Environmental Chemistry

Introduction

The environmental pollution may be defined as direct or indirect undesirable changes in our surrounding as a result of human activities that have harmful effects on plants, animals and human beings.

A substance, which causes pollution, is known as pollutant. Pollutants may be solid, liquid or gaseous substance present in greater concentration than in natural abundance and are produced due to human activities or due to natural happenings.

(a) Pollutants can be fast degradable i.e. which rapidly break down by natural processes. For example, discarded vegetable.

(b) Pollutants can be non-degradable. These remain in the environment in an unchanged form for many decades. For example dichloro diphenyltrichloroethane (DDT), plastic materials, heavy metals, nuclear wastes etc, if once released into environment are difficult to remove.

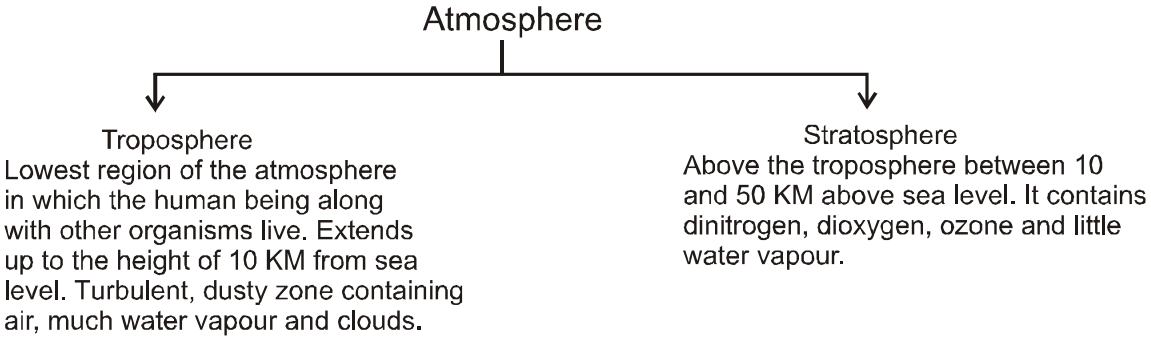
The process of environmental pollution involves :

(i) The origin of pollutant from different source

(ii) Transportation by air or water or dumping into soil by human being.

Atmosphere

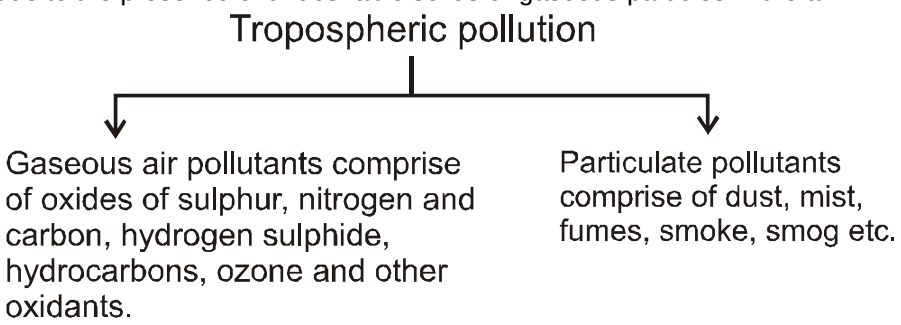
It is a protective blanket of gases surrounding the earth. The atmosphere is held to the earth by the force of gravity. The total mass of atmosphere is about 5×10^{15} metric tones. The constituents which make up the atmosphere are gases, water vapours and aerosols.



Section (A) : Gaseous air pollutants

1. Tropospheric pollution :

It occurs due to the presence of undesirable solids or gaseous particles in the air.



1.1 Oxides of sulphur

Sulphur (from fossil fuel) $\xrightarrow{\text{Burn}}$ Oxides of sulphur (SO_2 ,SO_3)

Toxic effect : SO_2 is poisnous to both animals and plants.

(i) A low concentration of SO_2 causes respiratory diseases e.g. asthma, bronchitis, emphysema in human being.

(ii) It causes irritation to the eyes resulting in tears and redness.

(iii) High concentration of SO_2 is responsible for the **stiffness of flower buds** which eventually fall off from plants.

$$2SO_2(g) + O_2(g) \xrightarrow[\text{Matter(catalyst)}]{\text{Particulate}} 2SO_3$$

$$SO_2(g) + O_3(g) \longrightarrow SO_3(g) + O_2(g)$$

$$SO_2(g) + H_2O_2(\square) \longrightarrow H_2SO_4(aq)$$

The SO_2 present in the atmosphere is generally contaminated with SO_3. The SO_3 so formed gets converted into H_2SO_4 in the presence of moisture. This acid comes down from the atmosphere in form of sulphuric acid rain.

1.2 Oxides of nitrogen

N_2 and O_2 at high altitudes combine to form oxides of nitrogen when lighting strikes. NO_2 is then oxidised to NO_3^- which is washed into soil, where it serves as a fertilizer.

