Chapter 13

ENVIRONMENTAL POLLUTION TYPES, CAUSES, EFFECTS AND CONTROL

Environmental pollution is defined as an undesirable change in the physical, chemical or biological characteristics of our environment (land, water or air) that harmfully affects various forms of life, living conditions and cultural assets; or that deteriorates our raw material resources.The word pollution is derived from the Latin word "*polluere*" which means to "*soil or make unclean or dirty*". The substances that cause pollution are called *pollutants*. A pollutant can be a substance (e.g. plastics, soot) a chemical (e.g. nitrogen oxides, CFC) or a factor (e.g. noise, heat) introduced into the environment that contaminates air, water, or soil and has the potentiality to adversely affect life, environment and property. Almost any substance, synthetic or natural, can act as a pollutant.Just as a weed is "a plant out of place," a pollutant is "a chemical out of place." Pollution occurs when pollutants are added to the environment at a rate faster than it can be dispersed, diluted, decomposed, recycled, or stored in some harmless form. Pollution disturbs our ecosystem and the balance in the environment. It produces negative impacts on crucial environmental services such as provision of clean air and clean water (and many others) without which life on Earth as we know it would not exist.

AIR POLLUTION

Air pollution is the contamination of the atmosphere by gaseous, liquid, or solid wastes or their by-products. The contaminants or combinations thereof may be present in such quantities and of such duration which may tend to be injurious to human, plant or animal life, or property or which may unreasonably interfere with the comfortable enjoyment of life or property or the conduct of business. According to the Air Act of 1981, Govt. of India

"Air pollutant means any solid, liquid or gaseous substance present in the atmosphere in such concentration as may be or tend to be injurious to human beings or other living creatures or plants or property or environment."

In the days before the proliferation of large cities and industry, nature's own systems kept the air fairly clean. With increasing urbanization and industrialization, humans started to release more wastes into the atmosphere than nature could cope with. It is when these concentrated gases exceed safe limits that we have a pollution problem. Nature can no longer manage air pollution without our help.

Sources of Air Pollution

The **natural sources** of air pollution emissions include *volcanoes* which produce smoke, ash, carbon dioxide, sulfur dioxide and other air pollutants; *methane and other gases* generated by the digestion of food and emitted by animals such as cattle; *windblown dust* from areas with little or no vegetation such as desert areas; *wind-blown sea water* which evaporates in the atmosphere and releases sodium chloride and other particulates into the atmosphere; *radon gas* released into the atmosphere by radioactive decay occurring in the Earth's crust; *forest fires* which result in the formation and release of smoke, ash, dust, carbon dioxide, nitrogen oxides and other air pollutants; *soil out gassing* wherein microbial action in soils result in the formation and release of significant amounts of nitrogen oxides.The **anthropogenic** or **man-made sources** of air pollution include the following.

1. **Burning of Fossil Fuels:** Pollution emitting from vehicles including trucks, jeeps, cars, trains, airplanes cause immense amount of air pollution. The improper or incomplete combustion of fossil fuels releases dangerous gases such as sulfur dioxide, carbon monoxide, nitrogen oxides etc. polluting the environment.
2. **Agricultural Activities:** Ammonia is a very common by product from agriculture related activities and is one of the most hazardous gases in the atmosphere. Use of insecticides, pesticides and fertilizers in agricultural activities has grown quite a lot. They emit harmful chemicals into the air and can also cause water pollution.
3. **Exhaust from Factories and Industries:** Manufacturing industries release large amount of carbon monoxide, hydrocarbons, organic compounds, and chemicals into the air thereby depleting the quality of air. Petroleum refineries also release hydrocarbons and various other chemicals that pollute the air and also cause land pollution.
4. **Mining Operations:** Mining is a process wherein minerals below the earth are extracted using large equipment. During the process dust and chemicals are released in the air causing massive air pollution.
5. **Solid Waste Disposal:** This category includes facilities that dispose of unwanted trash. Refuse incineration and open burning are important sources.
6. **Controlled Burns:** Controlled burning is a useful technique practiced in forestry management and in agriculture. Such controlled burns result in the formation and release of smoke, ash, dust, carbon dioxide, nitrogen oxides and other air pollutants.
7. **Waste disposal landfills:** Microbes and chemical reactions act upon the waste and generate *landfill gas* that contains methane and carbon dioxide as well as small amounts of ammonia, mercaptans and other sulfides. Eventually, that gas escapes from the landfill and is released into the atmosphere.

Gaseous and Particulate Air Pollutants

Gaseous air pollutants are substances which remain in the gaseous state in the atmosphere viz. sulfur dioxide, ozone and hydrocarbon vapors exist in the form of a gas. The gases lack definite volume and shape and the molecules are widely separated. *Particulate air pollutants* include substances that remain in solid or liquid state in the atmosphere viz. aerosols, smokes,

construction of more tightly sealed buildings, reduced ventilation, the use of synthetic materials for building and furnishing and the use of chemical products, pesticides, and household care products. Inadequate ventilation, high temperature and humidity levels are known to increase concentrations of some pollutants. Indoor air problems can be subtle and do not always produce easily recognized impacts on health. People also react very differently to exposure to indoor air pollutants.

Effects of Air Pollution

1. **Effects on Materials and Property.** *Particulate matter* cause corrosion of metals when air is humid, lead toerosion and soiling of building, sculpture & painted surface and the soiling of clothing and draperies. *Sulphur oxides* too damage materials and property through their conversion into highly reactive sulphuric acid causing discoloration and physical deterioration are produced in building materials and sculpture, deterioration and fading are also produced in fabrics, leather & paper, corrosion of metals like iron and zinc is accelerated. The drying time, brittleness and even gloss of paints is affected. *Hydrocarbons* induce chemical alteration in paper, textile, and rubber, polymers making them brittle and fragile.

2. **Effects on Environment.** Global effects of air pollution on climate are produced through acid rain, greenhouse effect and global warming, and by the depletion of ozone layer (*For details please refer to Chapter 16*). Particulate matter act as a major source of haze can scatter and absorb sunlight, thus reducing visibility. Particles also reduce visibility by attenuating and illuminating the air, reducing contrast between the objects and back ground. Methane a potential agent in producing global warming, is not toxic in itself but concentrations of few percent may lead to explosions. Hydrocarbons are instrumental in producing photochemical smog. Nitrogen oxides help form acid rain and can cause a wide range of environmental damage, including eutrophication and photochemical smog.

