

Environmental Chemistry

Introduction

- The word **Environment**, derived from Greek, literally **means surroundings**.
- The term encompasses the surrounding objects, regions, conditions and especially circumstances of life of all living beings.
- Environmental chemistry deals with the study of chemical phenomena in the environment.
- It includes the study of the sources, reactions and fates of the chemical species in the air, water and soil environments

Ecology or environmental biology.

- The study of the interactions between the different types of living organisms as well as that between the living organisms and the non-living components of the environment is called **ecology or environmental biology.**

Environment can be defined as the sum total of all social, economical, biological, physical and chemical factors which constitute the surroundings and influence the life of a living organism in its habitat.

Environment consists of the following **three** components :

1. **Abiotic or non-living component** : This consists of the lithosphere (solid earth), hydrosphere (water component) and atmosphere (gaseous envelope).
2. **Biotic or living component** : This consists of all living organisms.
3. **Energy component** : This includes solar energy, geochemical energy, thermoelectrical energy, hydroelectrical energy, nuclear energy, etc.

Segments of Environment

Four segments-atmosphere, hydrosphere, lithosphere and biosphere.

i) **Atmosphere** : Atmosphere is the **protective cover** of gases surrounding the earth which sustains life on earth and saves it from the hostile environment of outer space.

- Its major components -nitrogen and oxygen.
-also contains some CO_2 , argon and ozone as well as traces of He, Ne, CH_4 , etc.

Functions of atmosphere

1. It absorbs most of the **cosmic rays and all the harmful solar radiations**. It allows only the near ultraviolet, near infrared and radiofrequency waves to pass through it towards the earth.
2. It absorbs part of **infrared radiation emitted by the sun and also that re-emitted by the earth**. It thereby maintains the **thermal balance** of the earth.
3. It acts as the **source of oxygen** for living organisms, CO₂ and nitrogen for plants, nitrogen-fixing bacteria, etc.
4. It acts as the **vital carrier of water** from the oceans to land as part of the hydrological cycle.

(ii) **Hydrosphere** : includes all types of water resources, namely oceans, seas, rivers, lakes, streams, glaciers, polar ice caps, ground water, etc.

About 97% of earth's water is in the oceans and about 2% is tied up in the polar ice caps and glaciers.

- -- only about **1% is available in fresh water bodies like the rivers, lakes, streams, etc.** and as ground water which is fit for human consumption and for other uses.

- (iii) **Lithosphere** : Lithosphere is the outer mantle of solid earth, **consisting of minerals occurring in the earth's crust in the form of soil, rocks, etc.** Soil, in fact, comprises of a mixture of minerals, organic matter, weathered rocks, air and water. Rocks consist of various minerals like asbestos, gypsum, clay, haematite, calcite, quartz, etc.
- (iv) **Biosphere** : Biosphere denotes the realm of **living organism and their interactions** with the environment, namely lithosphere, hydrosphere and atmosphere.

ENVIRONMENTAL POLLUTION

Pollution and pollutant

- The contamination of any part of our environment, particularly through human activities, by undesirable substances which ultimately have a detrimental effect on the environment is called **environmental pollution**.
- Any substance present in nature in quantities greater than natural abundance due to human activities, and which is ultimately harmful to the environment and there-from to the living systems, is called a **pollutant**.

- In short, any substance or agent or factor that causes environmental pollution is known as a pollutant.
- Pollutants -several types depending upon where each pollutant acts.
- --there are air pollutants, water pollutants, soil pollutants, etc.
 - e.g., --Gases such as CO, SO₂, NO₂, etc. are air pollutants.
 - pesticides, fertilizers, detergents, acids, salts, etc. are water pollutants .
 - metals and their compounds, plastics, fertilizers, pesticides, etc. are soil pollutants.

Classification of Pollutants

One and the same substance may pollute air, water and soil at the same time.

(i) **Degradable** or non-persistent pollutants are those which are degradable by natural processes.

e.g., Vegetable waste, domestic sewage, etc.

(ii) **Slowly degradable** or persistent pollutants are those which remain in the environment in an unchanged form for many decades,

e.g., Pesticides such as DDT, plastics, many chemicals, nuclear wastes, etc.

(iii) **Non-degradable** pollutants are those that are not broken down by natural processes and therefore continue to accumulate in the environment from continued release.

- e.g., Toxic metals like lead, cadmium, mercury, etc.

Environmental pollution is directly related to the unbridled human population explosion and the rapid strides in urbanization and industrialization.

- It poisons the whole biosphere, brings about unfavourable changes in climate and other environmental conditions and poses a serious threat to the normal existence of living organisms.

WATER POLLUTION -Introduction

Water pollution is the contamination of water by foreign substances which unfavourably **alter its quality and characteristics** such that its normal functions and usefulness in domestic, agricultural, industrial, etc. fields are adversely affected or it constitutes a health hazard to living things.

Major sources of water pollution

- include domestic waste from urban and rural areas, industrial effluents, agricultural run-off water, etc. which are discharged into our natural water bodies.
- A **water pollutant** is a substance, agent or factor which degrades the quality of water so as to cause detrimental effects on consumers or on aquatic life.

Eg:, sewage, detergents, toxic heavy metals, fertilizers, pesticides, hazardous organic substances, etc.

Some of the water pollutant

(a) Water pollution by sewage

----Sewage consists of **organic and inorganic waste matter** of the community carried by water.

Eg:, the domestic sewage discharged to the near by water bodies like rivers, lakes or coastal waters.

water pollution problems

1. Sewage induces a foul odour or stench to water, imparts colour to it and causes turbidity.

2. As sewage contains human and animal excreta, it is the carrier of several **pathogenic microorganisms**.

-- It can cause immense harm to public health by spreading diseases.

Typhoid, paratyphoid, cholera, polio, etc. are waterborne diseases.

3. Organic pollution of water by sewage causes **dissolved oxygen depletion** because the microbial degradation of these organic substances consumes dissolved oxygen. This leads to fish kills.
4. Sewage contains huge quantities of nutrients in the form of nitrogen and phosphorus. This leads to **eutrophication** (Increases in algal productivity) which favours algal growth and results in algal bloom.

Control of pollution by sewage treatment

Pollution can be controlled by sewage treatment before discharge.

The process involves **Three** steps.

- **Primary** treatment re-moves settleable solids physically or chemically.
- **Secondary** treatment or biological treatment using aerobic and anaerobic microorganisms removes organic matter.
- **Tertiary** treatment involves advanced biological, chemical and physical treatment and also recycling.

b) Water pollution by industrial effluents

1. Effluents from **pulp and paper mills, sugar factories, organic chemical plants, pharmaceutical, plants, dairies, tanneries, distilleries**, etc. substantially pollute water bodies with organic matter.
2. The effluents from **fertilizer industries** release substantial quantities of nutrients into water bodies causing eutrophication.
3. Wastes released into water from **metal plating industries** contain large quantities of **heavy metals and cyanide**.
4. Effluents from **chemical factories** contain **acidic and alkaline** compounds which make water corrosive and are harmful to aquatic organisms.
5. **Paper mills** release effluents containing **mercuric compounds** which are used as fungicides. These are highly poisonous and carcinogenic.
6. **Radioactive wastes** discharged into water from uranium plants and atomic energy plants cause radiation pollution.etc

Control of pollution

Treatment involves,

Primarily, chemical treatment to bring about neutralization coagulation, oxidation, etc.

Secondary treatment uses microorganisms .

Tertiary treatment involves advanced biological, chemical and physical methods and recycling

c) Water pollution by soaps and detergents

- Domestic sewage and effluents **from soap and detergent factories** introduce a large quantity of soaps and detergents into fresh water bodies.
- Soaps are easily degraded by microorganisms and pose no serious problems to the receiving water with respect to degradability.
- **But** they are hydrolysed to the corresponding fatty acids which, in turn, increase the organic content of water. This leads to depletion of dissolved oxygen in water destroying aquatic organisms.
- Soaps also cause turbidity in water.
- Detergents belonging to the **tetrapropylene benzene sulphonate (TPBS) category** have the greatest **disadvantage** that they are not fully biodegradable by microorganisms.
- Such detergents do an excellent job of cleaning, but are not degraded in sewage treatment plants and thus make their way from washing buckets and washing machines directly to the water bodies.
- Detergents belonging to the linear **alkyl benzene sulphonate (LAS)** class and non-ionic esters of sucrose are much more biodegradable.

d) Pesticides

Pesticides like **DDT, chlordane, lindane, malathion, parathion, baygon**, etc. enter our water bodies by agricultural run-off, deposition from air and by direct sprays on water surface to kill mosquitoes and other pests.

- Once they enter into the aquatic ecosystem, they concentrate in all components of the system.
- They remain in water as in soluble or suspended form or get absorbed on the surface of silt and organic particles which sediment.
- From there, they enter into the food chain through bacteria, phytoplankton, other aquatic organisms and so on.
- By the process of biomagnification, the concentration of the pesticide residues increases on moving up in the food chain.

- In organisms placed at **the end of the food chains** like fish, aquatic birds and man, they are liable to **accumulate in a very high concentration.**
- These are **highly toxic** to all types of living organisms including animals and plants. They kill and destroy all organisms.
- In humans, the **chlorinated hydrocarbons** mainly affect the central nervous system while **others** affect the **circulatory or reproductive systems.**

Their toxic effects on humans are mentioned below:

1. Chlorinated hydrocarbon pesticides -cause hormonal imbalance, cancer of the organs, leukaemia, etc.
2. Organophosphate pesticides -the transmission of nerve impulses, causing unconditioned tremors, spasms, convulsions and paralysis.
3. Pesticides inhibit production and functioning of sex hormones, leading to sterility.
4. Higher concentrations of pesticides in pregnant women may result in abortions, still births and infant deformities.
5. Pesticides cause hypertension and damage to kidneys.

Several types of fish, crabs, fish-eating birds, etc. have been wiped out, or their population decreased, in various regions of the earth on account of pesticide pollution.

e) Fertilizers

Modern methods of agriculture, since the so called **green revolution**, use immense quantities of nitrogenous, phosphatic and potash fertilizers.

In most cases, a **large excess of fertilizer** than needed is being added to the fields.

As a result, a large quantity of these are carried from the fields by **agricultural run-off water into fresh water bodies causing pollution problems.**

- At high concentration, this contamination results from phosphate and nitrate ions present in fertilizers. These make fresh water bodies nutrient-rich. This is called **eutrophication**.
- This favours massive algal growth making it a dead pool of water.
- Further, the excessive growth of algae and aquatic weeds destroys the natural beauty in and around the water body and obstructively prevent the recreational and transportational uses of water.

