UNIT 5: ENVIRONMENTAL POLLUTION

Man has been exploiting the natural resources from down of his civilization, but the exploitation has accelerated at a very high rate since the advent of modern technological civilization i.e. the **industrial revolution**. Population explosion, dramatic increase in per capita resource demand, industrialization, urbanization and concomitant changes in land use are the determinants widening the gap between exploitation and replenishment. Consequences of these trends lead to deterioration of environmental quality, level of biological productivity, utility potential, etc. Atmosphere, hydrosphere and lithosphere are utilized as resource as well as medium for discharge of waste products, which upset the normal functioning of these vital components at varying degrees, and run the risk of inducing irreversible ecological changes. **Pollution** is an undesirable change in physical, chemical or biological characteristics of our air, land or water caused by excessive accumulation of **pollutants** (substances causing pollution). These changes will waste or deteriorate our raw-material resources and the environment. Pollution adversely affects biological species including humans and damages our industrial processes, living conditions and cultural assets.

KINDS OF POLLUTION

Pollution can be classified in many ways. On the basis of part of environment where it occurs most (atmosphere, hydrosphere and lithosphere), it can be classified as **air pollution, water pollution** and **soil pollution**. Or in terms of origin, pollution may be **natural** (e.g. volcanic eruptions which add tons of toxic gases and particulate matter in the environment) or **anthropogenic** (man-made, such as industrial pollution, agricultural pollution, etc.). According to the physical nature of the pollutants, the categories include: gases, particulate matter, temperature, noise, radioactivity, etc. These categories can be named as **gaseous pollution, dust pollution, thermal pollution, noise pollution, radioactive pollution**, etc.

From the ecosystem viewpoint, pollutants can be categorized into **non-biodegradable** and **biodegradable** pollutants. Non-biodegradable materials such as chlorinated hydrocarbon pesticides (dichloro diphenyl trichloro ethane or DDT, benzene hexachloride or BHC, etc.), waste plastic bottles, polyethylene bags, used soft-drink cans,

etc. are either not degraded or degraded only very slowly by decomposers in the nature. Therefore, 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.

Biodegradable pollutants such as market garbage, livestock wastes, municipal sewage, etc., on the other hand, can be decomposed efficiently by the decomposers. Therefore, biodegradable pollutants are easily manageable by natural processes or in engineered systems such as the waste treatment plants. If managed properly, biodegradable wastes can be turned into useful resources.

AIR POLLUTION

Degradation of air quality and natural atmospheric conditions constitutes air pollution. Air pollution is defined as the presence of one or more contaminants such a dust, gas, mist, odour, smoke, smog or vapour in the atmosphere, in quantities, of characteristics, and of duration so as to be injurious to human, plant or animal life or to property or which unreasonably interferes with the comfortable enjoyment of life and property.

Causes, Types and Effects

Air pollution may be personal, occupational or at community level. The exposure of an individual to air pollutants due to ones own activity is regarded **personal**. The exposure of an individual to potentially hazardous concentrations of air pollutants in his working environment is known as **occupational** air pollution. The **community** air pollution is not only caused by variety of sources and contaminants and affects many individuals, but can also exert a significant impact on individual's total environment including plants, animals, buildings and property.

An air pollutant may be a gas, liquid or particulate matter (i.e., suspended aerosols composed of solids and liquids). Concentrations of atmospheric pollutants depend mainly on the total mass emitted into the atmosphere, and the atmospheric conditions that affect their fate and transport. Most of the air we breathe is elemental oxygen ($O_{2)}$ and nitrogen ($N_{2)}$. About 1% is composed of other constituents such as carbon dioxide ($CO_{2)}$ and water vapour. A small part of this 1% may, however, be air pollutants. Even such a small concentration may be extremely harmful to life and property.

Natural sources of air pollution include pollen, marsh gases, dust and smoke (from forest fires and volcanic ash) emitted into the atmosphere. Anthropogenic air pollutants enter the atmosphere from stationary and mobile sources. **Stationary sources** include large factories, electrical power plants, mineral smelters, petroleum refineries and different small-scale industries, while **mobile sources** include all sorts of transport vehicles moving by road, rail or air.

Air pollutants can be classified into two categories, *viz*., **primary** and **secondary** air pollutants. Primary pollutants enter the atmosphere directly from various sources. Secondary pollutants are formed during chemical reactions between primary air pollutants and other atmospheric constituents, such as solar radiation and water vapour.

Primary Air Pollutants and Their Effects

Amongst the primary air pollutants most important are particulate matter, carbon monoxide (CO), hydrocarbons (HCs), sulphur dioxide (SO_2), nitrogen oxides (NO_x), and fluorides.

Particulate matter comprises solid particles or liquid droplets (aerosols) small enough to remain suspended in air; examples are soot, smoke, dust, asbestos fibres, pesticides, some metals (including Hg, Pb, Cu and Fe) and also biological agents like tiny dust mites and flower pollen. Atmospheric particles having diameter more than 10 µm generally settle out in less than a day, whereas particles with diameters 10 µm or less can remain suspended in air for weeks. Suspended particulate matter (SPM) in the lower atmosphere (troposphere) causes and aggravates human respiratory illness like asthma, chronic bronchitis, etc. Nasal passage prevents coarser particles bigger than 5µm from entering into the respiratory system. The particles less than 5 µm, known as **respirable suspended particulate matter** (**RSPM**) reach the alveoli of lungs and damage lung tissue. Soluble aerosols are dissolved in blood from alveoli, while the insoluble aerosols are carried to lymphatic stream. Workers exposed to asbestos particles mostly develop cancer called **mesothelioma** in the tissue lining abdomen. Lead, the most serious pollutant from automobile exhaust has detrimental effects on children's brain. Particulate can cause mutagenic and carcinogenic effects such as lead, cadmium, mercury, arsenic and hazardous organics absorbed on to the particulates such as poly aromatic hydrocarbons (PAHs).

Particulate pollutants also adversely affect plants by interfering with gaseous exchange and consequently reducing the yield. Metallic particulate pollutants are particularly toxic to the metabolic activities of plants after contaminating the tissues. Use of such contaminated vegetables and crop leads to variety of human health hazards indirectly caused by particulate pollutants. Particulates including dust, soot, aerosols can bring about severe damage to buildings, sculpture and monuments. 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.

Carbon monoxide (CO) is a product of incomplete combustion of fossil fuels. Nearly 50% of all CO emission originates from automobiles. It is also present in cigarette smoke. CO is short-lived in the atmosphere and gets oxidized to CO_2. Carbon monoxide is highly poisonous to most animals. When inhaled, CO reacts with hemoglobin of red blood corpusles and forms a stable co-ordinated complex **carboxyhaemoglobin**, which restricts the transport of oxygen from lungs to cells through reducing O_2 carrying capacity of blood. One packet of cigarette a day produces carboxy haemoglobin level of nearly 5 – 10% in the blood of the smoker, because inhaled cigarette smoke contains about 400-500 ppm CO. The classical symptoms of CO exposure are headache, fatigue and dizziness.

Hydrocarbons (HCs) or **volatile organic carbon** (VOCs) 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 carcinogen (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 coal. Different hydrocarbons have variety of effects on human and animal health, some injure the respiratory tract, and others cause cancer. Many HCs at a specific dose are toxic to plants. The most important anthropogenic source of HCs is automobiles. Hydrocarbons may escape to the atmosphere when a car's tank is being filled with gasoline or gasoline is spilled and evaporated.

Sulphur dioxide (SO_2) is the major constituent in the emission from coal fired electric power plants, smelting industries, manufacture of fertilizers and sulphuric acid and oil refineries. SO_2 does not remain in gaseous state for longer time in the atmosphere. It may be converted through complex reactions to fine particulate sulphate or it reacts with atmospheric moisture in presence of sunlight to form sulphuric acid, an important component of acid rain. Oxides of sulphur are the major contributors to lung diseases, cough and chocking. Higher concentration of SO_2 causes acute or chronic asthma. SO_2 is a severe allergenic agent, injuring mucosa, which may be infected by bacteria leading to dangerous allergenic infections.

SO_2 also affects plant growth, yield and nutritive quality of plant products. High SO_2 concentration causes bleaching of chlorophyll, leading to leaf necrosis (tissue death of leaves appearing as brown or black spots on foliar surfaces). SO_2 corrodes metals and damages stone and other materials. Leather too can be disintegrated by SO_2. Historic monuments are adversely affected by SO_2.

Nitrogen oxides (NO_X) are formed mainly from N_2 and O_2 during combustion of fossil fuels at high temperatures in automobile engines. NO_X stands for an indeterminate mixture of NO NO_2 and N_2O. Nitrogen oxides cause the reddish brown haze (**brown air**) in traffic-congested city air, which contributes to heart and lung problems and may be carcinogenic. Nitrogen oxides inhibit plant growth and reduce the productivity of a number of plant species at higher concentrations. NO_2 causes chlorosis on foliage and reduces the food manufacturing capacity of plants. Low NO_2 concentration irritate mucous membrane, while higher concentration causes bronchitis, gum inflammation internal bleeding, pneumonia and O_2 deficiency. Nitrogen dioxide fades away a number of textile dyes. Fibre strength of cotton and rayon is also reduced due to NO_2. Metals are corroded due to acidification caused by NO_2. When the oxides are converted to their nitrate form in the atmosphere, visibility is impaired. However, when nitrate is deposited on the soil, it can promote plant growth. Nitrogen oxides also contribute to acid rain because they combine with water droplets to produce nitric acid (HNO_3) and other acids.

Fluorides are ubiquitous. Fluoride, mostly in gaseous **hydrogen fluoride** (HF) form, is released into the atmosphere, whenever the clays, rocks, coal or ores containing it are heated. Volcanic eruptions contribute significantly as natural source to fluoride pollution.

Glass factories, phosphate fertilizer factories, brick klins and aluminium industry are major sources of flurorides. Particulate forms of fluorides namely cryolite dust, sodium aluminium fluoride, etc are emitted in the vicinity of smelters using fluoride containing ores. Accumulation of fluoride in plant tissue leads to visible injury symptoms on leaves damages the fruit and causes yield reductions. Fluoride accumulation through food chain lead to biomagnification. Excess fluoride ingestion leads to a disease called as **fluorosis**. Fluorides disrupts the ossification process. The teeth become weaker and mottled. Bone deformations develop in animals, which may become fatal. Milk production lower down in animals feeding on fluoride contaminated forage. Bees apiary does not survive in fluoride polluted areas.