In an automobile engine when fossil fuel (i.e. hydrocarbons) is burnt, N_2 and O_2 combine to give significant quantities of nitric oxide (NO) and NO_2.

$$N_2(g) + O_2(g) \xrightarrow{1483\ K} 2NO(g)$$

$$2NO(g) + O_2(g) \longrightarrow 2NO_2(g) \text{ (slow reaction)}$$

$$NO(g) + O_3(g) \longrightarrow NO_2(g) + O_2(g) \text{ (faster reaction)}$$

Toxic effect :

(i) The irritant **red haze** in the traffic and congested places is due to oxides of nitrogen.

(ii) Higher concentration of NO_2 damages the leaves of plants and retard the rate of photosynthesis.

(iii) It is toxic to living tissues.

(iv) NO_2 is also harmful to various textile fibres and metals.

1.3 Hydrocarbons

They are formed by incomplete combustion of fuel used in automobiles.

Toxic effect :

(i) They are carcinogenic, i.e. they cause cancer.

(ii) In plants, they cause ageing, break down of tissues and shedding of leaves, flowers and twigs.

1.4 Oxides of carbon

(1) Carbon monoxide

Sources of carbon monoxide

(i) Incomplete combustion of carbon, coal, fire wood, petrol etc.

(ii) Automobile exhaust

***Toxic effect :**

(i) Carbon monoxide is poisonous. It binds to haemoglobin to form carboxy haemoglobin which is about 300 times more stable than the oxygen-haemoglobin. This stable complex (when concentration reaches about 3 to 4%) reduces the oxygen carrying capacity of blood to greater extent. This oxygen deficiency causes headache, weak eyesight, nervousness and cardiovascular disorder.

(ii) In pregnant women increased CO level induces premature birth, spontaneous abortions and deformed babies.

(2) Carbon dioxide [CO_2]

Sources of carbondioxide

(i) Respiration (exhaled air contains CO_2)

(ii) Burning of fossil fuels for energy.

(iii) Decomposition of lime stone during the manufacture of cement.

(iv) Volcanic eruptions.

It is found 0.03 percent by volume of the atmosphere and is confined to troposphere only.

Green plants require CO_2 for photosynthesis and they, in turn, release oxygen, thus maintaining the delicate balance. But deforestation and burning of fossil fuel increses the CO_2 level and disturbs the balance in the atmosphere. This increased amount of CO_2 in the air is mainly responsible for global warming.

1.5 Global warming and green house effect

*It has been found that about 75% of solar energy reaching the earth is absorbed by the earth's surface and, in turn, this increases the temperature of the earth. The remaining of the heat radiates back to the atmosphere. Some of the heat is trapped by gases such as carbondixoide, methane, ozone, chlorofluorocarbon compounds (CFCs) and water vapour in the atmosphere. Thus, they increases the temperature of the atmosphere. This causes, global warming.

*Just as the glass in a green house holds the sun's warmth inside, atmosphere traps the heat form the sun near the earth's surface and keeps it warm. This is called natural green house effect because it maintains the temperature and makes the earth perfect for life.

*In a green house, visible light passes through the transparent glass and heats up the soil and the plants. The warm soil and plants emit infrared radiations. Since glass is opaque to infrared radiations (heat), it partly reflects and partly absorbs these radiations. This process keeps the energy of the sun trapped in the green house.

Similarly, CO_2 molecules also trap heat as they are transparent to sun-light but not to the heat radiation. If the amount of carbon dioxide crosses the delicate proportion of 0.03%, the natural green house balance may get disturbed.

CO_2 is the major contributor to global warming. In addition to CO_2, other green house gases are methane, water vapour, nitrous oxide, CFCs and ozone.

Sources :

(a) Methane (CH_4) :

(i) CH_4 is liberated naturally when vegetation is burnt, digested or rotted in absence of oxygen.

(ii) Methane is released in paddy fields, coal mines, from rotting garbage dumps and by fossil fuels.

(b) CFCs : CFCs are man-made industrial chemicals used in air conditioning etc.

Note : CFCs are responsible for depletion of the ozone layer.

(c) N_2O : Nitrous oxide occurs naturally in the environment but in recent years it's quantities have increased significantly due to the use of chemical fertilizers and the burning of the fossil fuels.

Increase in the global temperature increases the incidence of infectious diseases like dengue, malaria, yellow fever, sleeping sickness etc.

1.6 Acid Rain

The pH of rain water is 5.6 due to the presence of H^+ ions formed by the reaction of rain water with carbon dioxide present in the atmosphere as per following reactions :

$H_2O(\square) + CO_2(g) \rightleftharpoons H_2CO_3(aq)$:

$H_2CO_3(aq) \rightleftharpoons H^+(aq) + HCO_3^-(aq)$

When the natural rain falls through polluted air, it comes in contact with chemicals such as gaseous oxides of sulphur (SOx), oxides of nitrogen (NO_2), mist of hydrochloric acid and phosphoric acid. These substances dissolves in falling rain making it more acidic than normal pH ranging between 5.6 and 3.5.

