Minor Specialization

Environmental Monitoring and Wastewater Treatment

Course Structure

Course	Name	Course Code	Credits
Course 1	Fundamentals of Environmental Chemistry	CHM 101	4
Course 2	Instrumental Techniques for Environmental Monitoring.	CHM 102	4
Course 3	Water and Wastewater Treatment Technologies	CHM 103	4
Project I	Project I	CHM 104	3
Project II	Project II	CHM 105	3
	Total Credits		**18**

Course 1 – Fundamentals of Environmental Chemistry

Course Name	**:**	**Fundamentals of Environmental Chemistry**
Course Code	**:**	**CHM 101**
Credits	**:**	**4**
L T P	**:**	**3 0 2**

Course Objectives :

Students should be able -

- To understand the chemical processes and reactions occurring in the environment.
- To learn about the sources, fate, and effects of pollutants in air, water, and soil.
- To analyse the principles of chemical equilibrium and kinetics in environmental contexts.
- To evaluate the impact of human activities on environmental chemistry.
- To develop skills for the chemical analysis of environmental samples.

Total No. of Lectures – 42

Lecture wise breakup		No. of Lectures
Unit 1	**Introduction to Environmental Chemistry** Definition and scope of environmental chemistry. The Earth's environmental compartments: atmosphere, hydrosphere, lithosphere, and biosphere. Basic concepts in chemistry relevant to the environment.	**7**
Unit 2	**Atmospheric Chemistry and Aquatic Chemistry** Composition of the atmosphere. Chemical reactions in the atmosphere. Air pollutants: sources, types, and effects. Stratospheric ozone depletion and tropospheric ozone formation. Greenhouse gases and global warming. Properties of water and its role in the environment. Chemical composition of natural waters. Acid-base equilibria in aquatic systems. Redox reactions in water. Water pollutants: sources, types, and effects.	**10**

Unit 3	**Soil Chemistry and Environmental Toxicology** Composition and properties of soils. Soil minerals and organic matter. Chemical processes in soils. Soil pollutants: sources, types, and effects. Remediation of contaminated soils. Principles of toxicology. Types of environmental toxins. Mechanisms of toxicity. Bioaccumulation and biomagnification. Risk assessment and management.	**9**
Unit 4	**Chemical Kinetics and Equilibrium in the Environment** Reaction kinetics and rate laws. Factors affecting reaction rates. Chemical equilibrium and Le Chatelier's principle. Applications of kinetics and equilibrium to environmental systems.	**8**
Unit 5	**Case Studies and Emerging Issues in Environmental Chemistry** Case studies of major environmental pollution incidents. Emerging pollutants (microplastics, pharmaceuticals, etc.). Sustainable chemistry and green chemistry principles. Future directions in environmental chemistry research.	**8**

Course Outcomes: On successful completion of the course, students will be able to	
1	Explain the fundamental chemical principles that govern environmental processes.
2	Identify and characterize the major pollutants in air, water, and soil.
3	Analyze the chemical behavior and transformations of pollutants.
4	Assess the environmental impact of chemical pollutants and propose remediation strategies.

List of Experiments

1. To determine the pH, electrical conductivity, and total dissolved solids in various water samples and soil leachates to assess chemical characteristics.
2. To quantify nitrate and phosphate concentrations in water and soil samples using UV-Vis spectrophotometer for pollution assessment.
3. To determine the COD of water samples as an indicator of organic pollution using the colorimetric method.
4. To measure the BOD of water samples to evaluate the level of biodegradable organic matter.
5. To determine the total hardness of water samples using complexometric titration with EDTA.
6. To estimate the concentration of chloride and sulfate ions in water samples using titrimetric and gravimetric methods respectively.
7. To analyze the concentration of Fe and Mn ions in water and soil samples using UV-Vis spectrophotometry.
8. To detect and quantify lead and cadmium in water and soil extracts using electrochemical workstation.
9. To determine the dissolved oxygen content in water samples using the classical Winkler’s method.
10. To assess the leachability of nitrate and sulfate from soil using leaching tests and subsequent spectrophotometric analysis.