Secondary Air Pollutants and Their Effects

Photochemical smog: The classical example of secondary pollutant, photochemical smog is formed in traffic-congested metropolitan cities where warm conditions and intense solar radiation are present. Photochemical smog is composed mainly of **ozone** (O_3), **peroxyacetyl nitrate** (PAN) and NO_X and 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 and these play an important role in O_3 and PAN formation. A simplified set of the photochemical reactions involved in smog formation is as follows:

Reaction occurring inside engine:

$$N_2 + O_2 \rightarrow 2NO$$

Reactions occurring in atmosphere:

$$2NO + O_2 \rightarrow 2NO_2$$

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

$$O + O_2 \rightarrow O_3$$

$$NO + O_3 \rightarrow NO_2 + O_2$$

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

Ozone may damage plant as well as animal life. In plants, the main damage occurs in leaf in form of flecks on surface. The effects of O_3 on plants can be subtle. At very low concentration, O_3 can reduce growth rates while not producing any visible injury. At higher concentrations O_3 kills leaf tissue, eventually killing entire leaves and whole plants. The death of white pine trees planted along highways in New England, USA is believed to be due in part to O_3 pollution. Ozone production is directly related to the light intensity, temperature and sunshine hours, therefore O_3 is a pollutant of **hot summer**. Ozone's effect on animals, including human beings involves various kinds of damage, especially to the eyes and the respiratory system. Ozone aggravates lung diseases in humans. Ozone is also associated with lung cancer, visual impairment and loss of immune system. Ozone, an effective oxidant, corrodes the heritage building surfaces, damages marble statues and other cultural assets. Ozone destroys paints and textiles and causes rubber cracking. 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. In humans, PAN causes acute irritation of eyes and negative effects on respiratory system.

Acid rain: In a broad sense, acid rain refers to several ways in which acids from the atmosphere are deposited on the earth. Acid deposition includes wet and dry deposition. **Wet deposition** refers to acidic water received through rain, fog, and snow. **Dry deposition** relates to the wind blown acidic gases and particles in the atmosphere which settle down on the ground. 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.

Nitrogen oxides (NO_X), 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. These gases are highly reactive in air. They rapidly oxidize to acids (sulphuric or nitric) which quickly dissolve in water and are washed out to the ground as **acid rain**. Normally rainwater is slightly acidic (pH 5.6 – 6.5) because water and CO_2 combine in air to form a weak acid. The pH of acid rain is less than 5.6, and could be as low as 4 or below.

Because the pH scale is logarithmic, a pH value of 3 is 10 times more acidic than pH value of 4, and 100 times more acidic than pH value of 5. The use of taller stacks have reduced local concentrations of air pollutants, but have increased regional effects by spreading the pollution more widely. Swedish scientists have traced acid precipitation problems in Scandinavian lakes to air borne pollutants from Germany, France and Great Britain.

Acid precipitation in all forms adversely affects trees. Acid rain and other air pollutants have caused death of thousands of acres of evergreen trees in USA and Canada. Soils are particularly vulnerable to acid rain, which loose their fertility either because of nutrient leaching or because the acid releases elements into the soil that are toxic to plants.

Acid rain adversely affects aquatic ecosystems. Most plankters, molluscs and fish fry cannot tolerate water having pH below 5.0. Records of 15 years or more from Scandinavian lakes show an increase in acidity accomponied by a decrease in fish population. In acidified lakes, phytoplanktons (algae) do not grow due to nutrient unavailability. Small animals that feed on the algae thus have little to eat. The fishes which are typically predators of small vertebrate animals also lack food. The acidic water has other adverse effects on reproduction of aquatic organisms. The elevated concentrations of heavy metals under acidic water clog the gills and cause suffocation of fishes. Heavy metals may pose health hazards to humans, because they may become concentrated in fish and then passed on to birds, other mammals and people when the fishes are eaten. Drinking water taken from acidic lakes may also have high concentrations of toxic metals. Low pH conditions also damage soil microbial community.

Acid rain damages building materials, including steel, paint, plastics, cement, masonry, galvanized steel and several types of rock, especially limestone, sandstone and marble. Acid rain damages furnishing fabrics. Classical buildings show considerable decay that has accelerated in this century as a result of air pollution. Our heritage monuments (such as Taj Mahal at Agra) are threatened by the corrosive action of acid deposition.

Control of Air Pollution

Important preventive strategies to control air pollution are: (i) suitable fuel selection (e.g. fuel with low sulphur content) and its efficient utilization to reduce pollutant level in

emission; (ii) modifications in industrial processes and/or equipments to reduce emissions; (iii) correct selection of manufacturing site and zoning for industrial set-up to disperse pollution sources. The most common methods of eliminating or reducing pollutants to an acceptable level include destroying the pollutant by thermal or catalytic combustion, changing the pollutant to a less toxic form, or collecting the pollutant by use of equipment to prevent its escape into the atmosphere.

Control of Particulate Matter

A variety of settling chambers or collectors are used to control emissions of coarse particulate from industries and power plants by providing a mechanism that causes particles in gases to settle out in a location where they may be collected for disposal in landfills. These are called **gravity settling chambers**. Principally, two devices remove particulate air pollutants, *viz.*, **arresters or collectors** (used ideally to separate particulate matters from contaminated air) and **scrubbers** (used to clean air for both dusts and gases by passing it through a dry or wet packing material). Particulate matter arresters may be of different kinds. **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. **Filters** are usually used to collect extremely fine particulate matters. Different types of filter materials are available to suit different quality and size of the particulate matters. However, **electrostatic precipitator** (ESP) is the most effective device to remove particulate pollutants from flue gases and is standard equipment for power plants and big industries. ESP works on the principle of electrical charging of the dust particles and collecting it on a differently charged platform. Both dry and wet type **scrubbers** are also used for dust separation. However, scrubber is the least used device for separating particulate matters from the emissions, as this device is best suited for the removal of gaseous pollutants.

Control of Gaseous Pollutants

Combustion, absorption and adsorption techniques are used to control gaseous pollutants. In **combustion** process, oxidizable gaseous pollutants are completely burnt at a high temperature. Petro-chemical, fertilizer, paints and varnish industries use combustion control of gaseous pollutants. In **absorption** technique, gaseous pollutants are absorbed

in suitable absorbent materials. **Adsorption** technique is applied to control toxic gases, vapours and inflammable compounds that could not be efficiently removed or transferred by the aforesaid techniques. Such air pollutants are adsorbed on large solid surfaces.

Control of Automobile Exhaust

Efficient engine (for example, multi-point fuel injection engine) can reduce the unburnt HCs in auto-emissions. Good quality automobile fuels can also drastically reduce the toxic contaminants in exhaust. Lead-free petrol can reduce the load of lead in the exhaust. Automobile engines operated with compressed natural gas (CNG) have significantly lowered toxic contaminants in exhaust. The control of nitrogen oxides from automobile exhausts is accompanied by recirculating exhaust gas, diluting the air to fuel mixture being burned in the engine. The dilution reduces the temperature of combustion and decrease O_2 concentration in burning mixture, thus producing fewer NO_x. To remove NO_x, CO and HC emissions from automobiles, **catalytic converter** are used. In this CO is converted to CO_2, NO_x in N_2 and HCs to CO_2 and water by passing exhaust gases over a catalyst (platinum, palladium, or a blend of both). There are number of other options, most of which aim to reduce the number of cars on the roads. These include mandatory carpooling, incentives for the use of public transport, restrictions of total number of vehicles in a region, development of vehicles that use clean full, use of cleaner-burning fuel and proper maintenance of vehicles.

WATER POLLUTION

Water is a precious natural resource for survival and health of living organisms. Water pollution means the presence of any foreign substance (organic, inorganic, radiological and biological) in water, which tends to degrade its quality so as to constitute a hazard or impair the usefulness of the water.

Sources of Water Pollution

On the basis of their origin, the sources of water pollutants can be broadly categorized into: (i) **point sources**, where the effluent discharge occurs at a specific site; for example, sewage outlet of a municipal area or effluent outlet of a factory; and (ii) **non-point sources**, where inflow of pollutants occurs over a large area; for example, city storm water flow, agricultural runoff, constructional sediments, etc. Point source pollution can

be effectively checked with appropriate technology. Non-point source pollution is difficult to control and needs application of control measures on a large scale.

Water pollutants can be: (i) **biological** (pathogens, such as viruses, bacteria, protozoa, algae and helminths), (ii) **chemical** (organic chemicals, like biocides, polychlorinated biphenyls or PCBs; inorganic chemicals, like phosphates, nitrates, fluoride, etc., also heavy metals like As, Pb, Cd, Hg, etc., and (iii) **physical** (hot water from industries, oil spills from oil carriers, etc.). Water pollutant are divided into eight categories:

Sediment pollution: It is caused by soil particles that enter the water as a result of runoff from agricultural lands, forests, over grazed rangelands, strip mines and construction sites. Sediment pollution causes problems by reducing light penetration, covering aquatic organisms, bringing insoluble toxic pollutants into the water and filling water ways. The suspended particles make the water turbid, which in turn reduces the productivity by reducing the ability of producers to photosynthesize. Sediments can envelop coral reefs and shellfish beds and clog the gills and feeding structures of many aquatic animals. Sediments from urban areas and industrial sites affect water quality by carrying toxic chemicals, both inorganic and organic including heavy metals and acids into water. Disease causing agents can also be transported into water via sediments.

Sewage pollution: Liquid wastes from domestic activities such as kitchen, toilet and other household wastewater are, in most cases, discharged directly into a river or into a large water body nearby. Many rivers in India, including the river Ganga, are polluted by indiscriminate discharge of wastewater. The famous Dal Lake in Kashmir is also heavily polluted by domestic sewage. Sewage creates two serious environmental problems in water, **enrichment** and **oxygen demand**. Enrichment is fertilization of water body by high levels of plant nutrients such as nitrogen and phosphorus. Excess input of nutrients occurs from detergent residues (e.g. phosphates) and organic remains (e.g. nitrates). Domestic effluents mostly carry organic wastes, which are biodegradable and require oxygen. High levels of sewage consume most of the dissolved oxygen leaving little for other aquatic organisms. At extremely low oxygen levels, fishes begin to die off.