When the pH of rain water drops below 5.6, it is called acid rain. Nowadays, the term acid rain is used to describe the way in which acid from the atmosphere is deposited on the earth's surface.Oxides of nitrogen and sulphur which are acidic in nature can be blown by wind along with solid particles in the atmosphere and finally settle down either on the ground as dry deposition or in water, fog and snow as wet deposition.

Chemistry of acid rain :

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

(i) Burning of fossil fuels (which contain sulphur and nitrogeneous matter) such as coal and oil in power station and furnaces or petrol and diesel in motor engines.

(ii) Volcanic eruptions, forest fires and bacterial decomposition of organic matter.

$2SO_2(g) + O_2(g) + 2H_2O$ (□) $\longrightarrow 2H_2SO_4$ (aq)

$4NO_2(g) + O_2(g) + 2H_2O$ (□) $\longrightarrow 4HNO_3$ (aq)

Beside these ammonium salts are also formed and can be observed as an atmospheric haze (Aerosol of fine particles).

Aerosol particles of oxides or ammonium salts in rain drops settle down as wet deposition. SO_2 is also absorbed directly on both solid and liquid ground surfaces and is thus deposited as dry-deposition.

Harmful effect of acid rain

(i) Acid rain is harmful for agriculture, plants and trees because it dissolves and washes away nutrients needed for their growth.

(ii) Acid rain affects plants and animal life in aquatic ecosystem.

(iii) It causes respiratory ailments in human beings and animals.

(iv) It corrodes water pipes resulting in the dissolution of heavy metals such as iron, lead and copper into the drinking water.

(v) Building materials such as stone, marble, dolomite, mortar, slate or metal are corroded and weakened on reaction with acid rain because of the formation of soluble compounds.

$$CaCO_3 + H_2SO_4 \longrightarrow CaSO_4 + CO_2 \uparrow + H_2O$$

1.7 Particulate pollutants

Particulate refers to minute solid particles or liquid droplets in air. These are found in vehicle emissions, smoke particles from fires, dust particles and ash from industries. Particulates in the atmosphere may be viable or non-viable.

Viable Particulates : The viable particulates are minute living organisms that are dispersed in the atmosphere. Some examples are bacteria, fungi, molds, algae etc. They cause plant diseases and also produce allergic reactions to human beings.

Non-viable Particulates : Non-viable particulates may be classifed according to their nature and size as given below.

(a) Smoke particulates : They consist of solid or mixture of solid and liquid particles formed during combustion of organic matter. Examples are cigarette smoke, smoke from burning of fossil fuel, garbage and dry leaves, oil smoke etc.

(b) Dust : It consists of fine solid particles over 1µm in diameter produced during crushing, grinding and attribution of solid materials.

Examples are sand from sand blasting, saw dust from wood works, pulverized coal, cement and fly ash from factories, dust storms etc.

(c) Mists : They are produced by particles of spray liquids and by condensation of vapours in air. Examples are H_2SO_4 mist, herbicides and insecticides that miss their target and travel through air and form mists.

(d) Fumes : They are generally produced by the condensation of vapours during sublimation, distillation, boiling and several chemical reactions. Organic solvents, metals and metallic oxides form fume particles.

Air borne particles such as dust, fumes, mists etc are dangerous for human health.

Toxic effect :

(i) Particulate pollutants bigger than 5 microns are supposed to lodge in the nosal passage.
(ii) Particulate pollutants of about 1.0 micron enter into lungs easily.
(iii) Leaded petrol is the primary source of air-borne lead emission. Lead interferes with the development and maturation of red blood cells.

1.8 Smog

Word smog is obtained from the combination of the words smoke and fog. It is the one of the most common examples of air pollution that occurs in many cities through out the world. There are two types of smog as explained below.

Classical Smog

It is also known as **sulphurous smog** or **London smog** (as first occured in London). It occurs in cool and humid climate. It is a mixture of smoke, fog and sulphur dioxide. Because of the presence of SO_2 and carbon particles (soot), it is a reducing mixture and therefore it is also called as **reducing smog**.

Photochemical Smog

It is also known as **Los Angles smog** (as first occured in Los Angles). It occurs in warm, dry and sunny climate. The main components of this smog result from the action of sunlight on unsaturated hydrocarbons and nitrogen oxides produced by automobiles and factories. Photo chemical smog has high concentration of oxidising agents like NO_2 therefore called **oxidising smog.**

Mechanism of photochemical smog :

*Burning of fossil fuels yields variety of pollutants into the earth's troposphere. Most important pollutants are hydrocarbons (unburned fuels) and nitric oxide (NO).