Text Book:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	**"Environmental Chemistry"** by Stanley E. Manahan	2022
2	**"Environmental Organic Chemistry"** by René P. Schwarzenbach, Philip M. Gschwend, Dieter M. Imboden	2002
3	**"Principles of Environmental Chemistry"** by James E. Girard	2013
Reference Books: (at least 3)		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	**"Introduction to Environmental Chemistry"** by Julian E. Andrews, Peter Brimblecombe, Tim D. Jickells, Peter S. Liss, Brian Reid	2004
2	**"Environmental Toxicology: Biological and Health Effects of Pollutants"** by Ming-Ho Yu.	2011
3	**"Chemistry of the Environment"** by Thomas G. Spiro, William M. Stigliani	2002

Equivalent MOOCs courses

Sr. No.	**Course Links**	**Offered by**
1	Environmental Chemistry https://onlinecourses.nptel.ac.in/noc20_ce57/preview	NPTEL

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	**3**	**2**	**-**	**-**	**-**	**2**	**3**	**2**	**-**	**-**	**-**	**2**	**-**	**-**	**-**
CO2	**1**	**3**	**2**	**2**	**1**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
CO3	**-**	**2**	**3**	**3**	**3**	**-**	**-**	**-**	**2**	**-**	**2**	**-**	**-**	**-**	**-**
CO4	**-**	**-**	**3**	**-**	**3**	**3**	**-**	**-**	**2**	**-**	**2**	**-**	**-**	**-**	**-**
CO5	**-**	**3**	**-**	**1**	**3**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**		**--**

Paper 2: Instrumental Techniques for Environmental Monitoring

Course Name	**:**	**Instrumental Techniques for Environmental Monitoring**
Course Code	**:**	**CHM 102**
Credits	**:**	**4**
L T P	**:**	**3 0 2**

Course Objectives :

Students should be able -

- To analyze the interaction of matter with electromagnetic radiations and its applications in various fields of engineering.
- To understand fundamental knowledge of the principles and instrumentation of spectroscopic and chromatographic techniques.
- To apply in-depth theoretical and practical insights into commonly occurring modern electroanalytical techniques.
- To develop the students' ability to independently select and optimize appropriate instrumental techniques for various applications.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**X-ray Diffraction and Scattering Techniques and Microscopic techniques** X ray diffraction: principle, mechanism and applications, Amorphous vs. crystalline materials, Small Angle X-ray Scattering: Principle, Basics, Modelling techniques and Applications in Material Science and Engineering. Time-of-Flight Secondary Ion Mass Spectrometry (ToF-SIMS), Atomic Force Microscopy (AFM): Principle instrumentation and applications, Image formation and contrast generation (mass-thickness contrast, atomic number contrast, diffraction contrast etc.).	**7**
Unit 2	**Spectroscopic techniques** Raman spectroscopy, UV-Vis photoelectron spectroscopy (UPS), Auger electron spectroscopy (AES), X-ray Photoelectron Spectroscopy (XPS), Circular Dichroism, Laser ablation–ICP-optical emission/mass spectroscopy (LA–ICP-OES/MS).	**9**
Unit 3	**Electroanalytical techniques** Potentiometric Methods (Reference electrodes, Indicator electrodes, Measurement of cell potentials, Applications), Polarography Voltammetry (Linear-scan voltammetry, Pulse methods, Strip methods, Cyclic voltammetry), Coulometry (Current-voltages relationships, Coulometric methods, Amperometric methods.	**10**
Unit 4	**Chromatographic techniques** High-Performance Liquid Chromatography, Gas Chromatography, Ion-Exchange Chromatography.	**8**
Unit 5	**Environmental Testing and Monitoring Techniques.** Water Quality Analysis: pH, Conductivity, Total Dissolved Solids (TDS), Dissolved Oxygen (DO), Turbidity**.** Heavy Metal Detection: Inductively Coupled Plasma Mass Spectrometry (ICP-MS), Atomic Absorption Spectroscopy (AAS)**.** Organic	**8**

