Pollution

(i) Source: It is the system (material or activity) which releases the pollutant.

(ii) Sink: It is the store where the pollutant is received and stored for a long time.

"Pollution is the introduction of substances (or energy) that cause adverse changes in the environment and living entities."

Pollution need not always be caused by chemical substances such as particulates (like smoke and dust). Forms of energy such as sound, heat or light can also cause pollution. These substances that cause pollution are called pollutants. A pollutant creates damage by interfering directly or indirectly with the biogeochemical process of an organism.

Pollutants may be −

- **Natural Pollutants** − Natural pollutants are caused by natural forces such as volcanic eruption and forest fire.
- **Man-made Pollutants** −These refer to the release of excess amount of gases or matter by human activities. For instance, increase in the number of automobiles adds excess carbon monoxide to the atmosphere causing harmful effect on vegetation and human health.

Classification of Pollution

As stated before, there are different types of pollution, which are either caused by natural events (like forest fires) or by man-made activities (like cars, factories, nuclear wastes, etc.) These are further classified into the following types of pollution:

- Air pollution
- Water pollution
- Noise pollution
- Soil or land pollution
- Thermal pollution
- Radiation pollution

Air Pollution

"Air Pollution is the release of pollutants such as gases, particles, biological molecules, etc. into the air that is harmful to human health and the environment." It is the contamination of air by harmful gases, dust and smoke which affects plants, animals and humans drastically.

There are a certain percentage of gases present in the atmosphere. An increase or decrease in the composition of these gases is harmful to survival. This imbalance in the gaseous composition has resulted in an increase in earth's temperature, which is known as global warming.

Types of Air Pollutants

There are two types of air pollutants:

Primary Pollutants

The pollutants that directly cause air pollution are known as primary pollutants. Some are released by natural processes, like ash from volcanoes. Most are released by human activities.

- Carbon oxides are released when fossil fuels burn.
- Nitrogen oxides form when nitrogen and oxygen combine at high temperatures. This occurs in hot exhausts from vehicles, factories, and power plants.
- Sulfur oxides are produced when sulfur and oxygen combine. This happens when coal that contains sulfur burns.
- Toxic heavy metals include mercury and lead.. Both metals come from industrial uses.
- Volatile organic compounds (VOCs) are carbon compounds, such as methane. VOCs are released by many human activities.
- **Particulates** are solid particles. These particles may be ash, dust, or even animal wastes. Many are released when fossil fuels burn.

Examples of primary pollutants include sulfur dioxide (SO2), carbon monoxide (CO), nitrogen oxides (NOX), and particulate matter (PM).

Secondary Pollutants

The pollutants formed by the intermingling and reaction of primary pollutants are known as secondary pollutants. Smog, formed by the intermingling of smoke and fog, is a secondary pollutant. Photochemical smog is also secondary pollutants. This type of smog is seen as a brown haze in the air. Photochemical smog forms when certain pollutants have a chemical reaction in the presence of sunlight. Photochemical smog consists mainly of **ozone** (O_3). This ozone is harmful to humans and other living things. However, ozone in the stratosphere protects Earth from the Sun's harmful ultraviolet radiation.

Examples of secondary pollutants include photochemical oxidants (ozone, nitrogen dioxide, sulfur trioxide) and secondary particulate matter.

Sources of Air pollution

The rising number of air pollutants has made breathing fresh, clean air next to impossible. As pollutants in the air cannot be seen with our naked eyes, we don’t realize the sources of the increasing pollution levels. In order to understand the sources of air pollution, we need to first go through the basic causes of air pollution.

Following are the important causes of air pollution:

Burning of Fossil Fuels

The combustion of fossil fuels emits a large amount of sulphur dioxide. Carbon monoxide released by incomplete combustion of fossil fuels also results in air pollution.

Automobiles

The gases emitted from vehicles such as jeeps, trucks, cars, buses, etc. pollute the environment. These are the major sources of greenhouse gases and also result in diseases among individuals.

Agricultural Activities

Ammonia is one of the most hazardous gases emitted during agricultural activities. The insecticides, pesticides and fertilizers emit harmful chemicals in the atmosphere and contaminate it.

Factories and Industries

Factories and industries are the main source of carbon monoxide, organic compounds, hydrocarbons and chemicals. These are released into the air, degrading its quality.

Mining Activities

In the mining process, the minerals below the earth are extracted using large pieces of equipment. The dust and chemicals released during the process not only pollute the air, but also deteriorate the health of the workers and people living in the nearby areas.

Domestic Sources

The household cleaning products and paints contain toxic chemicals that are released in the air. The smell from the newly painted walls is the smell of the chemicals present in the paints. It not only pollutes the air but also affects breathing.

Effect of air pollution on environment

The effects of air pollution on the environment are disastrous. However, air pollution has been around before man evolved – in the form of forest fires and volcanic eruptions. The environmental crisis that we know today, began only with anthropogenically introduced air pollution. Ever since the use of coal began, greenhouse gases began to accumulate in the atmosphere. This has a negative impact on the planet, which consequently affects all life too.

Effects of air pollution can manifest themselves in different ways. It can occur as smog or as acid rain.

These are the some effects of air pollution

- Ecosystems can become imbalanced from air pollution
- Pollution particulates eventually fall back to earth, contaminating the soil
- Air pollution creates acid rain, which can damage plants.
- Acid rain also changes soil chemistry, which can alter plant growth.
- Animals also get affected by air pollution – reproduction may get damaged, and reproductive anomalies may occur.
- Furthermore, air pollution can also cause health and respiratory issues for animals.
- Air pollution is also one of the major causes of global warming
- Global warming can also lead to more destructive natural calamities such as storms and cyclones.
- Burning certain substances may release potentially carcinogenic substances.

Air Pollution Control

Following are the measures one should adopt, to control air pollution:

Avoid Using Vehicles

People should avoid using vehicles for shorter distances. Rather, they should prefer public modes of transport to travel from one place to another. This not only prevents pollution, but also conserves energy.

Energy Conservation

A large number of fossil fuels are burnt to generate electricity. Therefore, do not forget to switch off the electrical appliances when not in use. Thus, you can save the environment at the individual level. Use of energy-efficient devices such as CFLs also controls pollution to a greater level.

Use of Clean Energy Resources

The use of solar, wind and geothermal energies reduce air pollution at a larger level. Various countries, including India, have implemented the use of these resources as a step towards a cleaner environment.