*When the concentration of these pollutants increases to sufficiently high levels, a chain reaction occurs from their interaction with sunlight in which NO is converted into NO_2. This NO_2 in turn absorbs energy from sunlight and decomposes into NO and free oxygen atom.

$$NO_2(g) \xrightarrow{h\nu} NO(g) + O(g) \quad \text{(i)}$$

Oxygen atom being very reactive combines with atmospheric oxygen forming ozone.

$$O(g) + O_2(g) \rightleftharpoons O_3(g) \quad \text{(ii)}$$

The ozone formed in the above reaction reacts rapidly with the NO(g) formed in the reaction (i) to regenerate NO_2. NO_2 is a reddish brown/brown gas and at sufficiently high level can contribute to haze.

$$NO(g) + O_3(g) \longrightarrow NO_2(g) + O_2(g) \quad \text{(iii)}$$

*Like NO_2, O_3 is a toxic gas and both NO_2 and O_3 are strong oxidising agents : They can react with the unburnt hydrocarbons in the polluted air to produce compounds like formaldehyde, acrolein and peroxyacetyl nitrate (PAN).

$3CH_4 + 2O_3 \longrightarrow 3CH_2{=}O + 3H_2O$

$CH_2{=}CHCH{=}O$ (acrolein)

CH_3COONO_2 (peroxyacetyl nitrate, PAN)

$O_3 \longrightarrow O_2 + [O]$

O + hydrocarbons $\longrightarrow RC\dot{O}$ (free radical) $\xrightarrow{O_2} RC\dot{O}_3$ (peroxyl acyl free radical)

$RC\dot{O}_3$ + hydrocarbons $\longrightarrow CH_2 = O,$

$CH_2 = CHCHO$, ketones etc.

$RC\dot{O}_3 + O_2 \longrightarrow RC\dot{O}_2 + O_3$

$RC\dot{O}_3 + NO \quad RC\dot{O}_2 \longrightarrow \quad + NO_2$

$R{-}\overset{\overset{O}{\|}}{C}{-}O{-}\dot{O} + NO_2 \longrightarrow R{-}\overset{\overset{O}{\|}}{C}{-}O{-}O{-}NO_2$ (PAN)

Harmful/toxic effects of photochemical smog

(i) Components of photochemical smog, NO and O_3, irritate the nose and throat and their high concentration causes headache, chest pain, dryness of the throat, cough and difficulty in breathing.
(ii) Both ozone and PAN act as powerful eye irritants.
(iii) Photochemical smog leads to cracking of rubber and extensive damage to plant life.
PAN inhibits photo system, inhibits formation of chlorophyll and also spoils enzymes.
(iv) Photochemical smog also causes corrosion of metals, stones, building materials, rubber and painted surfaces.

Control of photochemical smog

(i) Certain chemical compounds are sprayed into atmosphere, which generate free radicals. These free radicals combine with those free radicals which are responsible for the formation of the component of photo chemical smog.
(ii) Using catalytic converters in the automobiles, which prevent the release of NO and hydrocarbons to the atmosphere.
(iii) By plantation of certain plants like pinus, juniparus, quercus, pyrus ant vitis which metabolise NO and thus help in the control of the formation of photochemical smog.

2. Stratospheric Pollution

Formation and break down of ozone

***** The upper part of stratosphere consists of considerable amount of ozone (O_3). The ozone layer protects us from the harmful ultra violet (UV) radiations (λ = 255 nm) coming from the sun.
***** These radiations cause skin cancer (melanoma) in human beings and, therefore, it is important to maintain and protect the ozone shield/layer.
***** Ozone is produced as a result of the action of ultraviolet radiations on dioxygen as given below.

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

$$O(g) + O_2(g) \underset{\text{dynamic equilibrium}}{\overset{UV}{\rightleftharpoons}} O_3(g) \text{ (thermodynamically unstable)}$$

***** The main reason of ozone layer depletion is believed to be the release of chlorofluorocarbon compounds (CFCs) which are also known as freons.
***** The CFCs are non reactive, nonflammable, non-toxic organic molecules and, therefore, used in refrigerations, airconditioners, in the production of plastic foam and by the electronic industry for cleaning computer parts. Released CFCs come in contact with the normal atmospheric gases and eventually reach stratosphere where they cause depletion in ozone layer as described below.

$$CF_2Cl_2(g) \xrightarrow{UV} \dot{Cl}\ (g) + \dot{C}F_2Cl\ (g)$$

$$\dot{Cl}(g) + O_3(g) \longrightarrow Cl\dot{O}(g) + O_2(g)$$

$$Cl\dot{O}(g) + O(g) \longrightarrow \dot{Cl}(g) + O_2(g)$$

In this the chlorine radicals are continuously regenerated and cause the decomposition of ozone.
Hence, CFCs act as transporting agents for continuously generating chlorine radicals into the stratosphere and damaging the ozone layer.

Ozone Hole

In Antarctica, scientists reported about the depletion of ozone layer commonly known as ozone hole over the south pole. They reported that a unique set of conditions was responsible for the ozone hole.

