

## Air Pollution

Air pollution is the excessive concentration of foreign matter in the air which adversely affects the well being of the individual or causes damage to property.

### Methods of identifying air pollution:-

There are 3 methods

1. Sensory recognition.
2. Physical measurement of pollution.
3. Effects on plants, animals and buildings.

1. Sensory recognition - The first awareness of an air pollution problem is through some effects on the individual. These are :-

- a) Strong or unusual odours.
- b) Reduction in visibility.
- c) Eye irritation.
- d) Acid taste in the mouth.
- e) Feel of grit under foot.

2. Physical Measurement:- It is often not possible to detect trace quantities of many air-borne toxic substances by the presence of radioactive matter through the senses. Their identification requires physical measurement by standard methods of sampling and analysis.

### 3. Effects on plants, animals and buildings :-

Effects of air pollution can be observed on the growth of plants and health of animals. Similarly, its deleterious effect on buildings can also be observed.

### Sources & classification of Air Pollutants :-

The air pollutants may be usually classified into groups according to the general nature of source:

- Natural sources :- natural fog, pollen grains, bacteria, and products of volcanic eruption.
- Anthropogenic sources :- originating from combustion, heating processes in industries, manufacturing of chemicals, pulp and paper and petroleum products, food processing and agricultural products.
- Aerosols (Particulates) :- dust, smoke, mists, fog and fumes
- Gases and vapours :-

1. Sulphur compounds	$\text{SO}_2$ , $\text{SO}_3$ , $\text{H}_2\text{S}$ , mercaptans
2. Nitrogen compounds	$\text{NO}$ , $\text{NO}_2$ , $\text{NH}_3$
3. Oxygen Compounds	$\text{O}_3$ , $\text{CO}$ , $\text{CO}_2$
4. Halogen Compounds	$\text{HF}$ , $\text{HCl}$
5. Organic Compounds	Aldehydes, hydrocarbons
6. Radioactive compounds	Radioactive gases.

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Natural Contaminants:- Among natural contaminants pollen is important because of its peculiar properties irritating to some individuals.

- Pollen grains are the male gametophytes of gymnosperms and angiosperms and they are discharged into the atmosphere from weeds, grasses and trees.
- Because wind pollution, thousands of pollen grains are liberated. While air transported pollen grains range between 10 and 50  $\mu$ .

Aerosols:- The particulate particles larger than a molecule but small enough to remain suspended in air are called aerosols.

- An aerosol can also be defined as a "colloidal system in which the dispersion medium is a gas and the dispersed phase is solid or liquid.
- The particulate matter in air may occur in air largely in solid form as particles of dust, smoke, fume etc.
- In form of liquid it is known as mist and fog.

- Dust:- Dust is made up of solid particles predominantly larger than those found in colloids and capable of temporary suspension in air (or) other gases.
- Dust is produced by the crushing, grinding etc., of organic and inorganic materials.
  - It may be by-product of mechanical process such as the sawing of wood, or made up of residue of mechanical operation such as sand blasting.

- Dust do not diffuse, they settle under the influence of gravity.
- Dust may range in size from "1 to 1000  $\mu\text{m}$ "
- ii) Smoke: It consists of fine, solid particles resulting from the incomplete combustion of organic particles such as coal, wood (or) tobacco.
- It consist mainly of carbon and combustible mate
- Generally the size of particles is less than "1  $\mu\text{m}$ ".
- iii) Mists:- It is a light dispersion of minute water droplets suspended in the atmosphere.
- Mists are usually less than "10  $\mu\text{m}$ " in dia.
- Natural mist particles formed from water vapour in the atmosphere are rather large, ranging from 500 - 40  $\mu\text{m}$ .
- iv) Fog:- It refers to visible aerosols in which the dispersed phase is liquid.
- Formation by condensation is usually implied.
- In meteorology, it refers to dispersion of water or ice in the atmosphere near the earth's surface reducing visibility to less than  $\frac{1}{2}$  Km.
- Natural fog particles ranges from "40 - 1.0  $\mu\text{m}$ "
- v) Fumes:- These are solid particles generated by condensation from the gaseous state, generally after volatilization from melted substances, and often accompanied by chemical reaction such as oxidation.
- They range in size from 0.03 to 0.3  $\mu\text{m}$ .

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Spray:- It consists of liquid particles formed by the atomization of parent liquids, such as pesticides and herbicides.

