

UNIT - 5

ENVIRONMENTAL POLLUTION

For normal and healthy living a conducive environment is required by all the living beings, including humans, livestock, plants, micro-organisms and the wildlife. The favourable unpolluted environment has specific composition. When this composition gets changed by addition of harmful substances, the environment is called polluted environment and the substances polluting it are called **pollutants**. Environmental pollution can, therefore, be defined as **any undesirable change in the physical, chemical or biological characteristics of any component of the environment (air, water, soil), which can cause harmful effects on various forms of life or property**. Environmental pollution could be of various types:

Air pollution: It is an atmospheric condition in which certain substances (including the normal constituents in excess) are present in concentrations which can cause undesirable effects on man and his environment. These substances include gases, particulate matter, radioactive substances etc.

Gaseous pollutants include **oxides of sulphur** (mostly SO_2 , SO_3) **oxides of nitrogen** mostly (NO and NO_2 or NO_x) carbon monoxide (CO), volatile organic compounds (mostly hydrocarbons) etc. “**Particulate pollutants** include smoke, dust, soot, fumes, aerosols, liquid droplets, pollen grains etc.

Radioactive pollutants include Radon-222, iodine-131, strontium-90, plutonium-239 etc.

Sources of air pollution

The sources of air pollution are natural and man-made (anthropogenic).

Natural Sources: The natural sources of air pollution are volcanic eruptions, forest fires, sea salt sprays, biological decay, photochemical oxidation of terpenes, marshes, extraterrestrial bodies, pollen grains of flowers, spores etc. Radioactive minerals present in the earth crust are the sources of radioactivity in the atmosphere.

Man-made Sources: Man made sources include thermal power plants, industrial units, vehicular emissions, fossil fuel burning, agricultural activities etc. Thermal power plants have become the major sources of generating electricity in India as the nuclear power plants couldn't be installed as planned. The main pollutants emitted are fly ash and SO_2 . Metallurgical plants also consume coal and produce similar pollutants. Fertilizer plants, smelters, textile mills, tanneries, refineries, chemical industries, paper and pulp mills are other sources of air pollution.

Automobile exhaust is another major source of air pollution. Automobiles release gases such as carbon monoxide (about 77%), oxides of nitrogen (about 8%) and hydrocarbons (about 14%). Heavy duty diesel vehicles spew more NO_x and suspended particulate matter (SPM) than petrol vehicle which produce more carbon monoxide and hydrocarbons.

Indoor Air Pollution

Many houses in the under-developed and developing countries including India use fuels like coal, dung-cakes, wood, kerosene in their kitchens. Complete combustion of fuel produces carbon dioxide which may not be toxic. However, incomplete combustion produces carbon monoxide. Coal contains varying amounts of sulphur which on burning produces sulphur dioxide. Fossil fuel burning produces black soot. These pollutants i.e. CO , SO_2 , soot and many others like formaldehyde, benzene (α) pyrene (BAP) are toxic and harmful for health. Benzene (α) pyrene is also found in cigarette smoke and is considered to cause cancer. A house wife using wood as fuel for cooking inhales BAP equivalent to 20 packets of cigarette a day. Radioactive Radon (Ra^{222}) causes indoor air pollution in concrete buildings.

Effects of air pollution: Air pollution has adverse effects on living organisms and materials.

Effects on Human Health: Human respiratory system has a number of mechanisms for protection from air pollution (Fig. 5.1). Bigger particles ($> 10 \mu\text{m}$) can be trapped by the hairs and sticky mucus in the lining of the nose. Smaller particles can reach tracheobronchial system and there get trapped in mucus. They are sent back to throat by beating of hair like cilia from where they can be removed by spitting or swallowing. Years of exposure to air pollutants (including cigarette smoke) adversely affect these

natural defenses and can result in lung cancer, asthma, chronic bronchitis and emphysema (damage to air sacs leading to loss of lung elasticity and acute shortness of breath). Suspended particulates can cause damage to lung tissues and diseases like **asthma**, **bronchitis** and **cancer** especially when they bring with them cancer causing or toxic pollutants attached on their surface. Sulphur dioxide (SO_2) causes constriction of respiratory passage and can cause bronchitis like conditions. In the presence of suspended particulates, SO_2 can form acid sulphate particles, which can go deep into the lungs and affect severely.

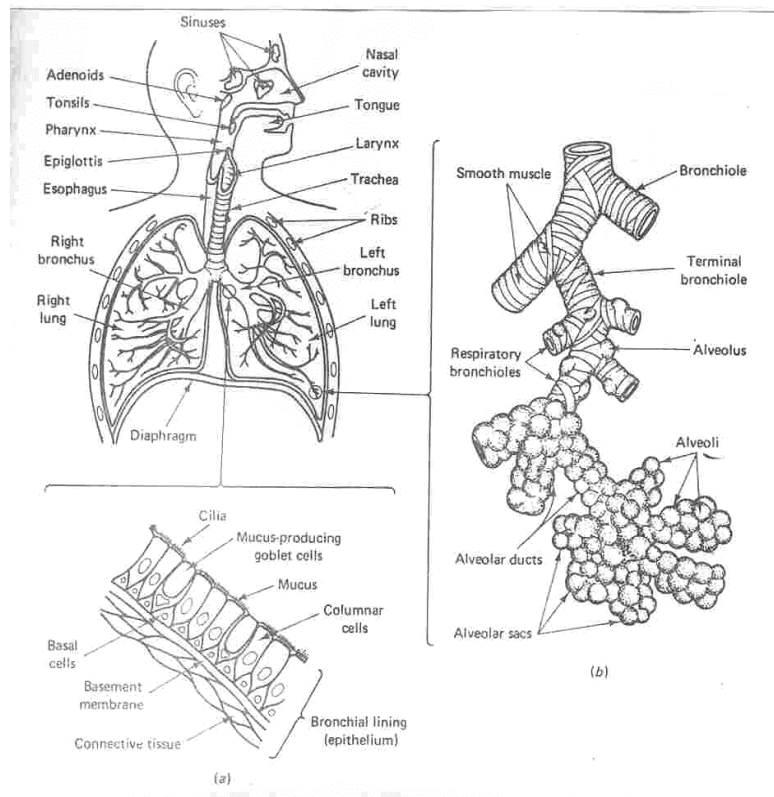


Fig 5.1 (a) Human Respiratory System and cross section of bronchial lining showing cilia (b) Lower part of respiratory system with terminal alveoli

Oxides of nitrogen especially NO_2 can irritate the lungs and cause conditions like chronic bronchitis and emphysema. Carbon monoxide reaches lungs and combines with haemoglobin of blood to form carboxyhaemoglobin. CO has affinity for haemoglobin 210 times more than oxygen. Haemoglobin is, therefore, unable to transport oxygen to various parts of the body. This causes suffocation. Long exposure to CO may cause dizziness, unconsciousness and even death.

Many other air pollutants like benzene (from unleaded petrol), formaldehyde and particulates like polychlorinated biphenyls (PCBs) toxic metals and dioxins (from burning of polythene) can cause mutations, reproductive problems or even cancer.