3. **Effects on Plants.** Particulate matter settles down on the leaves of trees and block stomata pores, thereby affecting gas exchanges, water relation and other physiological processes. Sulphur dioxide competes with carbon dioxide, retards photosynthesis and thereby carbon assimilation. High concentrations over short period produce *acute leaf injury* by necrotic blotching of board leaved plants & gasses, brownish discoloration of the tips of pine needles. Low concentrations over long periods produce *chronic leaf injury* by gradual yellowing as chlorophyll production is impelled. Ethylene is known to inhibit plant growth by interfering with the activities of plant hormones. Nitrogen oxides at low concentrations adversely affect plants by producing *necrosis* (dead areas on leaf), *chlorosis* (reduction of chlorophyll), *epinasty* (downward curvature of leaf) and *abscission* (dropping of leaves). They may also cause defoliation, chlorosis, necrotic spots, tip burns and general growth retardation. *Ozone* in the lower atmosphere can prevent plant respiration by blocking stomata (openings in leaves) and negatively affecting plants' photosynthesis rates which will stunt plant growth. Ethylene is known to inhibit plant growth by interfering with the activities of plant hormones.

4. **Effects on Human Health.** Exposure to *particulate matter* as such can lead to a variety of serious health effects. Particle pollution can cause coughing, wheezing, and decreased lung function even in otherwise healthy children and adults. Scientific studies have linked particle pollution, especially fine particles, with a series of significant health problems, including respiratory morbidity, deficiencies in pulmonary (lung) functions including decreased lung function (especially in children), lung cancer, premature death in people with heart or lung disease, nonfatal heart attacks, irregular heartbeat, and aggravated asthma. Prolonged inhalation of particulate matter causes serious lung problems including fibrosis called *pneumoconiosis* or *byssinosis*. The disorder is named variously depending upon the pollutant material like *siderosis* (iron particles), *silicosis* (silica particles) *asbestosis* (asbestos particles) flour mill pneumoconiosis and coal miner's pneumoconiosis. *Sulphur oxides* too cause eye irritation, asthma, bronchitis and emphysema in human beings.

One of the pollutants of serious concern with regards to human health is carbon monoxide. The toxic effects of CO on human beings and animals arise from its reversible combination with Hemoglobin (Hb) in the blood forming carboxyhemoglobin. The affinity of CO for hemoglobin is 210 times greater than that of oxygen. The combination of Hemoglobin with CO lessens the oxygen carrying capacity of the blood so that less O_2 is available to the body cells, reduces the dissociation of oxy-hemoglobin (HbO_2) so that anoxia – oxygen starvation may result. As the levels of carboxyhemoglobin keep on increasing in the blood it may lead to muscular weakness, nausea, dizziness, slurring of speech, tendency to collapse, convulsion fatal coma and death.

Among the *hydrocarbons*, cyclic hydrocarbons affect respiratory system, nervous system, dilate pupils of eyes, and affect DNA and cell growth, aromatic hydrocarbons produce irritation in the mucous membrane, carcinogenic hydrocarbons such as vinyl chloride, ethylene dichloride cause cancer of liver, bladder, stomach and lungs. Raised levels of nitrogen dioxide increase the likelihood of respiratory problems in man. Nitrogen dioxide inflames the lining of the lungs, and it can reduce immunity to lung infections. This can cause problems such as wheezing, coughing, colds, flu and bronchitis.

that about 30% of the injured were unable to return to their jobs.

Table 13. Summary of Bhopal Gas Tragedy

Accident	Bhopal Gas Tragedy
Location	Bhopal, Madhya Pradesh, India
Year	1984
Pollutant	Methyl isocyanate
Cause of death	Primary : Pulmonary edema Secondary: Respiratory infections such as bronchitis and bronchial pneumonia
Reproductive adverse effects	Leucorrhea, pelvic inflammatory disease, excessive menstrual bleeding, suppression of lactation, still births, spontaneous abortions

Measures for Control of Air Pollution

1. **Control of Deforestation :** Plants help remove pollutants from the atmosphere. It must be ensured that 33 percent of the land remains under forest cover by restricting deforestation and encouraging afforestation. A green belt should be created around every industry, township and village.
2. **Use of High Chimneys :** Industrial plants should be advised to use high chimneys for escape of smoke fumes or heated air so that harmful gases may not disperse in the lower atmosphere.
3. **Control of Particulate Matter :** This can be achieved by using *arresters* and *scrubbers*. Arresters are devices that are used for separating particulate matter from polluted air. Scrubbers are devices to separate both particulate matter and gases from polluted air by passing the same through a dry or wet packing material. Arresters are of several types like gravity settling chambers, trajectory separators, filters, cyclone separators and electrostatic separators etc.
4. **Control of Gaseous Pollutants :** The most common method for controlling gaseous pollutants is the addition of add-on control devices to recover or destroy a pollutant. There are four commonly used control technologies for gaseous pollutants:
   a. ***Absorption*** : Absorption is a process in which a gaseous pollutant is dissolved in a liquid. The removal of one or more selected components from a gas mixture by absorption is probably the most important operation in the control of gaseous pollutant emissions.
   b. ***Adsorption*** : When a gas or vapor is brought into contact with a solid, part of it is taken up by the solid. The molecules that disappear from the gas either enter the inside of the solid, or remain on the outside attached to the surface. The former phenomenon is termed absorption (or dissolution) and the latter adsorption. The most common industrial adsorbents are activated *carbon*, *silica gel*, and *alumina*.

c. ***Condensation*** : Condensation is the process of converting a gas or vapor to liquid. Any gas can be reduced to a liquid by lowering its temperature and/or increasing its pressure.

Condensers are typically used as pretreatment devices. They can be used ahead of absorbers, absorbers, and incinerators to reduce the total gas volume to be treated by more expensive control equipment.

d. ***Incineration*** : Incineration, also known as combustion is most used to control the emissions of organic compounds from process industries. This control technique refers to the raped oxidation of a substance through the combination of oxygen with a combustible material in the presence of heat. When combustion is complete, the gaseous stream is converted to carbon dioxide and water vapor.

5. **Providing Biogas Facilities in Villages :** Pollution in Indian villages is mainly due to burning of firewood, cow dung and farm waste and smoke produced from brick work. In recent times improved biogas facilities are being made available to reduce the pollution.

6. **Mandatory Development of Green Areas:** Many plant species have been evaluated for their scavenging potential against air pollutants and it has been suggested that more efforts should be made for the development of green belts since they serve as an effective sink for air pollutants.