→ Spray particles range in size from 10 to 1000 nm.

Gases:- Following are the gases in air pollutants.

(i) Sulphur Dioxide:-

→  $\text{SO}_2$  is the basic air pollutant amongst all the oxides of sulphur.

→  $\text{SO}_2$  is an irritant gas, and when inhaled, affects our mucous membranes.

→  $\text{SO}_2$  is responsible for causing acidity in fogs, smokes and in rain and hence is the major source of corrosion of buildings and metallic objects.

→ The main source of  $\text{SO}_2$  is the combustion of fuel, especially coke, coal.

→ The major contributors of  $\text{SO}_2$  are refineries, chemical-plants, municipal incineration plant etc.

→ Among the miscellaneous operations releasing  $\text{SO}_2$  into the atmosphere are sulphuric acid plants and paper manufacturing plants.

(ii) Carbon Monoxide (CO):-

→ CO is a colourless, odourless and toxic gas.

→ It is produced when organic materials like natural-gas, coal (or) wood are incompletely burnt.

→ It is highly poisonous gas and is generally classified as asphyxiant.

→ Chief source of CO in the atmosphere is combustion, especially due to automobile exhausts.

### (iii) Oxides of Nitrogen ( $\text{NO}_x$ ):-

- It is probable that oxides of nitrogen are the second most abundant atmospheric contaminants in many cities, ranking next to  $\text{SO}_2$ .
- Atmospheric nitrogen may combine with oxygen at high temperatures, as generated during fuel combustion, to form nitric oxide ( $\text{NO}$ )
- The nitric oxide at low levels is relatively harmless but at high concentrations may cause asphyxiation and respiratory discomfort.
- The oxides of nitrogen originates from automobile exhausts, incineration plant, furnace smokes etc.
- Out of seven oxides of nitrogen ( $\text{N}_2\text{O}$ ,  $\text{NO}$ ,  $\text{NO}_2$ ,  $\text{NO}_3$ ,  $\text{N}_2\text{O}_3$ ,  $\text{N}_2\text{O}_4$ ,  $\text{N}_2\text{O}_5$ ) only nitric oxide and nitric dioxide are classified as pollutants.

### (iv) Hydrocarbons (HC):-

- They are group of compounds consisting of carbon and hydrogen atoms.
- They are either evaporated into the atmosphere from the petroleum fuel supplies or are emitted in the automobile exhausts that did not burn completely. They may also be contained in furnaces of oil refineries.
- HC are washed out of the air when it rains and run into surface water. Their presence in water causes an oily film on the water surface.

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→ HC are generally divided into 2 categories i.e.

- i) aliphatic group of hydrocarbon
- ii) aromatic group of hydrocarbon

→ Aldehydes and ketones are considered under hydrocarbons, because they are formed by the photochemical oxidation of hydrocarbons, as secondary pollutants in the atmosphere.

⑤ Hydrogen Sulphide and Mercaptans :-

- H<sub>2</sub>S is a foul smelling gas.
- The major source of its natural emission include anaerobic biological decay processes on land, in marshes and in the oceans.
- Volcanoes and natural water springs emit H<sub>2</sub>S to some extent.
- Major source of H<sub>2</sub>S is the Kraft pulp industry.
- The other industrial sources of H<sub>2</sub>S are petroleum refineries, coke-oven plants and some chemical operations.
- The other sulphur compound like mercaptans are important because of their strong odour. The mercaptans are emitted in mixtures of pollutants from some pulp mills, petroleum refineries and chemical manufacturing plants.

vi) Hydrogen fluoride:-

- HF is more important in terms of injury to vegetation and animals than in terms of injury to humans.
- HF is an important air contaminant.
- The major sources of fluorides are the manufacture of phosphate fertilisers, the aluminium industry, brick plants, pottery and ferro-enamel works.

Radio active Gases:-

- A major source of radio-active gases and particulate is the nuclear power reactor and related fuel handling facilities.
- The other sources are experimental accelerators, testing of nuclear bombs in the atmosphere, agricultural, industrial & medical use of radioactive isotopes.
- Another important source is the nuclear fuel reprocessing plant.

## Primary and Secondary Air Pollutants:

The natural hazardous events like dust storms, volcanoes etc. or from human activities like burning of wood, coal, oil in homes or industries or automobiles etc. are called the primary pollutants.

→ These contribute about 90% of the global air pollution.