Disease causing agents: Municipal wastewater usually contains many bacteria, viruses, protozoa, parasitic worm and another infectious agents that cause human and animal

diseases. Typhoid, cholera, bacterial dysentery, polio and infectious hepatitis are some common diseases transmissible through contaminated water and food.

Inorganic plant nutrients: Fertilizer runoff from agricultural and residential lands is a major contributor of inorganic plant nutrients such as nitrogen and phosphorus to water, where they encourage excessive growth of algae and aquatic plants. Their excessive growth disrupts the natural balance between producers and consumers causing other problems such as enrichment, bad odour and low oxygen.

Industrial wastewater: Both small-scale and large industrial activities produce wastewater contaminated by a variety of organic pollutants. Almost all the rivers of India, at least in certain stretches, are heavily polluted by the discharge of industrial wastewater. Most components of industrial effluents are toxic to ecological systems even at low concentrations, and many are non-biodegradable.

Organic chemicals: Most of the organic compounds in water are synthetic chemicals such as pesticides, solvents, industrial chemicals and plastics. Some of these compounds can cause cancer or birth defects as well as variety of other heath disorders.

Inorganic chemicals: A large number of inorganic chemicals pollute surface water from sources such as industrial plants, mines, oil drilling, and municipal storm water. Mercury is one important inorganic chemicals causing long term impact on kidney function and nervous system. Acid drainage from mines containing high levels of heavy metals is another example of inorganic chemicals in water bodies.

Radioactive substances: Sources such as mining and processing of radioactive minerals, industrial use of radioactive substances, nuclear power plants, nuclear weapon industry and medical and scientific research facilities contaminate water with radioactive substances having carcinogenic potential.

Thermal pollution: Many industries including power plants and oil refineries, use water as coolant for the machinery. Release of hot wastewater, having 8 – 10^{o}C higher temperatures than the intake water, causes thermal pollution in the water body.

Effects of Water Pollution

Water pollutants adversely affect the physical, chemical and biological characteristics of the aquatic ecosystems and the quality of groundwater.

Effects on aquatic ecosystem: Organic and inorganic wastes decrease the **dissolved O_2** (DO) content of water bodies. Water having DO content below 8.0 mg L^{-1} may be considered as contaminated. Heavily polluted waters have DO content below 4.0 mg L^{-1}. DO content of water is important for the survival of aquatic organisms. The 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.

Higher amounts of organic waste increase the rates of decomposition and O_2 consumption, thereby causing a drop in DO content of water. The demand for O_2 is directly related to increasing input of organic wastes and is expressed as **biochemical oxygen demand** (BOD) of water. BOD is a measure of oxygen required by aerobic decomposers for the biochemical degradation of organic materials (i.e. biodegradable materials) in water. Higher the BOD lower would be the DO. **Chemical oxygen demand** (COD) is another measure of pollution load in water. COD is the measure of oxygen equivalent of the requirement for oxidation of total organic matter (biodegradable + non-biodegradable) present in water.

Therefore, contamination of water bodies by pollutants will reduce DO content, and sensitive organisms, like plankton, molluscs, and fish etc. will be eliminated. Only a few tolerant species like annelid worm *Tubifex* and some insect larvae may survive in highly polluted, low DO water, and they may be recognised as **indicator** species for polluted waters. Biocide residues, PCBs and heavy metals, such as Hg, Pb, Cd, Cu, As, etc. can directly eliminate different species of organisms.

Higher the temperature of water, lower is the rate of dissolution of O_2 in water. Hence, hot wastewater discharged from industries, when added to water bodies, also lower its DO content.

Biological magnification: The phenomenon through which certain pollutants get accumulated in tissues in increasing concentrations along the food chain is called **biological magnification**. Such pollutants (e.g. DDT) are non-biodegradable i.e. once they are absorbed by an organism, they cannot be metabolized and broken down or excreted out. These pollutants generally get accumulated in fat-containing tissues of the organism. The classic example of biological magnification is that of DDT, an insecticide which is sprayed on water bodies to check the growth of mosquitoes. In Long Islands in

USA, after regular DDT spraying for few years, the populations of fish-eating birds began to decline. Later, it was found that the concentration of DDT had increased about 800 times in the phytoplankton relative to the concentration in water. Zooplankton contained about five times greater DDT than phytoplankton. In different fishes, the DDT concentration increased 9-40 times relative to the concentration in zooplankton. Birds showed about 25 times greater DDT concentration relative to that in fishes. Many other persistent pesticides and radionuclides also show biological magnification.

Eutrophication: Besides inorganic nutrient input with the inflow of wastewater, decomposition of organic wastes too increases the nutrient content of the water bodies. Availability of excess nutrients causes profuse growth of algae (**algal bloom**), especially the blue-green algae. Such algal blooms may totally cover the water surface, often release toxins in water, and sometimes cause deficiency of oxygen in the water. Thus, in bloom-infested water body the growth of other algae may be inhibited due to toxins, and aquatic animals (e.g. fishes) may die due to toxicity or lack of oxygen. The process of nutrient enrichment of water and consequent loss of species diversity is referred to as eutrophication.

Effects on human health: Domestic sewage contains pathogens like virus, bacteria, parasitic protozoa and worms. Contaminated water, therefore, can carry the germs of water-borne diseases like jaundice, cholera, typhoid, amoebiasis, etc. Such contamination may make the water unfit for drinking, bathing, and swimming and even for irrigation.

Heavy metal contamination of water can cause serious health problems. Mercury poisoning (**Minamata disease**) due to consumption of fish captured from Hg-contaminated Minamata Bay in Japan was detected in 1952. Mercury compounds in wastewater are converted by bacterial action into extremely toxic methyl mercury, which can cause numbness of limbs, lips and tongue, deafness, blurring of vision, mental derangement. Cadmium pollution can cause **itai-itai** disease (ouch-ouch disease, a painful disease of bones and joints) and cancer of liver and lung.

Groundwater pollution: In India at many places, the groundwater is threatened with contamination due to seepage from industrial and municipal wastes and effluents, sewerage channels and agricultural runoff. Hazardous substances including radioactive compounds, particulates, fertilizers, organic compounds, and heavy metals can seep into

ground water from municipal sanitary landfills. Excess nitrate in drinking water is dangerous for human health and may be fatal for infants. It reacts with hemoglobin and forms non-functional **methaemoglobin** that impairs oxygen transport. This is called **methaemoglobinemia** or **blue-baby syndrome**. Excess fluoride in drinking water causes teeth deformity, hardened bones and stiff and painful joints (**skeletal fluorosis**). At many places in India, groundwater is contaminated with arsenic mainly from naturally occurring arsenic in bedrocks. Over exploitation of groundwater may possibly initiate leaching of arsenic from soil and rock sources and contaminate groundwater. Chronic exposure to arsenic causes **black-foot disease**. Arsenic causes diarrhoea, peripheral neuritis, and hyperkeratosis, and also lung and skin cancers.

Water Pollution Control

Water quality can be improved both by reducing the number of contaminants that enter into the water bodies and cleaning up wastewater. The industrial and municipal wastewater are treated in **Effluent Treatment Plant (ETP)** prior to disposal in water bodies. Generally, the following treatments are given in ETP:

Primary treatment: This physical process involves the separation of large debris, followed by sedimentation in tanks or clarifiers. It, however, does little to eliminate the inorganic and organic compounds that remain suspended in the wastewater.

Secondary treatment: This is a biological process and is carried out by microorganisms. In this treatment, the wastewater is pumped in shallow **stabilization** or **oxidation** ponds, where the microbes oxidize its organic matter. The process results in release of CO_2 and formation of **sewage sludge** or **biosolid**. The sludge is continuously aerated to further its oxidation. Algae grown in the upper-lighted zone of the wastewater provide aeration by generating O_2. One of the several types of secondary treatement is **trickling filters**, in which wastewater trickles through areated rock beds that contain bacteria and other microorganisms, which degrade the organic material in water.

Tertiary treatment: This physico-chemical process removes turbidity in wastewater caused by the presence of nutrients (nitrogen, phosphorus, etc.), dissolved organic matter, metals or pathogens. This step involves chemical oxidation of wastewater by strong oxidizing agents, such as chlorine gas, perchlorate salts, ozone gas and UV radiation.

After tertiary treatment, the wastewater can be discharged into natural waters or used for irrigation.

Disposal of sewage sludge: A major problem associated with wastewater treatment is disposal of the sewage sludge that is formed during primary and secondary treatments. Sewage sludge can be anaerobically digested into methane and CO_2 and methane can be trapped and burned to heat the digester. Sewage sludge being rich in plant nutrients can be dried and used as fertilizer. Sewage sludge can be used as soil conditioner.

SOIL POLLUTION

Soil pollution usually results from different human activities like urban and industrial waste dumping, use of agrochemicals, mining operations and urbanization. Modern agricultural practices accelerate the processes of soil destruction by advocating deep ploughing, and increase use of chemical fertilizers and pesticides.

Types, Causes and Effects

Waste Dumps

Land gets polluted by dumping of industrial wastes, municipal wastes, and medical or hospital wastes. Industrial solid wastes and sludge are the major sources of soil pollution by toxic organic and inorganic chemical compounds and heavy metals. The fall out from industrial emissions, for example, the fly ash emitted by thermal power plants, can pollute surrounding land. The particulate of the industrial emissions from the tall chimneys always come back to the earth's surface sooner or later. Radioactive wastes from nuclear testing laboratories, nuclear power plants and the radioactive fall out from nuclear explosions also contaminate the soil. Radioactive materials thrive in the soil for long periods because they usually have a long half-life. Strontium-90, for example, has a half-life of 28 years, and of Caesium-137 is 30 years.

