9 ENVIRONMENTAL POLLUTION

Recently, first time in his entire cultural history, man has I faced one of the most horrible ecological crisis-the problem of „ pollution of his environment which sometime in past, was pure, virgin, undisturbed, uncontaminated and basically quite hospitable for him. Pollution is an undesirable change in the physical, chemical or biological characteristics of our air, land, and water that may or will harmfully affect human life or that of desirable species, our industrial processes, living conditions, and cultural assets. In other words, pollution is the I unfavourable alteration of our environment, largely as a result of human activities.

By and large, the term pollution is used to refer to harmful materials introduced by man into the environment. Thus, in a way, pollution is the release in excess of permitable limits of foreign substances within the environment.

POLLUTANTS: THE CREATORS OF POLLUTION

Every human society, be it rural, urban, industrial and most technologically advanced socienu dispose of certain kinds of byproducts and waste products which when are injected into the biosphere in quantities so great that they affect the normal functioning of ecosystems and have an adverse efrec: on plants, animals, and man are collectively called pollutants (Smith, 1977). A pollutant is *i* constituent in the wrong amount, at the wrong place or at the wrong time. For example, nitrogen m phosphorus are essential nutrients for living organisms and are extensively used in agriculture k increase crop yields but they can also cause pollution in lakes and rivers when found in excess by promoting undue algal growth (eutrophication).

Types of Pollutants

Pollutants primarily are grouped into the following two types:

1. Natural pollutants. Certain pollutants such as carbon dioxide, carbon monoxide, sulphor dioxide, lead, mercury and other trace elements are the consequence of life processes being produce: through respiration, faeces, urine and body decomposition. With an increase in human population, tre pollutants are increasing with alarming rate.
2. Synthetic, man-made, anthropogenic or xenobiotic pollutants. A vast array of syntherc pollutants are increasing continuously with urbanization and industrial growth. They include pesticides, detergents, pharmaceuticals, cosmetic products, organic acids, aerosols, and metals, etc. Several of these compounds are extremely stable and persist in the environment for a considerable penic posing serious environmental hazards.

From the ecosystem viewpoint, these pollutants can be classified into two basic types nondegradable pollutants and biodegradable pollutants. The materials aai poisons, such as aluminium cans, mercurial salts, long-chain phenolic chemicals and DDT that either do not degrade or degrade only very slowly in the natural environment, are called nondegradabk pollutants. Such nondegradable pollutants not only accumulate but are often “biologically magnifiec as they move in biogeochemical cycles and along food chains. Also they frequently combine with other compounds in the environment to produce additional toxins. The biodegradable pollutants incluae domestic sewage, heat, etc. The domestic sewage can be rapidly decomposed by natural processes or in engineered systems (such as a municipal sewage treatment plant) that enhance nature’s great capacity to decompose and recycle.

Problems arise with the biodegradable pollutants when their input into the environment exceeds the decomposition or dispersal capacity.

AIR POLLUTION

Air pollution is the presence in the atmosphere, or injection into it, of substances that are ax present naturally, or present naturally but is in much smaller concentrations, and that may harm linK organisms directly or indirectly. Thus, when due to some natural processes or huirc activities the amount of solid waste or concentration of gases other than O_2 increase in the air whin normally has constant percentage of different gases in it, the air is said to be polluted and this phenomenon is referred to as air or atmospheric pollution. Air pollution is one of the most dangerous and common kind of environmental pollution that is reported in most industrial towns and metropolitans of India and abroad such as Delhi, Bombay, Calcutta, Kanpur, Madras, Hyderabad, Jaipur, Ahmedabad, Nagpur, Firozabad and also in London, New York, Tokyo, Pittsburg, etc.

Air Quality

In our country, data on air quality have been collected by NEERI. Although there exist several parameters to determine air quality, but only three, *i.e., SO*$_2$ NO_x and SPM (= suspended particulate matter) are used; these give fair idea of load of pollution carried by the air. NEERI has collected data from ten Indian cities/ Metropolitans such as Delhi, Kanpur, Calcutta, Nagpur, Hyderabad, Madras, Cochin, Bombay, Ahmedabad and Jaipur to assess the extent and nature of degradation of air quality due to industrialization and urbanization. Each of these ten Indian cities was surveyed for residential, commercial and industrial situations.

Thus, for sulphur dioxide (SO_2), Calcutta is found to be most polluted city, followed in a descending order by Bombay, Delhi, Ahmedabad, Kanpur, Hyderabad, Madras, Nagpur and Jaipur. However, yearly averages did not exceed 80 ($\mu g/m^3$. Levels of oxides of nitrogen (NO_x) ranged from 4 $\mu g/m^3$ in residential and industrial areas of Jaipur to the highest 40 $\mu g/m^3$ in industrial areas of Ahmedabad (1980) and commercial areas in Kanpur (1980). Level of SPM was highest in Delhi and Calcutta and the lowest in Madras and Bombay (coastal cities). In general, SPM levels in all cities were much above the international levels. Residents of Delhi are exposed to some of the highest levels of air pollution in the country and perhaps the world.

Methods of Detection and Measurement of Air Pollution

Air pollution is usually measured by sampling of air by thermal and by electrostatic precipitarion, Sonkin impactor and electrostatic dust collectors. The particulate pollution is measured by the instrument called deposit gauge or by Owen's dust counter. The thickness of the smoke is measured by Liegean sphere and by Ringelmann chart. The rough estimation of SO_2 in air can be made by ;hemical analysis of the dust collected in a deposit gauge or by a bubbler method. Fluorides are estimated by colour reactions.

Sources of Air Pollution

Air Pollution by Natural Means

Nature adds few natural pollutants such as pollen, hydrocarbons released by vegetation, dusts from deserts, storms, and volcanic activity. Thus, volcanic eruptions may eject large amounts of gases Vehicle exhausts release a collection of chemicals including carbon monoxide, sulfur dioxide, nitrogen oxides and hydrocarbons. Some gasoline also contains lead, which appears in the exhaust fumes and

can have adverse effects on brain development in children. Throughout the world's cities, many people - such as cyclists, who have to breathe deeply while in close proximity to vehicle exhausts - have begun to wear masks to filter the air they breathe. Here, a Green Party protestor against the poor quality of city air in rome emphasizes the point and particulate matter. Settling volcanic ash can kill vegetation by coating leaves and prevent photosynthesis and transpiration *(e.g.,* following the 1980 eruption of Mt. St. Helens, USA). Fine particles, mainly of sulphates, may penetrate the stratosphere, spread widely and reflect signified amounts of solar radiation, leading to climatic cooling. Likewise, dust storms sometimes carry fine sand for thousands of kilometers and favourable weather conditions stimulate the release of pollen, affecting people sensitive to it.

Air Pollution by Human Activities

(a) *Industrial chimney wastes:* There are a number of industries which are potent sources of air pollution. Petroleum refineries are the major sources of gaseous pollutants *(e.g.,* SO_2, NO_x, etc.) Mathura-based petroleum refinery has been accused to aggravate the pollution-related decay of Taj Mahal in Agra and other historical monuments of Fatehpur Sikri Complex. Industrial processors such as metallurgical plants and smelters, chemical plants, petroleum refineries, pulp and paper mills, sugar mills, cotton mills, and synthetic rubber manufacturing plants are responsible for about one fifth of the air pollution. Cement factories emit plenty of dust, which is potential health hazard. Stone crushes and hot mix plants also create a menace. The SPM levels in such stone crushing areas are found to be five time the industrial safety limits. Chemical manufacturing industries emit acid vapours in aic.

(b) *Thermal power stations:* The coal consumption of thermal power stations of India (*e.g.,* Delhi has three thermal power stations, one at Indraprastha Estate, others at Rajghat and Badarpur) is several million tonnes. The chief pollutants of coal burning are fly ash, SO_2' and other gases (CO, NO_2), aldehydes and hydrocarbons.

