



Essence of Environmental Chemistry

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ABSTRACT

Environmental chemistry studies the occurrence, movements, and transformations of chemicals in the living environments. It is an interdisciplinary field that studies the presence and impact of chemicals in soil, water, and living environment. It deals with the impact of chemicals and their effects on human health and organisms in the environment. It helps us trace and control contaminants. This paper provides the fundamentals of environmental chemistry and the effects of mankind's activities on the earth's chemical systems.

Key Words: Environmental Chemistry, Chemical Pollution.

1. INTRODUCTION

Environmental chemistry is the branch of chemistry that deals with the production, transport, and effects of chemicals in the water, air, earth, and natural environments. It is the field that studies chemical phenomena that occur in natural places. It involves understanding the chemical processes that occur in water, air, terrestrial, and living environments. Although some key chemical concepts are fundamental to understanding environmental chemistry, it is an interdisciplinary discipline that covers analytical chemistry, aquatic and soil chemistry, atmospheric chemistry, astrochemistry, engineering, mathematics, biology, geology, ecology, toxicology, and environmental sciences. Due to its multidisciplinary nature, environmental chemistry requires the contribution and collaboration of a wide variety of scientists to succeed. Figure 1 is a typical illustration of environmental chemistry [1].

Assessing the environmental impact may require a variety of experts: soil scientists to understand its fate in the soil, biologists to analyze the effect of the drug on living creatures, and atmospheric scientists to predict its transformations in the water and air [2].

Environmental chemistry should not be confused with green chemistry, which seeks to reduce potential pollution at its source, while environmental chemistry is the scientific study of the chemical phenomena that occur in natural places. Green chemistry involves the development of chemical products and processes that reduce or eliminate the use of hazardous substances. It focuses on minimizing the environmental impact of chemistry. It reduces toxicity, minimizes waste, and saves energy. Green chemistry is not confined to industrial sector. It applies to all areas of chemistry including organic chemistry, inorganic chemistry, biochemistry, analytical chemistry, and physical chemistry [3].

2. HISTORICAL BACKGROUND

Importance of the environment was realized in the 1960s and reached its climax in 1970, with the celebration of "Earth Day" under the auspices of the United Nation. As a distinct field in chemistry, environmental chemistry emerged as a discipline when scientists started studying the occurrence of chemical in the natural environment. During the 1960s, industries, agriculture, and households started to use more chemical compounds such as pesticides, detergents, polyester, synthetic rubber, etc. A major impetus for environmental chemistry dates from the discovery in the 1970s of human health hazards caused by environmental pollution. Environmental chemists also began studying the effects of human-caused chlorofluorocarbons (CFCs) on the stratospheric ozone layer. Since then, environmental chemistry expanded to include the study of chemical compounds in water, soil, biological systems.

3. CHEMICALS IN THE ENVIRONMENT

A contaminant or pollutant is a substance present in nature at a level higher than fixed levels or that would not otherwise be there. There are four million known chemicals in the world today and another 30,000 new compounds are added to the list every year. When a chemical is released into the environment, it is distributed among the four major environmental compartments: (1) air, (2) water, (3) soil, and (4) living organisms. The environmental interest in acid-base chemistry is focused on the capacity of natural waters and soils to resist pH changes resulting from human activity [2].

Where do these chemicals come from? Some are from food additives, contamination, pollution, atmosphere, radioactive chemicals, etc. Some of these sources are discussed as follows [4,5].

