

## **Module – IV**

### **Environmental Pollution**

#### **DEFINITION**

Pollution is the effect of undesirable changes in our surroundings that have harmful effects on plants, animals and human beings.

This occurs when only short-term economic gains are made at the cost of the long-term ecological benefits for humanity. No natural phenomenon has led to greater ecological changes than have been made by mankind. During the last few decades we have contaminated our air, water and land on which life itself depends with a variety of waste products.

Pollutants include solid, liquid or gaseous substances present in greater than natural abundance produced due to human activity, which have a detrimental effect on our environment. The nature and concentration of a pollutant determines the severity of detrimental effects on human health. An average human requires about 12 kg of air each day, which is nearly 12 to 15 times greater than the amount of food we eat. Thus even a small concentration of pollutants in the air becomes more significant in comparison to the similar levels present in food. Pollutants that enter water have the ability to spread to distant places especially in the marine ecosystem.

From an ecological perspective pollutants can be classified as follows:

Degradable or non-persistent pollutants: These can be rapidly broken down by natural processes.

Eg: domestic sewage, discarded vegetables, etc.

Slowly degradable or persistent pollutants: Pollutants that remain in the environment for many years in an unchanged condition and take decades or longer to degrade. Eg: DDT and most plastics.

Non-degradable pollutants: These cannot be degraded by natural processes. Once they are released into the environment they are difficult to eradicate and continue to accumulate. Eg: toxic elements like lead or mercury.

#### **CAUSES, EFFECTS AND CONTROL MEASURES OF AIR POLLUTION**

##### **What is air pollution?**

Air pollution occurs due to the presence of undesirable solid or gaseous particles in the air in quantities that are harmful to human health and the environment.

Air may get polluted by natural causes such as volcanoes, which release ash, dust, sulphur and other gases, or by forest fires that are occasionally naturally caused by lightning. However, unlike pollutants from human activity, naturally occurring pollutants tend to remain in the atmosphere for a short time and do not lead to permanent atmospheric change.

##### **Types of Air pollutants:**

Pollutants that are emitted directly from identifiable sources are produced both by natural events (for example, dust storms and volcanic eruptions) and human activities (emission from vehicles, industries, etc.). These are called primary pollutants. There are five primary pollutants that together contribute about 90 percent of the global air pollution. These are carbon oxides (CO and CO<sub>2</sub>), nitrogen oxides, sulphur oxides, volatile organic compounds (mostly hydrocarbons) and suspended particulate matter.

Pollutants that are produced in the atmosphere when certain chemical reactions take place among the primary pollutants are called secondary pollutants. Eg: sulphuric acid, nitric acid, carbonic acid, etc.

##### **Causes:**

Carbon monoxide is a colourless, odourless and toxic gas produced when organic materials such as natural gas, oil, coal or wood are incompletely burnt. Vehicular exhausts are the single largest source of carbon monoxide. Carbon monoxide is however not a persistent pollutant. Natural processes can convert carbon monoxide to other compounds that are not harmful.

Sulphur oxides are produced when sulphur containing fossil fuels are burnt.

Nitrogen oxides are found in vehicular exhausts.

Hydrocarbons are a group of compounds consisting of carbon and hydrogen atoms. They either evaporate from fuel supplies or are remnants of fuel that did not burn completely. Hydrocarbons are washed out of the air when it rains and run into surface water. Using higher oxygen concentrations in the fuel-air mixture and using valves to prevent the escape of gases, fitting of catalytic converters in automobiles, are some of the modifications that can reduce the release of hydrocarbons into the atmosphere.

Particulates are small pieces of solid material (for example, smoke particles from fires, bits of asbestos, dust particles and ash from industries) dispersed into the atmosphere. The effects of particulates range from soot to the carcinogenic (cancer causing) effects of asbestos, dust particles and ash from industrial plants that are dispersed into the atmosphere. Repeated exposure to particulates can cause them to accumulate in the lungs and interfere with the ability of the lungs to exchange gases.

Lead is a major air pollutant that remains largely unmonitored and is emitted by vehicles. High lead levels have been reported in the ambient air in metropolitan cities. Leaded petrol is the primary source of airborne lead emissions in Indian cities.

### **What happens to pollutants in the atmosphere?**

Once pollutants enter the troposphere they are transported downwind, diluted by the large volume of air, transformed through either physical or chemical changes or are removed from the atmosphere by rain during which they are attached to water vapour that subsequently forms rain or snow that falls to the earth's surface. The atmosphere normally disperses pollutants by mixing them in the very large volume of air that covers the earth. This dilutes the pollutants to acceptable levels. The rate of dispersion however varies in relation to the following aspects:

#### *Topography*

Normally as the earth's surface becomes warmed by sunlight the layer of air in contact with the ground is also heated by convection. This warmer air is less dense than the cold air above it, so it rises. Thus pollutants produced in the surface layer are effectively dispersed. However on a still evening, the process is reversed.

#### *Meteorological conditions*

The velocity of the wind affects the dispersal of pollutants. Strong winds mix polluted air more rapidly with the surrounding air diluting the pollutants rapidly. When wind velocity is low mixing takes place and the concentration of pollutants remains high.

When sulphur dioxide and nitrogen oxides are transported by prevailing winds they form secondary pollutants such as nitric acid vapour, droplets of sulphuric acid and particles of sulphate and nitrate salts. These chemicals descend on the earth's surface in two forms: wet (as acidic rain, snow, fog and cloud vapour) and dry (as acidic particles). The resulting mixture is called acid deposition, commonly called acid rain.

### **Effects of air pollution**

When the upper respiratory system is irritated by pollutants sneezing and coughing expel contaminated air and mucus. Prolonged exposure to air pollutants can overload or breakdown these natural defences causing or contributing to diseases such as lung cancer, asthma, chronic bronchitis and emphysema.

Acid deposition has many harmful effects especially when the pH falls below 5.1 for terrestrial systems and below 5.5 for aquatic systems. It contributes to human respiratory diseases such as bronchitis and asthma, which can cause premature death.

Cigarette smoking is responsible for the greatest exposure to carbon monoxide. Exposure to air containing even 0.001 percent of carbon monoxide for several hours can cause collapse, coma and even death.

Sulfur dioxide irritates respiratory tissues. Chronic exposure causes a condition similar to bronchitis. It also reacts with water, oxygen and other material in the air to form sulfur-containing acids. The acids can become attached to particles which when inhaled are very corrosive to the lung.

Nitrogen oxides especially NO<sub>2</sub> can irritate the lungs, aggravate asthma or chronic bronchitis and also increase susceptibility to respiratory infections such as influenza or common colds.

Suspended particles aggravate bronchitis and asthma. Exposure to these particles over a long period of time damages lung tissue and contributes to the development of chronic respiratory disease and cancer.

