurring species or pollutants. The course: Environmental chemistry lab covers basic chemical lab techniques for the analysis of environmental samples and on written presentation of analytical results.

Course Objectives:

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

Course Outcomes:

After successfull 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	Analyse

CO → PO, PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3						2	1		
CO2	3		2				3	2		
CO3	2			2			2	2		

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

Assessment Pattern:

Category	Assessment Methods			Examination
	Test 1	Test 2	Test 3	
Understand	20	20	20	20
Apply	60	60	60	60
Analyze	20	20	20	20

SYLLABUS

ANALYSIS OF WATER AS PER BIS & APHA STANDARD METHODS

Parameters Analysed for Water				
No	Parameters	Method	BIS (Reference)	APHA Method
1	pH	Determination of pH using pH meter (Potentiometry)	IS 3025 (Part 11)	2310 , 2-31
2	Conductivity	Determination of Electrical Conductivity using Conductivity meter	IS 3025 (Part 14)	2510, 2-52
3	Redox potential	Determination of Redox potential (Potentiometry)		2580, 2-84
4	Alkaliniy	Determination of Total Alkalinity by Acid-base titration.	IS 3025 (Part 23)	2320 , 2-34
5	Total Hardness	Determination of Total Hardness by Complexometric Titration	IS 3025 (Part 21)	2340, 2-44
6	Total Solids	Determination of Total Solids (TS) by Gravimetry.	IS 3025 (Part 15)	2540 B, 2-64
7	Total Dissolved Solids	Determination of Total Dissolved Solids (TDS) by Gravimetry.	IS 3025 (Part 16)	2540 C, 2-65
8	Turbidity		IS 3025 (Part 10)	2130, 2-12
9	Dissolved Oxygen	Determination of Dissolved Oxygen (DO) by Azide modification of Winkler Method (Redox Titration)	IS 3025 (Part 38)	4500 O, 4-137
10	Chloride	Determination of Chloride by precipitation titration	IS 3025 (Part 32)	4500, Cl- 4-72
11	Biological Oxygen Demand	Determination of BOD	IS 3025 (Part 44)	5210 B, 5-5
12	Chemical Oxygen Demand	Determination of COD (Open Reflux Method)	IS 3025 (Part 58)	5220B, 5-17
13	Total Organic Carbon (TOC)	Determination of TOC by TOC Analyser.	IS 3025 (Part 18)	5310, 5-23

ANALYSIS OF SOIL

No.	ANALYSIS OF SOIL	REFERENCES
1	Determination of Moisture Content Section	5.4.4, Chapter 5, Practical Environmental Analysis
2	Determination of Bulk Density Section	5.4.2, Chapter 5, Practical Environmental Analysis

3	Determination of Specific Gravity Section	5.4.3, Chapter 5, Practical Environmental Analysis
4	Determination of pH Section	5.5.3, Chapter 5, Practical Environmental Analysis
5	Determination of Electrical Conductivity Section	5.5.2, Chapter 5, Practical Environmental Analysis
6	Determination of Redox Potential Section 5.	5.4, Chapter 5, Practical Environmental Analysis
7	Determination of Soluble Calcium Section	5.7.1, Chapter 5, Practical Environmental Analysis
8	Determination of Soluble Magnesium Section	5.7.1, Chapter 5, Practical Environmental Analysis
9	Determination of Soluble Sodium Section	5.7.1, Chapter 5, Practical Environmental Analysis
10	Determination of Soluble Potassium Section	5.7.1, Chapter 5, Practical Environmental Analysis
11	Determination of Organic Matter Section	5.8, Chapter 5, Practical Environmental Analysis
12	Determination of Cation Exchange Capacity	Section 5.12.4, Chapter 5, Practical Environmental Analysis
13	Determination of Soil Texture Section	5.4.6, Chapter 5, Practical Environmental Analysis

Environmental & Geological Analysis

1	Wind Rose Analysis
2	Climogram Analysis
3	Identification of Important Minerals and Rocks.
4	Particle size analyses- Estimation of Gravel, Sand, Silt and Clay contents in Soil and Sediments

References

1. Clair, N. S.; Perry L. McCarty.; Gene F. P.; (2003). "Chemistry for Environmental Engineering and Science". Tata McGraw Hill.
2. Miroslav, R.; Vladimir N.B.; (1999). "Practical Environmental Analysis", The Royal Society of Chemistry, Cambridge.
3. Eugine, W. R.;, Rodger, B.; Andrew, D E.; Lenore S C.; (2012). "Standard Methods for the examination of Water and Wastewater", 22nd Edition, Published by American Public Health Association, American Water Works Association, Water Environment Federation, Washington DC.
4. IS 10500:2012 Indian Standard Drinking Water-Specification 2nd Edition, Bureau of Indian Standards, New Delhi.
5. Indian Society of Soil Science. (2012). "Fundamentals of Soil Science" (2nd Edition, revised) ISBN: 8190379747.
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7. Maiti, N.J S. K.; (2011). "Handbook of methods in Environmental Sciences: Water and wastewater analysis" V.2 Air, Noise, soil and overburden.
8. Lewis D W (1992), Practical Sedimentology, Prentice- Hall Pvt Ltd.

24-360-0111 ENVIRONMENTAL MICROBIOLOGY LAB

(**Credits : 2**)

Course Description:

Course will introduce the students to the hands on techniques in microbiology. By the end of the course students will able to identify and describe the basic apparatus and equipment used in microbiology. Students will able to culture microbes from various environmental samples and able to identify them up to genus level. Students also could analyze the portability of drinking water through microbial analysis.

Course Objectives:

Students will able to handle microorganisms, isolate, and identify bacteria, fungi and protozoa. They will able to enumerate the coliforms in drinking water and identify the bacteria present in polluted water.

Course Outcomes:

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

CO1	prepare the media for isolation of bacteria and fungus, identify the bacteria and fungus morphology , isolation of bacteria and fungus from different sources,	Understand, Analyze
CO2	identify the bacteria and fungus upto genus level,	Analyse
CO3	Evaluate the polluted water containing coli forms and enumeration of coligenic bacteria in water	Evaluate

CO → PO, PSO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	3			2		3	3	2		
CO2	2			2		2	3	2		
CO3	1			1			2	1		

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

SYLLABUS

1. **Media**: Simple Nutrient media and Differential media for bacteria (nutrient broth, peptone water nutrient agar, MacConkey agar, Eosin Methylene Blue agar) and media for the isolation of fungus(Sabouraud dextrose agar and Potato dextrose agar)
2. **Enumeration and isolation** of heterotrophic bacteria and fungi and their preservation.
3. **Pure culture techniques**: spread plate, pour plate, drop inoculation, streaking on plates, serial dilution and plating.
4. **Staining techniques and microscopic observation**: Simple staining, Grams staining, Acid Fast staining, Capsule staining, flagella staining and spore staining.
5. **Slide culturing of fungi** and their identification based on morphology and structure of spores.
6. **Most probable number (MPN)** of estimation of Coliforms and E.Coli

References

1. James G. Cappuccino and Natalie Sherman (2013). Microbiology: A Laboratory Manual, 10th ed, ISBN No: 978-0321840226, Benjamin Cummings.
2. H. Seeley and W.H. Freeman(1991), Microbes in Action: A Laboratory Manual of Microbiology, 4th ed, ISBN No: 978-0-7167-2100-0 , New York, W. H. Freeman.
3. Willey, Joanne, Linda Sherwood, Chris Woolverton (2011) Lab Excercises in Microbiology, 8th edition. New York: McGraw Hill.

SEMESTER II

24-360-0201 ENVIRONMENTAL POLLUTION

(**Credits : 3**)

Course Description:

Quality of air, water and soil plays a vital role for maintaining health, safety and security of mankind, ecosystems and natural environment. Urbanization and industrialization ultimately deteriorating the quality of the above environmental systems and many species face threat for survival. Service life, aesthetic beauty of materials and economic slowdown of society are also directly related to the quality of the natural systems. The science of interaction of many material components in air, water and soil strata and their concentration distribution profiles measured, analyzed and interpreted as per the assured regulations for decision making to ensure a safe living to all is the essential necessity of this course.

Exposure to the principles of sampling, gravimetric, wet-chemical, continuous/ real-time instrumental techniques used in the conventional measurement methods are prescribed. It will achieve the student to improve their capability to understand, to monitor, evaluate and take appropriate decisions so as to enable them to support the Government and society in many ways to provide timely directions to ensure a secured healthy living and wellbeing.

Course Objectives:

To give exposure to the students to the pollution problems, science of interaction of chemical ingredients and molecules in the natural and industrial (man-made) environment, the need of regulation, directive approaches and statutory guidelines for prevention and control for abatement. Methodology to be followed for monitoring and reporting to decision making authorities in the capacity of Environmental Experts for organizations, departments and judiciary. Students will get an overall basis for originating innovative thoughts to link environmental analytics with legal jurisprudence to support industry, pollution control boards, courts and tribunals.

Course Outcomes:

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

CO1	Sources, nature and magnitude of air pollution as per the statutory regulation and standards, method of analysis and evolution of the extent of pollution.	Understand
CO2	Expertise achieved to realize sources, nature and magnitude of Noise pollution as per the statutory regulation and standards, method of analysis and evaluation of the extent of pollution.	Apply
CO3	Expertise achieved to decide sources, nature and magnitude of water pollution as per the statutory regulation and standards, method of analysis and evaluation of the extent of pollution.	Analyse

CO4	Expertise achieved to realize the sources of air pollution as per the statutory regulation and standards, method of analysis and evaluation of the extent of pollution.	Evaluate
CO5	Expertise attained to study the pollution problems assigned, capable enough to prepare documents and reports to the authorities	Create

CO → PO, PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	2	3	1	2	3	2	3	1
CO2	1	1	1	2	1	1	2	1	2	1
CO3	1	2	2	3	1	2	3	2	3	1
CO4	2	1	1	3			3			
CO5					3					3

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

Assessment Pattern:

Category	Assessment Methods			Examination
	Test 1	Test 2	Test 3	
Understand	20	20	20	20
Apply	20	20	20	20
Analyze	20	20	20	20
Evaluate	20	20	20	20
Create	20	20	20	20

SYLLABUS

Module I : Air Pollution

Air pollution control acts, rules and notifications issued thereunder by Government of India. Sources and types of Pollutants – Natural and anthropogenic sources, primary and secondary pollutants. Criteria air pollutants. Sampling and monitoring of air pollutants (gaseous and particulates); period, frequency and duration of sampling. Principles and instruments for measurements of (i) ambient air pollutants concentration and (ii) stack emissions. Indian National Ambient Air Quality Standards. Impact of air pollutants on human health, plants and materials. Acid rain & Dispersion of air pollutants. Mixing height/depth, lapse rates, Gaussian plume model, line source model and area source model. Control devices for particulate matter: Principle and working of: settling chamber, centrifugal collectors, wet collectors, fabric filters and electrostatic precipitator. Control of gaseous pollutants through adsorption, absorption, condensation and combustion including catalytic combustion. Indoor air pollution, Vehicular emissions and Urban air quality.

Module II : Noise Pollution

Noise pollution control acts, rules and notifications issued thereunder by Government of India. Sources, weighting networks, measurement of noise indices (Leq, L10, L90, L50, LDN, TNI). Noise dose and Noise Pollution standards. Noise control and abatement measures: Active and Passive methods. Vibrations and their measurements. Impact of noise and vibrations on human health.

Module III : Water Pollution

Water pollution control acts, rules and notifications issued thereunder by Government of India. Types and sources of water pollution. Impact on humans, plants and animals. Measurement of water quality parameters: sampling and analysis for pH, EC, turbidity, TDS, hardness, chlorides, salinity, DO, BOD, COD, nitrates, phosphates, sulphates, heavy metals and organic contaminants. Microbiological analysis – MPN. Indian standards for drinking water (IS:10500, 2012). Drinking water treatment: Coagulation and flocculation, Sedimentation and Filtration, Disinfection and Softening. Wastewater Treatment: Primary, Secondary and Advanced treatment methods. Common effluent treatment plant. Designated Best Use of Water Sources as per CPCB.

Module IV : Soil Pollution

Standards for Emission or Discharge of Environmental Pollutants from selected industries of locality and relevant to Kerala (chemical, petrochemical, rubber, pulp and paper, thermal, pesticide manufacturing, black carbon and sulphuric acid). Physico-chemical and biological properties of soil (texture, structure, inorganic and organic components). Analysis of soil quality. Soil Pollution control. Industrial effluents and their interactions with soil components. Soil micro-organisms and their functions – degradation of pesticides and synthetic fertilizers.

Module V :

Costal Regulation Zone 9 (CRZ), Environmental Impact Assessment Notification, The Hazardous Wastes (Management, Handling and Transboundary Movement) Rules, 2008. Thermal Pollution, Marine Pollution and Radioactive Materials: Sources of Thermal Pollution, Heat Islands, causes and consequences. Sources and impact of Marine Pollution. Methods of Abatement of Marine Pollution. Coastal management. Radioactive pollution – sources, biological effects of ionizing radiations, radiation exposure and radiation standards, radiation protection. Monitoring, sampling, analysis, interpretation and report writing taking up case studies.

References

1. Stanley, E. M.; (2017). -Environmental Chemistry , CRC Press
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5. Metcalf.; Eddy.; (2017).Waste Water Engineering: Treatment and reuses, , McGraw- Hill
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24-360-0202 GEO-INFORMATICS

(Credits : 3)

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

CO → PO, PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3		1	2			3	2		1
CO2	3		2	3			3	2		1
CO3	3		2	2			3	2		1
CO4	2		1	1			2	1		

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

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 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 II : 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 III : 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 IV : Basics of Cartography and Surveying Techniques

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

24-360-0203 ENVIRONMENTAL TOXICOLOGY

(Credits : 3)

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 Objectives:

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 molecular biology 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 and scope of Environmental Toxicology, including dose-response relationships and factors influencing toxicity.	Understand
CO2	Analyze toxicity testing methods, statistical tools, and bioassays to assess toxicity and interpret data effectively.	Analyse
CO3	Apply knowledge of molecular biology techniques in ecotoxicology, including biomarker analysis and gene expression assays, to assess ecotoxicological impacts.	Apply
CO4	Evaluate the environmental fate of contaminants and emerging issues in environmental toxicology, such as microplastics and nanotoxicology.	Evaluate
CO5	Apply cell culture techniques and cytotoxicity assays to assess the effects of contaminants on cell viability and function in practical applications and case studies.	Apply

CO → PO, PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3		2				3	2		
CO2	2	3	2				3	2		
CO3	1		3	2			2	3		
CO4	2			3			2		3	
CO5					3					3

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

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 : Introduction to Environmental Toxicology

Definition of Toxicology, History and Evolution of Environmental Toxicology, Scope of Modern Toxicology, Environmental toxicology and chemistry, Sub disciplines of Toxicology, Numbers in Toxicology- Dose - Response Relationships, Dose-Response graphs, Frequency Response curve, Cumulative Response curve, Potency versus Toxicity, Safety versus Toxicity, Hypersensitivity and Hyposensitivity, Response concepts, Reserve Functional capacity, LD 50, LC 50, EC 50 . Practical problems in toxicity assessment – Entry Routes and its influence in toxicity, Factors that influence toxicity- Chemical, biological, nutritional and physical factors.

