

ENVIRONMENTAL CHEMISTRY

Environmental chemistry : The branch of science which deals with the chemical phenomena occurring in the environment is called as environmental chemistry.

Introduction : The environment means surroundings. It has 4 following component.

(I) Atmosphere :

(A) Function of the atmosphere :

- u It **contain all the gases** which are essential for the life on the earth.
- u It is a **carrier of water vapour** which are needed for all life.
- u **O₃ is present** in it which absorbs harmful U.V. radiations.
- u It maintain heat balance of the earth by absorbing infrared radiation coming from the sun and remitted from the earth.

(B) Pressure, weight and temp of the atmosphere :

- u Pressure of atm = 10^5 N/m^2
- u Mass of atm = 5×10^{15} tonnes.
- u Temp. of atm = -100°C to 1200°C
- u Increases in altitude of 5 km, the pressure and the density of air decrease by one half.

(C) Composition of air (or atmosphere) :

- u It is divided in 3 categories.
- u Major component = N₂, O₂, water vapour.
- u Minor component = Ar, CO₂
- u Traces component = He, Ne, Ar, Kr, CH₄, H₂, CO, N₂O, SO₂, NO, NO₂, HCHO, NH₃, O₃.

(D) Regions (or structure) of the atmosphere :- It has 4 region. These regions are defined by the temp.

| Region | Altitude from earth's surface | Temp. range | Species present or gasses present |
|----------------------------------|-------------------------------|---|---|
| Troposphere | 0 - 11 km | decrease from 15°C to -56°C | N ₂ , O ₂ , CO ₂ , H ₂ O vapour |
| Stratosphere or coroyones sphere | 11 - 50 km | increase from -56°C to -2°C | N ₂ , O ₂ , O ₃ , 0-atm |
| Mesosphere ionosphere | 50 - 85 km | decrease from -2°C to -92°C | N ₂ , O ₂ , NO ⁺ , O ₂ ⁺ |
| Thermosphere ionosphere | 85 - 500 km | increase from -92°C to 1200°C | O ₂ ⁺ , O ⁺ , NO ⁺ , e ⁻ |

(II) Hydro sphere (75% of earth) : The part in which contain water in the form of sea, oceans, reivers, lakes, ponds.

(III) Lithosphere : It is solid component of the earth constiting of soil, rocks, mountains.

(IV) Biosphere : It is the part of the lithosphere, hydrosphere and atm. Where living organism interact with these parts and lived together. Ex. Green plants.

- (1) **Environmental pollution & environmental pollutant** : The addition of any undesirable material to air, water and soil by a natural source (or due to human activity) which affects the **quality of environment** is called as environmental pollution.

The undesirable material which added to the environment is called as pollutant.

Causes of pollution :

- u Fast population growth.
- u Excessive industrialisation.
- u Rapid urbanisation.
- u Use of pesticides in agriculture.

Types of pollutants : 2 types

- (I) **Primary and secondary pollutants :**

(A) **Primary pollutants** : Those which after their formation enter the environment and remain as such.

Ex. : NO, NO₂, SO₂

(B) **Secondary pollutants** : The harmful material which are formed by chemical reaction between primary pollutants in the atm.

Ex. : Hydrocarbon + Oxide of nitrogen $\xrightarrow{h\nu}$ compound

- (II) **Bio degradable and Non bio degradable pollutants :**

(A) **Bio degradable pollutants** : The materials (such as cow dungs) which are easily decomposed by the micro-organism. Thus are not harmful, but in the excess in environment, they do not undergo degradation completely and thus become pollutant.

(B) **Non bio degradable pollutants** :- The material (such as Hg, Al, DDT) which do not undergo degradation (or degrade very slowly) but their presence even in very small amount in the environment is very harmful.

They may react with other compounds present in the environment and produce more toxic compound.

Types of pollution :

- (I) **Depending on the part of the environment polluted :**

(A) Air pollution (B) Water pollution (C) Soil pollution (or land pollution)

- (II) **Depending on the nature of the pollutant added into the environment :**

- (A) Radio active pollution
- (B) Plastic pollution
- (C) Soap and detergent pollution
- (D) Oil pollution
- (E) Acid-rain pollution
- (G) Chemical pollution
- (M) Soap and detergent pollution
- (F) Smog pollution
- (H) Slit pollution
- (I) Metal toxicity pollution
- (J) Effluent pollution
- (K) Noise pollution
- (L) Thermal pollution

1. **Air pollution** : It is defined as the undesirable materials into the atmosphere either due to natural phenomena (or due to human activity on the earth). Which affect the quantity of the air and also affect the life on the earth.