	Pollutant Analysis: Gas Chromatography-Mass Spectrometry (GC-MS), Liquid Chromatography-Mass Spectrometry (LC-MS)**.** Nutrient Analysis: Ion Chromatography (IC) for Nitrate, Phosphate, and Sulfate Detection**.** Particulate Matter (PM) Analysis: Gravimetric and Optical Methods**.**	

Course Outcomes: On successful completion of the course, students will be able to	
1	Develop an understanding of the range and theories of advanced instrumentation methods.
2	Search for and evaluate scientifically relevant information from the instrumental characterization data.
3	Perform the quantitative and qualitative analysis of various engineering materials.
4	Review, select and optimize appropriate instrumental techniques for various applications.

List of Experiments

1. To determine nitrate concentration in water samples using UV-Vis spectrophotometry.
2. To isolate and quantify pesticide residues from water samples using flash chromatography and analyze them using gas chromatography.
3. To identify functional groups in organic pollutants using Fourier Transform Infrared Spectroscopy (FTIR).
4. To analyze and compare FTIR spectra of soil organic matter before and after simulated contamination.
5. To identify and quantify aromatic hydrocarbon compounds in water samples using High-Performance Liquid Chromatography (HPLC).
6. To separate and quantify dyes in wastewater using HPLC for quality monitoring and environmental compliance.
7. To detect and quantify lead and cadmium in water and soil extracts using electrochemical workstation (voltammetry).
8. To measure sodium and potassium ions in water samples using flame photometry or potentiometric techniques.
9. To calibrate and analyze NaCl concentration using conductometric titration.
10. To determine nitrite concentration in water using UV-Vis spectrophotometry and a standard calibration curve.

Text Book:

Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	Instrumental Methods of Analysis : B Sivasankar, OUP	2012
2	Principles Of Instrumental Analysis, Douglas A. Skoog, Cengage	2018

Reference Books: (at least 3)

Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	X-Ray Diffraction Crystallography: Yoshio Waseda, Eiichiro Matsubara, Sringer	2011
2	Electroanalytical Methods: Guide to experiments & applications: Fritz Scholz, Springer	2010
3	Chromatography: Principles and Instrumentation, Mark F. Vitha, Wiley	2016

Equivalent MOOCs courses

Sr. No.	Course Links	Offered by
1	Electron Diffraction and Imaging, https://archive.nptel.ac.in/noc/courses/noc17/SEM2/noc17-me30/	NPTEL
2	Optical Spectroscopy and Microscopy: Fundamentals of optical measurements and instrumentation, https://nptel.ac.in/courses/102108082	NPTEL

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**2**	**-**	**2**	**3**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
CO2	**-**	**3**	**2**	**1**	**3**	**-**	**-**	**-**	**-**	**1**	**-**	**-**	**-**	**-**	**-**
CO3	**3**	**-**	**-**	**2**	**2**	**1**	**1**	**-**	**-**	**-**	**2**	**1**	**-**	**-**	**-**
CO4	**-**	**-**	**-**	**3**	**1**	**2**	**1**	**3**	**-**	**-**	**2**	**1**	**-**	**-**	**-**

Paper 3: Water and Wastewater Treatment Technologies

Course Name	**:**	**Water and Wastewater Treatment Technologies**
Course Code	**:**	**CHM 103**
Credits	**:**	**4**
L T P	**:**	**3 0 2**

Course Objectives :