Other air pollution control measures include:

- By minimising and reducing the use of fire and fire products.
- Since industrial emissions are one of the major causes of air pollution, the pollutants can be controlled or treated at the source itself to reduce its effects. For example, if the reactions of a certain raw material yield a pollutant, then the raw materials can be substituted with other less polluting materials.
- Fuel substitution is another way of controlling air pollution. In many parts of India, petrol and diesel are being replaced by CNG – Compressed Natural Gas fueled vehicles. These are mostly adopted by vehicles that aren't fully operating with ideal emission engines.
- Although there are many practices in India, which focus on repairing the quality of air, most of them are either forgotten or not being enforced properly. There are still a lot of vehicles on roads which haven't been tested for vehicle emissions.
- Another way of controlling air pollution caused by industries is to modify and maintain existing pieces of equipment so that the emission of pollutants is minimized.
- The last and the best way of reducing the ill effects of air pollution is tree plantation. Plants and trees reduce a large number of pollutants in the air. Ideally, planting trees in areas of high pollution levels will be extremely effective.

Air Quality

When air quality is good, the air is clear and contains only small amounts of solid particle and chemical pollutants. Poor air quality which contains high levels of pollutants is often hazy and dangerous to health and the environment. Air quality is described according to the Air Quality Index (AQI), which is based on the concentration of pollutants present in the air at a particular location.

Major air pollutants emitted from thermal power plants

The main emissions from coal combustion at thermal power plants are **carbon dioxide (CO_2), nitrogen oxides, sulfur oxides, chlorofluorocarbons (CFCs), and airborne inorganic particles such as fly ash and soot**; CO_2, methane, and CFCs are greenhouse gases.

WATER POLLUTION

Water pollution can be defined as the contamination of water bodies. Water pollution is caused when water bodies such as rivers, lakes, oceans, groundwater and aquifers get contaminated with industrial and agricultural effluents.

When water gets polluted, it adversely affects all life forms that directly or indirectly depend on this source.

Sources of Water Pollution

i. **Point Sources:** When the cause and place of pollution is easily identifiable, it is known as a point source of water pollution. *Examples:* Municipal and industrial discharge pipes.
ii. **Nonpoint Sources:** When the cause and place of pollution cannot be readily identified, it is known as a nonpoint source of water pollution. *Examples:* Mining runoff and acid rain.

The most significant sources of water pollution are:

- **Sewage (Waste Water):** The sewage water carries pathogens, a typical water pollutant, other harmful bacterias, and chemicals that can cause serious health problems and thereby diseases.
- **Agricultural Pollution:** Chemical fertilizers and pesticides are used by farmers to protect crops from insects and bacterias. However, when these chemicals are mixed up with water, they produce harmful pollutants for plants and animals.
- **Oil Pollution:** Oil spill poses a huge threat to marine life when a large amount of oil spills into the sea and does not dissolve in water. It causes problems for local marine wildlife, including fish, birds, and sea otters.
- **Industrial Waste:** Industries produce a tremendous amount of waste, which contains toxic chemicals and pollutants, causing water pollution and damage to our environment.
- **River and Marine Dumping:** The garbage produced by households in the form of paper, plastic, food, aluminium, rubber, and glass, is collected and dumped into the rivers and seas. They not only cause water pollution but also harm aquatic animals.

Water Pollutants

(i) Organic Pollutants : They include oil, synthetic organic compounds, sewage and agricultural run-off, disease-causing wastes and oxygen-demanding wastes.

(ii) Inorganic Pollutants : They include metals, metal compounds, organometallic compounds, mineral acids, inorganic salts, etc.

(iii) Suspended Solids and Sediments: They comprise of sand, silt and minerals eroded from the land.

(iv) Radioactive Materials: They include radioactive isotopes from nuclear reactors, nuclear power plants, research, industrial applications, agriculture and therapeutic as well as diagnostic medical applications.

(v) Thermal Pollution: They include discharge of waste heat to water bodies by thermal and nuclear power plants.

Types of Water Pollution

Surface water pollution

The water on the surface of the planet is made up of seas, oceans, lakes, rivers and other waterways. These bodies of water can become contaminated from point sources (such as industrial effluents and improper wastewater management systems) or non-point sources (such as agricultural run-off, precipitation and seepage). This can contaminate the surface water and make it unsafe for humans, animals and plants alike.

Groundwater pollution

When contaminants (such as fertilizers, pesticides, heavy metals and wastewater) are allowed to pollute the soil, they can penetrate far deeper and render groundwater supplies unpotable and unusable.

Chemical pollution

Chemicals are used in a wide variety of anthropogenic activities, from protecting agricultural crops from pests and disease to manufacturing consumer goods to transporting and consuming energy sources such as oil and petrol. Automatically some of these chemicals find their way into the natural environment, either through agricultural run-off after heavy rainfall, accidental spillage or improper disposal of waste products. This can have a dramatic impact on water sanitation.

Microbiological pollution

Microbiological pollution refers to that which is caused by microorganisms within the water. This type of contamination largely occurs naturally and, on many occasions, the bacteria, protozoa and viruses are harmless or even beneficial to the ecosystems they inhabit. However, this is not always the case and some microorganism kill off plant & animal life and causing disease among humans which consume or use this water.

Nutrient pollution

Fertilizers, pesticides and other products used during agricultural processes often contain significant amounts of nutrients, such as phosphorous and ammonia. These are specifically used to protect crops from pests or disease, or increase their growth and maximize yields. When run-off sends these chemicals into water sources, they can cause an imbalance of nutrients, promoting the growth of some organisms (such as algae) to the detriment of others.

Suspended matter pollution

Although water is often dubbed the universal solvent, some particles of pollution are simply too large to mix with water molecules. This means that they either form a layer of floating silt atop the water’s surface, or else sink to its floor in the form of a thick mud. Either way, they can inhibit the growth of marine life beneath the waves and compromise the quality of the water in their vicinity, posing a risk to humans as well as animals.

Effects of Water pollution

1. Diseases: In humans, drinking or consuming polluted water in any way has many disastrous effects on our health. It causes typhoid, cholera, hepatitis and various other diseases.

2. Destruction of Ecosystems: Ecosystems are extremely dynamic and respond to even small changes in the environment. Water pollution can cause an entire ecosystem to collapse if left unchecked.

3. Eutrophication: Chemicals in a water body encourage the growth of algae. These algae form a layer on top of the pond or lake. Bacteria feed on this algae and this decreases the amount of oxygen in the water body, severely affecting the aquatic life there.

4. Affects the food chain: Disruption in food chains happens when toxins and pollutants in the water are consumed by aquatic animals (fish, shellfish etc) which are then consumed by humans.

Eutrophication

Eutrophication is the process in which a water body becomes overly enriched with nutrients, leading to excessive growth (or bloom) of algae and plankton in a water body Eutrophication is considered to be a serious environmental concern since it often results in the deterioration of water quality and the depletion of dissolved oxygen in water bodies.

Marine pollution

When the salt content of a water body is equal to or more than 35 parts per thousand (ppt), then it is known as a *marine water body*.

Examples of Marine Water Bodies: Seas, oceans, brackish water, salt marshes, etc.