- (i) **Major source of air pollution :**

Ex. due to CO, H₂S, SO₂
Forest fire

- (ii) **Man made air pollution or source due to human activity :**

Natural sources :

Ex. Burning of fossil fuels.

Which produce some poisonous gases as CO, CO₂, CH₄, oxide of nitrogen.

Combustion of gasoline in the automobiles : The automobiles emit the CO, oxide of nitrogen

Deforestation : Due to this % of CO₂ is increased and % of O₂ is decreased.

Fast industrialisation : The smoke of carbon and CO, CO₂, SO₂, H₂S, NO, NO₂ are coming out from the industries. The industries are responsible 20% of total air pollution.

Agriculture activities : The pesticides are added in the soil. They give a foul smell and affect the health of animals and human being.

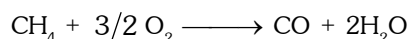
Wars : The nuclear weapons are used in war which emit the radiation.

(1) **Air pollutants :** (Five)

(A) **CO as pollutant :** Source of CO

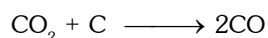
(a) **Due to human activity :**

(i) Due to incomplete combustion of hydro carbons.

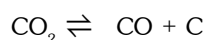


(ii) Due to forest fire (or agriculture waste) burning.

(iii) Reduction of CO₂



(iv) Dissociation of CO₂ at high temp. (2000 K)



u Only 7% CO arises from the main made

(b) **Natural sources :**

u From conversion of methane

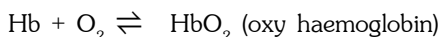
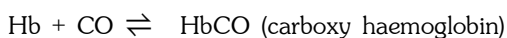
u From synthesis and decay of chlorophyll

u From oceans.

Sink of CO : A large amount of CO are added in the atm. But the level of CO does not rise too much due to CO is converted in CO₂ by the micro organism which is present in the soil.

The micro organism (bacteria) act as sink for CO.

Harmful effect of CO : The CO is poisonous because it combine with haemoglobin of R.B.C. about 300 times easily than O₂, to form carboxy haemoglobin.



Controlling of CO pollution : The CO pollution due to human activity is the use of internal combustion engines in the automobiles. For controlling the CO emission, some modification is used in the internal combustion engine or in the quality of fuels.

u The **carburetor** is adjusted to give proper air fuel ratio.

u The **exhaust system** is adjusted to give complete combustion.

u The **catalytic chamber** is fitted in the exhaust pipe so that the poisonous gases are converted in harmless gases.

u The modification of **internal combustion** is done by certain company.

u Instead of gasoline, the use of CNG and LNG

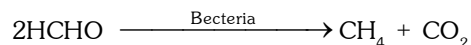
CNG = Condensed Natural Gas.

LNG = Liquefied Natural Gas.

(B) **Hydro carbon** : Source of hydro carbon.

(a) **Natural sources** :

(i) Due to decomposition of organic matter in soil.



(b) **Main made sources** :

(i) Due to burning of stationary fuel. (ii) Evaporation of organic solvent.

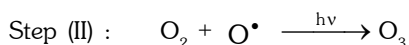
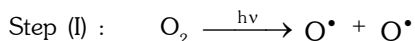
(C) **Sulphur compounds** : eg. SO_2 , H_2S

u H_2S is more poisonous than CO_2

(D) **Nitrogen compound** : eg. NO , NO_2 .

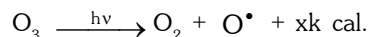
STRATOSPHERIC POLLUTION

(A) **Formation of ozone layer** : In the stratosphere (11-50 km), the O_2 is partially converted into O_3 . Now at an altitude of 25-30 km, we have a layer in which the conc. of O_3 is 10 ppm. It is called as O_3 layer in 2 step.



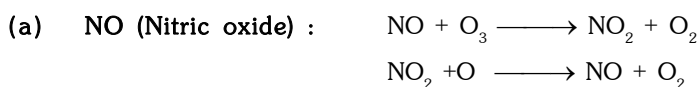
In I step : The ultraviolet radiation coming from the sun have sufficient energy to split the O_2 into 2 oxygen atoms.

