5 Environmental Pollution

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INTRODUCTION

Environmental pollution is a serious problem of the environment in which human activities have played a prominent role. Serious degradation and depletion have been caused through over use, misuse and mismanagement of resources to meet the human needs and to satisfy the increasing greed. At present the situation is so alarming that the man-made environment causing a major threat to the survival of man as well as of the other organisms.

Pollution may be defined as '*an undesirable change in the physical, chemical or biological characteristics of our air, water and land that may or will harmfully, affect human life, the lives of the desirable species, our industrial processes, living conditions and cultural assets, or that may or will waste or deteriorate our raw material resources*'. It may also be defined as '*an addition or excessive addition of certain materials to the physical environment (water, air and lands), making it less fit or unfit for life*'.

Pollution is mostly man made, but it can also be natural. Natural pollution is caused by volcanic erruptions, emission of natural gases, soil erosion, ultraviolet rays, cosmic rays etc.

POLLUTANTS

Pollutants are the materials or factors, which cause adverse effect on the natural quality of any component of the environment. Pollutants are the waste products or by-products of the materials we make use or throw away. For example, smoke from industries and automobiles,

chemicals from factories, radioactive substances from nuclear plants, sewage of houses and discarded household articles are the common pollutants. However, all pollutants are not waste materials, nitrogen and phosphorus are used to increase soil fertility, but their excess amount may cause water pollution.

CLASSIFICATION

Pollutants are classified from different point of view as follows :

I. According to the form in which they persist after release into the environment, the pollutants may be primary or secondary.

1. **Primary Pollutants.** These persist in the form in which they are added to the environment *e.g.* DDT, plastic.

2. **Secondary Pollutants.** These are formed by interaction among the primary pollutants. For example, peroxyacetyl nitrate (PAN) is formed by the reaction of two primary pollutants, namely nitrogen oxides and hydrocarbons released from motor vehicle in presence of sunlight.

II. According to their existence in nature, the pollutants may be quantitative or qualitative.

1. **Quantitative Pollutants.** These are the substances, which occur in nature but become pollutant when their concentration reaches beyond a threshold value in the environment. *e.g.* carbon dioxide, nitrogen oxide.

2. **Qualitative Pollutants.** These are the substances which do not occur in the environment but are passed into it through human activity *e.g.* fungicides, herbicides, DDT etc.

III. According to their natural disposal, the pollutants may be biodegradable and nondegradable.

1. **Biodegradable (Degradable) Pollutants.** They are actually waste products, which are slowly degraded by microbial action. They cause pollution, when their production exceeds the capacity of the environment to degrade them. *e.g.* sewage.

2. **Non-degradable (Non-biodegradable) Pollutants.** They are pollutants, which are not decomposed or are decomposed very slowly. They include wastes (*e.g.* plastics, glass, plastic bottles, polythene bags, used soft drink cans etc.) or poisons (*e.g.* pesticides like DDT, salts of heavy metals, radioactive substances etc.). The non-biodegradable pollutants are difficult to manage and in most cases there is no treatment process to handle the anthropogenic input of such materials in the ecosystem.

IV. In terms of origin pollution may be natural and anthropogenic.

1. **Natural.** Volcanic eruptions add tons of toxic gases and particulate matter in the environment.

2. **Anthropogenic.** It is a man made pollution, such as industrial pollution, agricultural pollution, etc.

TYPES OF POLLUTION

Pollution is of five types—atmospheric (air) pollution, water pollution, soil pollution, radioactive pollution and noise pollution.

Atmospheric or Air Pollution

Air pollution may be defined as *'the presence of materials in the air in such a concentration, which are harmful to man and the environment'*. In other words *'the occurrence or addition of foreign particles, gases and other pollutants into the air, which have an adverse effect on human beings, animals, vegetation, buildings and other objects is called air pollution'*.

Atmospheric pollution is complex in origin and varied in effect. It may be natural or man- made. Natural air pollution has been occurring before the man came on the scene, volcanic erruptions, forest fires, natural organic and inorganic decays let out large quantities of harmful dust and gases. It is estimated that out of the total annual emission of 1×10^{12} tonnes entering the earth's atmosphere only 5×10^{8} tonnes (0.05 per cent) is contributed by human activities. Air pollutants resulting from human activities are mainly discharged in over populated cities and industrial centres. This pollution may be marginal in global terms, but it has serious effect locally. Many pollutants do not rise above 600 metre of earth's surface or at least become highly diluted. The movement of the air pollutants is restricted due to certain physical barriers. This leads to high concentration of the pollutants in certain areas.

Types of Air Pollutants

On the basis of physical state, air pollutants are of two types—gaseous and particulate.

(*i*) ***Gaseous Pollutants.*** These pollutants are in gaseous state at normal temperature and pressure. The vapour of compounds whose boiling point is below 200°C are also included in this type.

(*ii*) ***Particulate Pollutants.*** These pollutants occur as solid and liquid particles. They are of two types—setteable and suspended.

(*a*) *Setteable.* The particles larger than 10 μm in diameter such as water drops, sand etc. which, settle down rapidly in still air, are called setteable pollutants. These particles settle out in less than a clay.

(*b*) *Suspended.* The smaller particles such as dust, smoke etc. which remain suspended for long period in the air are called suspended pollutants. These include soot, asbestos fibres, pesticides, some metals (including Hg, Pb, Cu and Fe) and also biological agents like tiny dust mites and pollen. The larger suspended particles with more than 1 μm in diameter are often called **dust** (solid) and **mist** (liquid). Aerosols, smokes and fumes are also suspended particles with a diameter less than 1 μm. These particles can remain suspended in air for weeks. Suspended particulate matter in the lower atmosphere (troposphere) causes and aggravates human respiratory illness like asthema, chronic bronchitis etc. when accumulated in the upper atmosphere (stratosphere), particulate matter may significantly alter the radiation and thermal budgets of the atmosphere, lowering the temperature at the earth's surface.

Sources of Air Pollution

Combustion of fossil fuels and wood in industries, automobiles, aircrafts, railways, thermal plants, kitchens etc., agricultural operations and industrial processing are the major sources of air pollution. Volcanic erruptions and solar flares are the main natural sources of air pollution. *Table 5.1* and *Fig. 5.1* shows important man-made sources of air pollution and the type of emission released from them.

Table 5.1. Important Air Pollution Sources and Emissions

Category	*Examples*	*Important Pollutants*
Chemical plant	Petroleum refineries, fertilizers, cement, papermills, ceramic, clay products and glass manufacture.	Hydrogen sulphide, sulphur oxide, fluorides, organic vapours and dusts.
Crop spraying	Pest and weed control.	Organophosphates, chlorinated hydrocarbons, lead, arsenic.
Fuel burning	Domestic burning, thermal power plants.	Sulphur and nitrogen oxides.
Metallurgical plants	Aluminium refineries, steel plants.	Metal fumes (Lead and Zinc) fluorides and particulates.
Nuclear device testing	Bomb explosions,	Radioactive fallout, Sr-90, Cs-137, C-14, etc.
Ore preparation	Crushing, grinding and screening.	Uranium and Beryllium dust, other particulates, Argon-41 Iodine-131.
Spray painting, solvent extractions, inks, solvent cleaning	Furniture and appliances dyeing, printing and chemical separations, dry cleaning.	Hydrocarbons and other organic vapours.
Transportation	Cars, trucks, aeroplanes and railways.	Carbon monoxide, nitrogen oxides, lead, smoke, organic vapours, etc.
Waste recovery	Scrap metal yards, rendering plants.	Smoke, soot, odours, organic vapours metal fumes.

The sources which contribute pollutants to the air are discussed below :

Stationary Combustion Sources

Burning of fuels in industries, residential establishments, hotels, bakeries, thermal plants, and brick klins contribute most of the gaseous and particulate pollutants in the air. Coal and wood are largely made of carbon mixed with some incombustible minerals, sulphur and nitrogen. Petroleum consists mainly of hydrocarbons, sulphure and nitrogen. Therefore, when fossil fuels are burnt they produce a mixture of oxides of carbon, nitrogen and sulphur and water vapour. Burning of coal also produce mineral ash, some of which is discharged as fly ash.

(*i*) *Oxides of Carbon.* They are formed by the combustion of carbon of the fuels and include carbon monoxide (CO) and carbon dioxide (CO_2). The concentration of carbon dioxide in the atmosphere has increased 15 per cent in the last 100 years due to excessive fuel burning.

Nearly 50 per cent of all CO emission originates from automobiles. It is also present in cigarette smoke. Carbon monoxide is short lived in the atmosphere and gets oxidised to CO_2. It is a colourless and odourless gas. It is non-irritating but highly toxic and impares respiration. Several cases of death are reported every year from carbon monoxide poisoning from gas heaters, charcoal stoves, other heating devices and coal mines.

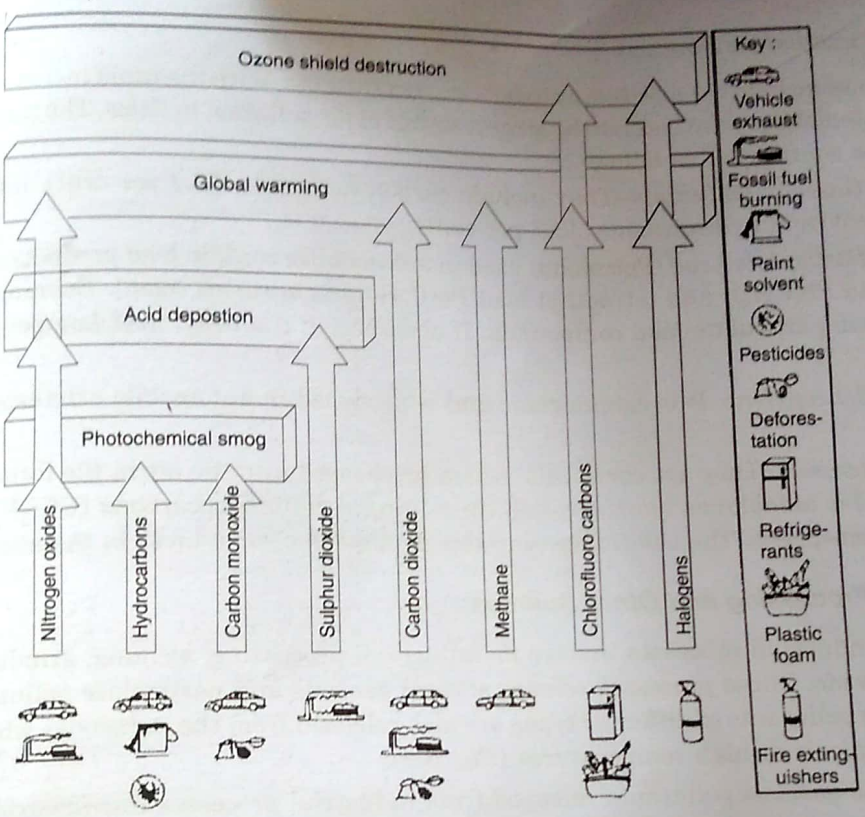


Fig. 5.1. Sources of air pollutants and their environmental effects.

(ii) Oxides of Sulphur. Oxidation of sulphur in the fossil fuels produces sulphur dioxide (SO_2) and sulphur trioxide (SO_3). These gases react with water and form sulphurous and sulphuric acids. Precipitation of these acids as rain or snow produce **acid rain** or **acid precipitation**.

(iii) Oxides of Nitrogen. Oxide of nitrogen present in the coal and petroleum produce nitrogen oxide (NO) and nitrogen dioxide (NO_2) on combustion. These produce a reddish brown haze called **brown air** in traffic congested city air. The oxides of nitrogen are in gaseous state and react with water to form nitrous and nitric acids.

(iv) Hydrocarbons (HCs) or Volatile Organic Carbon (VOCs). These are compounds composed of hydrogen and carbon. HCs are produced naturally during decomposition of organic matter and by certain types of plants (*e.g.* pine trees). Methane (CH_4), the most abundant hydrocarbon in the atmosphere, is evolved from soil in flooded rice fields and swamps. Benzene and its derivatives such as formaldehyde, are carcinogenic (substance that causes cancer). Formaldehyde emitted from indoor sources, such as newly manufactured carpeting causes indoor pollution. Some relatively reactive HCs contribute to the generation of secondary pollutants. HCs are also generated during the burning of fossil fuels.

Mobile Combustion Sources

These include locomotives, automobiles, aircrafts etc. With the rapid increase in vehicular traffic, automobiles have become the largest source of air pollution in cities. The major pollutants from these sources are as follows :

(*i*) *Gaseous Pollutants.* They include carbon monoxide (77.2 per cent), nitrogen oxides (7.7 per cent) and hydrocarbons (13.7 per cent).

(*ii*) *Particulate Lead.* Petroleum used in automobiles contain lead products such as tetra-methyl lead $Pb(CH_3)_4$ and tetraethyl lead $Pb(C_2H_5)_4$ as antinock agent. Burning of such fuels emit various particulate lead compounds. If absorbed in the body, lead hamper haemoglobin formation.

(*iii*) *Benzopyrene.* It is carcinogenic and is produced in automobile exhausts and tobacco smoke.

(*iv*) *Aerosols.* They are chemicals, which are passed into the air in the form of vapour or fine mist. Jet aeroplanes emit aerosols containing chlorofluorocarbons (CCl_2F_2 and CCl_3F) into the atmosphere. The chlorofluorocarbons deplete the ozone layer in the atmosphere.

Industrial Processing and Other Sources

The industrial processes involve metallurgical processing, welding, grinding, synthesis of chemicals etc. These processes release several gaseous and particulate pollutants into the air. Gaseous pollutants of different types are also released from the industries which processes organic chemicals at high temperatures (*Fig. 5.2*).

(*i*) The gaseous pollutants released from industrial processes include oxides of carbon, sulphur and nitrogen, fluorides and vapours of several compounds.

(*ii*) The compounds containing chlorine and fluorine such as chlorofluoromethane, are widely used as propellants for aerosols, cans and as refrigerants. These when dispersed in stratosphere cause profound effect in the ozone layer.

(*iii*) The particulate matter released from industries includes metal dust, fly ash, soot, cotton dust and radioactive substances. A number of harmful trace metals such as antimony, arsenic, beryllium, cadmium, germanium, lead, mercury, nickel, selenium, vanadium and titanium are present in the metal dust and fly ash.

(*iv*) A number of poisonous gases are also released into the atmosphere accidentally from industries. Accidental release of phosgene ($COCl_2$) and methyl isocynate or MIC (CH_3NCO) from Union carbide—a chemical factory in Bhopal on December 2, 1984, killed over 2500 and maimed several thousand person.

(*v*) Burning of plastic and its processing produces polychlorinated biphenyls (PCBs). They reach human body through food chain and damage liver and impare vision.

(*vi*) A large number of gaseous and particulate pollutants are released in agriculture burning and pesticide spraying.

(*vii*) Pollen spores and microbes are the natural pollutants present in the air. Their number increases in certain seasons and cause allergies and diseases.

(*viii*) Tobacco smoke contains a number of hydrocarbons including benzopyrene (a carcinogen). It is a potent pollutant in close atmosphere like buses, trains, cinema theatres and auditorium.

