1.2 DEFINITIONS

1. Environment

Environment is defined as, *"the sum of total of all the living and non - living things around us influencing one another."*

2. Environmental Science

Environmental science is the *study of the environment, its biotic (ie., biological) and abiotic (ie., non biological) components and their interrelationship.*

3. Environmental Engineering

Environmental engineering is *the application of engineering principles to the protection and enhancement of the quality of the environment and to the enhancement and protection of public health and welfare.*

4. Environmental Studies (or) Environmental Education

Environmental studies are *the process of educating the people for preserving quality environment.*

1.3 TYPES OF ENVIRONMENT

Environment can be divided into two categories

1. Natural environment
2. Man - made environment

1. Natural environment

Natural environment is characterized by natural components. All biotic (living) and abiotic components (non-living) are created through a natural process. Creation of these biotic and abiotic components do not require any human support.

Soil, water, air, trees, radiations, noise, etc.,

2. Man - made environment

Man is the most powerful environmental agent. He modifies the environment using modern technologies, according to his needs to a great extent. Thus the man-made environment is created by man.

House, road, schools, railway lines, parks, etc.,

1.4 COMPONENTS OF THE ENVIRONMENT

The environment consists of the following three important components.

1. Abiotic or Non-living component.
2. Biotic or Living component.
3. Energy component.

1.4.1 Abiotic (or) Non - Living Component (or) Physical Component

The non - living components of the environment are called abiotic components.

Air, water, soil and minerals.

These abiotic components enter the body of living organisms directly or indirectly, take part in metabolic activities and then return to the environment.

Abiotic components are sub divided into three categories

1. Atmosphere
2. Lithosphere
3. Hydrosphere

1. Atmosphere

The cover of air, that envelopes the earth is known as the atmosphere. The atmosphere extends upto 500 kms from the earth surface.

The atmosphere is essential for all living organisms. It comprises 78% of nitrogen, 21% of oxygen and 1% of other gases.

Structure of atmosphere

Structure of atmosphere can be classified into the following 3 types.

(a) Troposphere (10 - 18 kms)

It contains 75% of the atmospheric air mass. It also contains moisture.

(b) Stratosphere (18 - 50 kms)

It is rich in ozone gas and free from moisture and clouds. It prevents the UV radiation from the sun.

(c) Mesosphere (50 - 85 kms)

It contains less ozone, but more nitrogen oxide.

Functions of atmosphere

1. It maintains the heat balance on the earth by absorbing the IR radiations.

2. The gaseous constituents play an important role in sustaining life on earth.

Gaseous Constituent	Functions
Oxygen	supports life of living organisms.
Carbon-dioxide	essential for photosynthetic activity of plants.
Nitrogen	essential nutrient for plant growth.

2. Lithosphere

The soil and rock components of the earth is called lithosphere.

Functions of lithosphere

1. It is a home for human beings and wildlife.
2. It is a storehouse of minerals and organic matters.

3. Hydrosphere

The aqueous envelope of the earth (ie., 75% of the earth surface) is called hydrosphere. Oceans, lakes, streams, rivers and water vapour constitute hydrosphere. About 97% of earth's water is in oceans, which is too salty and not fit for drinking. Only 3% is available as fresh water.

Functions of hydrosphere

1. It is used for drinking purpose and also supports the aquatic life.
2. It is also used for irrigation, power production, industries and transport.

1.4.2 Biotic (or) Living Component

The living components of the environment are called biotic components.

(ii) Water Pollution
(iii) Soil Pollution
(iv) Marine Pollution
(v) Noise Pollution
(vi) Thermal Pollution and
(vii) Nuclear hazards.

5.2 AIR POLLUTION

Definition

Air pollution may be defined as, "***the presence of one or more contaminants like dust, smoke, mist and odour in the atmosphere which are injurious to human beings, plants and animals.***"

The rapid industrialization, fast urbanization, rapid growth in population, drastic increase in vehicles on the roads and other activities of human beings have disturbed the balance of natural atmosphere.

Composition of Atmospheric Air

During several billion years of chemical and biological evolution, the composition of the earth's atmosphere has varied. Today, about 99% of the volume of the air we inhale consists of two gases: Nitrogen and Oxygen.