Module II : Fundamental Concepts in Toxicology

Introduction to toxicity testing, Principles of biological tests, Typical toxicological testing methods, Standard methods, Statistical concepts in toxicity testing, Acute, Chronic, Prolonged toxicity tests, Potentiation, Teratogenicity, Carcinogenicity, Mutagenicity tests, Immune, Skin, Eyes, Behavior, Reproduction tests, Species and Multispecies toxicity tests. Statistical tools- Probit, TEST, ToxR, EPA ProUCL, R, SAS, SPSS. Translocation and Structure-activity factors, Concept of bioassay, Threshold limit value, Margin of safety, Therapeutic index.

Module III : Environmental Fate of Contaminants and emerging issues

Types of toxicants. Chemical Speciation- Operationally and classically defined species. Abiotic transformation reactions- hydrolysis and Redox reactions. Chlorinated Xenobiotics Transformation- Biological- non-biological degradation process, photochemical degradation- chemical degradation. Long term effects of xenobiotics on aquatic organisms, Biotransformation and Absorption, distribution and excretion (ADME) of toxic agents. Case studies in Environmental toxicology- historical cases of Environmental toxicity. Emerging environmental toxicology- Microplastics, Emerging contaminants, Climate change induced toxicity, pesticide residues, genetic toxicity, Nanotoxicology, Ecotoxicogenomics.

Module IV : Molecular Biology application in Ecotoxicology

Introduction to Molecular Biology- Importance in ecotoxicology. Molecular biomarkers – DNA, protein biomarkers, genotoxicity assays to assess ecotoxicological impacts, significance. Genomics and Proteomics- Gene sequencing and analysis-Proteomics techniques- applications

in ecotoxicology. Molecular Techniques-PCR and its variants-DNA sequencing methods, genetic mutations, Gene Expression Analysis-Real-time PCR (qPCR), Microarray technology in eco-toxicology, Gene editing techniques- CRISPR/Cas9, gene knockout. Case Studies and Applications- Real-world applications of molecular biology in eco-toxicology, Case studies highlighting the integration of molecular biology in eco- toxicology research.

Module V : Metabolism of Toxic Substances in cells and organisms

Comparative Metabolism- Invertebrates and Vertebrates Variations- Uptake, Transport, Metabolism, Storage, and Excretion. Plant Metabolism of Toxic Substances- Uptake, Translocation, Excretion- Plants as Pollution Indicators and Sources. Occupational Health and Hazards- Radiation, Emissions, Toxic Chemicals- Noise, Vibrations. Environmental Epidemiology- Ecological Studies, Case-Control, Cross-Sectional, Cohort Studies. QSAR and Toxicity. Computational Toxicology for Emergency Response Assessment. Cell culture- Importance, Types of cells used in Ecotoxicology, cell culture conditions, cytotoxicity assays- MTT, LDH release assay. Case studies and practical application.

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16. Nano toxicology; Yuliang Zhao and Harising Nalwa (2007). American Scientific Publishers.
17. Michael C Newman and William H Clements (2008). Ecotoxicology. Taylor & Francis Group. CRC Press.
18. Environmental Toxicology, an open online textbook (2023) By Sylvia Moes ; Kees van Gestel ; Gerco van Beek
19. Cell and Molecular Biology: Concepts and Experiments, Gerald Karp, Sixth Edition
20. Freshney’s Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications by R. Ian Freshney, Eighth Edition
21. Molecular Cloning- A laboratory Manual, by Michael R Green and Joseph Sambrook, Fourth Edition.

24-360-0204 ENVIRONMENTAL ENGINEERING

(**Credits : 2**)

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. This course gives an overview of the basic laws and the unit operations of chemical engineering which find extensive use in environmental engineering. Details of the engineered systems for public water supply, industrial wastewater treatment, air pollution control and solid and hazardous waste management are also presented in this course.

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 and hazardous waste management.

Course Outcomes:

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

CO1	Explain the basic laws and the unit operations in chemical engineering applicable to environmental systems.	Understand
CO2	Identify the characteristics of water and the various methods or techniques adopted for purifying raw water.	Apply
CO3	Classify the techniques and the equipments used for the physical, physico-chemical and biological treatment of wastewater.	Analyse
CO4	Examine the sources and types of air pollutants, the meteorological factors influencing the dispersion of air pollutants and the methods and equipments used for control of particulate matter and gaseous contaminants.	Analyse
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

CO → PO, PSO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	2	3	3		2		2			
CO2	1	3	2				3		2	
CO3	1	2	2	2		3	3	3	1	1
CO4	1	2	2	3		3	3	3	1	1
CO5		3	2			3	3	3	1	1

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

Assessment Pattern:

Category	Assessment Methods			Examination
	Test 1	Test 2	Test 3	
Understand	30	30	30	30
Apply	40	40	40	40
Analyze	30	30	30	30

SYLLABUS

Module I :

Chemical Engineering - Units and Dimensions – Primary and secondary quantities, Conversion factors, Dimensionless equations and consistent units. Law of conservation of mass. Law of conservation of energy. Concept of material balance and energy balance. Molal units. Ideal-gas law. Unit operations and unit processes. Basic laws of heat, mass and momentum. Flow of fluids: nature of fluid, viscosity, velocity profile, flow field, types of fluid motion, laminar and turbulent flow, flow of a fluid past a solid surface. Reciprocating, rotary, and centrifugal pumps. Diffusion, mass transfer operation, absorption, Vapour-Liquid Equilibrium, Relative Volatility, Principle of distillation. An overview of the equipment of gas-liquid Operations. Mixing and agitation. Agitated vessels. Major types of agitators.

Graphical tools for Environmental Engineering: 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.

Module II :

Fundamentals of Hydrology: The hydrologic cycle, Surface water hydrology – Precipitation, Stream flow, Surface runoff, Ground water hydrology – Water table (unconfined) aquifer, The hydrologic equation.

Public Water Supply: Sources of potable water, Water quality – Physical, Chemical and Microbiological Characteristics of water, Water quality standards, IS 10500: 2012. Methods adopted for purifying water for public water supply: Flow diagram of a surface water treatment plant, Principles of Screen, Coagulation and flocculation, Sedimentation, Filtration and Disinfection. Aeration of water. Softening of water. Demineralization of water. Water distribution systems. Requirements of water distribution systems. Arrangements for distribution pipes and accessories of water distribution. Sanitary sewer systems. Industrial waste water drains. Storm water drains.

Module III :

Water pollutants and their sources, Effect of oxygen-demanding wastes on rivers – Biochemical oxygen demand, Carbonaceous and nitrogenous BOD, DO sag curve, Streeter-Phelps equation. Effects of nutrients on water quality in rivers.

Water and Wastewater Treatment: Engineered systems for water and wastewater treatment. Variations in quality and quantity of wastewater. Volume reduction and flow equalization. Significance of primary, secondary and tertiary treatment. Primary treatment - Grit removal and screening. Chemical precipitation. Sedimentation - Flocculent settling, hindered settling and compression settling. Plain sedimentation and sedimentation aided with coagulation. Flocculation. Filtration - Gravity and pressure filtration. Dissolved air flotation. Secondary treatment- Suspended growth and attached growth aerobic and anaerobic processes.

Aerobic processes for oxidation of carbonaceous matter Activated sludge process. Trickling filter and biofilter. Rotating biological contactor. Aerobic ponds. Anaerobic degradation of organic matter – Stages in the anaerobic process. Anaerobic contact filters. Upflow anaerobic sludge blanket (UASB) reactor. Tertiary treatment Nitrification and denitrification processes. Removal of recalcitrant organics from water and wastewater. Construction and working principles of equipments for physical, chemical and biological treatment of wastewater.

Module IV :

Air Pollution: Sources of air pollutants. Classification of air pollutants based on origin, chemical composition and state of matter. Origin and Fate of air pollutants. Effects of meteorological conditions on air pollution. Lapse rates. Atmospheric stability. Inversions. Effect of lapse rates and atmospheric stability on dispersion of air pollutants. Plume patterns of gas emission from stacks. Dispersion models for estimation of contaminant concentrations.

Air Pollution Control: Atmospheric cleansing processes. Approaches to air pollution control. Dilution and control at source. Engineered systems for control of particulate contaminants. Construction and working principle of equipments used for particulate removal. Gravitational settling chambers. Centrifugal collectors. Wet collectors. Fabric filters. Electrostatic precipitators. Engineered systems for gaseous pollution control. Major treatment processes for control of gaseous contaminants. Adsorption. Absorption. Condensation. Combustion. Construction and working principle of equipments used for control of gaseous contaminants. Spray towers. Plate towers. Packed towers. Venturi scrubbers. Condensers. Combustion equipments. Indoor air quality. Vehicular pollution and automotive emission control. Noise pollution. Sources of noise. Noise control methods.

Module V :

Solid Wastes: Sources of solid wastes. Types of solid wastes: municipal wastes, industrial wastes and hazardous wastes. Properties of solid wastes. Individual components, particle size, moisture content, density and chemical composition. Engineered systems for solid waste management. On-site handling, storage and processing, collection, transfer and transport, processing and recovery and final disposal. Manual component separation. Processing systems. Mechanical volume reduction. Thermal volume reduction. Processing techniques for resource and energy recovery from solid wastes - biochemical and thermochemical processes. Ultimate disposal of solid wastes. Landfilling methods. Area method. Trench method. Leachate and gas collection systems.

Hazardous wastes – Definition and Classification. Characteristics of hazardous wastes. Hazardous waste handling. Source reduction and control. Waste exchange, Waste recycling and reuse. Hazardous waste transportation. Hazardous waste treatment, storage and disposal. Waste destruction methods. Incineration. Wet air oxidation. Supercritical water oxidation. Waste concentration methods. Solidification and stabilization technologies.

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3. Tchobanoglous, G.; Burton, F. L.; Stensel, H. D.; (2003). "Wastewater Engineering: Treatment and Reuse". 4th Edition. Metcalf and Eddy Inc., New York, NY: McGraw-Hill.
4. Rao, C.S. (2018). Environmental Pollution Control Engineering, Third Edition, New Age International (P) Ltd., New Delhi.
5. Garg S. K.; (2010). Water Supply Engineering. Khanna Publishers, New Delhi.
6. Tchobanoglous, George (2014). Integrated solid waste management: Engineering principles and management issues, Mc Graw Hill Education, New Delhi

24-360-0205 METHODS IN ENVIRONMENTAL ANALYSIS

(Credits : 2)

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

CO → PO, PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2						3	2		
CO2	2						3	2		
CO3							2			
CO4	1			3	2					2

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

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 : Chromatographic Techniques
Introduction to chromatographic separations: General description, migration rates of solutes, zone broadening, column efficiency, optimization of column performance, applications of chromatography. Gas Chromatography: Principle of Gas - Liquid Chromatography (GLC), Instruments for GLC, Columns and stationery phases, detectors, applications. Gas - Solid Chromatography (GSC). Liquid chromatography (LC): Scope of High-Performance Liquid Chromatography (HPLC), column efficiency in Liquid Chromatography (LC), Instruments for LC, Theory and applications of Partition chromatography, Adsorption chromatography, Ion-exchange chromatography, Size-exclusion chromatography, Thin-layer chromatography(TLC) and GC/MS.

Module IV : 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, Phosphate, Sulphate, Nitrite, and Iron (Fe2+ / Fe 3+).

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).

TOC Analyser- Total Organic Carbon Analysis - Sample Preparation testing, Interpretation of the data and reporting of the results for selected compounds (Surface water, groundwater and wastewater).

References

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2. Christian, G.D.; Purnendu, K.; Sandy Dasgupta.; Kevin, A. S.; (2014). Analytical Chemistry. 7th edition , ISBN 978-0-470-88757-8
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24-360-0206 FLUID MECHANICS

(Credits : 2)

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

CO → PO, PSO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	3						3			
CO2	2	3					3			
CO3	1		3				3	3		
CO4	2		3					3		
CO5					3					3

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

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.

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24-360-0207 ENVIRONMENTAL BIOTECHNOLOGY AND BIO REMEDIATION

(**Credits : 2**)

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 Objectives:

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

CO → PO, PSO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	2						3			
CO2	2	3					3			
CO3	2		3				2	3		
CO4	2			3			2	3		
CO5	2				3				3	

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

SYLLABUS

Module I : Biotechnological and Pollution Control

A Historical Perspective; Scope of Environmental Biotechnology; Wastewater biotreatment: Aerobic biotreatment; Anaerobic biotreatment; Advanced bio treatment – membrane technology; Development and optimization of membrane bioreactor process for use in sanitary and industrial sewage treatment; Biotreatment of gaseous streams; Biofilters, Biofilms in treatment of wastewater; Metals removal by microorganisms from wastewaters.

Module II : Environmental Biotechnology and agriculture

Precision agricultural technology; 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 III : Environmental Biotechnology and Waste Management

Aerobic and anaerobic treatments of solid wastes; Composting; Vermiculture; Biogas generation; Comparison of aerobic and anaerobic methods; Treatment of hazardous wastes; Origin, sources and treatment strategies for polychlorinated biphenyls, pesticides, toxic pollutants, polymers, Textile chemical residues etc.; Biomedical wastes, Types of biomedical wastes; Hazards caused by biomedical wastes; Treatment strategies for biomedical wastes. Development of environmentally friendly processes such as integrated waste management.

Module IV : Applications of Environmental Biotechnology

Biosensors: structure and construction; biosensor components: biological elements and principle of detection; Biosensor types and its applications; Bioindicators and Biomarkers. Role of biotechnology in integrated environmental protection approach; Process modification and product innovation; Role of environmental biotechnology in management of resources; Reclamation of wasteland; Biomass production; Biogas and biofuel production.

Module V : Bioremediation

An emerging clean-up technology; Bioremediation as an option to treat contaminated soils and groundwater. 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; Microbial interactions with xenobiotics; Bioremediation of plastic waste. future prospects for bioremediation.

