Course Title: Introduction to Environmental Chemistry			
Course code: UES 106	**No. of credits: 3**	**L-T-P:** 39-06-0	**Learning hours: 45**
			L: Lectures**; T:** Tutorials**; P:** Practicals
Pre-requisite course code and title (if any): None			
Department: Natural and Applied Sciences			
Course coordinator:		**Course instructor:**	
Contact details:			
Course type: Major		**Course offered in:** Semester 2	

Course Description

The course is about understanding the basic concepts of chemistry. The students would learn the basics of physical, inorganic, and organic chemistry and would accordingly develop the understanding of these concepts in relation to environment. The reactions, processes that govern the chemical nature of our environment and the anthropogenic contaminants that lead to environmental disasters the effects, reactions, and origins of chemicals in the air, water, earth and living environments. It gives a brief background and overview of chemistry in the environment and then covers a more detailed and in-depth topics within each component of the environment. The course describes the chemistry of the atmosphere, hydrosphere and lithosphere and related environmental issues. Specifically, we will examine the sources, reactions, effects, and fates of chemical species found in air, water and soil followed by getting insights of major environmental disasters around the world

Course objectives

- Outline the basic concepts of inorganic, organic and physical chemistry in relation to environment
- Understanding the chemical basis behind the range of environmental processes in air, water, and soil.
- Gain understanding of major environmental disasters around the world

Course content

Module	Topic	L	T	P
1	**Inorganic Chemistry and Environment**			
	This module covers the aspects of basic chemistry and discusses law of conservation of mass, law of definite proportions, law of multiple proportions, modern view of atomic structure, atomic and molecular weights, overview of periodic table. The student would understand what ions, molecules and diverse types of chemical bonds are along with molecular and ionic compounds. Understand metal, non-metals, and metalloids. The topics that would be covered in this module will be i. Atomic theory and atomic structure of matter, orbitals, and electronic configuration ii. Periodic table and periodic properties of elements; ionization energy, electron affinity iii. Basic concepts of chemical bonding; ionic, covalent and coordination compound, free radicals, ions iv. Reactions in the atmosphere, water, and soil: chemistry of troposphere, photochemical smog, ozone chemistry, GHGs, CFC's, acid rain, v. Chemical analysis in the field, simple colorimetric tests and sensors, chemical analysis in the laboratory using titrimetric methods	12	3	
2	**Physical Chemistry and Environment**			
	The module covers the important topics of physical chemistry and tries to explain the concepts of rates of chemical reactions, half-life period, order of reactions. The module will cover the concept of solubility, normality, molarity, catalysis, chemical equilibria, stoichiometry, buffer solutions and electrochemistry	14		

	i. Chemical kinetics, chemical equilibria, differential and integrated rate laws. Properties of solutions; solution process, solubility, concentration, mole concept ii. Reactions in aqueous solution; acid base reactions, acid base equilibria, oxidation, reduction iii. Thermo- and nuclear chemistry: enthalpy, entropy, laws of thermodynamics, radioactivity, half-life, nuclear processes, food, and fuels iv. Electrochemistry, voltaic cells, Gibb's energy, corrosion, electrolysis, batteries, and fuels v. Weathering; physical and chemical, heavy metals, toxicity and bioaccumulation, Environmental impact of Hg, F, Pb, Cd, As, U, Se. acid-base chemistry of natural waters due to the CO_2/carbonate system and chemical equilibrium equations. Acid mine drainage (use appropriate chemical equations) and its impact on natural waters, major source(s) of the drinking water contaminants.			
3	**Organic Chemistry and Environment**			
	The module covers the introduction to organic chemistry including the concepts on hydrocarbons, alkanes, functional groups, chirality in organic chemistry. The students would also be exposed to the biomolecules and would learn basics aspects of biochemistry. i. General characteristics of organic molecules. ii. Hydrocarbons, unsaturated hydrocarbons, functional groups. iii. Chirality in organic chemistry iv. Introduction to biochemistry, proteins, carbohydrates, nucleic acids v. Soil chemical properties, and dominant reactions mechanisms, the use and impacts of fertilizers, insecticides, herbicides, and wood preservatives. The nature of soil, soil properties, important soil chemical reactions, COD, BOD	8	3	
4	**Case Studies of Environmental Disasters**			
	Japan's four big pollution disease, Bhopal gas tragedy, Chernobyl disaster, Arsenic poisoning, Fluorosis, Fukushima nuclear accident, London smog, Ecuador's Amazon degradation, Italy's Seveso dioxin cloud, France's Amoco Cadiz tanker spill, Romania's cyanide spill, Ivory Coast's toxic waste dumping, Deep water horizon oil spill	5		
	Total	39	6	0