GREEN HOUSE EFFECT

Carbon dioxide is a natural constituent of the atmosphere, but, its concentration is increasing in the air with an alarming rate. A byproduct of the burning of fossil fuel, it is not necessarily a pollutant. It produces adverse physiological efects only at very high levels. It is estimated that approximately one-half of the CO_2 input stays in the atmosphere and other half of it is removed by the oceans and by plants. The increased amount of CO_2 in atmosphere is found to increase the temperature of earth.

The spectral properties of CO_2 in the atmosphere are such that it tends to prevent the long wave radiations (i.e., infra-red heat radiation) from earth from escaping into outer space and deflect it back to earth. The latter has an increased temperature at surface. This phenomenon is called atmospheric effect or greenhouse effect.

The simultaneous cooling and heating effects of air pollution on earc have increased variability in the world-wide weather patterns which may be a serious threat to global foof production. Recently, certain ecologists have tried to correlate air pollution with serious and prolonged droughts, heavier rains am floods, and more serious hurricanes and tornadoes.

Scientists fear that increased level of CO_2, will increase the greenhouse effect and thereby increase the temperature of the earth. Only a slight temperature rise would cause the polar ice caps to melt and to cause an enough rise in sea level submerging a number of major cities of the world, because many are along coasts.

Simultaneously, along with carbon dioxide man has been adding solid particles and droplets into the air which increase the albedo or shineness of the earth. This should act contrary to the greenhouse effect, reduce the sunlight reaching the earth and tend to lower the temperature of earth.

(c) *Automobiles:* The transportation industry exclusive of automobiles and including railroads, ships, aircrafts, trucks, buses, tractors, etc., contribute the same type of pollutants as cars. The vehicular exhausts are toxic being a source of considerable air pollution, next only to thermal power plants. The ever increasing vehicular traffic density poses continued threat to the surrounding air quality. At the global level, there are over 300 million cars, trucks and buses and their number is increasing rapidly. India too has millions of vehicles, of which more than 65% are two wheelers operating on petrol.

The sources of emission in the automobiles are (i) exhaust system; (ii) fuel tank and carburettor and (iii) crankcase. The exhaust produces many air pollutants including unbumt hydrocarbons, CO, NO_x and lead oxides. There are also traces of aldehydes, esters, ethers, peroxides and ketones; these are chemically active and combine to form smog in presence of light. Due to volatile nature of petrol, evaporation from fuel tank goes on constantly and results in emission of hydrocarbons. The evaporation through carburettor occurs when engine is stopped and heat builds up and as much as 12 to 40 ml of fuel (petrol/diesel) is lost during each long stop causing emission of hydrocarbons. Some gas vapour escapes between walls and the piston, which enters the crankcase and then discharges into the atmosphere. Thus, the total hydrocarbon emission of an engine reaches upto 25%.

Other sources of air pollution are minor in quantities but bear significance due to the harmful substances they release, these are agriculture, which is responsible for pesticides, dust from agriculture practices and field burning, and the construction industry.

Types of air pollutants: All the just described sources of air pollution release the following air pollutants: 1. Carbon compounds *(e.g.,* CO_2, CO); 2. Sulphur compounds *(e.g.,* SO_2, H_2S and H_2SO_4) 3. Nitrogen oxides *(e.g.,* NO, NO_2 and $HN0_3$); 4. Ozone (0_3); 5. Flurocarbons; 6. Hydrocarbons *(e.g.,* benzene, benzypyrene, etc.); 7. Metals *(e.g.,* lead, nickel, arsenic, beryllium, tin, vanadium, titanium, cadmium, etc.); 8. Photochemical products *(e.g.,* olefins, aldehydes, photochemical smog, PAN, PB_2N, etc.); 9. Particulate matter *(e.g.,* fly ash, dust, grit and SPM); and 10. Toxicants.

Ecology of Air Pollution

Once injected into the atmosphere, pollutants enter the biogeochemical cycles by different routes. The air above many cities can assimilate and disperse great quantities of fine particulate and gaseous pollutants as long as air can move and disperse. But if air masses over cities become stagnant, pollutants accumulate quickly and deteriorate air quality which cause many respiratory diseases in man and other animals. Air pollutants also accumulate during temperature inversions, when cooler surface layers of air become trapped under warmer upper layers. In these situations, the upper layers of warm air prevent the vertical rise and disperse! pollutants which are held near the ground. Temperature inversions commonly occur in surrounded by mountains or bordered by mountains on the leeward side.

Further a portion of air pollutants reaches land as dry fallouts; it may then enter various nutrient cycles and food chains through water and soil. Other contaminants of air react chemically photochemically with other and produce such ondary pollutants sulphuric acid, ozone, peroxyacetyl nitrate or PAN Aerosols and other for fine particulate matter condensation nucl which water vapours in the air quickly surr form droplets of fog or rain.

Moreover, different air pollutants adversely affect flora, fauna and climate of a given area

variously and some of the common air pollutants and their specific effects on vegetation, climate, etc., have been discussed as follows:

Gaseous Pollutants

Sulphur oxides and hydrogen sulphide: These gaseous pollutants are naturally released the biological decomposition and from volcanic eruptions. They are also released artificially human activities such as smelting of sulphide-containing ores, combustion of sulphur-containing such as coal and oil, petroleum refining and obtaining of geothermal energy.

According to a report the sulphur dioxide (SO_2) content of the atmosphere in Delhi cirreached the level of 0.233 ppm, whereas in USA and West Germany the permissible limit is only 0.1 and 0.05 ppm. Concentrations as low as 0.3 ppm may damage plants. Lichens are particularly to SO_9 and in polluted regions one does not find lichens growing on the tree trunks. Thus, quantities of sulphur dioxide suppresses the overall vegetative as well as reproductive growth and Its high atmospheric concentrations produce various injuries to leaves such as interveinal and damage, necrosis of leaves and cellular collapse. However, moderate SO_2 pollution in chlorosis of leaves without cellular collapse. Pine trees are more susceptible than broad leaved and react by partial defoliation and reduced growth. Plant's exposure to hydrogen sulphide sulphide results in leaf lesions, motting, defoliation and reduced growth.

Sulphur dioxide pollution causes in human beings various types of injuries such as eye irritation, chest constriction, headache, vomiting and death from respiratory ailment. It paralyzes or destroys bronchial cilia in air passages of man, constricts bronchii, damages lungs, lowers resistance to pneumonia and influenza and causes bronchitis, emphysema and irritation of the mucous membranes (i.e., an increase in cough and sputum). In fact, SO_2, and other pollutants bring about coalescence of alveoli and reduce the amount of surface area available for the transport of oxygen and also reduce the rate at which air is exchanged. When there occurs severe pollution of SO_2, the death rate and bronchial asthma are found to increase and in past it caused such disasters as Meuse Valley in Belgium in 1930; Donora, in 1938; London, in 1952; and New York and Tokyo in 1960s.