Effects on Plants: Air pollutants affect plants by entering through stomata (leaf pores through which gases diffuse), destroy chlorophyll and affect photosynthesis. Pollutants also erode waxy coating of the leaves called cuticle. Cuticle prevents excessive water loss and damage from diseases, pests, drought and frost. Damage to leaf structure causes necrosis (dead areas of leaf), Chlorosis (loss or reduction of chlorophyll causing yellowing of leaf) or epinasty (downward curling of leaf), and abscission (dropping of leaves). Particulates deposited on leaves can for incrustations and plug stomata. The damage can result in death of the plant.

Effects on aquatic life: Air pollutants mixing up with rain can cause high acidity (lower pH) in fresh water lakes. This affects aquatic life especially fish. Some of the freshwater lakes have experienced total fish death.

Effects on materials: Because of their corrosiveness, particulates can cause damage to exposed surfaces. Presence of SO_2 and moisture can accelerate corrosion of metallic surfaces. SO_2 can affect fabric, leather, paint, paper, marble and limestone. Ozone in the atmosphere can cause cracking of rubber. Oxides of nitrogen can also cause fading of acetate, cotton and rayon fibres.

Control of Air Pollution

Air pollution can be minimized by the following methods:

- Siting of industries after proper Environmental Impact Assessment studies.

- Using low sulphur coal in industries
- Removing sulphur from coal (by washing or with the help of bacteria)
- Removing NO_x during the combustion process.
- Removing particulate from stack exhaust gases by employing electrostatic precipitators, bag-house filters, cyclone separators, scrubbers etc.
- Vehicular pollution can be checked by regular tune-up of engines, replacement of old, more polluting vehicles, installing catalytic converters, by engine modification to have fuel efficient (lean mixtures) to reduce CO and hydrocarbon emissions and burning fuels slow and cooler to reduce NO_x emission (Honda Technology).
- Using mass transport system, bicycles etc.
- Shifting to less polluting fuels (hydrogen gas).
- Using non-conventional sources of energy.
- By using biological filters and bio-scrubbers.
- By planting more trees.

NOISE POLLUTION

We hear various types of sounds everyday. Sound is mechanical energy from a vibrating source. A type of sound may be pleasant to someone and at the same time unpleasant to others.

The unpleasant and unwanted sound is called noise.

Sound can propagate through a medium like air, liquid or solid. Sound wave is a pressure perturbation in the medium through which sound travels. Sound pressure alternately causes compression and rarefaction. The number of compression and rarefaction of the molecule of medium (i.e. air) in a unit time is described as frequency. It is expressed in Hertz (Hz) and is equal to the number of cycles per second.

There is a wide range of sound pressures, which encounter human ear. Increase in sound pressure does not invoke linear response of human ear. A meaningful logarithmic scale has been devised. The noise measurements are expressed in Sound Pressure Level (**SPL**) which is logarithmic ratio of the sound pressure to a

reference pressure. It is expressed as a dimensionless unit, **decibel (dB)**. The international reference pressure of 2×10^{-5} Pa is the average threshold of hearing for a healthy ear. Decibel scale is a measure of loudness. Noise can affect human ear because of its loudness and frequency (pitch).

The Central Pollution Control Board (CPCB) committee has recommended permissible noise levels for different locations.

NOISE STANDARDS RECOMMENDED BY CPCB COMMITTEE

<i>Area</i>	<i>Noise level (dB)</i>	
	<i>Day</i>	<i>Night</i>
Industrial	75	70
Commercial	65	55
Residential	55	45
Silence Zone	50	40

Sources of Noise Pollution: The main sources of noise are various modes of transportation (like air, road, rail), industrial operations, construction activities and celebrations (emotional and religious, elections etc) electric home appliances.

High levels of noise have been recorded in some of the cities of the world. Noise level of 105 dB have been recorded in Nanjing (China), while in Rome 90 dB, New York 88, Calcutta 85 dB, Mumbai 82 dB, Delhi 80 dB, Kathmandu 75 dB.

Effects of Noise: Noise causes the following effects:

- i) **Interferes with man's communication:** In a noisy area communication is severely affected.
- ii) **Hearing damage:** Noise can cause temporary or permanent hearing loss. It depends on intensity and duration of sound level. Auditory sensitivity is reduced with noise level of over 90 dB in the midhigh frequency for more than a few minutes.

Different sounds and their sound levels on Decibel Scale

	<i>Sound Level (dB)</i>	<i>Source of Sound</i>
	180 -	Rocket engine
	170	
	160	
	150 -	Jet plane take off
Threshold of Pain -	140	
	130 -	Maximum recorded rock music
	120 -	Thunder cap
	110 -	Autohorn 1m away
	100 -	Jet fly over at 300 m, construction work, Newspaper press
	90 -	Motor cycle/8 m away, food blender
	80	
	70 -	Vacuum cleaner, ordinary conversation
	60 -	Air conditioning unit- 6m away, light traffic noise- 30m away
	50 -	Average living room
	40	
	30 -	Library, soft whisper
	20 -	Broadcasting studio
	10 -	Rustling leaf
Threshold of hearing -	0 -	

- iii) **Physiological and Psychological changes:** Continuous exposure to noise affects the functioning of various systems of the body. It may result in hypertension, insomnia (sleeplessness), changes in gastro-intestinal (digestive) activities, peptic ulcers, blood pressure changes, behavioural changes, emotional changes etc.

Control of Noise Pollution

1. Reduction in sources of noise: Sources of noise pollution like heavy vehicles and old vehicles may not be allowed to ply in the populated areas.
2. Noise making machines should be kept in containers with sound absorbing media. The noise path will be interrupted and will not reach the workers.
3. Proper oiling will reduce noise from the machinery.
4. Use of sound absorbing silencers: Silencers can reduce noise by absorbing sound. For this purpose various types of fibrous material could be used.
5. By planting more trees having broad leaves.
6. Through Law: Legislation can ensure that sound production is minimized at various social functions. Unnecessary horn blowing should be restricted especially in vehicle-congested areas.

WATER POLLUTION

Water pollution can be defined as alteration in physical, chemical or biological characteristics of water making it unsuitable for designated use in its natural state.

Sources of water pollution: Water is an essential commodity for survival. We need water for drinking, cooking, bathing, washing, irrigation, and for industrial operations. Most of water for such uses comes from rivers, lakes or groundwater sources. Water has the property to dissolve many substances in it, therefore, it can easily get polluted. Pollution of water can be caused by point sources or non-point sources. Point sources are specific sites near water which directly discharge effluents into them. Major point sources of water pollution are industries, power plants, underground coal mines, offshore oil wells etc. The discharge from non-point sources is not at any particular site, rather, these

sources are scattered and individually or collectively pollute water. Surface run-off from agricultural fields, overflowing small drains, rain water sweeping roads and fields, atmospheric deposition are the non-point sources of water pollution.

Ground water pollution: Ground water forms about 6.2% of the total water available on planet earth and is about 30 times more than surface water (streams, lakes and estuaries). Ground water seems to be less prone to pollution as soil mantle through which water passes helps to retain various contaminants due to cation exchange capacity. However, there are a number of potential sources of ground water pollution. Septic tanks, industry (textile, chemical, tanneries), deep well injection, mining etc. are mainly responsible for ground water pollution, which is irreversible. Ground water pollution with arsenic, fluoride and nitrate are posing serious health hazards.