In II step : The oxygen atom react with more O_2 to form O_3 the O_3 absorbed the U.V. radiations and again broken into O_2 and O atom. The heat is also given out from this reaction which warm up stratosphere. For this reason stratosphere is a ozone of increasing temp.



In this way the O_3 cycle is completed in this region.

(B) **Depletion of ozone layer** : Due to human activity 2 compounds NO and CFC are responsible for depletion of O_3 layer.

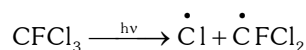
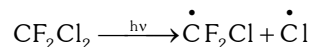


The NO react with O_3 so decrease the amount of O_3 and forms NO_2 which react with oxygen atoms available in the stratosphere and producing back NO .

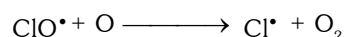
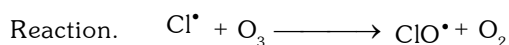
Thus no NO is consumed but O_3 gets depleted.

(b) **Chlorofluoro carbons (CFC) or freons** :

The freons decomposes in the presence of U.V. radiation coming from the sun.



The reactive chlorine atoms then destroy the ozyone layer through the following sequence of reaction. Which are repeated because chlorine atom are regenerated in the second reaction :



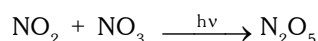
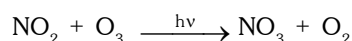
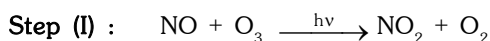
The one molecule CFC can destroy more than one thousand O_3 molecules in the stratosphere.

(c) **Effect of depletion of O₃ layer** : Due to depletion of O₃ layer, U.V. radiation fall on the earth.

- u The U.V. radiation, damage the cornea and lens of the eyes.
- u The U.V. radiation affect the plant proteins so reduce the chlorophyll.
- u The U.V. radiation, up set the heat balance of the earth.

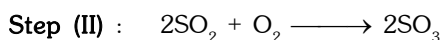
Acid Rain : The rain containig H₂SO₄, HNO₃ (and small amount of HCl) which are formed from the oxide of S and N₂ present in the air is called as acid rain. The pH of acid rain is 4-5.

Formation of acid rain : The oxide of nitrogen undergo oxidation reaction. The reaction with the water vapour present in the atm to form HNO₃.



HNO₃ come down with rain to earths.

The SO₃ react with water vapour and formed H₂SO₄.



The HNO₃ and H₂SO₄ combine with HCl present in the air to produce acidic precipitation which is called as acid rain.

| | | | |
|--------------|--------------------------------|---|--------------------|
| In acid rain | H ₂ SO ₄ | = | 60-70% |
| | HNO ₃ | = | 30-40% |
| | HCl | = | Very small amount. |

Special note : The normal rain water has a pH about 5.6 due to dissolution of CO₂ in water.



when pH of rain water 5.6, it become acidic.

Harmful effect of acid-rain :

- u It **damage to building** and status which contain marble, lime stone, state, mortar etc.
- $$\text{CaCO}_3 + \text{H}_2\text{SO}_4 \longrightarrow \text{CaSO}_4 + \text{H}_2\text{O} + \text{CO}_2$$
- u It **damage iron and steel** structure.
 - u It **corrodes water pipe**. So heavy metal (like Fe,Pb, Cu) are mixed with water which have toxic effect.
 - u The acid rain **increase the acidity of the lake**. Which is harmful to fishes.
 - u It **damage the trees, plants** and retards the growth of the plant.

Green House Effect : The warming of earth due to remission of sun's energy absorbed by the earth. The remission of earth's energy is absorbed by CO₂ molecules and H₂O vapour present near the earth's surface and then its radiation back to the earth, is called as green house effect. So the temp. of the earth is increased is called as global warming.

(1) **Industrial air pollution** : Pollutant of industries are given

- (I) **H₂SO₄ Industry** : It release large amount of SO₂ and SO₃ in atm.
- (II) **HNO₃ Industry** : It discharge NO₂ in air.
- (III) **HCl Industry** : It discharge HCl vapour, Cl₂ vapour, ClO in air.

(IV) **H₃PO₄ Industry** : It discharge H₃PO₄, H₃PO₃ vapour, and P₂O₅ in air.

(V) **Iron and steel Industry** : It discharge oxide of carbon, sulphur and metal.