Further, in the atmosphere, SO_0 does not remain in the gaseous state for long time, but very soon it reacts with moisture to form sulphuric acid or H_2SO_4. Sulphuric acid causes many respiratory diseases in man and also produces acid rainfalls over parts of the earth. In Scandinavia, downwind from the industrial centers of Britain and the Ruhr Valley, the acidity of the rainfall has increased 200 fold since 1966, with pH values as low as 2.8 being recorded. This acid rainwater has increased the acidity of Scandinavian streams, interfering with salmon reproduction and destroying salmons runs. It has reduced forest growth and increased the amount of calcium and other nutrients leached from agricultural soil. The

PHOTOCHEMICAL SMOG

In the atmosphere nitrogen dioxide is reduced by ultraviolet light

to nitrogen monoxide and atomic oxygen:

$$NO_2 — NO + O$$

Atomic oxygen reacts with oxygen to form ozone:

$$O_2 + O_3 — NO_2 + O_2$$

Ozone reacts with nitrogen monoxide form nitrogen dioxide and oxygen, thus, closir the cycle:

$$NO + O_3 — NO_2 + O_2$$

Sometimes, in the presence of sun atomic oxygen from the photochemical reduc of NO_2 also reacts with a number of hydrocarbons (such as methane, ethane, tol etc., all of which originate from burning of fuels or directly from plants) to form reactive intermediates called radicals. These radicals take part in a series of reactions to form still radicals that combine with oxygen, hydrocarbons, and NO_2. As a result nitrogen dioxide is regenerated, nitric oxide disappears, ozone accumulates a number of secondary pollutants are formed such as formaldehyde, aldehydes and peroxyacetyl nit or PAN ($C_2H_3O_5N$). All of these collectively form photochemical smog.

acid rainfall is also involved in the erosion of building materials as lime stone marble, the slate used in roofing, mortar and deterioration of statues.

2. Carbon monoxide: It is released chiefly from gasoline engines and burning of coal in the defective furnaces. In man, CO produces headache, dizziness, inability to distinguish time intervals, nausea, ringing in the ears, heart palpitation, pressure in chest and difficulty in breathing. This gas combines with haemoglobin of blood to form carboxy-heamog-lobin in RBC which reduces its oxygen carrying capacity to all parts of body and, thus, causing asphyxia. The higher concentrations of carbon monoxide (CO) may be even fatal. CO and nicotine from the cigarette smoke increase the tendency for the blood to clot and so block the coronary arteries. Carbon monoxide also increases the rate at which the fatty materials are deposited in the arteries.

Nitrogen oxides: The natural sources of this pollutant are anaerobic bacterial breakdown of nitrogenous compounds, forest fires and lightning. Its chief anthropogenic sources are power generators and automobile exhausts (motor vehicles). Burning of organic wastes, and manufacture of explosives and nitrogenous fertilizers further add to nitrogen oxide pollution.

Nitrogen dioxide (NO_2), a pungent gas that produces a brownish haze, causes nose and eye irritations and pulmonary discomfort in man. It also produces general and pulmonary oedema and hemorrhage. In plants, NO_2 brings about bifacial necrosis leading to collapse of leaves, enhancement of green colour followed by chlorosis and extensive leaf drop. Ultimately there occur an increase in fruit drop and decrease in fruit crop.

Ozone, PAN and nitrogen dioxide severely injure many forms of plant life, destroying the cell of leaves, damaging the chloroplasts, and interfering with the plant's metabolic processes.

PAN is known to block "Hill reaction" of photosynthesis. It results in bronzing and glazing of abaxial leaf surface which is due to plasmolysis and collapse of mesophyll cells around substomatal chambers. Epidermal and guard cells are not injured by PAN.

Ozone: Levels of ozone (O_3) may rise in atmosphere due to human activities. It is also formed by NO_2 under UV-radiations effect. Minor amounts of ozone are also added to the atmosphere by electric discharges such as lightning flashes, by vertical flux of stratopheric ozone and by tropospheric storms.

Ozone near the earth's surface in the troposphere creates pollution problem. Increase in O_3 concentration near earth's surface is toxic to plants reducing crop yields significantly. It also has adverse effects on human health. Thus, while higher levels of O_3 in the atmosphere protects us, it is harmful when it comes in direct contact with us and plants at earth's surface.

Fluorocarbons (Hydrogen fluoride): Natural sources of fluorides in the atmosphere are active volcanoes. Their man-made or artificial sources are petroleum refining, aluminium, steel and electrochemical reduction plants, blast furnaces, brick-kilns, and tile, glass etching and superphospbac fertilizer industries and combustion of coal.

Fluoride bums the tip of plant leaves. It's low amounts impair plant growth, resflt in excessive dropping of bloom and young fruits, development of small, partially or compieek seedless fruits and premature formation of soft red flesh and splitting of peach. In human being, it irritates and corrode all body passages.

Hydrocarbons: Biological decomposition of organic matter, spill and seepage from natural gas and oil fields and volatile emissions from plants are some major natural causes for the release of hydrocarbons such as methane,

terpenes, ethylene and aniline. Incomplete combustion of fuels, automobile exhaust, petroleum-refineries, agricultural burning, motor fuel marketing, manufacture of explosives and cracking of natural gas in petrochemical plants (as a blow-off emissions) constitute the man-made sources that emit hydrocarbons.

The hydrocarbon ethylene causes yellowing and occasional necrosis of leaves, chlorosis floral buds, inhibition of terminal growth, epinasty of leaves, shortening of intemodes, thickening of stems, lack of apical dominance, stunted growth, dry sepal disease of orchids and decrease in the amount of chlorophyll and carotenoids. Another hydrocarbon aniline results in the appearance of bands on leaves as if they are water-soaked, necrotic spots and abscission of leaves. In man, hydrocarbons bring about irritation of mucous membrane, bronchial constriction and eye irritation. One of the hydrocarbons released due to incomplete combustion, is 3-4 benzpyrene which is said to cause lung cancer. Methyl isocyanate gas when accidentally leaked out from the storage tanks of the pesticide factory in Bhopal on December 2, 1984, had killed over 3,000 persons and seriously affecting lakhs of residents.

Hydrogen chloride: This pollutant is released from combustion of coal, paper, plastics, chlorinated hydrocarbons, accidental spills from the chemical manufacturing plants and ignition of solid-fuel rocket engines in plants, hydrogen chloride causes plasmolysis and collapse of epidermal cells of leaves and thereby results in abaxial glazing of leaves.

Ammonia: The main anthropogenic sources of this gaseous pollutant are refrigerator, precooler systems of cold storages, manufacture of dyes, explosives, lacquers (varnishes) and anhydrous ammonium fertilizers and nitric acids and domestic incineration. Ammonia causes in plants, bleaching of leaves, rusty spots on leaves and flowers, reduction of root and shoot growth, browning and softening of fruits, development of dark, corky lenticels in apples, and reduction in the rate of seed germination. In man, it inflames upper respiratory passages.

Tobacco smoke: Tobacco smoke contains about 300 chemical compounds including nicotine and carcinogens such as tar ("aromatic hydrocarbon"). It is mainly produced by smoking cigarettes and bidis. It is gradually becoming a pollutant especially in closed atmospheres such as buses, trains, auditoria, discotheques and so on. Nicotine stimulates some types of synapse of nervous system, increase blood pressure and heart rate by the production of adrenaline, causes vasodilation in the muscles and vaso-constriction in the skin. When a person smokes, tiny particles in the smoke get caught on the lining of the windpipe and bronchial tubes. Extra mucus is produced and the cilia stop beating. The mucus collects in the bronchial tube and this gives rise to a "smoker's cough".

Repeated coughing may cause the delicate walls of the alveoli to break down into larger spaces. This cuts down the surface area over which gaseous exchange can take place, so the person gets very short of breath. Doctors call this condition emphysema. Tobacco smoke also

BIOMAGNIFICATION OR BIOAMPLIFICATION

Many of pesticides, such as DDT, aldrin and dieldrin, have a long life time in the environment. They are fat-soluble and generally not biodegradable. They get incorporated into the food chain and ultimately deposited in the fatty tissues of animals and man. In the food chain, because of their build up, they get magnified in the higher trophic levels (called biological magnification or biological amplification). The pesticides have been in use during last 50 years. Their targets are insect pests, fungi, nematodes and rodents which damage crops. But these pesticides have created great problems for non-target organisms consisting largely beneficial species such as earthworms, honeybees, fish, amphibia, some reptiles, birds, mammals and man.