Many volatile organic compounds such as (benzene and formaldehyde) and toxic particulates (such as lead, cadmium) can cause mutations, reproductive problems or cancer.

Every year air pollutants cause damage worth billions of rupees. Air pollutants break down exterior paint on cars and houses. All around the world air pollutants have discoloured irreplaceable monuments, historic buildings, marble statues, etc.

The CFCs and the halons migrate into the upper atmosphere after they are released. In the stratosphere unfiltered UV-radiation severs the chemical bonds releasing chlorine from the rest of the CFC. This attacks the ozone molecule resulting in its splitting into an oxygen molecule and an oxygen atom. Sunburn, cataract, aging of the skin and skin cancer are caused by increased ultra-violet radiation due to ozone layer depletion.

Atmospheric changes induced by pollution contribute to global warming (**GreenhouseEffect**), a phenomenon which is caused due to the increase in concentration of certain gases like carbon dioxide, nitrogen oxides, methane and CFCs.

### **Control measures for air pollution**

Air pollution can be controlled by two fundamental approaches: preventive techniques and effluent control.

One of the effective means of controlling air pollution is to have proper equipment in place. This includes devices for removal of pollutants from the flue gases through scrubbers, closed collection recovery systems through which it is possible to collect the pollutants before they escape, use of dry and wet collectors, filters, electrostatic precipitators, etc.

Providing a greater height to the stacks can help in facilitating the discharge of pollutants as far away from the ground as possible.

Industries should be located in places so as to minimize the effects of pollution after considering the topography and the wind directions.

Substitution of raw material that causes more pollution with those that cause less pollution can be done.

### **Water Pollution**

When the quality or composition of water changes directly or indirectly as a result of man's activities such that it becomes unfit for any purpose it is said to be polluted.

**Point sources of pollution:** When a source of pollution can be readily identified because it has a definite source and place where it enters the water it is said to come from a **point source**.

Eg. Municipal and Industrial Discharge Pipes.

When a source of pollution cannot be readily identified, such as agricultural runoff, acid rain, etc, they are said to be **non-point sources** of pollution.

There are several classes of common water pollutants. These are **disease-causing agents**(pathogens) which include bacteria, viruses, protozoa and parasitic worms that enter water from domestic sewage and untreated human and animal wastes.

Another category of water pollutants is **oxygen depleting wastes**. These are organic wastes that can be decomposed by aerobic (oxygen requiring) bacteria. Large populations of bacteria use up the oxygen present in water to degrade these wastes. In the process this degrades water quality.

The amount of oxygen required to break down a certain amount of organic matter is called the biological oxygen demand (BOD). The amount of BOD in the water is an indicator of the level of pollution.

A third class of pollutants are **inorganic plantnutrients**. These are water soluble nitrates and phosphates that cause excessive growth of algae and other aquatic plants. The excessive growth of algae and aquatic plants due to added nutrients is called eutrophication. They may interfere with the use of the water by clogging water intake pipes, changing the taste and odour of water and cause a build up of organic matter. As the organic matter decays, oxygen levels decrease and fish and other aquatic species die.

A fourth class of water pollutants is **water soluble inorganic chemicals** which are acids, salts and compounds of toxic metals such as mercury and lead. High levels of these chemicals can make the water unfit to drink, harm fish and other aquatic life, reduce crop yields and accelerate corrosion of equipment that use this water.

Another cause of water pollution is a variety of **organic chemicals**, which include oil, gasoline, plastics, pesticides, cleaning solvents, detergent and many other chemicals. These are harmful to aquatic life and human health.

**Sediment of suspended matter** is another class of water pollutants. These are insoluble particles of soil and other solids that become suspended in water. High levels of soil particles suspended in water, interferes with the penetration of sunlight. This reduces the photosynthetic activity of aquatic plants and algae disrupting the ecological balance of the aquatic bodies.

**Water soluble radioactive isotopes** are yet another source of water pollution. These can be concentrated in various tissues and organs as they pass through food chains and food webs. Ionizing radiation emitted by such isotopes can cause birth defects, cancer and genetic damage.

**Hot water** let out by power plants and industries that use large volumes of water to cool the plant result in rise in temperature of the local water bodies. The warm water not only decreases the solubility of oxygen but changes the breeding cycles of various aquatic organisms.

**Oil** is washed into surface water in runoff from roads and parking lots which also pollutes groundwater. Accidental oil spills from large transport tankers at sea have been causing significant environmental damage.

#### **Groundwater pollution:**

While oil spills are highly visible and often get a lot of media attention, a much greater threat to human life comes from our groundwater being polluted which is used for drinking and irrigation.

1. Ground water is polluted due to:
2. Urban run-off of untreated or poorly treated waste water and garbage
3. Industrial waste storage located above or near aquifers
4. Agricultural practices such as the application of large amounts of fertilizers and pesticides, animal feeding operations, etc. in the rural sector
5. Leakage from underground storage tanks containing gasoline and other hazardous substances
6. Leachate from landfills
7. Poorly designed and inadequately maintained septic tanks
8. Mining wastes

#### **Control measures for preventing water pollution**

While the foremost necessity is prevention, setting up effluent treatment plants and treating waste through these can reduce the pollution load in the recipient water. The treated effluent can be reused for either gardening or cooling purposes wherever possible. A few years ago a new technology called the Root Zone Process has been developed by Thermax. This system involves running contaminated water through the root zones of specially designed reed beds. The reeds, which are essentially wetland plants have the capacity to absorb oxygen from the surrounding air through their stomatal openings. The oxygen is pushed through the porous stem of the reeds into the hollow roots where it enters the root zone and creates conditions suitable for the growth of numerous bacteria and fungi. These micro-organisms oxidize impurities in the wastewaters, so that the water which finally comes out is clean.

#### **Soil Pollution**

We can no more manufacture a soil with a tank of chemicals than we can invent a rain forest or produce a single bird. The soil is a resource for which there is no substitute.

Soil is a thin covering over the land consisting of a mixture of minerals, organic material, living organisms, air and water that together support the growth of plant life. Several factors contribute to the formation of soil from the parent material. This includes mechanical weathering of rocks due to temperature changes and abrasion, wind, moving water, glaciers, chemical weathering activities and lichens. Climate and time are also important in the development of soils. Extremely dry or cold climates develop soils very slowly while humid and warm climates develop them more rapidly. Under ideal climatic conditions soft parent material may develop into a centimeter of soil within 15 years. Under poor climatic conditions a hard parent material may require hundreds of years to develop into soil.

## Erosion

Soil erosion can be defined as the movement of surface litter and topsoil from one place to another. While erosion is a natural process often caused by wind and flowing water it is greatly accelerated by human activities such as farming, construction, overgrazing by livestock, burning of grass cover and deforestation.