7. **Other Methods :** These include strict enforcement of Air (prevention and Control of Pollution) Act, 1981; use of purified fuel like lead free petrol; encouragement of the use of alternative energy vehicles; removing road jams; stress on using mass transport system, pool cars.; reduction of pollution at source; creating public awareness about pollution hazards etc.

WATER POLLUTION

Water is regarded as polluted when it is changed in quality or composition, directly or indirectly as a result of mankind's activities, so that it becomes less suitable for drinking, domestic, agricultural, recreational fisheries or other purposes for which it would otherwise be quite suitable in the natural or unpolluted state (Kumar 1977). Water pollution happens when toxic substances enter water bodies such as lakes, rivers, oceans and so on, getting dissolved in them, lying suspended in the water or depositing on the bed. This degrades the quality of water. Not only does this spell disaster for aquatic ecosystems, the pollutants also seep through and reach the groundwater, which might end up in our households as contaminated water we use in our daily activities, including drinking. Anything that is added to the water, which is above and beyond its capacity to break it down, causes water pollution.

Direct sources of water pollution include effluent outfalls from factories, refineries, waste treatment plants etc. that enter water bodies. *Indirect sources* include contaminants that enter the water supply from soils/groundwater systems and from the atmosphere via rain water. *Point source water pollution* represents those activities where wastewater is routed directly into receiving water bodies by, for example, discharge pipes. In contrast, *non-point source water pollution*, have no obvious point of entry into receiving watercourses include runoff including sediment, fertilizer,

chemicals and animal wastes from farms, fields, construction sites and mines. *Natural agencies* contributing to water pollution include soil erosion, landslides, coastal and cliff erosion, volcanic eruption and decay and decomposition of plants and animals. The *anthropogenic agencies* of water pollution include the urban and industrial areas as well as the agricultural fields.

Biodegradable and Non-biodegradable Pollutants

Water pollutants which can be broken down and decomposed by biological means such as decomposers/ micro-organisms are called **biodegradable** or simply degradable pollutants. These pollutants are also called as organic pollutants. **Non degradable pollutants** are those which cannot be degraded by biological means. Such pollutants are also called as inorganic pollutants. Examples of biodegradable or organic pollutants are leaf litters, sewage, garbage, plants and animals, human and animal excreta etc. Non-degradable pollutants include all of the chemical pollutants and toxic solid substances.

Sources of Water Pollution

1. **Municipal Sewage :** Sewage is obtained from the disposal of wastes and spent water from lavatories, bathrooms, kitchens, laundries, laboratories, etc. It also results from the disposal of wastes in factories and trade premises and also from the use of waters in dwellings, schools, offices, hospitals, shops etc. Present-day sewage contains appreciable quantities of synthetic detergents. Trace amounts of metals, such as copper, chromium, zinc, manganese, lead and nickel, may also be present. Because of its varied content of easily decomposable material, sewage is an excellent medium for the growth of bacteria.
2. **Industrial Water Pollution:** Water is the major raw material in industry. It is used in the technological processes as a solvent, as cleaning and cooling substance; it is a part of the final product content. The industrial wastewater may include various inorganic or organic pollutants, depending upon the type of industry and the chemicals used in various processes. The pollutants include oils, greases, plastics, metallic wastes, suspended solids, phenols, toxins, acids, salts, dyes, and cyanides, DDT etc., many of which are not readily susceptible to degradation and thus cause serious pollution problems.
3. **Agricultural Water Pollution.** Pollutants discharged into water courses due to agricultural activities includes soil and silt removed by erosion, synthetic fertilizers, herbicides, insecticides, fungicides, rodenticides, plant residue etc. which find their way into water bodies through rain water, run off from agricultural fields, accidental spillage etc. This also includes the farm animal wastes. The problem is really acute near large feedlots where large number of cows, cattle, pigs and poultry are located.
4. **Heat :** Heat can be a source of pollution in water. Thermal pollution is caused through the discharge of water that has been used to cool power plants or other industrial equipment. A single 100MW power plant may use one half million gallons of cooling water per minute. This hot water is let into the water bodies without the temperature being reduced. With increased temperatures the oxygen concentration of the water decreases.

5. **Sediment :** Sediment is one of the most common sources of water pollution. Sediment consists of mineral or organic solid matter that is washed or blown from land into water sources. Sediment pollution is difficult to identify, because it comes from non-point sources, such as construction, agricultural and livestock operations, logging, flooding, and city runoff.

6. **Radioactive Pollutants:** Radioactive atoms, known as 'radionuclides,' are a water pollutant that comes originally from underground deposits of radium, uranium and other radioactive metals. Health becomes a concern when radionuclide's become concentrated in bodies of water due to natural occurrences, accidental releases of radioactivity, or improper disposal practices.

7. **Pharmaceuticals and Personal care Products (PPCPs):** Personal-care products include laundry detergent, bleach, or fabric softener; window cleaner, dusting spray, or stain remover; hair dye, shampoo, conditioner; cologne or perfume; toothpaste or mouthwash; antibacterial soap or hand lotion etc. Almost all of it goes down the drain when we do laundry, wash our hands, brush our teeth, bathe etc. Similarly, when we take medications, we eventually excrete the drugs in altered or unaltered form, sending the compounds into the waterways. Studies have shown that up to 90% of our original prescription passes out of us unaltered.

8. **Shipping Water Pollution:** This includes both human sewage and other wastes, the most important of which is oil. Oil and petroleum chemicals (introduced into water bodies during oil spills, run-offs from land or vessels, etc.) are toxic to the entire marine ecosystem.

Effects of Water Pollution

1. **Changes in Physical Characteristics of Water:** Pollutants change the quality of water by affecting its taste, odor, color, clarity etc. These problems are of concern mainly because they affect uses of waterways, such as swimming, drinking water supply, or aesthetic enjoyment and are mainly based mainly on the undesirable sensations they cause rather than for actual harm to human or environmental health. Odor and taste, which can be caused by a wide variety of dissolved substances, are useful indicators of water quality even though odor-free water is not necessarily safe to drink. Color may be indicative of dissolved plant material or the presence of dissolved metals. Most water quality standards too require that generally that lakes, streams and other waters must be free from objectionable odors, tastes or colors, regardless of their use.