- When water polluted with nitrates is consumed by humans, **nitrates** are **reduced** to **nitrites** by intestinal bacteria.
- Nitrites cause the serious methemoglobinemia ('blue baby syndrome') in which **nitrite reduces oxygen-carrying capacity of blood causing** suffocation as well as damage to respiratory and vascular systems.

Control of water pollution by fertilizers

- can be achieved by the use of biofertilizers.
- These involve the use of efficient strains of microorganisms like Rhizobium, Azospirillum, Azobacter, etc. or blue green algae capable of converting atmospheric nitrogen into nitrate.
- PSM capable of solubilizing phosphate to fixed form. They are cheaper, renewable and pollution-free.

(f) Heavy metals

Substantial pollution by heavy metals is caused by discharge of effluents from mining and ore-processing, metal plating, chemical, paint, leather and a host of other industries.

1. Lead in natural water

--- is caused by effluents from of industries such as petroleum, paint, ceramics, battery and plastics, burning of leaded gasoline, use of the pesticide lead arsenate, etc.

Lead is highly toxic to all living organisms.

Lead affects aquatic even in very small concentrations.

In animals and man, lead accumulates in bones from where it comes into circulation in the body, particularly at the time of stress or illness.

Lead interacts with the —SH group in proteins and enzyme causing their denaturation.

This leads to the break down of several enzyme systems.

It causes anaemia, disruption of haemoglobin synthesis as well as damage system, kidneys and brain.

Lead toxicity is more acute in children than in adults.

2. Mercury

--effluents from various industries such as electrochemical industries those manufacturing batteries, caustic soda, mercury vapour lamps, etc.

Mercury is highly toxic to all aquatic as well as terrestrial organisms.

It has a tremendous capacity to bioaccumulate in the form of methylmercury.

It cause brain damage

- This was evidenced when many normally fish-eating people of the **Minamata city of Japan** died in 1960 by **irreversible brain damage**.
- This was caused by the mercury present in the effluents run into the **Minamata bay** from a chemical factory situated there.

3. Cadmium

- --through effluents from electroplating, paint, ink, plastics, etc. industries and from gold jewellery works.
- Like mercury, cadmium also undergoes biomagnification through food chains reaching its maximum level in man.
- Cadmium accumulates in liver, kidneys, pancreas and thyroid in humans.
- At high levels, it causes damage to lungs, kidney, etc. and causes anaemia and bone marrow depression.

- A typical example of cadmium poisoning in the past was the outbreak of `itai itai' or 'ouch ouch' disease (so named to indicate the terrible pain associated with it) in the Jintsu River basin in Japan.
- The disease made bones fragile.
- Thousands of people died through microfracture of bones and thousands were affected by this bone disease.
- The disease was caused by the consumption of cadmium-ingested rice from the fields irrigated using water from the Jintsu river.
- The river was contaminated with cadmium by drainage water from the surrounding mines.

4. Chromium :

- Natural waters get polluted with chromium by effluents from **metal plating industries**.
- It is toxic to **aquatic and terrestrial organisms**.
- In humans, it causes **skin and respiratory disorders and respiratory tract cancer**.

5. Arsenic

- Arsenic pollutes water bodies through pesticides, (e.g., lead arsenate), chemical waste and effluents from mining industries.
- It is highly toxic to all types of organisms (as is evidenced by the fact that arsenic compounds have been used as pesticides for hundreds of years).
- It inhibits the action of enzymes which catalyse cellular reactions.
- It kills at high levels of concentration and causes cancer on accumulation at lower levels.

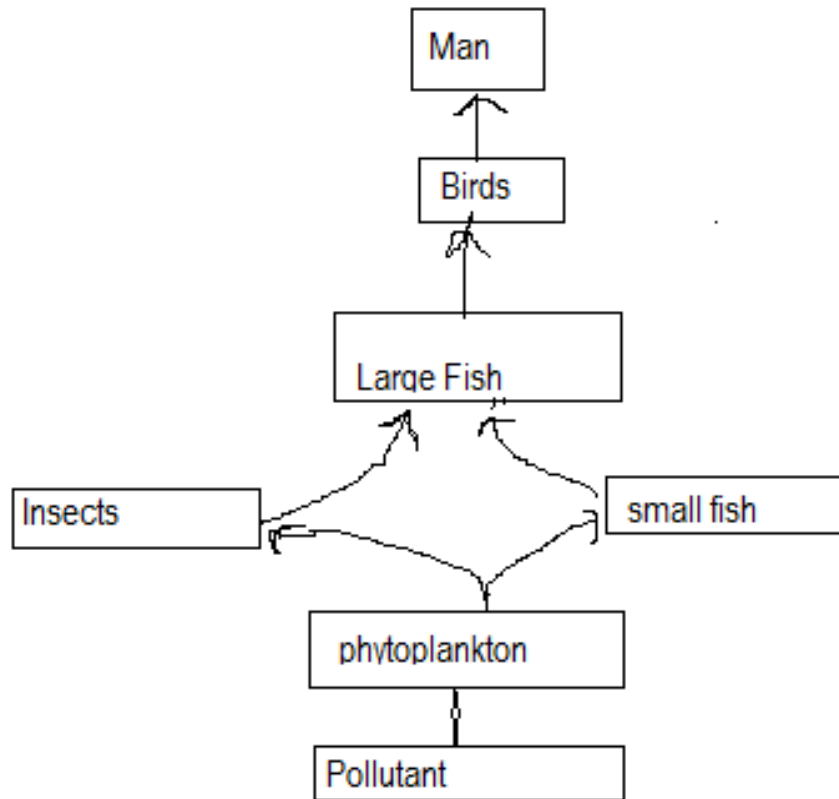
Bioaccumulation

- Pollutants which can accumulate in organisms are called **persistent substances or biologically accumulative substances** and the process is called **biological accumulation or bioaccumulation**.
- e.g., Fairly large quantities of certain heavy metals or pesticides accumulate in aquatic organisms.

Biological magnification or biomagnification

- is the process in which a **stable and non-biodegradable persistent pollutant** increases in concentration at each higher trophic (nutritional) level as it is passed successively from one organism to another through the **food chain**.
- Biomagnification occurs when a persistent pollutant gets **accumulated** in lower organisms and these are consumed by another organism at a higher trophic level.

Fig. 3.1 : Schematic representation of biomagnification in the food chain



Detrimental effects of water pollution: a synopsis

- Some of the important adverse effects of water pollution are summarised below:
1. Water pollution by **domestic sewage** leads to induction of various pathogenic organisms into water and this causes the **spreading of various diseases** like **typhoid, cholera**, etc.
 - It also causes **eutrophication and algal bloom** leading to depletion of dissolved oxygen, thereby affecting aquatic life.
 - It causes a foul odour and taste to water.
 2. Water pollution by **industrial effluents** leads to a concentration of highly **toxic organic, inorganic and metallic components in water**.

This causes destruction of aquatic population as well as terrestrial plants and animals.

3. Pollution of water by soaps and detergents causes eutrophication, algal bloom, depletion of dissolved oxygen in water and foaming.
4. Pollution of water by highly toxic pesticides leads to the massive destruction of aquatic organisms and all those who consume pesticide-polluted water.
5. Water pollution by fertilizers causes eutrophication, algal bloom and the subsequent depletion of dissolved oxygen, leading to the destruction of aquatic population.

Water polluted by fertilizers is also highly harmful to humans and causes various diseases such as the 'blue baby syndrome'.

6. Pollution of water by **heavy metal ions** is highly harmful to all organisms.

These persistent pollutants enter the food chain and, by the processes of **bioaccumulation and biomagnification**, destroy the consumers by their toxic action.

Man, at the end of the food chain, suffers the maximum toxic effects of these metal ions.

7. Pollution of water by **radioactive materials** from mining and ore-processing industries, nuclear power plants, etc. and from the use of radioisotopes in industry, medicine, research, etc. is a major radiation hazard to all living organisms.

8. Oil pollution destroys marine life, water birds, coastal plants, etc.

9. Thermal pollution destroys aquatic life.

Control of water pollution.

Some of the steps that have to be taken to prevent or control water pollution are given below:

1. Sewage should be treated in **sewage treatment plants** before it is let off into water bodies.
2. Treatment of **industrial effluents** to **remove** as much pollutants from them as possible should be made compulsory and discharged into outer sea.

3. **Non-biodegradable** detergents should be **banned**.
4. Use of chemical **fertilizers and pesticides** should be **minimised**. As far as possible biofertilizers and less persistent pesticides should be used.
5. Sources of **drinking water** should be **protected** from all possible means of infiltration by harmful chemicals and pathogenic organisms.
6. **Drainage system** in cities, towns and villages should be **improved** and the of impure water into wells and tanks should be prevented by proper means.
7. **Eutrophication** and algal blooms leading to depletion of dissolved oxygen should be prevented.
8. **Laws** should be enforced to ensure harmless disposal of wastes from factories and other enterprises.

Water quality parameters

- In order to assess the **quality of water**, physical, chemical and microbial analysis is very essential.
- The quality of water is usually expressed in terms several of its character:
- such as colour, taste, turbidity, pH, salinity, electrical conductivity, etc.
- Three of parameters commonly used to express water quality are (i) **dissolved oxygen (D.O)** (ii) **biochemical oxygen demand (BOD)** and (iii) **chemical oxygen demand (COD)**.

Dissolved oxygen (D.O)

- Dissolved oxygen is a **fundamental requirement** for the maintenance of aquatic population.
- It is an important parameter **of the extent of water purity or extent of pollution** associated with it.
- In most waters, varying concentrations of dissolved oxygen are found.
- This is because solubility of oxygen is greatly influenced by **temperature, pressure, salinity, etc.**

- Dissolved oxygen (D.O) is expressed as the **weight of oxygen in milligrams present per litre of water** or **as parts per million** (ppm).
- The **optimum value** of D.O for good water quality is **4-6 mg/L**- ensure healthy aquatic life in a water body
- When **oxygen demanding substances** such as organic matter, reducing agents. etc. are present in water, their oxidation by microorganisms **consumes** the dissolved oxygen and its level falls.

- When the level of D.O falls below the minimum critical value -indicates pollution of water.
- Dissolved oxygen is usually determined **iodometrically**.
- D.O is allowed to react with **KI** to liberate I, which is then titrated with **standard sodium thiosulphate solution**.
- Alternatively, D.O may first be treated with Mn^{2+} in strongly alkaline medium to quantitatively precipitate MnO_2 .
- The MnO_2 is then estimated iodometrically in acid medium.

(ii) Biochemical oxygen demand (BOD)

- Biodegradation of organic matter into simple inorganic molecules by aquatic microorganisms takes place using dissolved oxygen.
- So, the amount of dissolved oxygen consumed by microorganisms in the process is a measure of the quantity of organic matter present in water .
- Or, a measure of the organic pollution in water.