Table 5.1 Composition of atmospheric air

Constituents	%
Nitrogen	78
Oxygen	21
Argon (Ar)	< 1
CO_2	0.037
Water vapour	Remaining
O_3, He, NH_3	Trace amount

5.2.1 Sources of Air Pollution

The sources of air pollution are of two types

1. Natural sources

Volcanic eruptions, forest fires, biological decay, pollen grains, marshes, radioactive materials etc.

These pollutants are caused by the natural sources.

2. Man-made activities

Thermal power plants, vehicular emissions, fossil fuel burning, agricultural activities etc.,

5.2.2 Classification of Air Pollutants

Depending upon the form of pollutants present in the environment, they are classified as

(i) Primary pollutants.

(ii) Secondary pollutants.

1. Primary pollutants

Primary pollutants are those emitted directly in the atmosphere in harmful form.

CO, NO, SO_2, etc.,

2. Secondary pollutants

Some of the primary pollutants may react with one another or with the basic components of air to form new pollutants. They are called as secondary pollutants.

Examples

$$NO/NO_2 \xrightarrow{Moist} (HNO_3/NO_3) \text{ etc.,}$$

Indoor Air Pollutants

Indoor air pollutants are primary air pollutants. The most important indoor air pollutant is radon gas.

Sources of indoor air pollutants

1. Radon gas is emitted from the building materials like bricks, concrete, tiles, etc., which are derived from soil containing radium.
2. It is also present in natural gas and ground water and is emitted indoors while using them.
3. Burning of fuels in the kitchen, cigarette smoke, liberates the pollutants like CO, SO_2, formaldehyde, BAP (benzo-(a) pyrene).

5.2.3 Common air pollutants sources and their effects

According to the World Health Organization (WHO), more than 1. 1 billion people live in urban areas where outdoor air is unhealthy to breathe. Some of the common air pollutants are described below.

1. Carbon monoxide (CO)

Description

It is a colourless, odourless gas that is poisonous to air-breathing animals. It is formed during the incomplete combustion of carbon containing fuels.

$$2C + O_2 \longrightarrow 2CO$$

Human Sources

Cigarette smoking, incomplete burning of fossil fuels. About 77% comes from motor vehicle exhaust.

Health Effects

Reacts with heamoglobin in red blood cells and reduces the ability of blood to bring oxygen to body cells and tissues, which causes headaches and anemia. At high levels it causes coma, irreversible brain cell damage and death.

2. Nitrogen dioxide (NO_2)

Description

It is a reddish-brown irritating gas that gives photochemical smog. In the atmosphere it can be converted into nitric acid (HNO_3).

$$NO_2 + \text{Moisture} \longrightarrow HNO_3$$

Human Sources

Fossil fuel burning in motor vehicles (49%) and power industrial plants (49%).

Health Effects

Lung irritation and damage.

Environmental Effects

Acid deposition of HNO_3 can damage trees, soils and aquatic life in lakes, HNO_3 can corrode metals and eat away

stone on buildings, statues and monuments. NO_2 can damage fabrics.

3. Sulphur dioxide (SO_2)

Description

It is a colourless and irritating gas. It is formed mostly from the combustion of sulphur containing fossil fuels such as coal and oil. In the atmosphere it can be converted to sulphuric acid (H_2SO_4) which is a major component of acid deposition.

Human Sources

Coal burning in power plants (88%) and industrial processes (10%).

Health Effects

Breathing problems for healthy people.

Environmental Effects

Reduce visibility, acid deposition of H_2SO_4 can damage trees, soils and aquatic life in lakes.

4. Suspended particulate matter (SPM)

Description

It includes variety of particles and droplets (aerosols). They can be suspended in atmosphere for short periods to long periods.

Human Sources

Burning coal in power and industrial plants (40%), burning diesel and other fuels in vehicles (17%), agriculture, unpaved roads, construction etc.,

Health Effects

Nose and throat irritation, lung damage, bronchitis, asthma, reproductive problems and cancer.

Environmental Effects

Reduces visibility, acid deposition and H_2SO_4 droplets can damage trees, soils and aquatic life in lakes.

5. Ozone (O_3)

Description

Highly reactive irritating gas with an unpleasant odour that forms in the troposphere. It is a major component of photochemical smog.