The phenomenon of biological magnification is also reported for certain other pollutants such as heavy metals such as lead, mercury and copper and radioactive substances (or radionuclids) as strontium-90.

brings about thickening of bronchial epithelial layer, loss of ciliated cells and appearance of cells with bizarre nuclei, which are probably the precursors of cancerous cells. Although smoking mainly affects the lungs, it can also cause cancer of other organs such as mouth, throat, oesophagus and bladder. It is also associated with heart disease and stomach ulcers and a woman who smokes while she is pregnant is more likely to have spontaneous abortion of still birth or to give birth to an under sized baby.

Particulate Pollutants

Fluorides: The particulate fluorides originate in the same way as the gaseous fluorides. The settle and accumulate on the grass and other vegetation. They are less toxic to these plants causing occasional leaf-tip bums. However, ingestion by cattle of various fluorine compounds falling on forage, causes fluorosis, a disease characterized by abnormal calcification of bones and teeth eventually resulting in loss of teeth, body weight and in lameness.

Fluoride pollution in man and animals is mainly through water. In our country, fluorosis is a public health problem in states of Gujarat, Rajasthan, Punjab, Haryana, U.P., Andhra Pradesh, Tamil Nadu, Karnataka, and some areas of Delhi. Globally it is a problem of various other countries such as USA, Italy, Holland, France, Germany, Spain, Switzerland, China, Japan and some African and American countries.

Lead: Lead, a heavy metal, is injected in the atmosphere mainly from automobile exhaust. Automobile gasoline contains tetraethyl lead that is used as an antiknock additive. Lead is emitted into the air with the exhaust as volatile lead halides (bromides and chlorides). About 75% of lead burnt in gasoline comes out as lead halides through tail pipe in exhaust gases. Of this about 40% settles immediately on the ground and the rest (60%) goes into air. That is why its concentration is higher in urban areas where automotive and industrial exhausts are more.

Mercury: It is a liquid volatile heavy metal which is found in rocks and soil. It is present in air due to human activities such as the use of mercury compounds in production of fungicides, cosmetics, paper pulp, etc. Inhalation of 1 mg/m^3 of mercury in air for three months may lead to human death. Nervous system, liver and eyes are damaged. Infant may be deformed. Other symptoms of mercury toxicity are headache, fatigue, anxiety, lethargy, loss of appetite, etc.

Zinc: Zinc in air occurs mostly as white zinc oxide fumes and is toxic to man. It exists in air around zinc smelters and scrap zinc refineries.

Cadmium: This metal is emitted to air by human activities and industries (*e.g.*, electroplating and welding of cadmium containing materials; industries producing pesticides and phosphate fertilizers. Cadmium occurs in the air in the form of oxide, sulphate or chloride compounds. It is poisonous at very low levels and is known to accumulate in human liver and kidney, Cadmium causes hypertension, emphysema and kidney damage. It may also act as carcinogen in mammals.

Potassium salts: These particulate pollutants are derived mainly from potash mines and cause in plants abnormalities such as branch tip death, chlorosis and necrosis of leaves.

Sodium chloride: Certain salts such as sodium chloride, used to remove ice and snow from roads in winters, are found to cause multiple damage to the roadside trees such as leaf necrosis, defoliation, suppression of flowering, and dieback of terminal shoots in apple.

Agricultural chemicals: Several types of chemicals such as insecticides, herbicides, fungicides and pesticides, used widely in agriculture are found to result in foliar lesions, chlorosis and abscission of leaves and reduction in fruit set.

Particulate matter: The word particulate has been derived from particle and includes all solid or liquid substances primarily in the air. Particulate matter is usually divided into two categories: suspended particulates and dust fall.

(a) Suspended particulates: These are smaller than 10 microns. They are generated by various industrial processes, combustion processes and black soot. In polluted air, their concentration may reach up to 100,000 per cubic centimeter.

(b) Dust fall: Dust fall includes the particles larger than about ten microns. They are emitted into the air by physical processes such as grinding and abrasion, a soot and fly ash (or PFA = Pulverised fly ash) from fuel combustion. Dust particles settle at the ground quickly and cause nuisance to certain industries requiring aseptic conditions such as drug industries and food processing plants. The average level of dust and particulate matter in Dehi is about 600 mg/m^3 in Bombay about 200 mg/m^3, in Calcutta about 300mg/m^3, whereas it is just 150 mg/m^3 in other polluted western cities.

Dust may be inorganic and organic in nature:

1. Inorganic dust containing silica and trapped heavy metals is the main pollutant in mining, quarrying and stone cutting operations.
2. Organic dust raised in cotton textile mills, ginning plants, coir retting and processing, jute and hemp processing, saw mills and plywood industries are also potentially toxic with properties of sensitization of persons exposed to them.

Particulates emitted from cement manufacturing units cause in plants premature fall of needles, higher puberty of leaves, formation of more stomata and trichomes, reduction in number and size of cobs and weight of seeds and increase in number of infertile seeds. Dust from stone crushers, lime kilns and slate making units is also hazardous to plants and human beings. Particles of asbestos that are released from factories can wear off brakes and gears of cars. Coal dust and asbestos have been found to cause in plants, necrotic lesions, reduction in fruit sets and silicosis, asbestosis and lung cancer in human beings. The common dust particles sometime become health hazards as they may lead to diseases such as allergic asthma, bronchitis, emphysema and even fibrosis of lungs. Pulverised fly ash (PFA) is getting accumulated in such large quantities particularly in areas where thermoelectric generators are installed that it has proved to be one of the major sources of solid wastes. Since it contains boron, its deposition by wind in agricultural tracts often results in deleterious effects.

In fact, living organisms are rarely exposed to a single pollutant in nature. The influence of mixtures of pollutants is usually synergistic, *i.e,* greater than the additive effects of the different pollutants alone.

Effects of Air Pollution on Weather, Climate, and Atmospheric Processes

At gross level, air pollution causes two worldwide problems - contamination of the upper atmosphere and the alteration of weather and climate.

Air pollution also affects weather on a continental or global basis. Many gaseous pollutants, fine aerosols reach the upper atmosphere, where they have basic effects on the penetration absorption of sunlight. Brodine (1973) and certain other modem environmental biologists feel increasing particulate pollution may be reducing the amount of sunlight energy reaching the surface, thereby, lowering solar radiation at the earth's surface and producing a cooling effect on world climates which could ultimately trigger another ice age.

Peeling of ozone umbrella by CFMs: Certain fluorocarbon compounds which are called chlorofluoromethanes or CFMs or "freon" are used as propellants in pressurized aerosol cans. They are inert in normal chemical and physical reactions, but they get accumulated in greater amounts at high altitudes and there in the stratosphere these inert gaseous compounds *(i.e.,* CFMs) release chlorine atoms under the influence of intense short-wave ultraviolet radiation.

Each atom of chlorine chain then reacts with more than 1,00,000 molecules of ozone, converting ozone to oxygen. The reduction in stratospheric ozone permits greater penetration of ultraviolet light, which intensifies UV radiation at the earth's surface. Some scientists feel that this intensified radiation will cause a significant increase in skin cancer and eventually have a lethal effects on many organisms, including man. In plants such enhanced level of UV radiations are feared to cause stunted growth, short, thick stems, smaller

leaves, plasmolysis of cells, destruction of anthocyanin, chlorophyll and nuclei. They are known to cause bronzing of leaves, injury to various fruits, somatic aberrations, discolouring of staminal hairs, inhibition of pollen germination and pollen tube growth.

The protective ozone layer of the stratosphere is also considered by many ecologists to be endangered by supersonic jets, the SSTs. The jet engines of supersonic aircraft flying at high altitudes release nitrogen oxides (NO_x) which catalytically destroy ozone molecules.