Loss of the topsoil makes a soil less fertile and reduces its water holding capacity. The topsoil, which is washed away, also contributes to water pollution clogging lakes, increasing turbidity of the water and also leads to loss of aquatic life. For one inch of topsoil to be formed it normally requires 200-1000 years depending upon the climate and soil type. Thus if the topsoil erodes faster than it is formed the soil becomes a non-renewable resource.

Thus it is essential that proper soil conservation measures are used to minimize the loss of top soil. There are several techniques that can protect soil from erosion. Today both water and soil are conserved through integrated treatment methods. Some of the most commonly employed methods include the two types of treatment that are generally used.

- Area treatment which involves treating the land
- Drainage line treatment which involves treating the natural water courses (nalas)

Continuous contour trenches can be used to enhance infiltration of water reduce the runoff and check soil erosion. These are actually shallow trenches dug across the slope of the land and along the contour lines basically for the purpose of soil and water conservation. They are most effective on gentle slopes and in areas of low to medium rainfall. These bunds are stabilized by fast growing tree species and grasses. In areas of steep slopes where the bunds are not possible, continuous contour benches (CCBs) made of stones are used for the same purpose.

### Area Treatment

Purpose	Treatment Measure	Effect
Reduces the impact of rain drops on the soil	Develop vegetative cover on the non arable land	Minimum disturbance and displacement of soil particles
Infiltration of water where it falls	Apply water infiltration measures on the area	In situ soil and moisture conservation
Minimum surface run off	Store surplus rain water by constructing bunds, ponds in the area	Increased soil moisture in the area, facilitate ground water recharge
Ridge to valley sequencing	Treat the upper catchment first and then proceed towards the outlet	Economically viable, less risk of damage and longer life of structures of the lower catchments

### Drainage line treatment

Purpose	Treatment measure	Effect
Stop further deepening of gullies and retain sediment run-off	Plug the gullies at formation	Stops erosion, recharges groundwater at the upper level.
Reduce run-off velocity, pass cleaner water to the downstream side	Crates temporary barriers in nalas	Delayed flow and increased groundwater recharge
Minimum sedimentation in the storage basins	Use various methods to treat the catchments	
Low construction cost	Use local material and skills for constructing the structures	Structures are locally maintained

Gradonies can also be used to convert wastelands into agricultural lands. In this narrow trenches with bunds on the downstream side are built along contours in the upper reaches of the catchment to collect run-off and to conserve moisture from the trees or tree crops. The area between the two bunds is use for cultivation of crops after development of fertile soil cover. Some of the ways in which this can be achieved are:

**Live check dams** which barriers created by planting grass, shrubs and trees across the gullies can be used for this purpose.

A **bund constructed out of stones** across the stream can also be used for conserving soil and water.

**An Earthen checkbund** is constructed out of local soil across the stream to check soil erosion and flow of water.

A **Gabion structure** is a bund constructed of stone and wrapped in galvanized chain link.

A **Gabion structure with ferrocement impervious barrier** has a one inch thick impervious wall of ferrocement at the center of the structure which goes below the ground level upto the hard strata. This ferrocement partition supported by the gabion portion is able to retain the water and withstand the force of the runoffwater.

**An Underground bandhara** is an underground structure across a nalla bed to function as a barrier to check the ground water movement.

### **Problems with pesticide use**

Pesticides not only kill the pests but also a largevariety of living things including humans. Theymay be persistent or non-persistent. Persistentpesticides once applied are effective for a longtime. However as they do not break down easilythey tend to accumulate in the soil and in thebodies of animals in the food chain.

### **Excess salts and water**

Irrigated lands can produce crop yields muchhigher than those that only use rainwater. Howeverthis has its own set of ill effects.The accumulation of these salts iscalled salinization, which can stunt plant growth,lower yields and eventually kill the crop and renderthe land useless for agriculture.

### **Marine Pollution**

Marine pollution can be defined as the introductionof substances to the marine environmentdirectly or indirectly by man resulting inadverse effects such as hazards to human health,obstruction of marine activities and lowering thequality of sea water. While the causes of marine pollution may be similar to that of generalwater pollution there are some very specificcauses that pollute marine waters.

- The most obvious inputs of waste is throughpipes directly discharging wastes into thesea. Very often municipal waste and sewagefrom residences and hotels in coastaltowns are directly discharged into the sea.
- Pesticides and fertilizers from agriculturewhich are washed off the land by rain, enterwater courses and eventually reach thesea.
- Petroleum and oils washed off from theroads normally enter the sewage system butstormwater overflows carry these materialsinto rivers and eventually into the seas.
- Ships carry many toxic substances such asoil, liquefied natural gas, pesticides, industrialchemicals, etc. in huge quantities sometimesto the capacity of 350,000 tonnes.Ship accidents and accidental spillages atsea therefore can be very damaging to themarine environment.
- Offshore oil exploration and extraction alsopollute the seawater to a large extent.

### **Pollution due to organic wastes**

The amount of oxygen dissolved in the water is vital for the plants and animals living in it. Wastes, which directly or indirectly affect the oxygen concentration, play an important role in determining the quality of the water. Normally the greatest volume of waste discharged to water courses, estuaries and the sea is sewage, which is primarily organic in nature and is degraded by bacterial activity. Using the oxygen present in the water these wastes are broken down into stable inorganic compounds. However as a result of this bacterial activity the oxygen concentration in the water is reduced. When the oxygen concentration falls below 1.5 mg/lit, the rate of aerobic oxidation is reduced and their place is taken over by the anaerobic bacteria that can oxidize the organic molecules without the use of oxygen. This results in end products such as hydrogen sulphide, ammonia and methane, which are toxic to many organisms.This process results in the formation of ananoxic zone which is low in its oxygen content from which most life disappears except for anaerobic bacteria, fungi, yeasts and some protozoa. This makes the water foul smelling.

**Control measures:** One way of reducing thepollution load on marine waters is through the introduction of sewage treatment plants. This will reduce the biological oxygen demand (BOD) of the final product before it is

discharged to the receiving waters. Various stages of treatment such as primary, secondary or advanced can be used depending on the quality of the effluent that is required to be treated.

**Primary treatment:** These treatment plants use physical processes such as screening and sedimentation to remove pollutants that will settle, float or, that are too large to pass through simple screening devices.

**Secondary treatment:** The main objective of secondary treatment is to remove most of the BOD. There are three commonly used approaches: trickling filters, activated sludge process and oxidation ponds. Secondary treatment can remove at least 85 percent of the BOD.

**Advanced sewage treatment:** This involves a series of chemical and physical processes that remove specific pollutants left in the water after primary and secondary treatment. Sewage treatment plant effluents contain nitrates and phosphates in large amounts. These contribute to eutrophication. Thus advanced treatment plants are designed to specifically remove these contaminants. Advanced treatment plants are very expensive to build and operate and hence are rarely used.

**Pollution due to oil:** Oil pollution of the sea normally attracts the greatest attention because of its visibility. There are several sources through which the oil can reach the sea.