- **Contamination:** This refers to the presence of one or more chemicals in the environment in higher concentrations than normally occurs but not high enough to cause harm and damage. Some industries emit metals that pollute the environment. For instance, lakes near Sudbury, Ontario, have been polluted by sulfuric acid, copper, nickel, and other metals which cause toxicity to plants and animals. Mercury contamination of fish is also a major challenge in many aquatic environments. Lead has caused significant environmental damage and lead poisoning has been known to cause death. Metal(loid)s resemble the most important group of inorganic contaminants in environmental chemistry, and have become an environmental-quality target worldwide. Besides arsenic (As), uranium (U) has also been identified as drinking-water contaminant.
- **Pollution:** This is the effect of undesirable changes in our surroundings that have harmful effects on humans, plants, and animals. There are several types of pollution: water pollution, air pollution, oil pollution, chemical pollution, etc. Sources of pollution include industrial waste disposal, water treatment plant, municipal sewage leakage, and sanitary landfills. These pollutants have damaged tens of thousands of lake and running-water ecosystems. A clear understanding of pollutants and their chemistry is essential for interpreting health effects, regulating emissions, and developing pollution-reducing technologies. Water is ubiquitous in the earth's atmosphere playing a major role in environmental chemistry. Pollution of water bodies is often associated with the dumping of human or industrial sewage. Large numbers of wildlife have been killed by pollution in North America. Smog (derived from smoke and fog) is the most common type of air pollution that occurs in many cities around the world. Figure 2 shows that photochemical smog occurs where sunlight acts on vehicle pollutants [6].
- **Atmosphere:** The atmosphere is a blanket of gases surrounding and protecting the earth. It can contain high concentrations of gases, vapors, or particulates that are potentially harmful to people or animals. The major gases in the atmosphere are nitrogen and oxygen, while the minor gases are argon, carbon dioxide, and some trace gases. Carbon dioxide and its carbonate minerals play an important role in environmental chemistry. Carbon monoxide is one of the most serious air pollutants. Green plants synthesize carbohydrates from carbon dioxide and water using light as an energy source. Sulfur (S) is emitted to the atmosphere as sulfur dioxide (SO₂) and hydrogen sulfide (H₂S), which are transformed by photochemical reactions into the negatively-charged sulfate.

4. ENVIRONMENTAL CHEMISTS

Professional environmental chemists usually have at least a bachelor's degree. They are often employed by remediation firms, environmental consulting companies, state and federal regulatory agencies (such as Environmental Protection Agency (EPA)), manufacturing companies research centers, and academic institutions. They work in collaboration with biologists, geologists, atmospheric scientists, engineers, lawyers and legislators. Figure 3 shows some environmental chemists in the field [7].

Figure 4 shows the mission of environmental chemists [8]. While responsibilities may vary significantly from one workplace to another, environmental chemists are responsible for the following [9].

- Develop data collection methods and systems according to the elements that are under study
- Collect information from observations, samples, and specimens
- Record and manage records of observations, samples and specimens in the lab and via fieldwork
- Use GIS and computer modeling to help forecast and analyze chemical impact
- Analyze literature, data, laboratory samples, and other sources of information to uncover primary, secondary, and tertiary chemical impacts
- Prepare reports and present research findings to internal and external stakeholders
- Communicate with team lead and executive through regular, scheduled reports and presentation of research findings
- Advise organizations and policymakers on the short and long-term impact and safety of chemicals in the environment
- Review research and literature in the field to stay abreast of current discoveries
- Classify contaminated soils as hazardous waste and manage their disposal

- Analyze new chemicals and their impact on the environment.
- Conduct laboratory work, take measurements, interpret data, and use computers for environmental modeling.

5. GLOBAL ENVIRONMENTAL CHEMISTRY

Scientists as well as politicians globally are looking for how to solve environmental problems. The UN's Sustainable Development Goals include universal calls to action to protect life on land and in water. Environmental chemistry is used by the United States Environmental Protection Agency, the Environment Agency in England, Natural Resources Wales, and other national agencies. Environmental chemists, environmental scientists, and chemists worldwide can play an important role in helping ensure nations maintains high-quality supplies of water in the nation's rivers, lakes, and underground reservoirs. We now consider environmental chemistry in some countries.

