

# Environmental Chemistry

## Environmental Pollution

- Environmental pollution is the effect of undesirable changes in our surroundings that have harmful effects on plants, animals and human beings. A substance, which causes pollution, is known as pollutant
- Pollutants can be solid, liquid or gaseous substances present in great concentration than in natural abundance and are produced due to human activities or due to natural happenings.
- Pollutants can be degradable, like discarded vegetables which rapidly break down by natural processes.
- pollutants which are slowly degradable, remain in the environment in an unchanged form for many decades.
- For example, substances such as dichlorodiphenyl trichloroethane (DDT), plastic materials, heavy metals, many chemicals, nuclear wastes etc., once released into the environment are difficult to remove.

## ATMOSPHERIC POLLUTION

- 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
  - Above the troposphere, between 10 and 50 km above sea level lies stratosphere.
  - Troposphere is a turbulent, dusty zone containing air, much water vapour and clouds. This is the region of strong air movement and cloud formation.
  - The stratosphere contains dinitrogen, dioxygen, ozone and little water vapour
  - Atmospheric pollution is generally studied as tropospheric and stratospheric pollution
- 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.

## 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.

## 1. Gaseous air pollutants

### (a) Oxides of Sulphur:

- Oxides of sulphur are produced when sulphur containing fossil fuel is burnt.
- sulphur dioxide, is a gas that is poisonous to both animals and plants
- even a low concentration of sulphur dioxide causes respiratory diseases e.g. asthma, bronchitis,
- emphysema in human beings.
- Sulphur dioxide causes irritation to the eyes, resulting in tears and redness
- High concentration of SO<sub>2</sub> leads to stiffness of flower buds which eventually fall off from plants.
- Uncatalysed oxidation of sulphur dioxide is slow
- However, the presence of particulate matter in polluted air catalyses the oxidation of sulphur dioxide to sulphur trioxide

### (b) Oxides of Nitrogen:

- Dinitrogen and dioxygen are the main constituents of air. These gases do not react with each other at a normal temperature.
- At high altitude when lightning strikes, they combine to form oxides of nitrogen
- NO<sub>2</sub> is oxidised to nitrate ion, NO<sub>3</sub><sup>-</sup> which is washed into soil, where it serves as a fertilizer.
- In an automobile engine (at high temperature) when fossil fuel is burnt, dinitrogen and dioxygen combine to yield significant quantities of nitric oxide (NO) and nitrogen dioxide (NO<sub>2</sub>)
- Rate of production of NO<sub>2</sub> is faster when nitric oxide reacts with ozone in the stratosphere
- The irritating red haze in the traffic and congested places is due to oxides of nitrogen.
- Higher concentrations of NO<sub>2</sub> damage the leaves of plants and retard the rate of photosynthesis.
- Nitrogen dioxide is a lung irritant that can lead to an acute respiratory disease in children.
- It is toxic to living tissues also. Nitrogen dioxide is also harmful to various textile fibres and metals

### (c) Hydrocarbons:

- Hydrocarbons are composed of hydrogen and carbon only and are formed by incomplete combustion of fuel used in automobiles
- Hydrocarbons are carcinogenic, i.e., they cause cancer
- They harm plants by causing ageing, breakdown of tissues and shedding of leaves, flowers and twigs.

### (d) Oxides of Carbon

#### (i) Carbon monoxide:

- Carbon monoxide (CO) is one of the most serious air pollutants.
- It is a colourless and odourless gas, highly poisonous to living beings because of its ability to block the delivery of oxygen to the organs and tissues
- It is produced as a result of incomplete combustion of carbon
- Carbon monoxide is mainly released into the air by automobile exhaust.
- Other sources, which produce CO, involve incomplete combustion of coal, firewood, petrol, etc.

#### Why carbon monoxide is poisonous?

- It binds to haemoglobin to form carboxyhaemoglobin, which is about 300 times more stable than the oxygen-haemoglobin complex.
- In blood, when the concentration of carboxyhaemoglobin reaches about 3–4 per cent, the oxygen carrying capacity of blood is greatly reduced.
- This oxygen deficiency, results into headache, weak eyesight, nervousness and cardiovascular disorder
- This is the reason why people are advised not to smoke.
- In pregnant women who have the habit of smoking the increased CO level in blood may induce premature birth, spontaneous abortions and deformed babies.

#### (ii) Carbon dioxide:

- Carbon dioxide (CO<sub>2</sub>) is released into the atmosphere by respiration, burning of fossil fuels for energy, and by decomposition of limestone during the manufacture of cement.
- It is also emitted during volcanic eruptions.
- Carbon dioxide gas is confined to troposphere only.

- Normally it forms about 0.03 per cent by volume of the atmosphere.
- With the increased use of fossil fuels, a large amount of carbon dioxide gets released into the atmosphere.
- Excess of CO<sub>2</sub> in the air is removed by green plants and this maintains an appropriate level of CO<sub>2</sub> in the atmosphere.
- Green plants require CO<sub>2</sub> for photosynthesis and they, in turn, emit oxygen, thus maintaining the delicate balance.
- deforestation and burning of fossil fuel increases the CO<sub>2</sub> level and disturb the balance in the atmosphere. The increased amount of CO<sub>2</sub> in the air is mainly responsible for global warming.

### **Global Warming and Greenhouse 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.
- atmosphere traps the sun's heat near the earth's surface and keeps it warm. This is called natural greenhouse effect because it maintains the temperature and makes the earth perfect for life.
- carbon dioxide molecule also trap heat as they are transparent to sunlight but not to the heat radiation.
- If the amount of carbon dioxide crosses the delicate proportion of 0.03 per cent, the natural greenhouse balance may get disturbed.
- Carbon dioxide is the major contributor to global warming
- Besides carbon dioxide, other greenhouse gases are methane, water vapour, nitrous oxide, CFC and ozone.
- Methane is produced naturally when vegetation is burnt, digested or rotted in the absence of oxygen
- Large amounts of methane are released in paddy fields, coal mines, from rotting garbage dumps and by fossil fuels.
- Chlorofluorocarbons (CFCs) are man-made industrial chemicals used in air conditioning etc.
- CFCs are so damaging the ozone layer (Section 14.2.2). Nitrous oxide occurs naturally in the environment.
- In recent years, their quantities have increased significantly due to the use of chemical fertilizers and the burning of fossil fuels

- If these trends continue, the average global temperature will increase to a level which may lead to melting of polar ice caps and flooding of low lying areas all over the earth.
- Increase in the global temperature increases the incidence of infectious diseases like dengue malaria, yellow fever, sleeping sickness, etc.

### **What can we do to reduce the rate of global warming?**

- minimise the use of automobiles. one can use bicycle, public transport system, or go for carpool.
- plant more trees to increase the green cover.
- Avoid burning of dry leaves, wood etc. It is illegal to smoke in public place and work places

### **Acid rain**

- When the pH of the rain water drops below 5.6, it is called acid rain
- Acid rain refers to the ways in which acid from the atmosphere is deposited on the earth's surface.
- Oxides of nitrogen and sulphur which are acidic in nature can be blown by wind along with solid particles in the atmosphere and finally settle down either on the ground as dry deposition or in water, fog and snow as wet deposition.
- Acid rain is a byproduct of a variety of human activities that emit the oxides of sulphur and nitrogen in the atmosphere
- 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<sub>2</sub> and NO<sub>2</sub> after oxidation and reaction with water are major contributors to acid rain
- Aerosol particles of oxides or ammonium salts in rain drops result in wet deposition
- SO<sub>2</sub> is also absorbed directly on both solid and liquid ground surfaces and is thus deposited as dry deposition.