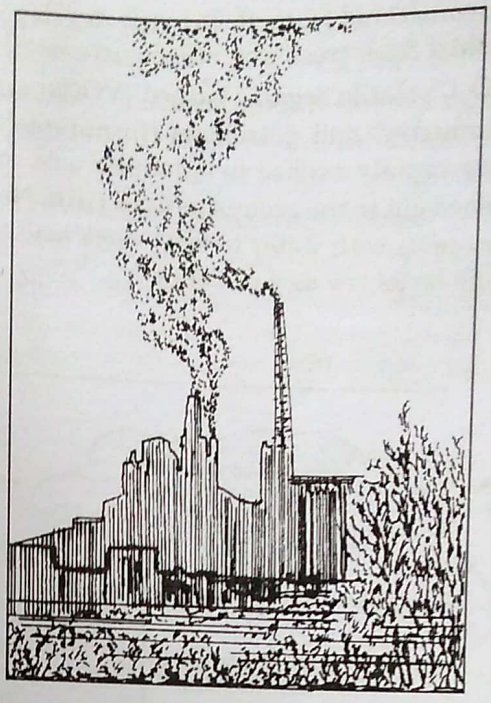


Fig. 5.2. Industrial emission.

Secondary Air Pollutants

These are formed from primary pollutants by photochemical reaction. Photochemical smog and acid rain are the main secondary air pollutants.

(*i*) *Photochemical Smog.* Photochemical smog is formed in traffic congested metropolitan cities where warm conditions and intense solar radiation are present. It is composed mainly of ozone (O_3), peroxyacetyl nitrate (PAN) and NO_x. It is often called **brown air**, where solar radiation is intense. In areas or seasons of lesser solar radiation, smog formation is incomplete and the air is referred to as **grey air**. Automobile exhaust contains HC and NO, which undergo photochemical reaction and form photochemical smog in urban areas. The reactions involving in photochemical smog formation are as follows.

(*a*) Reaction occurring inside engine :

$$N_2 + O_2 \longrightarrow 2NO_2$$

(*b*) Reactions occurring in atmosphere :

$$2NO + O_2 \longrightarrow 2NO_2$$

$$NO_2 \xrightarrow{\text{UV radiation}} NO + O$$

$$O + O_2 \longrightarrow O_3$$

$$NO + O_3 \longrightarrow NO_2 + O_2$$

$$HC + NO + O_2 \longrightarrow NO_2 + PAN$$

(*ii*) *Acid Rain.* It refers to the deposition of acid from the atmosphere on the earth (*Fig. 5.3*). Acid deposition includes wet and dry deposition. The acidic water received through rain, fog and snow is called **wet deposition**. While the wind blown acidic gases and particles in the atmosphere which settle down on the ground is called **dry deposition**. About half of the

acidity in the atmosphere is transferred to earth through dry deposition. Dry deposited gases and particles can also be washed from trees and other surfaces by rainfall.

Oxides of nitrogen (NO_x), volatile organic carbon (VOCs) and SO_2 are produced during the combustion of coal (in industry) and petroleum (in automobile). Lightning in sky also produces NO_x naturally. They rapidly oxidise to sulphuric acid or nitric acid, which quickly dissolve in water and are washed out to the ground as **acid rain**. Normally rainwater is slightly acidic because CO_2 of the air reacts with water to form weak acid (pH 5.6–6.5). The pH of acid rain is less than 5.6, and could be as low as 4 or below.

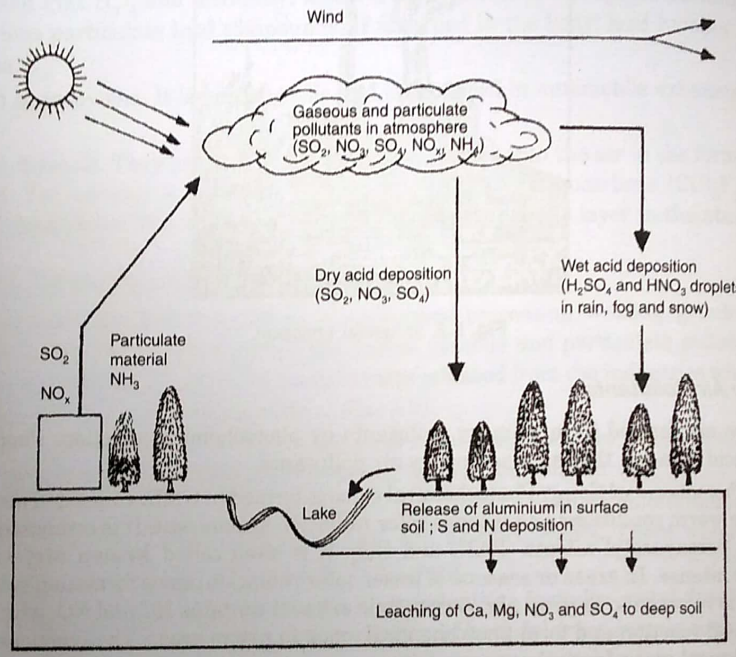


Fig. 5.3. Dry and wet acid deposition or acid rain.

Effects of Air Pollution

Our health depends on the quality of air we breathe in our immediate environment. Foul air had been held responsible for various health hazards and diseases (*Figs. 5.4* and *5.5*). Air borne spores, pollen grains, bacteria, fungi, fur, hair etc. cause various allergic reactions, bronchial asthema, tuberculosis and other infections. With rapid increase in industries and vehicular traffic, the air of Indian cities is becoming increasingly polluted.

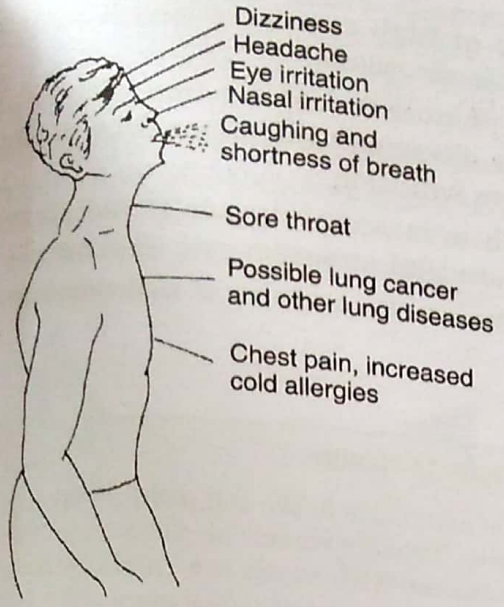


Fig. 5.4. Health hazards caused by air pollution.

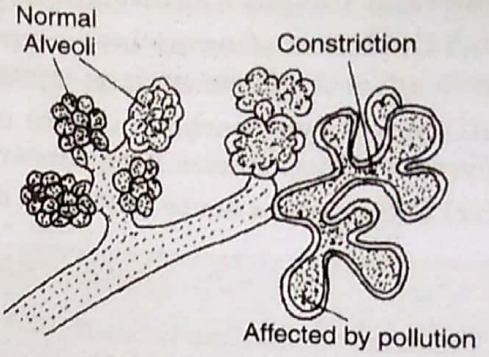


Fig. 5.5. Effect of polluted air on bronchial tubes.

Air pollution has become a serious problem in big, congested, industrialized cities with heavy rush of vehicular traffic. Air pollution effect man, animals, plants, buildings materials (*Table 5.2*) and climate. The various effects of air pollution are discussed below :

A. Effects on Human Health

The effect of particulate pollutants depends upon the fate of the particles in our body. Particles more than 2 μm are trapped in nasal hair and bronchial mucus and coughed out or swallowed. The smaller particles enter the alveoli, where they may be engulfed by the special cells or absorbed in the blood. The effect of gaseous pollutants depends upon their solubility in water, which allows their diffusion into the tissues.

(*i*) Dust, soot and smog cause several respiratory troubles such as bronchitis, asthema, emphysema and lung cancer. Lung diseases are four times more in urban settlements than rural areas. Cotton dust produce lung fibrosis or **pneumoconiosis** also called **byssinosis**. Pneumoconiosis also affects the coal miners and flour mill workers. Lung fibrosis produced in the workers of some other industries include **asbestosis** (asbestos industry), **silicosis** (stone grinding), **siderosis** (iron mill), etc.

(*ii*) Fly ash and metal dusts cause headache, loss of appetite, dizziness, insomnia, anaemia, weakness and miscarriage.

(*iii*) Air borne organic materials such as spores, pollen, bacteria, fungi, fur, feathers cause several diseases and allergic reactions or **hay fever**. Common plants which produce allergic pollen are *Amaranthus spinosus, Chenopodium album, Cynodon dactylon, Ricinus communis, Sorghum vulgure, Prosopis chilensis* etc.

(*iv*) Sulphur dioxide causes drying of mouth, sore throat and eye irritation. It may damage the tissues by forming sulphuric acid.

(*v*) Sulphur trioxide, nitrogen oxide and carbon monoxide combine with haemoglobin of the blood and reduce the oxygen carrying capacity of the blood. Inhaling of carbon monoxide also lead to giddiness, exhaustion, reduced vision, nervous and cardiovascular disorder and even death. Such symptoms are quite common at the time of traffic jams on the busy roads.

Nitrogen oxide is comparatively less soluble, but at high concentrations it impares the functioning of lungs causing accumulation of water in air spaces.

(*vi*) Ozone is formed in the atmosphere by photochemical reaction. Though in the stratosphere it protects the earth from high energy ultraviolet radiations. But in the lower atmosphere, it produces chest pain, coughing and eye irritation.

(*vii*) Depletion of ozone layer exposes the earth to increase ultraviolet radiations. This may have adverse effects such as increased skin cancer and mutation rate in general.

(*viii*) Many hydrocarbons induce cancer. Tobacco smoke contains a hydrocarbon called benzopyrene, which causes lung cancer (*Fig. 5.6*).

(*ix*) PAN causes acute irritation of eyes.

Tobacco Smoking is Injurious to Health

Smoking is injurious to health. The concentration of pollutants in the self polluted air in a room of a smoker is higher than that of out doors. Tobacco smoke contains at least seven polycyclic hydrocarbons and radioactive polonium-210, which are carcinogens. In smokers, the risk of developing and dying from lung cancer ten times more than a non-smoker. The risk of lung diseases is six times and that of heart diseases twice as compared to a non-smoker. Certain other diseases are also related to smoking. There is a world wide campaign to probihit smoking in public places as smokers affect the health of even non-smoker, called passive smoker (*i.e.*, who inhale tobacco smoke passively).

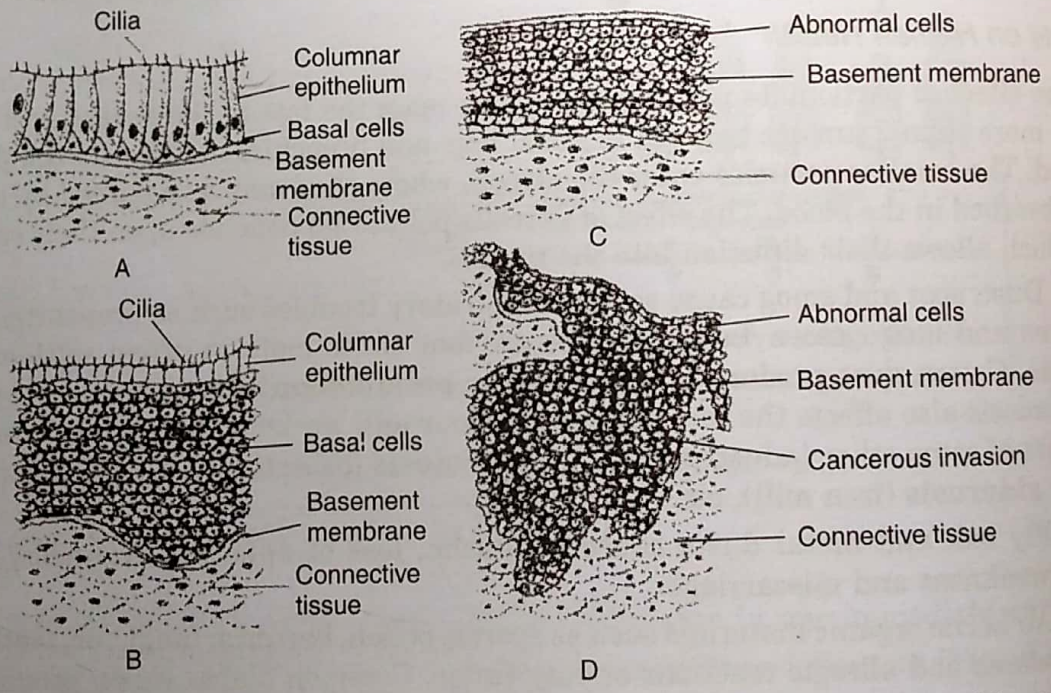


Fig. 5.6. Tobacco smoke causes abnormal changes in the bronchinal epithelium of the smokers (B, C) as compared to those of non-smoker (A) resulting in cancerous growth (D).

B. Effects on Vegetation

Air pollution causes wide spread damage to plants (*Fig. 5.7*) :

(*i*) Dust, smoke and other particulate matter reduce sunlight and settle on the leaves of plants, thereby retard photosynthesis.

(*ii*) Sulphur dioxide causes chlorosis, plasmolysis, membrane damage and metabolic inhibition. The leaves often assume water soaked appearance. Fruit trees and cereal crops are more sensitive to oxides of sulphur. Therefore, they suffer a great loss in the areas around smelters and industrial belts.

(*iii*) Fluorides destroy tissues in leaves causing necrosis of leaf margins and tips.

(*iv*) Several plant species are also very susceptible to PAN in smog. PAN damages chloroplasts and, thus the photosynthetic efficiency and growth of plants are reduced. It also inhibit electron transport system and interferes with enzyme systems that play important role in cellular metabolism.

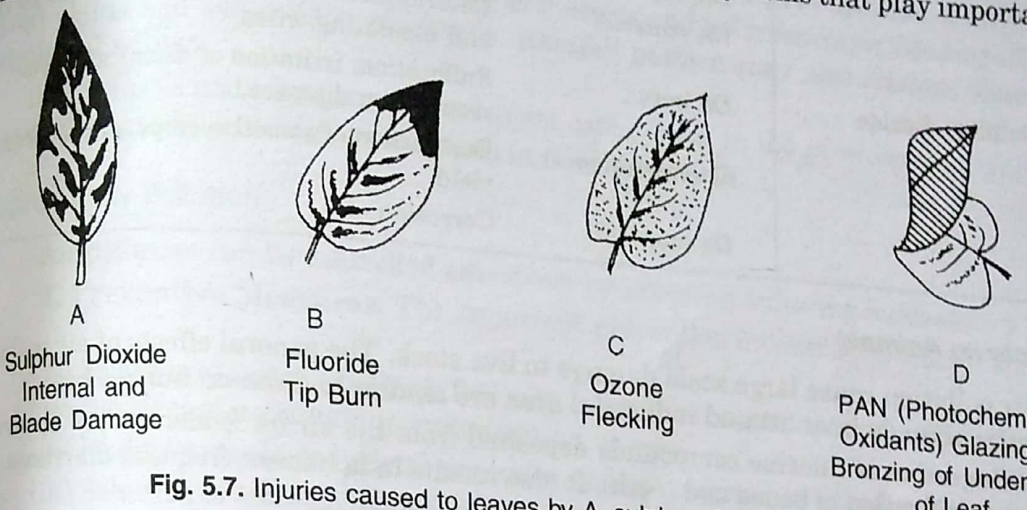


Fig. 5.7. Injuries caused to leaves by A. sulphur dioxide B. fluorides C. ozone D. PAN (photochemical smog).

(*v*) Hydrocarbons such as ethylene cause premature leaf fall, fruit drop, shedding of floral buds, curling of petals and discolouration of sepals.