Surface water pollution: The major sources of surface water pollution are:

1. **Sewage:** Pouring the drains and sewers in fresh water bodies causes water pollution. The problem is severe in cities.
2. **Industrial effluents:** Industrial wastes containing toxic chemicals, acids, alkalis, metallic salts, phenols, cyanides, ammonia, radioactive substances, heat etc. are sources of water pollution.
3. **Synthetic detergents:** Synthetic detergents used in washing and cleaning produces foam and pollute water.
4. **Agrochemicals:** Agrochemicals like fertilizers (containing nitrates and phosphates) and pesticides (insecticides, fungicides, herbicides etc.) washed by rain-water and surface run-off pollute water.
5. **Oil:** Oil spillage into sea-water during drilling and shipment pollute water.
6. **Waste heat:** Waste heat from industrial discharges increases the temperature of water bodies and affects distribution and survival of sensitive species.

EFFECTS OF WATER POLLUTION

Following are some important effects of various types of water pollutants:

Oxygen demanding wastes: Organic matter which reaches water bodies is decomposed by micro-organisms present in water. For this degradation oxygen dissolved in water is consumed. **Dissolved oxygen (D.O.)** is the amount of oxygen dissolved in a given quantity of water at particular temperature and atmospheric pressure. Amount of dissolved oxygen depends on aeration, photosynthetic activity in water, respiration of animals and plants and ambient temperature.

The saturation value of D.O. Varies from 8-15 mg/L. For active fish species (trout and Salmon) 5-8 mg/L of D.O. is required whereas less desirable species like carp can survive of 3.0 mg/L of D.O.

Lower D.O. may be harmful to animals especially fish population. Oxygen depletion (deoxygenation) helps in release of phosphates from bottom sediments and causes eutrophication (excess plant growth).

Nitrogen and Phosphorus Compounds (Nutrients): Addition of compounds containing nitrogen and phosphorus helps in growth of algae and other plants which when die and decay consume oxygen of water. Under anaerobic conditions foul smelling gases are produced. Excess growth or decomposition of plant material will change the concentration of CO_2 which will further change pH of water. Changes in pH, oxygen and temperature will change many physico-chemical characteristics of water.

Pathogens: Many wastewaters especially sewage contain many pathogenic (disease causing) and non-pathogenic micro-organisms and many viruses. Water borne diseases like cholera, dysentery, typhoid, jaundice etc. are spread by water contaminated with sewage.

Toxic Compounds: Pollutants such as heavy metals, pesticides, cyanides and many other organic and inorganic compounds are harmful to aquatic organisms.

The demand of D.O. increases with addition of biodegradable organic matter which is expressed as biological oxygen demand (BOD). BOD is defined as the amount of D.O.

required to aerobically decompose biodegradable organic matter of a given volume of water over a period of 5 days at 20°C. More BOD values of any water sample are associated with poor water quality. “The non-biodegradable toxic compounds **biomagnify** in the food chain and cause toxic affects at various levels of food chain.

Some of these substances like pesticides, methyl mercury etc. move into the bodies of organisms from the medium in which these organisms live. Substances like **DDT** are not water soluble and have affinity for body lipids. These substances tend to accumulate in the organism’s body. This process is called bioaccumulation. The concentration of these toxic substances builds up at successive levels of food chain. This process is called biomagnification. Following is the example of biomagnification of DDT in aquatic food chain-

Component	DDT concentration (ppm)
Birds	10.00
Needle fish	1.0
Minnows	0.1
Zooplankton	0.01
Water	0.000001

Toxic substances polluting water ultimately affect human health. Some heavy metals like lead, mercury and cadmium cause various types of diseases. Mercury dumped into water is transformed into water soluble methyl mercury by bacterial action. Methyl mercury accumulates in fish. In 1953, people in Japan suffered from numbness of body parts, vision and hearing problems and abnormal mental behaviour. This disease called Minamata disease occurred due to consumption of methyl mercury contaminated fish caught from Minamata bay in Japan. The disease claimed 50 lives and permanently paralysed over 700 persons. Pollution by another heavy metal cadmium had caused the disease called Itai-Itai in the people of Japan. The disease was

caused by cadmium contaminated rice. The rice fields were irrigated with effluents of zinc smelters and drainage water from mines. In this disease bones, liver, kidney, lungs, pancreas and thyroid are affected.

Arsenic pollution of ground water in Bangladesh and West Bengal is causing various types of abnormalities.

Nitrate when present in excess in drinking water causes blue baby syndrome or methaemoglobinemia. The disease develops when a part of haemoglobin is converted into non-functional oxidized form. Nitrate in stomach partly gets changed into nitrite which can produce cancer-causing products in the stomach.

Excess of fluoride in drinking water causes defects in teeth and bones.

Pesticides in drinking water ultimately reach humans and are known to cause various health problems. DDT, aldrin, dieldrin etc. have therefore, been banned. Recently, in Andhra Pradesh, people suffered from various abnormalities due to consumption of endosulphan contaminated cashew nuts.

Control of Water Pollution

It is easy to reduce water pollution from point sources by legislation. However, due to absence of defined strategies it becomes difficult to prevent water pollution from non-point sources. The following points may help in reducing water pollution from non-point sources.

- i. Judicious use of agrochemicals like pesticides and fertilizers which will reduce their surface run-off and leaching. Avoid use of these on sloped lands.
- ii. Use of nitrogen fixing plants to supplement the use of fertilizers.
- iii. Adopting integrated pest management to reduce reliance on pesticides.
- iv. Prevent run-off of manure. Divert such run-off to basin for settlement. The nutrient rich water can be used as fertilizer in the fields.

- v. Separate drainage of sewage and rain water should be provided to prevent overflow of sewage with rainwater.
- vi. Planting trees would reduce pollution by sediments and will also prevent soil erosion.

For controlling water pollution from point sources, treatment of wastewater is essential before being discharged. Parameters which are considered for reduction in such water are-

Total solids, biological oxygen demand (BOD), chemical oxygen demand (COD), nitrates and phosphates, oil and grease and toxic metals etc.

Wastewater should be properly treated by primary and secondary treatments to reduce the BOD, COD levels upto the permissible levels for discharge.

Advanced treatment for removal of nitrates and phosphates will prevent eutrophication. Before discharge of wastewater, it should be disinfected to kill disease-causing organisms like bacteria, viruses etc.

Proper chlorination should be done to prevent the formation of chlorinated hydrocarbons or disinfection by ozone or ultraviolet radiations should be done.

THERMAL POLLUTION

Thermal pollution can be defined as presence of waste heat which can cause undesirable changes in the natural environment.

Causes of thermal pollution: Heat producing industries i.e., thermal power plants, nuclear power plants, refineries, steel mills etc. are the major sources of thermal pollution. Power plants utilize only 1/3 of the energy provided by fossil fuels for their operations. Remaining 2/3 is lost in the form of heat generally to cooling water. Cold water, generally, is drawn from some nearby water-body passed through the plant and returned to the same water body with temperature 10-16°C higher than the initial temperature. Excess of heat reaching such water bodies causes thermal pollution of water.

Effects of thermal pollution

- i. The dissolved oxygen content of water is decreased as the solubility of oxygen in water is decreased.