Marine Pollution refers to trash and pollutants that come from land sources to end up in the ocean. This pollution causes widespread damage to ocean life as well as to economic structures that rely on marine infrastructure.

Thus, marine pollution is harmful and is caused by human activities. Damages or disturbances caused by earthquakes, volcanic eruptions, tsunamis, etc., are not considered marine pollution.

Steps to control marine pollution

- Almost 80% marine pollution caused due to waste from lands. We can reduce this.
- Plastic bags, bottles etc. have become one of the big reasons for marine pollution. We need to stop using plastic made material to save marine life and our environment.
- We all need to put efforts to clean the sea beaches. If beaches will be cleaned, marine pollution can be reduced to some extent.
- The farmers should use organic farming techniques instead of using chemical pesticides and fertilizers. When these fertilizers and pesticides entered into ocean water causes various health issues to the plants & animals of the sea.
- We all need to make sure that only rainwater goes into the drainage because most of the drain water goes into oceans. If we allow sewage and waste material to get into the drainage, it will eventually affect the marine life.
- Most of the rivers flow into the oceans and also the wastes get entered in the sea water. Hence we also need to take care of the cleanliness of the rivers so that it cannot contaminate the marine life.

- We should stop using single-use plastic to protect the marine ecosystem.
- Say “NO” to disposables such as straws, tumblers, plastic carry bags, etc. These items only increase the amount of waste that ultimately goes into oceans.
- Recycling helps a lot to protect ocean ecology.
- We should try to minimize energy use to reduce the oceanic temperature.
- Give preference to buy Eco-friendly products and materials.

Point Sources	**Non-point Sources**
Pollutants are discharged directly into water bodies.	Pollutants are discharged away from water bodies and at various places.
Easy to treat the pollutants in the water treatment plant before they enter the water bodies	Difficult to treat the pollutants before they enter water bodies.
More harmful	Less harmful in comparison to point source water pollution.
For Example- Sewage outlets in the municipal area, power plants, oil wells, and underground coal mines close to water bodies.	For Example- Garden, roads, construction sites, runoff water from the field, etc.

BOD and COD: Biochemical oxygen demand (BOD) is the amount of oxygen required by the microorganisms to break down organic materials. In contrast, chemical oxygen demand (COD) is the amount of oxygen required to break down the organic material via oxidation.

Biological Oxygen Demand	**Chemical Oxygen Demand**
It is the amount of oxygen the microbes require to decompose the organic matter under aerobic conditions.	It is the total amount of oxygen required to break down the organic matter by chemical oxidation.
Test: It can be determined by putting a sealed water sample under specific temperature conditions for five days.	Test: It can be determined by placing a water sample with a strong oxidizing agent under specific temperature conditions for a short period.
Value: Lower than COD	**Value:** Higher than BOD
It is used to waste loadings in treatment plants. Evaluation of BOD removal efficiency of the waste plants.	To quantify the amount of oxidisable pollutants found in water bodies. It provides a measurement on how an effluent will affect the water body.

SOIL/LAND POLLUTION

Soil pollution is defined as the presence of toxic chemicals (pollutants or contaminants) in soil, in high enough concentrations to pose a risk to human health and the ecosystem or in simple words Alteration in the natural soil due to human activities is termed Soil Pollution. For example, exposure to soil containing high concentrations of benzene increases the risk of contracting leukaemia.

Types of Soil Pollutants

- Agriculture soil pollution is caused due to the excessive use of pesticides and insecticides.
- Soil Pollution by industrial discharges of chemicals from mining and manufacturing of goods.
- Solid waste / poor management or inefficient disposal of waste.
- Soil Pollution due to urban activities.

Effects of Soil Pollution

The harmful effects of soil pollution are briefly described below:

(i) Fluorosis occurs as a result of consumption of fluoride containing maize and jawar *crops*. The fluoride is absorbed by the crops from the fluoride-contaminated soil.
(ii) Emission of toxic gases (from dumped solid wastes on land) is detrimental to health. The unpleasant smell and spread of insects cause inconvenience to people.
(iii) Poisoning of the ecosystem takes place by soil pollution.
(iv) *Contamination* of underground and surface drinking *water* takes place by soil pollution.
(v) Reduction in the fertility of *soil* takes place by soil pollution.

Control of Soil Pollution

The soil pollution can be controlled by the following methods:

(i) Polluted soil can be *treated* by *bioremediation*. It uses microorganisms (yeast, fungi or bacteria) to break down, or degrade, hazardous substances into less toxic or nontoxic substances (such as CO_2 and H_2O). Proper treatment of liquid wastes from industries and mines must be done.
(ii) The principles of three Rs, namely, *Recycle*, *Reuse* and *Reduce*, help in minimizing the generation of solid waste. For example, use of bio fertilizers and natural pesticides help in minimizing usage of chemical fertilizers and pesticides.
(iii) Proper disposal methods must be employed. For example, composting of biodegradable solids and incineration of non-biodegradable solids should be done.
(iv) Planned *afforestation* helps in preventing soil erosion.
(v) Formulation and effective implementation of stringent pollution-control *legislation* also helps in controlling soil pollution.
(vi) Faulty *sanitation practices* must be improved.

NOISE POLLUTION

Noise pollution is defined as environmental noise or an unwanted sound that is annoying, distracting, or physically harmful. Harms include hearing loss, stress, sleeplessness etc. Noise pollution is also known as sound pollution.

Sources of Noise

Source is the equipment or process directly responsible for sound generation.

The major sources of noise are summarized below:

(i) **Transportation Sources** Railways, road traffic and air traffic.

(ii) **Industrial Sources** Noise is generated in mostly all industrial activities such as power generation, processing, product fabrication and product assembly.

(iii) **Public Address System Sources** Use of loudspeaker at any occasion like marriages, functions, festivals, etc.

(iv) **Agricultural Machine Sources** Use of tractors, tubewells, farm machines for agriculture.

(v) **Defence Equipment Sources** Shooting practices, wars, bomb explosion, etc.

(vi) **Household Sources** Mixer-grinder, lawn mowers, food blenders, vacuum cleaners, etc.

(vii) **Other Sources** Rock concerts, barking dogs, construction equipment, etc.

Effects of Noise Pollution

Noise affects human health in the following ways:

(i) **Physical Effects:** Damage to ear drum, temporary impairment of hearing, permanent deafness.

(ii) **Physiological Effects**: Muscular strain, headache, eye strain, decreased color perception, nervous breakdown, pain in heart, etc.

(iii) **Psychological Effects**: Emotional disturbance, depression, fatigue, frustation, irritation, reduced efficiency, etc.

Prevention of Noise Pollution

Some noise pollution preventive measures are provided in the points below.