(*vi*) Ozone damage chlorenchyma and thus destruct the foliage in large number of plants.

(*vii*) Lichens are very sensitive to air pollution. Their growth is inhibited in polluted air. The death of lichens in an area is an indicator of air pollution.

(*viii*) Acid rain adversely affects terestrial and aquatic vegetation. Low pH also damage soil microbial community.

Table 5.2. Effects of Air Pollution on Man, Vegetation and other Materials

Pollutant	*Effects on Man, Vegetation and other Materials*	
Carcinogenic hydrocarbon	*On man*	Cancer
Carbon monoxide	*On man*	Poisoning, increased accident liability.
Dust	*On man*	Respiratory diseases, diseases like silicosis (cough, cold, sneezing, allergic diseases, etc.), asbestosis, byssinosis, poisoning from metallic dust.
Hydrogen sulphide	*On man*	Irritation of respiratory passages, danger of respiratory paralysis and asphyxiation.
	On materials	Darkening of painted surfaces, corrosion.
Hydrogen fluoride	*On man*	Irritation, diseases of bone (fluorosis), mottling of teeth, respiratory diseases.

Heavy metals	*On vegetation*	Destruction of crops.
	On man	Specific poisoning, retardation of activities of brain, interference in enzyme activities in liver and kidney.
Nitrogen dioxide	*On man*	Irritation, bronchitis, oedema of lungs.
Photochemical smog (oxidants)	*On man*	Lung irritation, asthma, bronchitis, etc.
	On vegetation	Destruction of vegetation.
	On material	Deterioration of rubber products such as tyres and insulating wires.
Sulphur dioxide	*On man*	Suffocation, irritation of throat and eyes, respiratory diseases.
	On vegetation	Destruction of sensitive crops and reduced yield.
	On materials	Corrosion.

C. Effects on Animals

Air pollution cause large scale damage to live stock. The general effects of air pollution on domestic animals in or around industrial area are similar to those on human beings.

(*i*) Ingestion of fluorine compounds deposited from the air on fodder causes **fluorosis** (excessive calcification of bones and teeth). It also results in lameness, frequent diarrhoea and loss of weight.

(*ii*) Several air borne microbes cause diseases.

D. Deterioration of Materials

(*i*) Oxides of sulphur and nitrogen and products of photochemical smog have deteriorating effect on buildings, metals, textiles and marble.

(*ii*) Acid rains produced by oxides of sulphur and nitrogen have corrosive effect on the buildings and other materials.

(*iii*) Large number of historical buildings are damaged by acid rains and other air pollutants. It is feared that the famous marble monument Taj Mahal at Agra is under acute danger of air pollution. Many industrial units have been shifted to save the precious monument.

(*iv*) Hydrogen sulphide discolour silver and lead paints.

(*v*) Ozone has deteriorating effects on rubber goods.

(*vi*) Acid rain affects animal life. Most planktons, molluscs and fish fry cannot tolerate water having pH below 5.0.

E. Aesthetic Loss

Air pollution has strong bearing on the aesthetic side of human life :

(*i*) A clear and transparent atmosphere is not only aesthetically pleasing but is necessary for clear vision. A dust haze or hanging smoke blurs our views.

(*ii*) Foul odour emitted by industries, automobiles, dirty drains and garbage heaps make urban life unpleasant.

(*iii*) Coal dust and their materials discharged from the industries settle down on the floor and other objects of houses and give dirty look.

F. Effect on Climate

Earth's climate depends on various factors including composition of atmosphere and balance of gases. Therefore, air pollution may bring about harmful effect on the climate.

(*i*) Heat produced by the industrial plants raises the temperature of the area.

(*ii*) Carbon dioxide content of the atmosphere is increasing due to destruction of forests and excessive burning of fossil fuels and is likely to be doubled by 2020. It will lead to rise in global temperature by more than two or three degree due to **greenhouse effect.** A rise in global temperature may result in melting of glaciers and polar ice caps, flooding of low lying coastal plains and submersion of islands. Rainfall pattern may also change, thus affecting agricultural output.

(*iii*) Aerosols and nitrogen oxides deplete ozone layer in the stratosphere, which permit most of the harmful ultraviolet radiations to reach the earth.

Control of Air Pollution

Air pollution can be controlled effectively by adopting following methods :

1. Preventive Measures. The important preventive measures to control air pollution are :

(*i*) Selection of suitable fuel (*e.g.* fuel with low sulphur content) and its efficient utilization to reduce the level of pollutants in emissions.

(*ii*) Modifications in industrial processes and/or equipments to reduce emission.

(*iii*) Selection of suitable manufacturing site and zoning for industrial set up to disperse pollution sources. *e.g.* setting of industries at a distance of residential areas, installation of tall chimneys.

2. Control Measures. The most common method of eliminating or reducing pollutants to an acceptable level include (*i*) destroying the pollutants by thermal or catalytic combustion (*ii*) changing the pollutants to a less toxic form, (*iii*) collecting the pollutant by using equipment to prevent its escape into the atmosphere.

Different types of air pollutants can be eliminated/minimised by following methods :

(*a*) ***Control of Particulate Matter.*** Two type of devices are used to remove particulate pollutants from air. These are arresters and scrubbers.

(*i*) *Arresters.* These are used to separate particulate matters from contaminated air. The particulate matter arresters may be of different types. **Cyclonic separators** and **trajectory separators** are commonly used to separate out particulate matters from industrial emissions with minimum moisture content. These separators work on the principle of dust separation by centrifugal force and are efficient for coarser dust particles. Extremely fine particulate matters are collected by **filters**. Different types of filter materials are available to suit different quality and size of the particulate matters.

The most effective device to remove particulate pollutants is electrostatic precipitator (ESP). It works on the principle of electrical charging of the dust particles and collecting it on a differently charged plateform (*Fig. 5.8*).

(*ii*) *Scrubbers.* These are used to clean air for both dusts and gases by passing it through a dry or wet packing material. These devices are best suited for the removal of gaseous pollutants.

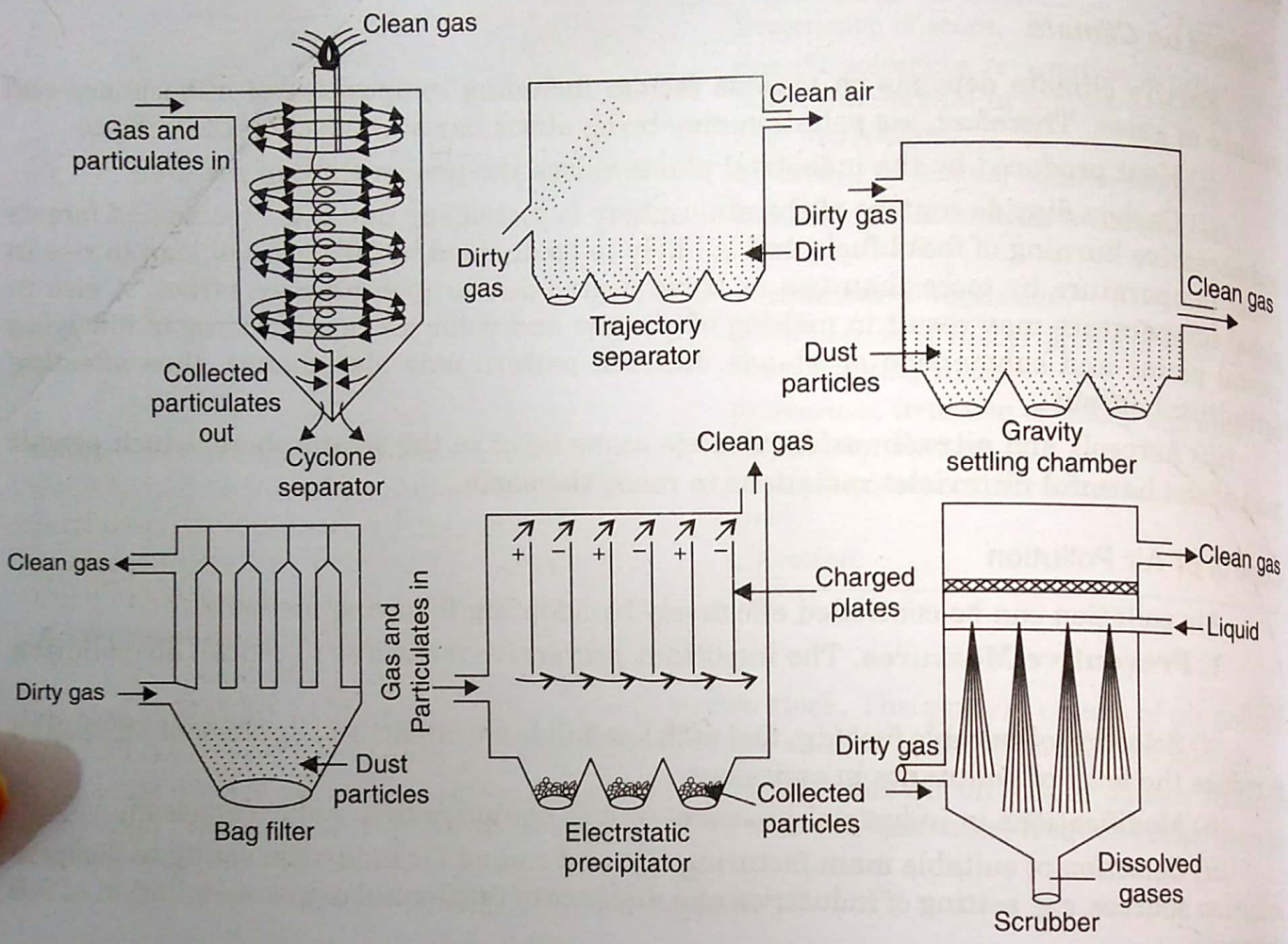


Fig. 5.8. Devices to control air pollution.

(*b*) ***Control of Gaseous Pollutants.*** The gaseous pollutants can be controlled through the techniques of **combustion, absorption** and **adsorption**.

(*i*) In combustion process oxidizable gaseous pollutants are completely burnt at a high temperature. The combustion control of gaseous pollutants is used in petro-chemical, fertilizer, paint and varnish industries.

(*ii*) In absorption technique gaseous pollutants are absorbed in suitable adsorbent materials.

(*iii*) Adsorption technique is applied to control toxic gases, vapours and inflammable compounds that could not be efficiently removed or transferred by the above techniques. Such air pollutants are adsorbed on large solid surfaces.

(*c*) ***Control of Automobile Exhaust***

(*i*) The unburnt hydrocarbons in auto-emissions can be reduced by the use of efficient engines (*e.g.* multi point fuel injection engine).

(*ii*) Catalytic converter filters in the vehicles can convert NO to nitrogen and reduce the potential hazards of NO_x.

(*iii*) By using good quality automobile fuels, the toxic contaiminants in exhaust can be reduced drastically.

(*iv*) The load of lead in the exhaust can be reduced by using lead free petrol.

(*v*) The toxic contaiminants in exhaust can significantly be minimised by the use of automobile engines operated with compressed natural gas (CNG).

Pollutant Separators

A cyclone collector consists of a special chamber with tight circular spirals. The gas stream containing particulate pollutants is whirled through it. The particles are centrifuged out, which are collected and removed periodically.

An electrostatic precipitator consists of electrically charged collecting surfaces, which attract the particulate pollutants bearing opposite charge. The electrostatic precipitator can remove 95 per cent of the particles in diameter range of 5-20 μm. Electrostatic precipitators are largely used in thermal power plants.

Water Pollution

Water pollution is defined as '*the addition of some substance (organic, inorganic, biological or radiological) or factor (heat), which degrade the quality of water so that it either becomes health hazard or unfit for use*'. Most surface waters usually contain small quantities of suspended particles, organic and inorganic substances and number of living organisms (bacteria, protists, fungi, algae, viruses etc). When concentration of these substances in water increases, the water becomes polluted and hence unfit for use. Some other substances pollute water even at low concentration include poisons, toxic chemicals and pathogens.

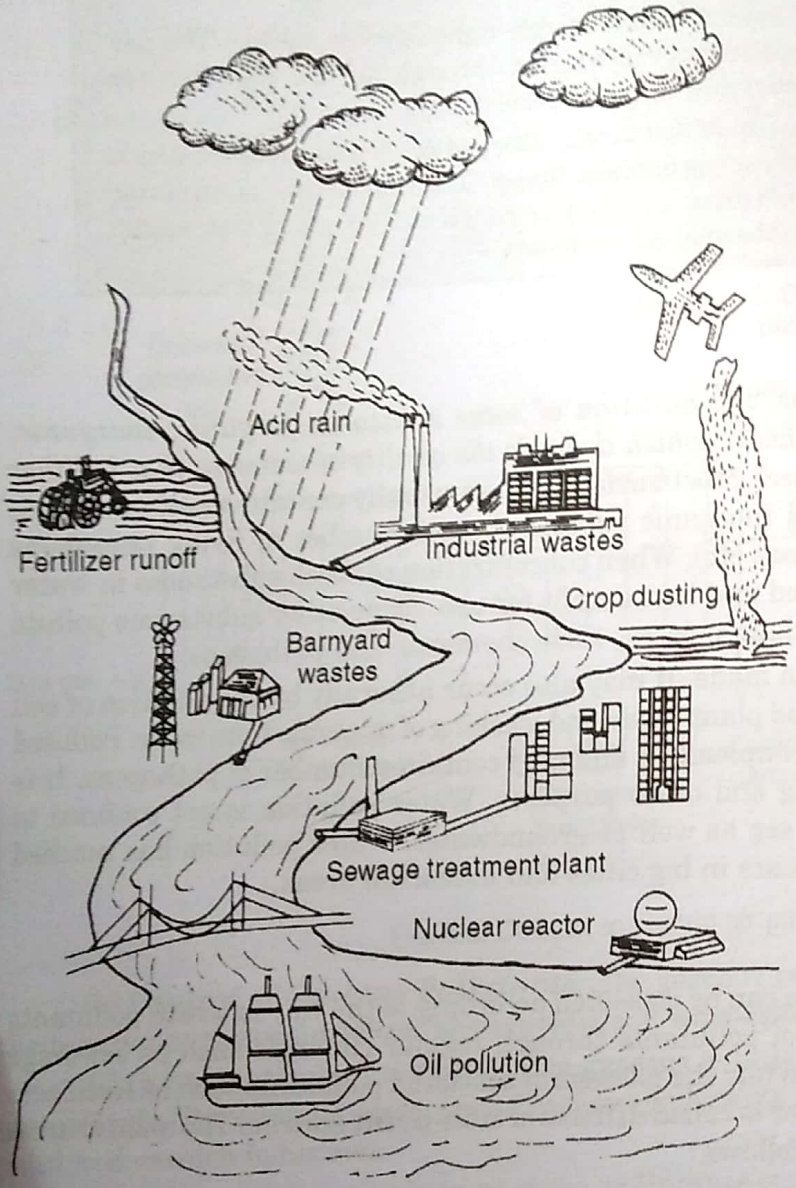
Most of water pollution is man made. It may also occur naturally by the addition of soil particles (through erosion), animal and plant waste and leaching of minerals from rocks. Polluted water may be turbid, foul smelling, unpleasant and may contain a number of pathogens. It is unfit for drinking, bathing, washing and other purposes. Water pollution is not confined to surface water, but it has spread to sea as well as groundwater. Water pollution has reached alarming proportion in the recent years in big cities and industrial areas.