- ii. High temperature becomes barrier for oxygen penetration in deep cold waters.
- iii. Toxicity of pesticides, detergents, chemicals in the effluents increases with increase in temperature.
- iv. The composition of flora and fauna changes because the species sensitive to increased temperature due to thermal shock will be replaced by temperature tolerant species.
- v. Metabolic activities of aquatic organisms increase requiring more oxygen.
- vi. Heated water discharge near shores can disturb spawning and kill young fish.
- vii. Fish migration is affected due to formation of various thermal zones.

Control of Thermal Pollution: The following methods can be employed for control of thermal pollution:

(i) Cooling ponds, (ii) Spray Ponds, (iii) Cooling towers

1. **Cooling Ponds:** Water from condensers is stored in ponds where natural evaporation cools water which can be recirculated or discharged in nearby water body.

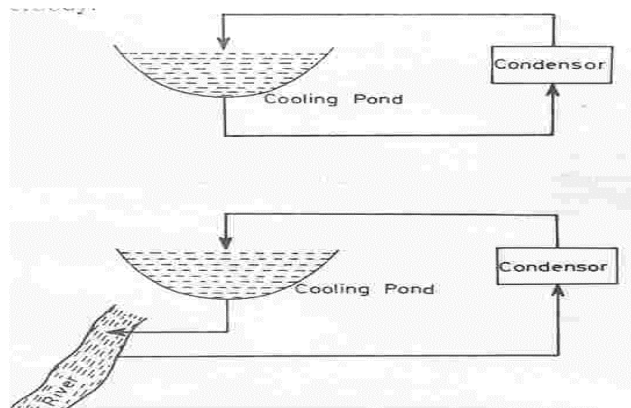


Fig. 5.2: Dissipation of heat by Cooling Ponds.

2. **Spray Towers:** The water from condensers is received in spray ponds. Here the water is sprayed through nozzles where fine droplets are formed. Heat from these fine droplets is dissipated to the atmosphere.

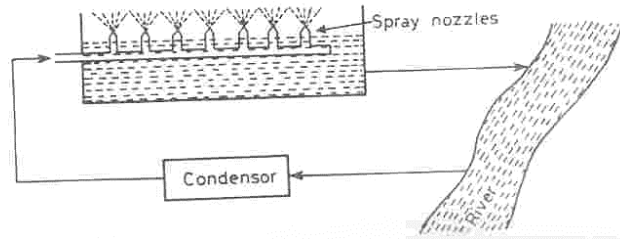


Fig. 5.3: Dissipation of heat by spray towers

3. Cooling Towers:

- (a) Wet cooling tower: Hot water is sprayed over baffles. Cool air entering from sides takes away the heat and cools water. This cool water can be recycled or discharged. Large amount of water is lost through evaporation and in the vicinity of wet cooling tower extensive fog is formed which is not good for environment and causes damage to vegetation.

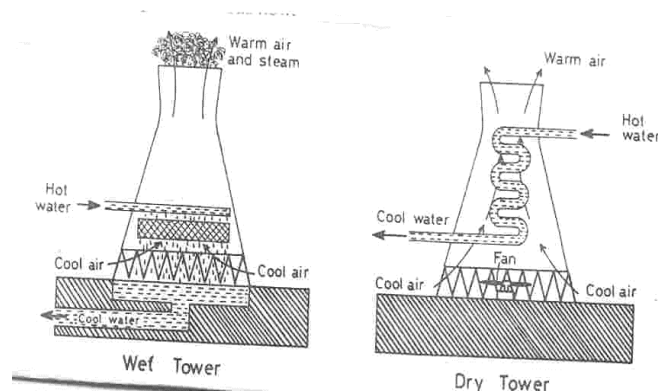


Fig. 5.4: Cooling Towers : Wet and dry.

- (b) Dry cooling tower: The heated water flows in a system of pipes. Air is passed over these hot pipes with fans. There is no water loss in this method and

installation and operation of dry cooling tower is many times higher than wet cooling tower.

MARINE POLLUTION

The main sources of marine pollution are (i) rivers, which bring pollutants from their drainage basins, (ii) Catchment area i.e. coastline where human settlements in the form of hotels, industry, agricultural practices have been established, and (iii) oil drilling and shipment.

Most of the rivers ultimately joint the ocean. The pollutants which these rivers carry from their drainage basin are finally poured in the sea. These include sewage sludge, industrial effluents, synthetic detergents, agrochemicals, solid wastes, plastics, metals, waste heat released by industries as discussed earlier.

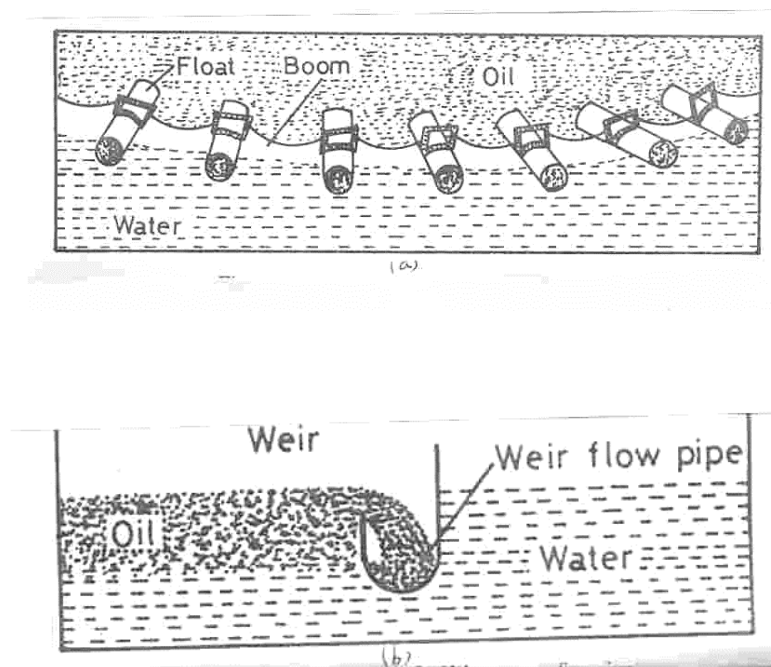


Fig. 5.5: (a) Floating containment barrier (boom); (b) Weirs for removal of oil.

In the sea the pollutants get diluted and as in river water the organic matter is further broken down. Still many pollutants specially recalcitrant ones remain unchanged or partially degraded and cause marine pollution. These pollutants get biomagnified and affect fisheries and other marine life. Another important source of marine pollution is the leaking toxic substances, radioactive wastes etc. which are stored in large containers and dumped in deep sea considering sea to be a better disposal site than land.

Tankers and other shipping means, industries (petroleum refinery, lubricating oil using industry, metal industry, paint industry), automotive wastes, refineries, ship-accidents, off shore production. Tankers transporting oil contribute to oil pollution significantly. After delivering oil through sea-route, earlier the empty tankers used to be filled with water called ballast-water to maintain balance. The ballast-water containing residual oil from tankers was released into the sea on completion of return journey. Now-a-days the oil floating on the ballast water is removed in the newly designed 'load-on-top-tankers' before ballast-water is let-off.

Oil in sea water can spread over a large area of the sea, remain dispersed or get adsorbed on sediments. It can cause adverse effects on marine life.