2. **Effects on Organisms :** Water pollutants can have many different effects on organisms, always depending on the pollutant and the organism in question. One property of pollutants is their possibility to interact with one another. Chemical reactions that cause pollutants to combine can reduce their overall chemical effect, but can also increase it, making a pollutant even more dangerous to organisms. Pollutants may cause *genotoxicity* (damage to DNA)*carcinogenity* (induce cancer in the body of humans and animals) *neurotoxicity* (damage the nervous system) *reproductive failure* or alter the *behavioral responses* of organisms.

3. **Depletion of Dissolved Oxygen Content:** Dissolved oxygen refers to the level of free, non-compound oxygen present in water and is necessary to many forms of life including fish, invertebrates, bacteria and plants. A healthy aquatic ecosystem has a dissolved O_2 content of 14 mg/L. DO content below 8 mg/L indicates pollution. In heavily polluted waters, the DO content may fall below 4 mg/L.

Microorganisms such as bacteria are responsible for decomposing organic waste which reaches the water bodies. When this happens, much of the available dissolved oxygen is consumed by aerobic bacteria, robbing other aquatic organisms of the oxygen they need to live. As dissolved oxygen levels in water drop below 5.0 mg/l, aquatic life is put under stress. Oxygen levels that remain below 1-2 mg/l for a few hours can result in large ***fish kills***. An area of water with little or no dissolved O_2 is called a ***dead zone***. They are so called because no aquatic organisms can survive there.

BOD & COD

The Biological Oxygen Demand (BOD) is a test used in order to determine the oxygen requirements of wastewaters. It is defined by the amount of oxygen required for the aerobic micro-organisms present in the sample to oxidize the organic matter to a stable inorganic form. It is an approximate measure of the amount of biochemically degradable organic matter present in a water sample. Chemical Oxygen Demand (COD) test is a measure of the oxygen required from a strong chemical oxidant for the destruction of an organic material. It is a measure of the oxygen equivalent of the organic matter in a water sample that is susceptible to oxidation by a strong chemical oxidant, such as potassium permanganate or potassium dichromate.

4. **Biomagnifications:** Biomagnification occurs when the toxic burden of a large number of organisms at a lower trophic level is accumulated and concentrated by a predator in a higher trophic level. Organisms lower on the food chain take up and store toxins from the environment. They ate eaten by large predators, which are eaten in turn, by even larger predators. The top carnivores in the food chain, game fish, fish-eating birds, and humans, can accumulate such high toxic levels that they suffer adverse health effects.

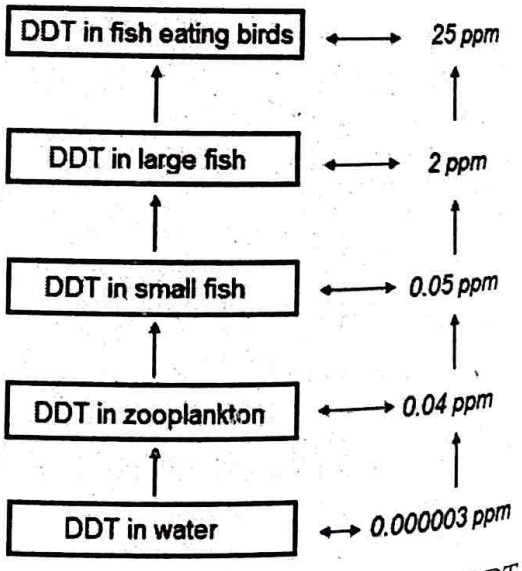

Fig 13.1. *Biomagnification of DDT*

One of the first well-known examples of bioaccumulation and biomagnification is that of DDT. DDT's environmental problems arise because of two important properties: persistence and lipid-solubility. The term persistence refers to the fact that DDT does not break down very easily. Once the pesticide has been used in an area, it is likely to

remain there for many years. In addition, DDT does not dissolve in water, although it does dissolve in fatty or oily liquids. DDT thus accumulated through food chains, so that by the 1960s it was shown to be interfering with reproduction of peregrine falcons, brown pelicans, and other predatory birds at the top of their food chains. DDT is however not the only toxin to biomagnify. Other compounds known to have the potential to biomagnify include PCB's (polychlorinated biphenyls), PAH's (polynuclear aromatic hydrocarbons), heavy metals (such as mercury copper cadmium chromium lead nickel) cyanide, selenium etc.

5. **Eutrophication :** Eutrophication is a natural aging process for most lakes and ponds. It involves the accumulation of nutrients in the water and the bottom sediments. As the nutrient availability increases, more plant growth is supported in the lake. Shed or dead plant material falls to the bottom and as it decays it contributes to even more plant growth. Over time, the lake may accumulate so much sediment that it fills in and becomes a swamp or a meadow. Generally, this takes many centuries or even millennia to occur.All water bodies are subject to such a natural and slow eutrophication process, which in recent decades has undergone a very rapid progression due to the presence of man and his activities (so called cultural eutrophication). The cultural eutrophication process consists of a continuous increase in the contribution of nutrients, mainly nitrogen and phosphorus (organic load) until it exceeds the capacity of the water body (i.e. the capacity of a lake, river or sea to purify itself) , triggering structural changes in the waters.

Table 13.2. **Common diseases transmitted to humans through contaminated water**

Type of organism	Disease
Bacteria	Typhoid fever, Cholera, Bacterial dysentery, Enteritis
Virus	Infectious hepatitis, Poliomyelitis
Parasitic protozoa	Amoebic dysentery, Giardiasis
Parasitic worms	Schistosomiasis, Ancylostomiasis

6. **Effects on Human Health:** Infectious water-borne diseases spread primarily through water contaminated by municipal sewage. Though these diseases are spread either directly or through flies or filth, water is the chief medium for spread of these diseases and hence they are termed as water-borne diseases (Table 13.2). In addition, industrial water or ground water may contain heavy metals that may cause serious health problems. Some of the more common diseases caused by metals are detailed as follows

   a. **Mercury Poisoning - Minamata disease:** In Minamata, Japan, inorganic mercury was used in the industrial production of acetaldehyde. It was discharged from a chemical plant (Chisso Co. Ltd.) into the nearby bay as waste water and was ingested by organisms in the bottom sediments. Fish and other creatures in the sea were soon contaminated and eventually residents of this area who consumed the fish suffered from MeHg (methyl mercury) intoxication. It was in May 1956,

that the disease was first 'discovered' in Minamata City, south-west region of Japan's Kyushu Island. Hence it came to be known as Minamata disease. Typical symptoms of Minamata disease included sensory disturbances, ataxia, dysarthria, constriction of the visual field; auditory disturbances and tremor were also seen. The symptoms were serious, and extensive lesions of the brain were observed.