Students should be able –

- To understand the principles and technologies used in advanced treatment processes for water, soil, and air.
- To learn about the design, operation, and optimization of advanced environmental treatment systems.
- To evaluate the performance of different treatment methods for various contaminants in water, soil, and air.
- To gain practical knowledge on the application of advanced treatment technologies in real-world environmental scenarios.
- To develop skills for selecting appropriate treatment methods based on specific environmental quality requirements.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**Introduction to Advanced Environmental Treatment** Overview of environmental treatment processes for water, soil, and air. Importance of advanced treatment for pollution control. Regulatory standards and guidelines for water, soil, and air quality. Membrane Filtration Technologies: Principles of membrane filtration. Types of membranes (microfiltration, ultrafiltration, nanofiltration, reverse osmosis). Applications and limitations in water, wastewater, and air treatment (e.g., gas separation membranes). Design and operation of membrane systems.	**10**
Unit 2	**Advanced Oxidation Processes (AOPs) and Adsorption Techniques** Fundamentals of AOPs**,** Types of AOPs (ozonation, photocatalysis, Fenton reaction, etc.) Mechanisms of contaminant degradation in water, soil and air. AOPs for air pollution control (e.g., photocatalytic oxidation of VOCs, plasma treatment for gaseous pollutants). Case studies and practical applications**.** Adsorption principles and isotherms, Types of adsorbents (activated carbon, zeolites, biochar, etc.). Design and optimization of adsorption systems. Regeneration and reuse of adsorbents.	**12**
Unit 3	**Biological Treatment Methods and Electrochemical Treatment Methods** Primary, Secondary and tertiary Water Treatment. Advanced biological treatment processes. Biofilm reactors and membrane bioreactors. Emerging biological treatment technologies. Application in wastewater treatment and reuse. Principles of electrochemical water treatment. Electrocoagulation,	**10**

	electrooxidation, and electroflotation. Design and operation of electrochemical systems. Case studies and applications.	
Unit 4	**Integrated Water Treatment Systems and Emerging Technologies in Water Treatment** Combining different treatment methods, Hybrid treatment systems, Case studies of integrated systems in practice. Performance evaluation and optimization. Nanotechnology in water treatment. Advanced sensors and monitoring systems. Innovative materials for water treatment. Future trends and research directions.	**10**

Course Outcomes:	
On successful completion of the course, students will be able to	
1	Explain the scientific principles underlying advanced water treatment processes.
2	Design and optimize advanced water treatment systems for different applications.
3	Assess the effectiveness of various water treatment technologies.
4	Apply advanced treatment methods to address specific water quality challenges.

List of Experiments

1. To evaluate the adsorption capacity of activated carbon for phenol and fit the data to isotherm models using UV-Vis spectroscopy.
2. To study the degradation of various pollutants in synthetic wastewater using H_2O_2 under UV light.
3. To identify functional group changes in pollutants before and after treatment using FTIR.
4. To investigate the efficiency of electrochemical oxidation in removing hexavalent chromium from wastewater.
5. To detect and quantify volatile organic compounds in water samples using gas chromatography.
6. To assess the synergistic removal of pollutants using combined electrochemical and adsorption treatment methods.
7. To study the removal efficiency of dyes from wastewater using flash column chromatography with different packing materials.
8. To design and operate a bench-scale membrane system for physical filtration of particulates from water.
9. To compare the chemical oxygen demand in treated and untreated water samples using HPLC.
10. To determine the effectiveness of alum in removing turbidity and suspended solids from wastewater through coagulation and flocculation.

Text Book:

Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	**Water Treatment: Principles and Design,** by MWH, John C. Crittenden, R. Rhodes Trussell, David W. Hand, Kerry J. Howe, and George Tchobanoglous.	2012
2	**Advanced Water Treatment: Advanced Oxidation Processess, Mika Silanpaa.**	2020

3.	**Adsorption Technology and Design"** by By W John Thomas, FEng, Barry Crittenden.	1998
Reference Books: (at least 3)		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	**Advanced Oxidation Processes for Water and Wastewater Treatment"** by Simon Parsons	2005
2	**Electrochemical Water and Wastewater Treatment"** by Carlos Alberto Martínez-Huitle and Maosy Ariza Aguilar	2018
3	**Handbook of Advanced Industrial and Hazardous Wastes Treatment"** by Lawrence K. Wang, Yung-Tse Hung, Howard H. Lo, and Constantine Yapijakis	2004

Equivalent MOOCs courses

Sr. No.	Course Links	Offered by
1	Water and waste water treatment https://onlinecourses.nptel.ac.in/noc21_ce25/preview	NPTEL