Oil in the sea water affects sensitive flora and fauna. Phytoplankton, zooplankton, algal species, various species of invertebrates, coral reefs, fish, birds and mammals are affected by oil pollution. Fishes show mortality (death) because the fish gills get laden with oil after the slimy mucus of gills is affected. Oil disrupts the insulating capacity of feathers. Death occurs due to loss of buoyancy and subsequent drowning of birds. Leakage from oil tanker near Alaska in 1989 caused damage to coral reefs and resulted in death of about 390 thousand birds. Some important cases of bird mortality due to oil are at Brittany, France where 20 thousand birds died due to more than 220 tonnes of oil spillage in 1978. At Elbe, Germany 500 thousands birds died in 1955. During the 1991 Gulf War 200 million gallons of oil spread in the Persian Gulf badly affecting marine ecosystem.

Control of marine pollution

- i. Toxic pollutants from industries and sewage treatment plants should not be discharged in coastal waters.
- ii. Run off from non-point sources should be prevented to reach coastal areas.
- iii. Sewer overflows should be prevented by having separate sewer and rain water pipes.
- iv. Dumping of toxic, hazardous and sewage sludge should be banned.
- v. Developmental activities on coastal areas should be minimized.
- vi. Oils and greases from service stations should be reprocessed for reuse.
- vii. Oil ballast should not be dumped into sea.
- viii. Protecting ecologically sensitive coastal areas by not allowing drilling.

SOIL POLLUTION

Soil is the upper layer of the earth crust which is formed by weathering of rocks. Organic matter in the soil makes it suitable for living organisms. Dumping of various types of materials especially domestic and industrial wastes causes soil pollution. Domestic wastes include garbage, rubbish material like glass, plastics, metallic cans, paper, fibres, cloth rags, containers, paints, varnishes etc. Leachates from dumping sites and sewage tanks are harmful and toxic.

Industrial wastes are the effluents discharged from chemical industries, paper and pulp mills, tanneries, textile mills, steel industries, distilleries, refineries, pesticides and fertilizer industries, pharmaceutical industries, food processing industries, cement industries, thermal and nuclear power plants, mining industries etc. Thermal power plants generate a large quantity of 'Fly ash'.

Pesticides are used to kill pests that damage crops. These pesticides ultimately reach soil and persist there for a long time. Pesticides which are persistent are chlorinated hydrocarbon

insecticides e.g. DDT, HCH, endrin, lindane, heptachlor, endosulfan etc.

Industrial wastes contain organic and inorganic compounds some of which are refractory and non-biodegradable. Industrial sludge may contain various salts, toxic substances, metals like mercury, lead, cadmium, arsenic etc. Agrochemicals released with the wastes of pesticide and fertilizer factories or during agricultural practices reach the soil and pollute it.

Soil also receives excreta from animals and humans. The sewage sludge contains many pathogenic organisms, bacteria, viruses and intestinal worms which cause pollution in the soil.

The sources of radioactive substances in soil are explosion of radioactive devices, radioactive wastes discharged from industries and laboratories, aerial fall-out etc. Isotopes of radium, uranium thorium, strontium, iodine, caesium and of many other elements reach soil and persist there for a long time and keep on emitting radiations.

Effects of Soil Pollution

Sewage and industrial effluents which pollute soil ultimately affect human health. Various types of chemicals like acids, alkali, pesticides, insecticides, weedicides, fungicides, heavy metals etc. in the industrial discharges affect soil fertility by causing changes in physical, chemical characteristics and biological properties.

Some of the persistent toxic chemicals inhibit the non-target organisms, soil flora and fauna and reduce soil productivity. These chemical accumulate in food chain and ultimately affect human health. Indiscriminate use of pesticides specially is a matter of concern.

Sewage sludge has many types of bacteria, viruses, intestinal worms which may cause various types of diseases. Decomposing organic matter in soil produces toxic vapours.

Radioactive fallout on vegetation is the source of radio-isotopes which enter the food chain in the grazing animals. Some of these radio isotopes replace essential elements in the body and cause abnormalities e.g. strontium-90 instead of calcium gets deposited in the bones and tissues. The bones become brittle and prone to fracture.

Radio isotopes which attach with the clay become a source of radiations in the environment.

Nitrogen and phosphorus from the fertilizers in soil reach nearby water bodies with agricultural run-off and cause eutrophication. Chemicals or their degradation products from soil may percolate and contaminate ground-water resources.

Control of Soil Pollution:

- i. Effluents should be properly treated before discharging them on the soil.
- ii. Solid wastes should be properly collected and disposed off by appropriate method.
- iii. From the wastes, recovery of useful products should be done.
- iv. Biodegradable organic waste should be used for generation of biogas.
- v. Cattle dung is used for methane generation. Night-soil (human faeces) is also used in the biogas plant to produce inflammable methane gas.
- vi. Microbial degradation of biodegradable substances is also one of the scientific approaches for reducing soil pollution.

NUCLEAR HAZARDS

Radioactive substances are present in nature. They undergo natural radioactive decay in which unstable isotopes spontaneously give out fast moving particles, high energy radiation or both at a fixed rate until a new stable isotope is formed.

The isotopes release energy either in the form of gamma ray (high energy electromagnetic radiation) or ionization particles i.e. alpha particles and beta particles. The alpha particles are fast moving positively charged whereas beta particles are high speed electrons. All these ionization radiations have considerably variable penetration power. Alpha particles can be interrupted by a sheet of paper while beta particle can be blocked by a piece of wood or a few millimeter of aluminium sheet. The gamma rays can pass through paper, wood but can be stopped by concrete wall, lead slabs, or water.

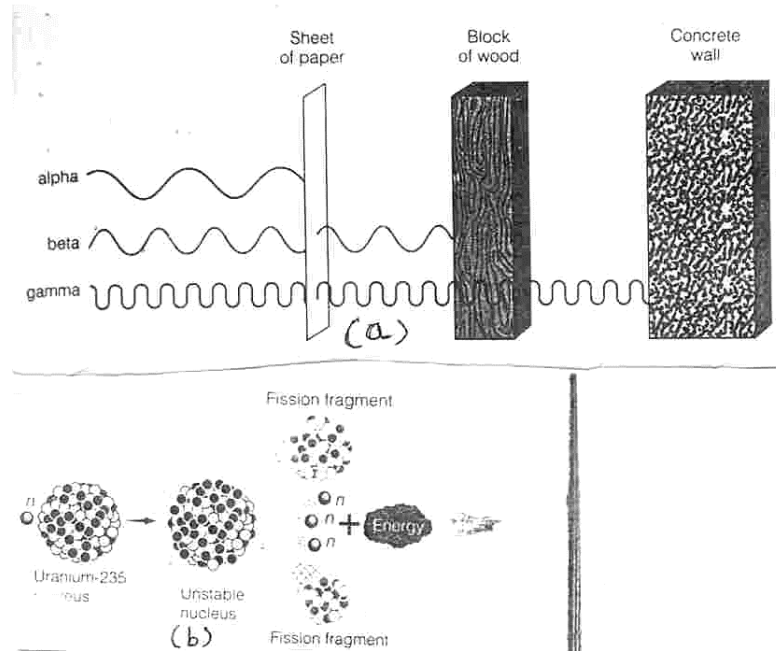


Fig. 5.6: (a) Variable penetration power of ionisation radiations emitted by radio isotopes; (b) Neutron (n) triggered fission of uranium-235.

Sources of Radio activity

Various sources of radioactivity can be grouped into (i) Natural sources (ii) Anthropogenic (man made) sources of radioactivity.