Municipal wastes mainly include domestic and kitchen wastes, market wastes, hospital wastes, livestock and poultry wastes, slaughterhouse wastes, waste metals, and glass and ceramic wastes, etc. Non-biodegradable materials like used polyethylene carry-bags, waste plastic sheets, pet-bottles, etc. persist in soil for long periods. Hospital wastes contain organic materials, chemicals, metal needles, plastic and glass bottles, vials, etc.

Dumping of domestic sewage and hospital organic wastes contaminate the environment with a variety of pathogens that can seriously affect human health.

Agrochemicals

Pesticides and weedicides are being increasingly applied to control pests and weeds in agricultural systems. Excess inorganic fertilizers and biocide residues are contaminating the soil as well as surface and groundwater resources. Inorganic nutrients, like phosphate and nitrate are washed out to aquatic ecosystems and accelerate eutrophication there. Inorganic fertilizers and pesticide residues change the soil chemical properties and can adversely affect soil organisms.

Prior to second world war, pesticides were inorganic made up of arsenic, mercury, selenium and lead compounds. Post war period experienced the introduction of chlorinated hydrocarbon pesticides like dichlorophenol trichloroethane (DDT) with great acclaim as a new era of freedom from hunger and pestilence. A number of side effects due to unforeseen biological activities of pesticide residues have raised questions of their widespread use in due course of time. Pesticide residues interfere with organic matter decomposition, nitrogen and sulphur transformation, phosphorus and trace elements availability and soil enzyme activities, which influence soil fertility. The persistent organochlorine gradually increase in concentration from lower to higher trophic levels through a process of **biomagnification**. Pesticides disturb the equilibrium between insect pests and their parasites and predators. Pesticides sometimes increase disease susceptibility in hosts to those other than for which pesticide is used. A variety of insects develop significant levels of tolerance due to intense selective pressure from pesticides. Large-scale application of pesticides is often associated with negative effects on non-target species affecting their reproduction and behaviour.

Trace metal contamination

Most trace elements are potentially toxic when absorbed at higher concentrations. Lead, mercury and cadmium are few most hazardous trace elements. Other trace elements which are frequently involved in environmental toxicity problems are arsenic, boron, chromium, copper, molybdenum, nickel, zinc, etc. Heavy metals accumulated in soil constitute a selective course in plant evolution. The flora on contaminated sites show poor growth and low reproductive potential. High levels of trace elements in food

through soil and water cause problems in excretory, digestion, nervous and reproductive systems of animals and human being.

Mining Operations

Opencast mining (a process where the surface of the earth is dug open to bring out the underground mineral deposits) completely devastates the topsoil and contaminates the area with toxic heavy metals and chemicals. Mining leads to loss of grazing and fertile lands, soil erosion from soil dumps and sedimentation and siltation of water resources.

Control of Soil Pollution

Control measures for soil pollution and land degradation involve safer land use, planned urbanization, controlled developmental activities, safe disposal and management of solid wastes from industries and human habitations. Management of solid wastes involves: (i) collection and categorization of wastes, (ii) recovery of resources like scrap metals, plastics, etc., for recycling and reuse, and (iii) safe disposal with minimum environmental hazards.

Sewage sludge and industrial solid wastes are used as landfills. Toxic chemicals and hazardous metal-containing wastes are used as bedding material for road construction. Fly ash is also used for similar purposes. Fly ash bricks are also being used for building constructions. Other notable methods to get rid of the solid wastes are incineration (burning in presence of oxygen) and pyrolysis (combustion in the absence of oxygen). Municipal solid wastes containing biodegradable organic wastes can be transformed into organic manure for agriculture. Rapid cost effective rehabilitation strategy using suitable plant species should be adopted for speedy recovery of mine spoil land. This may also enhance natural regeneration and supply of fodder and fuel wood to the public.

Marine Pollution

The discharge of waste substances into the sea resulting in harm to living resources, hazards to human health, hindrance to fishery, and impairment to quality of seawater is defined as marine pollution.

Causes of Marine Pollution

The greatest damage to seawater is caused by spill of petroleum and its products. An **oil spill** is the accidental discharge of petroleum in oceans or estuaries. Capsized oil tankers,

offshore oil mining and oil exploration operations and oil refineries mainly contribute to oil pollution of marine ecosystem. Other sources include overburden of nutrients, foaming agents used in synthetic detergents, organic and inorganic compounds, etc. Shipping introduces plastic debris and sewage into oceans. Several large oil spills from underwater oil drilling operations have occurred during recent years. Although spills make headlines, normal shipping activities probably release more oil over a period of year to the ocean of the world than is released by occasional spill.

Effects of Marine Pollution

Oil films on sea surface retard the rate of oxygen uptake by water. Oil slick decreases the light intensity up to 90% thereby reducing the photosynthetic activity of marine flora. Smothering coats of oil kill the lichen and algae along the shorelines. Excessive spreading of oil affects the floating marine life severely. Oil spilling causes extensive fish mortality and lethal toxicity to other animals and plants. Oil coating of marine birds, seals and sea otters destroys their natural insulation and their buoyancy, so that they can either die from loss of body heat or drown. Aromatic hydrocarbons in oil accumulate in marine plant tissues causing carcinogenic effect. Hydrocarbons cause anesthesia and necrosis in a wide variety of lower animals. Studies conducted near oil spill site revealed the immediate massive destruction of marine life including fish, worms, crabs, invertebrates, lobsters, etc. Birds are especially vulnerable to damage from oil coating, losing insulation and developing respiratory ailments. When ingested oil damages liver, kidney, and lungs. Heavier tar like oil sinks, killing bottom dwelling organisms. In addition to severe effects of marine pollution, unpleasant aesthetic impact remains visible at oil-covered coastal region. Oil spills are also immensely harmful to coral reef and can drastically damage the marine local biodiversity.

Control of Oil Pollution

Floating oil on the sea surface can be removed following variety of methods. Sucking the oil from surface through a suction device to absorption of oil by absorbing material like polyurethane foam are important physical methods of removing oil pollution. Dispersion of oil in form of small droplets using some dispersant is one of the most satisfactory methods of oil removing. **Emulsification**, which involves incorporation of water on oil layer forming a water in oil emulsion called **mousse**, which disintegrate by wind and

wave action into tar balls that wash ashore, is an effective weathering process of oil removal. Improved navigation aids may further reduce the chances of marine pollution by oil.

NOISE POLLUTION

Types,Causes and Effects

Noise pollution can be defined as the loud disturbing sound dumped into the ambient atmosphere without regard to the adverse effects it may have. 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 $W\ m^{-2}$). The **sound level** is the logarithm of ratio of the ambient intensity to the reference intensity (usually considered $10^{-12}\ W\ m^{-2}$). The unit of sound level is **decibel** (dB), a name that was chosen 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, at which point physical discomfort starts. In view of the logarithmic nature of scale, 10, 20 and 100 decibels represent 10 times, 100 times and 10^{10} times the threshold intensity, respectively.

Man-made noise originates from industrial machines, transport vehicles, sound amplifiers, cracker blasting, industrial and mini site detonation, etc. Jet aircraft landing and take-off create a lot of noise pollution to the inhabitants near the busy airports. Noise may be broadly categorized in:

a). **Industrial noise** caused by many machines. Noise from mechanical saws and pneumatic drill is unbearable. Heavy industrial blower also makes very high noise leading to occupational pollution to the workers.

b). **Transport noise** comes from road traffic, rail traffic and craft. Inhabitants of cities are subjected to most annoying form of transport noise.

c). **Neighborhood noise** is created by house hold as well as community activities and constructional sites. Entertainment and musical instruments, air conditioners, food mixer, vacuum cleaner, coolers are house hold gadgets causing noise. Use of loud speakers for community or religious activities and burning of firecrackers are additional sources of neighborhood noise.

Some typical sound levels are 50-60 dB for normal conversation, 55 dB for average offices, 90 dB for large factory, 110 dB for boiler factory and 130 dB for aeroplace noise at a distance of 3 meters. Traffic causes a noise of 90 dB, while a loud speaker causes 83 dB. Noise is categorised on the basis of its loud levels as threshold of hearing 0 dB just audible; 10 dB normal voice; 55 dB conversational speech; 60 dB moderately loud; 70-90 dB very loud; 95-110 dB uncomfortably loud; 120 dB painfully loud; and 130-140 dB severely loud.

The various effects of noise pollution on human beings may be classified as **auditory** and **nonauditory** including **biological** and **sociological**. The most acute and immediate effect of noise pollution is impairing of hearing, which may cause auditory fatigue and may even lead to deafness. Non auditory effects include annoyance, irritability, mental disorientation and violent behaviour. Physiological disorders caused due to noise lead to neurosis, anxiety, insomnia, hypertension, cardiovascular diseases, hepatic stress, nausea, giddiness, quicking of human foetus and heart rate, and malformation of its nervous system. Noise seriously affects heartbeat, peripheral circulation, and breathing pattern. Studies have shown a rise in serum cholesterol and body plasma concentration in workers exposed to noise. Auditory fatigue appears at 90 dB associated with whistling and buzzing in ears. Emotional breakdown may also be due to too much noise. Persistent noisy environment can cause annoyance, irritability, headache, and sleeplessness and may seriously affect productive performance of humans.

The Central Pollution Control Board has recommended the zone-wise ambient noise levels as given below:

Zone-wise Permissible Ambient Noise Levels.

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

Control of Noise Pollution

Soundproof insulating jackets or filters are used to reduce noise from machines. Industrial workers and runway traffic control personnel may use **earmuffs** to protect themselves from unwanted noise exposure. **Acoustic zoning** to prevent noise propagation may also be helpful. A '**silent zone**' around 100 meters of hospitals or schools can give comfort to ailing patients or help students to concentrate in studies. Forests and dense hedge of plants can effectively act as noise barrier. Sound must be considered as a potentially harmful pollutant around us and should be treated with no less importance than the other pollutants of our environment. Efforts must be made to increase awareness among people about the perils of noise in our surroundings.

Proper designing of doors and windows reduce the noise in the houses. A rationale town planning can help in reducing outdoor noise pollution from railways, heavy machinery, road traffic, etc. Residential zones should be away from these sources of noise pollution. Vehicles should be restricted from unnecessary blowing of horns. Loud speakers should not be allowed at high noise at community and religious functions.

