HS I - NCERT Syllabus

Environmental Chemistry

Environmental Pollution

Contamination of the environment (*ie*, our surroundings such as air, water, soil etc) with harmful wastes arising mainly from certain human activities is called environmental pollution.

Pollutants

Any substance which pollute the environment is known as **pollutant**. A substance becomes a pollutant when it is present in concentrations harmful to the natural environment.

Primary Pollutants

These are the pollutants persisting in the environment in the form, they are produced, *eg*, carbon monoxide.

Secondary Pollutants

These are formed by the combination of primary pollutants present in the environment, *eg*, two primary pollutants, nitrogen oxides and hydrocarbons, react together in the presence of sunlight to form secondary pollutant, peroxyacetyl nitrate, (PAN).

Biodegradable Pollutants

Biodegradable pollutants are those which are decomposed by microorganisms either by itself or by suitable treatment, *eg*, sewage, various oxides of nitrogen and sulphur etc.

Non-Biodegradable Pollutants

Non-biodegradable pollutants are not decomposed naturally and are not recycled. They are harmful to environment even in low concentrations, *eg*, aluminium cans, Hg^{2+} salts, lead components etc.

Types of Pollution

On the Basis of Pollutant

(i) Thermal pollution, (ii) Noise pollution,
(iii) Chemical pollution, (iv) Metal pollution,
(v) Smog pollution, (vi) Oil pollution.

On the Basis of Part of Environment Polluted

(i) Air pollution, (ii) Water pollution
(iii) Soil pollution.

24.4 Air Pollution

Structure of Atmosphere

The lowest region, called the troposphere extends up to the height of ~ 10 km from sea level. Above troposphere, between 10 and 50 km above sea level, lies the **stratosphere**. Troposphere contains about 80% of the total mass of air and water vapours while stratosphere contains nitrogen, oxygen and ozone.

- **Mesosphere** extends 50–85 km from earth surface. N_2 and O_2 are present in low concentration in this region.
- **Thermosphere** extends between 85-500 km from earth surface and in it temperature rises to 1200°C.

Sources of Air Pollution

Addition of undesirable substances into atmosphere either by natural or artificial activity is known as air pollution. Sources of air pollution are :

(i) Burning of fossil fuel such as coal, wood and oil.
(ii) Exhaust gases emitted by internal combustion engines of vehicles.
(iii) Chemical industries and their released products.

Various Air Pollutants

CO_2 — release from decomposition of organic matter, from oceans and from fossil fuel combustion. **Concentration** – 330 ppm throughout troposphere.

CO – release from decomposition of organic matter, industrial processes and from fuel combustion. **Concentration** – 1 to 50 ppm in urban traffic areas.

CH_4 — release from decomposition of organic matter, natural gas seepage. **Concentration** – 1 to 2 ppm throughout troposphere.

NO – release from electrical discharges, internal combustion engines, combustion of organic matter. **Concentration** – 0.2 ppm in smog atmospheres.

O_3– release from electrical discharges, diffusion from stratosphere, photochemical smog. **Concentration** – 0.5 ppm in photochemical smog.

SO_2– release from volcanic gases, forest fires, bacterial action, industrial processes such as roasting and from fossil fuel combustion.

Particulates Particulates in atmosphere may be viable or non viable. The viable particulates are the minute living organisms such as bacteria, fungi that are dispersed in atmosphere. Human beings are allergic to some of the fungi found in air. Mist, smoke, fumes and dust are non viable particulates in atmosphere.

Classical and photochemical smog Smog is the combination of smoke particles with tiny droplets of fog.

- SO_2 and particulate matter are main components of **classical smog**. It is mostly observed in cool humid climate. It is chemically reducing in nature.
- **Photochemical smog** contains a mixture of primary pollutants such as nitrogen oxides and carbon monoxides and secondary pollutants such as O_3 and HCHO. It occurs in warm, dry and sunny climate and are caused by the action of sunlight on nitrogen oxides and hydrocarbons. It is oxidising in nature. Its formation can be shown as follows :

$$N_2 + O_2 \rightarrow 2\,NO \quad \text{(in automobile engines or power plant)}$$

$$2\,NO + O_2 \rightarrow 2\,NO_2 \quad \text{(Oxidation in air)}$$

$$NO + O_3 \xrightarrow{\text{(air)}} NO_2 + O_2$$

$$NO_2 \rightarrow NO + \underset{\text{atomic oxygen}}{O}$$

$$O + O_2 \rightarrow O_3$$

Both NO_2 and O_3 are strong oxidising agents.

$$3CH_4 + 2O_3 \rightarrow 3\,HCHO + 3\,H_2O$$

$$\text{Hydrocarbons} + O_3, O_2, O, NO, NO_2 \rightarrow \underbrace{R-\overset{\overset{O}{\|}}{C}-O-O-NO_2}_{\text{PAN}} + HCHO + \underbrace{CH_2=CH-CHO}_{\text{acrolein}}$$

photochemical smog

Effect of Air Pollution

(i) Ozone depletion Chlorofluorocarbons present in aerosols and air conditioning and refrigeration devices destroys ozone layer and reduces our protection against UV rays from the sun.

$$CF_2Cl_2 + h\nu \rightarrow Cl^\bullet + {}^\bullet CF_2Cl$$

$$Cl^\bullet + O_3 \rightarrow ClO^\bullet + O_2$$

$$ClO^\bullet + O \rightarrow Cl^\bullet + O_2$$

- One molecule of CFC can destroy more than thousand molecules of O_3. This leads to the formation of ozone hole.
- CFCs are stable in lower atmosphere but when they reach the stratosphere, they split and become unstable by sunlight.