The important primary air pollutants are:

- i) Finer particles (less than  $100\mu\text{m}$  in dia)
- ii) Coarse particles (greater than  $100\mu\text{m}$  dia)
- iii) Sulphur compounds
- iv) Oxides of nitrogen
- v) Carbon monoxide
- vi) Halogen compounds
- vii) Organic compounds
- viii) Radioactive compounds

Finer aerosols include particles of metal, carbon, tar, resin, pollen, bacteria, etc.

These primary pollutants react with one another (or) with water vapour, with or without photoactivation to form entirely a new set of pollutant called the secondary pollutants.

The important secondary pollutants are

- i) Sulphuric acid ( $\text{H}_2\text{SO}_4$ )
- ii) Ozone ( $\text{O}_3$ )
- iii) Formaldehydes
- iv) PAN (Peroxy acetyl nitrate)
- v) Photochemical Smog

ab) Smog: It is a synonym of two words - Smoke & fog. Smog can be of two types - photochemical or coal induced.

- Photochemical smog is restricted to highly motorised areas in metropolitan cities, e.g., Los Angeles.
- It occurs under adverse meteorological conditions when the air movement is restricted.
- Smog is caused by the interaction of hydrocarbons and oxidants under the influence of sunlight giving rise to dangerous PAN.
- Its main constituents are nitrogen oxides, PAN, hydrocarbons, carbon monoxide and ozone.
- It reduces visibility, causes eye irritation, damage to vegetation and cracking of rubber.

Coal induced Smog:

- The fog from burning coal covers urban areas at night or on cold days when the temperature is below  $10^{\circ}\text{C}$  and when the calm meteorological conditions prevail.  
e.g. London (Dec 1952).
- This fog consists of smoke, sulphur compounds & fly ash.

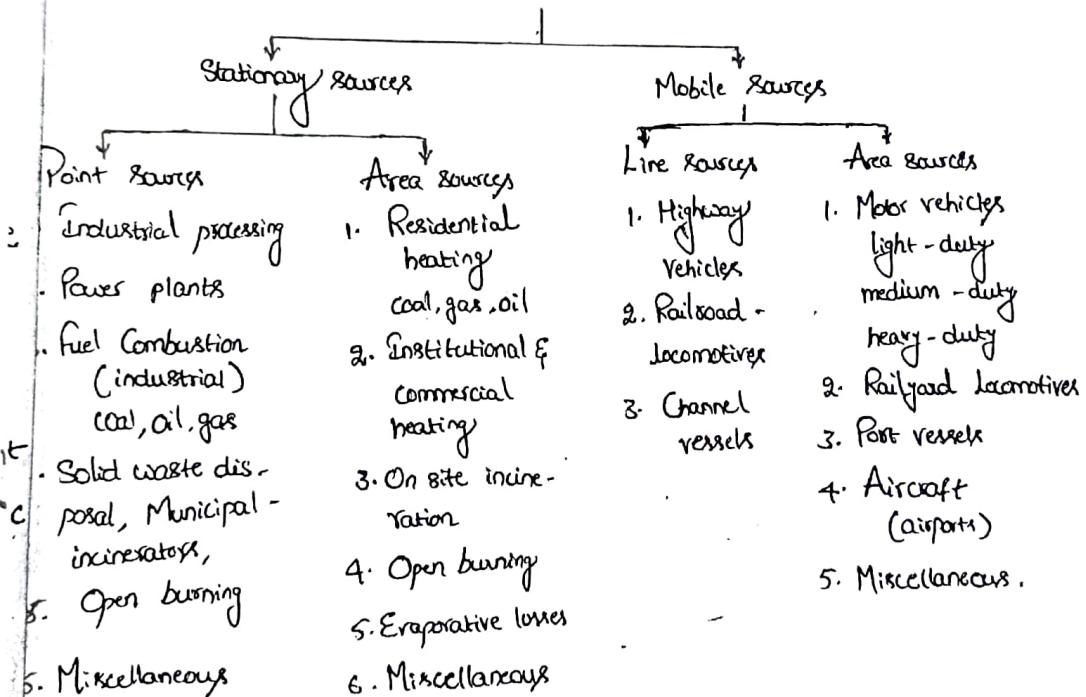
Effect: Prolonged exposure to smog may result in a high mortality rate especially among the elderly those who have histories of chronic bronchitis, broncho-pneumonia and other lung or heart disease.