**Tanker operations:** Half the world production of crude oil which is close to three billion tons a year is transported by sea. After a tanker has unloaded its cargo of oil it has to take on seawater as ballast for the return journey. This ballast water is stored in the cargo compartments that previously contained the oil. The ballast water thus becomes contaminated with this oil. When a fresh cargo of oil is to be loaded, these compartments are cleaned with water, which discharges the dirty ballast along with the oil into the sea.

**Dry docking:** All ships need periodic dry docking for servicing, repairs, cleaning the hull, etc. During this period when the cargo compartments are to be completely emptied, residual oil finds its way into the sea.

**Tanker accidents:** A large number of oil tanker accidents happen every year. Sometimes this can result in major disasters such as that of the Exxon Valdez.

**Offshore oil production:** Oil that is extracted from the seabed contains some water. Even after it is passed through oil separators the water that is discharged contains some oil, which adds to marine pollution.

**Control measures for oil pollution:** Cleaning oil from surface waters and contaminated beaches is a time consuming labour intensive process. The natural process of emulsification of oil in the water can be accelerated through the use of chemical dispersants which can be sprayed on the oil. A variety of slick-lickers in which a continuous belt of absorbent material dips through the oil slick and is passed through rollers to extract the oil have been designed. Rocks, harbour walls can be cleaned with high pressure steam or dispersants after which the surface must be hosed down.

Two techniques have substantially reduced oil pollution due to tanker operations. In the load-on-top system, the compartments are cleaned by high pressure jets of water. The oily water is retained in the compartment until the oil floats to the top. The water underneath that contains only a little oil is then discharged into the sea and the oil is transferred to a slop tank. At the loading terminal, fresh oil is loaded on top of the oil in the tank and hence the name of the technique.

In the second method called 'crude oil washing', the clingage is removed by jets of crude oil while the cargo is being unloaded. Some modern tankers have segregated ballast where the ballast water does not come in contact with the oil. Thus with the introduction of these new methods of deballasting, the amount of oil entering the sea has been considerably reduced.

**Effects of marine pollution:** Apart from causing eutrophication a large amount of organic wastes can also result in the development of red tides. These are phytoplankton blooms of such intensity that the area is discolored. Many important commercially important marine species are also killed due to clogging of gills or other structures.

When liquid oil is spilled on the sea it spreads over the surface of the water to form a thin film called an oil slick. Oil slicks damage marine life to a large extent. Salt marshes, mangrove swamps are likely to trap oil and the plants, which form the basis for these ecosystems thus suffer.

If liquid oil contaminates a bird's plumage its water repellent properties are lost and water gets clogged in feather and the birds may sink and drown. Even if this does not happen loss of thermal insulation results in exhaustion of food reserves in an attempt to maintain body temperature often followed by death.

Fish and shellfish production facilities can also be affected by oil slicks. The most important commercial damage can however also come from tainting which imparts an unpleasant flavour to fish and seafood and is detectable at extremely low levels of contamination. This reduces the market value of seafood.

### **Noise Pollution**

Noise may not seem as harmful as the contamination of air or water but it is a pollution problem that affects human health and can contribute to a general deterioration of environmental quality. Noise is undesirable and unwanted sound. Not all sound is noise. What may be considered as music to one person may be noise to another. It is not a substance that can accumulate in the environment like most other pollutants. Sound is measured in a unit called the 'Decibel'.

There are several sources of noise pollution that contribute to both indoor and outdoor noise pollution. Noise emanating from factories, vehicles, playing of loudspeakers during various festivals can contribute to outdoor noise pollution while loudly played radio or music systems, and other electronic gadgets can contribute to indoor noise pollution. A study conducted by researchers from the New Delhi based National Physical Laboratory show that noise generated by firecrackers (presently available in the market) is much higher than the prescribed levels. The permitted noise level is 125 decibels, as per the Environment (Protection) (second amendment) Rules, 1999.

The differences between sound and noise is often subjective and a matter of personal opinion. There are however some very harmful effects caused by exposure to high sound levels. These effects can range in severity from being extremely annoying to being extremely painful and hazardous.

### **Effects of noise pollution on physical health**

The most direct harmful effect of excessive noise is physical damage to the ear and the temporary or permanent hearing loss often called a temporary threshold shift (TTS). People suffering from this condition are unable to detect weak sounds. However hearing ability is usually recovered within a month of exposure. In Maharashtra people living in close vicinity of Ganesh mandals that play blaring music for ten days of the Ganesh festival are usually known to suffer from this phenomenon. Permanent loss, usually called noise induced permanent threshold shift (NIPTS) represents a loss of hearing ability from which there is no recovery.

Below a sound level of 80 dBA hearing loss does not occur at all. However temporary effects are noticed at sound levels between 80 and 130 dBA. About 50 percent of the people exposed to 95 dBA sound levels at work will develop NIPTS and most people exposed to more than 105 dBA will experience permanent hearing loss to some degree. A sound level of 150 dBA or more can physically rupture the human eardrum.

The degree of hearing loss depends on the duration as well as the intensity of the noise. For example, 1 hour of exposure to a 100 dBA sound level can produce a TTS that may last for about one day. However in factories with noisy machinery workers are subjected to high sound levels for several hours a day. Exposure to 95 dBA for 8 hours everyday for over a period of 10 years may cause about 15 dBA of NIPTS. In addition to hearing losses excessive sound levels can cause harmful effects on the circulatory system by raising blood pressure and altering pulse rates.

### **Effects of noise pollution on mental health:**

Noise can also cause emotional or psychological effects such as irritability, anxiety and stress. Lack of concentration and mental fatigue are significant health effects of noise. As noise interferes with normal auditory communication, it may mask auditory warning signals and hence increases the rate of accidents especially in industries.

Thus noise is just more than a mere nuisance or annoyance. It definitely affects the quality of life. It is thus important to ensure mitigation or control of noise pollution.

## Permitted noise levels

### Ambient Noise Levels dB

<i>Zone</i>	<i>Day-time</i>	<i>Night-time</i>
Silent Zone	50	40
Residential Zone	55	45
Commercial Zone	65	55
Industrial Zone	70	70

A standard safe time limit has been set for exposure to various noise levels. Beyond this 'safe' time continuing exposure over a period of a year will lead to hearing loss.

<b>Duration</b>	<b>dBA</b>
8 hours	90
4 hours	93
2 hours	96
1 hour	99
30 minutes	102
15 minutes	105
7 minutes	108
4 minutes	111
2 minutes	114
1 minute	117
30 seconds	120
Instantaneous rupture of membrane	150

### Noise Control techniques

There are four fundamental ways in which noise can be controlled: Reduce noise at the source, block the path of noise, increase the path length and protect the recipient. In general, the best control method is to reduce noise levels at the source.

