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Chemical Reactions of the Environment

Dr. Neeta Garg

Associate Professor, Department of chemistry, SK Govt. College, Sikar

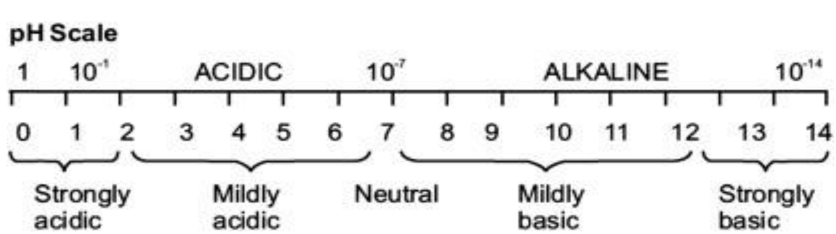
ABSTRACT

Environmental chemistry is the scientific study of the chemical and biochemical phenomena that occur in natural places. It should not be confused with green chemistry, which seeks to reduce potential pollution at its source. It can be defined as the study of the sources, reactions, transport, effects, and fates of chemical species in the air, soil, and water environments; and the effect of human activity and biological activity on these. Environmental chemistry is an interdisciplinary science that includes atmospheric, aquatic and soil chemistry, as well as heavily relying on analytical chemistry and being related to environmental and other areas of science. Environmental chemistry involves first understanding how the uncontaminated environment works, which chemicals in what concentrations are present naturally, and with what effects. Without this it would be impossible to accurately study the effects humans have on the environment through the release of chemicals. Environmental chemists draw on a range of concepts from chemistry and various environmental sciences to assist in their study of what is happening to a chemical species in the environment. Important general concepts from chemistry include understanding chemical reactions and equations, solutions, units, sampling, and analytical techniques When a chemical is released into the environment, it becomes distributed among the four major environmental compartments: (1) air, (2) water, (3) soil, and (4) flora and fauna, that is, living organisms. Each of the first three categories can be further subdivided in floral (plant) environments and faunal (animal, including human) environments. The fraction of the chemical that will move into each compartment is governed by the physicochemical properties of that chemical.

INTRODUCTION

In addition, the distribution of chemicals in the environment is governed by physical processes such as (1) sedimentation, (2) adsorption, and (3) volatilization and the chemical can then be degraded by chemical and/or biological processes. Chemical processes generally occur in water or the atmosphere and follow one of four reactions: oxidation, reduction, hydrolysis, and photolysis. Biological mechanisms in soil and living organisms utilize oxidation, reduction, hydrolysis, and conjugation to degrade chemicals. The process of degradation will largely be governed by the compartment (water, soil, atmosphere, biota) in which the chemical is distributed, and this distribution is governed by the physical processes already mentioned (i.e., sedimentation, adsorption, and volatilization).[1,2]

The impact of the changes in the chemical state of organic chemicals on the environment is only partially elucidated, but will be significant in many cases. Atmospheric abundance of radioactive gases could lead to substantial drift in the climate of the earth, including changes in temperature and precipitation, and in the frequency of occurrence of extreme events (such as hurricanes). Ecosystem damage and problems related to human health also result from regional and global pollution, such as acid rain (also called *acidic precipitation*), which can vary between mildly acidic and strongly acidic on the pH scale (Fig. 1.2) and can suppress life and, together with enhanced ozone levels, can lead to forest damage. In fact, when assessing the impact of chemicals on the environment, the most critical characteristics are: (1) the type of chemical discharged, which depends on the type of industries and processes used, and (2) the amount and concentration of the chemical. Solid wastes (containing chemicals) and/or gaseous emissions generated from industrial sources also contribute to the amount and concentration of chemicals in the environment.[3]



A contaminant is a substance present in nature at a level higher than fixed levels or that would not otherwise be there. This may be due to human activity and bioactivity. The term contaminant is often used interchangeably with *pollutant*, which is a substance that has a detrimental impact on the surrounding environment. Whilst a contaminant is sometimes defined as a substance present in the environment as a result of human activity, but without harmful effects, it is sometimes the case that toxic or harmful effects from contamination only become apparent at a later date.

DISCUSSION

The "medium" such as soil or organism such as fish affected by the pollutant or contaminant is called a *receptor*, whilst a *sink* is a chemical medium or species that retains and interacts with the pollutant such as carbon sink and its effects by microbes.