Polar stratospheric clouds

(i) In summer season, nitrogen dioxide and methane react with chlorine monoxide and chlorine atom forming chlorine sinks and, thereby, preventing much ozone depletion.
In winter, special type of clouds called polar stratospheric clouds are formed over antarctica. These polar stratospheric clouds provide surface on which chlorine nitrate formed gets hydrolysed to form hypochlorous acid. It also reacts with HCl produced to give molecular chlorine.

$Cl\dot{O}(g) + NO_2(g) \longrightarrow ClONO_2(g)$;

$\dot{Cl}(g) + CH_4(g) \longrightarrow \dot{C}H_3(g) + HCl(g)$

$ClONO_2(g) + H_2O(g) \longrightarrow HOCl(g) + HNO_3(g)$

$ClONO_2(g) + HCl(g) \longrightarrow Cl_2(g) + HNO_3(g)$

(ii) In spring, when sunlight returns to the Antarctica, the sun's warmth, break up the clouds and HOCl and Cl_2 are photolysed by sun light according to the following reactions.

$HOCl(g) \xrightarrow{h\nu} \dot{O}H(g) + \dot{Cl}(g)$; $Cl_2(g) \xrightarrow{h\nu} 2\,\dot{Cl}(g)$

The chlorine radicals thus formed, initiate the chain reaction for ozone depletion.

Harmful effects of depletion of ozone layer :

(i) UV radiation lead to ageing of skin, cataract, sunburn, skin cancer, killing of many phytoplanktons, damage to fish productivity etc.

(ii) UV radiations affect the plant protein which eventually leads to the harmful mutation of cells.

(iii) UV radiations increase the evaporation of surface water through the stomata of the leaves and thus decreases the moisture content of the soil.

(iv) Increase in UV radiations damage paints and fibres, causing them to fade faster.

Ex-1. Explain tropospheric pollution in 100 words

Sol. Tropospheric pollution occurs due to the presence of undesirable gases and the solid particles in the air. The major gaseous and the particulate pollutants present in the troposphere are as follows :

- Gaseous air pollutants. These include mainly oxides of sulphur (SO_2, SO_3), oxides of nitrogen (NO, NO_2) and oxides of carbon (CO, CO_2) in addition to hydrogen sulphide (H_2S), hydrocarbons, ozone and other oxidants.
- Particulate pollutants. These include dust, mist, fumes, smoke, smog, etc.

Ex-2. What is the composition of photochemical smog ?

Sol. Mixture of NO_2,. O_3, peroxyacyl nitrates (PAN), aldehydes, ketones, hydrocarbons and CO.

Section (B) : Water pollution, soil pollution and waste management

3. Water pollution

Pollution of water originates from human activities :

(i) Point source pollution

Easily identified source of pollution is called as point source. Examples are municipal and industrial discharge pipes where pollutants enter the water source.

(ii) Non point source pollution

Non point sources of pollution are those where a source of pollution can not be identified. Examples are agriculture run off (from farm, animals and crop-lands), acid-rain storm water, drainage (from streets, parking lots and lawns) etc.

Water pollutants and their sources.

Pollutant	Source
(i) Micro-organisms	Domestic sewage
(ii) Organic wastes	Domestic sewage, animal excreta and waste, decaying animals and plants, discharge from food processing factories
(iii) Plant nutrients	Chemical fertilizers
(iv) Toxic heavy metals	Industries and chemical factories
(v) Sediments	Erosion of soil by agriculture and strip mining
(vi) Pesticides	Chemical used for killing insects, fungi and weeds
(vii) Radioactive substances	Mining of uranium containing minerals
(viii) Heat	Water used for cooling in industries.

3.1 Causes of water pollution :

(a) Pathogens :

Water pollutants which are the disease causing agents are called pathogens. Pathogens include bacteria and other organisms that enter water from domestic sewage and animal excreta.

Human excreta contains bacterias such as Escherichia coli and Streptococcus faecalis which cause gastrointestinal diseases.

(b) Organic waste :

Organic matter such as leaves, grass, trash etc. are major water pollutants. They pollute the water as a consequence of decay i.e. run off. Excessive phytoplankton growth within water is also a cause of water pollution. These wastes are biodegradable.

Biodegradable waste :

These are domestic wastes which can be rapidly decomposed under natural processes by micro-organism.

Non-Biodegradable waste :

These are poisonous wastes which do not degrade or degrade very slowy in the ecosystem naturally. These are not recycled in the natural environment.

3.2 Dissolved Oxygen (DO) :

Bacteria present in large population causes the decomposition of organic matter present in water. They consume oxygen dissolved in water. The dissolved oxygen (DO) is limited in water. In winter i.e. in cold water, dissolved oxygen can reach a concentration up to 10 ppm. That is why even a moderate amount of organic matter when decompose in water can deplete the amount of dissolved oxygen in water.