Control of Air Pollution

Most kinds of air pollutions can be controlled by modem technology, but the costs ultimately be borne by the public in the form of higher prices for manufactured goods, higher taxes, reduced profit margins in industry, and more restrictions on individual activities such as burning leaves and trash and use of automobiles. Following steps have to be taken to control pollution at source (prevention) as well as after the release of pollutants in the atmosphere.

1. Prevention and control of vehicular pollution: For controlling the air pollution because of vehicles, the following measures are adopted:

(a) Curbing the pollutant emission from vehicular exhaust: This type of control can be attained by (i) using new proportion of gasoline and air; (2) more exact timing of fuel feeding; (3) using gas additives to improve combustion; (4) by injecting air into the exhaust to convert exhaust compounds into less toxic substances, and by (5) correcting the engine design and/or fixing cessation device to improve combustion with the existing design. Complete elimination of three main pollutants, namely CO_2, NO_x and hydrocarbons can be attained by either updating the present design of engines or by making appropriate changes in devices for improving combustion. In recent years, I.K. Bharati of Mumbai has claimed to have devised a simple attachment (by the patent name Thermoreactor) to curb air pollution by motor vehicle. The reactor is fitted to the exhaust tail pipe and it converts carbon monoxide into oxygen. Various devices such as positive crankcase ventilation valve and catalytic convertor have been developed in USA to reduce exhaust emissions by automobiles.

(b) *Control of evaporation from fuel tank and carburetter:* This can be performed by (1) collection of vapours with activated charcoal when the engine is turned off; (2) subjecting the gasoline in the tank to slight pressure to prevent the gas from evaporation; and (3) developing low volatile gasoline that does not evaporate easily.

(c) Use of filters: Filters can be used to capture and recycle the escaped gases (hydrocarbons) from the engine *(i.e.,* the gas vapours which escape between walls and the piston and reach the crankcase).

BOD TEST

BOD or biological oxygen demand is the amount of oxygen required for biological oxidation by microbes in any unit volume of water. The test is done at 20°C for at least five days. BOD value generally approximates the amount of oxidisable organic matter (such as sewage and other organic wastes, animals and human excreta, all of which are called oxygen demanding wastes) and is, therefore, used as a measure of degree of water pollution and waste level. Thus, due to addition of sewage and waste, oxygen levels are depleted which are reflected in terms of BOD values of water. The number of microbes as *Escherichia coli* (bacterium) also increase tremendously and these also consume most of the oxygen. The number of bacteria as *E.coli* in unit volume of water is also taken (called *E.coli* index) as a parameter of water pollution. The quantity of oxygen in water (called dissolved oxygen or DO) along with BOD is indicated by the kind of organism present in water. For example, fish become rare at DO value of 4 to 5 ppm of water. Further decrease in DO value may lead to increase in anaerobic bacteria. Typical BOD value for raw sewage run from 200 to 400 mg of oxygen per liter of water (therefore, 200—400 ppm). Water for drinking should have a BOD less than 1.

2. Prevention and control of industrial pollution: To check the air pollution by industrial and power plant chimney wastes , measures are taken for the removal of particulate matter and gaseocs pollutants. In different industries, air pollution can be checked at various steps.

(a) Removal of particulate matter: This process involves collection of particulate matter under the influence of different forces, thereby, moving them continuously out of the gas stream. This step involves the use of following equipments:

(i) Cyclone collector: In this case the waste gas containing particles is subjected to centrifugation. The suspended particles move towards the wall of cyclone body and then to its bottom and finally are discarded out. The cyclone collectors can remove upto 70 per cent of the particles.

(ii) Electrostatic precipitators (ESPs): To remove the suspended particles from gas stream, the electrical forces are applied within the chamber in the precipitator. The particles become charged or ionized, and they are attracted to charged electrodes and removed. ESPs can remove 99 per cent of the particulate pollutants from the chimney exhaust. ESPs work very efficiently in power plants, papermills, cement mills, carbon black plants, etc. Sometimes, high resistivity dust may make separation in an ESP difficult. To overcome this difficulty, fibric filters or beg filters are employed. Further, tall chimneys are used for vertical dispersion of air pollutants.

(b) Removal of gaseous pollutants: These are removed from the chimney exhaust by the following three methods:

(i) Wet systems: These are used as washing towers in which alkali fluid circulate continuously. This liquid react with SO_2 to produce a precipitate. In gas scrubber, a fine spray of water can effectively separate many gases such as ammonia and sulphur dioxide.

(ii) Dry systems: In this case, the gas pollutants are allowed to react with an absorbent under a dry phase. Absorbents such as dolomite, lime (CaO) and limestone (CaOH) are placed in the the flowing gas (SO_2). The process is cheap and does not involve any spray of water.

(iii) Wet dry systems: In these cases water in the absorbent reacts with the acid components. The absorbent calcium hydroxide slurry is spread into the hot gas stream in the form of small Calcium reacts with SO_2, and the hot gases cause the water to evaporate simultaneously. The end product is a dry powder containing mostly fly ash and salts.

Control of air pollution through law: In our country there have been several legislative measures both at state and central Govt., levels to prevent and control different types of air pollutions:

1. Bengal smoke Nuisance Act, 1905;
2. The Motor Vehicle Act, 1938;
3. The Gujarat Smoke Nuisance Act, 1953;
4. The Air (prevention and Control of Pollution Act, 1981) (It was amended in 1987);
5. The Environment (protection) Act, 1986;
6. The Motor Vehicles Act, 1988 (This Act came into force from 1.7.1989).

WATER POLLUTION

The great solvent power of water makes the creation of absolutely pure water a theoretical rather than a practical goal. Even the highest-quality distilled water contains dissolved gases and to a slight degree, solids. The problem, therefore, is one of determining what quality of water is needed to meet a given purpose and then finding practical means of achieving that quality. The problem is further compounded because every use to which water is put-washing, irrigation, flushing away wastes, cooling, making paper, etc., adds something to the water. In fact for centuries rivers and lakes have been used as dumping grounds for human sewage and industrial wastes of every conceivable kind, many of them are highly toxic. Added to this are the materials leached and transported from land by water percolating through the soil and running off its surface to aquatic ecosystems.

The term water pollution is referred to any type of aquatic contamination between following two extremes: (1) a highly enriched,

over productive biotic community, such as a river or lake with nutrients from sewage or fertilizer (cultural eutrophication), or (2) a body of water poisoned by toxic chemicals which eliminate living organisms or even exclude all forms of life.

Normally water contains two types of impurities- dissolved and suspended. Dissolved impurities are gases (H_2S, CO_2, NH_3, etc.) and minerals (Ca, Mg, Na, salts). Suspended matter includes clay, silt and sand and even microbes. Polluted waters are turbid, unpleasant, foul smelling, unfit for drinking, bathing and washing or other purposes. They are harmful and means of many diseases as cholera, dysentery, typhoid, hepatitis, etc.

Types of Water Pollution

Types of water pollution may be classified by the *medium* in which they occur, such as surface water pollution, ground water pollution, soil water pollution, etc.; the habitat in which they occur, such as river pollution, lake pollution, estuarine pollution, coastal water pollution, open ocean pollution, etc.; and *source* or type of contamination, such as nutrient pollution, bacterial pollution, viral pollution, metallic pollution, petrochemical pollution, pesticide pollution, thermal pollu-tion, radioactive pollution, etc.

Kinds and Sources of Water Pollutants

Pollutants entering water sources are classified broadly into following categories: domestic sewage and oxygen-demanding wastes; infectious agents; plant nutrients; chemicals such as insec-ticides, herbicides, and detergents; other minerals and chemicals; sediment from land erosions: radioactive substances; and heat from power and industrial plants.