References

1. A Textbook on Precision Agriculture Technology , Kishore Chandra Swain, 2020
2. Microalgae biotechnology for soil and wastewater implications on ecosystems, Mohammed Asaraful Alam , 2019
3. Biotechnology in the chemical industry: towards a green and sustainable future, Pratima Bajpai, 2019
4. Agricultural biotechnology, A K Jain, 2018
5. Environmental pollutants and their bioremediation approaches, Ram Naresh Bharghawa, 2017
6. Calculations in molecular biology and biotechnology, Frank H Stephenson. 2016

7. Biotechnology for biofuel production and optimization, Carrie A Eckert and Cong T Trinh, 2016
8. Environmental biotechnology, Monika Jain, 2014.
9. Fermentation, microbiology and biotechnology, E L Manasi and Charlie Vrice, 2011
10. Environmental biotechnology and sustainable biodiversity, Harke Sanjay and others, 2010
11. Environmental biotechnology, M H Fulekar, 2010
12. Bioremediation technology, M H Fulekar, 2010
13. Recent trends in biotechnology, Patro Lingarj , 2010
14. Biotechnology applications in human healthcare, Nehra Sampat, 2009
15. Practical manual of biotechnology, Ali S Mansoor and Syed Yawer Hussain, 2009
16. Computational biotechnology, Sharad Srivastava, 2009
17. Textbook of biotechnology, Preeti Gupta, 2008.
18. Bioethics and biosafety in biotechnology, V Sree Krishna, 2007
19. Experiments in microbiology , plant pathology and biotechnology, K R Aneja, 2007
20. Aquaculture and marine biotechnology, I S Bright Sing and others, 2007
21. Environmental biotechnology, Joshi Rajmohan, 2006
22. Environmental biotechnology: concepts & applications, Jordening. 2005
23. Biotechnology : lessons from nature, David S Goodsell. 2004
24. Biotechnology 5: animal cells, immunology and plant biotechnology, M K Satheesh, 200325. Plants, genes and crop biotechnology, Chrispeels Martin J , 2002
25. Microbial fundamentals of biotechnology, Barun Volkumar and Friedrich Gotz, 2002
26. Protein engineering in industrial biotechnology, Albergina Lilia, 2000
27. Biological and biotechnological control of insect pests, Jack E Rechcigl, 1998
28. Environmental biomonitoring: biotechnology, ecotoxicology interface, Lynch James and Alan Wiseman, 1998
29. Applied plant biotechnology, S Ignacumuthu, 1997
30. Maintaining cultures for biotechnology and industry, Hunter Cevera Jenie C Angela Belt, 1996
31. Environmental biotechnology: principles and applications, Rittman Bruce E and Perry L McCarthy, 1996
32. Biotechnology theory and techniques, Jack G Chirikjian, 1995
33. molecular biology and biotechnology, H D Kumar , 1993
34. Genetic engineering and biotechnology: concepts, methods and applications, V Chopra and Anwar Nasim. 1990
35. Biotechnology: laboratory course, Becker Jefrey M, 1990
36. Forest genomic and biotechnology, Richard meiland and Matias Wiseman

24-360-0208 APPLIED MATHEMATICS & STATISTICS

(Credits : 2)

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

CO → PO, PSO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	2						2			
CO2	1						3			1
CO3	3	2	2	2			3	3		
CO4	2			3						
CO5	1			2	3					2

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

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 :

Derivatives: Derivatives and Rates of Change - The Derivatives as a Function – Basic Differentiation Formulas - The Product and Quotient Rules - The Chain Rule. Exponential Growth and Decay- Linear Approximation and Taylor Polynomials. Applications of Derivatives: Maximum and Minimum Values - Increasing and Decreasing Functions, Concavity, Graphing with Technology. L'Hospital's Rule: Indeterminate Quotients – Optimization Problems.

Module II :

Integrals: Areas and Distances - The Definite Integral - The Fundamental Theorem of Calculus - The Substitution Rule: - Integration by Parts - Area between curves – Average values-Volumes. Multivariable Calculus: Functions of Several Variables - Partial Derivative.

Module III :

Differential Equations: Modeling with Differential Equations – Phase Plots, Equilibria, and Stability - Direction Fields - Separable Equations. System of Differential Equations - Phase Plane Analysis; System of linear Differential equation:- Qualitative Analysis of Linear System - Solving Systems of linear Differential equations- System of Nonlinear Differentil equations.

Module IV :

Collection, classification and tabulation of data. Essentials of good longtable form. Preparation of one- way and two-way frequency tables. Diagrammatic and graphical representation of data (data bar, pie, picot and histograms, frequency polygons), frequency curves and cumulative curves. Measures of central tendency and dispersion: mean, median, mode , range, standard and relative deviation, coefficient of variation, skewness, kurtosis, confidence limits and confidence intervals and normal distribution curve, Analysis of variance one way and two way classification, probit analysis

Module V :

Accuracy, precision and errors: Classification, Minimization of errors, Rejection of data. Z, t, F, and chi-square tests. Correlation and Regression: Pearson's coefficient, Spearman's coefficient, regression lines and their use. Curve fitting. Probability: Exclusive and independent events, addition and multiplication theorems, dependent events and conditional probability.

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.

24-360-0209 INDUSTRIAL ECOLOGY

(Credits : 2)

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

CO → PO, PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2			2	3	2		
CO2	2	3	2	3		2	3	1		
CO3	1	3	3				3	3		
CO4		3	3					2		
CO5	2				3					3

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

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 (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 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 (e.g., Industry 4.0, blockchain)

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.
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24-360-0210 ENVIRONMENTAL MODELING

(Credits : 2)

Course Description:

Study of complex environmental systems based on simple mathematical relationships forms the basis of environmental modeling. Mathematical Equations otherwise called models are the abstraction of reality, 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 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 aquire 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 to 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 inference and conclusions are achieved.

Course Outcomes:

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

CO1	Understand the importance of environmental modeling for describing a process, and mass balance relationships. Study of isotherm model for basic understanding.	Understand
CO2	Basic aspects of environmental modeling 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

CO → PO, PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2			1	3	2		
CO2	3						2			
CO3	2		3	3			2	3		
CO4	2			3			3			
CO5	1			2						3

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

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. Modeling procedure, simulation and other tools. Aquasim and other tools for modeling 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. Diffussion, Importance of total and component mass balance. Modeling of biological hazard room, Air Filter Efficiency,Lake Model , Lake Pollution as a modeling 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. Modeling 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 Softwares

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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17. Reichert, P., AQUASIM 2.0 - Tutorial, Swiss Federal Institute for Environmental Science and Technology (EAWAG), CH-8600 Dübendorf, Switzerland, 213 p., 1998. pdf
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24-360-0211 APPLIED ENVIRONMENTAL MICROBIOLOGY

(**Credits : 2**)

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 its applications.

Course Outcomes:

After successfull 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 biocorrossion, bioleaching	Understand
CO5	Explain the cell culture techniques and its biomedical applications	Understand

CO → PO, PSO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	1	2			1	2	1	2		1
CO2		3	1			3	2	2		
CO3		2	3			2		3	1	
CO4		1	2			1		1		
CO5					3					3

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

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 : Animal Tissue culture techniques

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.

References

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24-360-0212 CLIMATE CHANGE AND ENVIRONMENT

(**Credits : 2**)

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	Understand, Apply
CO3	Understand the reasons for past climate change and future climate change projections.	Understand, Apply, Analyse
CO4	Analyse and interpret the impact of climate change on environment	Understand, Apply
CO5	Ability to analyse the impact and feasibility of climate change policies and climate intervention methods on earths future climate	Understand, Apply, Analyse

CO → PO, PSO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	2				3		2			
CO2						2	3	1	3	
CO3		1			2			2		3
CO4	3	2	3					1	3	2
CO5				3			2			

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

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.

24-360-0213 ENVIRONMENTAL ENGINEERING- LAB

(Credits : 1)

Course Description:

Study of engineering systems and optimization requires the determination of characteristic constants and parameters that controls the mass and energy balances of the reactor systems. The critical analysis of their magnitudes to identify the feasibility of the process too is also very important. Environmental Engineering laboratory practices in this respect are very important to allow the students get practiced into the way the process are conducted in the bench scale batch reactors, the conducting of the process and calculation of the controlling parameters.

Course Objectives:

During the course, the students will foster and develop rational thought processes as they pertain to the proficient and safe operation of environmental engineering processing units. Students will analyse data obtained from engineering unit operations and tell technical information they learned through the writing of reports and as well as clear oral presentations and communication during teamwork.

Course Outcomes:

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

CO1	Develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	Apply
CO2	Apply the laboratorial results to problem identification, quantification, and basic environmental design and technical solutions	Apply
CO3	Analyse basic reactor types and kinetics.	Analyse
CO4	Apply basic environmental engineering processes (physical/chemical) for the removal of contaminants	Apply

CO → PO, PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3		2	1			3	2	1	
CO2	1	3				2	3			
CO3				3						
CO4		3	2			3	3	2	1	

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

Assessment Pattern:

Category	Assessment Methods			Examination
	Test 1	Test 2	Test 3	
Understand	20	20	20	60
Apply	20	20	20	40
Analyze	30	30	30	
Evaluate	30	30	30	

SYLLABUS

List of Experiments

1. Buffer Intensity
2. Biological Oxygen Demand - Rate Constant
3. Removal of Iron from Waste Water
4. Water Softening
5. Adsorption Kinetics and Equilibrium
6. Settling Characteristics
7. Terminal Velocity
8. Jar Test for determining Optimum Coagulant Dose for Water Treatment

References

1. Santhosh Kumar Garg & Rajeshwary Garg (2001 & 2010), Water Supply Engineering (Vol.1) Khanna Publishers, 2-B, Nath Market, Nai Sarak, Delhi-110006.
2. Metcalf & Eddy (2003 4th Edition) Wastewater Engineering Treatment and Reuse – Tata McGraw-Hill Publishing Company Limited, New Delhi.

24-360-0214 CHEMICAL & BIOLOGICAL METHODS IN ENVIRONMENTAL ANALYSIS –LAB

(Credits : 2)

Course Description:

Study of the environment requires reliable and accurate measurement of extremely small quantities of chemicals and the ability to determine if they are naturally occurring species or pollutants. The course- ES 2209 covers basic chemical lab techniques for the analysis of environmental samples and on written presentation of analytical results.

Course Objectives:

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

Course Outcomes:

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

CO1	principle and procedure of experiments	Unerstand
CO2	Design and conduct experiments	Apply
CO3	analyze and interpret data	Analyse
CO4	Expertise in environmental sample preparation, physicochemical analysis and instrumental methods	Apply

CO → PO, PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2		1				2	1		
CO2	2	1	3			1	2	3		
CO3	1		2	3			1	2		
CO4	3	2	1			2	3	1	1	

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

Assessment Pattern:

Category	Assessment Methods			Examination
	Test 1	Test 2	Test 3	
Understand	20	20	20	20
Apply	60	60	60	60
Analyze	20	20	20	20

SYLLABUS

1. Determination of phosphate by Spectrophotometry
2. Determination of nitrite by Spectrophotometry
3. Determination of silicate by Spectrophotometry
4. Determination of chlorophyll pigments in water by spectrophotometry
5. Determination of iron content in water by spectrophotometry
6. Determination of fluoride content in water by spectrophotometry
7. Determination of turbidity of water using Nepheloturbidimeter
8. Determination of sulphate in water by Turbidimetry
9. Determination of sodium in water by Flame photometry
10. Determination of potassium in water by Flame Photometry
11. Determination of the strength of a base by Potentiometric titration
12. Demonstration of working of GC-MS.
13. Demonstration of working of ICP-AES.
14. Demonstration of sample preparation and working of IR.
15. Demonstration of working of AAS.
16. Indicators and pathogens -Coliforms as indicators of faecal pollution- Enumeration and identification of Coli forms (fecal and non-fecal) using MPN method.
17. Water borne pathogens - Salmonella, Shigella, Vibrio cholerae, Streptococcus and viruses - detection, enumeration, isolation and identification

ANALYSIS OF AIR

No	ANALYSIS OF AIR	REFERENCES
1	Working of High-volume Sampler	Section 3.8.2, Chapter 3, Practical Environmental Analysis
2	Determination of Suspended Particulate Matter (SPM)-SPM $\mu_{2.5}$	Guidelines for the measurement of Ambient Air Pollutants, Volume I, Guidelines for Manual Sampling and Analysis; CPCB, Ministry of Environment and Forest, National Ambient Air Quality Series-NAAQMS/36/2012-13. Noise Pollution Regulation in India, CPCB, 2001.
3	Determination of Suspended Particulate Matter (SPM)-SPM μ_{10}	
4	Determination of Gross composition of SPM $\mu_{2.5}$ and SPM μ_{10}	
5	Ambient Air Quality monitoring - Sulphur dioxide (SOx), & Nitrogen dioxide (NOx).	

References

1. Pradyot Patnaik (2010), Environmental Analysis Chemical Pollutants in Air Water Soil and Solid Waste, Second Edition, CRC Press, Taylor & Francis Group.
2. J. Mendam, R.C. Denny, J.D. Barnes and .J.K. Thomas(2007), Vogel's text book of Quantitative Chemical Analysis, 5th impression, Dorling Kindersley (India) Pvt. Ltd.
3. Andrew D. Eaton, Lenore S. Glesceri, Eugene W. Rice and Arnold E. Greenberg (Eds) (2005), Standards Methods for the Examination of Water and Wastewater Analysis, 21st Edition, APHA. Washington DC.
4. Grasshoff, K., Kremling, K. and Ehrhardt, M. eds., 2009. Methods of seawater analysis. John Wiley & Sons.

24-360-0215 ENVIRONMENTAL TOXICOLOGY -LAB

(Credits : 1)

Course Description:

This advanced laboratory course provides hands-on experience in environmental toxicology, integrating principles of ecotoxicology with molecular biology and cell culture techniques. Students will study toxic substances and their effects on ecosystems, learning various techniques for assessing toxicity and understanding mechanisms of action. The course covers basic principles of toxicology, including dose-response relationships, bioaccumulation, and ecological risk assessment. Additionally, students will gain experience in assessing molecular and cellular effects of contaminants, using advanced techniques such as genotoxicity assays, gene expression analysis, and cell culture-based toxicity testing.

Course Objectives:

This course aims to provide a comprehensive understanding of environmental toxicology, covering basic principles and techniques for assessing toxicity in environmental samples. Students will learn about the mechanisms of action of toxicants on organisms and ecosystems, analyze toxicity data, and evaluate ecological risks associated with exposure to toxic substances. Additionally, the course focuses on equipping students with practical skills in molecular biology techniques relevant to ecotoxicology and cell culture techniques for assessing contaminant effects on cell viability and function. By integrating molecular and cellular data with ecological endpoints, students will conduct comprehensive ecotoxicological assessments and apply advanced techniques to address real-world environmental issues.