- Honking in public places like teaching institutes, hospitals, etc. should be banned.
- In commercial, hospital, and industrial buildings, adequate soundproof systems should be installed.
- Musical instruments' sound should be controlled to desirable limits.
- Dense tree cover is useful in noise pollution prevention.
- Explosives should not be used in forest, mountainous and mining areas.
- Turn off Appliances at Home and offices
- Shut the Door when using noisy Machines
- Use Earplugs
- Lower the volume
- Stay away from Noisy area
- Follow the Limits of Noise level

- Control Noise level near sensitive areas

THERMAL POLLUTION

Thermal pollution may be defined as the degradation of water quality by any process that changes ambient water temperature.

Thermal pollution is best known as sudden increases or decreases in the temperature of water bodies like oceans, seas, rivers, lakes, streams, etc. Usually, the industries use water for cooling purposes for machinery or other production processes.

Causes of Thermal Pollution

Causes (or sources) of thermal pollution are briefly described below:

(i) **Coal-fired Power Plants**: River water is used for cooling the condenser rods of coal-fired thermal power plants. When water used as a coolant is returned to the river, its temperature is high which lowers down the dissolved oxygen of water and affects ecosystem composition.

(ii) **Nuclear Power Plants:** Large amount of heat along with toxic radionuclides are discharged into nearby water streams by nuclear power plants. Radiation leakages are also responsible for increasing the temperature of water bodies. Nuclear experiments and nuclear explosions are also responsible for thermal pollution.

(iii) **Domestic Sewage:** Normally, the municipal water sewage has a higher temperature than normal water. When domestic sewage is discharged into lakes, rivers, etc., it causes thermal pollution.

(iv) **Industrial Effluents:** Textile, sugar, paper, pulp and various other industrial effluents when discharged into lakes, rivers, etc., cause thermal pollution.

(v) **Deforestation**: When shade-providing trees are cut down, water temperature rises.

Effects of Thermal Pollution

The harmful effects of thermal pollution are described below:

(i) **Reduction in DO**: Elevated temperature typically decreases the level of dissolved oxygen in water. This can harm aquatic animals.

(ii) **Change in Quality**: With rise in temperature, the density, viscosity and solubility of gases in water decreases.

(iii) **Damage to Biological Activity**: Above 37°C, biological activity of enzymes of aquatic flora and fauna gets severely damaged.

(iv) **Interference with Reproduction Capability** Temperatures higher than 9 to 10°C interferes with reproduction capabilities of certain fishes.

(v) **Increase in Metabolic Activity**: At increased temperatures, metabolic activities such as oxygen uptake, food intake and mobility of fishes are increased.

(vi) **Increased Mortality Rate:** At higher temperatures, the mortality rate of fish and all other aquatic organisms increases.

(vii) **Malnutrition**: High temperatures can lead to the denaturing of life-supporting enzymes. It means, within the quaternary structure of the enzymes, hydrogen bonds and disulphide bonds break down.

(viii) **Ecological Effects of Cold Water** Elimination of native fish species and drastic alteration of macro invertebrate fauna has been observed by releases of unnaturally cold water from reservoirs like dams.

Control Measures of Thermal Pollution

Heated water from power plants, petroleum refineries, pulp and paper mills, steel mills and chemical plants can be cooled down for controlling thermal pollution by using cooling ponds, cooling towers, etc.

(i) ***Cooling ponds*** are man-made bodies of water which help in reducing the temperature of water by evaporation, convection and radiation.

(ii) ***Cooling towers*** transfer waste heat to the atmosphere through evaporation and/or heat transfer.

(iii) ***Cogeneration*** is a process for recycling waste heat for domestic and/or industrial heating purposes.

(iv) ***Storm water management facilities*** absorb urban run-off or direct it into groundwater, such as bioretention systems. Otherwise, urban run-off can have significant thermal impact during summers on small streams, as storm water passes over hot parking lots, roads and sidewalks.

(v) ***Afforestation*** By planting trees along streams and shorelines, thermal pollution can be controlled. If these trees and tall plants are not there for providing shade, the water warms by as much as 10°C. Even removal of vegetation far away from a lake can speed up the erosion of soil into water, making it muddy. Muddy water absorbs more energy from the sun than clear water does, resulting in further heating, Afforestation controls erosion, keeps water clearer and thus, cooler.

RADIATION POLLUTION [NUCLEAR HAZARDS]

Radioactive contamination is defined as the deposition or introduction of radioactive substances into the environment, where their presence is unintended, or the levels of radioactivity are undesirable. Such type of pollution is harmful to life due to the emission of ionizing radiation. This type of radiation is potent enough to cause damage to tissues and DNA in genes.

Sources/Causes of Nuclear Hazards:
Radioactivity can occur in one of two ways:

- Naturally occurring radioactivity
- Man-made radioactivity

Natural and man-made sources of nuclear hazards are briefly described below:

(A) Natural Radioactive Sources

Natural radioactivity, as the name suggests, occurs naturally in our environment. Some radioactive elements such as uranium and thorium are present in rocks and soil. Interestingly, humans and all other living organisms contain nuclides such as carbon-14, which are created by cosmic rays.

(i) **Cosmic Radiation** It is a stream of ionising radiation that enters the earth's atmosphere from outer space. The intensity of cosmic rays in the biosphere is low. Therefore, they are not a health hazard. However, cosmic rays are a major hazard in space.

(ii) **Terrestrial Radiation** It is long-wave electromagnetic radiation emitted by naturally radioactive materials on the earth including radon, uranium and thorium.

Humans have been exposed to low levels of radiation from these natural sources for

thousands of years. But it is the man-made sources which are posing a threat to mankind.

(B) Artificial (or Man-Made) Radioactive Sources

Man-made radioactivity is the result of nuclear weapon discharge or a nuclear reactor containment breach. In such scenarios, all living organisms in the vicinity of the nuclear event will become contaminated by fission products and remnants of nuclear fuel. This can be in the form of radioactive dust or even particles that are found on various surfaces.

These sources of radioactivity are waste materials that contain radioactive nuclei produced during the

(i) mining and processing of radioactive ores,
(ii) use of radioactive materials in nuclear weapons,
(iii) use of radioactive isotopes in medical, research and industrial applications, and
(iv) use of radioactive materials in nuclear power plants.

Radioactive materials are composed of unstable atoms. *Radioactivity* is a process by which an unstable atom emits radiation until it becomes stable. Radiation cannot be detected by sight, smell, etc., but it has harmful effects on humans. The longer a person is exposed to radiation, the greater the risk.

Effects of Nuclear Hazards

The effects of nuclear hazards may be somatic or genetic.

(i) Somatic Effects Somatic Effects of nuclear radiation appear in the exposed person. The quantity of radiation that leads to the absorption of 100 erg per gram of the absorbing material is known as Radiation Absorbed Dose (RAD).

When an individual receives an acute dose (typically ≥ 10 RAD) in a short period of time, prompt somatic effects occurs.