Finding of biochemical oxygen demand (BOD).

- Biochemical oxygen demand (BOD) of a sample of water is the **amount of dissolved oxygen used up** by suitable **aquatic microorganisms** for the **oxidation of organic matter present** in a well-aerated sample of water incubated for a period of five days at 20°C.
- BOD of a water sample is determined by finding out the **amount of dissolved oxygen** in it **before** and **after** its incubation for 5 days in the dark at 20°C.
- The **difference** between the initial and final values is the actual BOD.

- Before incubating the sample, it is well aerated to ensure that oxygen is present throughout the period of incubation.
- In domestic waste waters or surface waters, microorganisms will be sufficiently present, but if it is deficient in microorganisms, they have to be introduced before incubation.
- This is usually done by adding settled domestic waste water stored for 24-36 hours at 20°C.
- BOD is usually expressed in mg of oxygen/litre of water or as parts per million (ppm).

- Water may be considered fairly pure if the BOD is only 1-3 mg L⁻¹.
- Higher BOD's indicate pollution.
- Polluted water have -BOD's of the order of hundreds or thousands.
- BOD test is empirical and semi-quantitative result .

(iii) Chemical oxygen demand (COD)

--of a sample of water is the oxygen equivalent required for the oxidation of organic matter in water determined with the help of a strong chemical oxidant, usually potassium dichromate in acid medium.

Chemical oxygen demand (COD) test

-- involves **boiling** the water sample for two hours with excess of **standard potassium dichromate** in presence of sulphuric acid.

The **unreacted potassium dichromate** is then determined by **titration** against **standard ferrous ammonium sulphate**

---the oxygen equivalent of the reacted dichromate calculated.

- COD is a rapidly measurable parameter for water samples, particularly **useful** for industrial waste water studies.
- Any COD value higher than 250 ppm is regarded as indicative of pollution.

PURIFICATION OF WATER - Potable water

- The purification of water needed for drinking purposes in towns and cities is a matter of great importance with regard to public health.

Aims in water purification

- (i) **eliminating** health hazards and sanitary defects,
- (ii) **removal** of colour or turbidity and suspended impurities,
- (iii) **destroying** the bacteria and viruses
- (iv) **restricting** the presence of soluble mineral salts within the prescribed limits.

The following steps are generally involved in the process.

a) Pre-treatment

(i) Storage : Sedimentation of suspended impurities :

The raw water drawn from a water body is stored for some period in a large tank.

This is to improve the quality of water by natural sedimentation of silt and suspended impurities.

This also brings about an inactivation of several pathogenic organisms including enteric viruses.

(ii) Pre-chlorination :

If water contains greater quantities of algae and microorganisms, it is chlorinated to improve the water quality.

The process will also reduce and colour present in water.

(iii) **Aeration** : Aeration is carried out by **blowing air through water** or by spraying water in air.

- The suspended organic matter and Fe^{2+} , Mn^{2+} , etc. are oxidised and settle down.
- The process also eliminates gases like free CO_2 , H_2S , etc. present in water and removes disagreeable taste and odour.

b) Coagulation:

The impurity particles in the colloidal range are coagulated through promotion of their **aggregation** by adding a **coagulant** in required quantities, followed by gentle mechanical agitation.

The common coagulant used is *alum*.

The aggregated particles are commonly called *floccules* and the bulky precipitate thus formed is called *floc*.

c) Sedimentation

Water containing floc is kept stationary for some time in a sedimentation tank to allow the floccule particles to settle under the influence of gravity. .

d) Filtration

Water is then filtered by **passing through a porous medium**, usually a sand filter consisting of a bed of sand.

The sand retains all the suspended matter including floc and also removes the microorganisms still present in water.

The filters are cleaned periodically of the clogged suspended matter by a backwash or reverse flow of water under pressure.

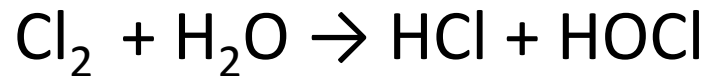
e) Disinfection

--disinfection of the water is carried out to **reduce the microbial populations** to a safe level and to get **hygienically** safe water.

This is commonly done by one of the following methods.

(i) **Chlorination**- : Addition of **liquid chlorine or bleaching powder** in minimum required quantities is one of the most effective methods commonly used for sterilizing water.

Chlorine yields **hypochlorous acid** (HOCl) in water which **kills bacteria and viruses** by oxidising proteins and reversibly denaturing the essential cellular enzymes.



- Chlorine, however, imparts a rather disagreeable taste and odour to water.

(ii) Treatment with ozone :

Ozonised air is either bubbled through water or it is passed up a tower, divided into compartments by perforated celluloid partitions, down which water is percolating.

Ozone, being a very good oxidising agent, oxidises and destroys bacteria, fungi and viruses.

The process does not introduce any disagreeable taste or odour to water, but is rather expensive.

(iii) Aeration :

Air is blown through water or water is sprayed in air.

On aeration, the organic matter gets oxidised and settle down. The process also eliminates carbon dioxide as well as disagreeable taste and odour.

(iv) Other disinfection processes : The disinfection of water can be carried out by exposing water to ultraviolet radiation which kills the bacteria and viruses in water quite effectively.

In another technique, electric current is passed through water containing a silver anode and a graphite or stainless steel cathode.

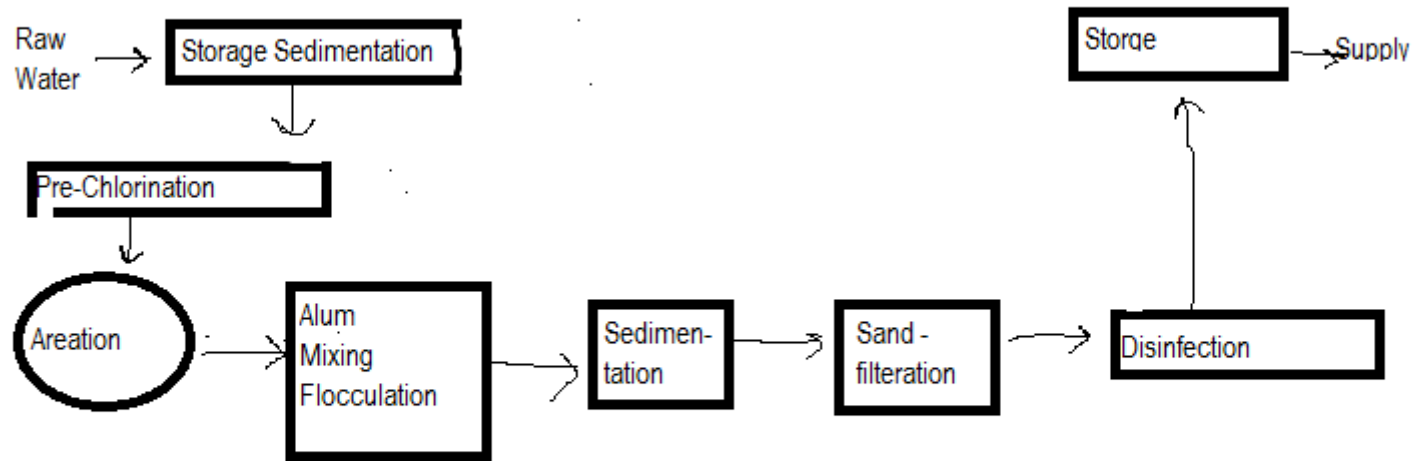
The silver ions produced have great bactericidal properties, react with most bacteria to form a slime which can be filtered out.

These methods are suitable for disinfecting smaller quantities of water.

(v) Storage and Supply:

The portable water is stored and supplied to the public

Fig 3.2 Steps in the purification of water

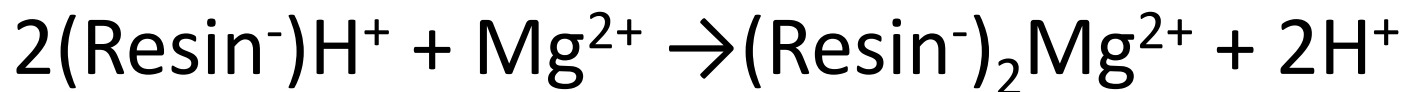
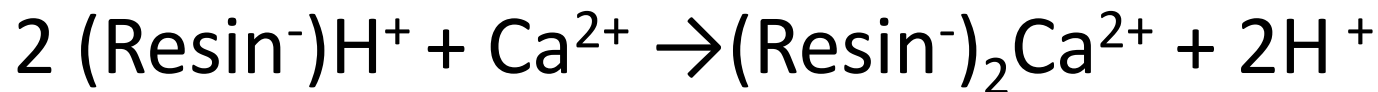


- Demineralisation (Desalination) of water :
The ion-exchange process:
- The process of removing all the impurity ions present in water is known as 'demineralisation of water' or deionization of water'.
- The resulting as 'demineralised water' or 'deionized water.
- Since the process it removal of all the saline impurities from water, it is also sometimes called desalination or desalting of water.

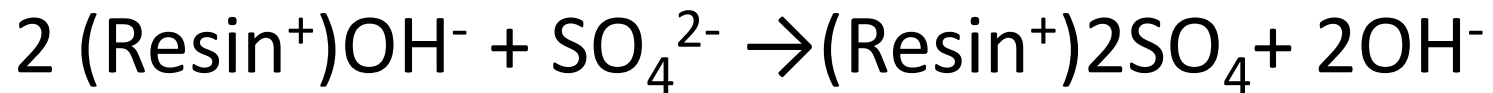
One method of demineralising water is by using organic cation-exchange and anion-exchange resins:

- Ion-exchange resins are insoluble cross-linked long chain organic polymers having functional groups suitable for the ion-exchange resins.
- Cation-exchange resins contain **acidic functional groups** and exchanging their H^+ ions for other cations.
- Anion-exchange resins contain **basic functional groups** and are capable of exchanging their anions, say OH^- anions.

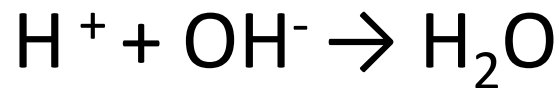
- Water containing dissolved ions is passed through a **deionizer** in which it comes into contact alternatively with a **cation-exchange resin [(resin⁻)H⁺]** and an **anion-exchange resin [(resin⁺)OH⁻]** a number of times.
- The cations present such as Ca²⁺, Mg²⁺, etc. get exchanged for the H⁺ ions of the cation-exchange resin.