Chemical measures of water quality include dissolved oxygen (DO), chemical oxygen demand (COD), biochemical oxygen demand (BOD), total dissolved solids (TDS), pH, nutrients (nitrates and phosphorus), heavy metals, soil chemicals (including copper, zinc, cadmium, lead and mercury), and pesticides.[4]

Environmental chemistry is used by the Environment Agency in England, Natural Resources Wales, the United States Environmental Protection Agency, the Association of Public Analysts, and other environmental agencies and research bodies around the world to detect and identify the nature and source of pollutants. These can include:

- Heavy metal contamination of land by industry. These can then be transported into water bodies and be taken up by living organisms.
- PAHs (Polycyclic Aromatic Hydrocarbon) in large bodies of water contaminated by oil spills or leaks. Many of the PAHs are carcinogens and are extremely toxic. They are regulated by concentration (ppb) using environmental chemistry and chromatography laboratory testing.
- Nutrients leaching from agricultural land into water courses, which can lead to algal blooms and eutrophication.
- Urban runoff of pollutants washing off impervious surfaces (roads, parking lots, and rooftops) during rain storms. Typical pollutants include gasoline, motor oil and other hydrocarbon compounds, metals, nutrients and sediment (soil).
- Organ metallic compounds

Quantitative chemical analysis is a key part of environmental chemistry, since it provides the data that frame most environmental studies.

Common analytical techniques used for quantitative determinations in environmental chemistry include classical wet chemistry, such as gravimetric, titrimetric and electrochemical methods. More sophisticated approaches are used in the determination of trace metals and organic compounds. Metals are commonly measured by atomic spectroscopy and mass spectrometry: Atomic Absorption Spectrophotometry (AAS) and Inductively Coupled Plasma Atomic Emission (ICP-AES) or Inductively Coupled Plasma Mass Spectrometric (ICP-MS) techniques. Organic compounds, including PAHs, are commonly measured also using mass spectrometric methods, such as Gas chromatography-mass spectrometry (GC/MS) and Liquid chromatography-mass spectrometry (LC/MS).Tandem Mass spectrometry MS/MS and High Resolution/ Accurate Mass spectrometry HR/AM offer sub part per trillion detection. Non-MS methods using GCs and LCs having universal or specific detectors are still staples in the arsenal of available analytical tools.[5,6]

Other parameters often measured in environmental chemistry are radio chemicals. These are pollutants which emit radioactive materials, such as alpha and beta particles, posing danger to human health and the environment. Particle counters and Scintillation counters are most commonly used for these measurements. Bioassays and immunoassays are utilized for toxicity evaluations of chemical effects on various organisms. Polymerase Chain Reaction PCR is able to identify species of bacteria and other organisms through specific DNA and RNA gene isolation and amplification and is showing promise as a valuable technique for identifying environmental microbial contamination.

RESULTS AND CONCLUSION

Green chemistry, also called sustainable chemistry, is an area of chemistry and chemical engineering focused on the design of products and processes that minimize or eliminate the use and generation of hazardous substances. While environmental chemistry focuses on the effects of polluting chemicals on nature, green chemistry focuses on the environmental impact of chemistry, including reducing consumption of nonrenewable resources and technological approaches for preventing pollution.[7]

The overarching goals of green chemistry—namely, more resource-efficient and inherently safer design of molecules, materials, products, and processes—can be pursued in a wide range of contexts.
The twelve principles of green chemistry are:

1. Prevention. Preventing waste is better than treating or cleaning up waste after it is created.
2. Atom economy. Synthetic methods should try to maximize the incorporation of all materials used in the process into the final product. This means that less waste will be generated as a result.
3. Less hazardous chemical syntheses. Synthetic methods should avoid using or generating substances toxic to humans and/or the environment.
4. Designing safer chemicals. Chemical products should be designed to achieve their desired function while being as non-toxic as possible.
5. Safer solvents and auxiliaries. Auxiliary substances should be avoided wherever possible, and as non-hazardous as possible when they must be used.
6. Design for energy efficiency. Energy requirements should be minimized, and processes should be conducted at ambient temperature and pressure whenever possible.
7. Use of renewable feedstocks. Whenever it is practical to do so, renewable feedstocks or raw materials are preferable to non-renewable ones.
8. Reduce derivatives. Unnecessary generation of derivatives—such as the use of protecting groups—should be minimized or avoided if possible; such steps require additional reagents and may generate additional waste.
9. Catalysis. Catalytic reagents that can be used in small quantities to repeat a reaction are superior to stoichiometric reagents (ones that are consumed in a reaction).
10. Design for degradation. Chemical products should be designed so that they do not pollute the environment; when their function is complete, they should break down into non-harmful products.
11. Real-time analysis for pollution prevention. Analytical methodologies need to be further developed to permit real-time, in-process monitoring and control *before* hazardous substances form.[8,9]
12. Inherently safer chemistry for accident prevention. Whenever possible, the substances in a process, and the forms of those substances, should be chosen to minimize risks such as explosions, fires, and accidental releases.[10]

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