

## 14. Environmental Chemistry

When some chemical species (*pollutants* - either naturally occurring or human generated) increase beyond a certain limit in the environment, it cause pollution.

### ATMOSPHERIC POLLUTION

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

#### TROPOSPHERIC POLLUTION

**Troposphere** is the lowest region of the atmosphere (~10 km) in which man along with other organisms including plants exist.

- Tropospheric pollution is due to-
  - Gaseous pollutants**- Various oxides of sulphur, nitrogen, carbon, halogens etc.
  - Particulate pollutants**- Dust, mist, pesticides, smoke, smog, pollen grain, bacteria etc.

#### Gaseous Pollutants

##### I. Oxides of Sulphur: SO<sub>2</sub>, SO<sub>3</sub>

- ◆ **Source:** Burning of sulphur containing **fossil fuel**.
- ◆ **Harmful effects:**
  - Causes **respiratory diseases** e.g., asthma, bronchitis, emphysema.
  - Causes **irritation to the eyes**, resulting in tears and redness.
  - Leads to **stiffness of flower buds** which eventually fall off from plants.

##### II. Oxides of Nitrogen: NO, NO<sub>2</sub>

- ◆ **Source:** Combination of N<sub>2</sub> and O<sub>2</sub> at high altitudes when **lightning** strikes or when **fossil fuel** is burnt.
- ◆ **Harmful effects:**
  - Causes acute **respiratory disease** in children.
  - Damage the **leaves of plants** and retard the rate of photosynthesis.

##### III. Oxides of Carbon: CO, CO<sub>2</sub>

- ◆ **Source:** **Incomplete combustion** of coal, firewood, petrol, during volcanic eruptions etc.
- ◆ **Harmful effects:**
  - **Block the delivery of O<sub>2</sub>** to the organs, results in headache, weak eyesight and cardiovascular disorder.

#### Greenhouse Effect & Global Warming

- Greenhouse Effect:** It is a **natural** phenomenon in which the atmospheric gases (CO<sub>2</sub>, CH<sub>4</sub>, O<sub>3</sub>, CFC's, water vapour etc.) traps the requisite amount of solar energy for the sustenance of life.
- Global warming:** It is the **raise in temperature** of the earth's atmosphere due to increase in the **greenhouse gases**.
  - **Consequence-** **Melting of polar ice caps** and submergence of the costal areas
    - Increases the incidence of **infectious diseases** like dengue, malaria, yellow fever, sleeping sickness etc.
  - **Control measures:** Minimise the use of automobiles, afforestation etc.

#### Acid Rain

- The gaseous pollutants come down to the earth in the form of acid rain.
  - **Consequence-** Harmful for agriculture, trees and plants as rain dissolves and **washes away nutrients** needed for their growth.
    - It causes **respiratory ailments** in human beings and animals.
    - It affects plants and animal **life in aquatic** ecosystem.
    - It **corrodes water pipes** resulting in the leaching of metals such as Fe, Pb and Cu into the drinking water.
    - **Damages buildings** and other structures made of stone or metal.
  - **Control measures:** Use **less sulphur content fuels** for power plants and industries.
    - Use **catalytic converters** in vehicles which convert unburnt fuel, CO and NO<sub>x</sub> in exhaust gas into CO<sub>2</sub> and N<sub>2</sub>.

#### Particulate Pollutants

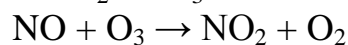
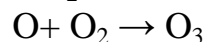
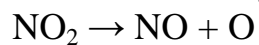
- Particulates in the atmosphere may be viable or non-viable,
  - Viable particulates** - Minute living organisms that are dispersed in the atmosphere.
    - Ex:** Bacteria, fungi, moulds, algae etc.
  - Non-viable particulates** - Minute solid particles or liquid droplets in air.
    - Non-viable particulates may be classified according to their nature and size as follows:
      - Smoke** particulates consist of solid or mixture of solid and liquid particles formed during combustion of organic matter.
        - Ex:** Cigarette smoke, smoke from burning of fossil fuel, garbage and dry leaves, oil smoke etc.
      - Dust** is composed of fine solid particles (over 1µm in diameter), produced during crushing, grinding and attribution of solid materials.
        - Ex:** Sand from sand blasting, saw dust from wood works, pulverized coal, cement and fly ash from factories, dust storms etc.
      - Mists** are produced by particles of spray liquids and by condensation of vapours in air.
        - Ex:** Sulphuric acid mist and herbicides and insecticides that miss their targets and travel through air and form mists.
      - Fumes** are obtained by the condensation of vapours during sublimation, distillation, boiling and several other chemical reactions.
        - Ex:** Fumes from organic solvents, metals and metallic oxides.

## Smog

- **Smog:** It is the combination of smoke and fog in atmosphere. There are two types of smog:
  - (i) **Classical smog** occurs in cool humid climate. It is a mixture of smoke, fog and  $\text{SO}_2$ .
  - (ii) **Photochemical smog** occurs in warm, dry and sunny climate.

### Formation of photochemical smog

Photochemical smog is produced by the action of sunlight on hydrocarbons and  $\text{NO}_x$  produced by automobiles and factories.



- Both  $\text{NO}_2$  and  $\text{O}_3$  are strong oxidising agents and can react with the unburnt hydrocarbons in the polluted air to produce chemicals such as formaldehyde, acrolein and peroxyacetyl nitrate (PAN).