(VI) **Petro chemical refineries** : It discharge CO, NO₂, vapour of gasoline, kerosene, fuel oil and formal dehyde.

(VII) **Thermal power plant** : It discharge SO₂ in air.

(VIII) **Combustion engine** : It discharge CO, NO_x, SO_x, O_xHy, O and Pb particles.

Particulates in Atomospheric Pollution : The black smoke released into the air by a diesel truck is often the most obvious form of pollution that wer routinely encounter. This smoke is composed of particulate matter. Particulates are the tiny solid or liquid particles suspended in air. These particles are usually individually invisible to the naked eye. Collectively, however, small particles often form a haze that restricts visibility. Particulates in the atmosphere may be **viable** or **non-viable**. the **viable particulates** are the minute living organisms that are dispersed in atmosphere. These include bacteria, fungi, moulds, algae etc. It may be notes that human beings are allergic to some of the fungi found in air. Fungi can also cause plant diseases. Non-viable particulates of importance are formed either by the breakdown of larger materials or by the condensation of minute particles and droplets. There are four types of non-viable particulates in the atmosphere : **mists, smoke, fumes and dust**.

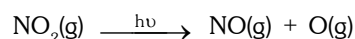
- (a) **Mists** are produced by particles of spray liquids and the condensation of vapours in air. Examples are portions of herbicides and insecticides that miss their targets and travel through the air to form mists.
- (b) **Smoke** denotes very small soot particles produced by burning and combustion of organic matter. Oil smoke, tobacco smoke and carbon smoke are typical examples of this type of particulate emission.
- (c) **Fumes** are condenses vapours : fumes of metals are the well-known particulates of this type. Examples of this category also include metallurgical fumes and alkali fumes.
- (d) **Dust** consists of the particles produced during crushing, grinding and attribution of solid materials. Non-viable dust particulates in the atmosphere consist of ground limestone, sand tailings from floatation, pulverised coal, cement, fly ash and silica dust.

The effects of particulate pblutants are largely dependent on the particle size. Whereas the coarser particles of size greater than 5 microns are likely to lodge in the nasal passages, the smaller ones are more lilely to penetrate into the lungs - the rate of penetration being inversely proportional to the size of particles. A number of these fine particulates are carcinogens. Inhalation of small particles irritates the lungs and exposure to such particles for long periods of time causes 'scarring' or 'fibrosis' of the lung lining. This type of disease is well known in industrial settings and is termed as '**Pneumoconiosis**'.

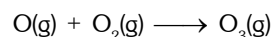
The suspended particulate matter in the atmosphere effectively reduces the amount of light rays reaching the surface of the earth and thus lowers the temperature of the earth. By blocking the sunlight, they contribute to a drop in the earth's temperature and by providing condensation nuclei; they contribute to increased fog and rain cities. Suspended particles in the city atmosphere also reduce the visibility. The visibility decrease as the atmospheric particulate concentrations increase.

Smogs : Smogs which describe the "smoke-fog" like condition, are the best-known examples of air pollution that occurs in many cities throughout the word. There are two types of smogs : (i) classical smogs which occur in cool humid climate and are the result of buildup of sulphur oxides and particulate matter from fuel combustion and (ii) photochemical smogs which occur in warm, dry and sunny climate and result from the action of sunlight on the nitrogen oxides and hydrocarbons produced by automobiles and factories. Photochemical smog is an oxidising smog having a high concentration of oxidising agents whereas classical smog is chemically reducing smog with high concentrations of SO₂. Photochemical smog occurs generally in those cities which have very large populations and high vehicular density.

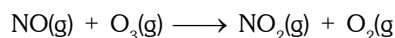
Formation of photochemical smog : The chemistry of formation of photochemical smog centres around nitric oxide (NO). At the high temperatures, in the petrol and diesel engines of cars and trucks, N_2 and O_2 react to form a small quantity of NO, which is emitted into air with the exhaust gases. This NO oxidised in air to NO_2 which in turn absorbs energy from sunlight and breaks up into nitric oxide and free oxygen atom. (Photochemical decomposition)



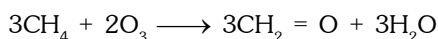
Oxygen atoms are very reactive and can combine with O_2 to form ozone;



The O_3 formed in the above reaction reacts rapidly with the NO(g) formed in reaction to regenerate NO_2 .