These aquatic pollutants come from many sources. Excessive nutrients, such as nitrates anc phosphates, commonly originate in domestic sewage, run-off from agricultural fertilizer, waste materials from animal feed lots, packing plants, etc. Toxic chemicals as agents of water pollutioc originate in industrial operations, acid mine drainage, surface erosion from strip mines, washing of herbicides and insecticides, radioactive fall out from atomic explosion, and commercial accidents such as oil spills or the rupture of chemical tanks. Besides the pollutants which come from point sources such as sewage, factory or industry, there are many pollutants which come from watershed run-off. Urban and sub-urban run-off, for example, contains many pollutants such as oil, pesticides, radioactive dus. salt, fertilizers, miscellaneous chemicals, and nematodes, pathogenic protozoans, ,bacteria anc viruses. However, Kimbal (1975) recognized only three major sources of pollution: *domestic, industrial* and *agricultural.*

Ecology of Water Pollution

Each type of water pollution affects the abiotic and biotic factors of different aquatic systems 9 different degrees and its ultimate effect on man remains quite drastic in medical, aesthetic, anc economical sense. Some of the well known ecological effects of water pollution are following:

Sewage Pollution

Contamination of freshwaters and shallow offshore seas by sewage is a common occurrence. Domestic sewage and waste-water is about 99.9 per cent water and 0.02-0.04 per cent solids of which proteins and carbohydrates each comprise 40-50 per cent and fats 5-10 per cent. In other words, sewage includes mostly biodegradable pollutants such as human faecal matter, anima wastes, and certain dissolved organic compounds *(e.g.,* carbohydrates, urea,

etc.) and inorganic sais such as nitrates and phosphates of detergents and sodium, potassium, calcium and chloride ions. Under natural processes most of the biodegradable pollutants of sewage are rapidly decomposed, but, wha they accumulate in large quantities, they create problem, *i.e.,* when their input into environment exceeds the decomposition or dispersal capacity of the latter. Most cities of well developed countno such as USA, Britain, etc., and some cities of developing countries such as India have evolved cenaa engineering systems, such as, septic tanks, oxidation ponds, filter beds, waste water treating plants and municipal sewage treatment plants for the removal of many harmful bacteria and other microbes, organic wastes and other pollutants from the sewage, before it is tipped into river or sea.

Sewage treatment is usually performed in following three stages: (1) Primary treatment, whka: removes large objects and suspended undissolved solids of raw sewage and converts them into *a* biologically inactive and aesthetically inoffensive state, the sludge, a valuable fertilizer. (2) Secondary treatment, which supplies aeration and bacteriological action to decompose organic compound into harmless substances such as CO_2, sulphate and water. During later stages of secondary treatment, whole waste water is chlorinated *(i.e.,* treated with chlorine) to reduce its content of bacteria. (3) Tertiary treatment, which removes nitrates and phosphates and releases pure water. These three stages of sewage treatment have become increasingly expensive and only in most advanced countries all the three treatments of sewage are done. However, most Indian cities either lack any sewage or waste-water treatment plant or have inadequate sewage treatment facilities. Consequently, normally and especially during heavy downpour and floods, raw sewage or incompletely treated sewage is dumped into rivers which cause severe water pollution problems in following ways:

(i) Bacterial and viral contamination: Sewage wastes may contain pathogenic bacteria and viruses which are a threat to human health. Waterborne diseases such as typhoid, bacillary dysentery, amoebic dysentery, botulism, poliomyelitis, and hepatitis all represent potential health hazards in sewage-contaminated waters. Due to such kinds of sewage pollution waters of many ponds, lakes, rivers, sea beaches in India and abroad have been prohibited for human use, whether for drinking, bathing, swimming or other sort of water recreation.

(ii) Eutrophication. According to Hutchinson (1969), the eutrophication is a natural process which literally means "well nourished or enriched." It is a natural state in many lakes and ponds which have a rich supply of nutrients, and it also occurs as part of the aging process in lakes, as nutrients accumulate through natural succession. Eutrophication becomes excessive, however, when abnormally high amounts of nutrients from sewage, fertilizer, animal wastes and detergents, enter streams and lakes, causing excessive growth or 'bloom' of microorganisms and aquatic vegetation.

Most secondary sewage treatment plants, though, precipitate solids and inactivate most bacteria in domestic sewage, yet they do not remove the basic nutrients such as ammonia, nitrogen, nitrates, nitrites and phosphates. These nutrients stimulate algal growth and lead to plankton blooms. Some plankton blooms, particularly those of blue-green algae produce obnoxious odours and tastes in waters. Others, such as the dinoflagellate bloom' or "the red tide" of southern coastal regions, produce toxic metabolic products which can result in major fish kills.

Effect of Organic Pollution on aquatic animal life: Organic pollution tends to bring about changes in faunal composition in a freshwater ecosystem. Nymphs of stone flies and may flies are the first to disappear from water which has high organic pollution. As pollution increases, caddishfly larvae and many fish which require high levels of environmental oxygen move into less polluted area of the stream. Shrimps, water fleas, leeches; snails and most of the fish vanish as the pollution becomes severe. At such levels of pollution there is very little of dissolved oxygen and the animals present are chironomid larvae (blood worms) and the oligochaete worms Tubifex. Some decomposing plants are known

to produce toxins as strychnine which kills animals including cattle.

INDUSTRIAL POLLUTION

Most of the Indian rivers and freshwater streams are seriously polluted by industrial waste of effluents. Effluents are waste products in a liquid form resulting from industrial processes and domestic activities. They are released by different industries such as petro-chemical complexes; fertilizer factories; oil refineries; pulp, paper, textile, sugar and steel mills, tanneries, distilleries, coal washeries, synthetic material plants for drugs, fibres, rubber, plastics, etc. The industrial wastes of these industries and mills include metals (copper, zinc, lead, mercury, etc.), detergents, petroleum, acids, alkalis, phenols, carbamates, alcohols, cyanide, arsenic, chlorine and many other inorganic and organic toxicants. All of these chemicals of industrial waste are toxic to animals and many cause death or sublethal pathology of the liver, kidneys, reproductive systems, respiratory systems, or nervous systems in both invertebrate and vertebrate aquatic animals (Wilbur, 1969). Chlorine which is added to water to control growth of algae and bacteria in the cooling system of power station, may persist in streams to cause mortality of plankton and fish. Heavy fish mortality in river Sone near Dehri-on-sone in Bihar is reported to cause by free chlorine content of the chemical wastes discharged by factories near Mirzapur in U.P.

Mercury like other heavy metals such as lead and cadmium has cropped up as a toxic agent of serious nature. Mercury, a byproduct of the production of vinyl-chloride, is used in many chemical industries and it is also a byproduct of some incinerators, power plants, laboratories and even hospitals, (Aaronson, 1971). In Japan, illness and even death occurred in the 1950s among fishermen who ingested fish, crabs, and shell-fish contaminated with methyl mercury from Japanese coastal industries. This mercury poisoning produced a crippling and often fatal disease called Minamata disease. Initial symptoms of minimata disease included numbness of the limbs, lips, and tongue, impairment of motor control, deafness, and blurring of vision. Cellular degeneration occurred in the cerebellum, midbrain, and cerebral cortex and this led to spasticity, rigidity, stupor and coma. In Japan in 1953, due to Minamata disease 17 persons died and 23 became permanently disabled.