THERMAL POLLUTION

Thermal pollution is the addition of excess of undesirable heat to water bodies that makes it harmful to man, animals or aquatic life, or otherwise causes significant departures from the normal activities of the aquatic communities.

Causes of Thermal Pollution

A number of industries including steam- generated electric power plants; use water to remove excess heat from their operations. Afterward, the heated water is allowed to cool a little before it is returned to waterways, but its temperature is still higher by 8-10^0 C than it was originally. The result is that the waterway is warmed. Sources of thermal pollution are nuclear power plants, industrial effluents, coal fired power plants, hydroelectric power plants and domestic sewage. About 80% of the total water withdrawn for industrial operations is utilized for cooling. There exists different intermixing zones, showing the water temperature rise of varying degrees in a river after receiving warm water.

Effects of Thermal Pollution

A rise in temperature of water body has a number of chemical, physical and biological effects. Chemical reactions including decomposition of wastes occur faster depleting the water of oxygen. Moreover, less oxygen dissolves in warm water than in cool water. For example dissolved oxygen (DO) concentration is 14.6 ppm at 0^0C and 6.6 ppm at 14^0C temperature. The amount of DO in water has important effects on aquatic life. There may be subtle changes in the activities and behavior of living organisms in the thermally polluted water, because temperature affects reproduction cycles, and digestion and respiration rates. In fishes, activities like nesting, spawning, hatching, migration and reproduction depend on a certain temperature. The warm water can destroy the laid eggs. The egg hatching is earlier due to high temperature, but the food may not available for developing fingerlings, which will die off due to short supply of food.

High temperature decreases the viscosity of water, which increases the setting speed of suspended particles, thus seriously affecting the food supplies of aquatic organisms. Toxicity of a poison increases with rise in temperature of water. Fishes show a mark rise in basal rate of metabolism with temperature to lethal point. The respiratory rate, food uptake and swimming speed in fishes increase with rise in temperature. Activities of several pathogenic microorganisms are accelerated at high temperatures. Many bacterial diseases such as those in Salmon fish and banded Sunfish are due to temperature increase. Thermal pollutants may permit the invasion of organisms that are tolerant to warm water and highly destructive.

All the major groups of algae have distinct tolerance for temperature. High temperatures promote **blue green algal blooms**, which disrupt the aquatic food chain. Blue green algae are indicators of extreme thermal pollution condition. High temperature of water may induce increase in activity, which exhausts the organisms and shorten its life. Distribution of aquatic organisms is also affected in hot water. Since temperature rise in water affects density, surface tension and viscosity of water, the organisms move towards suitable temperature. Planktonic organisms cannot compensate for pull of gravity in less dense water and ultimately sink. Benthic organisms are also distributed according to temperature of water. At higher temperature, fish requires more food to maintain body

weight. They also typically have shorter life spans and smaller populations. In case of extreme thermal pollution, fish and other aquatic organism die.

Control of Thermal Pollution

Evaporative cooling towers are suggested to be used to reduce temperature of water. Cooling pond constitutes the simplest method of removing heat through maximizing heat dissipation in atmosphere from pond.

NUCLEAR HAZARDS

Nuclear energy is the energy of atomic nucleus. The changes in the nuclei of atoms release large amounts of energy. Two nuclear processes can be used to release the energy: fission and fusion. **Nuclear fission** is the splitting of an atom nucleus into smaller fragments. **Nuclear fusion** is the combining of atomic nuclei to form heavier nuclei. A byproduct of both reactions is the release of energy. Nuclear explosion tests include nuclear fusion as well as nuclear fission processes. Nuclear reactions produce 100,000 times more energy per atom than chemical reactions such as combustion. In nuclear bombs, this energy is released all at once, producing a tremendous surge of heat and power that destroys everything in the vicinity.

Atoms and Radioactivity

All atoms contain positively charged electrons and electrically neutral neutrons. The sum of protons and the neutrons in the nucleus of an element is **atomic mass**. Each element contains a characteristic number of protons per atom, called its **atomic number**. The number of neutrons in an atom of elements may vary resulting in different electronic masses. Forms of single element that differ in atomic mass are known as **isotopes**. Some of the isotopes are unstable and are said to be **radioactive** because they spontaneously emit radiation, a form of energy. As radioactive element emits radiation, changes into nucleus of different element; this process is known as **radioactive decay**. The period of time required for one half of a radioactive substance to change into different material is known as **radioactive half life**. Actual dose of radiation delivered by radioactivity in relation to environment is measured as **rads** (rd) and **rems**. In International System (SI) the corresponding units are **grays** (gy) and **sieverts** (sv). 1 gray is equivalent to 100 rads.

Causes of Nuclear Pollution

Nuclear hazards come from both natural and anthropogenic sources. Natural sources are solar rays, radio nucleotides in earth's crust and internal radiation. Uranium and Thorium extensively occur in nature and are present in rocks, ores, soils, river and seawater. Anthropogenic sources of radiations include nuclear tests, nuclear power plants, radioactive ores processing, industrial, medical and research uses of radioactive material, radioactive depositions, etc. Radioisotopes administered to patients during radiation therapy are now proving a hazardous source of nuclear pollution. Throughout the entire nuclear cycle from mining and processing of uranium (an isotopes ^{234}U has half life of 250,000 years) to control fission in a reactor, the reprocessing of spent nuclear fuel, the decommissioning of power plants and the disposal of radioactive waste, various amounts of radiation may enter and affect the environment.

During atom bomb detonation, 15% of energy is released as radioactivity and fall to earth as radioactive fallout, which mixed with soil, water and vegetation. Nuclear fallout contains about 200 isotopes including most dangerous ^{89}Sr, ^{90}Sr, ^{137}Cs and ^{14}C. Nuclear reactors processing nuclear fuel, discharge radioactive wastes containing large amounts of long-lived radio-nucleotides, posing extremely critical public health problem. Thermal power plants and fertilizer industries involved in large-scale coal combustion are also source of radiological pollution.

Effects of Nuclear Hazards

A number of radioactive elements concentrate in food chain, causing **biomagnification**. Radiation brings about alterations in DNA molecules, spawning cancerous cells and eventually resulting in **acute tumors**. Radiation causes gene mutations and chromosomal aberrations. Acute radiation damages include loss of hair, widespread ulcers, bleeding from mouth and gum, and sudden death. The chronic radiation damages include leukaemia, anaemia, cancer of skin and other organs and reduction of life spawn. Disorderly genetic effects may lead to the death of embryo, neonatal death or **birth defect**s in off springs.

The first **atom bomb** was detonated on August 6, 1945 at **Hiroshima** and second over **Nagasaki**. At least 100,000 people were reported killed, severely injured and missing in Hiroshima alone in about 15 km^2 area and 49000 in an area of 7 km^2 in Nagasaki.

Chernobyl was the **nuclear accident** at nuclear power station on April 25, 1986 in Ukraine area of Soviet Union. About 2000 people died, while vegetation, water and soil were contaminated. In 30 km zone 115,000 people were evacuated and as may as 24000 received higher radiation.

Protection and Control from Nuclear Hazards

Radiation safety standards should be maintained at work place to protect the workers from irradiation. Storage and packing of radioactive substances should be done properly with labeling and cautions for their hazardous effects. Special gloves, oversleeves aprons special footwear, goggles or masks with a transparent thermoplastic materials are used for personal safety from nuclear hazards in scientific labs and hospitals.

Nuclear devices should never be exploded in air. If these activities are extremely essential then they should be exploded underground. In nuclear reactors, closed cycle coolant system should be used to prevent extraneous activation products. In nuclear and chemical industries, the use of radioisotopes may be carried out under a jet of soil or water instead powder or gaseous fumes. Disposal of nuclear wastes should be done at proper place after giving due consideration to geologic and hydrologic situations and assumptions for future changes.

SOLID WASTE MANAGEMENT

During the first century of the industrial revolution the volume of waste produced was relatively small and could be handled by the concept of dilute and disperse. Unfortunately, as the industrial and urban areas expanded, this concept became inadequate and solid wastes are a nuisance in all cities and industrial areas. Solid waste is the organic and inorganic waste material produced by household, commercial, institutional and industrial activities that have no value in the eyes of the owner. With rapid urbanization, industrialization and population growth and increasing economy syndrome, the municipal solid waste (MSW) has become a serious threat for environmental degradation and health hazards in the cities.

Causes and Effects of Urban Industrial Wastes

In has been estimated that per capita waste generated in India is about 0.4 kg/day. A study, based on an analysis of more than 500 samples collected from different parts of

India depicts the composition of solid waste from cities as: paper/card board, 5.25%; plastic items, 0.6-0.9%; glass, ceramic, stones, 0.1-0.7%; sand/fine earth, 30-40%; metals, 0.6-1.0% and vegetables/compostible matter 50-60%. Major part of the plastic, paper and metals are taken away by the ragpickers and used by recycling industries to make new products. Most of the waste left for disposal is organic in nature. Other activities such as agriculture, forestry and animal husbandry also produce solid waste such as waste from fruit and vegetable processing, bagasse and pressmud from sugar factories, saw dust, rice husks, tea waste, slaughter house wastes, animal carcasses, fishery wastes and leather and wool wastes. Industrial solid wastes include blast furnace slag, coal ash including fly ash, mica waste, metal scraps, used batteries, pharmaceutical wastes. Hospitals also contribute significantly in producing solid wastes. Building waste also comes under the category of solid wastes.

Solid wastes are mainly organic compounds along with inorganic complexes and non-biodegradable materials. These compounds affect and alter the chemical and biological properties of soil. As a result hazardous chemicals can enter into human food chain and lead to serious negative effects. The wastes including building materials, sludge and thrown away garbage pile up at public places, give a filthy look and cause obstruction in daily life. Solid waste results in offensive odour and cause clogging of ground water filters. The leachates from dumping sites are extremely toxic due to presence of heavy metals and persistent pesticides. Heavy metals are known to cause kidney damage, cardiovascular diseases, dermatitis, anaemia, hypertension, neurological and behavioral disorders. Some heavy metals such as cadmium are carcinogenic.