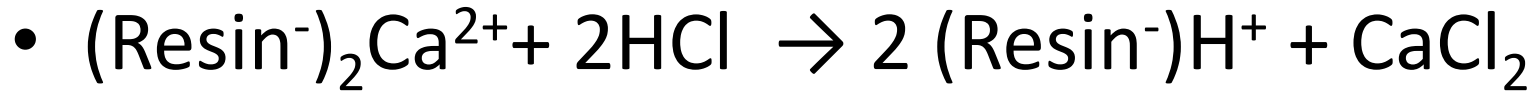
- The anions such as Cl^- , SO_4^{2-} , etc. present in water get exchanged for the OH^- ions of the **anion-exchange** resin.



The H^+ ions and OH^- ions gained by water combine to form water.

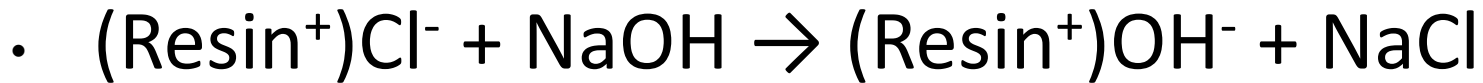


- The water coming out of the deionizer is thus **free** of all the cations and anions, including the hardness causing Ca^{2+} and Mg^{2+} which were previously present.
- The exhausted cation-exchange resin and anion-exchange resin can be **regenerated by** treating with **concentrated hydrochloric acid** and **sodium hydroxide solution** respectively.



Exhausted cation-exchange

Cation-exchange resin

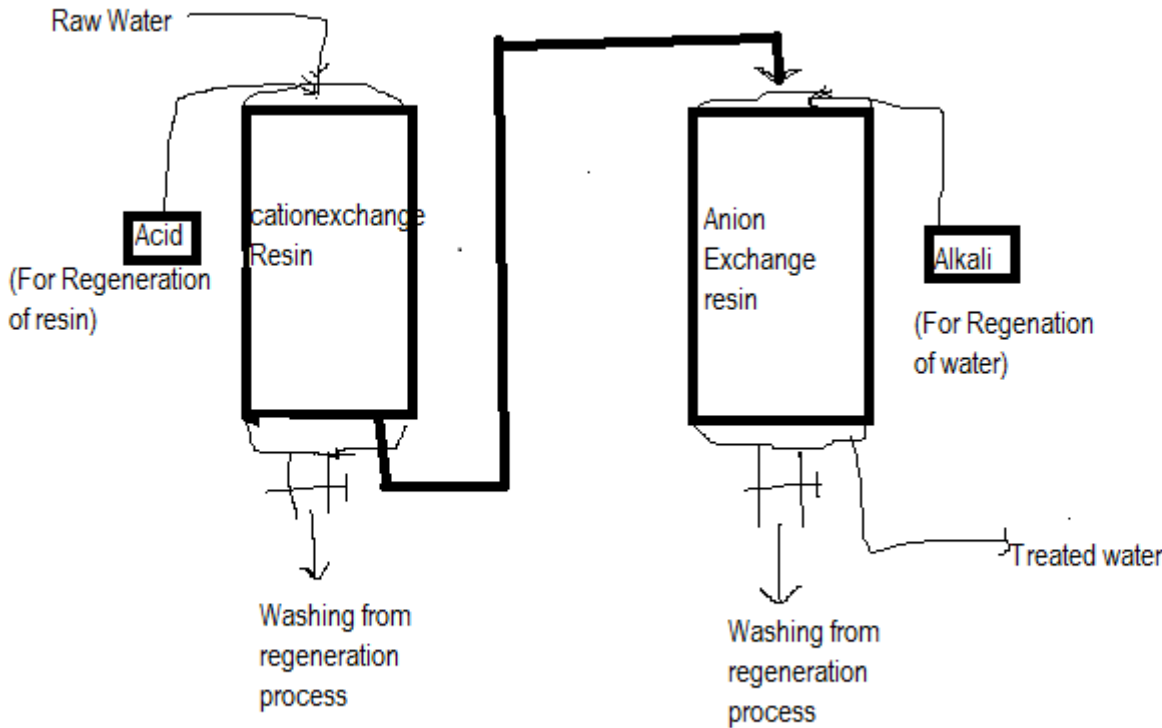


- Exhausted anion-exchange

Anion-exchange resin

- The ion-exchange process of demineralizing water is represented in Fig. 3.3.

Fig 3.3 Process of iron-exchange



Desalination or Desalinization or Desalting of sea water

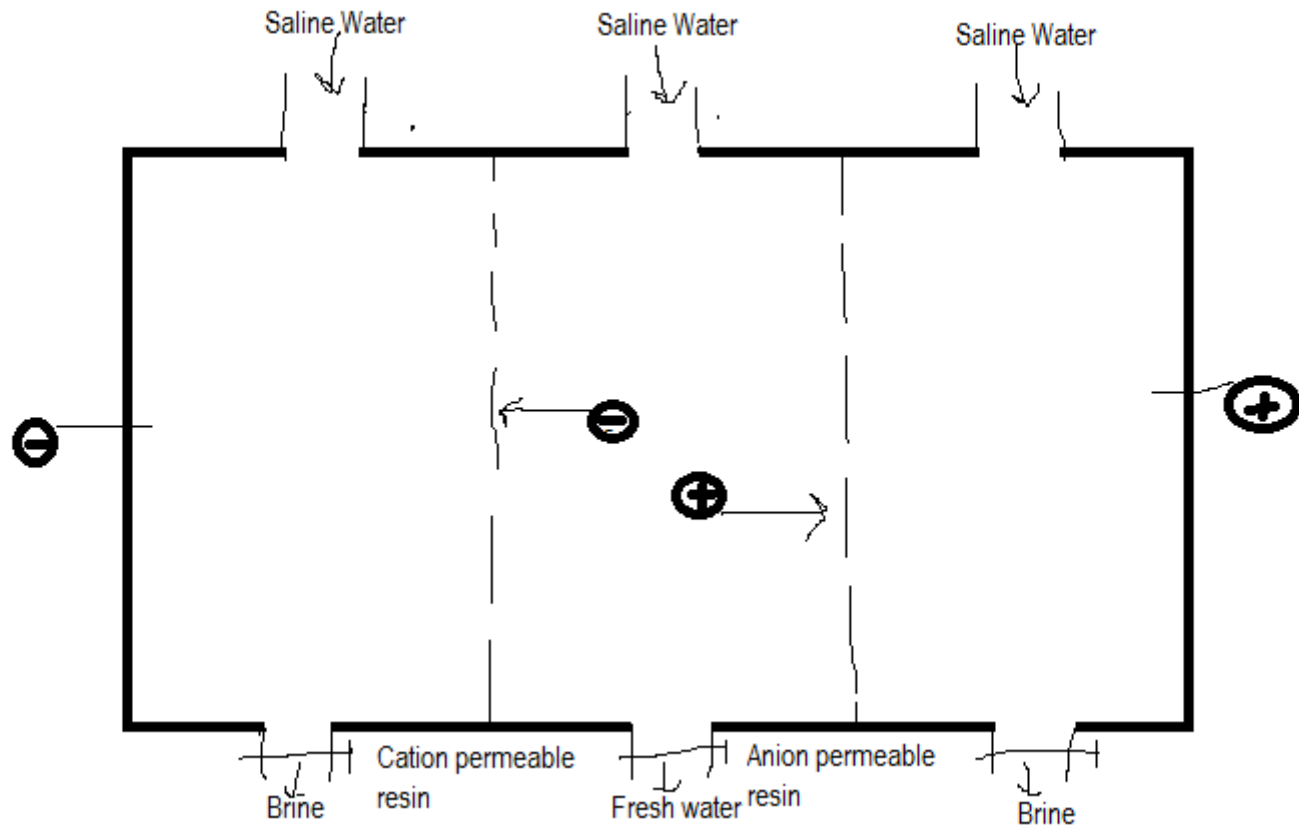
- The process of **effecting partial or complete demineralization of sea water or relatively less saline brackish water** (frequently found by drilling in arid lands) is known as **desalination or desalinization**.
- The **objective** of desalinization is obviously to get potable (drinkable) water from saline waters.
- This has been tried in various countries, where fresh water is not abundant, like the Middle East Countries.

Some of the methods tried for the purpose are given below:

- a) Distillation Sea water or brackish water is **distilled** and the **vapours condensed** by cooling with raw water entering the still to be distilled.
- The heat of condensation of steam thus made use of to pre-heat the water entering the distillation still, thus saving precious energy.
- The **pure condensed water** is collected and stored.

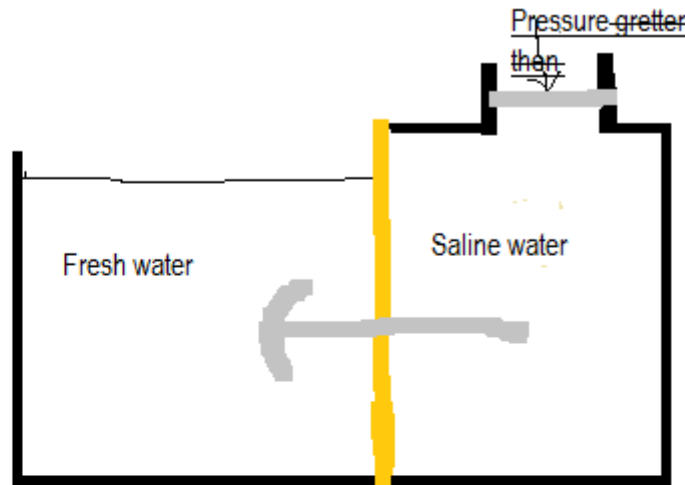
- b) Electrodialysis
- Sea water or brackish water is taken in large **electrolytic cells** divided into **three compartments** by **two ion-selective semipermeable** membranes.
- The electrodes are present in the outer compartments.
- The **arrangement** is such that the **membrane nearer to the cathode is permeable to cations** only while that **nearer to the anode is permeable to anions** only.
- On **applying electricity**, the cations and anions **move** from the **central compartment** into the two different outer compartments and towards the oppositely charged electrodes.
- The water in the central compartment gradually gets salt-free.
- The process is diagrammatically represented in Fig. 3.4.

Fig 3.4 Electrodiaylysis –desalination of saline water



- c) Reverse osmosis
- When saline water is kept separated from a pure sample of water by means of a semi permeable membrane, normally, water will flow into the solution (i.e., saline water) by osmosis.
- However, if a pressure just higher than the osmotic pressure is applied on the saline water, water will flow out from the solution into the pure sample.
- This process is called reverse osmosis and is used to desalinize sea water and bracksh water.
- Membranes specially prepared from nylon, cellulose acetate, etc. are used .
- -- are able to withstand the high pressure needed to be applied.
- Thus, in the process the water is forced out of the saline water ,not the salt.
- Fresh water can thus be obtained ,suitable for drinking puropse.

