

CHAPTER 3

Environmental Pollution

3.1. ENVIRONMENTAL POLLUTION

3.1.1. Meaning and Definition of Pollution

The presence of any solid, liquid or gaseous substance in the environment in a proportion or concentration which may be harmful for the health of environment and humans is known as 'environmental pollution'.

The substance present in an undesirable concentration causing harm to the environment and health of living beings is known as 'pollutant'.

According to Odum, "Pollution is an undesirable change in physical, chemical and biological characteristics of air, water and soil that may harmfully affect the life or create a potential health hazard for living organisms".

According to Mc Laughtin, "Environmental pollution means the introduction by man into any part of the environment, of wastes, water energy, energy, or surplus energy which changes the environment directly or indirectly adversely to affect the opportunity of men to use or enjoy it".

Environmental pollution is one of the most serious and severe ecological disasters. It harms the basic amenities required for the sustenance of livelihood, i.e., air, water, soil, land, etc. Statistics of the past years reveal that such amenities were previously undisturbed, uncontaminated, pure and most hospitable for living beings, but with the growth of science and technology, such amenities have now become polluted and a severe ecological imbalance is now being faced which is hazardous for the existence of mankind. The outcomes of urban industrial technological revolution and rapid exploitation of natural resources can be together considered as environmental pollution.

3.1.2. Causes of Pollution

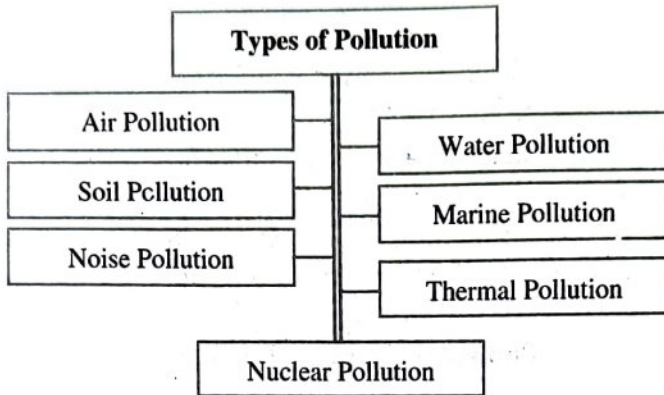
Following are the two major causes of pollution:

- 1) **Natural Causes:** The natural sources of environmental pollution are:
 - i) Smoke emanating from wildfire and trace gases.
 - ii) Hazardous gases released during volcanic eruptions and volcanic ash.
 - iii) Natural pollutants like bacteria, spores, cysts, pollens, etc.
 - iv) Release of marsh gas from dead and decaying organic matter.
 - v) Dust storms.
- 2) **Man-made or Anthropogenic Causes:** Anthropogenic sources consist of a wide variety of sources that lead to environmental pollution. Some of them are:
 - i) Industrialisation,
 - ii) Invention of automobiles,
 - iii) Over population,

- iv) Deforestation and destruction of natural habitat,
- v) Nuclear explosions,
- vi) Over-exploitation of natural resources,
- vii) Construction of buildings, roads and dams,
- viii) Explosives used in wars,
- ix) Use of fertilizers and pesticides,
- x) Quarrying and mining.

3.1.3. Types of Pollution

Following are different types of environmental pollution:



3.1.4. Air Pollution

The presence of foreign substances in air in an excessive and undesirable proportion with adverse effects on the living beings and properties is known as air pollution. There is no such place, where the air can be found entirely pure and uncontaminated. With the increase in industrial development, air at any place is contaminated to some level. Early pollutants noted in air pollution include smoke, fume, gases, ash, forest fires, sand or dust from windstorms, etc. However, the human-induced and anthropogenic sources started emitting pollutants which are considered as today's real problems of air pollution.

According to World Health Organisation, "Air pollution is defined as, substances put into air by the activity of mankind into concentration sufficient to cause harmful effect to his health, vegetables, property or to interfere with the enjoyment of his property".

According to Indian Standards Institute, "Air pollution is the presence in ambient atmosphere of substances, generally resulting from the activity of man, in sufficient concentration, present for a sufficient time and under circumstances which interfere significantly with the comfort, health or welfare of persons or with the full use or enjoyment of property".

3.1.4.1. Air Pollutants

Following are the various types of air pollutants:

- 1) **Carbon Monoxide (CO):** Carbon monoxide is a colourless, odourless, tasteless gas and is chemically inactive under normal temperature and pressure conditions. At normal concentration (0.1ppm), it has no side-effects, but at higher levels, it seriously impairs human metabolic activities.

Effects

Following are the effects of carbon monoxide on humans:

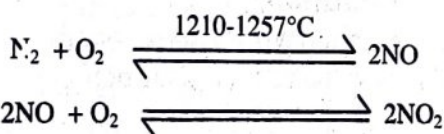
- i) It decreases the oxygen carrying capacity of the blood by combining with haemoglobin (Hb) and forms a complex compound known as carboxyhaemoglobin (COHb). It leads to conditions of nausea with symptoms of laziness and tiredness.
- ii) It affects vision and leads to cardiovascular disorders.
- iii) It is a very dangerous asphyxiant and at higher levels, it is lethal to human health.