Thermal Pollution

Various industrial processes may utilize water for cooling, and resultant warmed water has often been discharged into streams or lakes. Coal-or oil-fired generators and atomic energy plants cause into large amount of waste heat which is carried away as hot water and cause thermal pollution or calefaction (warming). Thermal pollution produces distinct charges in aquatic biota. A body of water at 30-35°C is essentially a biological desert and many game fish require temperatures of <10°C for successful reproduction, although they will survive above that temperature. A temperature rise of 10°C will double the rate of many chemical reactions and so the decay of the organic matter, the rusting of iron and the solution rate of salts are also accelerated by calefaction. Since the rate of exchange of salts in organisms increase, any toxin is liable to exert greater effects and temperature fluctuations are likely to affect organisms. Some plants and animals are killed out-right by the very hot water. Other adverse effects of aquatic pollution on aquatic life include (i) early hatching of fish eggs, (ii) failure of trout eggs to hatch, (iii) failure of salmon to spawn, (iv) increase in BOD, *i.e.,* solubility of oxygen is reduced causi deoxygenation; (v) change in diurnal and seasonal behaviour

and metabolic responses of organising (vi) significant shift in algal forms and other organisms towards more heat tolerant forms (this leads to decrease in species diversity); (vii) affect changes in macrophytes and (viii) migration of some aquatic forms.

Water Pollution by Agrochemicals

Water that flows on the surface of crop fields, where agrochemicals such as fertilizers, pesticides and herbicides are used, contributes to heavy water and soil pollution. Pesticides and weedicides arr used by human beings to control crop diseases by the pests or to kill the weeds and, hence, to increase the productivity. The use of these toxic chemicals has created health hazards not only for livestock and wild life but also for fish, other, aquatic organisms, birds and mammals including man.

Any substance or mixture of substances which prevents, repels, destroys or mitigates any peic *(e.g.,* bacteria, viruses, fungus, insects, nematodes, rodents, etc.) is called a pesticide. Pesticides have proved tremendously beneficial to human populations, in reducing or eliminating the target organism? *such* as insects, snails, rats, and other animals which transmit disease, destroy agricultural crops. *damage homes and stored products, and directly or indirectly affect* human health and welfare. Hence, the significance of chemical pesticides controlling mosquitoes, termites, houseflies, cockroaches, house crickets, weevils, locusts and grasshoppers, borers, snails, rats, rabbits, and a multitudes of other animals has been great, and it is difficult to imagine modem disease control and agricultural programmes without some forms of chemical control. Like pesticides, herbicides are specifically designed chemicals for the control of weed pests and unwanted plant growth.

Ecologically pesticides and herbicides have created two major serious problems which were not previously anticipated. In the first place many of them have persisted and accumulated in the environment and have harmed or contaminated numerous animals or plants not intended to be targets. Secondly, many of them have directly or indirectly affected human health.

Toxicity of pesticides. The toxicity of organo-chlorine pesticides (i.e., DDT orDichlorodiphenyl trichloroethane, hexachlorocyclohexane, chlordane, aldrin, dieldrin, etc.) lies in their inhibiting Na+, K+ and Mg+ adenosine triphosphatase activity in the nerve endings of animals particularly insects, affects the sensory, motor nerve fibers and the motor cortex. In the gi axons of cockroach, DDT is known to influence the efflux of potassium ions from the axon.

DDT and other organochlorine pesticides are absorbed from the intestinal tract, from the alv of lungs and also through the skin, if the pesticides are in solution A high concentration of DDT cau brain damage, centrolobular necrosis of the liver, and liver enlargement in small mammals. Conce tration as low as 5—10 ppm in diet cause liver damage. In some birds, DDT concentration of 1—3 ppm destroys the female sex hormone and the egg shell becomes so thin that the eggs break when the paren sit on them for hatching.

Marine Pollution

The marine ecosystem *(i.e.,* seas, oceans and estuaries) is so grand and vast but interacting various ways with human life. How mighty and majestic ocean may appear to us, it was once challen and tamed by Lord Rama during his march towards Ravana's Lanka. The oceans are used navigation, fisheries, aquaculture, mining, acquisition of water, naval and military exercises as well for the discharge and dumping of a variety of wastes. The very vastness of the ocean has led to assumption that all wastes dumped into them can be harmlessly absorbed. Such an assumption belongs to the past. The ever increasing range and volume of polluting activities and tend to seri affect marine production. Marine pollution is most evident in coastal waters and estuarine areas, oceans have in fact, become the final settling basin for millions of tons of waste products from h activities. For example, in the late 1960s West Germany was dumping 375 tons of sulphuric acid, 750 tons of iron sulphate, 20 tons of chlorinated hydrocarbons and 16,000 tons of gypsum wastes into North sea and North Altantic Ocean every day.

Oil is the most apparent pollutant of the ocean. It discharged into the sea either delibe when oil tankers are washed out prior to reloading or in accidental spills when tankers are wrecked (during war or otherwise). In coastal areas when oil spreads on the water surface, it clogs the fe of diving birds making their flight impossible. White preening themselves in an attempt to clear the plumage, they swallow enough oil to poison themselves. Apart from these, oil interferes with the insulation provided by the feathers and the birds die of cold or become susceptible to pneumonia. When oil covers the rocks and sea weeds, molluscs and crustaceans growing on them die. Oil-spills on the coasts of sea-side resorts, drive away holiday makers, affecting the economy of the place.

Control of Water Pollution

Most cities of world have evolved certain engineering systems such as septic tanks, oxidation ponds, filter beds, waste water treatment plants and municipal sewage treatment plants for the removal of various pollutants from the sewage before it is tripped into river or sea. It is essential to have modem sewage treatment plants for every town and city of India so that the biodegradable as well as non-biodegradable pollutants can be removed from it and pure water obtained for recirculation.

The urban sewerage condition of India is quite distressing. At present only 15 class-I cities out of 142 are fully sewered, whereas, only 7 of the 190 class-II towns claim to have this facility. Still the Indian cities continue to pour their waste water (286 thousand million cubic metre) into natural water sources.

Currently, water hyacinth *(Eichhornia crassipes),* an otherwise pernicious aquatic weed, has come into prominence for purifying domestic and industrial waste water. The plant regenerates rapidly and has a tremendous capacity to accumulate heavy and even radioactive metals. It is efficient in absorbing nitrogen, phosphorus and similar chemical pollutants. The polluted water fed into reservoirs or lagoons with water hyacinth, becomes markedly clean and free from 75-90 per cent of its pollutants. This plant has also been used as a new source of food, fertilizer and bioga? (energy).

In India, the enactment of 'Prevention and Control of Water Pollution Act' in 1974, has helped to a certain extent to prevent water pollution. However, adequate legislative measures have to be adopted by every state to ensure: (a) proper disposal of sewage and industrial wastes; (b) prevention of abuse of water resources; (c) recycling of waste waters through proper methods of purifications; and (d) punishment of erring industries which do not install effluent devices in their factories. A large number of international and inter-governmental agencies are now busy in controlling marine pollution. A number of highly hazardous pollutants are black listed and their discharge in the sea is total) prohibited. These are halogenated organic compounds, tin, mercury and cadmium compounds radioactive isotopes and carcinogenic material. Somewhat less toxic substances are gray listed such as compounds of arsenic, zinc, and antimony, cyanides, organosilicon compounds, crude oils, foair forming detergents and surfactants.

Realizing the devastation caused by the population of cities, towns and villages of 8 states and the union territory located along the coasts of river Ganga, through its run of 2525 km from Gangotr. (Himalayas) to Ganga Sagar (Bay of Bengal), the Government of India has launched Ganga Action Plan to restore its water quality. The first phase of this gigantic cleaning operation had been initiated in year 1985 and may take several years in its completion.

LAND POLLUTANTS AND LAND POLLUTION

The land pollution is caused by solid wastes and chemicals. There are many examples of land that has been stripped of vegetation by industrial development and disposal of waste. Some common soil contaminants, their sources and wide range impacts on the biota have been summarized as follows:

The slag heaps from mines bear witness to the destructive effects which this can have on our environment. Areas around smelting and mining complexes are usually soiled by metals such as cadmium, zinc, lead, copper, arsenic and nickel. These are not only phytotoxic even in small amounts but also render plants unsafe

for human and animal consumption. Zinc, often with cadmium, is released into the environment during the use or breakdown of lubricating oils, vehicle tyres, galvanized metals and fertilizers.