Fig 3.5 : Reverse osmosis method of desalinization of water



AIR POLLUTION- The major regions of atmosphere

- Atmosphere is the **protective cover of gases** that surrounds the earth.
- It sustains life on earth by protecting it from the hostile environment of outer space.

There are **five** concentric regions within the atmosphere which can be differentiated **on the basis** of temperature and other characteristics.

1. **Troposphere** : The troposphere is the lowest layer of atmosphere which extends up to a **height of 8 km at the poles and 18 km near the equator.**
Its temperature decreases with height.

It contains 80-90% of the mass of gases in the atmosphere.

The major gases present are **nitrogen and oxygen**.

Some argon as well as carbon dioxide and some trace amounts of He, Ne, CH₄, etc. are also present.

It is here that living organisms exist.

It is a turbulent region having strong air movements and cloud formation.

2. Stratosphere : The stratosphere is the region that lies above troposphere extending up to a height of 50 km, its temperature being -55°C to 5°C .

It contains nitrogen and oxygen.

It also contains ozone which acts as a shield and protects living systems from harmful ultraviolet rays.

Due to this absorption of ultraviolet rays, it gets warmer with increasing distance from the earth.

3. Mesosphere : The mesosphere is the **third** atmospheric layer from below.

It is the region that lies approximately between **50 km and 80 km** from earth.

Its temperature is very low and drops to about **-100°C** at a level of **80 km** from the earth.

N_2 , O_2 , Ozone, etc. are present in this region.

4. Ionosphere : The ionosphere is the **fourth atmospheric** layer lying above the mesosphere.

It spreads between **80 km and 500 km** from the earth.

Ionosphere contains ionised gas molecules and atoms like O_2^+ , O^+ , NO^+ , etc. and free electrons.

These ions and electrons are produced by the action of radiant energy on gas molecules.

This layer protects the earth from harmful cosmic rays.

Its particles reflect the radiowaves signalled from the earth back to the earth surface and thus enables the transmission of radio messages around the world.

5. Exosphere : The exosphere is the uppermost layer of the atmosphere.

It lies above the ionosphere up to **about 1600 km and gradually merges with outer space.**

It contains atomic particles of hydrogen and helium and has a very high temperature due to solar energy.

Air pollution

- The contamination of air by undesirable substances having a detrimental effect on living organisms is called air pollution.
- Any substance or agent that causes pollution of air is called an air pollutant.
- (i) Carbon monoxide, (ii) nitrogen oxides, (iii) sulphur oxides, (iv) hydrocarbons and (v) particulates (metallic, non-metallic and organic) are the five primary pollutants which together contribute 90% of global air pollution.

Sources of air pollution

- (a) Air pollution by automobiles : One of the major factors which contributes massively towards air pollution is the use of automobiles fuelled with petrol or diesel.

- **Automobile exhausts**, in fact, are responsible for more than **55% of total air pollution in** the world.
- The automobiles release huge amounts of poisonous gases into the atmosphere.
- The **major constituent pollutants** of automobile exhausts are the following.
 - (i) Carbon monoxide, produced due to the incomplete combustion of the fuel in the engine.
 - (ii) Sulphur oxides, namely SO_2 and SO_3 , produced on account of the sulphur content in the burning fuel.

- (iii) **Nitrogen oxides**, mainly NO and NO₂, produced during the high temperature combustion of the fuel.
 - (iv) **Unburnt hydrocarbons** escaping into the atmosphere from the engine, carburettor and other parts of the vehicle.
 - (v) Various particulate matter, particularly the **volatile lead compounds** produced on account of the use of **tetraethyl lead (TEL) as antiknock compound in petrol** (in some countries), soot from the **incomplete combustion** of the fuel, etc.
- All the above pollutants are highly injurious to the health of living organisms.
 - Many of them enter into secondary processes in the atmosphere to yield products which can produce disastrous effects.
 - **Smog, acid rain**, etc. are **adverse consequences** of such processes.

b) Air pollution by industries

- Various factories and industrial establishments such as chemical industries, pulp and paper mills, petroleum refineries, metallurgical plants and smelters, cotton mills, synthetic rubber industries, polymer factories, mining industries, asbestos industries, etc. are responsible for about 10-20% of global air pollution.
- The effluent gases from such industries contain major air pollutants such as CO, SO₂, H₂S, NO, NO₂, acid vapours, smoke and various other particulates such as asbestos dust.
- All these gases and particulate matter are injurious to the health of all living organisms.
- They also produce disastrous secondary consequences such as smog and acid rain.

c) Air pollution by electric power plants :
Thermal power plants burning **bituminous coal or high sulphur content fuel oils** let out large amounts of **SO₂** and several tons of flyash into the atmosphere.

These constitute major health hazards for humans and animals.

d) Other sources of air pollution

- **Agricultural activities** making use of various pesticides cause serious air pollution from these substances. All pesticides are poisons and thereby killers.
- The smoke let out from **houses contain various air pollutants** such as CO, SO₂, NO, NO₂, etc. and soot particles.
- The wear and tear of **asbestos products** like roofing materials, floor tiles, coatings, etc. and the demolition of buildings cause the **presence of dangerous asbestos dust and fibre in air.**

- Another important factor that contributes substantially to air pollution is the **frequent occurrence of wars and terrorist activities** in various parts of the world.
- The use of explosives and bombs introduce a large quantity of pollutants into the air.
- The radioactive rays that come out of **atomic reactors** and nuclear explosions constitute a major hazard for all living organisms on the earth.

PHYSIOLOGICAL EFFECTS AND OTHER CONSEQUENCES OF AIR POLLUTION

- **Air pollution by the oxides of carbon**
- **Carbon monoxide** is the most abundant and widely distributed air pollutant. It is produced by the incomplete combustion of carbon or carbon-containing compounds.
- Automobile exhausts contribute to about 80% of the total CO pollution. It is also produced during the burning of domestic fuel, domestic waste and industrial fuel.

- It is also formed by the high temperature reduction and decomposition of CO_2 .
- Incomplete combustion : $2\text{C} + \text{O}_2 \rightarrow 2\text{CO}$
- Reduction of CO_2 at high temperature :
$$\text{CO}_2 + \text{C} \rightarrow 2\text{CO}$$
- Decomposition of CO_2 at high temperature :
$$\text{CO}_2 \leftrightarrow \text{CO} + \text{O}$$

- CO is a very dangerous chemical.
- Its poisonous effect is due to the fact that it combines with haemoglobin of blood (about 210 times more readily than O_2) to form a stable complex called carboxyhaemoglobin.

- It thereby not only prevents the bonding of O_2 with haemoglobin to form oxyhaemoglobin but also displaces O_2 from the oxyhaemoglobin formed.
- (Haemoglobin) $Hb + CO \rightarrow COHb$ (Carboxyhaemoglobin)
- (Oxyhaemoglobin) $HbO_2 + CO \leftrightarrow COHb$ (Carboxyhaemoglobin) + O_2

- Thus, getting tied up with haemoglobin in this fashion, CO blocks the normal oxygen-transporting ability of blood and thereby causes **asphyxiation**.
- Inhalation of CO at levels higher than 100 ppm induces a variety of symptoms ranging from mental aberrations, throbbing headache, dizziness, nausea, vomiting, visual difficulty, breathing difficulty and unconsciousness.
- In a city during the peak hour: traffic or during the frequent traffic jams, pedestrians, traffic policemen, drivers and shop keepers are all prone to such symptoms due to excessive inhalation of CO.
- Inhalation of CO above 750 ppm level definitely produces death by **asphyxiation**.

- Cigarette smokers and those standing by (passive smokers) inhale large quantities of CO.
- The toxic effects of smoking is partly due to CO inhalation.
- CO is detrimental to plants also. It causes leaf drops, leaf curling, reduction in leaf size, decrease in chlorophyll content and premature ageing in plants. CO₂ also becomes an air pollutant when produced in excessive quantities.
- It then causes enhanced greenhouse effect and this leads to global warming.

Air pollution by the oxides of nitrogen

- The oxides of nitrogen, mainly NO along with some NO_2 , N_2O , N_2O_3 and N_2O_5 , are major air pollutants present in automobile exhausts and effluent gases from electric power industry, fertilizer industry, explosive industry and gold jewellery works.
- NO is formed by the high temperature combination of N_2 and O_2 and is slowly oxidised to NO_2 , and other oxides.

- high temperature $\text{N} + \text{O}_2 \leftrightarrow 2\text{NO}$
- $$2\text{NO} + \text{O}_2 \leftrightarrow 2\text{NO}_2$$
- NO, although not a major direct health hazard, produces NO_2 which is fairly toxic to humans.
- NO has an irritating effect on mucous membrane and in higher doses causes severe bronchitis and respiratory problems.
- In a concentration of 3 ppm for 1 hour, it causes bronchioconstriction in man and short exposure at 150-220 ppm levels produces fibrotic changes in the lungs with fatal results. NO, disrupts some cellular enzyme systems.
- It is a pulmonary irritant and causes pulmonary haemorrhage and pulmonary edema leading to death.

- High levels of NO_2 also cause gum inflammation, pneumonia, internal bleeding and lung cancer.
- Cigarette smoke contains high levels of NO_2 which causes lung diseases and lung cancer to active smokers as well as to passive smokers.
- The oxides of nitrogen involve in various photochemical reactions with hydro-carbon pollutants in the atmosphere.
- This gives rise to 'photochemical smog' which is characterised by brown hazy fumes which irritate eyes, nose, throat and lungs.
- This smog is a regular feature in some of the major cities of the world.
- Automobile exhausts are the major culprits in the formation of photochemical smog, which is also known as the 'Los Angeles type smog' in memory of the terrible smog experienced in Los Angeles in 1944. The nitrogen oxides also cause the precipitation of nitric acid in the atmosphere and leads to the detrimental phenomenon called 'acid rain'.

Air pollution by the oxides of sulphur

- The oxides of sulphur SO_2 and SO_3 are produced as a result of the burning of high sulphur-content fuels in thermal power plants and industries.
- $\text{S} + \text{O}_2 \leftrightarrow \text{SO}_2$
- $2\text{SO}_2 + \text{O}_2 \leftrightarrow 2\text{SO}_3$
- SO_2 and SO_3 are present in automobile exhausts also.
- Even at very low levels, SO_2 and SO_3 cause **irritation of eyes and damage the respiratory tract** producing cough and choking in humans.
- Inhalation of SO_2 at a level of 5 ppm for one hour causes constriction of the bronchial tubes and inhalation at a level of 10 ppm for one hour can cause severe respiratory distress.
- Inhalation of SO_3 at higher levels leads to bronchitis, emphysema, chronic asthma and even lung cancer. Inhalation at very high levels causes death by suffocation.

