Environmental Chemistry

1. **Air, Water and Soil Pollution**
2. **Chemical Reactions in Atmosphere-smog, acid rain**
3. **Ozone and Its Reactions, Green house effects and Global warming**
4. **Strategies to control Environmental Pollution**

Environmental chemistry plays a major role in environment. Chemical species present in the environment are either naturally occurring or generated by human activities.

Environmental pollution is the effect of undesirable changes in our surroundings that have harmful effects on plants, animals and human beings.

Pollutant: - A substance, which causes pollution, is known as pollutant.

Pollutants can be solid, liquid or gaseous substances present in greater concentration than in nature and are produced due to human activities or due to natural happenings.

For example, substances such as dichlorodiphenyltrichloroethane (DDT), plastic materials, heavy metals, many chemicals, and nuclear wastes etc., once released into the environment are difficult to remove.

Pollutants can be Biodegradable and Non-biodegradable:-

Biodegradable pollutants: These are the pollutants which are rapidly broken down by natural processes. Example: discarded vegetables

Non - biodegradable pollutants: These are the pollutants which are slowly degradable, and remain in the environment in an unchanged form for many decades.

Environmental pollution is of three types:

a. Atmospheric pollution

i. Tropospheric pollution

ii. Stratospheric pollution

Atmospheric pollution is generally studied as **tropospheric** and **stratospheric** pollution.

Atmospheric pollution occurs when the concentration of a normal component of the air or a new chemical substance added or formed in air builds up to undesirable proportions causing harm to humans, other animals, vegetation and materials.

Troposphere:- The lowest region of atmosphere in which the human beings along with other organisms live is called troposphere. It extends up to the height of ~ 10 km from sea level.Troposphere is a turbulent,dusty zone containing air, much water vapour and clouds.

Tropospheric Pollution:- Tropospheric pollution occurs due to the presence of undesirable solid or gaseous particles in the air.

The following are the major gaseous and particulate pollutants present in the troposphere:

1. Gaseous air pollutants: These are oxides of sulphur, nitrogen and carbon, hydrogen sulphide, hydrocarbons, ozone and other oxidants.

2. Particulate pollutants: These are dust, mist, fumes, smoke, smog, etc.

Acid rain: Normally rain water has a pH of 5.6 due to the presence of H+ ions formed by the reaction of rain water with carbon dioxide present in the atmosphere.

$H_2O(l) + CO_2(g)$ ---- > $H_2CO_3(aq)$

Source: Burning of fossil fuels (which contain sulphur and nitrogenous matter) such as coal and oil in power stations and furnaces or petrol and diesel in motor engines produce sulphur dioxide and nitrogen oxides.

SO_2 and NO_2 after oxidation and reaction with water are major contributors to acid rain, because polluted air usually contains particulate matter that catalyses the oxidation.

Harmful effects:-

- Harmful for agriculture, trees and plants as it dissolves and washes away nutrients needed for their growth.
- Causes respiratory ailments in human beings and animals.
- Affects plant and animal life in aquatic ecosystem when acid rain falls and flows as ground water to reach rivers, lakes etc. Corrodes water pipes resulting in the leaching of heavy metals such as iron, lead and copper into the drinking water.
- Damages buildings and other structures made of stone or metal. The Taj Mahal in India has been affected by acid rain.

The gaseous pollutants come down to the earth in the form of **acid rain**.

Green house effect: About 75 % of the solar energy reaching the earth is absorbed by the earth's surface, which increases its temperature. The rest of the heat radiates back to the atmosphere. Some of the heat is trapped by gases such as carbon dioxide, methane, ozone, chlorofluorocarbon compounds (CFCs) and water vapour in the atmosphere. Thus, they add to the heating of the atmosphere. This causes global warming.

This trapping of the sun's heat near the earth's surface and keeping it warm is called natural greenhouse effect. It maintains the temperature and makes the earth perfect for life.