### Effects of photochemical smog

- $\text{O}_3$  and PAN cause **eye irritation**.
- $\text{O}_3$  and NO **irritate the respiratory system**.
- Leads to **cracking of rubber** and extensive damage to plant life.
- It causes **corrosion** of metals, building materials etc.

### Control measures of photochemical smog

- Use **catalytic converters** in automobiles (prevent the release of NO and HC).
- Plantation of plants** like *Pinus*, *Juniparus*, *Quercus*, *Pyrus* and *Vitis* which metabolise NO.

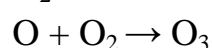
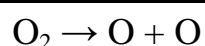
## STRATOSPHERIC POLLUTION

**Stratosphere** extends above troposphere up to 50 km above sea level.

## Ozone hole

**Ozone layer** is one of the important constituents of stratosphere. Ozone absorbs UV radiation coming from the sun and thus protect from the harmful effects of UV radiation.

### Formation & breakdown of Ozone



### Depletion of Ozone

**CFC (freon)** causes the depletion of ozone layer.

- ◆ **Sources:** Used in refrigerators, air conditioners, in the production of plastic foam and by the electronic industry for cleaning computer parts etc.

In stratosphere, CFC broken down by powerful UV radiations, releasing chlorine free radical and cause the breakdown of ozone.

### Harmful effects of UV radiation

- Lead to ageing of skin, cataract, sunburn, skin cancer etc.
- Increases evaporation of surface water through the stomata of the leaves and decreases the moisture content of the soil.
- Cause mutation of genes.

## WATER POLLUTION

Pollution of water originates from human activities.

### Causes of Water pollution

(i) **Pathogens:** Reach water from domestic sewage and animal excreta. ex: *Escherichia coli*, *Streptococcus faecalis*.

(ii) **Organic wastes:** Leaves, grass, trash etc.

**BOD** (Biochemical Oxygen Demand) is the amount of  $\text{O}_2$  needed by bacteria to oxidise the organic matter in a unit volume of water.

**Polluted water** has more than 17ppm BOD while less than 5ppm in clean water.

(iii) **Chemical Pollutants:** Heavy metals (Cd, Hg, Ni etc.), Acids (like sulphuric acid), Salts (used to melt snow), Petroleum products, industrial chemicals (like polychlorinated biphenyls-PCB), detergents, pesticides, fertilizers etc.

- ❖ The addition of large amount of nutrients (especially **phosphates**) in water enhances algae growth (**algal bloom**), which kills animal life by depriving it of  $\text{O}_2$  and results in subsequent loss of biodiversity is known as **Eutrophication**.

### The international standards of drinking water

Element	Desired concentration	Health issues
Fluoride	> 1 ppm	Deficiency cause tooth decay. Excess causes brown mottling of teeth.
Lead	> 50 ppb	Excess lead damage kidney, liver, reproductive system etc.
Sulphate	> 500 ppm	Excess sulphate causes laxative effect
Nitrate	> 50 ppm	Excess nitrate cause methemoglobinemia ('blue baby' syndrome).

### Control measures of water pollution

- Do not dump waste into any water body.
- Use compost instead of chemical fertilizers in gardens.
- Avoid the use of pesticides like DDT, malathion etc., at home and try to use dried neem leaves to help keep insects away.
- Add  $\text{KMnO}_4$  or bleaching powder to clean the water tank.

## SOIL POLLUTION

Indiscriminate use of pesticides, herbicides, insecticides, fertilisers cause soil pollution.

### Harmful effects

- Use of insecticide (eg: DDT-1,4 Dichlorodiphenyl Trichloro methane) give rise to resistant variety of insects.
- The toxins present in soil transferred from lower to higher trophic level through food chain. In higher animals, it causes metabolic and physiological disorders.
- Use of herbicides (eg: sodium chlorate-  $\text{NaClO}_3$ , sodium arsinite-  $\text{Na}_3\text{AsO}_3$ ) cause birth defects.

## INDUSTRIAL WASTES

Industrial solid wastes are classified as-

- Biodegradable**- Wastes generated by cotton mills, food processing units, paper mills, and textile factories.
- Non-degradable** - Fly ash from thermal power plants, blast furnace slag and steel melting slag from iron-steel plants, waste from aluminium industries, gypsum from fertilizer industry etc.

### Control measures

- Fly ash and slag from the steel industry are utilised by the cement industry
- Large quantities of wastes are destroyed by controlled incineration, whereas small quantities are burnt along with factory garbage in bins.
- Biodegradable wastes are deposited in land fills and are converted into compost.  
Non-biodegradable materials such as plastic, glass, metal scraps etc. are sent for recycling.

## GREEN CHEMISTRY

Green chemistry is a cost effective approach which involves reduction in material, energy consumption and waste generation.

### Application

Field	Old practice	Modern practice
Dry cleaning of clothes	Using <b>Tetra chlroroethene</b> ➤ Disadvantage- Contaminates the ground water and is carcinogenic.	Using <b>liquefied <math>\text{CO}_2</math></b> with a suitable detergent is used. ➤ Advantage- Harmless to ground water Using <b><math>\text{H}_2\text{O}_2</math></b> ➤ Advantage- Need less amount of water
Bleaching of paper	Using <b>Chlorine gas</b>	Using <b><math>\text{H}_2\text{O}_2</math></b>