Both NO and O_3 are strong oxidising agents and can react with the unburnt hydrocarbons in the polluted air to produce chemicals such as formaldehyde, acrolein and peroxyacetyl nitrate (PAN) that cause the eyes to water and burn and are harmful to the respiratory system. The brownish haze of photochemical smog is largely attributed to the brown colour of NO_2 .



Formaldehyde

Acrolein and peroxyacetyl nitrate (PAN) are particularly noxious.



Acrolein



Peroxyacetyl nitrate (PAN)

Effects of Photochemical Smog : The three main components of photochemical smog are nitrogen oxides, ozone and organic derivatives (such as acrolein, formaldehyde, PAN etc.) Each contributes to the hazardous effects of smog. Pungent smelling, smog-produced ozone is known to be toxic. It can cause coughing, wheezing, bronchial constriction and Peroxyacetyl nitrates and aldehydes found in smog are eye irritants. Materials are also adversely affected by some smog components. Rubber has a high affinity for ozone and is cracked and aged by it. Smog also affects to cause damage to vegetation and reduction in plant growth and crop productivity. Of all the components of smog, PAN has the highest toxicity to plants, attacking younger leaves and causing 'bronzing' and 'glazing' of their surfaces.

Control of Photochemical Smog : Efforts have been made to suppress or control formation of photochemical smog. Installation of efficient catalytic converters in the automobiles is the most straightforward way of reducing smog formation as it prevents the release of nitrogen oxides and hydrocarbons to the atmosphere. Photochemical smog can also be suppressed by certain compounds, which act as free radical traps. When these compounds are sprayed in the atmosphere, they generate free radicals which readily combine with free radical precursors of photochemical smog.

2. **Water Pollution :** The quality of drinking water is very important for human welfare. The pollution of water by sewage has been linked to the spread of diseases such as cholera and typhoid fever. Table lists the major water pollutants and their sources.

Pollutant

Microorganisms

Organic wastes

Plant nutrients

Toxic heavy metals

Sediments

Source

Domestic sewage

Domestic sewage, animal waste, decaying animals and plants and discharge from food processing factories

Chemical fertilizers

Industries and chemical factories

Erosion of soil by agriculture and strip mining

| | |
|------------------------|---|
| Pesticides | Chemicals used for killing insects, fungi and weeds |
| Radioactive substances | Mining of uranium containing minerals |
| Heat | Cooling water used by industrial plants (which is discharged as hot water) |

In addition, industrial wastes also contaminate water.

(i) **Heavy Metals** : Metals such as Cd, Pb and Hg may be present in industrial or mining waste. These metals can prove poisonous to humans – Cadmium and mercury can cause kidneys, liver brain and central nervous system. All of these metals are cumulative poisons the body does not excrete them and their concentration builds up.

(ii) **Detergents and Fertilizers** : These may contain phosphates as additives. The addition of phosphours to water, in the form of the phosphate anion PO_4^{3-} , encourages the formation of algae, which reduces the dissolved oxygen concentration of water. The process, known as eutrophication, impedes the development of higher life forms, such as fish.

(iii) **Acid-polluted water ($\text{pH} < 3$)** : This is deadly to most forms of aquatic life. Water downstream from a mine may be contaminated by acid mine drainage, the result of microbial oxidation of discarded waste material at the mine site. Acid mine water principally contain sulphuric acid produced by the oxidation of iron pyrites (FeS_2). Industrial wastes and acid rain may also contribute to the acidity of natural waters.

(iv) **Polychlorinated biphenyls (PCBs)** : These chemicals are relatively recent additions to the list of contaminants of water. Having high stabilities, PCBs find many applications, for example they are used as fluids in transformer capacitors. PCBs are resistant to oxidation and their release into the environment causes skin disorders in humans. They are reported to be carcinogenic.

Synthetic detergents : The quality of water is of vital concern for mankind since it is directly linked with human welfare. There are some international standars for drinking water, which must always be obeyed if water is to be used for drinking purposes. These are :

Fluoride : Soluble fluoride is often added to drinking water to bring it up to a concentration of 1 ppm or 1 mg dm^{-3} . This concentration is within agreed safety limits and has been shown to protect teeth against decay. High concentrations of fluoride are poisonous and are harmful to bone and teeth at levels over 10 ppm (mg dm^{-3}).