Sources of Water Pollution

The sources of water pollution can be classified according to the way in which pollutants are introduced in water. The flow of pollutants through regular channels such as sewerage systems are called **point sources.** While the passage of scattered pollutants such as fertilizers and pesticides from ground into water is called **diffuse** or **non-point source**. The main sources (*Fig. 5.9*) of water pollution are as follows :

(*i*) ***Community Waste Water.*** Community waste water include discharges from houses, commercial and industrial establishments connected to public sewerage system. The sewage contain human and animal excreta, food residues, cleaning agents, detergents and other wastes. It is always rich in organic matter, bacteria and other biological pollutants. It is characterized by its **putrescibility**. Putrescibility is the process of decomposition of organic matter present in water by microorganisms using oxygen. With increase in the amount of organic wastes in water, the bacteria multiply rapidly and use up the available oxygen. Lack of oxygen kills fishes and other aquatic life. Deoxygenation of water causes anaerobic bacteria to produce foul smelling gases.

Water pollution by organic wastes is measured in terms of **Biochemical Oxygen Demand (BOD)**. It is the amount of dissolved oxygen needed by bacteria in decomposing the organic wastes present in water. It is expressed in milligrams of oxygen per litre of water.



SOURCES OF WATER POLLUTION

Oxygen demanding wastes
Biodegradable organic compounds (*e.g.*, sewage, wastes from food processing plants, paper mills, and tanneries)

Plant nutrients
Nitrates and phosphates from detergents, fertilizers, and sewage treatment plants

Sediments
Enriched soil in water due to soil erosion

Thermal discharges
Heated water from power plants

Disease-causing agents
Bacteria and viruses from sewage (*e.g.*, food poisoning and hepatitis)

Synthetic organic compounds
Pesticides, industrial chemical (*e.g.*, PCBs)

Radioactive substances
From nuclear power plants, medical and research facilities, and nuclear weapons testing

Fig. 5.9. Main sources of water pollution.

Measurement of BOD

BOD (Biochemical oxygen demand) is measured by keeping a sample of water, containing known amount of oxygen for 5 days at 20°C in the dark. At the end of this period the oxygen content is again measured. The amount of oxygen utilized during the period indicates BOD of the water sample. A sample of water with weak organic waste has BOD below 1500 gm/litre. A high BOD indicates intense level of microbial pollution.

Since BOD is limited to organic wastes only, therefore, it is not a reliable method of measuring water pollution. Another slightly better mode is **Chemical Oxygen Demand (COD).** It measures all oxygen consuming pollutant materials present in water.

The waste water from industries, when discharged into public sewers, it becomes the source of large quantities of suspended solids and become the source of several chemical pollutants such as heavy metals, cyanides, nitrates, phosphates and ammonical nitrogen.

(*ii*) ***Industrial Wastes.*** The major source of water pollution is the waste water discharged from industries into water bodies. The industries which are the source of water pollution include chemical and metallurgical industries, food processing plants, textile, paper and sugar mills, rubber and plastic industries, oil refineries, tanneries and slaughter houses. They discharge several inorganic and organic pollutants, which may prove highly toxic to the living beings.

(*a*) *Inorganic Pollutants.* They include fine particles of different metals, chlorides, sulphates, cyanides, thiocynate, oxides of iron, copper, cadmium, mercury and chromium, acids and alkalies.

(*b*) *Organic pollutants.* They include cellulose fibres, carbohydrates, proteins, oils, fats, phenols, neptha, organic acids, aromatic compounds, antibiotics and several other putrescible organic compounds.

Some important sources of industrial pollutants are given in *Table 5.3.*

Table 5.3. Sources of Industrial Pollution

Type of Industry	*Inorganic Pollutants*	*Organic Pollutant*
Mining	Mine Wastes : Chlorides, various metals, ferrous sulphate, sulphuric acid, hydrogen sulphide, ferric hydroxide, surface wash offs, suspended solids, chlorides and heavy metals.	
Iron and Steel	Suspended solids, iron cyanide, thiocyanate, sulphides, oxides of copper, chromium, cadmium, and mercury.	Oil, phenol and neptha.
Chemical Plants	Various acids and alkalies, chlorides, sulphates, nitrates of metals, phosphorus, fluorine, silica and suspended particles.	Aromatic compounds solvents, organic acids, nitro compound dyes, etc.
Pharmaceutical		Proteins, carbohydrates, organic solvent intermediate products, drugs and antibiotics.
Soap and Detergent	Tertiary ammonium compounds alkalies.	Fats and fatty acids, glycerol, polyphosphates, sulphonated hydrocarbons.
Food processing	—	Highly putrescible organic matter and pathogens.
Paper and Pulp	Sulphides, bleaching liquors.	Cellulose fibres, bark, wood sugars organic acids.

(*iii*) ***Agricultural Sources.*** Artificial fertilizers and pesticides have become indispensable for the present day high yielding varieties of crop plants. Consequently, they have become a potential source of water pollution.

Fertilizers contain one or more of major plant nutrients mainly nitrogen, phosphorus and potassium. Excess fertilizers may reach the groundwater by leaching or may be mixed with surface water of rivers, lakes and ponds by run off and drainage.

Pesticides include insecticides, fungicides, herbicides, nematicides, rodenticides and soil fumigants. They contain a wide range of chemicals such as chlorinated hydrocarbons, organophosphates, metallic salts, carbonates, thiocarbonates, derivatives of acetic acid etc.

Many of the pesticides are non-degradable and their residues have long life. The organo-chlorine compounds such as DDT are the most persistent pesticide. They are absorbed by lower organisms and are passed to higher organisms including man through food chains. At each stage, the concentration of these pesticides goes on increasing. This is called **biological magnification** or **biomagnification.** (*Fig. 5.10*).

The animal excreta such as dung, wastes from poultry farms, piggeries and slaughter houses etc. are discharged into fields and open pits. These may reach to water through run off and surface leaching during rainy season.

(*iv*) ***Thermal Pollution.*** Thermal pollution of water is caused by the rise in temperature of water. The main source of thermal pollution are the thermal and nuclear power plants. The power plants use water as coolant and release hot waters to the original source. Sudden rise in temperature kills fishes and other aquatic animals.

(*v*) ***Underground Water Pollution.*** Underground water, which was considered fairly safe source of water is also becoming increasingly polluted these days. In India at many places, the groundwater is threatened with contamination due to seepage from industrial and municipal wastes and effluents, sewage channels and agricultural runoff.

(*vi*) ***Marine Pollution.*** Oceans are the ultimate sink of all natural and man made pollutants. Rivers discharge their pollutants into the sea. The sewerage and garbage of coastal cities are also dumped into the sea. The other sources of oceanic pollution are navigational discharge of oil, grease, detergents, sewage, garbage and radioactive wastes. Capsized oil tankers, off shore, oil mining and soil exploration operations and oil refineries mainly contribute to oil pollution of marine ecosystem. An accidential discharge of petroleum in oceans and esturies is called **oil spills** (*Fig. 5.10*).

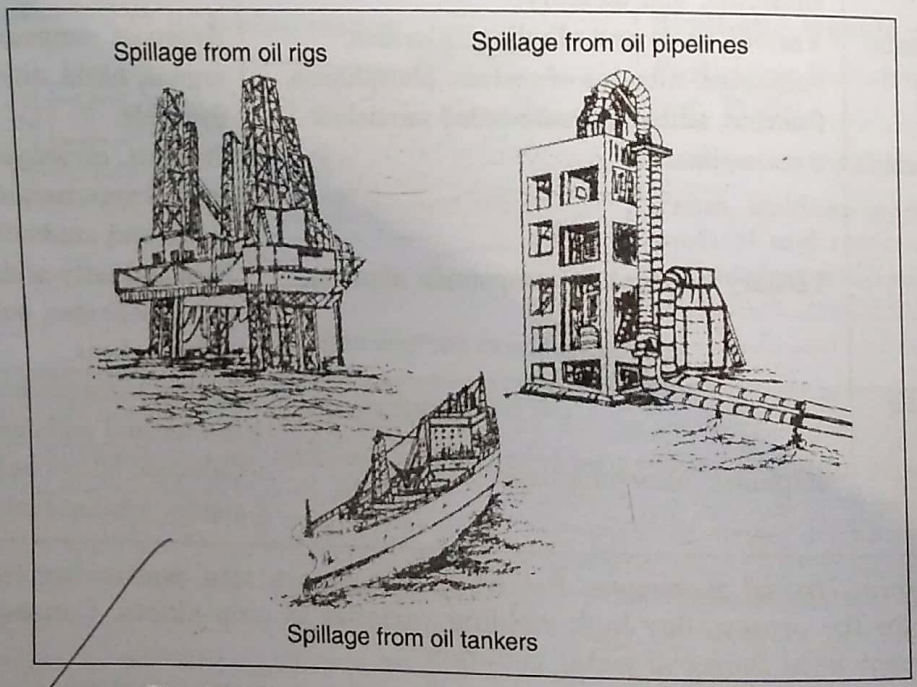


Fig. 5.10. Sources of oil spills causing marine pollution.

Effects of Water Pollution

The effect of water pollution depends on the type of pollutants present in water. Pollutants brings about physical and chemical changes that make the water unfit for drinking and harmful to aquatic life. The main effects of pollutants are mentioned below :

1. **Effects on Aquatic Ecosystem.** Presence of organic and inorganic wastes present in water decreases the dissolved O_2 (DO) content of the water. Water having DO content below 8.0 mg L^{-1} may be considered as contaminated. Water having DO content below 4.0 mg L^{-1} is considered to be highly polluted. DO content of water is important for the survival of aquatic organisms. A number of factors like surface turbulence, photosynthetic activity, O_2 consumption by organisms and decomposition of organic matter are the factors which determine the amount of DO present in water.

The higher amounts of organic waste increase the rates of decomposition and O_2 consumption, thereby decreases the DO content of water. The demand for O_2 is directly related to increasing input of organic wastes and is expressed as **biological oxygen demand (BOD)** of water. *'BOD is a measure of oxygen required by aerobic decomposers for the biochemical degradation of organic materials (i.e. bio-degradable materials) in water.'* It is expressed in milligrams of oxygen per litre of water. The higher value of BOD indicate low DO content of water. Since BOD is limited to biodegradable materials only, therefore, it is not a reliable method of measuring pollution load in water. **Chemical oxygen demand (COD)** is a slightly better mode used to measure pollution load in water. *It is the measure of oxygen equivalent of the requirement for oxidation of total organic matter (i.e. biodegradable and non-biodegradable) present in water.* Polluted water effects aquatic ecosystems in the following ways :

(*i*) The contamination of water bodies by pollutants reduces DO content, thereby, eliminates sensitive organisms like plankton, molluscs and fish etc. However, a few tolerant species like *Tubifex* (annelid worm) and some insect larvae may survive in highly polluted water with low DO content. Such species are recognised as **indicator species** for polluted water.

(*ii*) Biocides, polychlorinated biphenyls (PCBs) and heavy metals, such as Hg, Pb, Cd, Cu, As etc. directly eliminate certain species of organisms.

(*iii*) Hot waters discharged from industries, when added to water bodies, lowers its DO content.

2. **Biological Magnification.** *'The phenomenon through which certain pollutants get accumulated in tissues in increasing concentration along the food chain is called biological magnification.'* Many of the pesticides are non-degradable and their residues have long life. The organo chlorine compounds such as DDT, some other pesticides, radionuclides, etc. are the most persistent pesticides. Once they are absorbed by an organism, they cannot be metabolised and broken down or excreted out. These pollutants get accumulated in fat containing tissues of the organisms. A classic example of biological magnification is the accumulation of DDT in the tissues of organisms of aquatic food chain.

DDT is an insecticide which is sprayed on water bodies to check the growth of mosquitoes. After regular spraying of DDT for few years in long islands in USA, the population of fish eating birds began to decline. Later, it was found that the concentration of DDT had increased 800 times in the phytoplankton relative to the concentration in water, zooplankton contained about 5 times higher concentration than phytoplankton, different fishes had 9–40 times greater concentration than the zooplankton and birds contained about 25 times higher DDT concentration relative to than in fishes (*Fig. 5.11*).

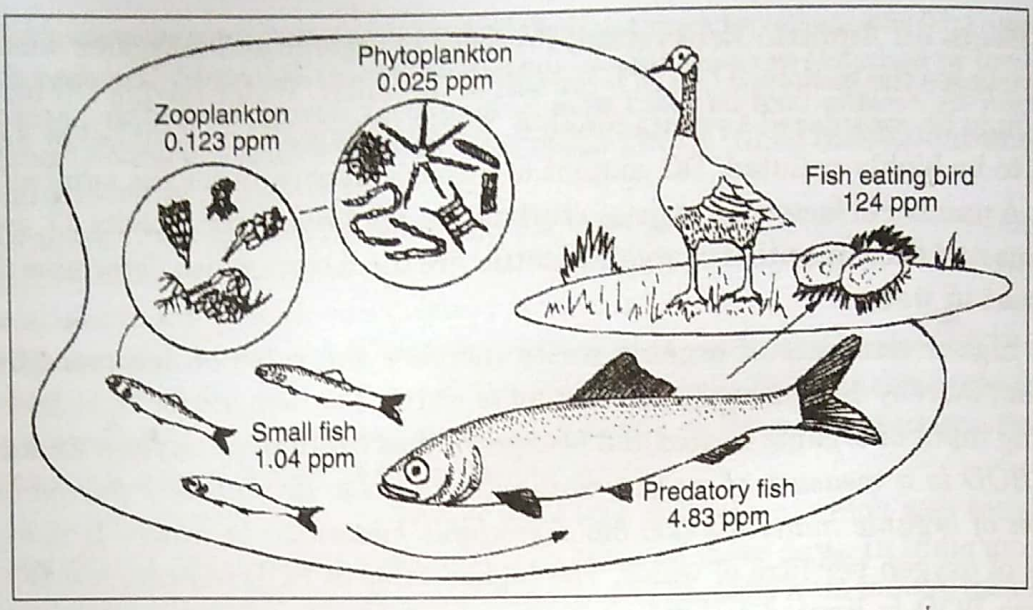


Fig. 5.11. Process of biological magnification ; DDT concentrations increase in organisms along the food chain.

Case Study

Pesticide Pollution in India. One of the dangerous effects of pesticide contamination of ground water come to light when pesticide residues were found in bottled water. Between July and December 2002, the Pollution Monitoring Laboratory of the New Delhi based centre for Science and Environment (CSE) analyzed 17 brands of commonly sold bottled water in the national capital region of Delhi. Pesticide residues of organochlorine and organophosphorus pesticides, which are commonly used in India, were found in all the samples. Among the organochlorines, gamma hexachlorocyclohexane (Lindane) and DDT were prevalent, while among organophosphorus pesticides, Malathion and Chlorpyrifos were the most common. All these were present above the permissible limits specified by the European Economic community (EEC).

Presently, there is no regulation that the bottled water industry must be located in clean zones. The manufacturing plants of most brands are situated in the dirtiest industrial estates or in the midst of agricultural fields. Most companies use bore wells to pump out water from the ground from depths varying from 24–152 m below the ground. The raw water samples collected from the plants also revealed the presence of pesticide residues. This clearly indicated that the sources of pesticide residues is in the polluted groundwaters, which are used to manufacture the bottled water. This is despite the fact that all bottled water plants use a range of purification methods. Thus, the fault obviously lies in the treatment methods used.