- **United States:** The US federal government that expanded risk assessment beyond food to include contaminants in air, water, and soil. In 1988, the United States ratified the Montreal Protocol, an international agreement ratified by 196 states to phase out the industrial production of chlorofluorocarbons (CFCs). According some data on chemical exposure collected by the U.S. Centers for Disease Control and Prevention, the average US citizen has detectable levels of more than 100 xenobiotic compounds in his/her blood. Some retailers such as Wal-Mart and Staples use some assessments to certify the superior environmental performance of the products they sell [10].
- **China:** In Asia, environmental chemists have been able to document pollution from electronic waste recycling in Southern China. Recent research indicates that the levels of PFAAs (a class of chemicals with unique water-, dirt-, and oil-repelling properties) in Chinese infants are higher than those for infants from other countries, suggesting that the use of PFC-containing products may be increasing in China [10].
- **United Kingdom:** Accurate measurements of pollutants are vital for ensuring compliance with national and international air quality directives. The United Kingdom has around 300 air quality monitoring sites measuring a variety of pollutants, including ozone, nitrogen oxides, sulfur dioxide, carbon monoxide, and particulates. The UK air quality target for nitrogen dioxide is an annual mean of 40 micrograms per cubic meter. The UK's professional and learned societies (including the sciences, social sciences, arts, humanities, medicine and engineering) have endorsed a communiqué on climate change calling for government action [11].
- **India:** Incidences of environmental issues in India include white marble of Taj Mahal and leakage of methyl isocyanate (MIC) vapors at Bhopal in 1984. Pollution of river water in India, use of plutonium or other isotopic fuel-based breeder/nuclear reactors for energy production, use of dangerous artificial food additives, and ozone hole in the Antarctic and Arctic regions are some typical chemical issues that need to be resolved critically. Pollutants such as sulfur dioxide and nitrogen oxides can form acid rain, which pollutes soil and water and damages buildings such as the Acropolis and the Taj Mahal [5].

6. CONCLUSION

Environmental chemistry focuses on how chemicals are formed, how they are introduced into the environment, and the effects they have on the environment and mankind. It examines the effects humans have on the environment through the release of chemicals.

Education and awareness on environmental chemistry is an expedient way to help prepare future leaders to be able to recognize hazard and determine risk. The Society of Environmental Toxicology and Chemistry (SETAC) (<http://www.setac.org/>) is a global professional organization that provides a forum for sharing ideas and promotes multidisciplinary approaches to solving environmental problems. More information on environmental chemistry can be found in the books in [12-29] and the following related journals

- Environmental Chemistry
- Environmental Chemistry Letters
- Environmental Briefs
- Frontiers in Environmental Chemistry
- Journal of Environmental Chemistry
- Journal of Environmental Chemical Engineering
- Journal of Environmental Chemistry and Ecotoxicology

- Journal of Environmental Chemistry and Toxicology
- International Journal of Environmental Chemistry
- International Journal of Environmental Analytical Chemistry