Lead : The limit for the concentration of lead ions in drinking water is 50 ppb ($\mu\text{g dm}^{-3}$). If water is relatively acidic and lead pipes are used for water transport, then the water is liable to get contaminated with lead.

pH : The pH of drinking water should be between 5.5 and 9.5. A decrease in the pH of the water increases the solubility of metal ions.

Other Metals : The maximum recommended levels of common metals in drinking water are as follows.

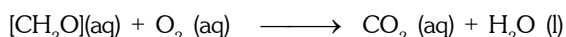
| Metal | Max. concentration (ppm or mg dm^{-3}) |
|-------|--|
| Zn | 5 |
| Fe | 0.2 |
| Mn | 0.05 |
| Cu | 3 |
| Cd | 0.005 |
| Al | 0.2 |

Sulphate : Sulphate is harmless at moderate levles, but excessive sulphate ($> 500 \text{ ppm}$) is thought to have a laxative effect.

Nitrate : Excess nitrate in drinking water can lead to methemoglobinemia (blue-baby syndrome). It also may be linked to stomach cancer, although this link has not been proved. A maximum limit of 50 ppm for the nitrate ion in drinking water has been set.

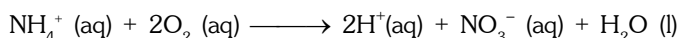
Importance of dissolved Oxygen in water : The concentration of dissolved oxygen in water is of vital importance for the support of aquatic life. The fish growth is inhibited if the dissolved concentration of oxygen in water is below 6 ppm. The lower the concentration of dissolved oxygen, the more polluted is the water sample. Oxygen reaches water through two sources. The first is that oxygen dissolves at the surface of the water from the atmosphere. Still water takes up oxygen slowly whereas turbulent water takes it up more rapidly since bubbles are often submerged. The second source of oxygen in water is from photosynthesis. Where there are many aquatic green plants present, the water often becomes supersaturated with oxygen during the hours of daylight. However, after dark, photosynthesis stops but the plants continue to respire and actually reduce the amount of dissolved oxygen. Therefore, during a 24 hour period, some water samples have a considerable range of dissolved oxygen levels.

Various processes contribute to the deoxygenation of water. The dissolved oxygen in water is consumed rapidly by microorganisms to oxidise organic matter of sewage.

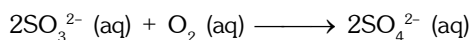
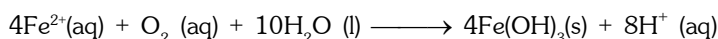


Unless the water restores its dissolved oxygen concentration for example, by the turbulent flow of shallow waters or by a reaction, it is not able to support many organisms.

In addition to the microorganism - mediated oxidation of organic matter described above oxygen in water may be consumed by the bio-oxidation of the nitrogenous material.



and by the chemical or biochemical oxidation of chemical reducing agents



Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) : The polluted water may contain large amounts of inorganic and organic compounds. Some of these can be oxidised by dissolved oxygen in the presence of microorganisms. Biochemical oxygen demand (BOD) is a measure of the dissolved oxygen that would be needed by the microorganisms to oxidise these compounds. BOD, therefore, is a measure of the contamination caused by the totality of those compounds which can be oxidised in the presence of microorganisms. A large number of organic and inorganic compounds, however, are resistant to microbial oxidation. They, therefore, don't contribute to the BOD, though their presence makes water unfit for consumption. The BOD is taken as a realistic measure of water quality 'clean water' would have a BOD value of less than 5 ppm whereas highly polluted river water could have a BOD value of 17 ppm or more. In order to find out BOD, the water sample is first saturated with oxygen. It is then incubated at constant temperature, usually 20 °C, for five days. This allows time for microorganisms in the water sample to oxidise pollutants. The remaining amount of dissolved oxygen is determined and BOD is obtained by subtraction. BOD measurement takes a few days (generally five days), so another parameter called the chemical oxygen demand (COD) is sometimes measured.

In a COD determination the water sample is treated with a known quantity of an oxidising agent, usually potassium dichromate $\text{K}_2\text{Cr}_2\text{O}_7$ in acidic medium. This reagent oxidises most of the polluting substances, including those which are resistant to microbial oxidation. The remaining $\text{K}_2\text{Cr}_2\text{O}_7$ is determined by back titration with a suitable reducing agent like Mohr's salt. From the concentration of $\text{K}_2\text{Cr}_2\text{O}_7$ consumed, the amount of oxygen used in the oxidation may be calculated using the following chemical equation



The results are expressed in terms of amount of oxygen, in ppm, that would be required to oxidise the contaminants. This is called COD.