The bottled water plants use membrane technology, which removes fine suspended solids and micro-organisms. While nanofiltration can remove insecticides and herbicides, it is expensive and thus rarely used. Most industries also use an activated charcoal adsorption process, which is effective in removing organic pesticides but not heavy metals. To remove pesticides, the plants use reverse osmosis and granular activated charcoal methods so even though the manufacturers claim to use these processes, the presence of pesticide residues points to the fact that either the manufacturers do not use the treatment process effectively or treat a part of the raw water.

The low concentrations of pesticide residues in bottled water do not cause acute or immediate effects. However, repeated exposurer even to extremely low conconcentration can result in chronic effects like cancer, liver and kidney damage, nervous disorders, damage to the immune system and defecting births.

3. **Eutrophication.** The addition of inorganic compounds and decomposition of organic wastes in water bodies increase the nutrient content of water. It causes profuse growth of algae especially the blue green algae, and may totally cover the water surface. This type of algal growth is called **algal bloom**. The algal bloom often release toxins in water, and inhibits the growth of other algae. Aquatic animals (*e.g.* fishes) may also die due to toxicity or lack of oxygen. *'The process of nutrient enrichment of water, which often lead to the loss of species diversity is called eutrophication.*

4. **Effects on Human Health.** A number of health hazards are caused due to various types of pollutants present in water. The important human health hazards related to water pollution are as follows :

(*i*) The water polluted with sewage usually contains pathogens like virus, bacteria, parasitic protozoa and worms. The sewage contaminated water, therefore, is a source of water borne diseases like jaundice, cholera, typhoid, amoebiasis etc.

(*ii*) The water contaminated with heavy metals can cause serious health problems. Mercury compounds in waste water are converted by bacterial action into extremely toxic methyl mercury, which can cause numbness of limbs, lips and tongue, deafness, blurring of vision and mental derangement.

A cripling deformity called **Minamata disease** due to consumption of fish captured from mercury contaminated Minamata Bay in Japan was detected in 1952. Water contaminated with cadmium can cause **itai itai disease** also called **ouch-ouch disease** (a painful disease of bones and joints) and cancer of lungs and liver. The compounds of lead cause anaemia, headache, loss of muscle power and bluish line around the gum.

Case Study

Minamata—An important lesson about mercury poisoning. A case of human mercury poisoning which occurred about 55 years ago in the Minamata Bay in Japan taught the world an important lesson about the dangers of mercury poisoning. A large plastics plant located near the Minamata Bay used a mercury containing compound in a reaction to produce vinyl chloride, a common plastic material. The left over mercury was dumped into the Bay along with other wastes from the plant. Though the mercury was in its less toxic inorganic state when dumped, the micro organisms at the bottom of the Bay converted the mercury into its organic form. This organic mercury then entered into the tissues of fish which, were in, turn consumed by the people living in the area. The contaiminated fish thus caused an outbreak of poisoning killing and affecting several people. Mothers who had eaten the contaminated fish gave birth to infants who showed signs of mercury poisoning. Mercury poisoning is thus called 'Minamata Disease'.

5. **Hazards of Ground Water Pollution.** Groundwater get contaminated due to seepage from industrial wastes and agricultural runoff.

(*i*) Presence of excess nitrate in drinking water is dangerous for human health and may be fatal for infants. It reacts with haemoglobin to form non-functional **methaemoglobin**, and impairs oxygen transport. This condition is called **methaemoglobinemia** or **blue baby syndrome**.

(*ii*) Excess fluoride in drinking water causes teeth deformity, hardening of bones and stiff and painful joints (**skeletal fluorosis**).

(*iii*) Over exploitation of groundwater may lead to leaching of arsenic from soil and rock sources and contaminate groundwater. Chronic exposure to arsenic causes **black foot disease**. It also causes diarrhoea, peripheral neuritis, hyperkerotosis and also lung and skin cancer.

Case Study

Fluorosis. Many of the ground water and surface water in our country are contaminated with fluoride ions. High concentration of fluoride ions are present in drinking water in 13 states in India. It has been found that the maximum level of fluoride, which the human body can tolerate is 1.5 parts per million (mg/l of water). Ingestion of fluoride ions for a long time causes **fluorosis**. It results in various neuro-muscular disorders, gastro- intestinal problems, allergies, dental disorders and severe skeletal disorders leading to crippling of people. In animals, ingestion of fluoride ions cause disorders of bones and teeth and swelling of knee bones.

Control of Water Pollution

Water pollution can be checked or at least minimised by the following measures :

1. The sewage should be suitably treated before releasing it into water. It is one of the most important means to recover usable water from the sewage. It involves three steps (*Fig. 5.12*) :

(*a*) In the **first step primary treatment stage**, the larger and suspended particles are removed by simple physical methods such as sedimentation and filteration.

(*b*) In the **second step** or **secondary treatment stage**, air is supplied to promote bacterial decomposition of the organic matter (biological oxidation). This process is carried out in shallow stabilization or oxidation ponds. It results in release of CO_2 and formation of **sludge** or **biosolid**. The sludge is continuously areated for further oxidation. In upper lighted zone of waste water algae are grown to provide aeration by producing oxygen.

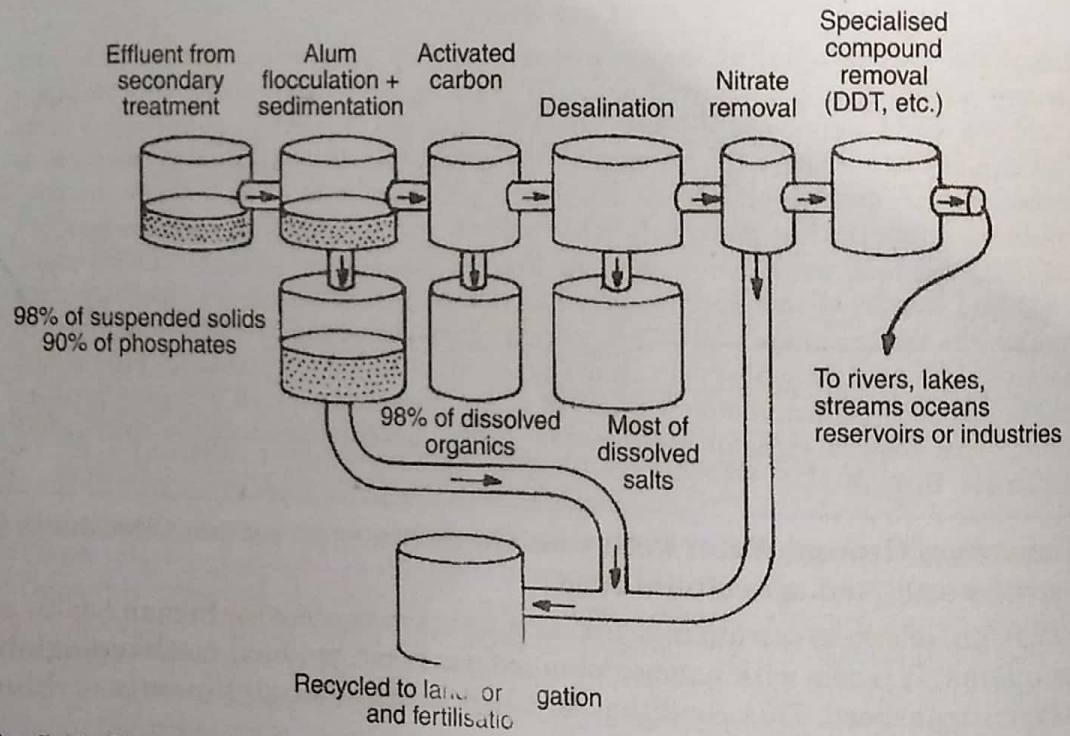


Fig. 5.12. Diagrammatic representation of tertiary treatment in an Efluent Treatment Plant.

(*c*) In the **third step** or **tertiary treatment stage**, turbidity in waste water caused by the presence of nutrients (nitrates, phosphates etc.), dissolved organic matter, metal or pathogens, etc. is removed by physico-chemical process. This step involves chemical oxidation of waste water by strong oxidising agents, such as chlorine gas, perchlorate salts, ozone gas

and UV radiation. After tertiary treatment, the waste water can be discharged into natural waters or used for irrigation.

2. The industrial effluents should be suitably treated before releasing them into water. The process requires different steps depending on the nature of pollutants. For example, the acids and alkalies can be neutralized, the colloidal materials can be coagulated, while the metallic salts can be precipitated.

3. Hot water should be cooled before release from the power plants.

4. Washing clothes and taking bath directly in tanks, streams and rivers, which supply drinking water, should be prohibited.

5. Excessive use of fertilizers and pesticides should be avoided and as far as possible less stable pesticides should be used.

6. Water hyacinth (an aquatic weed) can purify water by taking some toxic materials and a number of heavy metals from water.

7. Oil spills in water can be cleaned with the help of **bregoli**—a by-product of paper industry resembling saw dust.

Soil Pollution

Soil constitutes the upper crust of the earth which support land plants and animals. Like air and water, soil also gets polluted. Soil pollution can be defined '*the addition of substances to the soil, which adversely affect physical, chemical and biological properties of soil and reduces its productivity.*' The process of soil formation is very slow, therefore the soil may be considered as non-renewable resource. This makes the problem of soil pollution more acute.

Sources of Soil Pollution

Soil pollution is an extremely complicated process. It may occur directly by dumping and disposal of wastes, application of agro-chemicals or the indirect result of air pollution such as acid rains. The main soil pollutants are : (*i*) industrial wastes (*ii*) pesticides (*iii*) fertilizers and manures (*iv*) discarded wastes (*v*) radioactive (*vi*) other pollutants.

(*i*) ***Industrial wastes.*** Both solid and liquid wastes of industries are dumped over the soil. The wastes contain a number of toxic chemicals such as mercury, lead, copper, zinc, cadmium, cynides, thiocynates, chromates, acids, alkalies, organic substances etc. Some toxic chemicals reach the soil by mining operations also.

(*ii*) ***Pesticides.*** Now-a-days a number of chemicals are used to kill insects (insecticides), fungi (fungicides), algal bloom (algicides), rodents (rodenticides), weeds (weedicides or herbicides) in order to improve agriculture, forestry and horticulture. They are sprayed on the plants in the form of fine mist or powder. Most of the pesticides are broad spectrum and effect all types of life. They are, therefore, also called '**biocides**'. Pesticides reduce the population and number of species of living organisms including micro organisms, thus effect the structure and fertility of soil. Several pesticides or their degradation products are absorbed by plants, which in turn may affect the entire food chains and food webs.

(*iii*) ***Fertilizers and Manures.*** Chemical fertilizers are added to the soil for increasing crop yield. Excessive use of chemical fertilizers decreases population of useful bacteria and crumb structure of the soil. It also increases salt content of the soil and reduces productivity of the soil.

The excretory products of people and livestock and digested sewage sluge used as manure pollute the soil. The innumerable pathogens contained in these wastes contaminate the soils and vegetable crops and cause serious health hazards for man and domesticated animals. However, biological sources are the minor factors in altering soil composition.

(*iv*) ***Discarded Materials.*** A large number of discarded materials are dumped on the soil by man. These include concrete, asphalt, rugs, leather, cans, plastics, glass, discarded food, paper and carcasses. The addition of solid wastes is sometimes called the **third pollution**.

(*v*) ***Radioactive Wastes.*** Radioactive elements from mining and nuclear power plants, find their way into water and than into the soil.

(*vi*) ***Other Pollutants.*** Many air pollutants (acid rain) and water pollutants ultimately become part of the soil. The soil also receive some toxic chemicals during weathering of certain rocks.

Salination of Soil

Increase in the concentration of soluble salts in the soil is called **salination**. It adversely affect soil productivity and degrades the quality of land. Salination is caused by a number of process :

(*i*) The salts dissolved in irrigation and flood water accumulate on the soil surface due to inadequate drainage.

(*ii*) The salts from the lower layers move up by capillary action in summer and deposited on the surface.

(*iii*) The groundwater in arid regions is often saline. It adds to salination, if it is used for irrigation.

(*iv*) Excessive use of alkaline fertilizers such as sodium nitrate may cause salination of the soil.

(*v*) In coastal regions, winds bring lot of salt from raw water to land, thus causing salination of the soil.

(*vi*) The soil formed from the saline rocks are bound to be saline. When in excess, the salts form a white crust on the soil surface. This reduces soil productivity. India has about six million hectares of saline land. About 6000–8000 hectares of farmland turns saline every year in Punjab alone. This is due to the intensive farming with poor drainage of the soil.

Control of Soil Pollution

Soil pollution can be controlled by following measures :

(*i*) Transfer stations should be constructed at various points in cities for bulk transfer of refuse to discharge sites.

(*ii*) Pneumatic pipes should be laid for collecting and disposing wastes.

(*iii*) Special pit or low lying areas be selected for dumping industrial wastes.

(*iv*) Materials such as paper, glass and some kinds of plastic can be recycled. The process of cycling is costly but conserves resources. At least 17 trees can be saved by preparing one tonne of paper through recycling.

(*v*) Animal refuse and agricultural wastes can be utilized for production of biogas.

(*vi*) The use of chemical fertilizers can be reduced by applying biofertilizers.

(*vii*) Biological pest control methods can reduce the use of pesticides.

Period of Radioactivity

Each radioactive nuclide has a constant decay rate. Half-life is the time needed for half of the atoms to decay. Half-life of a radio nuclide refers to its period of radioactivity. The half-life may vary from a fraction of a second to thousands of years. The radio-nuclides with long half-time are the chief source of environmental radioactive pollution.

Sources of Radioactive Pollution

Sources of radioactive pollution are both natural and man-made.

I. Natural (Background) Sources. They include cosmic rays from space and terrestrial radiations from radio-nuclides present in earth's crust such as radium-224, uranium-238, thorium-232, potassium-40 and carbon-14.

II. Man-Made Sources. They include mining and refining of plutonium and thorium and explosion of nuclear weapons, nuclear power plants and fuels and preparation of radioactive isotopes.

(*i*) ***Atomic Explosion (Nuclear Fall Out).*** Atomic explosions are performed to test the nuclear arms. The nuclear arms use uranium-235 and plutonium-239 for fission and hydrogen or lithium as fusion material. Atomic explosions produce radioactive particles that are thrown high up into the air as huge clouds. These particles are carried to long distances by wind and gradually settle over the earth as fall out or are brought down by rain. The fall out contains radioactive substances such as strontium-90, cesium-137, iodine-131 and some others. From the soil, these materials are absorbed by plants and reach animals and man through food chains. From land radioactive materials are wasted to water sources.

The explosion of first atomic bomb was done in Nagasaki and second in the Hiroshima in Japan in 1945, which caused large scale destruction of human, animal and plant life. Inspite of this great tragedy, the big powers are still engaged in the race for nuclear arms. The present stock pile of these weapons is enough to destroy the earth completely.

(*ii*) ***Reactors and Nuclear Fuels.*** Radioactive isotopes such as uranium-235 are used as fuel to bring about disintegration of other atoms. The process releases large amount of energy as heat, which is used to produce steam for turning large turbines to produce electricity. Both the fuel elements and coolants contribute to radiation pollution. The biggest problem is the disposal of radioactive wastes, which contain excess of fission and activation products. The radioactive wastes are dumped in underground tanks for natural decay. If they escape, they pose grave public health hazards. Inert gases and halogens escape as vapours and become

potential pollutants of the environment by settling on ground or reaching surface waters by rain. People working in nuclear reactors, fuel processors, power plants or living nearby are vulnerable to radiation exposure.