Source reduction can be done by effectively muffling vehicles and machinery to reduce the noise. In industries noise reduction can be done by using rigid sealed enclosures around machinery lined with acoustic absorbing material. Isolating machines and their enclosures from the floor using special spring mounts or absorbent mounts and pads and using flexible couplings for interior pipelines also contribute to reducing noise pollution at the source. However one of the best methods of noise source reduction is regular and thorough maintenance of operating machinery.

A smooth flow of traffic also causes less noise than does a stop-and-go traffic pattern. Proper highway planning and design are essential for controlling traffic noise. Establishing lower speed limits for highways that pass through residential areas, limiting traffic volume and providing alternative routes for truck traffic are effective noise control measures.

Planting of trees around houses can also act as effective noise barriers. In industries different types of absorptive material can be used to control interior noise. Highly absorptive interior finish material for walls, ceilings and floors can decrease indoor noise levels significantly.

Sound levels drop significantly with increasing distance from the noise source. Increasing the path length between the source and the recipient offers a passive means of control. Municipal land-use ordinances pertaining to the location of airports make use of the attenuating effect of distance on sound levels.

Use of earplugs and earmuffs can protect individuals effectively from excessive noise levels. Specially designed earmuffs can reduce the sound level reaching the eardrum by as much as 40 dBA.

### **Thermal Pollution**

**Sources:** The discharge of warm water into a river is usually called a **thermal pollution**. It occurs when an industry removes water from a source, uses the water for cooling purposes and then returns the heated water to its source. Power plants heat water to convert it into steam, to drive the turbines that generate electricity. For efficient functioning of the steam turbines, the steam is condensed into water after it leaves the turbines. This condensation is done by taking water from a water body to absorb the heat. This heated water, which is at least 15°C higher than the normal is discharged back into the water body.

**Effects:** The warmer temperature decreases the solubility of oxygen and increases the metabolism of fish. This changes the ecological balance of the river. Within certain limits thermal additions can promote the growth of certain fish and the fish catch may be high in the vicinity of a power plant. However sudden changes in temperature caused by periodic plant shutdowns both planned and unintentional can change result in death of these fish that are acclimatized to living in warmer waters.

Tropical marine animals are generally unable to withstand a temperature increase of 2 to 30C and most sponges, mollusks and crustaceans are eliminated at temperatures above 370C. This results in a change in the diversity of fauna as only those species that can live in warmer water survive.

**Control measures:** Thermal pollution can be controlled by passing the heated water through a cooling pond or a cooling tower after it leaves the condenser. The heat is dissipated into the air and the water can then be discharged into the river or pumped back to the plant for reuse as cooling water. There are several ways in which thermal pollution can be reduced.

One method is to construct a large shallow pond. Hot water is pumped into one end of the pond and cooler water is removed from the other end. The heat gets dissipated from the pond into the atmosphere.

A second method is to use a cooling tower. Here most of the heat transfer occurs through evaporation. Here warm waters coming from the condenser is sprayed downward over vertical sheets or baffles where the water flows in thin films. Cool air enters the tower through the water inlet that encircles the base of the tower and rises upwards causing evaporative cooling.

The disadvantage in both these methods is however that large amounts of water are lost by evaporation.

### **Nuclear Hazards**

Nuclear energy can be both beneficial and harmful depending on the way in which it is used. We routinely use X-rays to examine bones for fractures, treat cancer with radiation and diagnose diseases with the help of radioactive isotopes. Approximately 17 % of the electrical energy generated in the world comes from nuclear power plants. However on the other hand it is impossible to forget the destruction that nuclear bombs caused the cities of Hiroshima and Nagasaki. The radioactive wastes from nuclear energy have caused serious environmental damage.

Naturally occurring uranium contains only 0.7 percent of fissionable U-235, which is not high enough for most types of reactors. Hence it is necessary to increase the amount of U-235 by enrichment though it is a difficult and expensive process. The enrichment process increases the U-235 content from 0.7 to 3 percent. Fuel fabrication then converts the enriched material into a powder, which is then compacted into pellets. These pellets are sealed in metal fuel rods about 4 meters in length which is then loaded into the reactor. As fission occurs the concentration of U-235 atoms decreases. After about three years, a fuel rod does not have enough

radioactive material to sustain a chain reaction and hence the spent fuel rods must be replaced by new ones. The spent rods are however still very radioactive containing about one percent U-235 and one percent plutonium. These rods are a major source of radioactive waste material produced by a nuclear reactor.

Initially it was thought that spent fuel rods could be reprocessed to not only provide new fuel but also to reduce the amount of nuclear waste. However the cost of producing fuel rods by reprocessing was found to be greater than the cost of producing fuel rods from ore. Presently India does operate reprocessing plants to reprocess spent fuel as an alternative to storing them as nuclear waste. At each step in the cycle there is a danger of exposure and poses several health and environmental concerns.

The degree and the kind of damage from nuclear accidents vary with the kind of radiation, the amount of radiation, the duration of exposure and the types of cells irradiated. Radiation can also cause mutations which are changes in the genetic makeup of the cells. Mutations can occur in the ovaries or the testes leading to the formation of mutated eggs or sperms which in turn can lead to abnormal offspring. Mutations can also occur in the tissues of the body and may manifest themselves as abnormal tissue growths known as cancer. Two common cancers that are linked to increased radiation exposure are leukemia and breast cancer.

### **SOLID WASTE MANAGEMENT: CAUSES, EFFECTS AND CONTROL MEASURES OF URBAN AND INDUSTRIAL WASTE**

Until recently the disposal of municipal solid waste did not attract much public attention. The favoured means of disposal was to dump solid wastes outside the city or village limits. Around most towns and cities in India the approach roads are littered with multi-coloured plastic bags and other garbage. Waste is also burnt to reduce its volume. Modern methods of disposal such as incineration and the development of sanitary landfills, etc. are now attempting to solve these problems. Lack of space for dumping solid waste has become a serious problem in several cities and towns all over the world. Dumping and burning wastes is not an acceptable practice today from either an environmental or a health perspective. Today disposal of solid waste should be part of an integrated waste management plan. The method of collection, processing, resource recovery and the final disposal should mesh with one another to achieve a common objective.

#### **Characteristics of municipal solid waste**

Solid wastes are grouped or classified in several different ways. These different classifications are necessary to address the complex challenges of solid waste management in an effective manner. The term municipal solid waste (MSW) is generally used to describe most of the non-hazardous solid waste from a city, town or village that requires routine collection and transport to a processing or disposal site. Sources of MSW include private homes, commercial establishments and institutions as well as industrial facilities. However MSW does not include wastes from industrial processes, construction and demolition debris, sewage sludge, mining wastes or agricultural wastes.

Municipal solid waste contains a wide variety of materials. It can contain food waste such as vegetable and meat material, leftover food, egg shells, etc which is classified as wet garbage as well as paper, plastic, tetrapacks, plastic cans, newspaper, glass bottles, cardboard boxes, aluminum foil, metal items, wood pieces, etc. which is classified as dry garbage.