- SO_2 is a major factor which causes the formation of sulphurous smog. Not only is it a major irritant of eyes, nose, throat and lungs, but also causes pneumonia, bronchitis and allied respiratory problems.
- This is also called London smog in memory of the terrible smog that London experienced in December 1952. The smog had then prevailed in the city for 5 days and had caused the death of 4000-5000 inhabitants, also making thousands ill.
- The sulphur oxides cause the precipitation of sulphuric acid in the atmosphere leading to the phenomenon 'acid rain' which is highly detrimental to living organisms and destroys buildings and sculptures. The sulphur oxides adversely affect plants also. They are absorbed through the stomata into the mesophyll of the leaves which inactivates the cells. This leads to tissue collapse, bleaching of leaves, dwarfing and destruction of the plants.

Air pollution by hydrocarbons

- Various hydrocarbons are let out into the atmosphere through unburnt fuel from automobile exhausts, evaporation from various parts of automobiles, incomplete combustion of coal and wood, refining of petroleum, its transfer and use, leakage of industrial solvents, incomplete incineration of wastes, etc.
- They are a grave health hazard to humans. Inhalation of hydrocarbons even at low levels increases mucous secretion and respiratory tract blockage resulting in breathing difficulty and cough.
- At higher levels, they cause severe suffocation and, further, many of them are carcinogenic in nature.

- The polynuclear hydrocarbon benzopyrene present in automobile exhausts and in the smoke from the burning of coal oil and gas industries, cigarettes etc. is a potential carcinogen causing lung cancer.
- Hydrocarbons enter into a series of photochemical reactions in the presence of NO, NO₂ etc. in the atmosphere and causes 'photochemical smog'.
- This causes irritation to eyes, nose, throat and lungs leading to severe respiratory problems.
- Hydrocarbons adversely affect plants also. They cause damage to leaf tissues, death of flowering parts and inhibition of their growth.

Air pollution by particulates

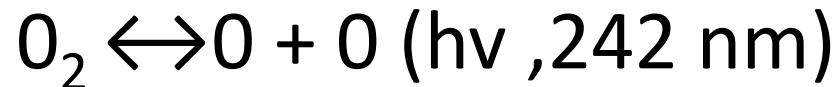
- Air-borne small solid particles and liquid droplets, commonly known as **particulates**, of inorganic and organic compounds cause considerable air pollution.
- Auto-mobile exhausts release particulates of oxidised polymeric hydrocarbons, aldehydes, ketones, nitrogenous heterocyclic compounds, etc. as well as soot into the atmosphere.
- Inhalation of these particulates cause irritation of eyes, nose, throat and lungs [This sensation is often felt when we move through the city in peak hours or get trapped in a traffic jam].
- Formaldehyde is highly toxic to humans. Particulates of volatile lead compounds (produced as a result of the usage of the antiknock compound tetraethyl lead in gasoline) present in automobile exhaust is particularly harmful to children resulting in brain damage and cancer.

- **Asbestos dust** in air caused by asbestos industries, wear and tear of asbestos products, etc. can penetrate deeply into the air passages and can stay intact for years in the innermost regions of the lungs.
- These can cause severe breathing trouble, emphysema and lung cancer.
- Small particles of ash called **flyash** entering the atmosphere from burnt coal in thermal power plants, industries, etc. contain compounds of various elements.
- These can cause lung disorders, emphysema, etc. and affect formation of red blood cells.
- Polycyclic aromatic hydrocarbons (PAH) are highly harmful organic particulate matter. Examples are benzo(a)pyrene, chrysene, etc. sorbed on soot particles. They are highly carcinogenic in nature.

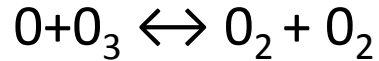
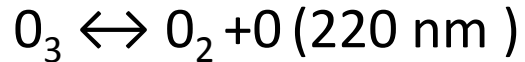
HOLES IN THE OZONE LAYER

- The ozone layer and its importance Ozone is present in the stratosphere.
- It is formed from oxygen and decomposed back to oxygen photochemically by various mechanisms.
- These are represented below:

Formation :



- Decomposition:

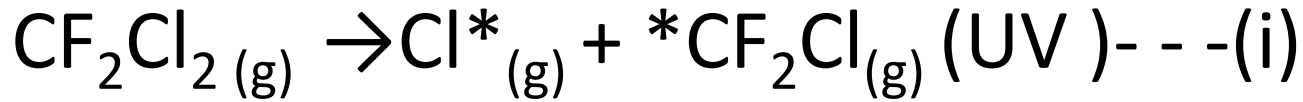


- An equilibrium concentration of ozone (— 10 ppm) is maintained in the stratosphere at an altitude of 25-30 km from the earth.
- This ozone which envelopes the lower atmosphere is called the ozone layer.
- The stratospheric ozone layer is also referred to as the ozone umbrella because it performs the very important function of acting as a protective radiation shield for the living organisms on earth against the biologically harmful solar radiations.
- The ozone layer strongly absorbs ultraviolet light in the region 220-330 nm and thereby protects the animal and plant life on earth from severe radiation damage.
- Only a small fraction of the harmful ultraviolet rays thus reaches the earth. By this process, it also warms the atmosphere through its exothermic decomposition and thereby maintains the thermal balance of the earth.

b) Holes in the ozone layer (Depletion of ozone of the ozone layer)

- One important adverse effect of air pollution by chlorofluorocarbons and nitrogen oxides is that holes of varying sizes have appeared in the stratospheric ozone umbrella at various regions due to depletion of ozone.
- A large hole over Antarctica from about 30% of ozone depletion was discovered by scientists in the early eighties.
- Since then, similar holes have been discovered in the arctic stratosphere and over some of the thickly populated European countries and U.S.A where ozone levels are found varyingly reduced by 3-30%.

- The major culprits responsible for ozone depletion in the stratosphere are the chlorofluorocarbons (CFC's) or freons which are used widely as refrigerants and aerosol can propellants.
- They are highly stable and inert in the troposphere, but slowly diffuse into the stratosphere where they generate chlorine free radicals (Cl^*) due to the action of ultraviolet light.



- These chlorine radicals immediately react with stratospheric ozone converting it into O_2 through a chain mechanism.



- The chlorine radicals are continuously regenerated and cause the breakdown of ozone. Since, by this mechanism, each chlorine free radical generated can cause the destruction of up to one lakh ozone molecules, a phenomenal depletion of stratospheric ozone is being caused by CFCs.
- Other important agents causing ozone depletion in the stratosphere are the nitro-gen oxides, NO_x. The supersonic aircrafts, which fly in the stratosphere, discharge large quantities of NO_x in their exhaust gases directly into the stratosphere. Nuclear explosions also increase the NO_x load of the stratosphere. These enter into a series of photochemical reactions with ozone, converting it into oxygen and thereby causing large scale depletion of stratospheric ozone.

- c) Impacts of stratospheric ozone depletion It is the stratospheric ozone umbrella that shields the biotic life on earth from extremely harmful solar rays. So, formation of holes in the ozone umbrella due to air pollution by CFCs and NO_x is a very serious threat to the biological life on earth because harmful ultraviolet radiations can pass through these ozone holes and reach earth.

- The most serious impact of ozone depletion on human health is that exposure to ultraviolet-B rays causes skin cancer. It is estimated that a 1% reduction in ozone may cause as much as 6% increase in skin cancer cases due to increased exposure to ultraviolet radiation.
- Exposure to ultraviolet radiations also leads to leukemia and breast cancer. These ultraviolet rays are also absorbed by cornea and lens in the eye leading to photokeratitis and cataract without the person even knowing about it.

- Another disastrous impact of stratospheric ozone depletion is that the yields of agricultural crops are reduced due to greater exposure to ultraviolet radiation. In other words, ozone depletion would spell disaster for mankind in terms of large scale damage to food production. Exposure to ultraviolet radiation decreases chlorophyll content of the leaves of plants leading to a decrease in photosynthesis and damage to the leaves.
- Ozone depletion causes destruction of aquatic organisms as they are not able to withstand the increased exposure to ultraviolet radiation.
- Ozone depletion may also cause serious climatic changes on earth because the ozone umbrella contributes to a great extent towards maintaining the thermal balance on earth.

d) Remedy to prevent ozone depletion

- The immediate remedial measure against more ozone depletion is to stop completely the use of CFCs.
- A large number of nations including India are collectively on the look out for substitutes for CFCs and the researches have brought forth hopeful results.
- A number of low cost substitute compounds have been tried out believed that the use of CFCs would be completely stopped in the near future

- GREENHOUSE EFFECT

- a) Greenhouse effect and global warming

- The greenhouse effect is the progressive **warming up** of the earth's surface, atmosphere due to the **blanketing effect** of CO_2 and certain other gases in the atmosphere.
- The earth **absorbs solar energy** mainly as **radiations** in the visible region maintains a steady state or balance by **giving off** bulk of this energy **at the same as radiations in the infrared region**.

- Much of the **outgoing radiation** is absorbed **CO₂ and water vapour** present in the atmosphere and is **partly re-emitted** back to the earth's surface.
- This leads to a **heating up of the earth's surface and atmosphere.**
- This phenomenon is called **greenhouse effect.**

- It is of great significance in governing climate of the earth.
- It is also important in maintaining the heat balance and average surface temperature of the earth within those narrow limits required for optimum climatic conditions to support life on earth.
- Carbon dioxide is not usually considered as a pollutant because it is a normal component of the air and directly involved in the give and take relationship between plants and animals.

- **Very large quantities** of CO₂ are now introduced into the atmosphere through large scale **combustion of fossil fuels in thermal power plants, factories, vehicles, etc.**
- Further, **global deforestation** is also contributing to an increase in the CO₂ content of the atmosphere because **trees are essential to maintain a balance in the CO₂ level.**
- The CO₂ gets confined exclusive' to the troposphere.
- Hence, this **large scale increase in the atmospheric CO₂** concentration leads to **abnormal global warming through enhanced greenhouse effect.**

- In other words,
- CO₂, in **large concentrations** in the atmosphere absorbs the outgoing infrared radiation to a great extent and re-emits it back to the earth leading to **a increase in the average global temperature.**
- Other greenhouse gases like **CH₄, N₂O and chlorofluorocarbons** (which strongly absorb infrared radiation) also contribute to the **increase in the mean global temperature.**
- This is a very serious environmental issue of grave concern.
- It is estimated that if the input of CO₂ and other greenhouse gases into the atmosphere continues at the present rate, their atmospheric concentrations would double by about year **2050** and this would bring **a 3°C** rise in the surface temperature of the earth.

b) Consequences of global warming from enhanced greenhouse effect

Some of the probable consequences of an abnormal global warming through enhanced greenhouse effect are given below:

1. Climatic changes : Persistent greenhouse effect and consequent increase in the temperature of the earth's surface and atmosphere would bring about **drastic changes in the global climate**.
- Some areas of the world would experience abnormally high evaporation of water and unusual changes in ocean currents and winds.