Human Sources

Chemical reaction with volatile organic compounds (emitted mostly by cars and industries) and nitrogen oxides.

Environmental Effect

Moderates the climate.

6. Photochemical smog

Description

The brownish smoke like appearance that frequently forms on clear, sunny days over large cities with significant amounts of automobile traffic.

It is mainly due to chemical reactions among nitrogen oxides and hydrocarbon by sunlight.

Health Effects

Breathing problems, cough, eye, nose and throat irritation, heart diseases, reduces resistance to colds and pneumonia.

Environmental Effects

Ozone can damage plants and trees. Smog can reduce visibility.

7. Lead (Pb)

Description

Solid toxic metal and its compounds, emitted into the atmosphere as particulate matter.

Human Sources

Paint, smelters (metal refineries), lead manufacture, storage batteries, leaded petrol.

Health Effects

Accumulates in the body, brain and other nervous system damage and mental retardation (especially in children); digestive and other health problems, some lead-containing chemicals cause cancer in test animals.

Environmental Effects

Can harm wild life.

8. Hydrocarbons

Description

Hydrocarbons especially lower hydrocarbons get accumulated due to the decay of vegetable matter.

Human sources

Agriculture, decay of plants, burning of wet logs.

Health Effects

Carcinogenic.

9. Chromium (Cr)

Description

It is a solid toxic metal, emitted into the atmosphere as particulate matter.

Human Sources

Paint, smelters, chromium manufacture, chromium plating.

Health effects

Perforation of nasal septum, chrome holes.

5.2.4 Control Measures

The atmosphere has several built-in self cleaning processes such as dispersion, gravitational settling, flocculation, absorption, rain washout and so on, to cleanse the atmosphere. In terms of a long range control of air pollution, control of contaminants at their source is a more desirable and effective method through preventive or control technologies.

1. Source control

Since we know the substances that causes air pollution, the first approach to its control will be through source reduction. Some actions that can be taken in this regard are as follows:

1. Use only unleaded petrol.
2. Use petroleum products and other fuels that have low sulphur and ash content.
3. Reduce the number of private vehicles on the road by developing an efficient public-transport system and encouraging people to walk or use cycles.
4. Ensure that houses, schools, restaurants and places where children play are not located on busy streets.
5. Plant trees along busy streets because they remove particulates and carbon monoxide, and absorb noise.

6. Industries and waste disposal sites should be situated outside the city centre preferably downwind of the city.

7. Use catalytic converters to help control the emissions of carbon monoxide and hydrocarbons.

II. Control measures in industrial centers

1. The emission rates should be restricted to permissible levels by each and every industry.

2. Incorporation of air pollution control equipments in the design of the plant layout must be made mandatory.

3. Continuous monitoring of the atmosphere for the pollutants should be carried out to know the emission levels.

Equipments used to control air pollution

Air pollution can be reduced by adopting the following approaches.

(i) To ensure sufficient supply of oxygen to the combustion chamber and adequate temperature so that the combustion is complete, eliminating much of the smoke consisting of partly burnt ashes and dust.

(ii) To use mechanical devices such as scrubbers, cyclones, bag houses and electro-static precipitators manufacturing process.

The above four figures (fig 5.1) are commonly used control methods for removing particulates from the exhaust gases of electric power and industrial plants. All these methods retain hazardous materials that must be disposed of safely. The wet scrubber can also reduce sulphurdioxide emissions.

(iii) Chemical treatment to deal with factory fumes.

The disposal of the collected air pollutants is equally important for successful control of air pollution.