Decomposable organic material in solid wastes are excellent medium for the growth of pathogenic bacteria, viruses and protozoa. Intestinal parasites are abundant in solid wastes. The pathogen *Anthrax bacilli* is present in tannery wastes. Metallic contaminants destroy bacteria and beneficial microorganisms in the soil reducing the soil fertility. Garbage having rotting food, kitchen waste, sanitary items has infectious microorganisms and unpleasant odors. The hazardous wastes can injure workers who collect or process them, if they catch on fire, give off fumes, or contact worker's skin or eyes. Hazardous wastes also damage the facilities that handle them. Wastes are called **hazardous** because of their characteristics such as toxicity, corrosivity, flammability and reactivity. The

wastes containing certain toxic chemicals, such as organochlorine solvents, phenols, heavy oil, metals and pathogenic organisms are hazardous in nature. Bio-medical waste is hazardous.

Solid Waste Management

The Government of India enacted a technology policy statement in 1983 on waste management with the objectives that 'Recycling waste material and make full utilization of products' and 'ensure harmony with the environment, preserve the ecological balance and improve the quality of habital.' A **National Waste Management Council** has been set in January 1990, by Ministry of Environment and Forest, Government of India to act as a nodal agency to recommend the waste utilization policy. The Ministry of Non Conventional Energy Source has launched a National Pilot Programme on Energy recovery from urban, municipal and industrial wastes, which offers incentive packages for promoters, financial institutions and beneficiary organizations to encourage their active participation.

Solid waste management starts from collection, which should be rapid and frequent, because the waste contains organic matter, which can cause insect propagation. In practice, priority is usually given to commercial areas, main streets and neighborhoods under municipalities. Final processing of the waste is the next step of waste management, wherein segregation of wastes in different categories is done followed by final disposal. It is a common practice to dump the wastes in **open dumping grounds**, where combustions occur regularly leading to emission of toxic gases such as **dioxins** and **furans**. Dumping sites are located at a safe distance outside the municipal boundaries, but are increasingly encircled by housing estates because of rapid urbanization. Water and soil pollution takes place at these sites.

A number of diseases such as gastroenteritis, cholera, plague, dysentery jaundice and malaria are inevitable consequences of waste at collection, segregation and dumping sites. **Sanitary land fills** are better planned and managed waste disposal sites which are designed to concentrate and contain refuse without creating a nuisance or hazard to public. The idea is to confine the waste to the smallest practical area, reduce it to the smallest practical volume and cover it with a layer of compacted soil at the end of each day of operation or more frequently if necessary. Covering the waste is what makes the

landfill sanitary. The most significant hazard from a sanitary land fill is pollution of ground water or surface water due to noxious, mineralized liquid capable of transporting bacterial pollutants to ground water. Siting of sanitary landfill is very important. A number of factors including topography, location of ground water table, amount of rainfall, type of soil and rock and surface and ground water flow system are important considerations.

Another solid waste management technique used in cities is **incineration**, which is an industrial combustion process designed to reduce wastes to simple solid and gaseous residues. Incinerators may be used separately for municipal, industrial and biomedical wastes. Carcinogenic gases such as dioxins and furans, heavy metals, acid gases are emitted into the atmosphere and ash left after combustion contains lot of toxic elements. **Composting** is another technology, which involves biological degradation with end products CO_2 and compost. **Biogas** production is an alternative technique used in India in many rural India. Earth warm farming, known as **vermiculture** is another biological technique for converting the solid wastes such as sewage sludge, domestic waste or agriculture waste into compost.

Anaerobic digestion process based on biotechnology has also been developed to treat solid waste and produce **methane** to be used as fuel to generate power and organic manure as by product. Segregation of wastes by hand picking stones, plastics and other organic solids is the first step followed by pretreatment with a stream of water to remove particles of < 40 mm size and then organic matter is pumped into the anaerobic reactor in form of a slurry, which undergoes decomposition and biogas is produced and organic matter is stabilized, which can be used as environment friendly organic manure having excellent fertilizer value. About 150 tonnes of solid waste can produce 14,000 m^3 biogas capable off generating 1.2 MW of power along with 45 tonnes of organic manure per day.

Recycling is an integral part of waste management. Many materials such as paper, metals aluminum cans, glass, plastics and waste oil can be recycled. The energy savings achieved by use of secondary waste materials such as plastics, rubber, glass, paper, steel and iron, magnesium and aluminium from recycling, compared to primary production are

95, 70, 22, 60, 65, 97 and 96%, respectively. Recycling is in true sense conservation of resources.

Reclamation of wastelands traditionally is done through landfills and composting. After few months, the compost is formed within the subsurface layers of landfills which increases the fertility of soil, and also reduces the vulnerability to soil erosion Afforestation with drought resistant and fast growing plants helps maintaining moisture and fast recovery of such waste lands.

Public consciousness: The rise in public consciousness surrounding environmental problems with waste disposal has resulted in the development of new waste management strategy known as **integrated waste management**, which is best defined as a set of management alternatives including reuse, source reduction, recycling, composing, landfill and incineration. The choice of one time use materials i.e **throw away** society should be avoided over use of recycled materials i.e. **sustainable society**. Cellulose wastes from agricultural industries such as bagasse, corncobs can be converted into glucose. Particle boards can be manufactured by rice husk. Coal pellets can be developed from bagasse and wheat straw. Biocoal is superior to hard coke. Flyash, the by-product of coal combustion process can be used to manufacture bricks and cement, in road making, etc. Use of flyash into timber, paint and glass fibres to develop natural geofibre jute and a fireproof fibre acrolite – 52 is attempted.

Bioremediation: Living organisms can be used to reduce the chemical at a waste disposal site, especially the hazardous waste. Certain plants can accumulate as much as 40% of their weight as heavy metals without harm to them. These plants can then be harvested and burned to recover the metals.

POLLUTION CASE STUDIES

Bhopal Gas Tragedy

The biggest air pollution episode occurred in India at Union Carbide of India Ltd, Bhopal on the night of December 3, 1984 taking a death tol1 of 14, 775 people. Union Carbide was manufacturing batteries, plastics carbamate pesticide, etc using methyl isocyanate (MIC). MIC plant started in February 1980. The pressure in MIC tank increased tremendously due to fault of an operator, who forgot to seal the rest of the system, when

connected the water hosepipes to the tubes for washing. Due to very high pressure in MIC tank, safety valve had opened and MIC vapour escaped from a vent line upto 120 feet in the air. The safety value remained open for about two hours releasing over 50,000 pounds of gaseous and liquid associated with other toxic chemicals. The safety valve reseated after three hours when tank pressure dropped tremendously.

The deadly poisonous gas spread over 40 sq. km seriously affecting the people at a distance of 5 to 8 kms. An estimated 50,000 people fled that night. Out of 2,50,000 people exposed, 65,000 were severely hit from eye, and suffered from respiratory, neuromuscular, gastro intestinal, lung fibrosis, pulmonary edema and gynecological disorders. Jai Prakash nagar was badly hitted by the emission, where domesticated amimals and human being were lying silent. The death toll continued for four days. About 1000 people became blind. The hospitals were crowded by patients. Reports are also that new generations are suffering from genetical disorders because of exposure of their parents.

Photochemical Smog at Los Angeles

Los Angeles in California, USA experienced a serious type of air pollution problem in 1944, which was characterized by reduced visibility, eye irritation and plant damage. The pollution was caused by photochemical smog, a brownish orange haze formed by chemical reactions involving sunlight. Photochemical smog was worst during summer months, when nitrogen oxides and hydrocarbons largely from automobile exhaust interact in presence of strong solar radiation to from 100 different secondary air pollutants such as ozone and peroxyacetyl nitrates, which can injure plant tissue, irritate eyes and aggravate respiratory illness in humans. The problem at Los Angeles was aggravated due to climate and topography of the area. Because of atmospheric stagnation and location of Los Angeles near the coast and surrounded by mountains from three sides, polluting gases remain trapped in higher concentrations close to the ground, where people live and breathe and crops grow. The rubber articles showed severe cracks in presence of photochemical smog.

Air Pollution and Periurban Agriculture in Varanasi

In Varanasi, results of a long-term field study conducted to evaluate the impact of urban air pollution on agriculture in urban fringes showed significant negative effects of urban

air pollution on yield of economically important plants. Pollutant concentrations showed spatial and temporal variations. Concentrations of primary pollutants like SO_2, NO_2 and particulate were higher in urban areas having small scale industries and road transactions, while O_3 concentration was highest at urban fringes and rural area supporting agriculture. Seasonally, SO_2 and NO_2 concentrations were highest during winter, while O_3 and particulates were maximum during summer. Areas having thick vegetation showed lower concentrations of all the pollutants. Yield reductions at various sites were assessed in response to ambient air pollution. The percent losses in production and economic value ranged from 18 to 30% for wheat, 29 to 42% for mung and 15 to 38% for pea plants in the outskirts of Varanasi. The yield losses were directly correlated with ambient concentrations of SO_2, NO_2 and O_3 in the area. Ozone was suggested to be most phytotoxic in rural areas.

Pollution in River Ganga

The sewage and industrial wastes produced by more than 500 million people who live in the Ganges river basin are dumped into the river along with surface runoff from agricultural fields on both the banks. Many physical and chemical properties of the water have shown sign of deterioration due to uncontrolled effluent discharge. The biological oxygen demand of the water exceeds the prescribed limit at several points. Many pathogenic microorganisms responsible for water borne diseases were found to show higher occurrence. The Indian Government had initiated an ambitious clean up project known as Ganga Action plan that includes construction of water treatment plants in large cities in the river basin and sitting up many electric crematoriums along the banks.

Pollution in Ground Water

In January 1994, the Central Pollution Control Board, Delhi undertook the first major ground water quality monitoring exercise. The report published in December, 1995 identified 22 places in 16 states of India as critical sites of ground water pollution, the culprit being industrial pollutants. Most of the industries deal with pharmaceuticals, paints, pigments, metal treatment and steel rolling. In Andhra Pradesh, mercury and arsenic levels in ground water in and around Pocharam village, Patancheru Industrial area are as high as 700 ppb against the permissible 10 ppb recommended by WHO. The

ground water in Ludhiana is a cocktail of heavy metals, cyanide, alkaline content and pesticides.