The major sources of land pollution are the industries such as pulp and paper mills, sugar mills, oil refineries, power and heating plants, chemicals and fertilizer manufacturing units, iron and steel plants, plastic and rubber producing complexes and so on. Huge amounts of solid wastes are either dumped, burnt, or emptied into rivers and seas. Most industrial furnaces produce a grey, powdery residue of unbumt material known as fly ash. The fiy ash, cinders, solid wastes and litter all are thrown away by industries and form huge mounds which spoil the landscape.

Our households too contribute a large amount of solid rubbish in the form of domestic wastes. Some common examples are groceries, food scraps, vegetable remains, packing materials, cans, cardboard cartons, rags, paper, cinders, ash, broken gadgets, wood, worn-out furniture, metals, bones of dead animals, plastics, polythene bags, ceramics, glass, aluminium, rubber, leather, construction rubbish, brick, sand and other junk. Some man-made materials can be used again such as paper, scrap metal, glass, polythene, plastic, etc. But the majority of these cannot be reused and must be got rid of somehow. All these go to constitute heaps of municipal refuse. If not properly disposed, this rubbish can prove perilous, filthy and unhygienic. Such places often become a home for rats, flies, mosquitoes, bacteria and many other vectors, which may spread numerous human diseases.

Minimizing Land Pollution

It should be necessary for the industries to install collectors to remove the particulate wastes (fly ash) from the chimneys. Appropriate methods should be developed to dispose off or utilize the other types of pollutants. The garbage, instead of burning in the open, can be used not only to produce energy but also as filler for cement, bricks, asphalt and pavings. Some of these wastes, if properly sifted and separated, can even be recycled as raw material for other industries.

Another simplest method is crude tipping or open dumping, a common method used in most Indian cities. More satisfactory is controlled tipping or the sanitary landfill, which is recently adopted in Delhi for solid waste disposal. The sanitary landfill is a better remedy for larger objects because it brings about inexpensive biodegradation of such trash without causing much pollution, disease and ugliness. In sanitary landfill, a layer of about 2 meters of refuse is covered by at least 23 cm of earth, ash or other inert material, up to the level of the hole chosen. The chosen holes may be low lying watery areas and ditches. The land, thus, reclaimed can be used for making gardens, parks, playgrounds or apartment complexes. Before such filling, the wastes can be pulverized by machines to a uniform size— by this method the volume of refuse is reduced and some of the refuse is more quickly biodegraded. There are certain persons like Nek Chand who has found an aesthetic use of household refuse in the construction of world famous monuments such as “Rock Garden” of Chandigarh.

RADIOACTIVE POLLUTION

Radioactive isotopes, or radionuclides, are forms of elements with unstable atomic nuclei; that is, they decompose with ionizing radiation in the form of alpha or beta particles, or gamma rays. Many radioisotopes, such as radium-226, uranium-235 or238, thorium-232, potassium-40, or carbon-14, occur naturally in rocks and soil. Other radioisotopes such as those of cesium, cobalt, iodine, krypton, plutonium, and strontium, result primarily as fission products from atomic bomb fallout, nuclear reactors or other radiation sources. Of more than 450 radioactive isotopes which can occur as fission products, only a few are of major environmental concern. These are primarily argon-41, cobalt-60. cesium-137, iodine-131, krypton-85, strontium-90, tritium and plutonium-239 (Bebbington, 1973).

Within biotic communities and ecosystems, these radioactive elements may become dispersed or accumulated, depending upon the biological activity of the element and period of radioactivity of the isotope. Strontium-90, for example, normally occurs in radioactive fallout,

has a half-life of 28 years and behaves like calcium in biogeochemical cycles. Thus it is absorbed by plants, ingested by animals and deposited in bone tissues close to blood forming tissue. Strontium-90 can also concentrate in natural biological systems in following method: water bottom sediments — aquatic plants — freshwater clams — minnows and small fish — musk rats. It is demonstrated that due to this food chain musk rats concentrate strontium-90, 3500 times above the levels of the water in which they live. Grazing animals concentrate strontium-90 by ingesting it through grass and forage, and it can then be passed on to humans through milk.

Radioactive phosphate, cesium and iodine-132 also can readily accumulate in plants and animals through natural food chains. However, in food chains involving arthropods radioactive isotopes of potassium, sodium, and phosphorus accumulate, but isotopes of strontium and cobalt do not.

Although isotopes may accumulate in human tissues as well as those of plants and animals, it is not established at the present time whether current levels of isotopes in human tissues represent serious health hazards to man (Southwick, 1976; Smith, 1977). Some medical scientists such as Gofman arc Tamplin (1970) and Sternglass (1972), however, feel that man's radiation exposure from artificial sources is already sufficient to produce serious disease problems (leukemia and bone tumors), genet: damage, and infant mortality.

NOISE POLLUTION

Noise is primarily a feature of cities and is defined as 'sound without value' or 'any noise tha is undesired by the recipient". Noise I 'vels in many urban-industrialized situations are known to rt deleterious to human health and efficiency, with effects on the sense organs, cardiovascular, glanduia- and nervous systems.

High intensity sopund or noise pollution is caused by many machines man has invented dunns his technological advancement. Thus, there exists a long list of sources of noise pollution includux different machines of numerous factories, industries and mills.different kind of auto and motor vehicles such as scooters, motorbikes, cars, tempos, buses, trucks, tractors, aircrafts, motorboats, ships, loudspeakers, social gatherings, loud pop-music, supersonic aircrafts, etc. Noise can be measured ry a sound metre and is expressed in a unit called the decibel (dB). The quietest sound that the human ea can detect (zero decibels) is called the threshold of hearing. Calcutta, Bombay and Delhi are regarjec to be nosiest cities in the world, where the average noise level was 90 decibels in 1975.

Noise pollution has certain well evident ecological and pathological effects on biota and huro* beings. For instance, the sonic boom path associated with SST projects such as Concorde porcfciss noise of a very different order, in the form of sudden but repeated shock waves, which is suspected to cause disturbance to wild birds as well as domestic stock and buildings. Noise is not only annoying but if continued for a long time can also result in emotional and behavioural alterations in man.

Health Hazards of Noise Pollution

Noise causes disturbances in the atmosphere which in turn interferes with the system rf communication. It affects our peace of mind, health and behaviour. Sudden loud note can cause acar damage to the ear drum and the tiny hair cells in the internal ear, whereas prolonged noise resute in temporary loss of hearing or even permanent impairment. It causes headache irritability and impairs focussing. Noise is known to flush the skin,

constrict stomach muscles and produce ulcers, heart disease, high blood pressure, nervousness and other defects in sensory and nervous systems.

Reducing Noise Pollution

Though it is almost difficult to completely get rid of the malady of noise pollution of current electronic age. However, there are certain methods by which deleterious influences of noise pollution can be minimized and intensity of noise level can be curbed. The means of noise control are : (a) to manipulate the source so as to reduce the noise at its origin; (b) to interrupt the path of transmission and (c) to protect the recipient.

Legislation and public awareness are essential. Nobody should be permitted to create noise in silent zones or during night. Noise producing traffic vehicles should be prevented from plying on the roads and their use of pressure horns should be entirely checked. Standards for noise control measures should be set up for industry and community, and a comprehensive safety programme enforced.

The path of the sound can be interrupted by using various materials which absorb the sound energy. Horticulturists should suggest adequate varieties of vegetation which can be planted around factories, hospitals, educational institutions, public libraries and houses which may reduce sound pollution and also may minimize dust pollution. Acoustic materials and mufflers can also be used to protect oneself. Under noisy situations, one may hold his hands over his ears or may run away from the source, or may simply stuff a bit of cotton or ear plugs in the ears to reduce much hazards of noise pollution.