75% of the solar energy reaching earth is absorbed by the earth surface and rest is radiated back to the atmosphere. These gases mentioned above trap the heat which result into **global warming**.

It is important to realise that these very gases are also responsible for the life on the earth as they trap the requisite amount of solar energy for the sustainance of life. The increase in the **greenhouse gases** is raising the temperature of the earth's atmosphere which, if not checked, may eventually result in melting of polar ice caps and consequently may submerge the costal land mass.

Smog: Smoke is a mixture of smoke, dust particles and small drops of fog.

Classical Smog	Photochemical Smog
It occurs in cool humid climate.	It occurs in warm, dry and sunny climate.
It is a mixture of smoke, fog & sulphur dioxide.	Components of photochemical smog result from the action of sunlight on unsaturated hydrocarbons & oxides of nitrogen produced by automobiles & factories.
It is also called reducing smog.	It is also called oxidizing smog.

Stratosphere: Above the troposphere, between 10 and 50 km above sea level lies stratosphere. Ozone layer is one of the important constituents of stratosphere.The presence of ozone in the stratosphere prevents about 99.5 per cent of the sun's harmful ultraviolet (UV) radiations from reaching the earth's surface and thereby protecting humans and other animals from its effect.

Formation and Breakdown of Ozone

The upper stratosphere consists of considerable amount of ozone (O3), which protects us from the harmful ultraviolet (UV) radiations (255 nm) coming from the sun. The UV radiations split apart molecular oxygen into free oxygen (O) atoms. These oxygen atoms combine with the molecular oxygen to form ozone.

$$O_2\,(g) \xrightarrow{UV} O\,(g) + O\,(g)$$

$$O\,(g) + O_2\,(g) \rightleftharpoons O_3\,(g)$$

Ozone is thermodynamically unstable and decomposes to molecular oxygen. Thus, a dynamic equilibrium exists between the production and decomposition of ozone molecules.

Many human activities are producing chemicals, which are responsible for the **depletion of ozone layer** in the stratosphere, leading to the formation of **ozone hole**.

Depletion of ozone layer

The main reason of ozone layer depletion is believed to be the release of chlorofluorocarbon compounds (CFCs), also known as freons.

These compounds are used in refrigerators, air conditioners, in the production of plastic foam and by the electronic industry for cleaning computer parts etc.

Once CFCs are released in the atmosphere, they mix with the normal atmospheric gases and eventually reach the stratosphere. In stratosphere, they get broken down by powerful UV radiations, releasing chlorine free radical.

$CF_2Cl_2(g) \xrightarrow{UV} Cl^{\cdot}(g) + CF_2Cl^{\cdot}$ **(g)**

$Cl^{\cdot}(g) + O_3(g) \longrightarrow ClO^{\cdot}(g) + O_2$**(g)**

$ClO^{\cdot}(g) + O(g) \longrightarrow Cl^{\cdot}(g) + O_2(g)$

This way, the chlorine radicals are continuously regenerated and cause the breakdown of ozone layer. Thus, CFCs are transporting agents for continuously generating chlorine radicals into the stratosphere and damaging the ozone layer.

Effects of Depletion of the Ozone Layer

- UV radiations lead to ageing of skin, cataract, sunburn, skin cancer, killing of many phytoplanktons, damage to fish productivity etc.
- It has also been reported that plant proteins get easily affected by UV radiations which leads to the harmful mutation of cells.
- It also increases evaporation of surface water through the stomata of the leaves and decreases the moisture content of the soil.
- Increase in UV radiations damage paints and fibres, causing them to fade faster.

Water is the elixir of life but the same water, if polluted by pathogens,organic wastes, toxic heavy metals, pesticides etc., will turn into poison.

WATER POLLUTION

Water is essential for life. Pollution of water originates from human activities. Through different paths, pollution reaches surface or ground water. Easily identified source or place of
pollution is called as **point source**. e.g., municipal and industrial discharge pipes where pollutants enter the water-source.