#### **Control measures of urban and industrial wastes:**

An integrated waste management strategy includes three main components:

1. Source reduction
2. Recycling
3. Disposal

**Source reduction** is one of the fundamental ways to reduce waste. This can be done by using less material when making a product, reuse of products on site, designing products or packaging to reduce their quantity.

**Recycling** is reusing some components of the waste that may have some economic value. Recycling has readily visible benefits such as conservation of resources reduction in energy used during manufacture and reducing pollution levels. Some materials such as aluminum and steel can be recycled many times. Metal, paper, glass and plastics are recyclable. Recycling of plastics and paper are not that easy.

**Disposal** of solid waste is done most commonly through a sanitary landfill or through incineration. A modern sanitary landfill is a depression in an impermeable soil layer that is lined with an impermeable membrane. The three key characteristics of a municipal sanitary landfill that distinguish it from an open dump are:

- Solid waste is placed in a suitably selected and prepared landfill site in a carefully prescribed manner.
- The waste material is spread out and compacted with appropriate heavy machinery.
- The waste is covered each day with a layer of compacted soil.

The problem with older landfills are associated with groundwater pollution. Pollutants seeping out from the bottom of a sanitary landfill (leachates) very often percolate down to the groundwater aquifer no matter how thick the underlying soil layer.

Even though landfilling is an economic alternative for solid waste disposal, it has become increasingly difficult to find suitable landfilling sites that are within economic hauling distance and very often citizens do not want landfills in their vicinity.

**Incineration** is the process of burning municipal solid waste in a properly designed furnace under suitable temperature and operating conditions. Incineration is a chemical process in which the combustible portion of the waste is combined with oxygen forming carbon dioxide and water, which are released into the atmosphere. This chemical reaction called oxidation results in the release of heat. For complete oxidation the waste must be mixed with appropriate volumes of air at a temperature of about 815o C for about one hour. Incineration can reduce the municipal solid waste by about 90 percent in volume and 75 percent in weight. The risks of incineration however involve air quality problems and toxicity and disposal of the fly and bottom ash produced during the incineration process.

### **Vermi – Composting**

Nature has perfect solutions for managing the waste it creates, if left undisturbed. The biogeochemical cycles are designed to clear the waste material produced by animals and plants. We can mimic the same methods that are present in nature. All dead and dry leaves and twigs decompose and are broken down by organisms such as worms and insects, and is finally broken down by bacteria and fungi, to form a dark rich soil-like material called compost. This soil can be used as manure for farms and gardens.

### **Hazardous wastes**

Modern society produces large quantities of hazardous waste which are generated by chemical manufacturing companies, petroleum refineries, paper mills, smelters and other industries. Hazardous wastes are those that can cause harm to humans or the environment. Wastes are normally classified as hazardous waste when they cause or significantly contribute to an increase in mortality or an increase in serious irreversible or incapacitating reversible illness or pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported or disposed of.

### **Characteristics of hazardous wastes**

A waste is classified as a hazardous waste if it exhibits any of the four primary characteristics based on the physical or chemical properties of toxicity, reactivity, ignitability and corrosivity. In addition to this waste products that are either infectious or radioactive are also classified as hazardous

### **Environmental problems and health risks caused by hazardous wastes.**

As most of the hazardous wastes are disposed of on or in land the most serious environmental effect is contaminated groundwater. Once groundwater is polluted with hazardous wastes it is very often not possible to reverse the damage.

Pesticides are used increasingly to protect and increase food production. They form residues in the soil which are washed into streams which then carry them forwards. The residues may persist in the soil or in the bottom of lakes and rivers. Exposure can occur through ingestion, inhalation and skin contact resulting in acute or chronic poisoning.

Lead, mercury and arsenic are hazardous substances which are often referred to as heavy metals and if they are consumed will cause serious damage to the organism in different ways.

Lead is an abundant heavy metal and is relatively easy to obtain. It is used in batteries, fuel, pesticides, paints, pipes and other places where resistance to corrosion is required. Most of the lead taken up by people and wildlife is stored in bones. Lead can affect red blood cells by reducing their ability to carry oxygen and shortening their life span. Lead may also damage nerve tissue which can result in brain disease.

Mercury occurs in several different forms. Mercury is used in the production of chlorine. It is also used as a catalyst in the production of some plastics. Industrial processes such as the production of chlorine and plastics are responsible for most of the environmental damage resulting from mercury. Our body has a limited ability to eliminate mercury. In the food web mercury becomes more concentrated as it is taken up by various organisms. In an aquatic environment, mercury can be absorbed by the plankton which are then consumed by fish and fish is consumed by human beings. It is a cumulative poison (it builds up in the body over long periods of time) and is known to cause brain damage.

Today the most common methods for disposing off hazardous wastes are land disposal and incineration. In spite of strong laws however illegal dumping of these wastes continues. Hazardous waste management must move beyond burying and burning. Industries need to be encouraged to generate less hazardous waste in their manufacturing processes. Although toxic wastes cannot be entirely eliminated, technologies are available for minimizing, recycling and treating wastes.

### **ROLE OF AN INDIVIDUAL IN PREVENTION OF POLLUTION**

There are a host of environmental problems caused by human actions on the environment. If we are to respond to these problems we have to recognize that each of us is individually responsible for the quality of the environment we live in. Our personal actions can either worsen or improve our environmental quality.

With the help of solar energy, natural processes developed over billions of years can indefinitely renew the topsoil, water, air, forests, grasslands and wildlife on which all forms of life depend, but only as long as we do not use these potentially renewable resources faster than they are replenished. Some of our wastes can be diluted, decomposed and recycled by natural processes indefinitely as long as these processes are not overloaded. Natural processes also provide services of flood prevention, erosion control at no costs at all. We must therefore learn to value these resources and use them sustainably.

Concepts that help individuals contribute towards a better quality of our environment and human life.

1. Develop respect or reverence for all forms of life.
2. Each individual must try to answer four basic questions:
  - a) Where do the things that I consume come from?
  - b) What do I know about the place where I live?
  - c) How am I connected to the earth and other living things?
  - d) What is my purpose and responsibility as a human being?
3. Try to plant trees wherever you can and more importantly take care of them. They reduce air pollution.
4. Reduce the use of wood and paper products wherever possible. Manufacturing paper leads to pollution and loss of forests which releases oxygen and takes up carbon dioxide. Try to recycle paper products and use recycled paper wherever possible.
5. Help in restoring a degraded area near your home or join in an afforestation program.
6. Use pesticides in your home only when absolutely necessary and use them in as small amounts as necessary.
7. Advocate organic farming by asking your grocery store to stock vegetables and fruits grown by an organic method. This will automatically help to reduce the use of pesticides.
8. Don't use aerosol spray products and commercial room air fresheners. They damage the ozone layer.
9. Do not pour pesticides, paints, solvents, oil or other products containing harmful chemicals down the drain or on the ground.
10. Buy consumer goods in refillable glass containers instead of cans or throwaway bottles.
11. Use rechargeable batteries.
12. Try to avoid asking for plastic carry bags when you buy groceries or vegetables or any other items. Use your own cloth bag instead.
13. Use sponges and washable cloth napkins, dish towels and handkerchiefs instead of paper ones.
14. Recycle all newspaper, glass, aluminum and other items accepted for recycling in your area.
15. Set up a compost bin in your garden or terrace and use it to produce manure for your plants to reduce use of fertilizers.
16. Try to lobby and push for setting up garbage separation and recycling programs in your localities.
17. Do not litter the roads and surroundings just because the sweeper from the Municipal Corporation will clean it up. Take care to put trash into dustbins or bring it back home with you where it can be appropriately disposed.