If the concentration of dissolved oxygen in water is below 6 ppm, the growth of fish gets inhibited. Oxygen reaches to water **(i)** through atmosphere and **(ii)** from the process of photosynthesis carried out by many aquatic green plants during day light.

However during night, photosynthesis stops but the plants continue to respire, resulting in the reduction of dissolved oxygen. The dissolved oxygen is also used by the microorganism to oxidise organic matter. If too much of organic mattter is added to water, all the available oxygen is consumed. This leads to the death of oxygen dependent aquatic life.

The concentration of dissolved oxygen in water is very important for aquatic life. Thus **anaerobic bacteria** (which do not require oxygen) begin to break down the organic matter/waste and produce chemicals that have foul smell and are harmful to human health. Aerobic (oxygen requiring) bacteria degrade these organic waste and keep the water depleted in dissolved oxygen.

3.3 Biochemical oxygen demand (BOD)

The amount of oxygen required by bacteria to break down the organic waste present in a certain volume of a sample of water is called biochemical oxygen demand (BOD).

Biochemical oxygen demand (BOD) is a measure of the amount of dissolved oxygen that would be needed by the microorganism to oxidise the organic compounds. 'Clean water' would have a BOD value of **less than 5 ppm** where as highly polluted water (river, lake, ponds etc.) could have a BOD value of **17 ppm or more**.

3.4 Chemical pollutants

Chemical pollutants include water soluble such as cadmium, mercury, nickel etc. All these metals are dangerous to human because our body can not excrete them. Over the time, the concentration of these metals crosses the tolerance limit and thus, these metals then can damage kidneys, central nervous system, liver, etc.

Acids (like H_2SO_4) from mine drainage and salts like sodium and calcium chloride which are used to melt snow and ice in the colder climates are water soluble chemical pollutants.

Organic pollutants include petroleum products (e.g. major oil spills in oceans), pesticides, various industrial chemicals (e.g. poly chlorinated biphenyls used as cleansing solvent), detergent and fertilizers PCBs (Polychlorinated biphenyl) are suspected to be carcinogenic. Detergents are biodegradable. However their use can create problem. The addition of fertilizer increases the amount of soluble phosphates in the water and this enhances the growth of algae. Such profuse growth of algae, covers the water surface and reduces the oxygen concentration in water. This leads to anaerobic conditions, commonly, with accumulation of abnoxious decay and death. Thus, bloom-infested water inhibits the growth of other living organism in the water body.

3.5 Eutrophication

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

3.6 International standards for drinking water

(a) Fluoride : Drinking water should contain fluoride ions concentration up to **1 ppm** or 1 mg dm^{-3}. Its deficiency in drinking water causes diseases such as tooth decay etc. The F^- ions make the enamel on teeth much harder by converting hydroxyapatite, $[3Ca_3(PO_4)_2.Ca(OH)_2]$, the enamel on the surface of the teeth, into much harder fluorapatite, $[3\ Ca_3(PO_4)_2\ .CaF_2]$.

However, F^- ion concentration above 2 ppm causes brown mottling of teeth. Similar excess fluoride (over 10 ppm) causes harmful effect to bones and teeth.

(b) Lead : The upper standard limit of lead concentration is about **50 ppb**. It can damage kidney, liver, reproductive system etc.

(c) Sulphate : Excessive concentration of sulphate (>500 ppm) causes laxative effect.

(d) Nitrate : The maximum of nitrate is **50 ppm** and excess nitrate in water can cause diseases such as methemoglobinemia ('blue baby' syndrome).

(e) Other metals :

Metal	**Maximum of concentration** (ppm or mg dm^{-3})
Fe	0.2
Mn	0.05
Al	0.2
Cu	3.0
Zn	5.0
Cd	0.005

4. Soil pollution

Insecticides, pesticides and herbicides cause soil pollution.

(a) Pesticides :

Pesticides are synthetic toxic chemicals with ecological repercussions.

The repeated use of the same or similar pesticide give rise to pests that are resistant to that group of pesticides thus making the pesticide ineffective. Therefore, other organic toxins such as aldrin and dieldrin were introduced, as insect resistance of DDT increased.

Most of them are water insoluble and non-biodegradable. These high persistant toxins are, therefore, transferred from lower trophic level to higher trophic level through food chain.

Over the time, concentration of the toxins in higher animals reach a level which causes serious metabolic and physiological disorders.

(b) Herbicides :

Herbicides such as sodium chlorate ($NaClO_3$), sodium arsenite (Na_3AsO_3) and many other are now a days used to kill weeds. However because of their toxic effect to mammals their use have been restricted, some herbicides cause birth effect.

These days, organic compounds such as **triazines** are widely used as herbicides.

(c) Insecticides : These are used to control insects and thus help to curb diseases and protect crops. They include chlorinated hydrocarbons, DDT, BHC and malathon etc. However, due to adverse effects, use of DDT has been banned in india.