## Stationary and Mobile Sources:

Another method of classifying air pollutants sources is by:

1. Point sources - large stationary sources
2. Area sources - small stationary sources and mobile sources with indefinite routes.
3. Line sources - mobile sources with definite routes.

### Total Sources



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## Effects of Air Pollution on Human Health

1. Eye Irritation
2. Nose and throat irritation
3. Irritation of the respiratory tract.
4. Gases like  $H_2S$ , ammonia and mercaptans cause odour nuisance even at low concentrations.
5. Increase in mortality rate and morbidity rate.
6. A variety of particulates particularly pollen, etc. initiate asthmatic attacks.
7. Chronic pulmonary diseases like bronchitis and asthma are aggravated by a high concentrations of  $SO_2$ ,  $NO_2$ , particulate matter and photochemical smog.
8. Carbon monoxide combines with the haemoglobin in blood and consequently increases stress on those suffering from cardiovascular and pulmonary diseases.
9. Hydrogen fluoride causes diseases of the bone (fluorosis) and mottling of teeth.
10. Carcinogenic agents cause cancer.
11. Dust particles cause respiratory diseases. Diseases like silicosis, asbestosis, etc., result from specific dusts.
12. Certain heavy metals like lead may enter body through the lungs and cause poisoning.

## Effects of Air Pollution on Animals

→ The adverse health effects of air pollutants on farm animals occur, when animals eat the plants, grasses, fodder and other vegetation, which has been contaminated by the air pollutants.

→ Important contaminants that affect the livestock are:

- i) Fluorine    ii) Arsenic    iii) Lead

i) Fluorine: Cattle and sheep are the most susceptible to fluorine.

→ Horses appear to be quite resistant to fluorine poisoning.

→ Poultry are probably the most resistant to fluorine, of all farm animals.

Symptoms: Lack of appetite, rapid loss in weight, decline in health and vigour, lameness, periodic diarrhoea, muscular weakness and death.

→ Symptoms of advanced fluorosis include lack of appetite, general ill health due to malnutrition, lowered fertility, reduced milk production and growth retardation.

ii) Arsenic: It occurs as an impurity in many ores and in coal.

### Symptoms of Acute Arsenic Poisoning

- Severe salivation, thirst, vomiting, uneasiness, feeble and irregular pulse and respiration. There is diarrhoea, and the faeces have a garlic odour.

and are sometimes bloody. The ears become cold, Death may occur in few hours or days.

### Chronic Arsenic Poisoning:

The animal becomes dull, and exhibits a loss of appetite, with a resulting weight loss. There may be chronic cough and diarrhoea may occur continually.

- There may be thickening of the skin, anaemia and abortion or sterility.
- Chronic poisoning can result in eventual paralysis and death.

iii) Lead: Lead contamination takes place due to industrial sources such as smelters, coke ovens and other coal combustion processes.

Acute Lead poisoning: Prostration, staggering and inability to rise are prominent symptoms.

- The pulse is always fast but weak.
- Some animals may fall suddenly, stiffen the legs and have convulsions.
- There is complete loss of appetite, prostration of the digestive tract and diarrhoea.
- In cattle, grinding of teeth and chewing of the cud.

Chronic Lead Poisoning: It has been observed frequent in horses that have been grazing on land near smelters, lead mines, and in orchards have been sprayed.

- Paralysis of the muscles of the larynx, difficulty in breathing are the symptoms.

## Effects of Air Pollution on Plants

### - Forms of Damage to Leaves

1. Necrosis : It is the killing or collapse of tissue
2. Chlorosis : It is the loss or reduction of the green plant pigment, ~~the~~ chlorophyll.
3. Abscission : Leaf abscission is dropping of leaves
4. Epinasty : Leaf epinasty is a downward curvature of the leaf due to higher rate of growth on the upper surface.