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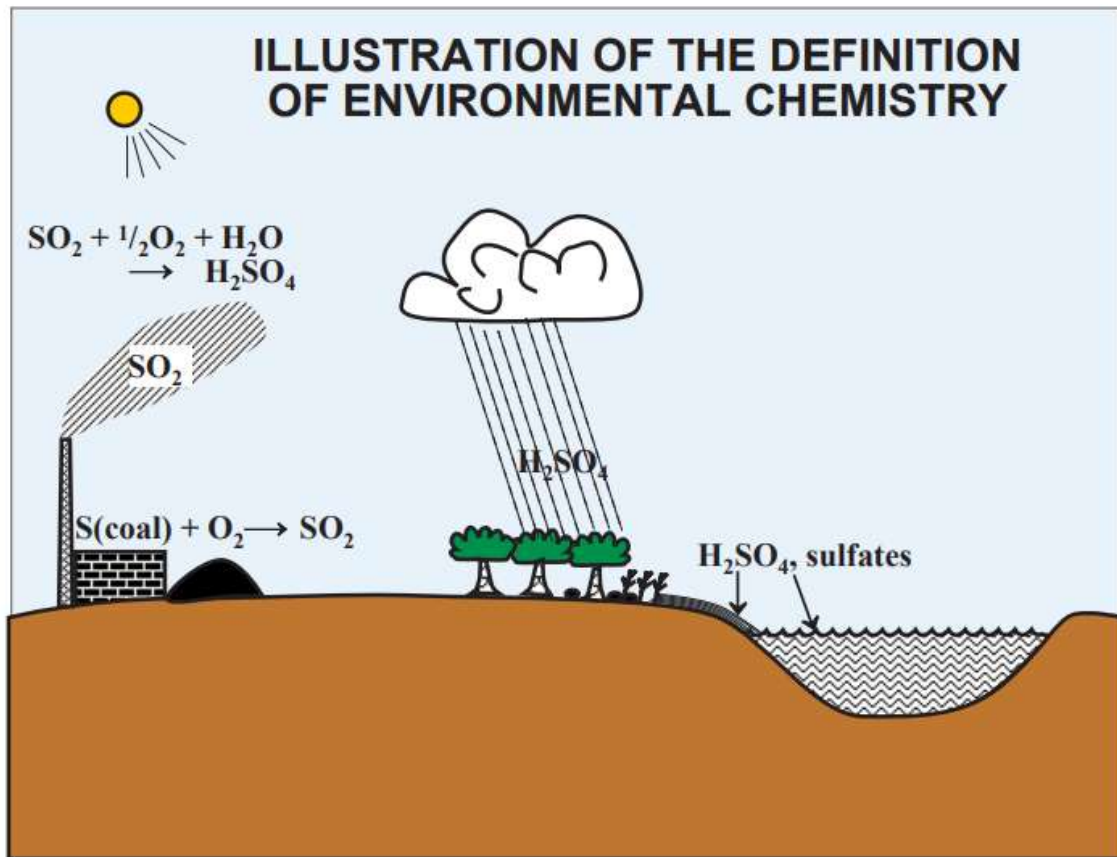


Figure 1 A typical Illustration of environmental chemistry [1].