5. Industrial waste

(i) Biodegradable waste

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

(ii) Nondegradable waste

Generated by thermal power plants (fly ash); integrated iron and steel plants (blast furnace slag and steel melting slag); aluminium, zinc and copper manufacture (mud and tailings); Fertilizer industires (gypsum)

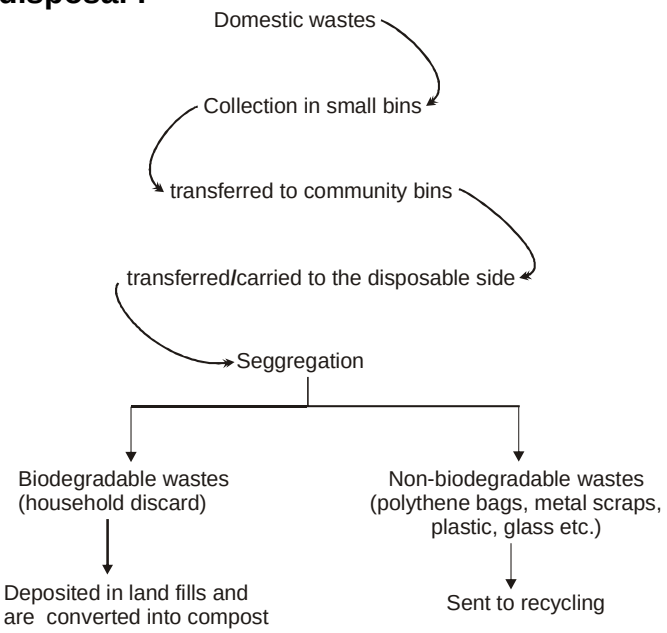
Disposal : Fly ash and slag from the steel industries are used in the cement industries.

Large quantities of toxic wastes are usually destroyed by controlled incineration, while small quantities are burnt along with factory garbage in open bins.

5.1 Waste Management

In addition to the improper disposal of the house hold wastes, disposal of medical, agriculture, industrial and mining wastes is one of the major causes of environmental degradation. Therefore, management of wastes is of utmost importance.

5.2 Collection and disposal :



Note : **(i)** Non-biodegradable waste like polythene bag, metal scraps, etc choke the sewers and if polythene bags are swallowed by cattle, it can cost their lives also. The poor waste management causes health problems leading to epidemics due to contamination of ground water.

(ii) The persons who are directly involved in the collection and disposal of waste should make the use of protective device such as gloves or water proof boots and gas masks.

6. Green chemistry

(i) Green chemistry is a way of thinking and is about utilising the existing knowledge and principles of chemistry and other services to reduce the adverse impact on environment.

(ii) Green chemistry is a continuous process that would bring about minimum pollution or deterioration to the environment.

(iii) The generation of by-products during a process if not used gainfully are not only environmental unfriendly but also cost-ineffective. In a chemical reaction, if reactants are fully converted by optimising reaction conditions into useful environment friendly medium then there would be no chemical pollutants introduced in the environment. It will be worth while to carry out the synthetic reactions in aqueous medium in place of organic solvents since water has high specific heat and low volatility. Water is cost effective, noninflammable and devoid of any carcinogenic effects.

Green chemistry in day-to-day life :

(i) Dry cleaning of clothes : Tetra chloroethene used for dry cleaning was found to contaminate the ground water and is also a suspected carcinogen. This compound has now been replaced by **liquefied carbondioxide** with a suitable detergent. This will result in less harm to ground water.

(ii) Bleaching of paper : Use of H_2O_2 with suitable catalyst has replaced the use of chlorine gas for bleaching paper.

(iii) Synthesis of chemicals :

$$CH_2 = CH_2 + O_2 \xrightarrow[Pd(II)/Cu(II)\ (in\ water)]{Catalyst} CH_3CHO \text{ (90\%, one step method)}$$

Important : Green chemistry leads to reduction in

(i) material (ii) energy consumption and (iii) waste generation.

MISCELLANEOUS SOLVED PROBLEMS

1. What would have happened if the greenhouse gases were totally missing in the earth's atmosphere ? Discuss.

Sol. The solar energy radiated back from the earth surface is absorbed by the greenhouse gases (i.e. CO_2, CH_4, O_3, CFC's and water vapour) present near the earth's surface. They heat up the atmosphere near the earth's surface and keep it warm. As a result, they keep the temperature of the earth constant and help in the growth of plants and existence of life on the earth. If there were no greenhouse gases, there would have been no vegetation and life on the earth.

2. A large number of fish are suddenly found floating dead on a lake. There is no evidence of toxic dumping but you find an abundance of phytoplankton. Suggest a reason for the fish kill.

Sol. Excessive phytoplankton (organic pollutants such as leaves, grass, trash, etc.) present in water is biodegradable. A large population of bacteria decomposes this organic matter in water. During this process they consume the oxygen dissolved in water. Water has already limited dissolved oxygen (= 10 ppm) which is further depleted. When the level of dissolved oxygen falls below 6 ppm, the fish cannot servive. Hence, they die and float dead in water.