- Abnormal changes in weather patterns and seasons as well as increased desertification are bound to ensue.
- Some regions of the world may lose up to 30% of the annual rain fall while some other regions may experience very high rainfall. The whole climatic pattern of the world would change.

2. **Drop in agricultural production** : Climatic changes would obviously affect **agricultural production adversely**.
 - Since some regions would become increasingly dry and some others increasingly wet, the whole agricultural pattern would be upset with a consequent drop in agricultural produces.
3. **Sea level rise** : Increase in **oceanic temperature may** cause the **melting of polar ice caps**, leading to an **abnormal rise in sea levels** around the globe.

4. **Destruction of aquatic organisms** : **Fish and other aquatic organisms** may not be able to withstand the **high temperature** of waters. So, they will perish.
5. **Refugee problems** : Climatic changes resulting in either **flood or drought**, agricultural loss, homelessness and starvation would force people to move within and between countries.

These refugees would cause very serious social and economic problems.

c) Control of greenhouse effect

- The essential step to control greenhouse effect and to **prevent abnormal global** warming would obviously be to control and **reduce the input of CO₂ into the atmosphere.**
- This control has to be achieved on a global basis and a **global policy on industrialization, deforestation, etc.** has to be adopted by all the nations of the world.
- **Solar energy** may be used as an alternative to the **conventional fossil fuels.**
- **Planned forestation** programmes should be implemented to **reduce the CO₂** , level as trees act as **natural 'sink' for CO₂** by utilizing it during photosynthesis.

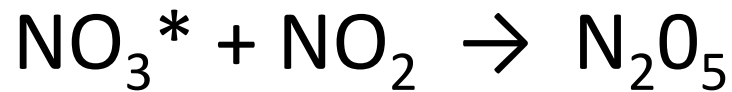
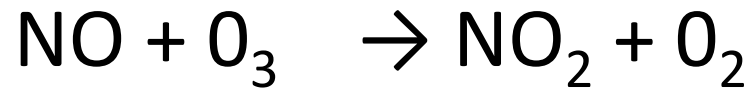
ACID RAIN

Formation of acid rain

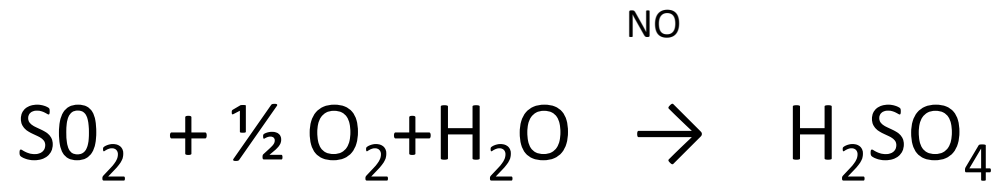
- The acids, mainly HNO_3 and H_2SO_4 , formed in the atmosphere from the air pollutants nitrogen oxides and sulphur oxides respectively are brought down the earth as constituents of rain, snow, hail, etc.
- This acid precipitation is known as acid rain.
- Tremendous amounts of nitrogen oxides and sulphur oxide the atmosphere as a result of the combustion of huge amounts of petroleum products and other fossil fuels.

- These pollutants are converted into acids , namely HNO_3 and H_2SO_4 , through a series of chemical reactions in the presence of light, water, oxygen, heavy metal ions, organic oxidants, etc. in the atmosphere.
- These acids come to the earth during rain, snow, hail, etc. and constitute the acid rain.
- It is thus a major secondary effect of air pollution.

- The reactions leading to the formation of HNO_3 and H_2SO_4 are given below
- Formation of HNO_3 :



Formation of H₂SO₄ :



Soot particles

The acid droplets formed get suspended in water vapour to form 'acid fog which gets dispersed far and wide by air currents.

In a **cool weather**, the acid fog precipitates as 'acid rain'.

b) Adverse effects of acid rain

1. Acid rain **increases the acidity of the soil** and thereby causes **serious damage** agricultural crops.

-----Cadmium absorption of plants increases posing a grave health hazard to plants and humans.

2. It **damages leaves of trees, reduces their photosynthetic capability and retard their growth, thereby destroying forests.**

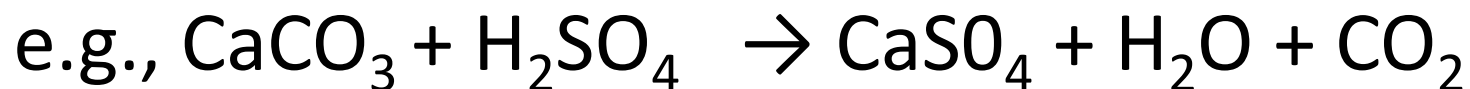
Thus, the natural resources for the production of wood pulp, paper, etc. are decreased.

3. Acid rain makes the water in tanks, ponds, lakes and rivers so much acidic -- fish and other aquatic life are eliminated in such regions.
4. The acid droplets in air as well as acid-contaminated potable water cause neurological, digestive and respiratory diseases in humans.

|

5. Acid rain causes **extensive damage** to **buildings, statues, monuments**, etc.

The acids in the rain attack the sculptural materials of marble, lime stone, slate, mortar, etc. to form **soluble sulphates and nitrates**.



- As a result, the structures become pitted as the soluble salts formed are leached out by rain water.

-----[Several invaluable stone statues and monuments in Greece, Italy and other parts of the world have been dissolved partially by acid rain. The Taj Mahal in Agra faces such a threat at present].

6. Acid rain destroys materials like fabric, paper, etc.

(C)Control of acid rain

- Short-term control of acid deposition problem can be achieved by using **lime** in acid-polluted soils and fresh water bodies.
- However, this is not a solution to the acid rain problem.
- The only **remedy** to acid rain is to **reduce airborne nitrogen oxides and sulphur oxides**.
- This needs basic changes in the patterns of using fossil fuels.
- **Advanced research** and tough legislation are required to **reduce** the emissions of NO_x and SO_x .
- **Solar energy** should be made use of wherever possible in place of fossil fuels.

Control of air pollution

1. Better automobile engines should be designed to ensure complete combustion of the fuel so that the toxic pollutants carbon monoxide and hydrocarbons would not be present in the exhaust gases.
2. In order to avoid the presence of volatile lead compounds in automobile exhaust gases, the use of leaded petrol should be completely banned.
Only the use of unleaded petrol must be permitted.
3. Use of gaseous fuels in automobiles would ensure more or less complete combustion of the fuel and thereby reduce emission of toxic pollutants like CO and hydrocarbons.

- 4. Entry of waste products into air from industries and power plants should be **prevented** by using proper equipments such as **filters, electrostatic precipitators, dust traps, adsorbent columns containing activated carbon, etc.**
- 5. The **heights of chimneys of factories** should be raised for allowing atmospheric dilution of the effluent gases.

6. Only furnace fuels of low sulphur content should be used in power plants industries, etc. so that pollution by sulphur oxides can be minimised.
7. Soluble gaseous pollutants like SO_2 in industrial effluent gases may be dissolved away by passing through a device called 'scrubber' in which a fine spray of water is used.
8. Excessive use of pesticides and chlorofluorocarbons should be prevented.

9. The **use of asbestos** should be totally banned in order to prevent air pollution by the highly harmful asbestos dust.
10. Cigarette smoking should be banned in all public places.
11. **Trees**, which can serve as **natural 'sinks'** for various pollutants should be planted on a large scale around industrial centres.

TOXICITY AND ENVIRONMENTAL HAZARDS OF PESTICIDES

- Pesticides are chemicals which are extensively **used for killing pest populations** that destroy economic crops, biological products etc. and cause diseases.
- Pesticides include **insecticides, rodenticides, herbicides and fungicides**.
- Pesticides have in use since very early times, e.g., the use of arsenic compounds as insecticides back to 70 A.D. Since 1940, synthetic organic pesticides have been extensively used.

Table 3.1 : Basic groups of pesticides

Group	Examples
1. Insecticides and acaricides	Chlorinated hydrocarbons (DDT, BHC aldrin, endrin, heptachlor, toxaphene, etc.), organic phosphorus chemicals (malathion, parathion, etc.), carbamates (pyrolan, isodan, etc.), inorganic chemicals (CuSO ₄ , lead arsenate, etc.)
2. Rodenticides	Pival, warfarin, thallium, sodium fluoroacetate, strychnine.
3. Herbicides	Sodium arsenite, 2, 4-D, 2, 4, 5-T, dalapon, methyl bromide
4. Fungicides	Mercuric chloride, Nabam, Ziram, Captan.

- Pesticides were once considered as the achievement of the twentieth century Paul Herman Mueller of Switzerland, who prepared the **first** synthetic **organochlorine pesticide** DDT, was later awarded Nobel peace prize.
- They were responsible for the boost in agricultural crops and the eradication of various diseases.

Pesticide pollution and the environmental hazards

- Contamination of the environment with harmful pesticides is known as **pesticide pollution**.
- Pesticides are applied as aerial sprays or directly to the soil.
- After getting deposited, most of them (almost all organic pesticides) **undergo biochemical modifications by heat, light and water** to yield **derivatives** commonly known as **pesticide residues**.
- Many of these **residues are stable, non-biodegradable and persistent in nature**.
- They can survive for long periods of time.

Table 3.2 : Persistence of pesticides in soil

Pesticide	Persistence
Parathion	3-6 months
2, 4, 5-T	6 months
Diuron	16 months
Toxaphene	6 years
Heptachlor	9 years
Aldrin	9 years
DDT	10 years
BHC.	11 years
Clordane	12 years

- The pesticides do not stay in their points of deposition. They move through the components of environment.
- A portion of pesticide residues in soil gets vaporised either directly or along with moisture into air.
- A portion seeps into the ground water.
- A significant portion moves in agricultural run-off water to reach lakes, streams, rivers and oceans.
- Then, they concentrate in the food chains.

- By the process of biomagnification, the **concentration of the pesticide residues increases** on moving up in the food chain, finally reaching the ultimate consumer, namely **man**, in the **most concentrated form**.
- Presently, residues of pesticides (e.g., DDT) are widely distributed.
- They are everywhere from the tissues of organisms to oceans and polar ice caps-continues its toxic effects for many years.

- Another important environmental consequence of the use of pesticides is that **pests develop resistance to them with time.**
- The population of such resistant pests grow faster, **necessitating the invention and application of more and more newer and stronger pesticides,** thereby creating more and more pollution problems. .

- Further, pesticides not only **kill** the targeted organisms (pests) but also **other beneficial organisms such as microorganisms of soil and phytoplankton of water.**
- Pesticides have thus become a grave environmental issue faced by man of modern times.