Exxon valdez Oil Spill

In the midnight of March 29, 1989, supertanker Exxon valdez carrying Alaskan crude oil ran aground near a town. The pipelines delivering to valdez through Alaskan pipelines poured out of the ruptured tanks of the tankers at about 20,000 barrels per hour. Approximately 11 million gallon crude oil entered the marine environment. This area is considered one of the most prestine and ecologically reach marine environment of the world. Immediate effects of the spill included the death of thousands of marine mammals more than 250,000 birds. More than 2 and 5 billion dollar has been spent to clean up the spill, which further killed coastal organisms that live under the rocks and had survived the initial impact of spill. In addition, oil spill disrupted the lives of the people who live and work in the vicinity of town Prince William Sound.

ROLE OF AN INDIVIDUAL IN PREVENTION OF POLLUTION

The most critical environmental problems from which all other arise, are our own attitudes and values. We are all travelers on a spaceship – the earth. Our survival depends upon the continuing function of the vital life support system of the spaceship the air, the water, and the soil. Unfortunately, we neglectfully dump pollutants into our spaceship at a faster rate than our support system can handle them. Our survival in the coming decades will depend, in part, on our ability to regulate and control the freedom of each individual to pollute our common spaceship, the earth. We are totally out of touch and out of balance with the world, and until we reconnect and readjust in some significant way, all solutions to prevent pollution will be stopgap ones.

As an individual, we don't feel part of the global ecosystem, we feel separate, above it, and therefore in a position to consume and abuse without thought of consequences. There is a **need to be part of nature not apart from nature**.

Frequently, single individual have, or at least believe they have only a minor effect in preventing pollution (even though they may understand that their aggregate effort is quite significant). Facing this "**commons dilemma**" individuals may believe that it is pointless for them to undertake environmentally safe actions. This logic has been observed in areas

such as recycling and air pollution. For example, auto emissions clearly contribute significantly to air pollution but there are also many other causes of air pollution (factories, power plants, and so on). Since any single auto does not have a significant effect on air quality, majority of people believe the costs of car pools outweigh their benefits. An additional and related feature of the commons dilemma is that the individual pays the cost of pollution prevention but "society" gets the benefits. Socially responsible action by a single person to reduce pollution causing emissions is for the benefit of "society". A second problem is that the primary locus of pollution prevention activity may be by commercial, industrial or government agencies, which may be the cause of paradoxical behavior by an individual regarding pollution issues. The third factor that influences individual decision making on environmental issues is the fact that payment for pollution prevention is in a different 'coinage' than perceived benefits. For example, if people are interested in reducing auto emissions, they might increase their use of public transportation and car pools. Payment of these changes is not in money or easily quantified foregone consumption, but in personal comfort and commuting time. Global warming, water contamination, recycling and reduction of the ozone layer all have long pay back periods.

Any actions taken today could severely influence future generation, but many people alive today may not be benefited at all. Individual decisions on the use of pesticides may have both long-term effects for the farmer and far-reaching effects for society. Success of organic agriculture depends both on growers focus on lowering the use of pesticide and on organic agriculture, which is self regulated on the part of grower, and on the willingness to pay by consumers for guarantees of sustainable agricultural practices. Individuals, who have many problems of their own, will simply fail to register ill-defined environmental problems as deserving their attention. The prescriptive 'cure' for this is that policy makers must set priorities and select for public discussion and participation for those few problems that are both environmentally important and for which individual participation is essential for several reasons:

(i) Individual is exposed to a risk, which can be avoided or mitigated through individual action.

(ii) Problems such as solid waste recycling, indoor air pollution, etc originate with the individual and require his/her participation in any solution.

(iii) Cost of the pollution prevention is large and public consensus is desirable.

For many high priority problems of pollution clear and direct communication to the individuals is essential ingredient to gain acceptance by the affected public that they should address the problem. The appeals to civic pride or to the global consequences of individual action '**think globally act locally**' cannot be successful unless individual behavior can be directly or clearly linked to the pollution effects in question. The important steps, which an individual can offer in prevention of pollution are:

1. Carefully control most important factor which tends to increase pollution i.e. **population control**.
2. Live in harmony with nature by growing more and more trees. Plants being outdoors can absorb assimilate and metabolize pollutants, and thus reduce its burden in air, water and soil environment. Plants have very high dust capturing capacity, therefore plantations reduce dust load in the cities. Even single trees in the house or potted plants are sufficient to reduce air pollutants in the house interior.
3. To reduce vehicular emission, individuals can use **public transport**. For going to the offices, **car share** or use of shared buses may reduce the use of personal cars. For short distances, it is better to walk than using personal automobile. Walking is otherwise good for health also.
4. Inefficient appliances may harm the environment through the excess use of electricity and its by products (SO_2, CO_2, NO_2 and fly ash). Restricting the wastage of electricity by individuals will not only put lower demand of electricity, but also prevent air, water and soil pollution.
5. Individuals can prevent pollution by following reuse and recycling approach. Recycling reduces resource costs (especially non-renewable) and also put lower pressure on solid waste disposal facilities.
6. By banning cigarette smoking, individuals not only reduce their health hazards, but also reduce the exposure of people around.

7. Proper, safe and hygienic disposal of household solid waste near individual houses is also the responsibility of a citizen. Decomposable solid waste from kitchen may be collected for composting and may be used in kitchen gardens.
8. Wastewater from kitchen and washrooms may also be used for watering plants in kitchen garden.
9. Individuals can deter from the use of hazardous household products such as pesticides, solvents, ammonia, and chloroform carbons. These hazardous substances may be kept out of reach to children.
10. Do not use the toxic if it is not necessary. For example drain cleaners are corrosive, avoid using them and maintain home drains with boiling water and baking soda. Similarly avoid using mothballs, which contain insecticide, instead store fabrics clean because moths are attracted to stains on fabrics. Dried neem leaves can also be used as natural pesticide without harmful effects on individuals.
11. Do not use aerosol products in closed rooms. The houses must be made well ventilated to reduce the indoor air pollution. The most common contaminants, of indoor air are radon, cigarette smoke, carbon monoxide and nitrogen dioxide from gas stoves, formaldehyde from carpeting and furniture household, pesticide, asbestos, microorganisms, dust mites, pollen, etc. Sick building syndrome is often described as presence of air pollution inside office buildings causing eye irritation, nausea, headaches, respiratory infections, depressions, and fatigue.
12. Leaded paint should be avoided in home. Oil based paints containing mineral spirits or petroleum distillates should be avoided. Water-based paint is less hazardous.
13. Out side home also pesticide use for removing weeds should be avoided. Use biological means to help deter predators or rotate the seasonal crops from year to year to lower the pest populations in kitchen gardens.
14. Individuals should be ready to pay higher cost for products of organic farming, an pollutant free technique instead of buying cheaper products obtained by using chemical fertilizers and pesticides.

15. Environmental awareness to the ill effects of pollution and benefits derived due to its prevention is also the responsibility of individuals. Individuals can enthuse public in pollution prevention through neighbors hood 'clean up' campaigns.
16. A well-informed individual can adequately fulfill watchdog function for pollution prevention. Individuals play major role in public awareness, public supervision and public pressure to prevent pollution.

DIASTER MANAGEMENT: FLOODS, EARTHQUAKE, CYCLONE AND LANDSLIDES

Disaster is a sudden adverse or unfortunate extreme event, which causes great damage to property, income and lives. Disasters occur rapidly, instantaneously and indiscriminately.

FLOODS

Floods mean a condition of abnormally great flow in a river or other water. Floods are one of the most common, but pervasive natural hazards in India. About 40 million hectares of land is prone to frequent floods in India, whereas 35% more can be affected occasionally. Approximately 3.8 million hectares cropped area supporting about 3% of the population is annually affected by floods and takes a toll of 2% of the food grain produced.

Causes of Floods: The causal factors of floods are:

(i) Large scale deforestation in hill catchment leading to rapid flow of water

(ii) Concentrated and torrential nature of monsoonal down pour

(iii) Excessive melting of snow

(iv) Silting up and rising up of river beds

(v) Sudden change in gradient from mountains (steep) to plain (flat)

(vi) Occasional cyclones, earthquakes and landslides

(vii) Heavy spell of rainfall in semiarid or arid zones, and

(viii) Broad basins, but narrow outlets.

In addition to these natural causes, human activities such as clearing of vegetated areas resulting in large scale erosion, landslides, irregular stream regimes and saturation of river beds contribute to severity of floods. The National Flood Commission has also

ranked deforestation as number one causal factor of floods. Broadly flood occurrences are linked with overall intensity of rainfall and denuded nature of water sheds.

The flood-affected tracts in the country are Gangetic plains (covering large parts of eastern U.P., Bihar, and West Bengal), along Brahmputra (Assam valley) and Mahanadi, Godavari, Narmada and Tapti (Deltaic region). The duration of floods is not uniform as it ranges from 6 to 12 weeks in Assam valley, 4 to 6 weeks in Gangetic plain and 1 to 3 weeks in Gujrat, Orissa, Panjab and Deltaic regions of South India. Floods have devastating capacity in terms of colossal loss of crops, other properties and lives owing to unrestrained great flow of water in and around the flood plains. Extensive flood plains are formed due to sedimentation of alluvia along the river.

Effects of Floods

Flood losses not only cause immediate losses of property and life, but also have long term losses in soil fertility and water resources and destabilization of ecosystems. In Gangetic plain 60% of the flood prone area is densely populated. An urban area with impervious surface and storm severs experiences more floods than before urbanization. Rivers like Kosi, Tista, Gandak and Ghaghra break through their embankments because of rise in riverbeds and high sediment load. Sediments spread over flood plains may not be useful for agriculture unless charged by humus and mineral nutrients.

Remedial Measures for Flood Control

Regulation of water flow within the rivers is most important remedial measures of flood. This effort requires a combination of biotic, engineering and administrative approaches.

Biotic Approach

Regulation of flow of water through afforestation. In vegetated areas, rainwater is largely absorbed and the rush of water to cause flood may be avoided. Plantations on slopes of calchment areas are suggested to be important components of watershed management aiming at reducing runoff, siltation and consequently floods.