b. **Cadmium Poisoning – Itai-Itai disease:** Itai-itai disease was the first documented occurrence of mass cadmium poisoning in the world. It occurred in 1950 in Toyama Prefecture in Japan. Itai-itai disease literally translates to "ouch-ouch", named for the painful screams of its victims. Cadmium is highly toxic even at low doses. Some of the effects of acute cadmium exposure are flu-like symptoms, called "*The Cadmium Blues*" leading to fever, chills, muscle aches. Any significant amount of cadmium taken up by the body immediately poisons the liver and kidneys causing irreversible damage. Serious damage is also inflicted upon the bones in a victim of Itai-itai. Cadmium is also a carcinogen.

c. **Lead Poisoning – Plumbism:** Also known as colicapictorum, saturnism, or painter's colic, is a type of medical condition in humans and other vertebrates caused by increased levels of the heavy metal lead in the body. Lead interferes with a variety of body processes and is toxic to many organs and tissues including the heart, bones, intestines, kidneys and reproductive and nervous systems. It interferes with the development of the nervous system and is therefore particularly toxic to children, causing potentially permanent learning and behavior disorders. Symptoms include abdominal pain, confusion, headache, anemia, irritability, and in severe cases seizures, coma and death.

CONTROL OF WATER POLLUTION

A. **Preventive Measures.** The best solution for water pollution is prevention. There are several steps that can be taken to help prevent water pollution from getting worse.

- ***Soil conservation*** : Erosion is one of the biggest causes of water pollution today. Planting vegetative covers, strict erosion management and implementing beneficial farming methods are just a few of the many possible approaches to soil conservation.
- ***Proper disposal of wastes*** : Sewage and toxic chemicals, such as paints, stains or cleaning supplies, should be disposed properly. Proper disposal keeps these substances out of storm drains, water ways and septic tanks.
- ***Reduced dependence of agrochemicals*** : Judicious use of agrochemicals like fertilizers and pesticides will ensure to reduce their surface run off and leaching. Adopting integrated pest management can reduce dependence on pesticides
- ***Reducing oil spills*** : Steps should be taken to repair oil leaks in cars and machinery as soon as they are spotted as also for prevention of large oil spills.
- ***Getting involved*** : Plastic bags in the water bodies are a well-documented water

pollutant. One should avoid plastics and help keep this problem from getting worse by changing to reusable grocery bags whenever possible. One should help spreading an awareness of problems of water pollution in order to combat it properly.

B. **Curative Measures**

Stabilization of the ecosystem: The principles involved in this technique include reduction of waste at source, harvesting and removal of biomass, trapping of nutrients, fish management and aeration

- ***Use of sludge as fertilizer*** : Using septic tanks, oxidation ponds, filter beds, wastewater treatment plants etc. solid wastes may be removed before water is tipped into river or sea. The solid waste can then be converted into sludge which is a valuable fertilizer.
- ***Special use of water hyacinth*** : Industrial water can be made less polluted before discharge by biological treatment using water hyacinth. Water hyacinth has the remarkable ability to accumulate poisonous metals including radioactive substances.
- ***Effective use of bacteria*** : Certain strains of bacteria can reduce oil spill effect and can use up the cyanides if judiciously used.
- ***Chemical methods*** : Sometimes chemical precipitation, solvent extraction, electro deposition, ion exchange, ultra-filtration and activated carbon adsorption systems are applied to remove heavy metals. All these methods are however extremely expensive.
- ***Use of solar power*** : Solar energy has recently been effectively used to purify waste water cheaply. It has been found that exposing the waste water to sunlight while using a catalyst such as titanium oxide can dissociate certain chemical toxicants.
- ***The 4R method*** : The best techniques to control water pollution consist of recycling, renovation, recharge and reuse. Scientific methods of recycling all waste materials and effluents can reduce water pollution to a great extent. For example, NEERI Nagpur has developed technology for reuse of waste water to provide cheap piped gas and generate electricity by recycling waste water.

Treatment of Municipal Waste Water

Municipal waste water is rich in sewage. The various treatment processes may reduce suspended solids,biodegradable organics,pathogenic bacteria and nutrients, including nitrates and phosphates. Widely used terminology refers to three levels of wastewater treatment (Fig 13.2)

1. **Primary** : Primary treatment is usually the first stage of wastewater treatment. It is designed to remove gross, suspended and floating solids from raw sewage. This level is sometimes referred to as "mechanical treatment", although chemicals are often used to accelerate the sedimentation process. Primary treatment can reduce the BOD of the incoming wastewater by 20-30% and the total suspended solids by some 50-60%.

may cause a person to be sick constantly. In China (Province of Taiwan) exposure to arsenic via drinking-water has been shown to cause a severe disease of the blood vessels, which leads to gangrene, known as *'black foot disease'*.

SOIL POLLUTION

Soil pollution is defined as the build-up in soils of persistent toxic compounds, chemicals, salts, radioactive materials, or disease-causing agents, which have adverse effects on plant growth and animal health.Soils are formed by the decomposition of rock and organic matter over many years. All soils contain a variety of compounds which are naturally present. Such contaminants include metals, inorganic ions and salts and many organic compounds. These compounds are mainly formed through soil microbial activity and decomposition of organisms. Additionally, various compounds get into soil from the atmosphere, with precipitation water, as well as by wind activity or other types of soil disturbances. At times, the amounts of some soil elements and other substances may exceed levels recommended for the health of humans, animals, or plants. When the amounts of soil contaminants exceed natural levels (what is naturally present in various soils) soil pollution is generated. The pollution of landscape due to severe misuse of land by dumping of garbage, industrial waste, sludge, ash etc. resulting in the conversion of once fertile land into a barren one is sometimes termed as *third pollution.*

Sources of Soil Pollution

1. **Urban Wastes:** Urban wastes comprise both commercial and domestic wastes including dried sludge of sewage. The main component of urban wastes is the urban solid wastes which include the discarded material resulting from community activities. These are materials which become useless and hence waste after short period of their use.
2. **Industrial Wastes:** Large quantity of unused and rejected chemicals, unwanted industrial wastes generated during manufacturing processes and industrial effluents discharged from pulp and paper mills, chemical industries, soil refineries, sugar factories, tanneries, pesticide industries, glass, cement, petroleum and other industries etc. are dumped over on the surface of soil by almost all industries. Such industrial wastes contain huge amount of toxic and industrial wastes most of which is non-biodegradable.
3. **Mining :** Extraction is the removal of mineral ores from the ground on a large scale by one or more of three principal methods: surface mining, underground mining, and *in situ* mining. The processes of ore extraction and concentration produce of large amounts of waste material (often very acidic) and particulate emissions. Mines waste-material rejects or traces due to mining activity can be found in the vicinity of the mine, sometimes pretty far away from the source.
4. **Pesticides :** Pesticides include substances that kill weeds (herbicides), algicides (algae), insects (insecticides), fungus (fungicides), rodents (rodenticides), mollusks (molluscicides), nematodes (nematicides), miticides (mites), plant growth regulators and others. Many of the chemicals used in pesticides are persistent soil contaminants, whose impact may endure for decades and adversely affect the soil ecosystem.