- i) **Natural Sources:** Sources of natural ionization include cosmic rays from outer space, radioactive radon-222, soil, rocks, air, water and food.
- ii) **Anthropogenic sources:** These sources are nuclear power plants, nuclear accidents, x-rays, diagnostic kits, test laboratories.

Effects of Radiations : Ionisation radiations can affect by causing

(i) genetic damage (ii) Somatic damage

- i) **Genetic Damage** is caused by radiations by causing mutations in DNA and affecting genes and chromosomes.

Damage is seen in the offsprings and may be transmitted upto several generations.

- ii) **Somatic Damage** includes burns, miscarriages, eye cataract, cancer (bone, thyroid, breast, lungs and skin).

Scientists think that due to the body's ability to repair some of the damage only, radiations show effects beyond a threshold level. However, the other group believes that even the small dose over a period of time may cause adverse effects. They believe that the permissible limits should be further reduced.

Damage caused by different types of radiations depends on penetration power and source (inside or outside the body). Alpha particles lack penetration power but they have more energy than beta. They will be therefore, dangerous when they enter the body by inhalation or through food. Alpha particles can not penetrate skin to reach internal organs whereas beta particles can damage the internal organs. Greater threat is posed by radioisotopes with intermediate half lives as they have long time to find entry in the human body.

Radioisotopes which enter the environment during mining of uranium, the radioactivity in the earth's crust enters crops grown there and ultimately in human beings. Radionuclides enter water on its coming in contact with the soil or rock.

I^{131} (labeled iodine) accumulates in thyroid gland and causes cancer. Similarly strontium – 90 accumulates in the bones and causes leukemia (cancer of bone marrow).

Control of nuclear pollution

- i) Siting of nuclear power plants should be carefully done after studying long term and short term effects.
- ii) Proper disposal of wastes from laboratory involving the use of radioisotopes be done.

SOLID WASTE MANAGEMENT

Higher standards of living of ever increasing population has resulted in an increase in the quantity and variety of waste generated. It is now realized that if waste generation continues indiscriminately then very soon it would be beyond rectification. Therefore, solid waste management becomes important in order to minimize the adverse effects of solid wastes. Solid waste (waste

other than liquid or air) can be classified as municipal, industrial, agricultural, medical, mining and sewage sludge.

Sources of Urban and Industrial Wastes

Urban waste consists of medical waste from hospitals; municipal solid wastes from homes, offices, markets (Commercial waste) small cottage units, and horticulture waste from parks/gardens.

- **Waste from homes (Domestic waste)** contains a variety of discarded materials like polyethylene bags, empty metal and aluminium cans, scrap metals, glass bottles, waste paper, diapers, cloth/rags, food waste, etc.
- **Wastes from shops** mainly consist of waste paper, packaging material, cans, bottles, polyethylene bags, peanut shells, eggshells, tea leaves etc.
- **Biomedical wastes** includes anatomical wastes, pathological wastes, infectious wastes etc.
- **Construction/demolition waste** includes debris and rubbles, wood, concrete.
- **Horticulture waste leaves and waste from slaughter houses** include remains of slaughtered animals and vegetable residues etc.

Some of these solid urban waste materials that can be degraded by micro-organisms are called **biodegradable wastes**. Examples of this type of waste are vegetable wastes, stale food, tea leaves, egg shells, peanut shells, dry leaves etc. Wastes that can not be degraded by micro-organisms are called **non-biodegradable wastes**. For example, polyethylene bags, scrap metal, glass bottles etc.

- **Industrial waste-** Industrial waste consists of a large number of materials including factory rubbish, packaging material, organic wastes, acids alkalis and metals etc. During some industrial processing large quantities of hazardous and toxic materials are also produced. The main sources of industrial wastes are chemical industries, metal and mineral processing industries. Radioactive wastes are generated by nuclear power plants. Thermal power plants produce fly ash in large quantities. Solid wastes from other types of industries include

scrap metal, rubber, plastic, paper, glass, wood, oils, paints, asphalt, tars, dyes, scrap leather, ceramics, abrasives, slag, heavy metals, asbestos, batteries. In Europe and North America the environmental laws and safety law are becoming more stringent due to which disposal of hazardous wastes is becoming a problem. Cost of disposal of such waste is increasing. Therefore, these wastes are being exported to developing countries who do not have sufficient knowledge or technique for their disposal.

Effects of Solid Wastes

Municipal solid wastes heaps up on the roads due to improper disposal system. People clean their own houses and litter their immediate surroundings which affects the community including themselves. This type of dumping allows biodegradable materials to decompose under uncontrolled, and unhygienic conditions. This produces foul smell, breeds various types of insects, becomes source of infectious organisms, besides spoiling the aesthetics of the site.

Industrial solid wastes are sources of toxic metals, hazardous wastes which may spread on land and can cause changes in physico-chemical and biological characteristics thereby affecting productivity of soils. Toxic substances may leach/percolate to contaminate ground water.

In refuse mixing the hazardous wastes are mixed with garbage and other combustible waste. This makes segregation and disposal all the more difficult and risky. Various types of wastes like cans, pesticides, cleaning solvents, batteries (zinc, lead or mercury) radioactive materials, plastics are mixed up with paper, scraps and other non-toxic materials which could be recycled. Burning of some of these materials produce dioxins, furans and polychlorinated biphenyls, which have the potential to cause various types of ailments including cancer.

Management of Solid Waste: For wastes management we stress on ‘three R’s’—Reduce, reuse and recycle before destruction and safe storage 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 less production of waste.

2. **Reuse of waste materials:** The refillable containers which are discarded after use can be reused. Villagers make casseroles, silos from waste paper and other waste materials. Making rubber rings from the discarded cycle tubes which are used by the newspaper vendors, instead of rubber bands thereby decreasing the waste generation during manufacturing of rubber bands. Because of financial constraints poor people reuse their materials to the maximum.
3. **Recycling of materials:** Recycling is the reprocessing of discarded materials into new useful products.
 - i. Formation of some old type products e.g. old aluminium cans and glass bottles are melted and recast into new cans and bottles.
 - ii. Formation of new products: Preparation of cellulose insulation from paper, preparation of fuel pellets from kitchen waste. Preparation of automobiles and construction materials from steel cans.

The process of reducing, reusing and recycling saves money, energy, raw materials, land space and also reduces 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 from ores and prevent pollution.

For discarding wastes the following methods can be adopted:

1. **Sanitary landfill:** In a sanitary landfill, garbage is spread out in thin layers, compacted and covered with clay or plastic foam.

In the modern landfills the bottom is covered with an impermeable liner, usually several layers of clay, thick plastic and sand. The liner protects the ground water from being contaminated due to percolation of leachate. Leachate from bottom is pumped and sent for treatment. When landfill is full it is covered with clay, sand, gravel and top soil to prevent seepage of

water. Several wells are drilled near the landfill site to monitor if any leakage is contaminating ground water. Methane produced by anaerobic decomposition is collected and burnt to produce electricity or heat.

Composting: Due to shortage of space for landfill in bigger cities, the biodegradable yard waste (keep separate from the municipal waste) is allowed to degrade/decompose in oxygen rich medium. A good quality nutrient rich environmental friendly manure is formed which improves the soil conditions and fertility.