18. You could join any of the several NGOs that exist in our country or become volunteers. Organize small local community meetings to discuss positive approaches of pollution prevention.
19. It is important that you do not get discouraged at the first sign of trouble. Do not dwell on the negative aspects. But take positive actions wherever you can to make the world a better place to live in.
20. Take care to put into practice what you preach. Remember environment protection begins with YOU.

## **POLLUTION CASE STUDIES**

### **A case study of groundwater pollution in India**

An example of groundwater pollution caused by excessive extraction is that fluoride contamination. Fluorosis is not a localized problem. It has spread across 19 states and across a variety of ecological regions ranging from the Thar desert, the Gangetic plains and the Deccan plateau. According to a report of the Rajiv Gandhi National Drinking Water mission, the bedrock of the Indian peninsula consists of a number of fluoride bearing minerals. When the bedrock weathers the fluoride leaches into water and the soil. Although the Indian peninsular bedrock has always been the same, this problem has only surfaced during the last three decades. This is related to the over extraction of groundwater which has resulted in the tapping of aquifers with high fluoride concentrations.

The beginnings of this phenomenon can be traced back to the 1970s and the 1980s when there was massive state investment in rural water development for irrigation as well as for drinking. Encouraged by state subsidies on diesel and electricity, people invested in diesel and submersible pumps in a bid to extract groundwater through borewells. This policy aggravated the fluoride problem.

Fluoride mainly enters the human body through drinking water where 96 to 99 percent of it combines with the bones as it has an affinity for calcium phosphate in the bones. Excess intake of fluoride can lead to dental fluorosis, skeletal fluorosis or non-skeletal fluorosis. Dental fluorosis is characterized by discoloured, blackened, mottled or chalky white teeth. Skeletal fluorosis leads to severe and permanent bone and joint deformities. Non-skeletal fluorosis leads to gastro-intestinal problems and neurological disorders. Fluoride can damage the foetus and adversely affect the IQ of children.

Once fluoride is detected in water, the only solution is to defluoridate it. Various technologies are available for this process. None of the Indian technologies are however fool-proof. Defluoridation plants and household water treatment kits are stop-gap solutions.

### **A case study of pesticide pollution in India**

One of the most terrifying effects of pesticide contamination of ground water came to light when pesticide residues were found in bottled water. Between July and December 2002, the Pollution Monitoring Laboratory of the New Delhi based Center for Science and Environment (CSE) analysed 17 brands of bottled water both packaged drinking water and packaged natural mineral water commonly sold in areas that fall within the national capital region of Delhi. Pesticide residues of organochlorine and organophosphorus pesticides which are most commonly used in India were found in all the samples. Among organochlorines, gamma-hexachlorocyclohexane (lindane) and DDT were prevalent while among organophosphorus pesticides, Malathion and Chlorpyrifos were most common. All these were present above permissible limits specified by the European Economic Community, which is the norm, used all over Europe.

One may wonder as to how these pesticide residues get into bottled water that is manufactured by several big companies. This can be traced to several facts. There is no regulation that the bottled water industry must be located in 'clean' zones. Currently the manufacturing plants of most brands are situated in the dirtiest industrial estates or in the midst of agricultural fields. Most companies use bore wells to pump out water from the ground from depths varying from 24m to even 152 m below the ground. The raw water samples collected from the plants also revealed the presence of pesticide residues. This clearly indicated that the source of pesticide residues in the polluted groundwater are used to manufacture the bottled water. This is despite the fact that all bottled water plants use a range of purification methods. Thus obviously the fault lies in the treatment methods used.

The low concentration of pesticide residues in bottled water do not cause acute or immediate effect. However repeated exposure even to extremely minuscule amounts can result in chronic effects like cancer, liver and kidney damage, disorders of the nervous system, damage to the immune system and birth defects.

Similarly six months after CSE reported pesticide residues in bottled water it also found these pesticides in popular cold drink brands sold across the country. This is because the main ingredient in a cold drink or a carbonated nonalcoholic beverage is water and there are no standards specified for water to be used in these beverages in India.

There were no standards for bottled water in India till on September 29, 2000 the Union Ministry of Health and Family Welfare issued a notification (no759(E)) amending the Prevention of Food Adulteration Rules, 1954. The BIS (Bureau of Indian Standards) certification mark became mandatory for bottled water from March 29, 2001. On 18th July 2003 amendments were made in the Prevention of Food Adulteration Rules stating that pesticide residues considered individually should not exceed 0.0001mg.lit and the total pesticide residues will not be more than 0.0005 mg/lit that the analysis shall be conducted by using internationally established test methods meeting the residue limits specified herein. This notification came into force from January 1, 2004.

### **A case study of river pollution in India**

Almost all the rivers in India are polluted. The causes of pollution may also be more or less similar. This is a case study of the river Damodar as reported in Down to Earth. The 563 km long Damodar river originates near Chandwa village in the Chhotanagpur hills in Bihar's Palamau district. It flows through one of the richest mineral belts in the world before draining into the Hooghly, about 50 km south of Calcutta. Indian industry depends heavily on this region as 60 percent of the coal consumed in our country comes from the Chhotanagpur belt. Coal based industries of all types dot the area because of locational advantages and the easy availability of water and power. In addition various industries such as the steel, cement, fertilizer and explosive plants are also located here. The river Damodar is polluted with minerals, mine rejects and toxic effluents. Both its water and its sand are infested by coal dust and waste from these industries. There are seven thermal power plants in the Damodar valley. The states of Bihar and West Bengal depend almost entirely on this area for their power requirements. These power plants not only consume a lot of water but also dump ash in the valley.

#### **Effects**

The river and its tributaries are the largest source of drinking water for the huge population that lives in the valley. On April 2, 1990 about 200,000 litres of furnace oil spilled into the river from the Bokaro Steel Plant. This oil traveled 150 km downstream to Durgapur. For a week after the incident five million people drank contaminated water in which the oil levels were 40 to 80 times higher than the permissible value of 0.03 mg/l.