Toxic effects of pesticides

- They kill and destroy all organisms. They can enter the human body orally, through skin or by inhalation.
- The **chlorinated hydrocarbons** mainly affect the **central nervous system** while others affect the circulatory or reproductive systems.
- They accumulate persistently in various parts of the body and exert their toxic influence.
- They can cause **cancer, blood cancer, hypertension, sterility, damage to kidney** and death at higher concentrations.

Repeat!!! Their toxic effects, in a very general sense, on humans are mentioned below:

1. **Excessive concentrations** of **chlorinated hydrocarbon** pesticides in human tissues cause **hormonal imbalance, cancer of the organs, leukemia**, etc.
2. **Organophosphate** pesticides interfere with the transmission of nerve impulses, causing **unconditioned tremors, spasms, convulsions and paralysis**.
3. Pesticides inhibit **production and functioning of sex hormones, leading to sterility**.
4. Higher concentrations of pesticides in pregnant woman may result in **abortions**, still births and infant deformities.
5. Pesticides cause **hypertension and damage to kidneys**.
6. In higher concentrations, **they cause death**.
 - They exert their toxicity on microorganisms, aquatic organisms, plants, animals and birds as well, causing death and destruction. Several types of fish, crabs, fish-eating birds, etc. have been wiped out, or their population decreased, in various regions of the earth on account of pesticide pollution.

Control of pesticide pollution

- Some steps which have been suggested for control of pesticides are the following:
 1. The use of **highly persistent pesticides** should be replaced by less persistent pesticides.
 2. Wherever the use of a persistent pesticide is necessitated, it should not be used excessively; only the **minimum required amount** should be used, strictly localised to that area.
 3. **Effluents from pesticide factories** should be treated by suitable methods before they are released to a water body.
 4. **Predators and parasites of pests can be released** for the biological control of pests, so that the use of pesticides can be minimised.
 5. **Spraying synthetic pheromones and sex stimulants** in non-cultivated areas can be tried to attract the pests from the cultivated areas and thereby the use of pesticides can be avoided.
 6. **Natural pesticides** like the petroleum products (kerosene, petrol, etc.) or **plant products** (tobacco preparation, neem and turmeric extracts, etc.) can be used as far as possible in place of synthetic pesticides.

RADIATION POLLUTION -What is radiation pollution?

- The pollution of the environment caused by **extremely dangerous radiations** from sources introduced into the environment by human activities is called radiation pollution.
- The main radiation hazard comes from ionising radiations (α -rays, β -rays, γ -rays, X-rays, etc.) which cause **genetic mutations** in living organisms.
- They form and negative ion pairs as they pass through the protoplasm which is the chief cause of damage in the living organisms.

Type of radiation pollution

- is radioactive pollution caused by **radionuclides** which contaminate **air, water and soil** and seriously endanger our planet's ecological equilibrium.
- Radiation cause damage to living organisms not only externally, but also internal system of the living organisms.

The menace of Radiation pollution

nuclear energy used for both **constructive purposes**- generation of electric power
destructive purposes -atom bombs, nuclear explosions, etc.

Anthropogenic sources of radiation pollution

Some of the man-made sources of radiation pollution are briefly given below:

- (i) **Medical diagnosis using X-rays** : The use of X-rays for medical diagnosis constitutes an important source of radiation pollution as they are highly penetrating in nature.
- (ii) **Radiotherapy** : Radionuclides used in radiotherapy of diseases like cancer constitute a source of radiation pollution as they are often indiscriminately used and improperly handled.

- (iii) **Nuclear tests and radioactive fall out** : Nuclear explosion tests carried out by various countries pose a major radiation threat to all living organisms as they **introduce a large quantity of long-lived radionuclides to the environment** which get distributed all over the globe.
- The radioactive dust that falls to the earth after a nuclear explosion is called **radioactive fall out**.
 - It becomes suspended up to heights of 7-8 km above the earth's surface and are carried by air currents around the world.
 - **The dust contains radionuclides which usually settle down with rain and pollute soil and water.**
 - From the soil, they enter into plants and thereby enter the food chain.
 - **Once they enter the body of a living organism, they radiate internally throughout its life-span.**

(iv) **Nuclear reactors** : The leakage of nuclear radiation from nuclear reactors contributes considerably to radiation pollution.

(v) **Nuclear power plants** : The nuclear power plants set up in various parts of the world to **produce electric power** have become a major radiation threat to the whole world,

The Three Mile Island power plant leakage in USA in 1979 and the Chernobyl power plant leakage in U.S.S.R in 1986 are examples for the disastrous power plant accidents which caused the death of thousands of innocent people and radiation damage to millions.

(vi) **Radioactive waste** : The radioactive waste from nuclear reactors and power plants contain a very large number of radionuclides. The storage, transportation and disposal of these wastes are **major problems** of the present nuclear industry and they **cause wide-spread radiation damage** from wherever they are deposited irrespective of whether **it is deep under the earth's surface or in the deepest portions of the oceans.**

- (vii) Radioactive ore processing** : Radionuclides from the **mining and processing units of radioactive ores pollute soil**, water and air and cause extensive radiation pollution.
- (viii) Industrial and medical research** : Researches in the industrial and medical fields often include the use of radionuclides and produce radiation effects which damage the environment.
- (ix) Other sources** : Advanced technological implements such as colour televisions, X-ray fluoroscopes, radars, etc. and even luminous dials of watches and clocks cause radiation pollution.

c) Hazards of radiation pollution

- Radiation pollution has negative effects on **all kinds of living organisms**. Radiation **damage depends** upon the type of radiation, period and frequency of exposure.

Some very general effects of exposure to ionizing radiations are given below:

1. **Sub-lethal doses** of radiations can cause symptoms like nausea, vomiting, diar-rhoea, loss of appetite and general weakness within a few hours of exposure.

2. **Exposure to acute doses** (i.e., — 600 Rad) would produce symptoms of nausea, vomiting, diarrhoea, etc. **initially and would cause death within a few weeks.**
3. **Long term exposure** to even small quantities of radiations would cause **cancer** in different parts of the body or **leukemia**.
4. **Even short-term exposure to slightly larger quantities** of radiation can cause cancer of the breast, thyroid, lung or even brain.

5. Radiations can **break down** enzymes, proteins and nucleic acids and thereby cause various metabolic disorders.
6. Radiations can cause **internal bleeding** and blood vessel damage which become evident as red spots in the skin.
7. Radiations can damage **eye cells** and induce cataract.
8. Radiations can cause **bone marrow depression**, kidney and liver disorders, damage to reproductive organs and gastrointestinal disorders.

9. Radiations produce genetic effects including gene mutations and chromosome abnormalities which are transmitted to the next generation.
10. Exposure to radiations kills plant cells and thereby destroy vegetation.
11. Water pollution by radioactive materials destroy aquatic population through radiation effects.

d) Control of radiation pollution

- Some preventive and safety measures.
1. X-rays for diagnostic purposes and radiations for therapy should be used as sparingly as possible and adequate protection should be made available to the persons who carry out these operations.
 2. High chimneys and high ventilators should be used at places where radioactive contamination is high.

3. While working with radionuclides, hoods, gloves and masks made of **protective materials** should be used.
4. **Production** of radioisotopes should be minimized.
5. **Extreme care** should be exercised during the disposal of radioactive waste.
6. **All safety precautions** should be taken to **prevent leakage** of radiation from nuclear reactors and power plants.

7. The number of nuclear installations should be **minimized**.
8. Nuclear explosion tests and production of nuclear weapons should be **stopped completely** because a nuclear war would obviously wipe out the entire human race from the surface of the earth.

NOISE POLLUTION

a) What is noise pollution ?'

- Noise pollution means pollution of the environment with **unpleasant and undesirable** sound, through human activities thereby causing adverse effects in all recipients.
- **Noise is a pollutant which is as harmful to humans and animals as any other pollutant.**
- With the development of technology, machinery and industry, noise has now become a global menace to human peace and tranquility.

b) Sources of noise pollution

Some of the man-made sources of noise pollution are mentioned below:

1. **Industries, factories and machinery.**
2. Vehicles such as **trains, buses cars, scooters**, etc. and the hooting of horns.
3. **Loud speakers and audio systems** used in social gatherings, celebrations, etc.
4. Domestic appliances such as **grinders, mixies, vacuum cleaners, audio systems**, etc
5. Various **construction works**.
6. **Sirens** from factories, etc.

The menace of noise pollution is growing day by day due to the population explosion, urbanization and rapid industrialization.

c) Adverse effects of noise pollution

- **Noise** in an
- **average living room** --40 decibels (db)
- normal conversational speech --50 db.
- Noise level up to **70 decibels** (e.g., that in a running bus) is more or less harmless to humans and up to **85 db, it is tolerable.**

- However, higher levels of noise would become a health hazard to humans.

The noise level would be about

- 80-90 db from the **beating of a drum**,
- **75-90 db** inside a **cinema hall**,
- **80 db** from a **mixie**,
- **120 db** from an **exploding cracker**,
- **130 db** from the **hoot of a train**.
- **150 db** from a **siren**.

Some of the adverse effects- produced by noise pollution on humans are mentioned below

1. It induces hormonal imbalances, anxiety, and fright.
2. It affects the hearing capacity and at higher levels, damages ear drum causing deafness.
3. It may induce emotional disturbances, psychological disorders, nervous break down and even insanity.
4. It disturbs sleep and cause fatigue and frustration.
5. It increases heart beats and raises blood pressure.
6. It aggravates gastric disorders and stomach ulcers.
7. It may affect the functioning of brain, kidneys and liver.
8. It disturbs man's methods of communication such as normal and telephonic conversations.

9. It causes headache nausea and fatigue as well as affects **work performance**.
- 10 It induces **abortions** and causes physical abnormalities in young children.
- 11.It encourages **addiction** to sleeping pills, drugs and alcohol.
12. At very high levels, it may kill a person inducing **heart attack or cerebral hemorrhage**.

Control of noise pollution

Although noise pollution cannot be totally eliminated, it can be reduced and its minimised by taking some preventive or safety measures.

- Some such measures mentioned below:
 1. Ear-protective aids such as ear plugs must be issued to workers in noisy factories.
 2. Walls and ceilings of factories must be insulated with sound-absorbing materials.

3. Old noisy factory machines are replaced by new with silencers.
4. The buildings situated in the middle of the city should have sound proofing techniques.
5. Noise creating operations conduct in large open place.
6. Air horns should be prohibited in cities, towns, near by hospitals and schools etc

9. By **growing trees** around factories and places of gathering, the impact of noises can be reduced.

10. **Busy bus stations, railway stations, aerodromes**, etc. should be away from heavily populated areas.

Thanking you

Before you assume,
learn the facts.

Before you judge,
understand why.

Before you hurt someone,
feel.

Before you speak,
think.