5. **Fertilizers :** Though chemical fertilizers increase crop production; their overuse has hardened the soil, decreased fertility, strengthened pesticides, polluted air and water, and released greenhouse gases, thereby bringing hazards to human health and environment as well.

6. **Biological Agents :** The excreta of humans, animals and birds are the major source of soil pollution by biological agents. Digested sewage sludge which is used as manure also causes soil pollution. In addition to excreta, faulty sanitation, accumulation of waste water and wrong methods of agriculture also induce soil pollution.

7. **Radionuclides:** Soil pollution by artificially produced radioactivity occurs through handling, transporting, testing and using of nuclear materials in warfare and industry. The radioactive waste is created by military weapons production and testing; mining; electrical power generation; medical diagnosis and treatment; consumer product development, manufacturing, and treatment; biological and chemical research; and other industrial uses.

8. **Farm Manure:** Giant livestock farms house thousands of cows, chickens or pigs and produce staggering amounts of animal manure. Such livestock farms produce far more waste than the land can absorb and ends up polluting the soil, degrading its water retention ability and fertility over time.

9. **Erosion:** The natural processes of erosion can lead to severe pollution as sediment finds its way into streams, rivers and oceans. As the sediment dumps into the water bodies, it can upset fragile aquatic eco-systems and aquatic life. Human activities responsible for erosion include deforestation land use changes etc.

Effects of Soil Pollution

1. **Effects on Agriculture :** Soil pollution degrades the quality of soils which results in substantial decrease in agricultural production. Contaminants typically alter plant metabolism, often causing a reduction in crop yields. Herbicides and chlorinated pesticides are very potent pollutants of the soil and affect soil texture and function of the agricultural ecosystem. Pesticides retained in soil concentrates in crops, vegetables, cereals and fruits which taint them to such an extent that they are not useable. Various vegetables, fruits, rice, grain, wheat, gram, barley and maize are known to contain significant amount of DDT, BHC and other organochlorine pesticides. They persist in the soil producing long term effects on vegetative cover.

2. **Effects on Ecosystems:** Soil pollution by contaminants can have significant deleterious consequences for ecosystems. Elevated levels of soil contaminants can negatively affect plant vigor, animal health, microbial processes, and overall soil health. Even relatively low concentrations of certain contaminants can alter soil chemistry and impact organisms that depend on the soil or plants for their nutrition and habitat. These changes can manifest in the alteration of metabolism of endemic microorganisms and arthropods resident in a given soil environment. The result can be virtual eradication of some of the primary food chain, which in turn could have major consequences for predator or consumer species. Even if the chemical effect on lower life forms is small, the lower

pyramid levels of the food chain may ingest alien chemicals, which through bio-magnification in the food chain can cause a far more deleterious effect to an organism higher up in the food chain. Many hunting birds feeding on grains, particularly contaminated with high levels of DDT are threatened with extinction.

3. **Effects on Human Health:** Polluted soil directly affects human health through direct contact with soil or via inhalation of soil contaminants which have vaporized. Potentially greater threats are posed by the infiltration of soil contamination into groundwater which is then used for human consumption. The effects are sometimes evident in areas apparently far removed from any apparent source of above ground contamination. At sufficient dosages a large number of soil contaminants can cause death by exposure via direct contact, inhalation or ingestion of contaminants in groundwater contaminated through soil. For any exposure to a contaminant, the likelihood that health effects will occur depends on the toxicity of the contaminant (how harmful it is to humans), how much of the contaminant is in contact with humans, and how long and how often the exposure occurs. Children are generally more vulnerable because they eat, drink and breathe more in relation to their body size than adults. The bodies of unborn babies, infants, and children are also still developing and are more vulnerable to contaminants.

Control of Soil Pollution

1. **Effective Disposal of Wastes :** This incorporates effective treatment of domestic sewage by suitable biological and chemical methods and adopting modem techniques of sludge disposal. Municipal wastes have to be properly collected by segregation, treated and disposed scientifically. Industrial wastes too have to be properly treated at source, by segregation of wastes or adopting integrated waste treatment methods.
2. **Regulated Use of Pesticides :** Ban should be imposed on chemicals, biocides, pesticides which are fatal to plants and animals. Ban on the use of highly toxic and resistant pesticides or regulating their use only for special purposes under thorough monitoring can control soil pollution.
3. **Change in Agricultural Practices :** Transforming intensive agriculture into a sustainable system can also help combat soil pollution effectively by adopting measures such as maintaining a healthy soil community in order to regenerate soil fertility by providing organic manures; increasing fallow periods; avoiding excessive use of chemical fertilizers;use of manures and biofertilizers in place of chemical fertilizers; infusing bio-diversity in agriculture by sowing mixed crops and crop rotation etc.
4. **Soil Conservation :** Proactive efforts should be made to prevent the loss of precious top soil from erosion and to maintain it in a fertile state for agricultural purposes. This can be achieved by launching extensive afforestation and community forestry programs and implementing deterrent measures against deforestation.Measures include planting of soil binding grasses,wind breaks and wind shields in areas which are prone to wind erosion, controlled grazing, proper forest management etc.
5. **Research and Development :** There is a need to sponsor more intensive R and D

efforts on bio-fertilizers, microbial degradation of wastes, and utilization of wastes by recovery, reusing and recycling solid wastes, safer treatment and disposal of hazardous wastes.

6. **Public Awareness Programs :** This includes imparting informal and formal public awareness programs to educate people at large regarding health hazards and undesirable effects due to soil pollution. Mass media, educational institutions and voluntary agencies should be involved to achieve these objectives.