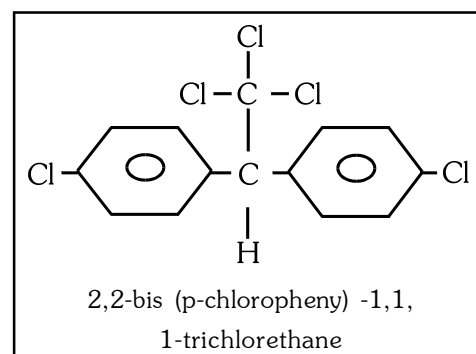
- (I) **Industrial wastes** : Some industries are responsible soil pollution. These industries are paper and pulp mills. Sugar mills textiles, chemical industries, metal processing industries, mining, cement, glass industries. petroleum industry.
- (II) **Urban wastes** : . If contain paper pieces, glass, plastics, used cans leaves, polythene bags. These wastes emit out poisonous gases, toxic hydrocarbons which cause diseases.
- (III) **Agricultural pollutants** : The use of fertilizers, pesticides, soil condition yield from the crop but polluted the soil.

Land Pollution : Most of the land pollution is caused by pesticides and other chemicals which are added to the soil grow better crops. Often, a pesticide poisons many more organisms than those intended. Some of these poisons pass through food chains and eventually reach harmful proportions. Solid wastes are another cause of land pollution.

Pesticides : Pesticides are substances that are used to kill or block the reproductive processes of unwanted organisms. Synthetic pesticides are of concern to us, because of the possible effect upon human health through eating of food, or drinking water, contaminated with these chemicals. Most pesticides can be put into one of three categories.

(i) **Insecticides** : Control of insects by insecticides helps to cure disease (for example malaria and yellow fever) and protect crops. Organochlorines are a group of compounds which have been developed and used as insecticides since the 1950s. The best known organochlorine compound is DDT (dichlorodiphenyltrichloroethane). Organochlorines are stable in the environment, toxic to insects in small amounts, but much less so to humans; and because they are organic compounds, not very soluble in water. The advantage of these insecticides is that, being persistent they show their biological activity for long periods of time. On the negative side, these insecticides by accumulating in the environment affect many non-target organisms, not just the target pests. It is primarily because of these persistent nature that many of these insecticides have been phased out of use.

(ii) **Herbicides**: Herbicides are used to kill weeds. Sodium chlorate, NaClO_3 and sodium arsenite Na_3AsO_3 were commonly used as weed killers in the first half of the last century, but inorganic arsenic compounds in particular are toxic to mammals. Organic herbicides are, therefore, now used. They are much more toxic to certain types of plants than to others. Organic herbicides such as triazines are present widely used to kill weeds in cornfields.



(iii) **Fungicides**: Fungicides are used to check the growth of fungi. Fungi, as you know, are the plants without chlorophyll. They, therefore cannot use solar energy to convert carbon dioxide and water into energy-rich carbohydrates. They live as saprophytes on decaying organic matter or as parasites at the expense of living organisms. Hence they are deemed as a threat to human interests. Fungicides are important because they counter the growth of fungi. Organic compounds of mercury have been used as fungicides. These compounds break down in soil and this has had disastrous consequences-many human deaths in Iraq (1971-72) resulted from the people eating bread made from grain that had been treated with the fungicide methylmercury.

Strategy for control of environmental pollution :

The management of waste : The production and improper disposal of waste are causes for a great deal of environmental pollution. In addition to the household waste which included sewage and municipal garbage, many toxic industrial wastes from manufacturing processes require treatment and/or safe disposal.

Recycling : When materials are recycled, there are several benefits, apart from saving on the cost of raw materials, waste disposal costs are reduced. Examples of recycling by industry are :

1. the collection and recycling of glass (in bottle banks);
2. the use of scrap metal in the manufacture of steel;
3. the recovery of energy from burning combustible waste.

Thus recycling converts waste into wealth.