### - Effects of Pollutants on plants

- |                  |        |   |
|------------------|--------|---|
| 1. $\text{SO}_2$ | - Mild | - Intervenital chlorotic bleaching of leaves  |
|                  | Severe | - Necrosis in interveinal areas and skeletonized leaves.                            |
| 2. Ozone         | - Mild | - Flecks on upper surfaces, premature aging and suppressed growth.                  |
|                  | Severe | - Collapse of leaf, necrosis and bleaching  |
| 3. Fluorides     |        | - Necrosis at leaf tip  |
| 4. $\text{NO}_2$ |        | - Suppressed growth, leaf bleaching   |
| 5. Ethylene      |        | - Epinasty, leaf abscission   |
| 6. PAN           |        | - Bronzing of lower leaf surface, suppressed growth. young leaves more susceptible. |

### 3) Effects of Air Pollutant on Materials and Services

- Air pollutant cause deteriorating effects on metallic surfaces, glass surface, painted surface, building stones, rubber surfaces etc. along with damaging the paper and fabric.
- Oxide of Sulphur and nitrogen react in the atmosphere with water vapour to form acidic fumes, which attack and damage the ~~reacted~~ metal surface.  
This problem is acute for the computer, switch gear and communication industries.
- Fluorine is highly reactive, at high atmospheric concentration may even cause etching of glass or windows etc.
- Hydrogen Sulphide in air reacts with lead oxide in paint, to form lead sulphate, due to which white painted surface in door, windows, wall in building tends to acquire brownish tint over night.
- Aging of rubber and synthetic fabric due to the atmospheric oxidant, which cause very quick cracking types of rubber and aging and discolourating of synthetic fabrics.
- Electric cables and electricity poles resulting in power failure from high voltage electric cables. This was caused due to deposition of particles, which are good conductors of electricity or insulator on electrical poles, resulting in leakage from high tension lines.

## Acid Rain

- The layer of greatest interest in pollution control is the troposphere, since this is the layer in which most living things exist.
- One of the most recent changes in the troposphere involves the phenomenon of acid rain.
- Acid rain or acid deposition results when gaseous emission of sulphur oxides ( $SO_x$ ) and nitrogen oxides ( $NO_x$ ) interact with water vapour and sunlight and are chemically converted to strong acidic compounds such as  $H_2SO_4$  and  $HNO_3$ .
- These compounds, along with other organic and inorganic chemicals are deposited on the earth as aerosols and particulates (dry deposition) or are carried to the earth by raindrops, snowflakes, fog or dew (wet deposition).
- The effects of acid deposition vary according to the sensitivity of the ecosystems upon which the deposit fall.
- \* Generally, clean rain is slightly acidic as it dissolves varying amounts of carbon dioxide. If pH of rain water falls to 5.6 or below then it is called acid rain (the lowest pH value of rain is 5.6 when it is clean).

Effect of acid rain: The effects of acid rain deposition vary according to the sensitivity of the ecosystems upon which the deposition fall.

- i) Acid rain has caused considerable damage to buildings and monuments in highly industrialized areas.
- ii) The growth of trees is adversely affected by acid rain. It affects forests and results in consequent vanishing of greenery.
- iii) Acidity also affects soil. A plant nutrient as potassium is gradually leached out of the soil. At the same time, a toxic element zinc accumulates due to acid rain.
  - Beneficial micro-organisms in the soil are reduced.

→ The population of earthworms which are popularly called "farmer friends", is reduced as they cannot tolerate an acidic environment.

Remedy: - The problem of acid rain is resolved by neutralising the acid with lime. It is a short-term measure, and it is ~~desir~~ to be repeated periodically.

→ But it is quite expensive, especially when area is large.

## Global Warming

- The atmosphere has a  $\text{CO}_2$  concentration of about 0.03%. However this concentration is observed to increase continuously due to burning of coal and fossil fuels with increasing use of vehicles etc.
- The effect of increasing concentration of  $\text{CO}_2$  is the much talked global warming which is known as the green house effect.
- A green house is a construction of transparent walls and roof in cold countries to provide adequate heat to the soil and plants.
  - The solar heat / energy penetrates the green house but is prevented from escaping, and thus heat remains within the green house keeping it warm.
  - A similar process keeping the atmosphere warm is therefore, called the green house effect where many  $\text{CO}_2$  entraps the incoming solar heat.
- Due to the presence of green house gases the heat remains within the atmosphere and does not escape out of it. Thus, the green house gases act like a thermal blanket surrounding the earth.
- $\text{CO}_2$  is the major green house gas which -
  - preserves the heat reflected back by the earth's surface;
  - It is obvious that if the concentration of  $\text{CO}_2$  keeps increasing more and more heat will

be built up in the atmosphere and on the earth's surface back to earth and the atmosphere. Temperature will increase. This process provides the basic mechanism for global warming.