NOISE POLLUTION

The word noise (*Latin nausea*) means any unwanted or unpleasant sound that causes discomfort. It is the wrong sound, in the wrong place at the wrong time. Noise pollution then is defined as *"Undesired sound that is disruptive or dangerous and can lead to health hazards in man as well as can cause harm to life, nature, and property".*

Today there is virtually no escape from the manmade plague of noise pollution, no matter where we are - in our homes and yards, on our streets, in our cars, at theaters, restaurants, parks, arenas, and in other public places. It is imposed on us without our consent, often against our wills, and at times, places, and volumes over which we have no control. The potential health effects of noise pollution are numerous, pervasive, persistent, and medically and socially significant. Noise produces direct and cumulative adverse effects that impair health and that degrade residential, social, working, and learning environments with corresponding real (economic) and intangible (well-being) losses.

Measurement of Sound : The Decibel Scale

The decibel (abbreviated dB) is the unit used to measure the intensity or loudness of a sound. The dB scale ranges from 0 to 120 dB.On the decibel scale, the smallest audible sound (near total silence) is 0 dB. A sound 10 times more powerful is 10 dB. A sound 100 times more powerful than near total silence is 20 dB. A sound 1,000 times more powerful than near total silence is 30 dB.Weighting filters are sometimes applied when measuring sound. The most common frequency weighting in current use is "A-weighting" providing results often denoted as ***dB(A). dB (A) Leq*** then denotes the time weighted average of the level of sound in decibels on scale A which is related to human hearing.The decibel values of some com non sounds are shown in Table 13.5. For humans the normal level of tolerance is 80 dB (A). Sound level above this is considered as noise pollution.

Table 13.5. Decibel values of common sounds

Sound level in dB	Typical environment	Subjective description
190	Bomb explosion	*Intolerable*
125 - 160	Diwali Crackers	
140	Military aircraft at take-off	
130	Mechanical machinery	

97 - 105	Rail engine at 15 m	*Very noisy*
100	Automatic Lathe machine shop	
	Underground train station at platform	
90 - 105	Horns of vehicles	
90	Heavy lorries at 6 metres	
	Construction site – pneumatic drilling	
80 - 90	Road traffic, heavy	
70 - 80	Road traffic, medium	*Noisy*
70	Loud radio	
60	Restaurant	
	Department store	
50	General office	*Quiet*
	Speech at 1 metre	
40	Whispered conversation at 2 metres	
30 to 10		*Very quiet*
0	Threshold of hearing	

Sources of Noise Pollution :

The sources of noise pollution can be natural and anthropogenic. The natural sources of noise pollution include noise generated by cloud thunder, high velocity wind such as hurricanes, tornado, gales, thunderstorms, high intensity rainfall, hailstorms, waterfalls, surf currents etc. These sources are however of rare occurrence. The **anthropogenic sources** of noise pollution include the following

1. **Transportation Noise :** Includes noise generated by road traffic, trains and aircraft
   a. ***Road traffic noise*** **:** Road traffic is the most widespread source of noise and directly proportional to the volume of vehicles. The major sources of noise in automobiles are exhaust, intake, engine and fan, and tires at high speed. The road traffic noise also depends on several associated factors like road conditions, traffic clearance, condition of vehicles, speed of the vehicle etc.
   b. ***Rail traffic noise*** **:** Noise from the trains is produced by diesel exhaust, engine and air intake, cooling fans, wheel-rail interaction, electric generator and electric traction motor, miscellaneous noise generated in freight and passenger cars sounds of sirens or horns etc.
   c. ***Aircraft noise*** **:** Noise from commercial aircraft is only a problem around airports as this is where aircraft converge at low altitude and high engine power. Supersonic jets flying at the speed of more than one Mach (the speed of sound) produce a series of shock waves called *sonic boom*. It produces sudden rattling of windows and doors, may sometimes break windowpanes, create crack on walls and shake

the buildings also.

2. **Industrial Noise :** Noise is produced, at every stage in industry by various aspects like welding, hammering, drilling, blowing, running machinery, motors, sheet metal work, lathe machine work, operation of cranes, grinding, turning, riveting, fabricating, forging, compressing, vacuuming, breaking, molding, steaming, boiling, cooling, heating, venting, painting, pumping, packing, transporting etc. High noise levels common in petrochemical, steel industries, thermal power stations, cement industries, and mines can be due to vibration of heavy equipment, sound from engines, reciprocating machines, trucks and dumpers etc.

3. **Community Noise**

   a. ***Functions*** **:** All social functions like marriages, religious functions and festivals, musical nights, cultural programmes and religious propaganda produce a lot of noise.

   b. ***Crackers and detonations*** **:** Crackers are burst during festivities. Many detonations are carried out for blasting rocks during mining operations, road and canal building

   c. ***Loudspeakers*** **:** Loudspeakers are the most significant noise pollutants used at large-scale during all types of festivals of all communities, national festivals like Independence Day (15th August) and Republic Day (26th January), electioneering, advertisement etc.

   d. ***Noise from commercial establishments*** **:** Several commercial establishments use T.V and music systems for attracting and entertaining customers. Other sound producing gadgets include fans, exhaust fans, desert coolers, generators, etc.

4. **Residential Noise**

   a. ***Domestic gadgets*** **:** Food blenders, pressure cookers, exhaust fans, fans, desert coolers, vacuum cleaners, washing machines etc. produce a lot of noise.

   b. ***Personal entertainment*** **:** Noise generated by radios, transistors, T.V. cassette players, music systems etc.

5. **Occupational noise:** Under occupational noise can be included the following:

   a. ***Defense equipment*** **:** Noise generated by tanks, artillery, rocket launchers, missiles, practice firings and explosions

   b. ***Builders*** **:** They use concrete mixers, scrapers, bulldozers, trolleys, road rollers and dynamite blasting which act as sources of noise pollution

   c. ***Agriculture machines*** **:** Noise produced by tractors, pump sets, harvesters, threshers, seed drills etc.