(*iii*) ***Radioactive Isotopes.*** A large number of radioactive isotopes such as ^{14}C, ^{125}I, ^{32}P and their compounds are used in scientific research. These radioactive materials reach water sources with waste water from laboratories. Some of these isotopes such as radioactive iodine and phosphorus enter human body through food chains.

(*iv*) ***Radiation Therapy.*** Human beings voluntarily receive radiations from diagnostic X-rays and radiation therapy for cancers.

Effects of Radioactive Pollution

The effects of radioactive pollutants depend upon (*i*) half-life (*ii*) energy releasing capacity (*iii*) rate of diffusion and (*iv*) rate of deposition of the pollutant. Various environmental factors such as wind, temperature, rainfall also influence their effects.

Radiations are of two types with regard to the mode of their action on cells—non-ionising and ionising.

(*i*) ***Non-Ionising Radiations.*** They include short-wave radiations such as ultraviolet rays, which forms a part of solar radiation. They have low penetrating power and become harmful to multicellular organisms only after long exposure. They affect the cells and molecules which absorb them.

(*a*) They damage eyes which may be caused by reflections from coastal sand, snow (snow blindness) directly looking towards sun during eclipse.

(*b*) They injure the cells of skin and blood capillaries producing blisters and reddening called **sunburns**.

(*c*) They inactivate biomolecules including DNA and RNA and increase the incidence of cancer and mutations.

(*ii*) ***Ionising Radiations.*** They include X-rays, cosmic rays and atomic radiations (radiations emitted by radioactive elements). They have penetrability. They damage the cells mainly by physically breaking the macromolecules called **ionisation**. The molecular damage may produce short range (immediate) or long range (delayed) effects.

(*a*) Short range effects include burns, impared metabolism, dead tissues and death of the organisms.

(*b*) Long range effects are mutations increased incidence of tumour and cancer, shortening of life-span and developmental changes.

(*c*) The mutated gene can persist in living organisms and may effect their progeny.

The actively dividing cells such as cells of skin, intestinal lining, bone marrow and gamete forming cells are more sensitive to radiations. Embryo is particularly susceptible to damage by radiation, because all of its cells are actively dividing. A foetus into womb may be killed by radiation. Cancer cells are actively dividing cells, they are destroyed by radiations.

Radioactive pollutants affect most animals and plants also. Some species preferentially accumulate specific radioactive materials. For example, oysters deposit ^{65}Zn, fish accumulate ^{55}Fe, marine animals selectively deposit ^{90}Sr. Even the dairy milk and milk products may get highly contaminated.

Control of Radiation Pollution

As there is no cure of radiation damage, all effects should be made to prevent radioactive pollution. The following measures can be adopted to prevent radioactive pollution :

(*i*) Leakage of radioactive elements from reactors and laboratories, processing or using them should be totally checked. All safety measures should be strictly enforced.

(*ii*) The disposal of radioactive waste must be safe. They should be changed into harmless form or stored in safe place, where they may regularly decay in a harmless manner.

(*iii*) Regular monitoring through frequent sampling and quantitative analysis has to be ensured in the sink areas.

(*iv*) Safety measures against nuclear accidents should be strictly enforced.

(*v*) Nuclear explosions and use of nuclear weapons should be completely banned.

(*vi*) Appropriate steps should be taken to prevent occupational exposure.

Problem of Radioactive Waste Disposal

The disposal of wastes is one of the major problems in using radioactive materials for peaceful purposes. Only the wastes with low radiations can be discharged into sewerage. Low activity waste can be stored for some time to further reduce their activity before disposal. Wastes with long half-time can not be discharged. The radionuclides from the wastes are separated by coagulation and precipitation exchanges and the concentrated parts are stored or burried. They are locked in insulated concrete filled sealed drums and then burried or discharged at least 1000 fathoms deep into the sea. The decontaminated portion may be discharged. Small amount of the concentrated wastes can be converted into unleachable through complicated treatments.

Noise Pollution

Sound is a normal feature of our life. It is a main mean of communication and entertainment. Sound is also one of the effective alarm system in many animals. A loud, unwanted or unpleasant sound that causes discomfort is called **noise**. A given sound may appear music to someone and noise to others. It depends upon loudness, duration, rhythm and mood of a person. *'The release of unwanted sound in the atmosphere is called noise pollution'.*

Sound travels in pressure waves and affects our eardrums. The intensity of a sound wave is the average rate per unit area at which energy is transferred by the wave onto the surface (expressed as weber per meter^2 or Wm^{-2}). The sound level is the logarithm of ratio of the ambient intensity to the reference intensity (usually considered 10^{-12} Wm^{-2}). The unit of sound level is **decibel** (dB), a name that was given to recognize the work of Alexander Graham Bell. When the ambient sound intensity is equal to the reference intensity, the sound or noise level is 0 dB. Noise level can range from 0 to more than 120 dB. Noise beyond 120 dB causes physical discomfort. In view of the logarithmic nature of scale, 10, 20 and 100 decibels represents 10 times, 100 times and 10^{10} times the threshold intensity, respectively. The intensity of normal conversation sound ranges between 35 dB to 60 dB. Prolonged exposure to noise of 80 dB or more may lead to impairment of hearing. A noise above 140 dB becomes painful. The workers of noisy factories and soldiers lose their ability to hear soft sounds.

Sources of Noise Pollution

Noise pollution is the result of industrialized urban life and congestion. The main sources of noise are various industries such as textile mills, engineering established, printing presses,

defence equipments and vehicles (tanks, artillery, rocket launching, explosions, practice firing), transport vehicles (trains, trucks, buses, cars, motor-cycles, scooters, jet planes), domestic gadgets (mixers, exhaust fans, desert coolers, air conditioners, vacuum cleaners), entertainment equipment (radios, record players, television sets), public address systems etc. (*Fig. 5.13 and 5.14*). The operations such as blasting, bulldozing, construction work, stone crushing etc. and use of crackers on festival occasions also contribute to noise pollution.

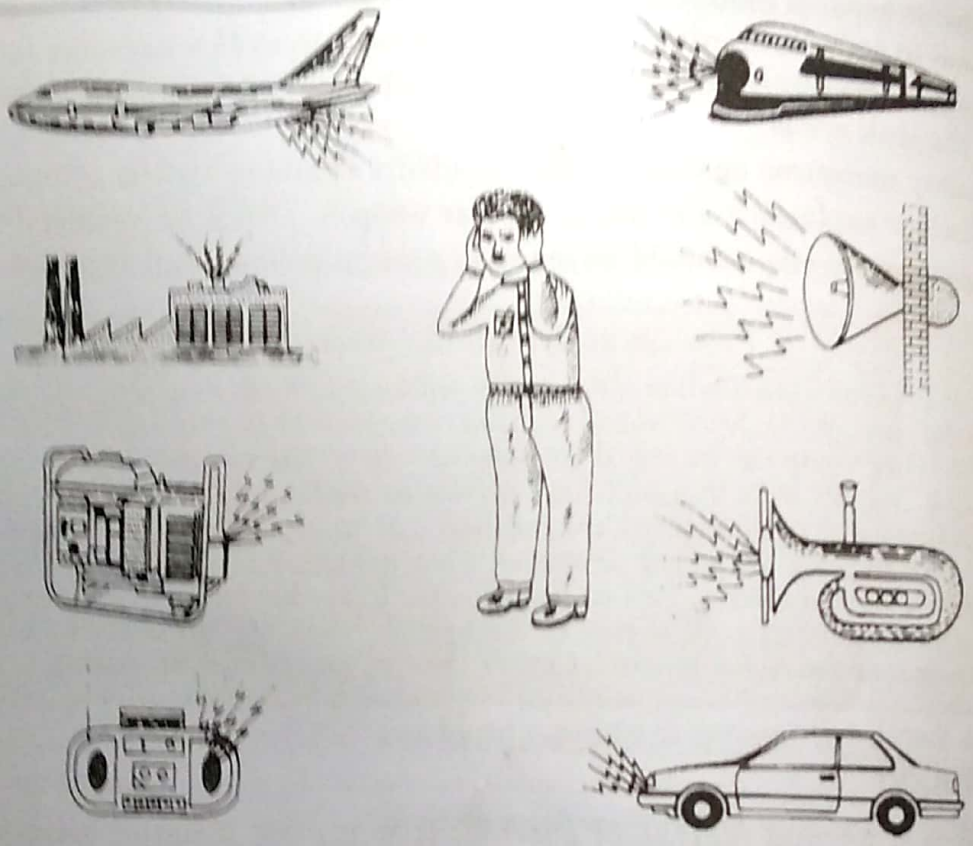


Fig. 5.13. Chief sources of noise pollution.

Fig. 5.14. Dance party with loud music.

The zone wise ambient noise levels as recommended by the Central Pollution Control Board is given in *Table 5.4*.

Table 5.4. Zone-Wise Permissible Ambient Noise Levels

Zones	Day (6.00—21.00 hr.)	Night (21.00—6.00 hr.)
Industry	75 dB	70 dB
Commercial	65 dB	55 dB
Residential	55 dB	45 dB
Silent zone	50 dB	40 dB

Effect of Noise Pollution

Noise pollution affects the power of hearing as well as general health of man.

(*a*) ***Effect on Hearing Ability.*** The most immediate and acute effect of noise pollution is impairment of hearing :

(*i*) Ear drum may be damaged by sudden loud noise or prolonged exposure to noise.

(*ii*) The sensory cells meant for hearing in our ears may be permanently damaged, if they are subjected to repeated sounds of high intensity before their recovery.

(*iii*) The noise in cities is often enough to deafen people gradually at least partially as they age.

(*b*) ***Effect on General Health.*** Following adverse effects on general health are caused by noise pollution :

(*i*) Noise cause anxiety and stress and in extreme cases may lead to fright.

(*ii*) Constant exposure to noise causes hormonal imbalance leading to several disorders such as increased rate of heart beat, constriction of blood vessels and increase in cholesterol level producing high blood pressure, hypertension and decreased heart output.

(*iii*) Noise causes digestive spasms and dilation of eye pupil, impairment of night vision and decrease in the rate of colour perception.

(*iv*) A sudden high intensity noise produces a startle reaction which may affect psychomotor performance of a person and even heart failure in a heart patient.

(*v*) Noise also detracts attention and causes emotional disturbance.

(*vi*) Damage to heart, brain and liver has been reported in animals due to prolonged noise pollution.

(*c*) ***Other Effects.*** Noise interferes with our conversation, disturb concentration and upsets mood.

Control of Noise Pollution

Following measures can be adopted to control noise pollution :

1. Proper lubrication and maintenance of machines can reduce noise.

2. Noisy machines should be installed in sound-proof chambers or quieter machines should be fabricated to replace the noisy ones.

3. Noise producing industries, railway stations, aerodromes should be located away from human settlements.

4. There should be silence zones around residential areas, educational institutions and hospitals.

5. Noise by motor vehicles on roads can be reduced by planting several rows of coniferous trees.

6. Occupational exposure to noise can be reduced using protective devices such as ear muffs or cotton plugs.

7. Use of loud-speakers and amplifiers should be restricted to a fixed intensity and fixed hours of the day.

8. Personal protection against noise can be done by stuffing a bit of cotton in the ears or holding hands over ears under noisy situations.

SOLID WASTE MANAGEMENT : CAUSES, EFFECTS AND CONTROL MEASURES

Any substance that is discarded is designated as **waste.** In any human society, bulk solid wastes are produced as by product of the normal and fundamental activities of living. These wastes may be rudimentary as food scraps, ash from fires, an excreta from humans and animals. In modern highly industrial society, however, the wastes go much beyond the fundamental materials both in quantity as well as in variety. The amount of wastes produced by modern industries are stagging and becoming a serious problem.

Urban wastes comprise a complex mixture of materials discarded by urban society. These include garbage, kitchen wastes, concrete, asphalt, rugs, leather can, plastic, glass, discarded food, paper and carcasses hospital wastes etc. (*Fig. 5.15*).

Industrial wastes include blast furnace slag, coal ash including fly ash, mica wastes, metal scraps, used batteries, wastes from chemical industries such as acids, alkalies, petrochemicals, dyes etc.

Fig. 5.15. Urban wastes.

Classification of Wastes

Wastes are classified into following categories :

1. **Biodegradable Wastes.** The waste materials that can be degraded by micro-organisms are called biodegradable wastes. There wastes include vegetable peelings, discarded food, tea leaves, egg shells, crop and farm residue etc.

2. **Non-biodegradable Wastes.** The wastes that cannot be degraded by micro-organisms are called non-biodegradable wastes. These wastes include polythene bags scrap metal, glass bottles, plastic, metal and aluminium cans, ceramics, asbestos etc.

3. **Toxic Wastes.** The poisonous wastes are called toxic wastes. Such wastes include pesticides, acids, alkalies, radioactive substances etc.

4. **Non-toxic Wastes.** The non-poisonous wastes are called non-toxic wastes. Such wastes include glass, ceramics, paper, wood scrap, leather, rubber etc.

5. **Biomedical Wastes.** These wastes are released by the hospitals and clinics and include cotton, syringe, glass and plastic bottles, anatomical and pathological wastes.

Impact of Waste Accumulation

Uncontrolled dumping of wastes not only gives an ugly look but also pollutes the environment. The main impacts of waste accumulation are :

1. **Spoilage of Landscape.** Municipal wastes heap up on roads due to improper disposal system. People clean their own houses and litter their immediate surroundings, which affects the community including themselves. Every year, several tons of solid waste is dumped along the highways and other places, thereby spoiling the landscape.

2. **Pollution.** Dumping of waste on the land may pollute ground water and also the water bodies present in the vicinity. Toxic chemicals present in the wastes may percolate in the ground and contaminate the ground water.

3. **Health Hazards.** Heaps of domestic and industrial wastes are dumped on vacant and unused land in residential areas which causes unhygienic conditions and ultimately results into outbreak of diseases like cholera, gastroenteritis, malaria, dengue etc. Decomposition of organic wastes produce foul smell and allows breeding of various types of insects and infections organisms. Rats thrive on these dumps and multiply rapidly causing menace to the people by destroying their property and spreading several diseases.

4. **Effect on Soil.** Many waste may spread on the soil and changes physico-chemical and biological characteristics of the soil. It adversely affects the fertility of the soil.

5. **Effect on Terrestrial and Aquatic Life.** Urban and industrial wastes often contain a variety of toxic chemicals. Such chemicals may enter into the food chain and affect both terrestrial and aquatic organisms.

Disposal of Solid Wastes

The disposal of solid wastes can be carried out by several methods such as composting, vermiculture, recycling, land filling and incineration.

1. **Composting.** It involves degradation of organic wastes by micro-organisms in presence of oxygen and provides a number of attractive features. The organic waste is converted into compost and CO_2. The urban solid waste can also be disposal off through a biotechnology based **anaerobic digestion process.** This process produce valuable organic manure and methane that can be used as fuel to generate power.

2. **Vermiculture** (Vermicomposting). This technique is popularly known as **earthworm farming.** It is an important biotechnique for converting solid wastes such as sewage sludge and domestic wastes into compost with the help of earthworms.

Steps for Vermiculture

- Dig a pit about half a meter square, one meter deep.
- Line the pit with straw, dried leaves and grass.
- Put the organic waste into the pit as and when generated.
- Introduce a culture of earthworms that is now produced commercially.
- Ensure that the contents are covered with a sprinkling of dried leaves and soil.
- Keep the waste in the pit moist by sprinkling water once or twice a week. everyday.
- Turn over the contents of the pit every 15 days.
- In about 45 days the waste will be decomposed by the action of the worms.
- The manure derived is fertile and rich in nutrients.