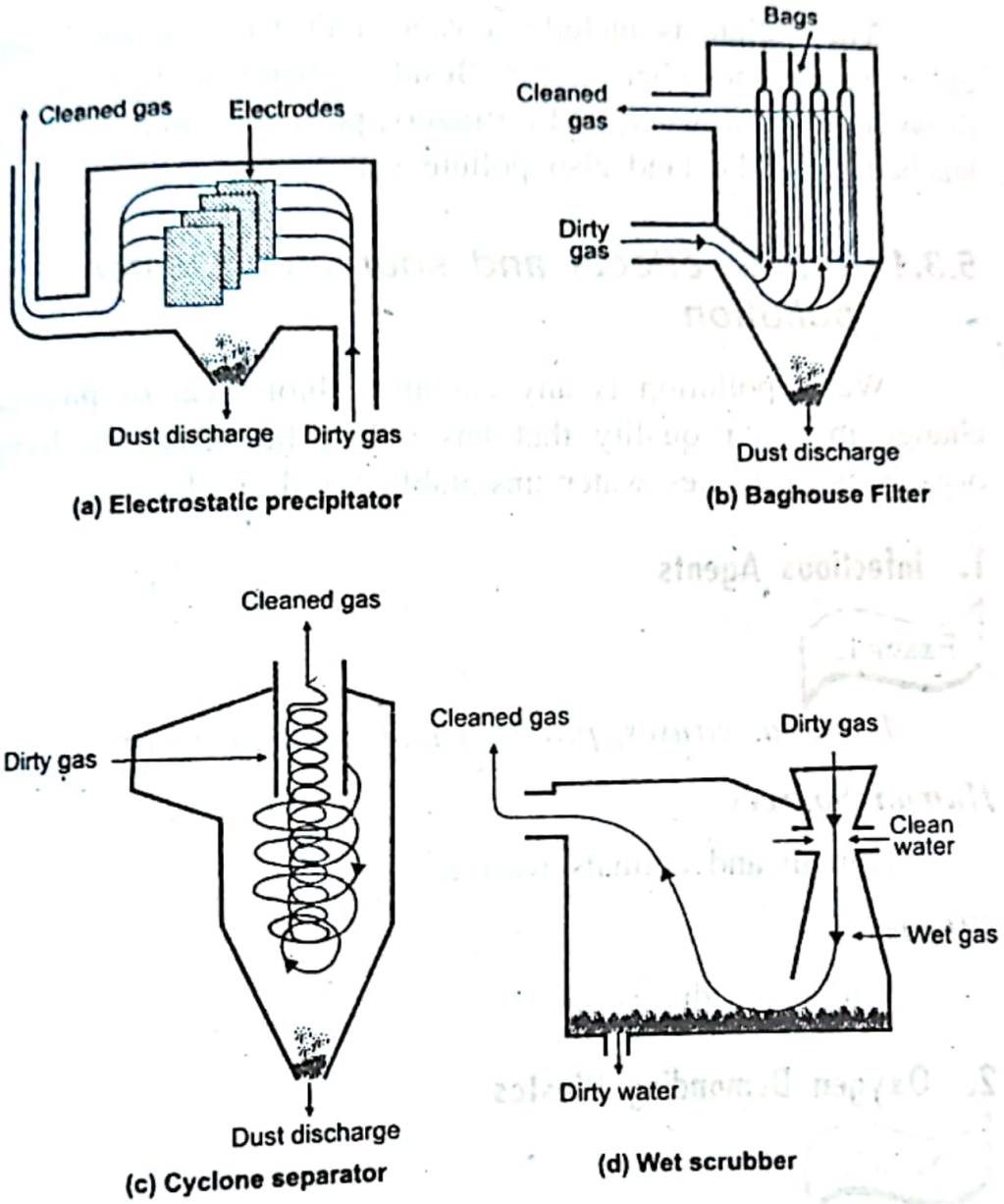

Fig. 5.1 Control methods for removing particulates from exhaust gases

5.3 WATER POLLUTION

Definition

Water pollution may be defined as, "the alteration in physical, chemical and biological characteristics of water which may cause harmful effects on humans and aquatic life."

The pollutants include sewage, industrial chemicals and effluents, oil and other wastes. Besides, chemicals from the air dissolved in rain water, and fertilizers, pesticides and herbicides leached from the land also pollute water.

5.3.1 Types, effects and sources of water pollution

Water pollution is any chemical, biological or physical change in water quality that has a harmful effect on living organisms or makes water unsuitable for desired uses.

1. Infectious Agents

Example

Bacteria, viruses, protozoa and parasitic worms.

Human Sources

Human and animals wastes.

Effects

Variety of diseases.

2. Oxygen Demanding Wastes

Example

Organic wastes such as animal manure and plant debris that can be decomposed by aerobic (oxygen-requiring) bacteria.