Course Outcomes:

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

CO1	Students will grasp fundamental principles of environmental toxicology, focusing on dose-response relationships and ecological risk assessment. Additionally, they will gain insight and attain skill into molecular and cellular ecotoxicity mechanisms, encompassing genotoxicity, gene expression changes, and cytotoxicity from contaminants.	Understand
CO2	Design and conduct toxicity tests for environmental samples, analyzing molecular and cellular data including genotoxicity assays and gene expression changes, and suggesting mitigation for contaminated sites.	Apply
CO3	Analyze toxicity impacts on ecosystems and health using lab techniques, including molecular biology methods like PCR and gene expression analysis, along with cell culture, to assess contaminant effects.	Analyse
CO4	Evaluate toxicity testing methods, analyze case studies for real-world applications, and assess the significance of molecular and cellular data, integrating it with ecological endpoints for broader contaminant exposure understanding.	Evaluate, Analayse

CO → PO, PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	1	2			1	3	2		
CO2	2	2	3			1	3	3	2	
CO3	2	1	2	2			2	2	1	
CO4	3		2	3	1		3	2		1

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

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

1. **Toxicity Testing Methods:** Conduct an acute toxicity test using Daphnia magna and zebra fish as the indicator species. Expose a group of Daphnia and zebra fish to varying concentrations of a toxicant (e.g., heavy metal solution) and record the mortality rate over a specified period. Calculate the LC50 (lethal concentration at which 50% of the organisms die) to determine the toxicity of the substance.

2. **Mechanisms of Toxicity:** Investigate the effects of a toxicant (e.g., pesticide) on enzyme activity in a model organism (e.g., yeast). Prepare different concentrations of the toxicant and incubate yeast cells with the substance. Measure the activity of specific enzymes (e.g., catalase) to assess the impact of the toxicant on cellular processes.

3. **Plant Toxicity Testing:** Investigate the effects of a toxicant (e.g., pesticide or heavy metals) in plants/seeds. Prepare different concentrations of the toxicant and incubate seeds with the substance. Employ methods like the OECD 208 Terrestrial Plant Test to assess the toxicity of substances to plants.

4. **Ecological Risk Assessment:** Conduct a bioaccumulation study using a fish species (e.g., zebrafish). Expose the fish to a known concentration of a pollutant (e.g., PCBs) over a specified period. Analyze the accumulation of the pollutant in the fish tissues using analytical techniques such as gas chromatography-mass spectrometry (GC-MS).

5. **Application of Molecular and Cellular Techniques in Environmental Monitoring:** Students extract DNA from the exposed test organism samples and environmental samples, quantify it using spectrophotometry, and assess DNA quality. Using gene specific primers, students analyze the expression of specific genes in response to contaminants in model organisms/cell lines, comparing them to control samples. Students culture cell lines (eg. Fish, Mammalian), maintaining them under sterile conditions and applying basic cell culture techniques for environmental monitoring.

References

1. Finney, D.J., 1952. Probit analysis: a statistical treatment of the sigmoid response curve. Cambridge university press, Cambridge.
2. Introduction to Environmental Toxicology: Impacts of Chemicals upon Ecological Systems; by Wayne G. Landis, Ruth M. Sofield, and Ming-Ho Yu.
3. OECD Test Guidelines for Chemicals, https://www.oecd-ilibrary.org/environment/oecd- guidelines-for-the-testing-of-chemicals-section-4-health-effects_20745788
4. Klaassen, Curtis D (Editor). 2008. Casarett & Doull's Toxicology: The Basic Science of Poisons. McGraw Hill Companies, Inc.; 7th Ed
5. Principles and Practice of Toxicology in Public Health, 2nd edition Ira Steven Richards and Marie Bourgeois, Jones & Bartlett Learning, 2014 ISBN 978-1- 4496-4526-7
6. Cell and Molecular Biology: Concepts and Experiments, Gerald Karp, Sixth Edition
7. Freshney's Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications by R. Ian Freshney, Eighth Edition
8. Molecular Cloning- A laboratory Manual, by Michael R Green and Joseph Sambrook, Fourth Edition.
9. Ted A. Loomis and A. Wallace Hayes., 1996. Essentials of Toxicology Fourth edition, Academic press, Inc. London.

SEMESTER III

24-360-0301 ENVIRONMENTAL IMPACT AND RISK ASSESSMENT

(**Credits : 3**)

Course Description:

This course provides an in-depth exploration of the principles, methodologies, and applications of environmental impact assessment (EIA) and risk assessment (RA) in the context of contemporary environmental management practices. The course aims to equip students with the knowledge and skills necessary to evaluate, mitigate, and manage the environmental impacts of various projects, policies, and activities and assess the associated risks to human health and ecosystems.

Course Objective:

- Understand the historical perspective, concepts, and theoretical foundations of environmental impact assessment globally and in India.
- Explore methodologies for quantifying and assessing risks to human health and the environment.
- Learn to identify, evaluate, and mitigate potential environmental impacts of various human activities using tools and techniques.
- To acquire knowledge of the socio-ecological and economic perspectives of any developmental project
- Cultivate critical thinking skills to assess the effectiveness of proposed mitigation measures and risk management strategies.

Course Outcomes:

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

CO1	Students will demonstrate knowledge of the legal and regulatory frameworks governing environmental impact and risk assessment processes at local, national, and international levels.	Understand
CO2	Students will be able to apply the principles and methodologies of environmental impact assessment to evaluate the potential environmental effects of proposed projects, policies, or activities.	Apply
CO3	Students will learn to identify, quantify, and assess risks to human health and the environment associated with various environmental stressors, contaminants, and activities.	Apply
CO4	Students will develop the ability to engage with diverse stakeholders, including communities, government agencies, industry representatives, and non-governmental organizations, to solicit input and address concerns throughout the environmental assessment process.	Analyse
CO5	Students will be able to propose and evaluate mitigation measures and alternatives to minimize adverse environmental impacts and reduce risks to human health and ecosystems.	Evaluate

CO → PO, PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2				1		1		
CO2		1	3	2				1		
CO3		1	3				3			
CO4		3	3				1	2		
C05					2		1	1		2

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

Assessment Pattern:

Category	Assessment Methods			Examination
	Test 1	Test 2	Seminar	
Remember	10	10	10	10
Understand	50	50	50	50
Apply	40	40	40	40

SYLLABUS

Module I : Introduction to Environmental Impact Assessment (EIA)

Nature and purpose of environmental impact assessment (EIA).- Historical Development of EIA- Evolution and milestones in the development of EIA globally-Legal and Regulatory Frameworks in EIA- Overview of international conventions, laws, and regulatory frameworks influencing EIA-Types and Scope of EIA- Different types of EIA methodologies, their applications, and limitations- Cross-Sectoral Considerations in EIA-Interdisciplinary and cross-sectoral aspects impacting EIA- Terms of References in EIA- Defining and establishing the terms of references for EIA studies- EIA in Project Cycle - Current issues in EIA-Legal and Regulatory Aspects in India.

Module II : EIA Process and Methodologies

Principles of EIA- EIA in India - Overview and steps involved in the EIA process- Screening, Scoping, and Public Participation- Methods for screening projects, scoping studies, and involving the public in the EIA process, presentation and review- Establishing the Environmental baseline- Criteria and standards for assessing significant Impact. -Mitigation Strategies- Approaches and techniques for mitigating potential environmental impacts-Generic structure of EIA Document

Module III : Tools and Techniques in EIA

Impact Prediction and Assessment-Prediction tools and methodologies for assessing impacts on air, water, soil, noise, and biological communities-Cumulative Impact Assessment- Techniques for evaluating cumulative impacts of multiple projects or activities.

Module IV : Economic Impact Assessment

Socio-economic Impact Assessment-Definition, models, and planning process for social impact assessment- Community Impacts- Impacts on individuals, families, communities, and institutions- Documentation of EIA Findings & Report Preparation.

Module V : Environmental Management and Risk Assessment

Environmental Management Plans (EMP)- Preparation, implementation, and rehabilitation

plans in EMPs. Monitoring and Auditing- Policies, guidelines, and post-project audit in environmentalmonitoring programs. Process of Environmental Risk Assessment- Risk Monitoring - Risk communication, emergency preparedness plans, and designing risk management programs- Role of GIS in ERM - Tools for Environmental Risk Assessment-HAZOP and FEMA methods- Event tree, fault tree and MCACA -Quality aspects of Environmental Impact Assessment-case studies.

References

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. Routledge.
17. 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

24-360-0302 BIODIVERSITY AND CONSERVATION

(Credits : 2)

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 critically evaluate the economic and philosophical dimensions of biodiversity.	Analyse, Evaluate
CO3	Proficiency in designing and implementing conservation strategies.	Analyse
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

CO → PO, PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	1	1				2	1	2		
CO2	1				1			1		1
CO3		2	3			3	2	3	2	1
CO4				3		1		2	3	
CO5	2	2				1	1	1		

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

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
Evaluate	25	25	25	25

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.

24-360-0303 CHEMISTRY OF WATER AND WASTEWATER TREATMENT

(Credits : 2)

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

CO → PO, PSO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	2	2	1			1	3	2		1
CO2	1	3		2			3		1	
CO3		2	2			1	2	3	1	
CO4				3			2	2	2	
CO5					3		1	1		3

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

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

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3. Metcaff and Eddy (2003). Waste Water Engineering, Fourth Edition, Tata McGraw-Hill, New Delhi.
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5. A. W. Hounslow (1995). Water Quality Data –Analysis and interpretation, Lewis Publishers, Boca Raton.
6. APHA (2012). Standard Methods for the Examination of Water and Waste water 2 st Centennial Edition, American Public Health Association, Washington DC.
7. Samuel D. Faust (2010). Chemistry of water treatment, 2 nd Edition, CRC Press, Tylor and Francis Group, New York.
8. AWWA (2010).Water Quality- Principle and practices of water supply operation series, Vol.4 Edition, American water works association, Denver.
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.
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14. Achari V S, Report of the healthiness study of secured landfill (SLF) at Travancore- Cochin Chemicals Limited, Udyogamandal, Kochi, Kerala, Final Report , June 2021.
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.

24-360-0304 WATER SCIENCE, QUALITY MONITORING, AND INTERPRETATION

(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

CO → PO, PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	1		2		1	2	2		
CO2	2	3	1	3	2	3	2	1	3	1
CO3	1	2	2	1		1	3	3		
CO4		2		3	3		3			3
CO5	2	3	3	3	3	2	3	3	2	3

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

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.
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5. Fifield, F.W.; (2000). “Environmental Analytical Chemistry”. 2nd edition, Blackwell Publishers.

24-360-0305 WASTEWATER TREATMENT TECHNOLOGIES

(Credits : 3)

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 successfull 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

CO → PO, PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	3	3	1		3	2	3	1	
CO2	1	3	2	2	1	2	3	2	2	
CO3	2	1	3	1		1	3	3		
CO4	1	2	3	3	2		2	1	3	1
CO5		3				3			2	

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

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

1. Loucks, D.P. and Van Beek, E., 2017. Water resource systems planning and management: An introduction to methods, models, and applications. Springer.
2. Simonovic, S.P., 2012. Managing water resources: methods and tools for a systems approach. Routledge.
3. Hoque, S.F., 2014. Water conservation in urban households. IWA Publishing.
4. Sturman, J., Ho, G. and Mathew, K., 2004. Water auditing and water conservation. IWA Publishing.
5. Soumaila, K.I., Niandou, A.S., Naimi, M., Mohamed, C. and Schimmel, K., 2019. Analysis of water resources vulnerability assessment tools. Journal of Agricultural Science and Technology, pp.69-86.
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24-360-0306 ADVANCED WATER TREATMENT TECHNOLOGIES

(**Credits : 3**)

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

CO → PO, PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	1	1	3	2	2		
CO2	2	3	1	2	1	2	3	2	2	
CO3	2	1	3	1		1	3	3		
CO4	1	2	3	3	2		2	1	3	
CO5		3								

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

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.
4. Parsons, S. ed., 2004. Advanced oxidation processes for water and wastewater treatment. IWA publishing.
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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.
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24-360-0307 FOUNDATIONS FOR CARBON MANAGEMENT

(Credits : 3)

Course Description:

The increasing concentration of carbon dioxide and other greenhouse gases in the Earth's atmosphere is linked to extreme weather events, rising sea levels, and significant disruptions to ecosystems. Understanding and managing carbon emissions is crucial for mitigating these impacts and steering society towards a sustainable future. This course equips students with the knowledge and tools necessary to tackle carbon emissions effectively. It covers the science behind carbon emissions, the economic and policy mechanisms designed to control them, and the technological and behavioral changes required to reduce them. By exploring emission trading systems, carbon offset strategies, and the policies governing carbon management, students are prepared to contribute meaningally to climate action efforts. Furthermore, the course highlights the importance of international cooperation and the role of innovation in achieving carbon reduction targets. In essence, this course empowers students with the capabilities to address climate change proactively, making it an indispensable part of environmental education and action plans globally.

Course Objectives:

This course provides a comprehensive understanding of carbon emissions, their environmental impact, and the strategies and policies designed to manage and reduce them. Through five modules, students will explore the sources of carbon emissions, learn about emission trading systems, carbon offset systems, and reduction strategies, and gain insight into the relevant policies and legislation. The course will also address the challenges faced in carbon control and discuss future perspectives for reducing global carbon footprints.

Course Outcomes:

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

CO1	Understand the sources and types of carbon emissions and their impact on the environment.	Understand
CO2	Describe the mechanisms of emission trading systems, including cap and trade, carbon tax, and carbon credits.	Analyse
CO3	Identify strategies for carbon offset and reduction, including renewable energy projects and energy efficiency measures.	Apply
CO4	Analyze policies and legislation related to carbon control, including international agreements.	Analyse
CO5	Evaluate the challenges in implementing carbon control measures and explore future perspectives for mitigating climate change.	Evaluate

CO → PO, PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	3				2	1	1		
CO2		2					3			
CO3		3	2			2	2	3		1
CO4				1	3		1	1		2
CO5					2			1	1	3

Assessment Patterns *1 – Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High*

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 : Introduction to Carbon Emissions

Understanding Carbon emissions, Importance of Carbon Emission Control, Sources of Carbon Emissions, Types of Carbon- the carbon rainbow.

Module II : Emission Trading systems

Emission trading systems, Cap and trade – Cap setting, Permit allocation, Trading mechanism, Compliance obligations, Penalties and enforcement. Carbon tax – Pricing mechanism, Revenue generation, Carbon credits – setting of cap, Allocation of permits, Trading, Compliance.

Module III : Carbon Offset Systems and Carbon Footprint Reduction Strategies

Renewable Energy Projects, Forestation projects, Energy efficiency projects, Purchasing Carbon Credits, Energy efficiency– Energy audits, Energy efficient appliances, Renewable Energy Sources, Building design and Insulation, Sustainable transport – Public transport, Adoption of Electric Vehicles, Smart mobility solutions, Waste management, Recycling initiatives

Module IV : Policies and Legislation for Carbon control

Carbon pricing, Renewable energy standards and incentives, Energy efficient standards and regulations, Vehicle emission standards and transportation policies, Forest conservation policies. United Nations Framework Convention on Climate Change (UNFCCC), Kyoto Protocol, Paris Agreement, Challenges and advantages.