For example, a dose of 400 RAD to the scalp results in temporary hair loss which occurs about three weeks after exposure. New hair is expected to grow within two months after the dose although the colour and texture may be different.

When an individual receives a small dose, *delayed somatic effects* are observed years after irradiation, for example, development of cataracts and cancer.

(ii) Genetic (or Heritable) Effects These effects appear as abnormalities in the future generations of the exposed person as a result of radiation damage to the reproductive cells.

Control Measures of Nuclear Hazards

Nuclear hazards can be controlled by practicing the following measures:

(i) Nuclear power plants should be located far from populated areas and should be provided with a suitable radiation-absorption zone around them to minimize the escape of radiation.
(ii) Safety measures should be enforced strictly to avoid nuclear accidents and occupational exposure.
(iii) Waste disposal must be effective, careful and efficient,
(iv) The following should be totally stopped:
Leakages from nuclear reactors, careless handling, transport and use of radioactive fuels and/or radioactive isotopes.

(v) Nuclear wastes have to be properly disposed off.

High-Level Wastes (HLW) like spent nuclear fuel has a very high radioactivity per unit volume. These are very dangerous. These wastes must be contained either by converting them into inert solids (ceramics) and then burying deep into earth or storing in deep salt mines.

Filters, reactor components, etc., are *Medium-Level Wastes* (MLW). These are solidified and mixed with concrete in steel drums before being buried in deep mines or below the sea bed in concentrate chambers.

Solids or liquids contaminated with traces of radioactivity are *Low-Level Wastes* (LLW). They are disposed of in steel drums in concrete-lined trenches in designated sites. After the disposal of nuclear waste, drilling activity must be prevented in and around the disposal site, and radioactivity must be monitored periodicallyaround the disposal sites.

Solid Waste

The waste materials which have been rejected for further use and which can neither readily escape into the atmosphere nor can be transported by water into streams are called solid waste.

All the discarded solid materials from municipal, agricultural and industrial activities are included in solid wastes.

Types and Sources of Solid Wastes

The various types of solid wastes are briefly described below:

(A) Municipal Wastes: These include *garbage* (i.e. biodegradable food waste), *rubbish* (i.e. non-biodegradable solid waste from homes, offices, markets, hotels, etc.). *Construction and Demolition Wastes*: *Sludges* from septic tanks, *wires*, ashes, *abandoned vehicles,* etc.

(B) Special Wastes: These include hazardous wastes like toxic substances (pesticides, heavy metal sludges), radioactive wastes, biological waste, explosives, inflammable substances, corrosive materials etc.

(C) Domestic Wastes These include wastes generated from domestic cooking and serving of food. *Examples* Garbage, waste paper, plastic, cloth, etc.

(D) Agricultural Wastes These wastes result from farms, feed lots and live- stock yards. *Examples:* Corn residues, bagasse from sugarcane manures, paddy husk, etc.

(E) Industrial Wastes These include the following:

(i) Process Wastes Here, waste depends on the products being manufactured. *Examples:* Plastic wastes, rubber wastes, metal scraps, food-processing wastes, etc.

(ii) Non-process Wastes Here, waste is common to all industries.
Examples: Office and cafeteria wastes, packing wastes, etc.

(F) E-Waste It is a new form of waste from discarded mobile phones, mobile chargers, remotes, CDs, headphones, batteries, computers/TVs, monitors, printers, CPUs, LCD/Plasma TVs, etc. It is also known as electronic waste.

Causes of Generation of Solid Wastes

The main causes for the rapid growth in the quantity of solid-waste generation are described below:

(i) Overpopulation Solid waste generated per person multiplied by total population results in increased generation of solid waste every day.

(ii) Urbanization: Urbanization requires various construction activities

like construction of buildings, markets, shopping malls, roads, railways, airports, bridges, dams, water supply and sewage disposal systems. Each construction activity also generates solid wastes.

(iii) Affluence: Consumers with high purchasing capacity discard 'obsolete goods'. This leads to solid waste generation.

(iv) Advances in Technology: These lead to large-scale production of goods for *consumption-based* society preferring disposable items and almost every item 'packaged'. All these results in generation of huge quantities of solid wastes.

Solid-Waste Management

The term solid waste management mainly refers to the complete process of collecting, treating and disposing of solid wastes. In the waste management process, the wastes are collected from different sources and are disposed of. This process includes collection, transportation, treatment, analysis and disposal of waste. It needs to be monitored so that strict regulations and guidelines are followed.

Important solid-waste management practices are briefly described below:

(i) Source Reduction : It involves changing the design manufacture or use of products and materials to reduce the amounts of solid-waste generation. *Examples:* Two-sided copying of paper, backyard composting, etc.

(ii) Recycling: From the waste stream; paper/glass/plastic/metal, etc., are sorted, collected, processed and then manufactured, sold and purchased as new products.

Advantages: Energy saving, prevention of emission of many greenhouse gases/ water pollutants, job creation, resource conservation for future.

(iii) Treatment: Suitable treatment is given depending on the nature of solid wastes.

(iv) Disposal: Solid wastes can be disposed in combustion facilities and land fills.

The most preferred method for solid waste management is source reduction (including reuse). It is followed by recycling and composting. Lastly, disposal of solid waste is done.

Solid-Waste Disposal

The various methods commonly employed for disposal of solid waste are explained below.

A. ***Composting:*** *Composting is the thermophilic and aerobic decomposition of organic matter present in solid waste by microorganisms, mainly bacteria and fungi*. As a result of this composting process, the organic matter is transformed into stable humus like substance, which is valuable manure for crops.

(i) Classification of Composting Techniques Based on Oxygen Use

(a) Aerobic Composting It requires high temperature and results in rapid decomposition of organic matter. Odors are also absent.

(b) Anaerobic Composting It requires low temperatures. Decomposition of organic matter of solid waste is slow. It needs minimum attention.

(ii) ***Vermicomposting*** It uses a special kind of earthworm and a container of food scraps. After some time, the food is replaced with worm droppings, a rich brown matter that serves as excellent natural plant food (manure).

Advantages of Vermicomposting Over Conventional Composting

- Vermicomposting needs less space than normal composting.
- Vermicomposting is ideal for apartments in high-density urban areas.
- Vermicomposting provides excellent natural plant food.

B. ***Illegal Dumping/Open Dumping/Fly Dumping/Midnight Dumping*** It is the disposal of solid waste by dumping in open areas, dumped from vehicles along roadsides, and/or dumped late at night.

(i) Advantages It is done to avoid either the time or effort required for proper disposal or to avoid disposal fees.

(ii) Disadvantages

(a) Illegal dumping of nonhazardous wastes often attract more waste, even the hazardous wastes.
(b) Illegal dump sites divert land from more productive uses.
(c) Property values decrease as a result of illegal dumping.
(d) Public nuisance is created by illegal dump sites.