3. **Recycling.** Recycling is an integral part of waste management and is truely an eco-**friendly technique.** In recycling, a product at the end of its service life *i.e.* waste, is converted into another useful product. It involves separating, collecting, processing, marketing and ultimately using the material that could have been thrown away. A sheet of paper can be recycled to other paper products, cans, bottles and pouches can be recycled for other uses. The process of creating a new product from a waste is important because it does not produce unwanted by product. The most important advantages of recycling are :

(*i*) It reduces our reliance on landfills and incinerators.

(*ii*) It protects our environment by effective handling of the waste.

(*iii*) It conserves natural resources because it reduces the need for fresh raw material.

4. **Landfilling.** Disposal of urban waste in sanitary landfill is one of the methods of handling urban garbage. In the landfilling process all the collected material is directly placed in a dump. A site of landfill should be away from human habitation because of public health and aesthetic reasons.

5. **Incineration.** Incineration is an industrial process designed to reduce unwanted materials to simple solid and gaseous residues. It is a process of controlled burning of the waste at high temperature (*i.e.* 850°C) in presence of air. It is an alternative to land filling and provide an efficient means for energy recovery. Although incineration reduces the volume of waste significantly so that much less land is required for final disposal, but it releases a number of toxic chemicals in the atmosphere.

Need for Reducing, Reusing and Recycling Waste

For effective waste management stress is given on three 'R's *i.e.* Reduce, Reuse and Recycle before storage and safe disposal of wastes.

1. **Reduction in use of raw materials.** Reduction in the use of raw materials will correspondingly decrease the production of waste. Reduced demand for any metallic product will decrease the mining of their metal and cause less production of waste.

2. **Reuse of waste materials.** The refillable containers (such as glass bottles, plastic containers) which are discarded after use can be reused villagers make casseroles and silos from waste paper and other waste materials.

3. **Recycling of materials.** In recycling used and discarded items are collected, melted and reprocessed into new products. For example iron scraps, aluminium cans etc. can be melted and recorded into new products.

The processes of reducing, reusing and recycling (called 3-R approach) saves money, energy, raw material, land space and also reduce pollution. Recycling of paper will reduce

cutting of trees for making fresh paper. Reuse of metals will reduce mining and melting of ores for recovery of metals and reduce pollution.

Legal Provisions for Handling and Management of Wastes

There are several legal provisions in our country which safeguard our environment. Indian constitution is the first constitution in the world which contains specific provisions for the protection of environment some of the legal provisions related to waste management are :

1. **Factories Act 1948, amended in 1987.** This act safeguards our environment. The basic objectives of this act are :
   (*i*) Cleanliness of the industrial establishments and factories.
   (*ii*) Proper and safe disposal of wastes and effluents.
   (*iii*) Safe use and handling hazardous substances.
   (*iv*) Penalizes any disobedience of law.
2. **The Environment (Protection) Act 1986.** This is meant for the protection of air, water and soil quality and the control of the environmental pollutants including wastes.

ROLE OF INDIVIDUAL IN PREVENTION OF POLLUTION

Environment belongs to each one of us, and it is the responsibility of each of us to contribute towards its protection. With our small individual efforts, we can help in prevention of pollution and protection of our environment. Each one of us should change his or her life style in a such a way as to reduce environmental pollution. Following are some suggestions for individual to prevent pollution.

1. Develop respect for all forms of life.
2. Each individual must try to answer four basic questions.
   - Where do the things that I consume come from ?
   - What do I know about the place where I live ?
   - How am I connected to the earth and other living things ?
   - What is my purpose and responsibility as a human being ?
3. Reduce the use of wood and paper products wherever possible. Manufacturing paper leads to pollution and loss of forests.
4. Try to recycle paper products and use recycled paper whenever possible.
5. Always use eco-friendly products such as degrable paper bags instead of polythene bags and earthen cups instead of thermocol/polystyrene cups.
6. Wherever possible promote reuse and recycle policy and reduce the production of wastes.
7. Cut down the use of chlorofluorocarbons (CFCs) by using CFC-free refrigerators to protect the ozone layer.
8. Reduce dependency on fossil fuels (*i.e.* petroleum and coal) by adopting renewable sources of energy.
9. Use public transport system, and for short distances use bicycle or go on foot.
10. Practise organic farming by adopting the use of organic manures, biofertilizers and biopesticides instead of inorganic chemicals.

11. Do not put harmful chemicals like pesticides, paints, solvents, etc., into the drain or water bodies.

12. Always use low phosphate/phosphate free washing liquids, detergents and shampoos to reduce eutrophication of water bodies.

13. Use rechargeable batteries to reduce metal pollution.

14. Plant more trees in your area, as they absorb many toxic gases and purify the air.

15. Protect trees from cutting.

16. Save electricity by not wasting it to minimise pollution caused by thermal power plants.

17. Adopt family planning measure to check the population growth.

18. Help in restoring a degraded area near your home or join programmes like afforestation.

19. Don't use aerosol spray products and commercial air freshners. They damage the ozone layer.

20. Avoid asking for plastic carry bags when you buy groceries or vegetable or any other items. Use your own cloth bag instead of it.

21. Set up a compost bin in your garden or terrace and use it to produce manure for your plants to reduce the use of fertilizers.

22. Try to lobby for setting up garbage separation and recycling programmes in your localities.

23. Choose items that have the least packaging or nopackaging.

24. Do not litter the roads and surroundings just because the sweeper from the Municipal Corporation will clean it up. Take care to put rash into dustbins or bring it back home with you where it can be appropiately disposed.

25. You can join any of the several NGOs that exist in our country or become volunteers. Organize small local community meetings to discuss positive approaches to prevent pollution.

26. Learn about the biodiversity of your own area. Understand the natural and cultural assets. This will help your develop a sense of pride in your city/town/village and will also help you understand the problems facing their survival.

27. Take care to put into practice you peach. Remember environment protection begins with you.

Case Studies

1. **The Bhopal Gas Tragedy.** The worst industrial accident of the world occurred in Bhopal (India) on the night of December 2, 1984. It happened at Union Carbide—a chemical factory which used to manufacture carbaryl (carbonate) pesticide using Methyl Isocyanate (MIC). About 40 tons of MIC leaked into the atmosphere from the tank due to accidental entry of water into the tank which overheated the reaction mixture and exploded the tank. It killed about 5100 people (about 2600 due to direct exposure of MIC and about 2500 due to after effects of exposure) and maimed several thousand others. It is estimated that about 65,000 people suffered from severe eye, respiratory, neuromuscular, gastro-intestinal and gynecological disorders.

2. **Chernobyl Nuclear Disaster.** It was the worst nuclear accident which occurred at Chernobyl power plant, Chernobyl (USSR) on April 26, 1986. Due to faulty operations of cutting down the plant, an explosion occurred in the reactor. Fuel and radioactive debris spread over most of the northern hemisphere. Due to exposure to radioactive substances like Iodine-131, Cesium-134 and cesium-137 about 2000 people were died.

It was also feared that more than 5.5 lac people exposed to radiations would suffer from cancers like thyroid cancer and leukaemia. Several people suffered from ulcerating skin, loss of hair, nausea and anemia. The intense radiations also damaged plants, animals and crops of that area.

3. **Arsenic Pollution in Groundwater.** In West Bengal and Bangladesh, the ground water at several places has become contaminated due to excessive use of lead arsenate and copper arsenate as pesticides in high yielding varieties of summer paddy and jute crops. The people drinking arsenic contaminated water develop white or black spots on the skin called melanosis. The spots later convert into leprosy like skin lesions and gangrenous ulcers. Long exposures often lead to bladder and lung cancer. Now the state government is marking arsenic contaminated tubewells with red paint, while those with safe water with green paint.

ENVIRONMENTAL DISASTERS AND THEIR MANAGEMENT

The environmental disasters may be defined as '*the extreme events either natural or man induced, which exceed the tolerable magnitude within or beyond certain limits, make adjustment difficult and results in catastrophic losses of property, income and lives*. The environmental disasters always viewed in terms of human beings. The enviornmental events that cause disaster for human society include cyclones, earthquakes, volcanic erruptions, droughts and floods. The intensity of environmental disasters always viewed in terms of the quantum of damages done to the human society. Thus, the hazardous environmental processes always create extreme events but not all the extreme events become disasters. These may become disasters only when they adversely affect human society. For example, a very strong tropical cyclone (typhoon, hurricane or tarnado) does not become disaster, when it occurs and dies in the midst of an ocean. However, it becomes disaster, when it strikes the inhabited coastal areas and inflicts colossal loss to human property and lives.

Tropical Cyclones (*Fig. 5.16*)

Tropical cyclones are the most powerful, destructive, dangerous and deadly atmospheric storms on the earth. The cyclones move like a spining top at the speed of 120-400 km/hour. These can last for a week or so and have a diameter varying between 100 to 1500 km. They are variously called in different parts of the world as **hurricanes** in the Caribbean Sea and south-eastern USA, **Typhoons** in North Pacific Ocean and southern coast of China, Japan and Phillipines, **cyclones** in Bangladesh and eastern coastal areas of India, and **Willy Willy** in Australia. Tropical cyclones become more disastrous because of their high speed, high tidal surges, high intensity of rainfall, very low atmospheric pressures causing unusual rise in sea level, and their persistance for several days. The destructions caused by tropical cyclones include loss of human lives and property in terms of destruction of buildings, transport and communication systems, agricultural crops, domestic and wild animals and so on.

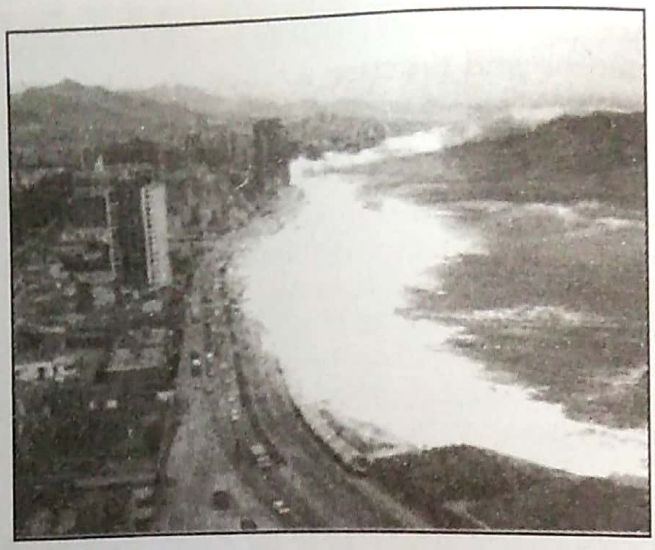
Mitigation of Cyclones. The severity of cyclones can be minimised by taking following steps :

(*i*) Tree plantation on coastal belts.

(*ii*) Construction of dams, dykes, embankments and wind breaks.

(*iii*) Installation of better warning systems.

(*iv*) Construction of proper drainage and wide roads for quick evacuation of affected people.



Tsunami

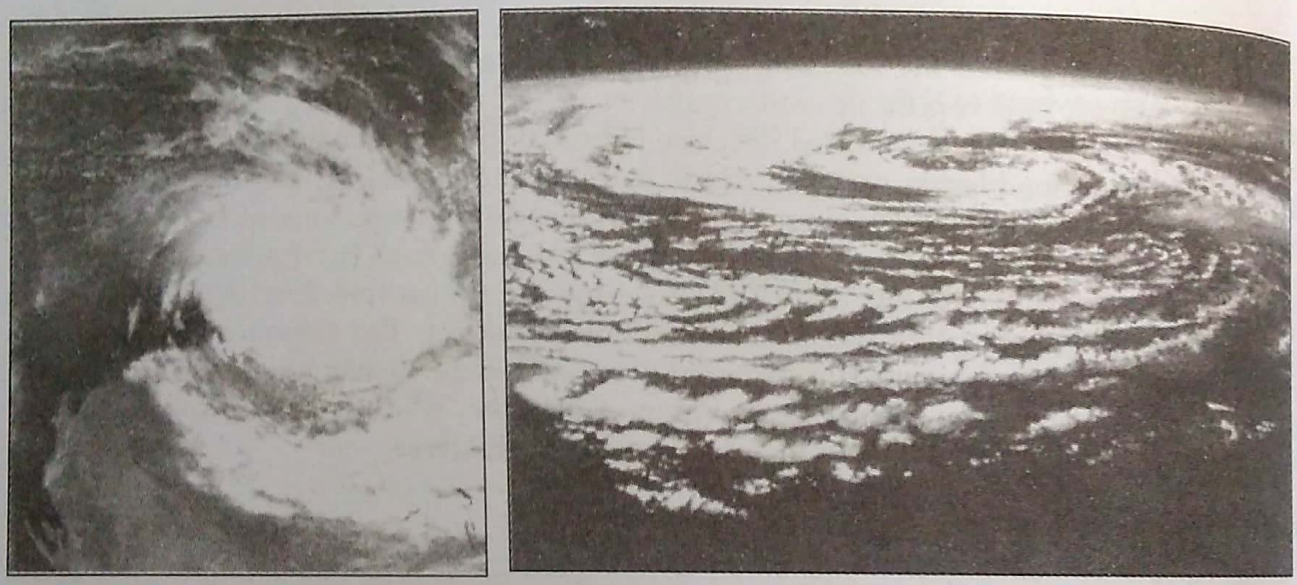


Fig. 5.16. Cyclone.

Management in Cyclone Hit Areas. Following measures could be of great help in cyclone hit areas :

(*i*) Identification of safe buildings in the area for providing safe shelters to the affected people.

(*ii*) Listening to the weather bulletins broadcasted/telecasted over radio/television.

(*iii*) In coastal areas, warning should be sent to the fishermen not to venture into the sea during the course of storm.