Module V : Challenges and future perspectives

Challenges - Global impact, Policy implementation and cost, Technological limitations, Public

awareness and acceptance. Future perspectives – Increased research and developments, Renewable energy expansion, Enhanced international cooperation, Carbon pricing mechanisms, Corporate responsibility initiatives, Public Education Campaigns.

References

1. Smit, B., Reimer, J., Oldenburg, C. M., & Bourg, I. C. (2014). Introduction to Carbon Capture and Sequestration. Imperial College Press, United Kingdom.
2. Hansjürgens, B. (Ed.). (2005). Emissions Trading for Climate Policy: US and European Perspectives. Cambridge University Press, United Kingdom.
3. Brohé, A., Eyre, N., & Howarth, N. (2009). The Carbon Markets: An International Business Guide. Earthscan, United Kingdom.
4. Muthu, S. S. (2015). The Carbon Footprint Handbook. CRC Press.
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24-360-0308 CARBON CAPTURE AND STORAGE

(**Credits : 3**)

Course Description:

This course on Carbon Capture and Storage aims for a comprehensive exploration into cutting-edge strategies for reducing atmospheric CO2 levels, a critical challenge in combatting climate change. The curriculum spans the sources of carbon emissions, innovative capture technologies, transportation methods, and storage solutions. Students will dive into understanding of natural and anthropogenic CO2 contributors, evaluating technological advancements like pre-combustion capture, oxy-fuel combustion, and biological sequestration methods involving microalgae. The course also examines CO2 transport logistics, including pipeline and shipping options, alongside storage practices in geological formations and through biochar sequestration. Importantly, it addresses the environmental impacts and safety considerations associated with carbon capture and storage (CCS) technologies. This program aims to equip learners with a deep understanding of carbon management techniques, preparing them to contribute effectively to global climate change mitigation efforts.

Course Objectives:

The objective of this course is to equip participants with a comprehensive understanding of the entire carbon management spectrum, from the sources of CO2 emissions to advanced capture, transport, and storage technologies. The course aims to foster critical analysis of various carbon reduction strategies, emphasizing technological innovations and environmental considerations. By the end of this course, learners will be prepared to contribute effectively to climate change mitigation efforts, applying their knowledge to develop sustainable solutions for reducing atmospheric CO2. This course is designed for those looking to make a meaningful impact in the field of environmental sustainability and carbon management.

Course Outcomes:

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

CO1	Understand the distinction between natural and human-induced CO2 emissions and their impact on climate change.	Understand
CO2	Learn the principles and evaluate the efficiency of various CO2 capture technologies, including biological methods.	Evaluate
CO3	Assess the pros and cons of different CO2 transportation methods, focusing on their environmental and safety implications.	Analyse
CO4	Explore carbon storage solutions, emphasizing geological and alternative methods, for long-term CO2 sequestration.	Understand
CO5	Analyze the environmental and health risks associated with CCS technologies through life cycle and risk assessment methodologies.	Analyse

CO → PO, PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	3				2	1	1		
CO2	3	2	1			1	3	2		
CO3				2			2	1	1	
CO4		2	2			1	1	3	2	
CO5				3	2		1	1	3	1

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

Assessment Pattern:

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

SYLLABUS

Module I : Sources of CO2

Understanding Carbon emissions, Natural Sources- Volcanic Activity, Decomposition, Ocean Release, Human Activities - Burning Fossil Fuels, Deforestation, Industrial Processes, Transportation Sector - Vehicular Emissions, Aviation and Shipping, Agricultural Practices - Livestock Farming, Crop burning, Waste disposal – Solid waste decomposition, Incineration

Module II : Capture of CO2

Systems for CO2 capture, Industrial process capture systems, Pre-combustion capture – Gasification, Shift reaction, CO2 separation, Compression and storage, Post-combustion capture – Capture process, Integration into existing infrastructure, Storage and utilization, Oxy-fuel combustion – Oxygen rich environment, CO2 separation, Storage and utilization, Direct air capture – absorption, adsorption, advantages and challenges, Carbon capture- Biological Technologies-Microalgal Carbon Capture, Enzymatic CO2 sequestration, Microbial carbon sequestration,

Module III : Transport of CO2

Pipeline, Shipping, Road or rail tankers, Hybrid methods, Advantages and disadvantages of each method, Challenges.

Module IV : Carbon storage technology

Carbon capture and storage (CCS) systems. Geological storage – Depleted Oil and Gas Fields, Deep Saline Formations, Unmineable Coal Seams, Basalt Formations. Ocean storage - benefits, Mineral carbonation – mineralization reaction, storage, advantages, Microbial Mineral Carbonation. Biochar sequestration, Enhanced weathering, Industrial uses of carbon dioxide, Blue Carbon Ecosystems.

Module V : Toxicity and Environmental impacts of CCS technologies

Toxicity of CCS solvents, degradation products, and chemical handling, CO2 leakage impacts

on ecosystems and organisms, Environmental effects of mineral carbonation, Occupational health risks in CCS facilities, Life cycle assessment and risk assessment methodologies, Integrating toxicological data for CCS decision-making.

References

1. Archer, D. (2016). The Long Thaw. How Humans Are Changing the Next 100,000 Years of Earth's Climate. Princeton University Press, United States.
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3. Herzog, H. J. (2018). Carbon Capture. MIT Press.
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6. Lackner, K. S., Brennan, S., Matter, J. M., Park, A-H. A., Wright, A., & van der Zwaan, B. (2012). The Urgency of the Development of CO2 Capture from Ambient Air. Proceedings of the National Academy of Sciences, United States.
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8. Wilson, E. J., & Gerard, D. (Eds.). (2007). Carbon Capture and Sequestration: Integrating Technology, Monitoring, Regulation. Iowa State Press, United States.
9. Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K.B., Tignor, M., & Miller, H.L. (Eds.). (2007). Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, United Kingdom.

24-360-0309 CARBON ACCOUNTING AND REPORTING

(Credits : 3)

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 successfull 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

CO → PO, PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	3	2	1	1	3	1	2	2	
CO2	1	2	3	2		1	3	3	3	
CO3	1	1	1	3	3		2	1		3
CO4		3	2	2	2	2	3	2	1	1

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

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.
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6. Wiedmann, T., & Minx, J. (2008). A Definition of 'Carbon Footprint'. In C. C. Pertsova (Ed.), Ecological Economics Research Trends. Nova Science Publishers, United States.
7. World Business Council for Sustainable Development, World Resources Institute. (2011). The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard. World Business Council for Sustainable Development, 2004, United States.
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.
9. Curran, M. A. (2012, November 7). Life Cycle Assessment Handbook. John Wiley & Sons.
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.

24-360-0310 ENVIRONMENTAL DATA ACQUISITION METHODS

(**Credits : 3**)

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 Objectives:

The main objective of this course is to provide students a basic understanding on 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 successfull 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

CO → PO, PSO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	3	2	2	1	1	2	3	2		2
CO2	2	3	1	2	2	1	3	2		3
CO3	2	1	3	2	2		2	3		1
CO4	1	2	2	3	2			1	3	
CO5										

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

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 measurment, 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. Decesion making and predictive modeling, Decesion 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 retrival - Data baseses 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.
10. Karimi, H. A. (2014, February 18). Big Data. CRC Press.
11. Zhang, C. (2024, February 29). Fundamentals of Environmental Sampling and Analysis. John Wiley & Sons

24-360-0311 ENVIRONMENTAL DATA MODELING

(Credits : 3)

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 Objectives:

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

CO → PO, PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	1	1	2	3	2		2
CO2	2	3	1	2	2	1	3	2		3
CO3	2	1	3	2	2		2	3		1
CO4	1	2	2	3	2			1	3	
CO5										

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

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

SYLLABUS

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.

24-360-0312 ENVIRONMENTAL MONITORING, ANALYTICAL INSTRUMENTS AND SENSORS

(Credits : 3)

Course Description:

The course on Environmental Monitoring, Analytical Instruments, and Sensors provides a comprehensive overview of the principles, parameters, instruments, and techniques used in monitoring various environmental factors. It covers a wide range of topics including air quality, water quality, soil contamination, climate change, noise pollution, and habitat monitoring. Additionally, the course delves into the analytical instruments and sensors employed in environmental monitoring, along with the integration of Geographic Information Systems (GIS) for spatial analysis and mapping.

Course Objectives:

Students should have an understanding on the principles and significance of environmental monitoring across different domains including air, water, soil, climate, noise, radiation, and habitat. They could identify the various parameters monitored in environmental monitoring and their respective significance in assessing environmental health and quality. They gain proficiency in the application of GIS techniques for spatial analysis and mapping in environmental monitoring, including integrating remote sensing data. They could appreciate the interdisciplinary nature of environmental monitoring and its importance in sustainable development and resource management. By the end of the course, students will be equipped with the knowledge and skills necessary to effectively monitor, analyze, and interpret environmental data using analytical instruments, sensors, and GIS techniques, contributing to informed decision-making and environmental stewardship.

Course Outcomes:

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

CO1	Identify and describe the types of environmental parameters commonly monitored in different environmental media such as air, water, soil, and climate, including key pollutants and indicators such as particulate matter, sulfur dioxide, pH levels, dissolved oxygen, and temperature.	Understand
CO2	Demonstrate knowledge of the analytical instruments utilized in environmental monitoring, including spectrophotometers, chromatographs, mass spectrometers, atomic absorption spectrometers, pH meters, and conductivity meters, among others, and understand their principles of operation and applications in environmental analysis.	Understand

CO3	Analyze the applications of Geographic Information Systems (GIS) in environmental monitoring, including spatial analysis techniques and the integration of remote sensing data with GIS for monitoring water quality, air pollution, forest management, and creating thematic maps for environmental reporting.	Analyze
CO4	Demonstrate proficiency in using analytical instruments and sensors for collecting, analyzing, and interpreting environmental data, and apply this knowledge to assess environmental conditions, identify sources of pollution, and develop mitigation strategies.	Understand
CO5	Classify case studies illustrating the practical application of environmental monitoring techniques, analytical instruments, sensors, and GIS in addressing real-world environmental challenges and informing decision-making processes.	Analyze

CO → PO, PSO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	2	1	2	2	1	1	2	2		2
CO2	1	3	1	1	2	2	3	1		1
CO3	2	1	3	2	2		2	3		
CO4	1	2	2	3	2				3	
CO5	1									

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

Assessment Pattern:

Category	**Assessment Methods**			**Examination**
	Test 1	**Test 2**	**Test 3**	
Understand	40	40	40	40
Apply	30	40	30	40
Analyze	30	20	30	20

SYLLABUS

Module I : Principles of Environmental monitoring

Air-quality monitoring, Water quality monitoring, Soil quality monitoring, Noise level monitoring, Radiation monitoring, Climate monitoring, Habitat monitoring, Pollution monitoring.

Module II : Types of Environmental Parameters Monitored

Air quality - Particulate matter (PM), sulfur dioxide (SO2), nitrogen oxides (NOx), ozone (O3), carbon monoxide (CO), Volatile Organic Compounds (VOCs). Water quality - pH levels, dissolved oxygen (DO), turbidity, chemical contaminants like heavy metals or pesticides.

Soil contamination - lead, arsenic, petroleum hydrocarbons from industrial activities or agriculture. Climate Change - Temperature, Humidity, Air Pressure, Wind Speed, Wind Direction, Precipitation, Solar Radiation, UV Index, CO2 Concentration, Ozone Levels. Noise pollution - Noise Levels.

Module III : Analytical Instruments Used in Environmental Monitoring

Spectrophotometers, Chromatographs, Mass spectrometers, Atomic Absorption Spectrometers, NMR Spectormeters, pH meters, Conductivity meters, Titrators, Thermal analysers.

Module IV : Sensors in Environmental Monitoring

Temperature sensors, Pressure sensors, Flow sensors, Level sensors, Humidity sensors, Gas sensors, Optical sensors, Motion sensors, Biosensors

Module V : GIS in Environmental Monitoring

Spatial analysis techniques, Integrating remote sensing data with GIS. Application of GIS in Water quality monitoring, Air pollution monitoring, Forest management, Map designing and creating thematic maps for environmental monitoring reports. Case studies.

References

1. Burden, F. R., McKelvie, I., Forstner, U., Guenther, A. (2002). Environmental Monitoring Handbook. United States: McGraw Hill LLC.
2. Reeve, R. N. (2002, February 22). Introduction to Environmental Analysis. Wiley.
3. de Nevers, N. (2010) "Air Pollution Control Engineering", McGraw-Hill Education, United States
4. . Bartram, J., Ballance, R. (1996) "Water Quality Monitoring: A Practical Guide to the Design and Implementation of Freshwater Quality Studies and Monitoring Programs", CRC Press, United States
5. Skoog, D.A., Holler, F.J., Crouch, S.R. (2016) "Principles of Instrumental Analysis", Cengage Learning, United States
6. Jay H. Lehr, Randy D. Down, 2005, Environmental Instrumentation and Analysis Handbook. Germany: Wiley.
7. McGrath, M. J., Scanaill, C. N., & Nafus, D. (2014, January 23). Sensor Technologies. Apress.
8. Andrew C. Millington, Patrick E. Osborne, Stephen J. Walsh, 2013, GIS and Remote Sensing Applications in Biogeography and Ecology. Switzerland: Springer US.

24-360-0313 WASTE MANAGEMENT PRINCIPLES AND PRACTICES

(**Credits : 3**)

Course Description:

The course begins by establishing fundamental waste management principles, examining the challenges of increasing waste generation and the imperative for sustainable solutions. Students will gain insights into waste characterization, collection, transportation, treatment, disposal methods, and strategies for minimizing waste generation at the source. The course explores Geographic Information Systems (GIS) and Global Positioning Systems (GPS) and their application in waste management. Students learn to leverage GIS and GPS technologies to optimize waste management processes, such as site selection, route optimization, monitoring, and spatial analysis, enabling them to make informed decisions and promote environmental sustainability in waste management practices.

Course Objective:

- To examine the various types of solid waste and methods to categorize it
- To learn the logistics of waste management and acquire knowledge on recycling and reuse of waste
- To understand various industrial by-products and microbial processes for resource recovery
- To study the fundamentals of GIS and GPS and its application in waste management.
- To acquire knowledge in various composting methods for managing bio-degradable wastes.