C. Land Dumping

Solid wastes are dumped in low-lying areas outside the city/town limits. These areas have no provision of leachate collection and treatment. Moreover, landfill gas is neither collected nor used.

(i) Advantages

(a) It requires no planning.
(b) It is cheaper.

(ii) Disadvantages

(a) The waste is untreated, uncovered and not segregated. It is the breeding ground for flies, other insects, rats, etc., that spread diseases.
(b) Rainwater run-off from these dump sites contaminates nearby land and water thereby spreading diseases.

D. Landfills

A *landfill site is a pit that is dug in the ground*. The solid waste is dumped and the pit is

covered with a layer of soil to form a cell. The process is repeated every day so that many cells completely fill the landfill site. Finally, about 1 m of earth-layer covering is done.

(i) Advantages

(a) Breeding of insects is prevented.
(b) Landfill sites can be developed as parks or parking spaces.

(ii) Disadvantages

All types of wastes are dumped in landfill sites without segregation. When rainwater seeps through them, it gets contaminated and in turn pollutes the surrounding area and groundwater.

E. Sanitary Landfills

Sanitary landfill is a method of waste disposal where the waste is buried either underground or in large piles. This method of waste disposal is controlled and monitored very closely.

For sanitary landfills, the process starts by digging a large hole in the ground that is then lined with thick plastic (normally 2-4 feet thick) and a layer of impervious clay. The bottom of the landfill is also lined with a network of plumbing that functions as a collection system for any liquids. These components of the sanitary landfill help prevent materials and liquids from spreading to the surrounding ground and waterways.

Once the landfill is set up, waste can then be added to the landfill. Instead of simply filling the landfill completely with waste, the landfill is organized in layers. The layers alternate between waste and soil. This alternation of materials reduces odors and allows for more rapid **decomposition**, which is the breakdown of materials. When a landfill is full, it is sealed and covered in a thick layer of clay. Once the landfill has been evaluated and considered safe, it can be converted into a park or open space for human use.

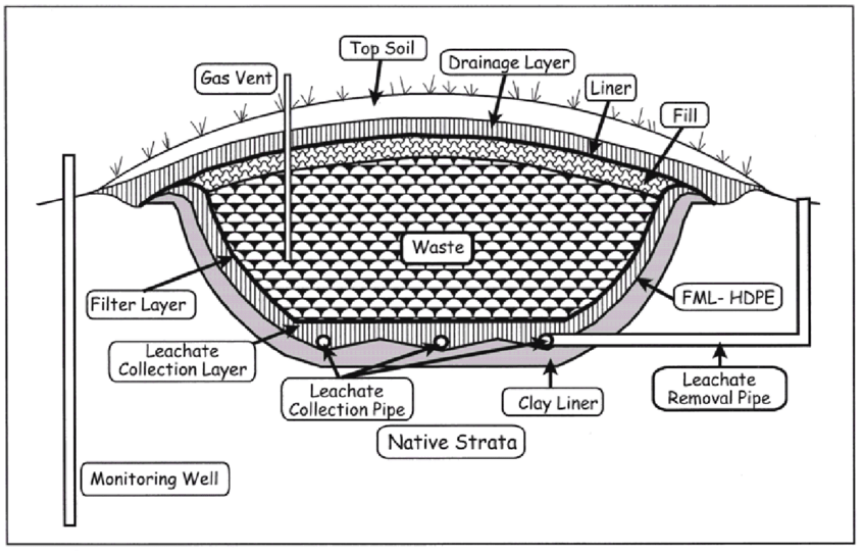
Sanitary Landfill- Advantages

- **Excellent Energy Source:** Sanitary landfills act as excellent energy sources due to the fact that they generate carbon dioxide and methane when the waste starts decomposing. These gasses can be extracted, purified, and used to generate energy.
- Sanitary landfills are eco-friendly.
- **The sanitary landfills are designed with engineering technology in mind; good soil lining and a leachate control system ensure minimal seepage or damage.**
- These are places where recyclable and non-recyclable waste can be dumped separately.
- **Good Storage Facility:** They also serve as a storage facility for more hazardous goods that must be kept away from the general population.
- **Low Cost Option:** The waste in the sanitary landfill will just have to travel a short distance to the dump, lowering transportation expenditures.
- **Pollution Reduction:** This will also help to reduce pollution caused by garbage transportation.
- The finished sanitary landfill can be used for the development of regions of recreation like parks, golf courses etc.

Sanitary Landfill- Drawbacks

a. Leachate from sanitary landfill site can contaminate the groundwater.
b. The sites cannot be used in future as productive farmland.

c. In a sanitary landfill, about 60% of methane gas (odorless) is generated. When its concentration in air reaches about 5%, it is explosive and so very hazardous.
d. Aesthetic problems may arise as a result of poorly operated landfill operations.



F. Combustion

Solid waste is burned at high temperature in combustion facilities.

(i) Advantages

(a) Energy is generated.
(b) Amount of waste is reduced by up to 90% in volume and 75% in weight.

(ii) Disadvantages

(a) Cost increases with rise in the moisture content of solid waste. This is because energy is required for preheating the solid waste.
(b) Ash formed after combustion has high concentrations of dangerous toxins such as dioxins and heavy metals. It results in air and water pollution.

G. Incineration

It is the controlled combustion of organic solid wastes so as to convert them into incombustible residue and gaseous products. The weight and volume of solid waste is reduced and often energy is also produced.

(i) Advantages

(a) As the volume of the waste is reduced, in taking the waste to the ultimate disposal site, less transportation cost is required.
(b) Larger wastes can be accommodated in a given landfill area because incineration reduces the land requirement to one-third.

(ii) Disadvantages

(a) Not applicable for radioactive wastes
(b) High capital and operational costs
(c) Air pollution chances if incineration is not properly done
(d) Highly trained manpower is needed

POLLUTION PREVENTION

Instead of complaining about the deteriorating environmental situation, individuals can play a very important role in pollution prevention.

Individuals can adopt the following activities in their daily routines for prevention of pollution:

(i) Whenever feasible, preferably use *public transport*, car pools and cycles instead of your own automobiles.

(ii) Purchase and use energy-efficient and pollution-free
   (a) vehicles
   (b) appliances (like refrigerators, ACs, etc.)
   (c) rechargeable batteries, etc.

(iii) Plant trees and help in *afforestation*.

(iv) *Conserve* natural resources; save water/electricity.

(v) *Reduce* consumption, waste generation, water leakages, etc.

(vi) *Reuse* paper and various products.

(vii) *Recycle* paper, metal, plastic, etc.

(viii) *Refuse* to buy and use toxic pesticides, fertilizers, lead-based paints, products without recycling symbol, products with unnecessary packaging, etc.

(ix) *Don't pollute* air, water, soil, etc.