Evaluation criteria

- Minor Test 1: Written test [at the end of teaching of modules 1 and 2] -- 25%
- Minor Test 2: Written test [at the end of teaching of module 3] -- 25%
- Major Test: Written test [at the end of the semester, full syllabus] -- 50%

Learning outcomes

By the end of the course, students will be able to:

- Describe the generic details of inorganic chemistry, understand the internal structure of atoms, diverse kinds of chemical bonding, generations of ions, free radicals. Once they gain the understanding of these processes they will learn about ozone depletion, environmental effects of acid deposition, tropospheric chemistry with photochemical smog, and how this leads to the "natural" greenhouse effect., evidence of global warming. [Module 1; Minor Test 1]
- Learn about physical chemistry concepts on kinetics, solutions, electro and nuclear chemistry, buffer solutions, concepts of acid-base. The students would be able to understand the concept of normality, molarity, mole concept etc. [Module 2; Minor Test 2]
- The chemistry of hydrocarbon, biomolecules/macromolecules thus will help them to understand the concepts of organics in soils. Aerobic decomposition of organic matter in natural waters, theory and

measurement of BOD, COD and qualitatively describe how these measurements are made. [Module 3 and 4; Major Test]

Pedagogical approach

- The course critically evaluates the concepts of chemistry and apply it in environmental processes understanding thus develops discussion in classroom through lectures, case studies and tutorials.
- The course will use several case studies for environmental pollution. The journal publications will be given to develop robust understanding of severe environmental problems

Reading Resources (* = compulsory readings)

- *Ibanez, J.G. Esparza, M.H., Serrano, C.D., Infante, A.F. (2006). *Environmental Chemistry Fundamentals* Springer
- *Ball, D.W., Hill, J.W. and Scott, R.J. (2011). *The basics of general, organic, and biological chemistry*. Open Textbook Library.
- *Corwin, C.H. (2011). *Introductory chemistry: Concepts and critical thinking*. Pearson Prentice Hall.
- Monks, P., Farmer, J. G., Graham, M. C., De Mora, S. J., Pulford, I., & Hulsall, C. (2007). *Principles of environmental chemistry*. Royal society of chemistry.
- Dara, S. S., & Mishra, D. D. (2006). *A textbook of environmental chemistry and pollution control*. S. Chand Publishing.
- Andrews, J. E., Brimblecombe, P., Jickells, T. D., Liss, P. S., & Reid, B. (2009). *An introduction to environmental chemistry*. John Wiley & Sons.
- De Anil, K. (2023). *Environmental chemistry*. New Age International Publishers.

Journals

Environmental Pollution, Elsevier
Bulletin of Environmental Contamination and Toxicology

Student Responsibilities

The students are required to come prepared with readings that would be given in the class. The students are required to participate in the discussion.

Course Designed by:

- Dr. Chander Kumar Singh, Department of Natural and Applied Sciences, TERI School of Advanced Studies, New Delhi

Course Reviewers:

The course is reviewed by the following reviewers:

- Dr. Dhanesh Tiwari, Professor, Department of Chemistry, IIT-BHU
- Dr. Anshumali, Professor, Indian Institute of Technology (ISM) Dhanbad