Course Outcomes:

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

CO1	Understanding of the types of waste and methods of its categorization	Understand
CO2	Knowledge of the logistics in waste management and Skill to recycle and reuse waste materials	Evaluate
CO3	Knowledge of industrial resource recovery through microbial processes.	Analyse
CO4	Knowledge of GIS, GPS, and Remote Sensing fundamentals.	Apply
CO5	Ability to manage bio-waste in an environment-friendly manner	Apply

CO → PO, PSO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	1	3	2			3	1	2		
CO2		3	2			2	2	3		1
CO3	1	2	3			1		3		
CO4				3			3			
CO5		3	2			3		2		

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

Assessment Pattern:

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

SYLLABUS

Module I :Overview of Waste Management

Introduction to waste - Waste Characterisation, Categories of solid waste, liquid waste, and E-waste Problem of Wastes- Effects of Excess Waste Generation; Waste Analysis and Waste Audit; World Scenario in Scrap Trade, Carrying Capacity; Waste reduction strategies, Zero Waste Living, Concept of 3R's.

Module II : Handling and disposal of significant types of wastes

Logistics in Waste Management - Technological Components- Waste Handling Equipment and Technology, Social Aspects and Managerial Goals, Steps in a Waste Management logistics process, Fleet Management, Information and Communication Technology (ICT) in Waste Management; Disposal of Municipal Solid Waste; Disposal of Bulk Waste - Market Waste and Hotel waste; Disposal of C & D; Recycle and Reuse of plastic, metal and other Waste.

Module III : Industrial resource recovery through microbial processes.

Industrial waste management and recovery methods, Microbial biopolymer (PHA) production from waste, Coir pith compost and its applications, Value-added products from industrial waste, The concept of value addition, Bio-oil, animal feed, bio sorbents, and plant growth from urban agricultural residue, Utilization of keratin waste for animal feed, food supplements, and enzyme production, Aquaculture waste management and resource recovery- towards blue economy.

Module IV :Remote Sensing in Waste Management.

Basics of remote sensing and GIS, Applications of GIS in waste management, Identifying potential waste disposal sites, Classification of landfill sites based on land use, Monitoring Solid, Liquid, and Gaseous Waste, Utilizing Remote Sensing for Environmental Pollution Monitoring, Waste management using GIS, Municipal Solid Waste: Data Collection, Management, and Operations, Review of Urban Applications of GIS in Waste Management, Case Studies on Effective Waste Management Solutions.

Module V :Bio-waste treatment and resource recovery.

Definition of Biowaste, physicochemical characteristics, Toxic substances in biowaste and examples; Sourcing biowaste; the issue of waste segregation and packaging; Food waste and composting technologies, Mixing biowaste types for suitable composting; Anaerobic digestion (Biogas),Toxicology in Biowaste management; Overview of biowaste treatment technologies; Legislative considerations

References

1. "Environmental Education and Solid Waste Management" - A Nag (2005)
2. "Handbook of Solid Waste Management" - Frank Kreith (2002)
3. "Biological Processing of Solid Waste" - Sunil Kumar (2019)

Other Reading

1. Wastes to Resource: Waste Management Handbook
   http://cbs.teriin.org/pdf/Waste_Management_Handbook.pdf
2. Performance audit on "management of Waste in India" https://swachcoop.com/pdf/CAG%20Audit.pdf
3. Technical EIA guidance manual for common hazardous waste treatment, storage and disposal facilities. http://environmentclearance.nic.in/writereaddata/Form-1A/HomeLinks/TGM_%20Comman%20Municipal%20Sold%20Waste%20Management_160910_NK.pdf.

24-360-0314 CIRCULAR ECONOMY AND RESOURCE RECOVERY

(Credits : 3)

Course Description:

The course's significant focus understands 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 successfull 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

CO → PO, PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	2	1	1	3	2	2		2
CO2	2	3	1	1	1	2	2	1		
CO3	2	1	1	1	2		2	2		
CO4										
CO5										

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

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

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24-360-0315 WASTE MANAGEMENT - LABORATORY TECHNIQUES AND FIELD VISIT.

(Credits : 3)

Course Description:

Laboratory techniques for analyzing municipal solid waste (MSW) will be a crucial component of the course, providing students with hands-on experience in assessing waste composition, identifying recyclable materials, and analyzing environmental impacts. Through practical sessions, students will develop proficiency in utilizing analytical tools and interpreting data to inform waste management strategies. The course incorporates a field visit component, allowing students to observe real-world waste management practices. This experiential learning opportunity provides invaluable insights into the operational aspects of waste management facilities, waste processing technologies, and environmental monitoring procedures.

Course Objective:

- To learn the techniques of manure analysis.
- Identification and classification of microorganisms using molecular method.
- To analyze the solid waste and characterize it.
- Gain knowledge in selecting a suitable technology for solid waste management.

Course Outcomes:

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

CO1	Perform the compost analysis-Physical, chemical and biological aspects	Apply
CO2	Identify the composition of solid waste and classify them.	Evaluate
CO3	Understanding the functioning of model business centres and entrepreneurship in waste management	Apply
CO4	Suggest suitable techniques for the management of solid waste	Apply
CO5	Skills to apply technology in waste disposal sites	Create

CO → PO, PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5
CO1				3	1		3			
CO2				3	1		3			
CO3				3	1	1	3	1		
CO4				3	3	1	3	1		
CO5				3	3	2	3	2		

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

Assessment Pattern:

Category	Assessment Methods			Examination
	Test 1	Test 2	Test3	
Apply	50	50	50	50
Evaluate	10	10	10	10
Create	30	30	30	

SYLLABUS

Experiments:

1. Compost analysis- pH, EC determination, alkalinity, acidity, nitrate, phosphate, potassium, sulphate, organic matter.
2. Hands on training in basic molecular biological techniques for the characterisation and identification of microorganisms (Extraction of DNA, Quality and quantity analysis using gel electrophoreses and UV-Visible spectrophotometer; 16sRNA gene amplification followed by sequencing for bacterial identification and classification.
3. Survey the composition of solid waste from a village and a town.
4. Survey the MSW of your locality, identify its sources, and write the composition of MSW.
5. Survey your locality and suggest methods of solid waste collection.
6. Survey your locality and suggest suitable methods of handling, separating, and storing solid waste.
7. Field/site visit to municipal solid waste/zero waste management sites/ Biomedical waste plant.

Site Visit

Sl No	Site
1	e-waste handling unit/recycling unit
2	Biomedical Waste Management Plant
3	Composting Unit/MCC (Micro Composting Centres), Visit to Model Community in Waste Management/Bio-gas plants
4	Plastic Waste Recycling Unit
5	Waste to energy projects
6	Hazardous Waste Management Unit.
7	Health and Safety –Management Information System (MIS)

References

1. A Comprehensive Laboratory Manual for Environmental Science and Engineering by P R Sreemahadevan Pillai, New Age International publishers, 2009.
2. Environmental laboratory exercises for Instrumental Analysis and Environmental chemistry by Frank M Dunnivant, Wiley International, 2004.
3. Standard protocols for microbial isolation, characterization, and molecular biology techniques published by organizations like the American Society for Microbiology (ASM) and Molecular Cloning: A Laboratory Manual by Sambrook and Russell.
4. Manuals provided by manufacturers of laboratory equipment and reagents for specific experimental procedures, such as PCR, DNA extraction kits, and bioreactor operation.

24-360-0316 ENVIRONMENTAL SUSTAINABILITY GOVERNANCE

(Credits : 3)

Course Description:

The course aims to provide students with a comprehensive understanding of environmental sustainability governance, corporate sustainability practices, and the integration of Environment, Social, and Governance (ESG) factors in business operations. Students will understand the drivers and frameworks for ESG disclosures, including international standards and regulatory requirements, and be able to engage with stakeholders, collaborate on sustainability initiatives, and analyze case studies of sustainability leadership across different industries.

Course Objective:

This course provides a comprehensive examination of environmental sustainability governance at local, national, and international levels. Students will explore the structures, mechanisms, and processes involved in governing environmental sustainability, including policy-making, regulation, enforcement, and stakeholder engagement. By the end of the course, students should be able to critically analyze environmental policies, corporate sustainability strategies, and ESG disclosures, and apply relevant tools and methodologies for assessing their effectiveness and impact.

Course Outcomes:

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

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

CO → PO, PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	3	2		1	3	2	3		2
CO2		3	2	1	1	3		2	1	2
CO3	1	2	3			1		3		
CO4		2	2				3	1		
CO5		3	2		3	2		1		3

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

Assessment Pattern:

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

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 economicarguments 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. Social impact assessment tools - Social Return on Investment 78(SROI). 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. Role of auditors in corporate governance. Governance reporting: Significance, methods for measuring and reporting on governance performance. Corporate governance frameworks and codes - The Organisation for Economic Co-operation and Development (OECD) Principles of Corporate Governance.

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

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2. Baxi, C. V., & Prasad, A. (Eds.). (2005). Corporate social responsibility: Concepts and cases: The Indian experience. Excel Books India.
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4. Matos, P. (2020). ESG and responsible institutional investing around the world: Acritical review.
5. Mondal, S., & Das, G. (2021). Business, sustainable development & other emerging issues. Sheba Blake Publishing.
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8. Prabakaran, S. (2010). Business ethics and corporate governance. Excel BooksIndia.
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11. Solomon, J. (2020). Corporate governance and accountability. John Wiley & Sons.
12. Visser, W., Matten, D., Pohl, M., & Tolhurst, N. (2010). The A to Z of corporate social responsibility. John Wiley & Sons.

24-360-0317 SUSTAINABLE DEVELOPMENT- PRINCIPLES AND PRACTICES

(**Credits : 3**)

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 sustainable development.	Analyse
CO5	Develop practical skills for implementing sustainable practices in various contexts.	Apply

CO → PO, PSO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	2	3				2		3		1
CO2		3		1		2	1	2		
CO3		2		2				1		2
CO4	3			3						1
CO5		3	2			3	2	3	1	

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

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 and evolution of sustainable development, Theoretical frameworks: Brundtland Report, Overview of the UN Sustainable Development Goals, Interlinkages between environmental, social, and economic sustainability, Ethical considerations in sustainable development. Synergies trade-offs and conflicts in Sustainable Development. Key Concepts for Sustainable Development: Factor 4 and Factor 10. The goals of sustainability (Ehrlich and Holdren's IPAT equation); Systems Thinking; Life Cycle Thinking; The Circular Economy; Industrial Ecology; Green Economy and Low Carbon Economy; The Natural Step; Resource Efficiency and Decoupling; Eco-efficiency and Triple Bottom Line.

Module II : Environmental, social and economic Sustainability

Ecological footprint and carrying capacity, Conservation of biodiversity and ecosystems, Sustainable resource management (water, energy, land), Climate change mitigation and adaptation strategies. Social equity and justice in sustainable development, Community engagement and participatory approaches, Gender equality and social inclusion, Human rights and sustainable development. Sustainable business models and corporate social responsibility, Circular economy principles, Green finance and sustainable investment, Economic indicators of sustainability

Module III : Sustainability in various sectors

Challenges and opportunities in agricultural sustainability: Agroecology and sustainable farming practices, Food security, nutrition, and sustainable diets. Sustainable Urbanization and Infrastructure: Urbanization trends and challenges, Sustainable urban planning and design principles, Green infrastructure and sustainable transportation systems. Sustainable Water Management : Water scarcity, pollution, and access issues, Sustainable water resource management strategies, Integrated water management approaches. Sustainable Consumption and Production: Consumption patterns and their environmental impacts, Strategies for promoting sustainable consumption and production, Circular economy initiatives and resource efficiency measures. Climate Change Mitigation and Adaptation: Causes and consequences of climate change, Mitigation strategies: renewable energy, carbon pricing, etc., Adaptation measures: climate-resilient infrastructure, disaster risk reduction, etc. Sustainable Tourism and Conser-

vation: Impacts of tourism on the environment and local communities, Principles of sustainable tourism and ecotourism, Conservation initiatives and protected area management

Module IV : Indicators of Sustainable Development and Sustainability Assessment

Indicators of Sustainable Development: Pressure indicators, State indicators, Response indicators, Impact indicators, Efficiency indicators, Sustainable indicators, Environmental performance indicators. Uses of Indicators. Characteristics of a good indicator - SMART - Specific, Measurable, Achievable, Realistic and Time-Bound. Sustainability Assessment: Introduction and need. Tools of sustainability assessment - Environmental Management Systems; Environmental Auditing; Cleaner Production Assessment; Environmental Impact Assessment; Strategic Environmental Assessment; Design for Sustainability and Stakeholder Engagement. Life cycle assessment.

Module V : Sustainable Development in Practice

Case studies of sustainable development projects in various sectors (e.g., agriculture, energy, urban planning). Sustainable Cities (Urbanisation and its impact of growth on Water, Energy, Non-motorised and motorised transport, Waste generation). Building Resilience in Cities; Planning for Sustainable Cities. Significance of green spaces. Comprehensive Sustainable Development Plan (CSDP). Case studies. Sustainable Buildings and Infrastructure Rating Systems: Indian Green Building Council (IGBC), Green Rating for Integrated Habitat Assessment (GRIHA), Leadership in Energy and Environmental Design (LEED), Excellence in Design for Greater Efficiencies (EDGE); Sustainable Energy/Energy Sustainability (BEE) and Urban Agriculture. Principles of Sustainable Lifestyle.

References

1. "Sustainable Development: Principles, Frameworks, and Applications" by Simon Dresner (Routledge)
2. "Introduction to Sustainability" by Robert Brinkmann and Sandra Garren (Wiley)
3. Theis, Tom, and Jonathan Tomkin. "Sustainability: A comprehensive foundation." (2015).
4. Ukaga, Okechukwu, Chris Maser, and Michael Reichenbach, eds. Sustainable development: Principles, frameworks, and case studies. CRC Press, 2010.
5. Shiroyama, Hideaki, and Takashi Mino. Sustainability science: A multidisciplinary approach. New York: United Nations University Press, 2011.
6. Blackburn, William R. The sustainability handbook: The complete management guide to achieving social, economic and environmental responsibility. Routledge, 2012.
7. Shove, Elizabeth, and Nicola Spurling. "Sustainable practices: Social theory and climate change." In Sustainable Practices, pp. 1-13. Routledge, 2013.
8. Shiva, Vandana. Making peace with the earth. London: Pluto Press, 2013.

24-360-0319 GREEN DESIGN & MANAGEMENT OF PROJECT AREAS

(Credits : 3)

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

CO → PO, PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	3	1			2	1	3		1
CO2		3	2			3	2	2	1	
CO3		3					3	1		
CO4		2		3						2
CO5							2			3

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

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.
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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.

24-360-0320 ADVANCED APPLIED BIOLOGY LAB: INTEGRATED APPROACHES TO BIODIVERSITY, CARBON CAPTURE, AND WASTEWATER CONTAMINANT TOXICITY ASSESSMENT

(**Credits : 2**)

Course Description:

This advanced applied biology lab covers techniques for assessing biodiversity, carbon capture, and toxicity. Students will learn methods for macroinvertebrate biomonitoring, plant community surveys, and cyanobacterial CO2 biofixation. Algal, zebrafish, and cellular assays will evaluate contaminant impacts on aquatic life and human health. The course emphasizes interdisciplinary approaches, critical thinking, and real-world applications to address environmental challenges.