Engineering Approach

This approach can direct the flood channels away from damageable property. It includes construction works such as embankment to prevent spilling of floodwater. Dams and reservoirs to control the water flow and also channel improvement work like dredging.

Careful planning of whole river basin through flood prone zoning with viable engineering measures will definitely reduce the severity of floods.

Administrative Measures

An orderly land use and settlement planing on the basis of identification of flood prone areas will discourage people to settle in such areas. A great deal of help in minimizing loss of lives may be achieved by providing flood forecasting and timely warning of this hazard. Quick relief measures to affected population by shifting them to proper place and make arrangements for proper food, medicine and sanitation also come under administrative measures. Floods are often followed by epidemics such as dysentery, diaorrhia, cholera and jaundice. Provision for compensation and insurance to agriculture and industries are another administrative measures for flood disaster preparedness.

EARTHQUAKES

It is the major demonstration of power of the tectonic forces caused by endogenetic thermal conditions of the interior of the earth. 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. Of all natural disasters at global level, earthquakes are most disastrous accounting for massive damage to settlements and human life. The intensity of energy released by an earthquake is measured by the **Richter scale** devised by Charles F. Richter in 1935. This scale ranges between 0 and 9. Earthquake of March 27, 1964 in Alaska measuring 8.4 to 8.6 and in Bihar during 1934 measuring 8.3-8.4 are among the greatest earthquakes of the world ever recorded. Deaths of more than 100 million people are recorded since the beginning of recorded history of man in the world.

The place of the origin of an earthquake is called **focus**. 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 waves generated by an earthquake are called **seismic waves**, which are measured by **seismometer**. The science that deals with the seismic waves is called **seismology**.

Causes of Earthquakes

Earthquakes are mainly caused by disequilibrium or isostatic imbalance in the earth's crust such as volcanic eruptions, faulting and folding caused by horizontal and vertical

movements, upwarping and downwarping, gaseous expansion and contraction inside the earth, hydrostatic pressure of man made water bodies like reservoirs and lakes and plate movement. Earthquakes occur restrictively on the margins of crustal plates and in zones of falts and thrust that cut the lithosphere plates into blocks and sheets.

Classification of Earthquakes

On the basis of hazardous impacts in terms of human causalities, earthquakes may be

(i) moderately hazardous: human deaths below 50,0000, (ii) highly hazardous: human deaths between 50,0000-10,00,000 and (iii) most hazardous causing human deaths more than 1,00,000. The world map of the distribution of earthquakes identifies three belts prone to this disaster:

(i) Circum-Pacific belt surrounding the Pacific ocean and accounts for 65% of the total earthquakes of the world.

(ii) Mid continental belt representing the epicentre along the Alpine-Himalayan range of Eurasia and northern and east African fault zones accounting for 21% of total seismic events of the world.

(iii) Mid Atlantic belt located along the mid Atlantic ridge including several islands nearer the ridge experiencing moderate and shallow focus earthquakes.

Earthquakes are mostly restricted to northern Indian segments including Kachchh, Pak, Afganistan ranges, Himalaya and Assam.

Effects of Earthquakes

The hazardous impacts of earthquakes are not determined on the basis of magnitude of seismic intensity, but on the quantum of damages done by a specific earthquake to human lives and property. An earthquake becomes disaster only when it strikes the populated area. The disastrous effects of earthquakes include deformation of ground surfaces, damage and destruction of human structures such as buildings, rails, roads, bridges, dams, factories, destruction of towns and cities, loss of human and animal lives, property, violent devastating fires, slope instability and failures leading to landslides, flash floods, disturbances in ground water conditions.

Remedial Measures

Earthquakes can not be avoided, but some preventive steps may save the loss of life and property. Primary tremors are felt a few minutes before the main shock. There would be

sufficient time to run to an open place of safety after recognizing primary tremor. The earthquake prediction technique may be helpful in avoiding loss of lives. An interpretation of past records concerning tectonic movements and ground water level variations may also indicate the possibility of coming events.

Specific designs of houses have been suggested for earthquake prone areas. Use of wooden frame and light materials for ceiling and better foundation of structures should be preferred in earthquake prone areas. The loss of life in an earthquake is due to the falling of the buildings. It is found that buildings on loose, unconsolidated mantle rock are more vulnerable than those placed on bedrock. Steel frames with all trimmings firmly fastened to the framework should be preferred in walls instead of just the use of brick and other loose objects which may be topple down very easily. Dwellings made of wood stand up much better than those of stone, because of greater flexibility of wood but these must be guarded against the possibility of fire.

Provision of relief measures to earthquake affected people is one of the most important step after the disaster. Relief measures must be concentrated in the high density areas of the affected locality. Special rescue tools, communication equipments, machines to remove the debris, water pumps are required for various works during rescue in affected localities. People must be aware about the possibility of such events in vulnerable areas so that they may be prepared to evacuate their houses in wake of timely warning of earth quakes.

CYCLONES

These are centers of low pressure surrounded by closed isobars having increasing pressure outward and closed air circulation from out side towards the central low pressure area in such a way that air blows inward in anticlock wise in the northern hemisphere and clockwise in the southern hemisphere. Cyclones are thus termed as **atmospheric disturbances**. When the velocity of winds increase to such an extent that they attain gale force, the cyclone is called a **cyclonic storm**.

Types and causes of cyclone

On the basis of location, cyclones are either extra tropical (also called temperate or wave cyclones) and tropical cyclones. **Temperate cyclones** are formed in the regions extending between $35^{o} – 65^{o}$ latitudes in both the hemispheres due to convergence of two

contrasting air masses i.e. warm, moist and light tropical air masses (westerly wind) and cold and dense polar air masses. **Tropical cyclones** develop in the region lying between the tropics of Capricorn and Cancer. These cyclones become very vigorous with high velocity over oceans, but become weak and feeble while moving over land areas and ultimately die out after reaching the interior portion of the continents. This is why these cyclones affect only the coastal areas of the continents. South and south east coast of India i.e. Tamil Nadu, Andhra Pradesh, Orissa and West Bengal are more vulnerable to cyclones. Cyclones are endemic on the Andhra Pradesh coast, one hitting every second year. On November 13,1970, cyclone in A.P. took a toll of 2,00,000 human lives, 80,000 heads of livestock, destroying more than 2,00,000 houses, 80% of standing paddy crops and 65% of fishing capacity. Tropical cyclones become disastrous natural hazards because of their high wind speed of 180-400 km per hour, high tidal surges, high rainfall intensity, and very low atmospheric pressure causing unusual rise in sea level and their persistence for several days. Tropical cyclones may be weak such as tropical disturbances and **tropical depressions** or strong and furious such as **hurricanes** or **typhoons** and **tornados**.

Effects of Cyclones

Tropical cyclones are very severe disastrous natural hazards causing heavy loss of human lives and property in terms of destruction of buildings, transport systems, disruption of communication system, destruction of standing agricultural crops, and domestic and wild animals, natural vegetation, and private and public institutions. Other ill effects of cyclones include encroachment of salt water to agricultural fields spoiling their fertility for long duration, electrocution, rail accidents and diseases.

Remedial Measures

Although cyclones can not be prevented, yet measures like provision for advance warning system may facilitate in reducing the intensity of damages. The role of storm forecasting stations of Indian Meteorological Department is very crucial especially to ports, railways, irrigation and fisheries departments. Radio, television and newspapers can help by way of warning the public in advance. Fishermen need to be warned much in advance not to go into the sea for fishing. Post cyclone rescue measures can be of great help in restoration of normal situation. Infrastructure to facilitate quick rescue operations

in cyclone prone areas needs to be strengthened for urgent repair works of electric and telephone wires and rebuilding of damaged structures.

LANDSLIDES

All types of mass movements of rock wastes including soils due to force of gravity are called landslides. Downslope movement of different types of debris inblocks is landslide. Uttaranchal, Jammu and Kashmir, Himanchal Pradesh, Arunachal Pradesh and North Bengal are the main states affected by vagaries of landslides. Mountain regions, Himalayas and Nilgiri are particularly common in geodynamically sensitive belts i.e. zones repeatedly rocked by earthquakes and other neotonic activities. Dargeeling Himalaya recorded more than 20,000 landslides in one day in vulnerable areas.

Types of Landslides

There are four categories of landslides based on type of movement. Instantaneous fall of weathered rock materials including large blocks from steep hill slopes or cliffed valleysides of streams is called **fall. Slides** commonly known as land slides signify mass movement of weathered debris downhill along discrete shear surfaces. Diagonal downslide movement of rock fragments and soils along sliding plane with enough water is called **flow**. Very slow and imperceptible downslide movement of rock material is called **creep**.

Causes of Landslides

The major factors affecting landslide are slope and excessive human interference. The slope generates gravity force for sliding, slumping and creeping of materials. Human interferences leading to landslides are construction of roads, hillside houses, dams, reservoirs, drainage and other utility structures. Removal of forests on mountains, overgrazing of hillside slopes and unscientific use of dynamites in susceptible areas are the important human interferences causing landslides in India. Landslides have been found to be associated with unfavorable geological structures and compositions, inadequate period for drainage or runoff and also deep seated earthquakes causing rock breaking.

Effects of Landslides

The impact of landslides can be measured with reference to the extent of damage and loss of property and human life and depletion of agricultural land. Floods are also caused by

landslides. Landslides cause inconvenience through substantial disruption of traffic and communication.

Remedial Measures

Provision for afforestation and vegetal cover on the hilltops, valley spurs and slopes, immediate restriction on overgrazing and large-scale deforestation are immediate steps required to prevent land slides in Indian condition. Prior information about the likelihood of landslide occurrences through installation of instruments on the slope and regular monitoring may indicate pattern of cracks, which may be early warning symptoms for the landslides. The electro osmotic stabilization proves more useful where ground level and increased pore water pressure are the causal factors of landslides. Avoiding use of high power explosives for road or rail excavation and other constructional activities in mountainous regions and protection of slopes from erosion near roads through construction of high embankments may also prevent landslide occurrences. Adoption of conservation methods of watershed management and allowance for draining of streams across the roads through cement pipes may also contribute to prevent landslides along the roads. In case of small rock masses, the load on the head can be released through removal of the rocks or the material could be added at the toe to increase the stability.