Non point sources of pollution are those where a source of pollution cannot be easily identified, e.g., agricultural run off (from farm, animals and crop-lands), acid rain, storm-water drainage (from streets, parking lots and lawns), etc.

Causes of Water Pollution

(i) Pathogens: The most serious water pollutants are the disease causing agents called pathogens. Pathogens include bacteria and other organisms that enter water from domestic sewage and animal excreta. Human excreta contain bacteria such as *Escherichia coli* and *Streptococcus faecalis* which cause gastrointestinal diseases.

(ii) Organic wastes: The other major water pollutant is organic matter such as leaves, grass, trash, etc. They pollute water as a consequence of run off. Excessive phytoplankton growth within water is also a cause of water pollution. These wastes are biodegradable.

Major Water Pollutants

Pollutant	Source
Micro-organisms	Domestic sewage
Organic wastes	Domestic sewage, animal excreta and waste, decaying animals and plants, discharge from food processing factories.
Plant nutrients	Chemical fertilizers
Toxic heavy metals	Industries and chemical factories
Sediments	Erosion of soil by agriculture and strip mining
Pesticides	Chemicals used for killing insects, fungi and weeds

Biochemical Oxygen Demand (BOD): The amount of oxygen required by bacteria to break down the organic matter present in a certain volume of a sample of water is called BOD.

Eutrophication: The process in which nutrient enriched water bodies support a dense plant population, which kills animal life by depriving it of oxygen and results in subsequent loss of biodiversity, is known as eutrophication.

International Standards for Drinking Water

Fluoride: For drinking purposes, water should be tested for fluoride ion concentration. Its deficiency in drinking water is harmful to man and causes diseases such as tooth decay etc.Soluble fluoride is often added to drinking water to bring its concentration upto 1 ppm or 1 $mg\,dm^{-3}$.

Lead: Drinking water gets contaminated with lead when lead pipes are used for transportation of water. The prescribed upper limit concentration of lead in drinking water is about 50 ppb. Lead can damage kidney, liver, reproductive system, etc.

Sulphate: Excessive sulphate (>500 ppm) in drinking water causes laxative effect, otherwise at moderate levels it is harmless.

Nitrate: The maximum limit of nitrate in drinking water is 50 ppm. Excess nitrate in drinking water can cause disease such as methemoglobinemia ('blue baby' syndrome).

Other metals: The maximum concentration of some common metals recommended in drinking water.

Fe	0.2 ppm
Al	0.05 ppm
Mn	0.2 ppm
Cu	3.0 ppm
Zn	5.0 ppm
Cd	0.005 ppm

Therefore, one should take care to follow international standards to maintain purity levels of drinking water. Industrial wastes and excessive use of pesticides, result into pollution of landmass and water bodies.

Strategies for controlling environmental pollution can be:

Waste management i.e., reduction of the waste and proper disposal, also recycling of materials and energy,

a. Waste management

Seperate the waste as biodegradable and non- biodegradable waste:

Biodegradable waste: Generated by cotton mills, food processing units, paper mills, and textile factories.

Management: are deposited in landfills and are converted into compost.

Non - biodegradable water: Generated by thermal power plants which produce fly ash; integrated iron and steel plants which produce blast furnace slag and steel melting slag.

Management:

- Recycling

-Toxic wastes are usually destroyed by controlled incineration

Green chemistry: Green chemistry is a strategy to design chemical processes and products that reduces or eliminates the use and generation of hazardous substances. The chemical reactions should be such that the reactants are fully converted into useful environmental friendly products by using an environment friendly medium so that there would be no chemical pollutants introduced in the environment.

Green chemistry in everyday life:

- Dry cleaning of cloth is done with hydrogen peroxide to replace chlorine.
- Bleaching of paper is now done with hydrogen peroxide.
- Synthesis of chemicals like ethanal is done with one step oxidation process.