Course Objective:

The objective of this course is to equip students and train them in macroinvertebrate-based biomonitoring to assess water quality, conduct plant biodiversity surveys, optimize cyanobacterial CO2 biofixation, and perform ecotoxicity assays to evaluate the impacts of environmental contaminants of wastewater on aquatic ecosystems and human health, developing interdisciplinary skills to address pressing environmental challenges.

Course Outcomes:

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

CO1	Demonstrate comprehension of principles and applications of macroinvertebrate biomonitoring, plant biodiversity assessment, cyanobacterial carbon capture, and wastewater contaminant ecotoxicology.	Understand
CO2	Interpret patterns of plant community diversity, environmental influences, and ecotoxicological effects of wastewater contaminants using analytical techniques.	Analyse
CO3	Utilize standardized protocols for macroinvertebrate-based biomonitoring and cyanobacterial cultivation for CO2 biofixation and biochar production.	Apply
CO4	Develop integrative strategies that combine biodiversity, carbon capture, and contaminant toxicity assessment techniques to design innovative solutions for environmental sustainability.	Evaluate

CO → PO, PSO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	3	2	1			1	2	3		1
CO2	2	1		2			3	2		1
CO3		2				2	3	1		
CO4	2	3	3			3	1	3	2	2

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

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

1. **Biotic Indices for Stream/estuary/Marine Biomonitoring:** Collect macroinvertebrate samples from stream/estuary/marine habitats. Identify and enumerate the macroinvertebrate taxa present. Calculate biotic indices (e.g., EPT index, BMWP score). Interpret the biotic index values to assess water quality and ecosystem health

2. **Plant Biodiversity Surveys and Analysis:** Conduct quadrat-based surveys to assess plant species richness and abundance. Measure community diversity indices (e.g., Shannon-Weiner, Simpson's). Analyze the spatial patterns and ecological relationships of plant communities. Study the effects of environmental factors on plant biodiversity

3. **Biofixation of CO2 by Cyanobacteria:** Use selected cyanobacterial strains for efficient CO2 biofixation. Cultivate cyanobacteria in laboratory with controlled CO2 supply. Quantify CO2 uptake rates and biomass production. Harvest and process the cyanobacterial biomass for biochar and value-added products.

4. **Algal Growth Inhibition Assay:** Expose freshwater algae (e.g., Chlorella, Scenedesmus) to various contaminants from wastewater. Measure algal growth inhibition as a function of contaminant concentration. Determine EC50 (effective concentration causing 50% inhibition) values. Assess the chlorophyll content to identify toxicity of the contaminants to primary producers in aquatic ecosystems.

5. **Zebrafish Embryo Toxicity Test:** Expose zebrafish embryos to different concentrations of contaminants from wastewater. Monitor the development and survival of the embryos over time. Observe and record any morphological abnormalities or lethal effects. Calculate the LC50 (lethal concentration causing 50% mortality) values.

6. **Oxidative Stress and Genotoxicity Assays using Cell Cultures:** Expose cell lines (e.g., human, fish, or algal cells) to contaminants like CO2 or wastewater. Measure indicators of oxidative stress (e.g., ROS levels, antioxidant enzyme activity). Evaluate the cytotoxicity and potential health implications of the contaminants.

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.
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9. Wilhelm Kuckshinrichs, Jürgen-Friedrich Hake. (2015). Carbon Capture, Storage and Use Technical, Economic, Environmental and Societal Perspectives
10. Eduardo Jacob-Lopes, Leila Queiroz Zepka, Maria Isabel Queiroz. Cyanobacteria: An Economic Perspective. Chapter 4-Cyanobacteria and carbon sequestration. Book Editor(s):Naveen K. Sharma, Ashwani K. Rai, Lucas J. Stal
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SEMESTER IV

24-360-0401 FINAL SEMESTER PROJECT WORK

Couse Code	Course Title	C/E	Credit	Marks
24-360-0401	Final Semester Project Work	C	14	
	Interim Report ii			50
	Presentation [Internal]			100
	Project Dissertation [External]			150

24-360-0402 VIVA VOCE (Internal)

Couse Code	Course Title	C/E	Credit	Marks
24-360-0402	Viva Voce [Internal]	C	2	50

Skill Development Programme in Environmental Science & Technology - AREAS

1. Waste management technologies
2. Water, wastewater and air quality assessment and monitoring
3. Environment Impact assessment
4. Environmental Biotechnology
5. Environmental Toxicology
6. Biodiversity Conservation
7. Geographical Information System
8. Carbon sequestration technologies
9. Bio-resource management
10. Instrumentation in environmental management

Note : –

1. **INTERNSHIP/ SKILL DEVELOPMENT PROGRAME** for two months during summer vacation in industries/ institutions after SEMESTER II Examination, before the start of SEMESTER III.
2. Candidates must submit interim report of the project at mid-term which will be evaluated as part of the internal assessment as **PROJECT- INTERIM REPORT.**

INTERDEPARTMENTAL ELECTIVES

24-360-0112 INTRODUCTION TO ENVIRONMENTAL STUDIES

(Credits : 3)

Course Description:

Environmental science is the field of science that studies the interactions of the physical, chemical, and biological components of the environment and also the relationships and effects of these components with the organisms in the environment. The field of environmental science can be divided into three main goals, which are to learn how the natural world works, to understand how we as humans interact with the environment, and also to determine how we affect the environment. The third goal of determining how humans affect the environment also includes finding ways to deal with these effects on the environment.

Course Objectives:

The Inter-Departmental Elective in Environmental Studies aims to train students to cater to the need for ecological citizenship through developing a strong foundation on the critical linkages between ecology-society-economy. Students will evolve into ecologically informed and socially responsible citizens who are empowered to protect the natural resources while ensuring sustainable lifestyle and developmental model.

Course Outcomes:

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

CO1	Understand the term —Environmental Studies‖ its multidisciplinary nature, scope and importance	Understand
CO2	Describe the structure and function of ecosystem; biogeochemical cycles and processes; Ecosystem services and its restoration	Understand
CO3	Develop critical thinking for shaping strategies (scientific, social, economic and legal) for environmental protection and conservation of biodiversity, social equity and sustainable development	Analyse
CO4	Acquire values and attitudes towards understanding complex environmental-economic social challenges, and participating actively in solving current environmental problems and preventing the future ones.	Apply
CO5	Adopt sustainability as a practice in life, society and industry	Apply

Assessment Pattern:

Category	Assessment Methods			Examination
	Test 1	Test 2	Test 3	
Understand	40	40	40	40
Apply	30	30	30	30
Analyze	30	30	30	30

SYLLABUS

Module I : Introduction to Environmental Studies

Multidisciplinary nature of environmental studies; Scope and importance; Concept of sustainability and sustainable development, Concepts of Environmental education and awareness Internationals environmental initiatives.

Module II : Ecosystem

Definition and concept of Ecosystem: Structure of ecosystem (biotic and abiotic components); Functions of Ecosystem – Physical (energy flow), Biological (food chains, food web, ecological succession) and Biogeochemical (nutrient cycling) processes. Concepts of productivity, ecological pyramids and homeostasis; Types of Ecosystem – Tundra, Forest, Grassland, Desert, Aquatic (ponds, streams, lakes, rivers, oceans, estuaries) – their importance and threats on them with relevant examples from India Ecosystem services- Basics of Ecosystem restoration,

Module III : Environmental Issues and Governance in India

Climate change, Global warming, Ozone layer depletion, Acid rain and impacts on human communities and agriculture International agreements: Earth Summit, UNFCCC, Montreal and Kyoto protocols and Convention on Biological Diversity (CBD) 4. Environmental Issues in India ; Environmental pollution (Air, water, soil, thermal and noise): causes, effects and controls; Air and water quality standards, water conservation for commercial and industrial facilities, Nuclear hazards and human health risks and case studies; Solid waste management: Control measures of urban and industrial waste Pollution case studies: Ganga Action plan (GAP), Delhi air pollution and public health issues etc, Environmental governance in India-Issues and Challenges- Environment legislation in India.

Module IV : Human Communities and the Environment

Human population growth: Impacts on environment, human health and welfare Resettlement and rehabilitation of project affected persons; case studies Disaster management: floods, earthquake, cyclones and landslides Environmental movements: Chipko movement, Silent valley movement, Bishnois of Rajasthan, Narmada Bachao Andolan etc Environment justice: National Green Tribunal and its importance Environmental ethics: Role of Indian and other religions and culturesin environmental conservation Environmental communication and public awareness, case studies (e.g., CNG vehicles in Delhi, Swachh Bharat Abhiyan)

Module V : Sustainable Development & Green technology

Definition and concepts of Sustainable development, Integration of: a. Economic, Social and Environmental sustainability, b. Biodiversity and c. Availability of natural resources in development. Critical review of drawbacks in traditional (based on economics) evaluation development, Cost benefit analysis, Sustainable Development Goals and India‘s National Action Plan

on Climate Change urban planning for India, Land use policy for India- Basic principles of green technology, concepts of carbon trading, tools of green technology.

Books

1. Environmental Pollution & Control – 2016 by Prof. N.H. Gopal Dutt
2. Earth as a living planet – 2010 by author Daniel B. Botkin and Edward A. Keller published by John Wiley & Sons (Asia) Private Ltd.
3. Environmental Science -2006 by Y K Singh
4. Industrial Waste management : Contemporary Practice and Vision for Future -2006 by Nelson Leonard Nemerow
5. Fundamentals of Air pollution -2014 by Daniel A. Vallero
6. A practical approach to water conservation for commercial and industrial facilities- 2007 by mohan seneviratne
7. Environmental governance in india- 2018 by Prakash Chand Kandpal
8. Understanding and solving environmental problems in the 21st century – 2002 by R.Costanza
9. Environmental issues in india ; a reader – 2006 by Rangarajan
10. Basic ecology - E. P. Odum
11. Ecology and field biology - R.L. Smith
12. Ecology - P.D. Sharma
13. Fundamentals of ecology -E.P. Odum
14. Principles of ecology – Rickleff
15. Natural Resource Conservation Owen and Chiras.
16. Environmental planning, policies and programs in India - K.D. Saxena.
17. Conservation Ecology- G.W.Cox.18) Restoration of degraded lands- J.S. Singh
18. Natural resources conservation -Oliver Ss. Owen.
19. Living of environment - T.J. Miller
20. Introduction to Green Chemistry- 2001 by Matlack, A. S.
21. Green Chemistry: Theory and Practice- 1998 by Anastas, P. T.; Warner, J. C..
22. Environmental law in India- 2016 by Leelakrishnan, P. LexisNexis.
23. India's Environmental Policies, Programmes and Stewardshi- 2016 by . Dwivedi, O. P.
24. Environmental Law from the Policy Perspective: understanding how legal frameworks influence environmental problem solving. Routledge.- 2014 by McGuire, C. J.
25. Environmental and Pollution Science, 3rd Edition- 2019 by Brusseau, M, Pepper, I, Gerba, Charles.
26. Understanding Sustainable Development – 2008 by John Blewitt.
27. Sustainable Development in Digital Era- 2019 by Dr. Aparna Mishra, Dr. Vikas Dahiya, Dr. Kamini Tandon, JSR Publishing House LLP.
28. Climate Change and Environmental Issues- 2016 by Singh N. and Thakur A. K., The Energy Resources Institute (TERI).
29. Green Technologies: For a Better Future. Mc-Graw Hill Publications.
30. Environmental Sustainability: Role of Green Technologies.- 2015 by Thangavel, P. & Sridevi, G.
31. Green Technology Choices: The Environmental and Resource Implications of LowCarbon Technologies International Resource Panel Report

References

1. Principles of Environmental Engineering and Science – 2004, By Mackenzie L. Davis and Susan J. Masten, Published by McGraw – Hill Higher Education.
2. Principles of Environmental Science and Technology – 1981 by S.E Jorgensen and I. Johnsen, Published by Elsevier Scientific Publishing Company.
3. Environmental law- 2017, by Bell, S., McGillivray, D., Pedersen, O., Lees, E., & Stokes, E.4) Environmental Compliance Handbook- 2016, by Jacob I. Bregman, Robert D. Edell.
4. Environmental law, policy, and economics: Reclaiming the environmental agenda. Mit Press- 2008 by Ashford, Nicholas Askounes, and Charles C. Caldart.
5. Environmental Laws: Summaries of Major Statutes Administered by the Environmental Protection Agency (EPA)- 2008 by Fletcher, S. R.
6. Climate Change and Biodiversity- 2006,By Thomas E. Lovejoy, Lee Jay Hannah Published by Yale University Press.

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

1. https://www.who.int/ceh/capacity/Outdoor_air_pollution.pdf
2. https://ocw.mit.edu/courses/chemical-engineering/10-571j-atmospheric-physics-andchemistry-spring-2006/
3. https://www.unenvironment.org/beatpollution/forms-pollution

24-360-0216 NATURAL RESOURCE MANAGEMENT

(Credits : 3)

Course Description:

Courses and specializations focus on environmental topics like land-use planning, conservation biology, energy use, climate change, renewable resource management, forest and wildlife management, or natural resource policy. Through this introductory course, students explore the modes employed to preserve the biological integrity of various ecosystems. They examine methods for encouraging a healthy genetic line, preserving natural habitats and making sure food sources are available. Students examine how new species affect and can destroy an area.

Course Objectives:

Course aims to give an outlook about natural resources and their management to the students. It includes management of various resources including human, soil, coastal zone, fisheries, forests and energy.

Course Outcomes:

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

CO1	Explain nature, usage, preservation and management of natural resources	Remember, understand, analyze
CO2	Discuss the conservation and management of soil, wetland, fisheries and coastal zone	Remember, understand analyze
CO3	Explain the conservation and management of forests	Remember, understand
CO4	Describe the conservation and management techniques of energy resources	Remember, understand

Assessment Pattern:

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

SYLLABUS

Module I : Concepts in ressource management

Nature of resources, an ecological outlook, human population, resource use, conservation, preservation, multiple use, national attitude. Classification of natural resources- renewable, non renewable resources. Approaches to natural resource management- exploitation, preservation, utilarian approach, ecological or sustainable approach.

Module II : Land and water resources

Soil conservation- soil erosion, controlling erosion on farm, non-farm erosion control, Wetland preservation and management, land use inventory and planning. Coastal zone management -Water use planning-dams, lakes and ponds, waterway use, desalinisation, use and reuse of water, water run off control from urban areas, rain water harvesting.. Trends in capture fisheries and aquaculture, Management options in fisheries.