Human Sources

Sewage, animal feedlots, paper mills, and food processing facilities.

Effects

Large populations of bacteria decomposing these wastes can degrade water quality by depleting water of dissolved

oxygen. This causes fish and other forms of oxygen-consuming aquatic life to die.

3. Inorganic Chemicals

Example

Water soluble inorganic chemicals.

(i) acids,

(ii) compounds of toxic metals such as lead (Pb), arsenic (As) and selenium (Se) and

(iii) salts such as NaCl in ocean water and fluorides (F^-) found in some soils.

Human Sources

Surface runoff, industrial effluents and household cleansers.

Effects

(i) Can make fresh water unusable for drinking or irrigation.

(ii) Causes skin cancers and neck damage.

(iii) Damage the nervous system, liver and kidneys.

(iv) Harm fish and other aquatic life.

(v) Lower crop yields.

(vi) Accelerate corrosion of metals exposed to such water.

4. Organic Chemicals

Examples

Oil, gasoline, plastics, pesticides, cleaning solvents, detergents.

Human Sources

Industrial effluents, household cleansers, surface runoff from farms.

Effects

(i) Can threaten human health by causing nervous system damage and some cancers.

(ii) Harm fish and wild life.

5. Plant Nutrients

Examples

Water-soluble compounds containing nitrate (NO_4^{3-}), *phosphate* (PO_4^{3-}) *and ammonium* (NH_4^+) *ions.*

Human Sources

Sewage, manure, and runoff of agricultural and urban fertilizers.

Effects

(i) Can cause excessive growth of algae and other aquatic plants, which die, decay, deplete dissolved oxygen in water and kill the fish.

(ii) Drinking water with excessive levels of nitrates lower the oxygen carrying capacity of the blood and can kill urban children and infants.

6. Sediment

Examples

Soil, silt, etc.,

Human Sources

Land erosion.

Effects

(i) Can cloud water and reduce photosynthesis.

(ii) Disrupt aquatic food webs.

(iii) Carry pesticides, bacteria, and other harmful substances.

(iv) Settle out and destroy feeding and spawning rounds of fish.

(v) Clog and fill lakes, artificial reservoirs, stream channels and harbours.

7. Radioactive Materials

Examples

Radioactive isotopes of iodine, radon, uranium, cesium, and thorium.

Human Sources

Nuclear power plants, mining and processing of uranium and other ores, nuclear weapons production and natural sources.

Effects

Genetic mutations, birth defects, and certain cancers.

8. Heat (Thermal Pollution)

Example

Excessive heat

Human Sources

Water cooling of electric power plants and some types of industrial plants. Almost half of all water withdrawn in United States each year is for cooling electric power plants.

Effects

1. Lowers dissolved oxygen levels and makes aquatic organisms more vulnerable to disease, parasites and toxic chemicals.
2. When a power plant first opens or shuts down for repair, fish and other organisms adapted to a particular temperature range can be killed by the abrupt change in water temperature known as thermal shock.

9. Point and Non-point Sources of Water Pollution

(i) *Point Sources*

Point sources are discharged pollutants at specific locations through pipes, ditches or sewers into bodies of surface water.

Example

Includes factories, sewage treatment plants, abandoned underground mines and oil tankers.

(ii) *Non-point sources*

They cannot be traced to any single site of discharge. They are usually large land areas or airsheds that pollute water by runoff, subsurface flow or deposition from the atmosphere.

Examples

Include acid deposition and runoff of chemicals into surface water from croplands, livestock feedlots, logged forests, urban street, lawn, golf courses and parking lots.

5.3.2 Control measures of water pollution

1. The administration of water pollution control should be in the hands of State or Central Government.

2. Scientific techniques are necessary to be adopted for the environmental control of catchment areas of rivers, ponds or streams.

3. The industrial plants should be based on recycling operations, because it will not only stop the discharge of industrial wastes into natural water sources but by products can be extracted from the wastes.

4. Plants, trees and forests control pollution and they acts as natural air conditioners.

5. Forests in and around big cities and industrial establishments are capable of reducing the sulphur dioxide and nitric oxide pollutants to a greater extent from the atmosphere. Hence the national goal should be "Conservation of Forests" and campaign should be "Plant more trees". The global destruction of forests should be discouraged or atleast minimized and afforestation should be encouraged because no one on this earth will escape from the adverse effects of a balding earth.