Incineration: Incinerators are burning plants capable of burning a large amount of materials at high temperature. The initial cost is very high. During incineration high levels of dioxins, furans, lead and cadmium may be emitted with the fly ash of incinerator. Dioxin level may reach many times more than in that environment. For incineration of materials, it is better to remove batteries containing heavy metals and plastic containing chlorine before burning the material. Removal of plastics will reduce dioxins and polychlorinated biphenyls (PCBs)

Role of individual in prevention of pollution

The role of every individual in preventing pollution is of paramount importance because if every individual contributes substantially the effect will be visible not only at the community, city, state or national level but also at the international level as environment has no boundaries. It is the responsibility of the human race which has occupied the commanding position to protect the earth and provide conducive environment for itself and innumerable other species which evolved on this earth. A small effort made by each individual will have pronounced effect at the global level. This justifies the proverb- “Think globally act locally”.

Each individual should change his/her life style in such a way so as to reduce environmental pollution. It can be done by following some of the following suggestions.

- Help in pollution prevention more than pollution control.
- Use ecofriendly products.
- Cut down the use of chlorofluorocarbons (CFC) as these destroy ozone layer. Do not use polystyrene cups that have

chlorofluorocarbon (CFC) molecules in them which destroy ozone layer.

- Use the chemicals derived from peaches and plums to clean computer chips and circuit boards instead of CFCs.
- Use CFC free refrigerators.

The manufacture and operation of such devices that don't pollute should be encouraged. If they cost more then their higher prices may be offset by including environmental, the social costs of pollution in the price of such products which pollute environment.

Air pollution can be prevented by using really clean fuel i.e. hydrogen fuel. Hydrogen for that matter should not be produced by passing current in water as for generation of this current, again the environment will be polluted. So solar powered hydrogen fuel is the need of the hour.

- Reduction in the dependency on fossil fuel especially coal or oil.
- Save electricity by not wasting it when not required because electricity saved is electricity generated without polluting environment. Put on warm cloths than switching on a heater.
- Adopt and popularize renewable energy sources.
- Improve energy efficiency. This will reduce the amount of waste energy, i.e. more is achieved with less energy.
- Increase reuse, recycling, and reduce the production of wastes.
- Use mass transport system. For short-visits use bicycle or go on foot. Decrease the use of automobiles.
- Use pesticides when only absolutely necessary and that too in right amounts. Wherever possible alternate pest control methods (biological control) should be used.
- Use rechargeable batteries. Rechargeable batteries will reduce metal pollution.
- Use less hazardous chemicals wherever possible. Baking soda, vinegar and borax can help in cleaning and cloth

bleaching and softening. Baking soda can replace modern deodorants.

- The solid waste generated during one manufacturing process can be used as a raw material for some other processes.
- Use low phosphate or phosphate-free or biodegradable dish washing liquid, laundry detergent and shampoo. This will reduce eutrophication of water bodies.
- Use organic manure instead of commercial inorganic fertilizers.
- Do not put pesticides, paints, solvents, oils or other harmful chemicals into the drain or ground water.
- Use only the minimum required amount of water for various activities. This will prevent fresh water from pollution.
- When building a home, save (don't cut) as many as possible trees in the area.
- Plant more trees.
- Check population growth.

POLLUTION CASE STUDIES

Air Pollution Episodes: A series of air pollution disasters from Meuse Valley, Belgium (1930) to Chernobyl nuclear disaster in the erstwhile USSR (1986) have occurred. Some of the important ones are given below-

1. **Donora air pollution disaster:** Donora of Pennsylvania (in USA) is a small mill town dominated by steel mill, zinc smelter and sulphuric acid plant. A four day fog occurred from October 25-31, 1948. Due to anticyclonic weather conditions there was no air movements and temperature inversion had set in due to sea breeze conditions. Donora lies in a horse shoe shaped valley on the Monongahela river, south of Pittsburgh with steep rising hills on each side of the river.

Fog which formed due to accumulation of cold air at the bottom of river valley persisted for 4 consecutive days.

This condition, when cold layer is trapped below the warm layer, is called inversion. The top fog layer reflected solar radiations during day time. So the heat received by the valley was not sufficient to break the inversion. During night time the top layer had been losing heat and further cooling the layer to stabilize. Wind speed in the inversion layer was also slow. The deadly pollutants emitted by steel mill, zinc smelter and sulphuric acid plant got trapped and concentrated in the stable weather conditions of the valley and remained there for four days. About 6000 of town's 14,000 inhabitants fell ill. Twenty of them died.

2. **The Bhopal Gas Tragedy:** The world's worst industrial accident occurred in **Bhopal, M.P.**, India on the night of 2nd and morning of **3rd December, 1984**. It happened at Union Carbide Company which used to manufacture Carbaryl (Carbamate) pesticide using Methyl isocyanate (MIC). When water accidentally entered the tank, it caused reaction mixture to overheat and explode because its cooling system failed. Other safety devices also did not work or were not in the working condition. Forty tons of MIC leaked into the atmosphere which may have contained 40 kg of phosgene as an impurity. MIC gas at lower concentrations affects lungs, eyes, skin and causes irritation in the skin. Higher amounts remove oxygen from lungs and cause death. In the winter night there were fog like clouds over south and east of the plant. The gas spread over 40 km². About 5100 persons were killed (2600 due to direct exposure to MIC and other 2500 due to after-effects of exposure) according to Indian officials. About 2,50,000 persons got exposed to MIC. 65,000 suffered from severe eye, respiratory, neuromuscular, gastrointestinal, gynecological disorders. About 1000 persons became blind. Without counting the damage of human lives, it cost about \$ 570 million in clean up and damage settlement. This tragedy could have been averted had the company spent about \$ 1 million on safety improvement.

The Love Canal Tragedy

The Love canal tragedy occurred in a suburb of **Niagara Falls, New York**. A love canal was built by William Love which was dug up and was used to dump sealed steel drums of chemical

wastes by Hooker Chemicals and Plastics Corporation between 1942-1953. In 1953, the dump site was covered with clay and topsoil by the company and was sold to the city Board of Education which built an elementary school on that site. Houses were also built near the school. In 1976, the residents started complaining of foul smell. Children playing in the canal area received chemical burns.

In 1977, the corroded steel containers started leaking the chemicals into storm sewers, basement of homes and the school playground. About 26 toxic organic compounds were identified. The dump site was covered with clay and the leaking wastes were pumped to new treatment plant. The affected families were relocated.

There could be many more dump sites similar to Love canal especially in the third world countries. Who knows what amount of harm such dump sites are causing to the underground aquifers?

Chernobyl Nuclear Disaster

Chernobyl nuclear accident is the worst nuclear disaster in the history which occurred at Chernobyl, Ukraine in the erstwhile USSR (now CIS). On **26 April, 1986** the accident occurred at reactor of the Chernobyl power plant designed to produce 1000 MW electrical energy. The reactor had been working continuously for 2 years. It was shut down on April 25, 1986 for intermediate repairs. This period coincided with the period when people including the top executives were busy in preparation for national holiday, The May Day. Due to faulty operations of shutting down the plant, an explosion occurred in the reactor at 01.23 hrs. on April 26, 1986. Three seconds later another explosion occurred.