(x) Advocate and *participate* in environment-friendly activities.

DISASTER

A disaster is defined as a disruption on a massive scale, either natural or man-made, occurring in short or long periods. Disasters can lead to human, material, economic or environmental hardships, which can be beyond the bearable capacity of the affected society.

Classification of Disasters

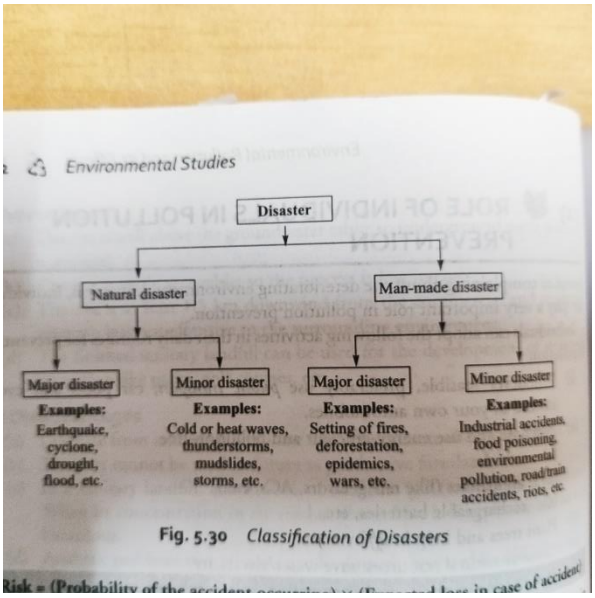


Fig. 5.30 *Classification of Disasters*

DISASTER MANAGEMENT

Disaster management is the practice of successful management of natural and manmade disasters.

The major objective of disaster management is to reduce the adverse effects of a disaster on the affected community and to help them return to normal life within the shortest possible time.

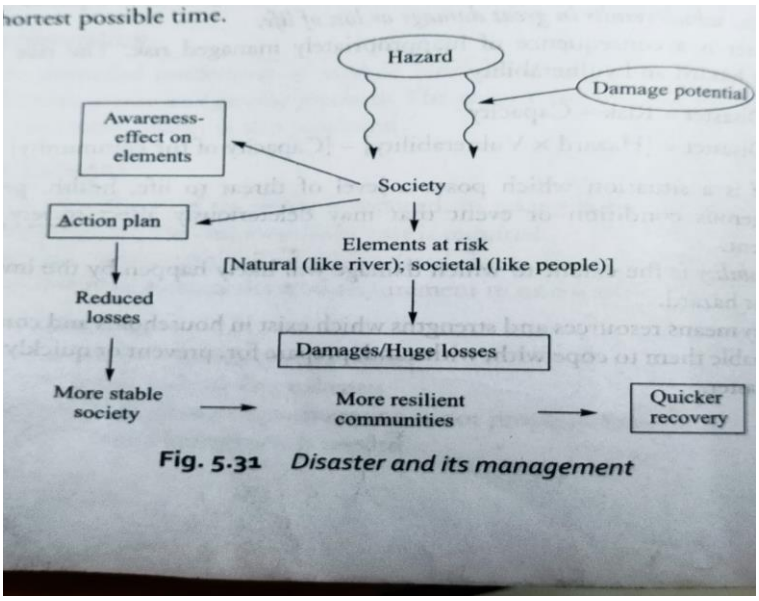


Fig. 5.31 *Disaster and its management*

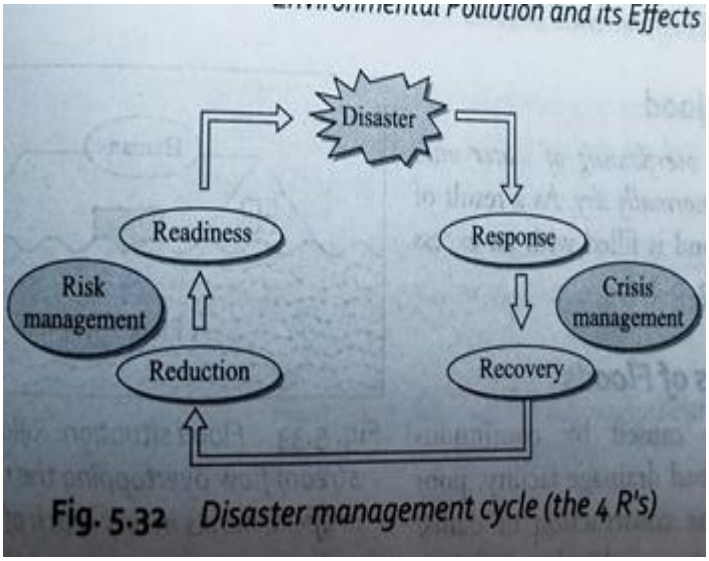


Fig. 5.32 Disaster management cycle (the 4 R's)

Response: It includes activities during a disaster such as public warning systems, emergency operations, search, rescue (i.e. save life) and relief (i.e., food aid).

Recovery: It includes activities following a disaster like rehabilitation and reconstruction which includes temporary housing; processing of insurance claims; distribution of grants; provisions for long-term medical care and counselling.

Mitigation or Reduction: It includes activities that reduce the effects of disasters like building codes and zoning, vulnerability analyses; public education.

Preparedness or Readiness: It includes activities prior to a disaster like preparation of emergency plans for disasters, emergency training through workshops; warning systems, etc.

To sum up, disaster management means the organization and management of resources and responsibilities for dealing with all humanitarian aspects of emergencies, in particular response, recovery, reduction and readiness, for reducing the impacts of disasters, *i.e. the 4R's.*

Flood

Flood is an overflowing onto land that's normally dry. As a result of flood, the land is filled with an excess of water.

A) Causes of Floods

A flood is caused by continuous heavy rain, bad drainage facility, poor design in the construction of dam/embankments, etc., blocking of river channels by landslides, silting of river bed,tsunami, cyclones, and melting of glaciers and sea tides.

Effects of Floods

(i) **Unavailability of Clean Water:** Water in wells, groundwater and piped water supply gets contaminated as a result of flood, resulting in shortages of clean water.

(ii) **Damage to Crops and Food Shortages** Standing crops are damaged by flood. Flood can erode the top soil layer causing land to become infertile. If sea water floods the area, the land turns saline.