6. It is not advisable to discharge any type of waste, either treated, partially treated or untreated, into streams, rivers, lakes, ponds and reservoirs. The industries are expected to develop close-loop water supply schemes and domestic sewage may be used for irrigation.

7. Highly qualified and experienced persons should be consulted from time to time for effective control of water pollution.

8. Public awareness regarding adverse effects of water pollution is a must. So there should be propaganda for water pollution control on radios, TVs etc.,

9. Suitable laws, standards and practices should be framed to regulate the discharge of undesirable flow

of water in water bodies and such regulations should be modified from time to time in order to accommodate the changing requirements and technological advancements.

10. Basic and applied research in public health engineering should be encouraged.
11. The possible reuse or recycle of treated sewage effluents and industrial wastes should be emphasized and encouraged.

6.12 GREEN HOUSE EFFECT

6.12.1 Introduction

The sun heats the Earth, solar radiation passes through the atmosphere, and is absorbed at the earth's surface. This heat is readily lost, it is emitted from the surface as infrared radiation. Fortunately, this infrared radiation cannot escape the atmosphere as easily as the solar radiation can enter. Instead, some of it is "trapped" by a number of gases. Thus heat is allowed in but cannot get out-hence this effect in called "Green House Effect".

It is similar to the warming effect observed in the horticultural green house made of glass.

Definition

The green house effect may be defined as, "the progressive warming up of the earth's surface due to blanketing effect of man made CO_2 in the atmosphere."

6.13.2 Formation of acid rain

Acid rain means the presence of excessive acids in rain waters. The thermal power plants, industries and vehicles release nitrous oxide and sulphur dioxide into atmosphere due to burning of coal and oil. When these gases react with water vapour in the atmosphere, they form acids and descend on to earth's "acid rain" through rain water.

$$SO_X + H_2O \longrightarrow H_2SO_4$$

$$NO_X + H_2O \longrightarrow HNO_3$$

Due to the drifting of these gases in the atmosphere by the wind, their presence are felt as far as 2,000 kilometers. The air pollution of one nation could cause acid rain for another nation.