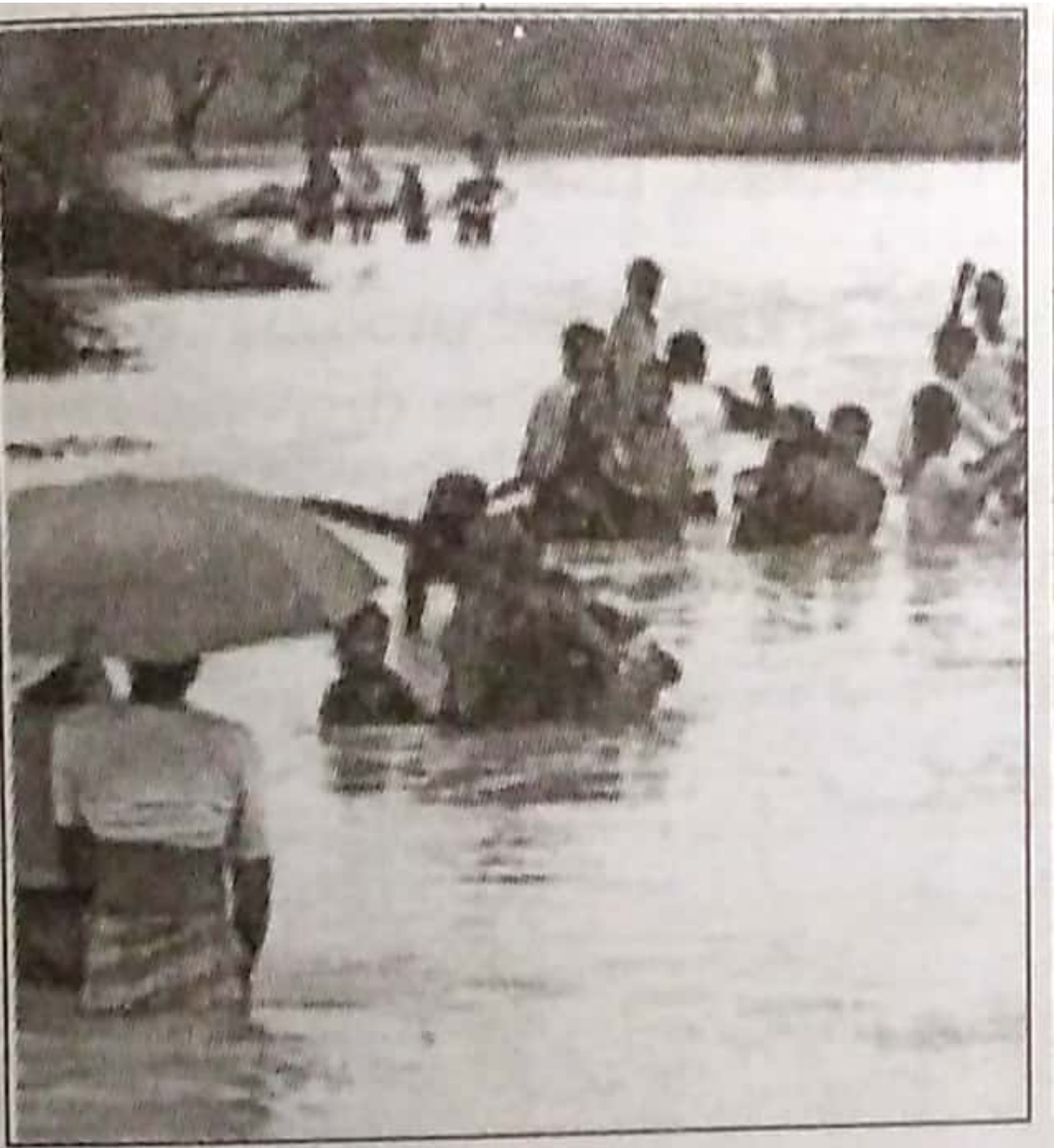
(*iv*) Emergency phone numbers and addresses should be kept ready and remain in touch with responsible members of the community.

(*v*) Keep away from fallen electric poles, damaged bridges and flood water areas.

(*vi*) Transportation and movements should be stopped during the coarse of storm.

(*vii*) People who have evacuated from their places must wait for the official declaration to come back to their homes.

(*viii*) Relief and rehabilitation should be immediately provided to the effected people.



Floods in Gujarat

Causes of Floods. Floods are caused by natural as well as anthrophogenic (human) factors. Among the natural factors, important are prolonged high intensity rainfalls, meandering courses of the rivers, break in slope in the long profiles of the rivers, blocking of free flow of the rivers due to enormous debris provided by landslides or volcanic eruptions etc. The anthropogenic activities such as building activities, channel manipulation through diversion of river course, construction of bridges barrages and reservoirs, deforestation, changes in land use etc., invite several hazards in the river system including floods, landslides, massive erosion along the river banks and deposition of sands, silts and clays in the flood plains (*Fig. 5.12*).

Flood Control Measures. The floods are natural phenomenon and one cannot entirely get rid off them, but their impact can be minimised by taking a series of steps such as :

(*i*) By delaying the return of run off resulting from rainfall to the rivers

(*ii*) By hastening the discharge of water.

(*iii*) By diverting the flow of water.

(*iv*) By forewarning the occurrence of floods.

Flood disaster can be mitigated by taking following measures :

(*i*) Forecast, warnings and advice should be provided through media (radio or television) to educate and aware people about the steps to be taken in the event of disaster.

(*ii*) Elderly people and children should be evacuated to safer places on priority basis.

(*iii*) Valuable household items, animals and other necessary materials (*e.g.*, food, clothes, medicines etc.) should be shifted to safer places.

(*iv*) Government agencies and non-governmental organisations (NGOs) should help the flood affected people in the control of epidemic diseases and maintaining proper sanitation.

Droughts (*Fig. 5.18*)

The term 'drought' refers to the condition of dryness for prolonged period. Droughts are more deadly natural environmental hazards because these are directly related to one of the basic requirement of life *i.e.* water. Droughts cause famine and starvation of human and animal population of the region concerned. Prolonged drought conditions in a given region change the biotic component of the natural ecosystem due to death of several plant and animal species, migration of certain animal species to other places and stiff competition among the remaining individuals of plants and animals thereby eliminating the weaker ones.

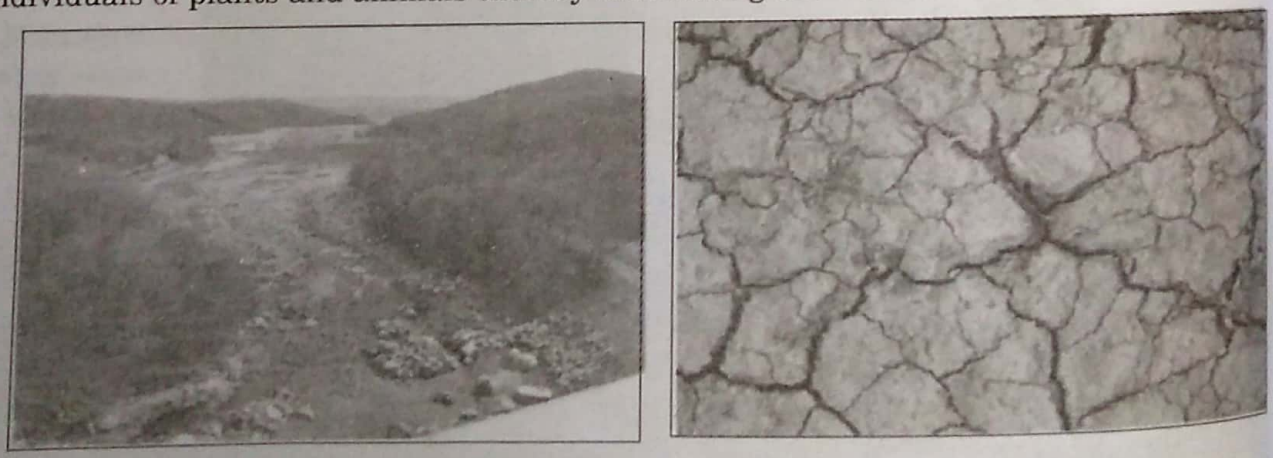


Fig. 5.18. Drought condition.

Drought Control Measures. The drought control measures include :

(*i*) Afforestation to increase the content of air moisture, the amount of precipitation, the rate of infiltration of rainwater and hence the replenishment of groundwater and rise of water-table.

(*ii*) Introduction of dry farming techniques to reduce the dependence of farming on rain-water.

(*iii*) Checking of desertification or desert spread.

(*iv*) Introduction of water conservation schemes. and

(*v*) Construction of water reservoirs and digging of wells etc.

Earthquake (*Fig. 5.19*)

An earthquake is a motion of the ground surface, ranging from a faint tremor to a wild motion capable of shaking buildings apart and causing gaping fissures to open in the ground. The earthquake is a form of energy of wave motion transmitted through the surface layer of the earth in widening circles from a point of sudden energy release, called **focus** or **hypocentre.** Hypocentre is always hidden inside the earth. The place on the ground surface (which is perpendicular to the buried focus) recording the seismic waves for the first time is called **epicentre.** The magnitude or intensity of energy released by an earthquake is measured by the **Richter scale** devised by **Charles F. Richter** (1935). The seismic waves move away from the source of earthquake which can be recorded with the help of an instrument called **seismometer.** The severity of an earthquake is generally measured by its magnitude on Richter scale as shown below.

Table 5.5

S. No.	*Richter Scale*	*Severity of Earthquake*
1.	< 4	Insignificant
2.	4—4.9	Minor
3.	5—5.9	Damaging
4.	6—6.9	Destructive
5.	7—7.9	Major
6.	> 8	Great

A view of collapsed building in Islamabad on 8th Oct, 2005

Bhuj (Gujarat) earthquake

People look at a 3-km-long crack in Simbal, near Jammu, which also recorded quake with epicentre in Pakistan on Oct 8, 2005

Fig. 5.19. Effects of Earthquake.

Causes of Earthquake. The earth's crust has several tectonic plates of solid rock which slowly move along their boundaries. Sometimes friction prevents these plates from slipping resulting in building up a stress. This leads to sudden fractures along the boundaries of the plates or fault lines (planes of weakness), resulting in an earthquake.

Human Activities and Earthquake. Certain human activities may cause or enhance the frequency of earthquakes. These activities are :

(*i*) Underground nuclear testing, and

(*ii*) Collection of huge quantities of water behind a dam.

Effects of Earthquake. The earthquakes inflict great damage to human structures such as buildings, roads, factories, dams, bridges and thus cause heavy loss of human property. The tremors of higher magnitudes shake the ground to such an extent that the large buildings collapse, water supply is totally disrupted and electric supply and telecommunication systems are completely disturbed. Severe tremors due to earthquake result in deformation of ground surface and cause damages to dams resulting in severe floods. The shocks produced by earthquakes in hilly and mountainous areas may cause landslides, which damage the settlements and transport systems on the lower slope segments.

Some Historic Earthquakes

- The earthquake occurred on **May 22, 1960 in Chile** was the largest with the magnitude of 9.5 on Richter scale. It affected 90,000 square miles and killed 6,000 people.
- A devastating earthquake hit **Bhuj town** and its surrounding area in Gujarat on **Jan. 26, 2001.** It caused massive damage to the property and took away lives of 25000 people.
- In **China**, tsunami waves killed 8,30,000 people in 1556 and 50,000 in 1976.
- On **December 26, 2004** tsunami waves hit **Indonesia**, **Sri Lanka** and **India** and killed more than 1 lac people and made several others homeless and jobless.

Mitigation of Earthquakes. Damage to property and life can be minimised by taking following steps :

(*i*) By constructing earthquake resistant buildings by keeping weak spot in houses to absorb vibrations or by making pads or floats beneath the buildings.

(*ii*) By making wooden houses in seismic zones.

During tremors, following measures can be taken to minimise the losses due to an earthquake :

(*i*) People should come out of their houses and stay in the open till the tremors subside.

(*ii*) Those who are already out of the houses should stay away from buildings, electric poles, trees and any tall object that has chances of falling down.

(*iii*) In case there are tremors, when you are in some public building, then you should stay in the corner or near a piller. You should not move about or create chaos, and remain away from heavy objects.

(*iv*) In the event of tremors while you are driving, you should park the vehicle on the roadside and wait in the open till the vibrations subsides.

(*v*) After the subside of tremors, one should inform the Police Control Room, Fire Control Office, Red Cross Office and Non-Government Organisations (NGOs) about the disaster immediately for the help.

(*vi*) The people who are trapped inside the buildings should be evacuated and those injured should be given first aid immediately. The seriously injured persons should be shifted to the nearby hospitals.

The disaster prone areas of our country are shown in Table 5.6.

Table 5.6. Natural Disaster Prone Areas in India

S. No.	*Type of Disaster*	*Disaster Prone Areas*	*Affected Population (in Million)*
1.	Cyclones	Entire 5700 km long coastline of Southern Peninsular India covering 9 States viz. Gujarat, Maharastra, Goa, Karnataka, Kerala, Tamil Nadu, Andhra Pradesh, Orissa and West Bengal and Union Territory of Pondicherry besides Islands of Lakshadweep and Andaman and Nicobar	10
2.	Floods	8 major river valleys spread over 40 million hectares of area in the entire country	260
3.	Drought	Spread in 14 states of Andhra Pradesh, Bihar, Gujarat, Haryana, Jammu & Kashmir, Karnataka, Madhya Pradesh, Maharashtra, Orissa, Rajasthan, Tamil Nadu, Uttar Pradesh, West Bengal and Himachal Pradesh covering a total of 116 districts and 740 blocks	86
4.	Earthquake	Nearly 55% of the total area of the country falling in the seismic zone IV and V.	400
5.	Landslide	Entire sub Himalayan region and Western Ghats	10

DISASTER MANAGEMENT

The natural disaster management involves the following steps :

1. **Relief Measures.** Relief measures should be provided immediately to the disaster victims. The high density areas of the affected locality must be given priority in the remedial and relief measures. Special rescue tools, communication equipments, heavy machines to remove debris, water pumps, cement and technicians are more important than drugs and doctors because the health dangers after a disaster are predominantly environmental in character and not medical. Relief measures should be provided by foreign countries only after they are requested by the affected country because unsolicited and unwanted supplies of men and material create confusion and complicate the problems.

2. **Disaster Predictions.** The predictions of natural hazards may be made on the basis of past history of the area prone to a particular hazard. There should be regular monitoring of the environmental changes caused by human activities to asses the genesis of natural disasters.

3. **Disaster Research.** It include the study of the contributing factors and mechanisms of natural disasters and identification of **terrain risk areas** on the basis of remote sensing, engineering and electronic techniques.

4. **Education.** Disaster education plays a significant role in disaster reduction. It arouse awareness about the hazards of disasters, help the people to improve the standard of constructions to escape the disasters.

5. **Geographic Information Systems and Aerospace Surveys.** These help in natural disaster reduction and management programmes by providing maps of the problem areas, historic informations from local people, a planning framework for local politicians and past experiences of the disasters.

IMPORTANT TERMS

1. **Afforestation.** Plantation of trees to grow new forests.
2. **Acid Rain (Acid Precipitation).** Precipitation of acids like sulphuric acid and nitric acid formed from the gases such as SO_2 and NO_2 in the atmosphere as pollutants.
3. **Biomagnification.** The process of increase in the concentration of a pollutant with increasing trophic level in a food chain.
4. **BOD (Biochemical Oxygen Demand).** The amount of dissolved oxygen needed by microorganisms in decomposing the organic wastes present in water.
5. **Dry Deposition.** Refers to wind blown acidic gases and particles which settle down on the ground.
6. **Earthquake.** A short term vibration of the ground surface, capable of shaking buildings over and causing gaping fissures to open in the ground.
7. **Eutrophication.** The process of nutrient enrichment of water, and consequent loss of species diversity.
8. **Hurricanes.** Cyclonic storms with heavy rains and wind with speed exceeding 119 km/h.
9. **Landslides.** Mass movement of rock or soil down hill.
10. **Oil spills.** Accidental discharge of petroleum in oceans or estuaries from oil tankers, offshore oil mining and oil exploration.
11. **Organic Farming.** Farming involving organic fertilizers and natural pest control, no use of inorganic fertilizers and pesticides.
12. **Photo-Chemical Smog.** A foggy smoke formed as a result of photo-chemical reaction between the products of incomplete combustion of petrol and diesel and oxides of nitrogen. It is composed of O_3, PAN and N_2.
13. **Pollutants.** The substances which cause pollution.
14. **Primary Pollutants.** The pollutants which enter the atmosphere directly from various sources.
15. **Sludge.** Settled solids removed from waste waters.
16. **Smog.** A product of smoke and fog.
17. **Soot.** Black coloured particulate pollutants produced due to incomplete combustion of hydrocarbons.
18. **Secondary Pollutants.** The pollutants which are formed by chemical reactions between primary air pollutants and other atmospheric constituents.
19. **Tectonic Plates.** Huge blocks of earth's crust that slide along slowly.
20. **Tsunamis.** Seismic waves caused by earthquakes travelling through sea water, generating high sea waves.
21. **Wet Deposition.** Refer to acidic water received through rain, fog and snow.

TEST QUESTIONS