Sewage treatment : The main stages in the treatment of sewage are as follows :

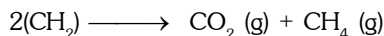
1. The removal of large solids that get into the system of filtering the waste water through screens. The solids that are removed are disposed of in landfill sites.
2. Settlement in tanks to allow the removal of solids that settle out (called sludge). This process also allows removal of grease which floats to the surface and can be skimmed off.
3. The degradation of the organic content of waste water by microbial oxidation.
4. Application of various physical and chemical processes for improving the quality of waste water. The processes include chemical removal of phosphate, coagulation, filtration and disinfection using chlorine.

The safe disposal of the sludge produced during water treatment is a problem.

The sludge is dried and then may be incinerated, digested or dumped.

Incineration : Incineration converts organic materials to CO_2 and H_2O . It may serve to destroy household waste, chemical waste and biological waste (e.g. from hospitals). A high temperature is required usually in excess of 1000°C , and a plentiful supply of oxygen. Exhaust gases must be filtered. The process greatly reduced the volume of waste—an inorganic ash is left behind, which is disposed of as landfill. Incineration provides a means to dispose of the relatively inert PCBs, and the high temperature generated allow endothermic reactions, such as the destruction of C-Cl bonds in organochlorine compounds, to take place. The chief disadvantage of incineration is that it leads to air pollution. Further the ash from municipal incinerators is very finely divided and can be ingested into the lungs. Incomplete combustion of PCBs can cause formation of highly toxic chloro compounds such as polychlorodibenzodioxin (PCDDs) and polychlorodibenzofurans (PCDFs). This is most likely to happen in older municipal waste incinerators.

Digestion : Anaerobic digestion occurs when microorganisms degrade wastes in the absence of oxygen. It may be used to treat sewage sludge, but the process can also be used to degrade a variety of toxic organic wastes. Carbon dioxide and methane, which may be used as a fuel, are the products. The overall process is the conversion of the organic material into carbon dioxide and methane i.e.



Dumping : Ocean dumping of sewage sludge has been widely practiced in the seas around the world. However, the practice of application to sludge the land is increasing. The sludge contains nitrogen and phosphorus which make it useful as a fertilizer. Urban areas produce sludge with high toxic metal content, so the amount of such sludge dumped in this way must be carefully controlled.

Green Chemistry : A New Route to Protection of Environment :

Green Chemistry or environmentally benign chemistry, introduced in 1990s, focuses on processes and products that reduce or eliminate the use and generation of hazardous substances. For success in achieving the objective of green chemistry, one has to take care of any aspects. The use of starting materials - reagents and solvent that pose less hazard to man and his environment, is one aspect. Using raw materials more efficiently and generating less waste is another. In this regard, the utilisation of reactions that are simple additions which completely incorporate the starting material into the final product and, therefore, do not produce waste that needs to be treated, disposed of, or otherwise dealt with becomes a goal.

Green chemistry and the design and development of green chemical products and processes follows the same tradition of scientific discovery and understanding that has characterized chemistry from its origins. Green chemistry simply utilises the information that is now available to the scientific community about the toxicity and other hazards posed by certain chemical in order to fully evaluate the negative as well as positive impact of the chemistry being designed. Databases of information on the hazardous properties of chemicals have only recently become available. In the previous years the absence of these data meant that chemists could not effectively evaluate the consequences of the chemical substances that were being designed and synthesized. Since this is no longer the case, it is the responsibility of the chemists and chemical community to use this information.

Achievements of Green Chemistry :

Since the inception of green chemistry, chemists from all over the world are using this creative and innovative skills to develop new processes synthetic method, analytical tools reaction conditions, catalysts, etc. A lot of success has been achieved on this front. The processes developed include among others.

- (i) Development of a new method of synthesizing ibuprofen in 99% yield, avoiding the uses of large quantities of solvent and wastes associated with the traditional stoichiometric use of auxiliary chemicals when effecting chemical conversions.
- (ii) Development of a method for 'catalytic dehydrogenation of diethanolamine' in which a new technique allows the production of an environmentally friendly herbicide in a less dangerous way. This technology represents a major breakthrough because it avoids the use of cyanide and formaldehyde. It is safer to operate, produces high overall yield and has fewer process steps.
- (iii) Development of processes using carbon dioxide as the blowing agent, for manufacture of polystyrene foam sheet packaging material. This technology allows elimination of chlorofluorocarbon blowing agents, chemicals that contribute to ozone depletion, global warming and ground level smog.
- (iv) Designing of a safer marine antifouling compound 'Sea-nine' that degrades far more rapidly than organotin compounds which persist in the marine environment and cause pollution problems.