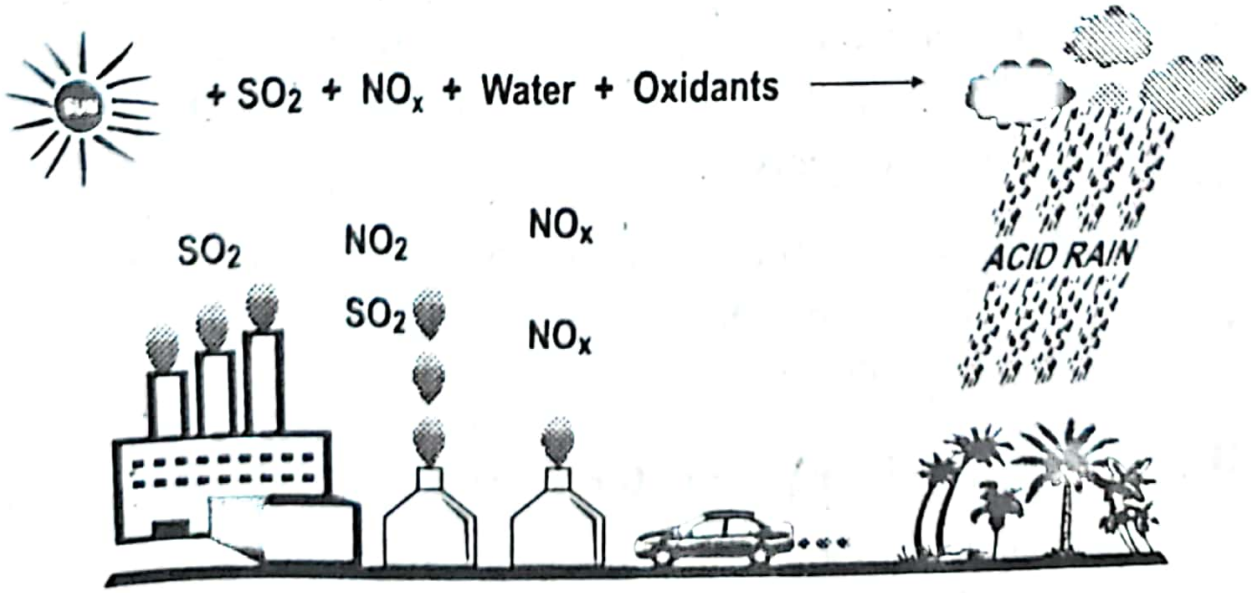

Fig. 6.4 Formation of acid rain

6.14 OZONE LAYER DEPLETION

6.14.1 Introduction

Ozone is a gas (O_3) found throughout the atmosphere, but most highly concentrated in the stratosphere between 10 and 50 km above sea level, where it is known as the 'ozone layer'.

6.14.2 Importance of ozone layer

Without the ozone layer, life on the Earth's surface would not be possible. It protects us from the damaging ultraviolet radiation of the sun. In particular it filters out UV-B radiation.

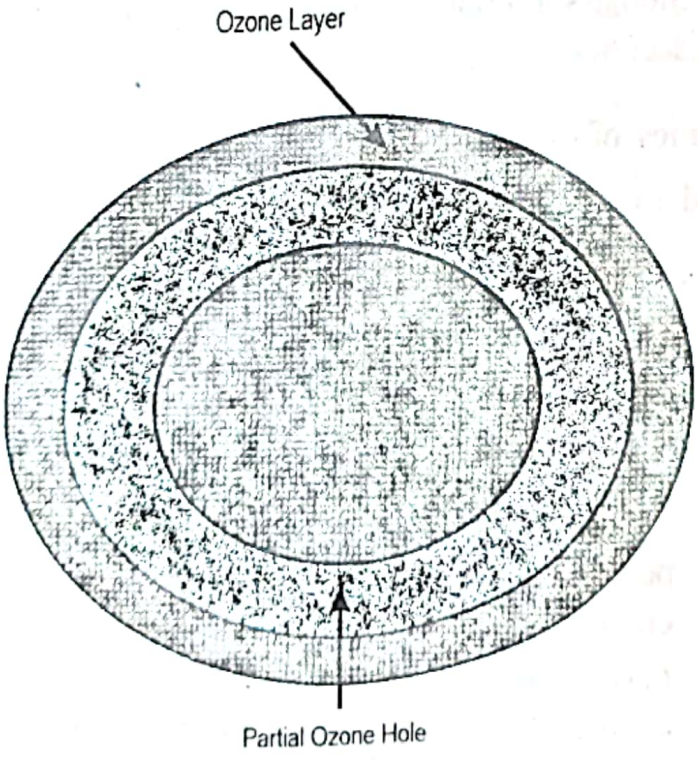

Fig. 6.5 Ozone layer depletion

Recent evidence has shown that certain parts of the ozone layer are becoming thinner and ozone 'holes' have developed. The consequence of any thinning of the ozone layer

is that more UV-B radiation reaches the Earth's surface. UV-B radiation affects DNA molecules, causing damage to the outer surface of plants and animals. In humans it causes skin cancer, and eye disease.

6.14.3 Formation of ozone

Ozone is formed in the stratosphere by photochemical reaction, viz.,

$$O_2 + h\nu \rightarrow O^{\bullet} + O^{\bullet}$$

The atomic oxygen rapidly reacts with molecular oxygen to form ozone.

$$O^{\bullet} + O_2 + M \rightarrow O_3 + M$$

where, M = third body such as nitrogen.

Ozone thus formed distributes itself in the stratosphere and absorbs harmful UV radiations.

6.14.4 Causes of ozone layer depletion

In 1970, it was found that the ozone layer was attacked by chlorofluoro carbons (CFCs) which are released into atmosphere by refrigeration units, air conditioning systems, aerosol sprays and cleaning solvents. Chlorofluoro carbons release chlorine which breaks ozone into oxygen.

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

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

Each chlorine atom is capable of attacking several ozone molecules. So that a long chain process is involved. A 1% loss of ozone results in a 2% increase in UV rays reaching the earth's surface.