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**-**	**-**	**-**	**-**	**2**	**3**	**2**	**-**	**-**	**-**	**2**	**-**	**-**	**-**
CO2	**-**	**-**	**3**	**2**	**3**	**-**	**-**	**-**	**2**	**-**	**2**	**-**	**-**	**-**	**-**
CO3	**-**	**3**	**-**	**2**	**2**	**-**	**-**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
CO4	**-**	**-**	**-**	**2**	**-**	**1**	**-**	**-**	**2**	**-**	**3**	**-**	**-**	**-**	**-**
CO5	**-**	**3**	**-**	**-**	**-**	**2**	**-**	**2**	**3**	**-**	**3**	**1**	**-**	**-**	**-**

Course Name	**:**	**Project I**
Course Code	**:**	**CHM 104**
Credits	**:**	**3**
LTP	**:**	**0 0 6**

Course Name	**:**	**Project II**
Course Code	**:**	**CHM 105**
Credits	**:**	**3**
LTP	**:**	**0 0 6**

Minors/Honors shall be awarded if and only if

1. There is no backlog in courses registered throughout his/her degree program including minor and honors courses.
2. His/her CGPA is ≥ 7.0/8.5 for minor/honors respectively at the end of his/her degree.
3. Minor specialization degree shall only be awarded if CGPA in minor specialization ≥ 6.0.

ENTRY CRITERIA FOR MINOR SPECIALIDSATION [ELIGIBILITY]

1. No backlog
2. CGPA ≥ 7.0

Criteria for passing of subjects and Reappear/Make-up Examination and its Grading

6.2 Evaluation

a) Make-up Examinations –

Comment:

1. The student's family relative should notify the concerned department of the student's absence on the same day of the examination or earlier, either via email or phone.

2. Students's representatives (parent/guardian) should be allowed to submit the required request in person with the necessary documents within three days instead of two.

3. The institute should prepare performas for the request and required documents, and the same should be uploaded to the website.

6.3 Grading System

A typical updated break-up for continuous evaluation should be as given below:

i. Mid-term Examination : 20 %
ii. End-term Examination : 40 %
iii. Assignments, Quizzes (Minimum 3), Projects, Practicals etc. : 40 %

Award of Grade using Statistical Method

1. The grading table is good, but a minimum of 25% marks in the end-term examination should be an essential condition for awarding passing or higher grades.
2. If the student fails to achieve a minimum of 25% marks in the end-term examination, he should be awarded an ‘F’ grade in that subject/course.

Grading System for Small Classes (≤ 30 students)

1. The grading table is good, but a minimum of 25% marks in the end-term examination should be an essential condition for awarding passing or higher grades.
2. If the student fails to achieve a minimum of 25% marks in the end-term examination, he should be awarded an ‘F’ grade in that subject/course.

Reappear Examination

1. The reappear examination should be executed only for 1st semester and final-year students because first-year students are adopting a new environment of engineering from the 12th standard Board Examination and final students are just going to pass.

2. Reappear examination should be executed for 1st-semester students after their 1st semester with a maximum of two subjects.

3. Reappear examination should be executed for final year students just after the 8th semester with a maximum of three subjects of final year courses having no backlog subject in earlier years (from 1st -3rd year).

4. The maximum grade for reappearing students should only be a ‘D’ grade.

5. No reappear examination should be conducted for 2nd to 6th-semester students in their failed subjects in the same semester/academic year.

6. The students who fail courses from the 2nd to the 6th semester should not be allowed to register for the courses and attend the classes of the failed courses in upcoming semesters/academic years.

7. Such students of the 2nd to 6th semester should be allowed to appear only in the End term examinations of the concerned subjects in the upcoming semesters with their pre-total as 50% weightage and the next end-term examination as 50% weightage in which they will appear.

8. The grading of the failed courses of students from the 2nd to the 6th semester should be one grade less from the semester grading matrix mark ranges based on his performance in the forthcoming semester end-term examination and earlier years pre-total.

9. In any particular semester, students should be allowed to appear in the end-term examination for a maximum of two failed subjects.

10. REQUIREMENTS

10.1 Attendance

1. Students who have less than 33% attendance should be considered non-interested students in that subject and should not be allowed to appear in the end-term examination. An F grade should be awarded in that subject.