Module III : Forest and Management

Forest – definition and types, Measuring the forest, intermediate cuttings, harvest cuttings, reproducing the forest; Management of grazing, invasives, fire and wild life. Forest as a life sustaining system, Forest produces, Man and forest.

Module IV : Energy Resources

Energy Conservation and Management - Green buildings, Energy conservation, urban planning & transportation. Renewable and non-renewable energy sources.

References

1. Campbell and Sayer. (2003), Integrated natural Resource Management. CABI Publishing.
2. Chiras DD and Reganold J. P. (2011), Natural Resource Conservation: Management for a sustainable future, 10/E Prentice Hall
3. Agras G. I. and Anderson F. O. (2011), Terrestrial Ecosystem Ecology . Cambridge University Press
4. Kaswamila A.(2012), Sustainable Natural Resources Management. In Tech Publ.
5. Menon A et al. (2007), Community based Natural Resource Management. Sage India.

24-360-0217 INTELECTUAL PROPERTY RIGHT, BIOSAFETY AND BIOETHICS

(Credits : 3)

Course Description:

The course provides a broad coverage of three areas of patenting—intellectual property rights (IPR), biosafety and bioethics. It creates awareness about the value of IPR in our lives and fosters a better understanding of the rights associated with IPR such as copyright, patent, trademarks, industrial designs, and geographical indications and so on. Biosafety and bioethical issues prevalent in modern society are discussed.

Course Objectives:

To introduce basic concepts of ethics and safety that are essential for different disciplines of science and procedures involved and protection of intellectual property and related rights. To understand balanced integration of scientific and social knowledge in sustainable development.

Course Outcomes:

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

CO1	Introduction to Patents, Trademarks, Copyright & Related Rights, Industrial Design, Traditional knowledge, Geographical Indications, Protection of New GMOs; International framework for the protection of IP, IP as a factor in R&D	Remember
CO2	Understand the basics of Patent, its important, the various stages in patent filing; National and International patent rules and procedures. Recognize importance of protection of new knowledge and innovations and its role in business	Understand
CO3	Recognize importance of biosafety practices and guidelines in research and comprehend benefits of GM technology and related issues	Understand
CO4	Interpret basics of biosafety and bioethics and its impact on all the biological sciences and the quality of human life	Understand

SYLLABUS

Module I : Introduction to Intellectual Property

Types of IP: Patents, Trademarks, Copyright & Related Rights, Industrial Design, Traditional Knowledge, Geographical Indications, Protection of New GMOs; International framework for the protection of IP IP as a factor in R&D; IPs of relevance to Biotechnology and few Case Studies; Introduction to History of GATT, WTO, WIPO and TRIPS. Concept of 'prior art'- Invention in context of —prior art‖; Patent databases; Searching International Databases; Country-wisepatent searches (USPTO, EPO, India etc.); Analysis and report formation

Module II : Basics of Patents

Types of patents; Indian Patent Act 1970; Recent Amendments; Filing of a patent application; Precautions before patenting-disclosure/non-disclosure; WIPO Treaties; Budapest Treaty; PCT and Implications; Role of a Country Patent Office; Procedure for filing a PCT application. Patent filing and Infringement- Patent application- forms and guidelines, fee structure, time frames; Types of patent applications: provisional and complete specifications; PCT and convention patent applications; International patenting-requirement, procedures and costs; Financial assistance for patenting- introduction to existing schemes; Publication of patents-gazette of India, status in Europe and US. Patenting by research students, lecturers and scientists-University/organizational rules in India and abroad, credit sharing by workers, financial incentives Patent infringement- meaning, scope, litigation, case studies and examples

Module III : Biosafety

Introduction; Historical Backround; Introduction to Biological Safety Cabinets; Primary Containment for Biohazards; Biosafety Levels; Biosafety Levels of Specific Microorganisms; Recommended Biosafety Levels for Infectious Agents and Infected Animals; Biosafety guidelines - Government of India; Definition of GMOs& LMOs; Roles of Institutional Biosafety Committee, RCGM, GEAC etc. for GMO applications in food and agriculture; Environmental release of GMOs; Risk Analysis; Risk Assessment; Risk management and communication; Overview of National Regulations and relevant International Agreements including Cartagena Protocol.

Module IV : Bioethics

Introduction and need of bioethics, its relation with other branches, types of risk associated with genetically modified microorganisms, Ethical Issues involving GMOs; ethics related to human cloning, human genome project, prenatal diagnosis, agriculture and animal rights, data privacy of citizens health; ethical issues in India and abroad through case studies; Socio-economic impact of biotechnology.

References

1. Sateesh, M.K., Bioethics and Biosafety, IK International Publishers (2008)
2. Singh I. and Kaur, B., Patent law and Entrepreneurship, Kalyani Publishers (2006).
3. Srinivasan, K. and Awasthi, H.K., Law of Patents, Jain Book Agency (1997)
4. Narayan, P., Patent Law, Eastern Law House (1975).
5. Jonathan, Y.R., Anthology of Biosafety (Vols. 1-4), American Biological Safety Association (2005).
6. Encyclopedia of Ethical, Legal and Policy issues in Biotechnology, John Wiley & Sons Inc. (2005).

Important Links

1. http://www.w3.org/IPR/
2. http://www.wipo.int/portal/index.html.en
3. http://www.ipr.co.uk/IP_conventions/patent_cooperation_treaty.html
4. www.patentoffice.nic.in

5. www.iprlawindia.org/-31k-Cached -Similar page
6. http://www.cbd.int/biosafety/background.shtml
7. http://www.cdc.gov/OD/ohs/symp5/jyrtext.htm
8. http://web.princeton.edu/sites/ehs/biosafety/biosafetypage/section3.html

24-360-0219 BIO-NANOTECHNOLOGY

(**Credits : 3**)

Course Description:

Bionanotechnology is the study of biology, in particular biological machines, and the application of biological building blocks to solve engineering challenges and create new areas of technological development. Learning about the structure and function of the inner workings of biological systems such as cells, bacteria and viruses has been used to improve existing applications of nanotechnology and to develop entirely new applications. Examples of bionanotechnological study include: mechanical properties of materials, such as cell interaction with surfaces, nanopatterns and nanoparticles, electrical and optical effects, such as electrical stimulation, energy storage, absorption, luminescence and fluorescence; and computing via chemical wet computers and DNA computing.

Course Objectives:

This module provides an introduction to the theory and practice of bionanotechnology, and the challenges of commercializing new technologies. It covers the types of macromolecules which form the building blocks of life, covering cell components such as DNA and proteins, describing how they are synthesized, interact and the role they play in cells. The structure and forms of the different molecules and the process by which they are constructed and how they exchange information will be framed within the context of the operation of machines and the potential engineering uses that the naturally occurring mechanisms can be put to.

Course Outcomes:

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

CO1	Understand the knowledge of the principles and concepts associated with bionanotechnology.	Understand
CO2	Know the basics of biomolecules and biomolecular interactions.	Understand
CO3	Understand relationship between molecular mynamics, nanoscale physics and macroscopic system behavior.	Understnd
CO4	Explain biophysical mechanisms in the context of bionanotechnology application areas.	Apply
CO5	Analyse and discuss the engineering requirements of multidisciplinary technology based on biology	Analyse

SYLLABUS

Module I : The Quest for Nanotechnology

Introduction; Biotechnology and the Two-Week Revolution; From Biotechnology to Bio- nanotechnology; What is Bio-nanotechnology ?. Bio-nanomachines in Action: The Unfamiliar

world of Bio-nanomachines; Modern Biomaterials; The legacy of Evolution; Guided Tour of National Bio- nanotechnology.

Module II : Biomolecular Design and Biotechnology

Recombinant DNA Technology; Biomolecular Structure Determination - X-ray crystallography, NMR spectroscopy, Electron microscopy, Atomic force microscopy; Molecular Modeling - computer- assisted molecular design.

Module III : Structural Principle of Bio-nanotechnology

Design of Natural Bio-nanomachinery; Construction of Nanomachines; The raw materials; Protein folding; self-assembly; self-organization; Molecular recognition; Flexibility.

Module IV : Functional Principles of Bio-nanotechnology

Information - Driven nanoassembly; Energetics; Chemical Transformation; Regulation; Biomaterials, Biomolecular Motors; Traffic Across membranes; Biomolecular sensing; self-replication; Machine - Phase Bio-nanotechnology.

Module V : Bio-nanotechnology Today

Basic capabilities; Nanomedicine Today; Self-Assembly at Many scales; Harnessing Molecular Motors; DNA computers; Molecular Design using Biological selection; Artificial life; Hybrid Materials, Biosensors. The Future of Bio-nanotechnology: Ethical Considerations; Respect for life; potential dangers; Final Thoughts.

References

1. David S. Goodsell (2004), Bionanotechnology: Lessons from Nature. by Wiley-Liss, Inc. ISBN: 0-471-41719-X
2. Elisabeth S, Aravind Parthasarathy (2007), Bionanotechnology, Morgan and Claypool Publishers, ISBN: 1598291386.
3. David E. Reiser (2009), Bionanotechnology- Global Prospects, CRC Press, Taylor & Francis group, Boca Raton. ISBN: 978-0-8493-7528-6.
4. Maheshwar Sharon, Madhuri Sharon (2012), Bionanotechnology, CRC PressINC, ISBN: 1439852146, 9781439852149.
5. Kirthi Rani (2012), Nanotechnology Vs Bionanotechnology: Fundamental Concept of Nanotechnology Vs Bionanotechnology and Their Environmental Implications, Lambert Academic Publishing, ISBN: 3848426218, 9783848426218.
6. Vencatesan Renugopalakrishnan, Randolph V. Lewis, (2006), Bionanotechnology: Proteins to Nanodevices, Springer, ISBN: 1402043759, 9781402043758.
7. Lynn Goldman and Christine Coussens, Implications of nanotechnology for environmental health research Editors. THE NATIONAL ACADEMIES PRESS www.nap.edu.
8. Nanophotonics: Accessibility and Applicability This free PDF can be downloaded from: http://www.nap.edu/catalog/11907.html
9. K. Eric Drexler - The Coming Era of Nanotechnology. This free PDF can be downloaded from: http://www.foresight.org/EOC/index.html
10. Richard P. Feynman, Transcript of speech: "There's plenty of room at the bottom" (1959) http://www.zyvex.com/nanotech/feynman.html

24-360-0321 ENERGY RESOURCES AND MANAGEMENT

(**Credits : 3**)

Course Description:

Energy is required for all life processes. Human energy consumption has grown steadily throughout human history. In the pre-industrial time, humans had modest energy requirements, mainly for food and fuel for fires to cook and keep warm. However, the energy requirement has grown tremendously in modern times. Energy resources refer to all forms of fuels which find applications in the development of the modern world. Heating, generation of electrical energy and energy conversion processes of all sorts, are the main function of fuels.

The primary energy sources include fossil energy (oil, coal and natural gas), nuclear energy, and renewable energy (wind, solar, geothermal and hydropower). The secondary energy source is from the conversion of primary sources such as electricity which flows through power lines and other transmission infrastructures. Fossil fuels have disadvantages as they are non-renewable and they cause several harmful effects on the environment. The need of exploiting renewable energy has become the top most priority in the modern world. At the same time a proper management strategy also needs to be worked out. The content of the syllabus —Energy Resource Management‖ 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 energy, its various ways of production, its uses and finally its management. The students will learn about energy production and utilization along with associated environmental management, regulatory and policy issues.

Course Objectives:

To impart a complete understanding of the basic characteristics of renewable sources of energy and related technologies. To identify new methods and technologies for effective utilisation of renewable energy resources. To deduce a complete protocol for the management of energy

Course Outcomes:

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

CO1	Discuss the relationship between energy usage and human development index, effect of energy services on productivity, health, education, safe water and communication	Understand
CO2	Describe the non renewable energy resources, its distribution, usage and environmental impacts	Understand
CO3	Provide with a solid foundation for developing the use of renewable energy systems	Understand
CO4	Analyse and interpret information related to renewable energy	Analyse
CO5	Ability to analyse the viability of energy conservation projects	Analyse

SYLLABUS

Module I : Introduction

Energy and Human development index, Sources of Energy, Renewable and non-renewable energy, Energy requirements and consumption pattern in the context of global, national and regional.

Module II : Non-renewable Energy Resources

Classification of Fossil fuels: Coal, Oil, Oil shale, Tar sands, Natural gas, Non-fossil fuels: Nuclear power, Ecological and social impacts of major thermal and nuclear power plants, Management of energy projects and its environmental impacts.

Module III : Renewable Energy Resources- and alternate fuels

Solar Energy: Technique for harvesting solar energy, direct utilization of solar energy by thermal conversion thermo-mechanical conversion, Photo-voltaic cells, indirect utilization through water power- Ocean Thermal Energy Conversion (OTEC), , Wind resources, Geothermal sources, Tidal energy and Ocean waves, biogas- recent advancements and upgradation technologies, fuel cell- storage and recent developments

Module IV : Energy conservation policies and acts

India‘s Energy and Climate Concerns: Schemes to promote energy conservation and energy efficiency - Standards and Labeling, Energy Conservation Building Codes (ECBC), National Mission for Enhanced Energy Efficiency (NMEEE).

Module V : Energy Management and Auditing - Demand Side Management (DSM) Scheme

Economic analysis in the Energy Management and Audit Programme, Energy audit; Phases in energy auditing; Energy bills; Energy rate schedules; Energy accounting; Energy audit report format; Case studies ; Green buildings

References

1. Energy for Sustainable World, Goldemberg, J., Johnansson, T.B., Reddy, A.K.N. and Williams,
2. R.H. Wiely Eastern Ltd, 1988.
3. The future Energy use , Hill, R., O‘Keef, P., and Snape, C. Earthscan publication Ltd. London, 1996
4. Environmental Chemistry ,Colin Baird,. W.H.Freeman and Company, 1999
5. Looking back to think ahead: Green India 2047. Tata Energy Research Institute (TERI), 1998
6. Energy Conservation Guidebook, Dale R Patrick, Stephen W Fardo, 2ndEdition, CRC Press, 2014
7. Handbook of Energy Audits, Albert Thumann, 9thEdition, CRC Press, 2012
8. Energy Management Handbook,W.C. Turner, 6thEdition, CRC Press, 2006
9. Guide to Energy Management, Capehart B.L., Turner W.C., Kennedy W.J. 7thEdition, Fairmont Press,2011
10. Energy Conservation Guidebook , Patrick D.R., Fardo S.W., Richardson R.E., Fardo B.W., 3rd Edition, Fairmont Press, 2014

24-360-0322 INDUSTRIAL ECOLOGY

(**Credits : 3**)

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 (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 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 (e.g., Industry 4.0, blockchain)

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. 4. Williams R.B. Greening the Economy, 2013. Taylor & Francis Ltd. ISBN: 9780415745505