Ozone depletion in Antarctica In stratosphere NO_2 and CH_4 acts as scavangers, for $ClO^\bullet$ and $Cl^\bullet$.

$$ClO^\bullet + NO_2 \rightarrow \underset{\text{chlorine nitrate}}{ClONO_2}$$

$$Cl^\bullet + CH_4 \rightarrow {}^\bullet CH_3 + HCl$$

Polar stratospheric clouds (PSCs) are formed over Antarctica in winter. These are of two types : type–I clouds (contain solidified $HNO_3 \cdot 3H_2O$) and type–II clouds (contain some ice). These clouds play an important role in ozone depletion.

$$ClONO_2 + H_2O \rightarrow HOCl + HNO_3$$

$$ClONO_2 + HCl \rightarrow Cl_2 + HNO_3$$

- The ozone depletion over Antarctica occurs during spring but gets replenished after spring is over. During spring,

$$HOCl + h\nu \rightarrow OH^{\bullet} + Cl^{\bullet}$$

$$Cl_2 + h\nu \rightarrow 2Cl^{\bullet}$$

(ii) **Global Warming** Green house gases such as CO_2, CH_4, O_3, CFCs, CCl_4, water vapours and nitrous oxide are responsible for global warming. Global warming causes polar ice caps to melt, raising sea levels and possibly flooding of many low lying areas of land.

(iii) **Diseases** Inhalation of metallic particles, flyash etc leads to respiratory disorders like asthama, bronchitis, lung cancer etc.

(iv) **Material damage** Oxides of nitrogen and sulphur in atmosphere causes **acid rain**. Acid rain causes extensive damage to building and sculptural materials of marble, limestone, slate, mortar etc. Fumes released by Mathura refinery lead to acid rains and damage to Taj Mahal at Agra.

- Acid rain is toxic to vegetation and aquatic life as it dissolves heavy metals from soils, rocks and sediments.

Remedial Measures

Industries should purify the smoke to a certain extent before releasing into air. They should use chimneys.

- Planting more and more trees is also a method to maintain the oxygen– carbon dioxide balance.

Water Pollution

It is the degradation of quality of water due to addition of inorganic, organic, biological or radiological substances, factors (*eg*, heat) and deprivation that makes it health hazard, unfit for human use and growth of aquatic biota.

Sources of Water Pollution

Natural sources of water pollution Leaching of minerals, silt from soil erosion and falling of organic matter from banks are the important natural sources of water pollution.

Man made sources of water pollution Sewage, domestic waste soaps and detergents, run off from agricultural fields having fertilizers and pesticides, industrial wastes, heat, waste from animal sheds and slaughter houses, oil pollution etc are the man made sources of water pollution.

Biochemical Oxygen Demand (BOD)

$$BOD = \frac{\text{number of milligrams of } O_2 \text{ needed}}{\text{number of litres of the sample}}$$

To determine BOD, water sample is first saturated with oxygen and then incubated at constant temperature for five days.

Chemical Oxygen Demand (COD)

In COD determination, a known quantity of water sample is oxidised by acidified $K_2Cr_2O_7$. The unused amount of dichromate is determined by back titration. The amount of oxygen used in oxidation is calculated from consumed concentration of $K_2Cr_2O_7$.

Effect of Water Pollution

- High concentration of fluoride are poisonous and are harmful to bones and teeth at levels over 10 ppm.
- Excessive sulphate (>500 ppm) have a laxative effect.
- Excess nitrate in drinking water can lead to blue baby syndrome (methemoglobinemia).

Remedial Measures

Sewage treatment Removal of large solids from waste water by filtration. (solids are disposed off in land fill sites)

- Settlement of the filtered waste water to remove suspended solids, oily and greasy material which floats on the surface can be skimmed off.
- Degradation of organic content of waste water by microbial oxidation.
- Removal of phosphates, coagulation, filtration, and disinfection using chlorine for improving the quality of waste water.

Soil or Land Pollution

Soil pollution is the addition of such chemical substances (in an indefinite proportion) which decrease its productivity, quality of plants and ground water, to the soil system. The polluted soil produces inferior quality of crop.

Causes of Soil Pollution

- Erosion of upper fertile layer and over use of the land.
- Addition of undesirable substances such as pesticides, fertilizers, industrial wastes and air pollutants washed down by rain.
- Dumping of waste such as garbage, rubbish, industrial wastes ash, sludge, broken cans and bottles etc.

Remedial Measures

- Forestation to check the spread of desert.
- Chemicals like fertilizers, insecticides, polymers, pesticides and herbicides should be used, only when necessary.
- Using, sanitary land fills.
- **Recycling**, *ie*, conversion of waste into useful products. It saves raw materials and reduces the cost of waste disposal, *eg*, recycling glass bottles, scrap metal in the manufacture of steel, generation of energy by burning combustible waste.
- **Incineration**, *ie*, reduction of many combustible wastes from households, hospitals etc, to ash by burning it at very high temperature (> 1000°C) in excess of oxygen. This is one of the best methods for disposal of polychlorinated biphenyls (PCBs) as high temperature breaks C — Cl bonds.
- **Digestion**, *ie*, conversion of the organic material (C,H,O) into carbon dioxide and methane by microorganisms (anaerobic digestion).

Green Chemistry

- It is an alternative tool for reducing pollution.
- It refers to the production of substances of daily use by chemical reactions which neither employ toxic chemicals nor release the same to atmosphere.
- Green chemistry includes concepts such as waste minimisation, solvent selection, atom utilisation, intensive processing and alternative synthetic routes from sustainable resources.

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