Green House Gases: The major green house gases are

- i) Carbon Dioxide ( $CO_2$ )
- ii) Methane ( $CH_4$ )
- iii) Nitrous oxide ( $N_2O$ )
- iv) Chlorofluorocarbons

### i) $CO_2$ :

→ It is estimated that the concentration of  $CO_2$  in atmosphere is increasing at the rate of about 1.8 mg/m<sup>3</sup>/yr.

→ The main factors contributing to the increase in  $CO_2$  concentration are:

- Use of fossil fuels,
- deforestation
- abuse of land and
- improper agricultural practices.

→  $CO_2$  absorbs infra red rays causing increase in the heat level. Thus, the increasing concentration of  $CO_2$  sets in motion a sort of heat trap.

### ii) Methane:

→ The methane concentration is increasing at a rate of 1% and its capacity to absorb heat is about 25 times more than that of  $CO_2$ .

→ So, although the concentration of methane is very low in the atmosphere, its capacity of absorbing heat is much more.

- Methane is produced as a result of decomposition of organic substances and enters the atmosphere.
- The role of methane as an agent of green house effect is taken as about 12%.

### iii) Nitrous Oxide:

- The heat absorbing capacity of  $\text{N}_2\text{O}$  is about 230 times more than that of  $\text{CO}_2$ .
- Its contribution for green house effect is 6% because of its much lower concentration in the atmosphere.
- The concentration of  $\text{N}_2\text{O}$  increases in the atmosphere due to excessive use of nitrogen-fertilizers, increased agricultural activities and intensive vehicular traffic.

### iv) Chlorofluoro Carbon:

- The use of CFC mainly takes place in the industries that manufacture refrigerators, air-conditioners, fire extinguishers, as cleaning solvents in factory, paints and sprays.
- These gases damage the ozone layer that surrounds the earth globe and allows the short wave radiation to reach the surface of the earth.
- Thus, the increase of temperature, but by puncturing the ozone layer and consequent happenings.

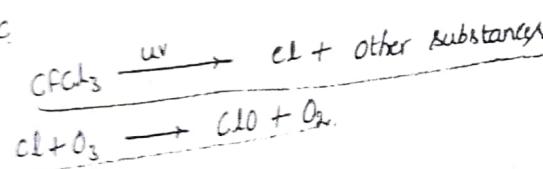
→ Impact of CFC compared to  $\text{CO}_2$  is 15000 times and is about 25% responsible for overall green house effect.

### Impact of Green House Effect:

- The temperature on earth may increase by about 1.5 to 2°C by the year 2050.
- As a result of increased temperature, the polar ice caps may melt vigorously and there would be rise in ocean level threatening to the population near the coastal zones.
- The flora & fauna would also be adversely affected by the increased temperature.
- Some of the organisms may become extinct as they may not be able to tolerate the high temperatures.
- Human health could, similarly get affected.
- Sudden changes in the climate, formation of cyclones, stability of seasonal cycles are expected to occur.

## Ozone Layer Depletion

- It is the most dreaded aspect of air pollution, having wide spread implication, extending over the entire atmosphere. This problem is caused by the reduction of naturally available ozone layer in the atmosphere.
- The stratosphere is the most important to man as which primarily contains ozone gas ( $O_3$ ) chiefly in the layers between 25 and 40 km above the ground level.
- This ozone layer cut off short wave length radiations (called UV radiation) from reaching the surface of the earth.
- Therefore, this process serves as a protective shield to human life against the adverse effects of UV like burn and skin cancer.
- It is obvious that any depletion of stratosphere ozone would be harmful to life on this earth. Hence ozone layer is formed as ozone umbrella.
- Primary reason for ozone layer depletion is CFC or freons.
- CFC contains chlorine, fluorine and carbon and it does not occur by itself in nature, but is produced only due to human activities.
- Ozone is destroyed due to the photolytic reaction of CFC.



- Methane, destroys Cl and thus affords protection to the ozone layer. Similarly, NO<sub>x</sub> reacts with Cl and helps to prevent the depletion of ozone layer.
- When there is no chlorine present in fluorocarbons, they are called hydrofluocarbons.
- These substances are a very important replacement for chlorofluorocarbon because they pose no threat to the ozone layer as they do not contain chlorine.
- As a result of ozone layer, the UV rays do not reach the surface of the earth, and the temperature does not rise.
- The CO<sub>2</sub> in the atmosphere does not allow the release of the reflected solar radiation striking the earth's surface.  
Thus it protects the heat from being lost out of the global set up. Thus ozone and CO<sub>2</sub> both control the temperature on the earth.