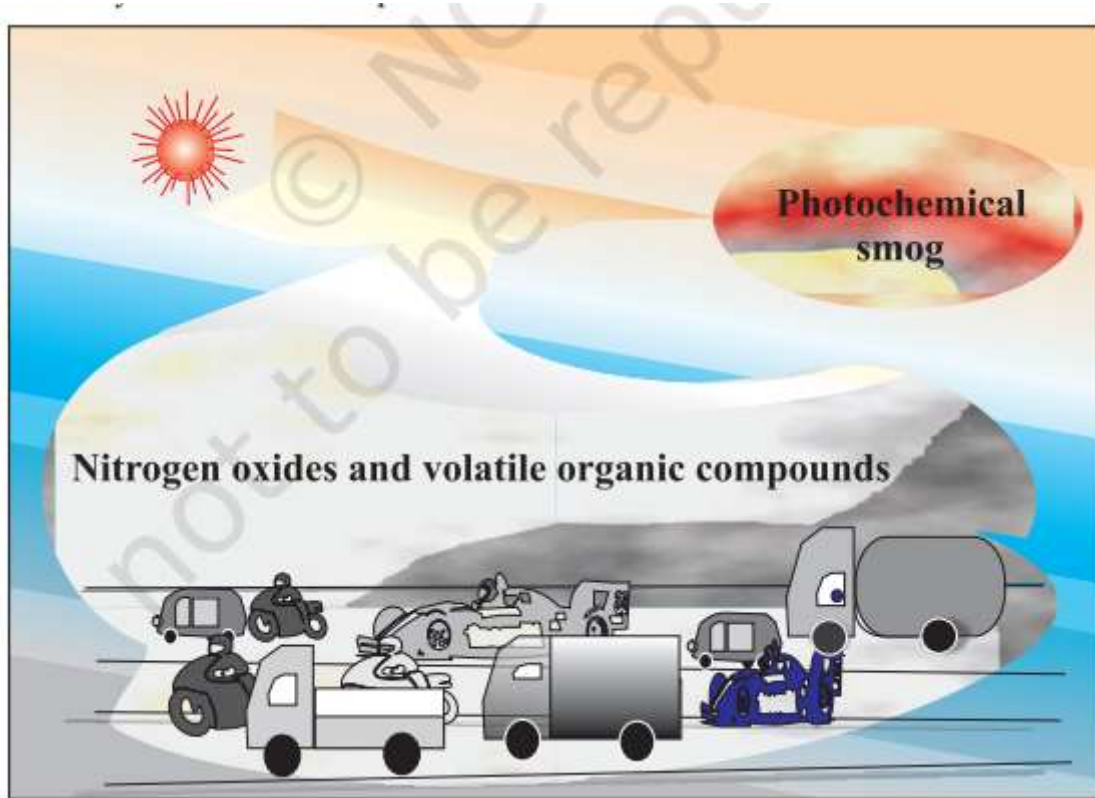


Figure 2 Photochemical smog occurs where sunlight acts on vehicle pollutants [6].



Figure 3 Some environmental chemists in the field [7].

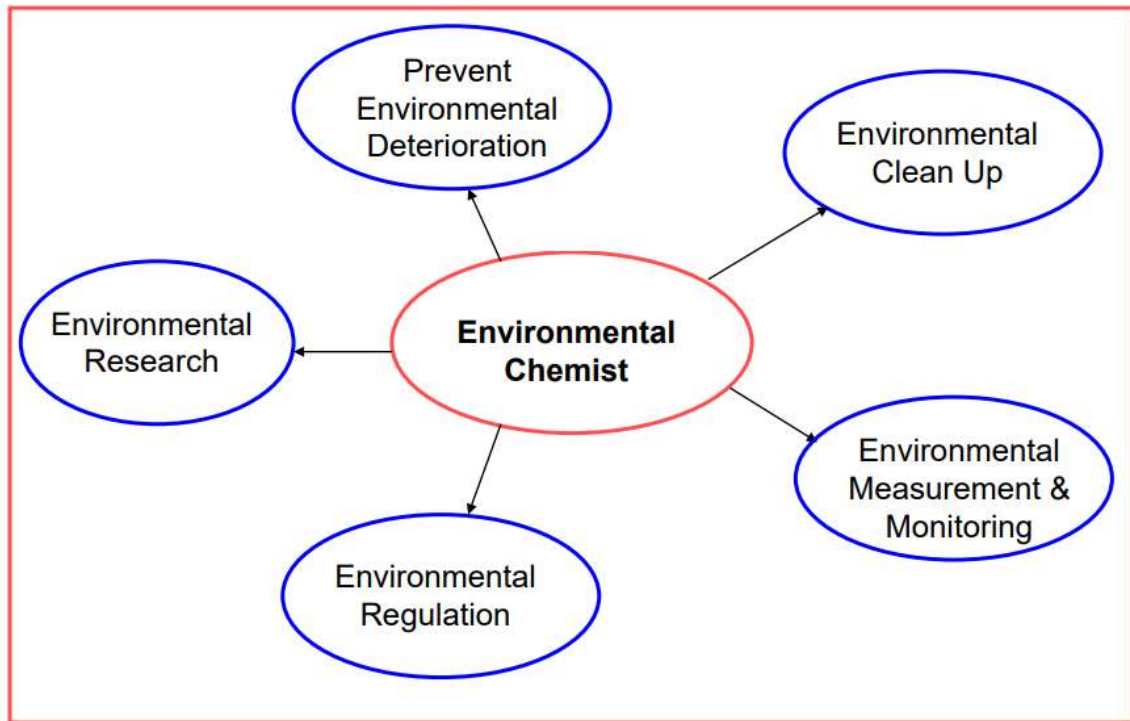


Figure 4 The mission of environmental chemists [8].