The Damodar Action Plan an end-of-the pipe pollution treatment scheme seeks to tackle effluents. One viable option could be to switch to less polluting industries and cleaner technology. This would need strong Government initiative and also a mass movement by people.

### **DISASTER MANAGEMENT: FLOODS, EARTHQUAKES, CYCLONES, LANDSLIDES**

The Indian subcontinent is very vulnerable to droughts, floods, cyclones, earthquakes, landslides, avalanches and forest fires.

Till very recently the approach towards dealing with natural disasters has been post disaster management involving problems such as evacuation, warnings, communications, search and rescue, fire-fighting, medical and psychiatric assistance, provision of relief, shelter, etc.

It is evident today that human activities are responsible for accelerating the frequency and severity of natural disasters. Natural occurrences such as floods, earthquakes, cyclones, etc. will always occur. They are a part of the environment that we live in. However destruction from natural hazards can be minimized by the presence of a well functioning warning system combined with preparedness on part of the community that will be affected. Thus though traditionally disaster management consisted primarily of reactive mechanisms, the past few years have witnessed a gradual shift towards a more proactive, mitigation based approach.

Disaster management is a multidisciplinary area in which a wide range of issues that range from forecasting, warning, evacuation, search and rescue, relief, reconstruction and rehabilitation are included. It is also multi-sectoral as it involves administrators, scientists, planners, volunteers and communities. These roles and activities span the pre-disaster, during disaster and post disaster plans. Since their activities are complementary as well as supplementary to each other there is a critical need for coordinating these activities.

Mitigation means lessening the negative impact of the natural hazards. It is defined as sustained action taken to reduce long term vulnerability of human life and property to natural hazards. While the preparatory, response and the recovery phases of emergency management relate to specific events, mitigation activities have the potential to produce repetitive benefits over time.

Certain guidelines if followed can result in an effective mitigation program.

1. Pre-disaster mitigation can help in ensuring faster recovery from the impacts of disasters.
2. Mitigation measures must ensure protection of the natural and cultural assets of the community.
3. Hazard reduction methods must take into account the various hazards faced by the affected community and their desires and priorities.
4. Any mitigation program must also ensure effective partnership between Government, scientific, private sector, NGOs and the community.

The main elements of a mitigation strategy are as follows:

- Risk assessment and Vulnerability analysis
- Applied research and technology transfer
- Public awareness and training
- Institutional mechanisms
- Incentives and resources for mitigation
- Landuse planning and regulations
- Hazard resistant design and construction
- Structural and Constructional reinforcement of existing buildings

### **Floods and mitigation measures**

The lower plain regions of India in particular Bihar, Uttar Pradesh and West Bengal in respect of the Ganga and Assam in respect of the Brahmaputra suffer from the adverse effects of floods every year. The mitigation measures for floods include both structural and non-structural measures. The structural measures include:

1. Reservoirs for impounding monsoon flows to be released in a regulated manner after the peak flood flow passes.
2. Prevention of over-bank spilling by the construction of embankments and floodwalls.
3. Improvement of flow conditions in the channel and anti-erosion measures.
4. Improved drainage.

The non-structural measures include:

1. Flood plain management such as Flood Plain Zoning and Flood Proofing including Disaster Preparedness
2. Maintaining wetlands
3. Flood forecasting and warning services
4. Disaster relief, flood fighting and public health measures
5. Flood insurance

### **Earthquakes and mitigation measures**

It has been several years since the earthquake struck Gujarat on January 26, 2001. In these years rehabilitation has been done on a massive scale. Gujarat's experience has taught that building shelters with less vulnerability to earthquakes should also take into consideration the specific needs of the victims instead of being a top down approach. The role of NGOs in this is very important. Their strength lies in their manpower, informality in operations and valuable human resources. Their ability to reach out to the community and sensitivity to local traditions is an asset in such situations.

Gujarat Woman's Economic Development Corporation initiative in reviving women's businesses after the calamity also provides many practical lessons in regenerating local economies and artisan markets. This project supported by the Asian Development Bank, puts premium on investments in income generation and asset building after a natural disaster. The farming kits provided to affected farmers by Gujarat's agriculture ministry is also showing promising results after two seasons. The coordination between Government, local NGOs and local community initiatives both for rescue as well as rehabilitation needs to be strengthened as this can cause delays, overlaps and waste of relief material and efforts.

## **Cyclones and mitigation measures**

The main dangers from cyclones are very strong winds, torrential rains and high storm tides. Most of the casualties are caused by coastal inundation by storm tides. This is often followed by heavy rainfall and floods. Storm surges cause the greatest destruction. Although one cannot control cyclones, the effects of cyclones can be mitigated through effective and efficient mitigation policies and strategies. A brief description of the same is given below.

**Installation of early warning systems:** Such systems fitted along the coastlines can greatly assist forecasting techniques thus helping in early evacuation of people in the storm surge areas.

**Developing communication infrastructure:** Developing communication infrastructure: Communication plays a vital role in cyclone disaster mitigation and yet this is one of the first services that gets disrupted during cyclones. Amateur Radio has today emerged as a second line unconventional communications systems and is an important tool for disaster mitigation.

**Developing shelter belts:** Developing shelter belts: Shelter belts with plantations of trees can act as effective wind and tide breakers. Apart from acting as effective windbreakers and protecting crops from being damaged they prevent soil erosion.

**Developing community cyclone shelters:** Cyclone shelters at strategic locations can help minimizing the loss of human life.

**Construction of permanent houses:** There is a need to build appropriately designed concrete houses that can withstand high winds and tidal waves.

**Training and education:** Public awareness programs that inform the population about their response to cyclone warnings and preparedness can go a long way in reducing casualties.

**Landuse control and settlement planning:** No residential and industrial units should be ideally permitted in the coastal belt of 5 km from the sea as it is the most vulnerable belt.

## **Landslides and mitigation measures**

Landslides are recurring phenomena in the Himalayan region. In the recent years however intensive construction activity and the destabilizing forces of nature have aggravated the problem. Landslides occur as a result of changes on a slope, sudden or gradual, either in its composition, structure, hydrology or vegetation. The changes can be due to geology, climate, weathering, land-use and earthquakes.

A significant reduction in the hazards caused by landslides can be achieved by preventing the exposure of population and facilities to landslides and by physically controlling the landslides. Developmental programs that involve modification of the topography, exploitation of natural resources and change in the balance load on the ground should not be permitted. Some critical measures that could be undertaken to prevent further landslides are drainage measures, erosion control measures such as bamboo check dams, terracing, jute and coir netting and rockfall control measures such as grass plantation, vegetated dry masonry wall, retaining wall and most importantly preventing deforestation and improving afforestation.

Disasters cannot be totally prevented. However early warning systems, careful planning and preparedness on part of the vulnerable community would help in minimizing the loss of life and property due to these disasters.