Effects of Noise Pollution

A. **Effects of Noise on Human Heath:** While high decibel noise can simply lead to speech interference and may not allow two people to communicate freely it is also known to cause a host of related psychological and physiological effects and problems (Table 13.6). Following are the deleterious effects produced by noise pollution on man

Table 13.6. Human health hazards associated with varying levels of noise intensity

Noise Intensity (dB)	Health Hazards
80	Annoyance
90	Hearing Damage
95	Very annoying
110	Stimulation of reception in skin
120	Pain threshold
130-135	Nausea, vomiting, dizziness
140	Pain in ear
150	Burning of skin
160	Rupture of tympanic membrane
180	Major permanent damage in short time

1. **Effects on Physiology :** Continuous noise causes an increase in cholesterol level resulting in the constriction of blood vessels making one prone to heart attack and strokes. Reports indicate that blood is also thickened by excessive noise. Acute exposure to noise leads to temporary increases in heart rate and peripheral resistance, blood pressure, blood viscosity, vasoconstriction, levels of blood lipids, causes shifts in electrolytes, and increases levels of epinephrine, norepinephrine, and cortisol. Noise is known to cause dilation of pupils of the eyes, neuromuscular tension, nervousness, *gastric problems* like spasms, nausea and peptic ulcers etc.Skin becomes pale and there occurs a tensing of the voluntary and involuntary muscles.It may produce *allergic reactions* in some people. *Night vision* and *color perception* too may be affected. Sudden high-level noise caused by sonic booms and explosion can lead to termination of pregnancy in early stages. Many cases of birth defects have been reported in areas close to high noise regions.

2. **Hearing Impairment (Auditory Effects) :** Hearing impairment due to noise pollution is called '*sociocusis.*' There is general agreement that exposure to sound levels less than 70 dB does not produce hearing damage, regardless of the duration of exposure. There is also general agreement that exposure for more than 8 hours to sound levels in excess of 85 dB are potentially hazardous. Noise induced hearing impairment may be accompanied by abnormal loudness perception (loudness recruitment), distortion (paracusis), and tinnitus (ringing or buzzing in ears). Tinnitus may be temporary or may become permanent after prolonged exposure.A sudden high intensity noise such as a bomb explosion can damage the tympanic membrane (ear drum). Ear bones too can be displaced when such a sound causes intense vibrations of ear drums.

3. **Sleep Disturbance :** A continuous noise in excess of 30 dB disturbs sleep. For intermittent noise, the probability of being awakened increases with the number of noise events per night. The primary sleep disturbances are difficulty falling asleep, frequent

awakenings, waking too early, and alterations in sleep stages and depth, especially a reduction in REM sleep.When sleep disruption becomes chronic, the results are mood changes, decrements in performance, and other long-term effects on health and well-being. Secondary effects include fatigue, depressed mood and well-being, and decreased performance.

4. **Psychological and Related Effects:** Noise pollution interferes with the ability to comprehend normal speech and may lead to a number of personal disabilities, handicaps, and behavioral changes. These include problems with concentration, fatigue, uncertainty, lack of self-confidence, irritation, annoyance, misunderstandings, decreased working capacity, disturbed interpersonal relationships, and stress reactions.A wide range of negative reactions too are associated with noise pollution; these include anger, disappointment, dissatisfaction, withdrawal, helplessness, depression, anxiety, distraction, agitation, or exhaustion. Noise also affects learning, reading, problem solving, motivation, school performance, and social and emotional development in children.

B. **Effects on Wildlife:** Wildlife faces far more problems than humans because noise pollution since they are more dependent on sound. Animals develop a better sense of hearing than us since their survival depends on it. The ill effects of excessive noise begin at home. Pets react more aggressively in households where there is constant noise. They become disoriented more easily and face many behavioral problems. In nature, animals may suffer from hearing loss, which makes them easy prey and leads to dwindling populations. Species that depend on mating calls to reproduce are often unable to hear these calls due to excessive man-made noise. As a result, they are unable to reproduce and cause declining populations. Others require sound waves to echo-locate and find their way when migrating. Disturbing their sound signals means they get lost easily and do not migrate when they should.

Control of Noise Pollution

1. **Noise Control at Source:** The noise pollution can be controlled at the source of generation itself by employing techniques likereducing the noise levels from domestic sectors, maintenance of automobiles, control over vibrations, prohibition on usage of loud speakers, selection of machinery machinery/equipment which generate less noise (sound), maintenance of machines like proper lubrication and maintenance of machines, vehicles etc. will reduce noise levels

2. **Control in the Transmission Path :** The change in the transmission path will increase the length of travel for the wave and get absorbed/refracted/radiated in the surrounding environment. The available techniques are briefly discussed below.

   - **Installation of barriers:** Installation of barriers between noise source and receiver can attenuate the noise levels.
   - **Design of building:** The design of the building incorporating the use of suitable noise absorbing material for wall/door/window/ceiling will reduce the noise levels.
   - **Sound Insulation :** Sound insulation can be done by constructing windows with

double or triple panes of glass and filling the gaps with sound absorbing materials.

- **Installation of panels or enclosures:** A sound source may be enclosed within a paneled structure such as room as a means of reducing the noise levels at the receiver.
- **Acoustic zoning:** Increased distance between source and receiver by zoning of noisy industrial areas, bus terminals and railway stations, aerodromes etc. away from the residential areas would go a long way in minimizing noise pollution.
- **Green belt development:** Green belt development can attenuate the sound levels. The statutory regulations direct the industry to develop greenbelt four times the built-up area for attenuation of various atmospheric pollutants, including noise.

3. **Using Protection Equipment:** Protective equipment usage is the *ultimate* step in noise control technology. The usage of protective equipment and the worker's exposure to the high noise levels can be minimized by:
   - **Job rotation:** By rotating the job between the workers working at a particular noise source or isolating a person, the adverse impacts can be reduced.
   - **Exposure reduction:** The schedule of the workers should be planned in such a way that; they should not be over exposed to the high noise levels.
   - **Hearing protection:** Equipment like earmuffs, ear plugs etc. are the commonly used devices for hearing protection.

Standards and Guidelines for Control of Noise Pollution in India

The Central Pollution Control Board constituted a Committee on Noise Pollution Control. The Committee recommended noise standards for ambient air and for automobiles, domestic appliances and construction equipments, which were later notified in **Environment (Protection) Rules,1986** as given in Table 13.7.

Table 13.7. Noise standards for ambient air in India

Area Code	Category of	Area Limits in dB (A) Leq	
		Day time	Night time
(A) Industrial area		75	70
(B) Commercial area		65	55
(C) Residential area		55	45
(D) Silence zone		50	40

Day time is reckoned in between 6 a.m. and 9 p.m. and night time between 9 p.m. and 6 a.m. ***Silence zone*** is referred as areas up to 100 meters around such premises as hospitals, educational institutions and courts. The silence zones are to be declared by the Competent Authority. Use of vehicular horns, loudspeakers and bursting of crackers shall be banned in these zones.