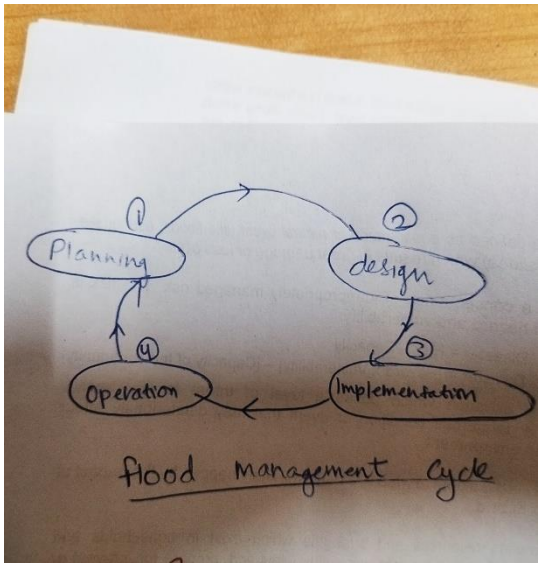
As a result of floods, godown and storage facilities get submerged in water resulting in spoilage of grains by fungus. Even entire harvests are lost as a result of flood resulting in sudden food shortages.

(iii) **Diseases and Deaths** Floods result in outbreaks of epidemics, diarrhoea, malaria and viral infections. Animals and humans die either due to these diseases or due to drowning.

(iv) **Physical Damage** In coastal areas, boats or fishing equipment may be lost or damaged. Property gets damaged or collapsed by flooding.

Flood Management: Management of flood requires a cyclic pattern linking

i) Planning ideas, proposals, consultations, adopting proposals, preparing guidelines.
ii) Design: Design of flood control structure
iii) Implementation: construction
iv) Operation: operating and maintaining finalized schemes



Earthquake

An earthquake is the vibration (sometimes violent) of the earth's surface that follows a release of energy in the earth's crust.

Or

Earthquake is any sudden shaking of the ground caused by the passage of seismic waves through Earth's rocks. Seismic waves are produced when some form of energy stored in Earth's crust is suddenly released, usually when masses of rock straining against one another suddenly fracture and "slip." Earthquakes occur most often along geologic faults, narrow zones where rock masses move in relation to one another. The *focus* is the point or center where the energy release starts. The epicenter is the point on the earth's surface directly above the focus of the earthquake.

Seismic waves are the waves of energy caused by the sudden breaking of rock within the earth or an explosion

Tsunami

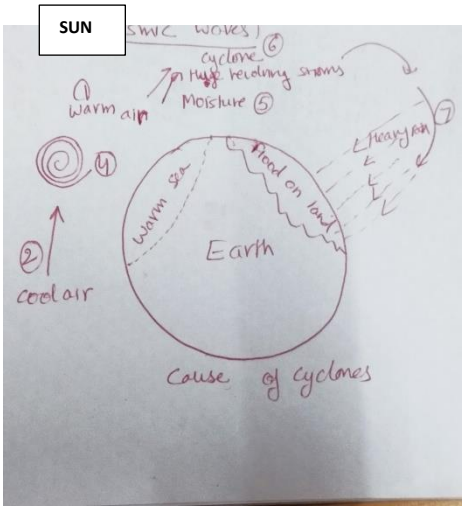
In Japanese, tsu means harbour and nami means waves. A tsunami is a series of waves in the ocean that can be hundreds of miles long and have been known to reach heights of 10.5 m. The massive December 26, 2004 tsunami travelled at a speed of 480 km per hour.

Origin of Tsunami The top layer of the earth (i.e, the lithosphere) is made up of a series of huge plates. They rest on an underlying viscous layer called the asthenosphere. On the earth, these plates are constantly in motion, moving along each other at a speed of 2.5 to 5 cm per year. When two plates come into contactat a plate boundary region, a heavier plate can slip under a lighter one, resulting in subduction. **When the energy of the force in transferred to the water, water is pushed upwards above normal sea level. This is the birth of a tsunami.**

Cyclone

Cyclones are swirling atmospheric disturbance in the form of huge revolving storms caused by powerful winds moving with very high velocities (sometimes exceeding 300 km/h). Cyclones are accompanied by rain and generate enormous waves in the ocean.

***(A)* Cause of Cyclones**



(1) Near the Equator, over warm seas, air heated by the sun rises upwards quickly and creates areas of very low pressures. (2) To fill the void that is left, cool air rushes in. (3) We know that the earth is constantly revolving around its axis. (4) Thus, the air is bent inwards and spirals outwards with great force.
(5) As the warm air rises, it becomes loaded with moisture which condenses into massive thunderclouds. (6) Due to the faster and faster rotation of the swirling winds, a huge circle of clouds get formed. The edge of a cyclone is called 'wall of the eye' which has a radius of 20 km–30 km. At the center of the cyclone, wind velocity is less. This calm, cloudless area is called the 'eye' of the cyclone.

When the cyclones move over the ocean, they drag clouds and moisture. They can also pick up energy when they travel across warm water. When cyclones move over land, they result in heavy rains leading to floods.

Effects of a Cyclone

Cyclones can cause the following damages:

(i) The standing *crop* and food stock lying in low-lying areas will be *ruined* due to powerful winds and heavy rain. Banana, coconut and other plantation crops are extremely vulnerable.
(ii) Sea water dragged through cyclones result in *inundation or flood of land*. This

increases salinity as a consequences of which soil becomes unfit for cultivation.

(iii) Heavy rain can cause *flooding*. This can lead to contamination of groundwater and surface water. Viral outbreaks, diarrhoea and malaria are consequences of contamination of water.

(iv) Gable-ended roofs made from cement, asbestos or tin sheets get high uplift as a result of powerful winds of cyclones. As these sheets are blown away, these then strikes against nearby buildings, animals and humans causing damage and deaths.

(v) Asymmetric buildings with empty pockets collapse due to the impacts of powerful winds.

(vi) Trees get uprooted and carried away along with powerful winds. These, then, destroy telephone lines, electricity poles, transmission line towers, etc. Thus, power supply and communication networks get disturbed.

(vii) Cyclones are powerful enough to damage loose or weak parts of buildings like doors, windows, etc.

Landslides

Landslide means downward sliding of a relatively dry mass of land and rock. It is alsoknown as landslip.

Effects of Landslides

(i) Landslides block or bury roads, lines of communication, railways lines, etc.

(ii) They destroy anything that comes in their path. They destroy settlements.

(iii) They destroy agricultural areas leading to loss to food production.

(iv) They block river flow; flooding may also occur.

(v) The flow of debris in landslides causes heavy casualties.

Landslides (Disaster) Management

or

Prevention and Mitigation

The following measures can be taken in this regard:

- The country should identify the vulnerable areas and actions should be taken in this regard on a priority basis.
- Early warning systems and monitoring systems should be there.
- Hazard mapping can be done to identify the areas which are more prone to landslides.
- Restriction on the construction in the risky areas should be imposed.
- Afforestation programs should take place.
- Restricting development in landslide areas and protecting the existing ones.
- The country should specify codes or standards etc. For the construction of the buildings and other purposes in such areas of risk.
- Insurance facilities should be taken by the people to deal with the loss.
- Terrace farming should be adopted in hilly areas.
- Response teams should be quick to deal with landslides if they occur.