The explosion was so severe that the 1000 tonne steel concrete lid of reactor 4 blew off. Fire started at the reactor due to combustion of graphite rods. The reactor temperature soared to more than 2000°C. Fuel and radioactive debris spew out in a volcanic cloud of molten mass of the core and the gases. The debris and gases drifted over most of the northern hemisphere. Poland, Denmark, Sweden, Norway were affected.

On first day of the accident 31 persons died and 239 people were hospitalized. Since the plume was rich in Iodine-131, Cesium-134 and Cesium-137, it was feared that some of the 576000 exposed people would suffer from cancer specially thyroid cancer and leukemia. Children were more susceptible as Iodine-131 is ingested mainly through milk and milk products. Since children consume more milk and their thyroid glands are in the growing stage, an increase in thyroid cancer in children from areas near Chernobyl was registered. More than 2000 people died. People suffered from ulcerating skin, loss of hair, nausea, anemia.

Agriculture produce was damaged for years, intense radiations killed several fields, trees, shrubs, plants etc. Sweden and Denmark banned Russian produce. Flora and fauna were destroyed. Blood abnormalities, hemorrhagic diseases, changes in lungs, eye diseases, cataract, reproductive failure and cancer cases increased.

The nuclear energy is cheap, inexhaustible and non-polluting source of energy. However, in the absence of proper care and caution, disasters like Chernobyl can rock the society.

DISASTER MANAGEMENT

Geological processes like earthquakes, volcanoes, floods and landslides are the normal events which have resulted in the formation of the earth that we have today. They are, however, feared as they result in severe consequences when they affect human population. Humans have witnessed many such natural hazards and have tried to learn to control these processes.

Earthquakes: Earthquakes occur due to sudden movements of earth's crust. The earth's crust have several tectonic plates of solid rock which slowly move along their boundaries. When friction prevents these plates from slipping, stress builds up and results in sudden fractures which can occur along the boundaries of the plates or fault lines (planes of weakness) within the plates. This causes earthquakes, (the violent, short-term vibrations in the earth). The point on a fault at which the first movement occurs during an earthquake is called the epicenter. The severity of an earthquake is generally measured by its magnitude on Richter Scale.

<i>Richter Scale</i>	<i>Severity of earthquake</i>
Less than 4	Insignificant
4 - 4.9	Minor
5 – 5.9	Damaging
6 - 6.9	Destructive
7 – 7.9	Major
More than 8	Great

The largest earthquake ever recorded occurred on May 22, 1960 in Chile with the estimated magnitude of 9.5 on Richter Scale, affecting 90,000 square miles and killing 6,000 people.

Earthquakes that hit various parts of our country with the magnitude on Richter Scale are given below.

The devastating earthquake which hit Bhuj Town in Gujarat had cause devastation killing 20,000-30,000 people and left many injured. It had an energy equivalent to a 5.3 megaton hydrogen bomb.

Earthquake-generated water waves (may also be generated by volcanic eruptions) called tsunamis can severely affect coastal areas. These giant sea swells can move at a speed upto 1000 km/hr or faster. When approaching sea shore may often reach 15m or more (upto 65 m) and cause devastation in coastal areas. In China it killed 8,30,000 people in 1556 and 50,000 in 1976.

Human activities called seismic activities can also cause or increase earthquake activities. These activities may cause minor earthquakes. Three such identified activities include.

- a) Added load of water in lake behind dam.
- b) Under ground nuclear testing.
- c) Deep well disposal of liquid waste.

Damage to property and casualties can be prevented by constructing building in the earthquake prone zones which can withstand tremors. The structures can be heavily reinforced. Strategically placing weak spots in the building that can absorb vibrations from the rest of the building. To have pads or floats beneath the building on which it can shift harmlessly with ground motion. Wooden houses are preferred in earthquake prone areas.

Floods

Generally, the stream channels accommodate average maximum stream flow. However, due to heavy rains or sudden snow melt the quantity of water in streams exceeds their capacity and water overflows the banks and causes inundation of the surrounding land. This situation is called flood.

A flood generally doesn't damage property or cause casualties as compared to other natural disasters. However, it causes a great economic loss as it causes widespread contamination. Virtually anything the flood water touches gets contaminated.

The main reasons of increasing severity and frequency of floods are human activities. Constructing roads, parking space and buildings cover earth's surface and doesn't allow infiltration of water into the soil. This speeds up the runoff. Clearing forests for agriculture also increases floods.

In India, Uttar Pradesh is considered to be among the worst flood hit states of the country. It has nearly 20% of the total 40 million hectares of flood prone zone in the country.

Flood plains, the low lying areas which get inundated during floods help to reduce floods. With the building up of the flood control structures like building of flood walls, deepening of river channels just transfers the problems downstream. Building walls prevents spilling out the flood water over flood plains. Rather it increases the velocity of water to affect the areas downstream with force.

To check floods, many people are of the opinion that money should be spent to restore wetlands, replace ground cover on water-courses, build check-dams on small streams, move buildings off the flood plains etc. Instead of raising buildings on flood plains, it is suggested that floodplains should be used for wildlife habitat, parks, recreational areas and other uses, which are not susceptible to flood damage.

Landslides

Landslide occurs when coherent rock or soil masses move downslope due to gravitation pull. Slow landslips don't cause much worry but sudden rockslides and mudslides are dangerous.

Water and vegetation influence landslides. Chemical action of water gradually cause chemical weathering of rock making it prone to landslides. Vegetation consolidates the slope material, provides cohesion by its root system also retards the flow of water and its erosion capacity.

However, this can be masked by many other exerting factors like:

- i) Earthquakes, vibration etc.
- ii) Disturbances in resistant rock overlying rock of low resistance.
- iii) Saturation with water of the unconsolidated sediments.
- iv) Unconsolidated sediments exposed by logging road or house building.

Landslides are governed by the forces which tend to pull earth material down slope (move in case of slopes with steeper slip plane) and resisting forces which tend to resist such movements.

It is difficult to control landslides. However these can be minimized by stabilizing the slope by:

- i) Draining the surface & subsurface water.
- ii) Providing slope support like gabions (wired stone blocks)
- iii) Concrete – support at the base of a slope.

Cyclones

Cyclones are recurring phenomena in the tropical coastal regions. Tropical cyclones in the warm oceans are formed because of heat and moisture. One of the requirements for formation of tropical cyclones is that the sea surface temperature (SST) should be above 26°C. Tropical cyclones move like a spinning top at the speed of 10-30 km per hour. They can last for a week or so and have a diameter varying between 100 to 1500 km. Since in the western parts of the main ocean no cold currents exist, tropical cyclones originate there. Tropical cyclones are called **hurricanes** in the Atlantic, **Caribbean** and north eastern Pacific, **typhoons** in the western Pacific; **'cyclones'** in the Indian Ocean and **'willy willies'** in the sea around Australia.

More storms form in the Bay of Bengal than in the Arabian Sea. Of 5-6 storms that forms in the year about half of them are severe. Hurricane winds (74 miles per hour or more) rains and storm surge (often 50-100 miles wide dome of water) often devastate the area where it strikes on land. The devastation is more when storm surge and normal astronomical tide coincide. Sea water with combined force rushes inlands and inundates the low lying areas.

Management: It is difficult to stop the recurrence of cyclones. Some long term defence measures can help to protect us from devastation. Such measures include, planting more trees on the coastal belt, construction of dams, dykes, embankments, storm shelter, wind breaks, proper drainage, wide roads for quick evacuation.