3. How can domestic waste be used as manure ?

Sol. Domestic waste comprises of two types of materials, biodegradable such as leaves, rotten food, etc., and non-biodegradable such as plastics, glass metal, scrap, etc. The non-biodegradable waste is sent to industry for recycling and the biodegradable waste should be deposited in the land fills. With the passage of time, it is converted into compost manure.

4. For your agricultural field or garden, you have developed a compost producing pit. Discuss the process in the light of bad odour, files and recycling of wastes for a good produce.

Sol. The compost producing pit should be set up at a suitable place or in a tin to protect ourselves from bad odour and files. It should be kept covered so that files cannot make entry into it and the bad odour is minimized. The recyclable material like plastics, glass, newspapers, etc. should be sold to the vendor who further sells it to the dealer. The dealer further supplies it to the industry involved in recycling process.

5. Answer the following subparts

(i) What is loam soil ?

(ii) What are asbestosis and silicosis ?

(iii) What are particulates and what is their approximate size ?

(iv) Name three natural sources of air pollution

(v) How are flue gases from industries feed from oxides of nitrogen and sulphur ?

Sol. (i) Soil containing 34% air, 66% water along with humus is called loam soil. It is best for crops.

(ii) Asbestosis and silicosis are lung diseases caused by particulates.

(iii) Particulates are finely divided solid or liquid particles suspended in air. Their size varies from 2×10^{-4} μ to 500 μ.

(iv) Volcanic erruptions, forest fires and pollen grains of flowers.

(v) The flue gases are subjected to scrubbing with conc. H_2SO_4 or with alkaline solutions such as $Ca(OH)_2$ or $Mg(OH)_2$ etc.

6. (i) Name two important sinks of CO_2.

(ii) What is marine pollution

(iii) What is humification ?

(iv) What are viable and non-viable particulates ?

Sol. (i) Oceans (which dissolve it) and plants (which use it for photosynthesis)

(ii) Pollution of sea water due to discharge of wastes into it is called marine pollution.

(iii) The decomposition of organic material (leaves, root etc.) in the soil by microorganism to produce humus is called humification.

(iv) Viable particulates are small size living organisms such as bacteria, fungi, moulds, algae, etc. Non-viable particulates are formed by disintegration of large size materials or condensation of small size particles or droplets e.g. mist, smoke, fume and dust.

7. (i) What is the composition of photochemical smog and classical smog ? How do the two differ in their behaviour ?

(ii) What should be the tolerable limit of fluoride ions in drinking water ? What happens if it is higher than 10 ppm ?

Sol. (i) Photochemical smog is mixture of a number of irritation causing compounds like NO_2, O_3 aldehydes, peroxyacyl nitrates, ketones, hydrocarbons and CO. It is formed in summer months after sunrise.
Classical smog is a mixture of oxides of sulphur and carbons (soot). It is formed in early hours of winter months. Photochemical smog is oxidising in nature whereas classical smog is reducing in nature.
(ii) 1 ppm or 1 mg dm^{-3}. Higher concentration is harmful to bones and teeth.

8. What do you understand by greenhouse effect ? What are the major gases ?

Sol. The warming of the earth or global warming due to re-emission of sun's energy absorbed by the earth followed by its absorption by CO_2 molecules and H_2O vapour present near the earth's surface and then its radiation back to the earth is called greenhouse effect.

Though CO_2 is the main gas in the greenhouse effect, there are some other greenhouse gases like methane, chlorofluorocarbons, ozone, nitrous oxide and water vapours.

9. (i) Why does rain water normally have a pH of about 5.6? When does it become acid rain ?

(ii) Why is acid rain considered as a threat to Taj mahal ?

(iii) Explain by giving reason " The presence of CO reduces the amount of haemoglobin available in the blood for carrying oxygen to the body cells."

(iv) State briefly the reactions causing ozone layer depletion in the stratosphere.

Sol. (i) Normally rain has a pH of about 5.6 due to dissolution of CO_2 into the atmosphere ($CO_2 + H_2O \longrightarrow H_2CO_3 \rightleftharpoons 2H^+ + CO_3^{2-}$). When the pH of rain falls below 5.6, it becomes acid rain.

(ii) Taj mahal is made of marble. The acid rain contains H_2SO_4 which attacks the marble ($CaCO_3$) thereby pitting it, discolouring it and making it lustreless.

$$CaCO_3 + H_2SO_4 \longrightarrow CaSO_4 + CO_2 + H_2O.$$

(iii) CO combines with haemoglobin of the red blood cells (RBCs) about 300 times more easily than oxygen to form carboxyhaemoglobin reversibly as follows.

$$Hb + CO \rightleftharpoons HbCO.$$

Thus it is not able to combine with oxygen to form oxyhaemoglobin and transport of oxygen to different body cells cannot take place.