Control

The major source of CO is vehicular emission. As such, efforts should be made for controlling vehicular pollution, which include taking the following measures:

- i) Design of energy efficient combustion engines so as to reduce the amount of pollutants emanating from burning fuels.
- ii) Development of exhaust systems that transform pollutants to non-lethal forms.
- iii) Development of substitutes to fossil fuels. In this respect, the use of both Compressed Natural Gas (CNG) and Liquefied Natural Gas (LNG) should be encouraged.
- iv) Development of pollution-less sources of power.

- 2) **Nitrogen Oxides (NO_x):** NO_x consist of eight different oxides of nitrogen. Among them NO, NO₂ and N₂O are generally air pollutant. NO is a colourless, odourless gas, whereas NO₂ is reddish brown gas with suffocating odour. NO and NO₂ are formed in the following manner:



NO is formed at high temperatures. NO₂ is also formed at high temperatures of about 1100°C through photolytic reaction.

Effects

Following are the effects of nitrogen oxides:

- i) Nitric oxide can combine with haemoglobin like CO and decrease the oxygen carrying capacity of blood.
- ii) NO is moderately toxic due to lower concentration levels in air.
- iii) In contrast to NO, NO₂ is more toxic as it affects alveoli of lungs and at times, it may also lead to acute bronchitis.

Control

Following measures should be adopted for controlling the concentration levels of nitrogen oxides in the air:

- i) Use of catalytic converters in automobiles, which reduces NO_x emission.
- ii) Controlling the emissions of NO_x from power plants, which can be controlled in the following manner:
 - a) Burning of the fuel at high temperature in the presence of less amount of air. Formation of NO is minimal when produced in the presence of less amount of air.

- b) The fuel is burned completely at lower temperatures with excess amount of air, which reduces the formation of NO.
 - c) NO_x can be removed from stack gas by chemical absorption with the help of H₂SO₄ or alkaline solution.
- 3) **Lead:** Lead is an important metal which has been mined for a long time. Besides the importance of lead, its toxicity to nervous system is also well-known. Modern humans have hundred times greater lead present in their teeth and skeleton as compared to found in the skeletons of pre-industrial age.

The major source of lead in the environment is the emission from burning of automobile fuels containing alkyl lead additives. Approximately 80 to 90 per cent of all lead in ambient air comes from the burning of leaded petrol in internal combustion engines. However, the level of contribution from this source is different for different countries depending upon vehicular density and the efficiency of leaded petrol combustion engines.

- 4) **Particulate Matter:** Particulate matter can be defined as single particles or collections of particles having diameters of greater than 2×10^{-10} m. Some of the particulate matter occurs naturally in the environment like snow, fog, rain, hail, mist, etc. Whereas, there are other particulate matter which are the result of human activities like fog, wind-blown soils, soot, fumes, etc. Others like smoke and soot are the products of incomplete fuel combustions in automobiles, furnaces and domestic heating.

3.1.4.2. Causes of Air Pollution

The various locations, activities and factors responsible for releasing air pollutants in the environment are considered as the causes of air pollution. Following are the main causes of air pollution:

- 1) **Anthropogenic Causes (Human Activity):** Such activities involve different kinds of fuel burning processes developed by human beings. These include:
 - i) **Stationary Sources:** Smoke stacks of power plants, waste incinerators, manufacturing factories, furnaces, fuel-burning heating devices and systems, etc., are included under stationary sources of air pollution.
 - ii) **Mobile Sources:** Mobile sources involve marine vessels, motor vehicles, sound effects, aircrafts, etc.
 - iii) **Chemicals, Dust and Controlled Burn Practices:** Such practices are usually found in forestry and agriculture management. Controlled burn activities are also practiced in farming, forest management, prairie restoration and greenhouse gas abatement. Such processes arouse the germination of desirable trees, which renew the forests.
 - iv) **Fumes:** Fumes emerging from hair sprays, paints, varnish, chemical solvents and aerosol sprays also add-up to the air pollution.
 - v) **Waste Deposition in Landfills:** The waste depositions generate methane which is a highly flammable gas that forms explosive mixtures with air. Methane also displaces oxygen under an enclosed space as it is asphyxiate.

- 2) **Natural Causes:** The various types of natural causes are:
- i) **Dust from Natural Sources:** These include big land areas usually with little or no vegetation.
 - ii) **Methane:** Emitted by food digestion of animals.
 - iii) **Radon Gas:** Radon is a health hazard which is colourless, odourless, radioactive, and naturally occurring noble gas formed by radium's decay. Radon gas from natural sources usually gathers in buildings, basements, etc., which can cause lung cancer.
 - iv) **Volcanic Activity:** Sulphur, chlorine, and ash particles are generated due to volcanic activities, acting as a major source of air pollution.

3.1.4.3. Effects of Air Pollution

Following are the major effects of air pollution:

- 1) **Acid Deposition:** As a result of fossil fuel combustion, sulphur dioxide and nitrogen oxides are released. They react with water to form sulphuric acid and nitric acid. Higher levels of acidity causes metals to dissolve in water, thereby polluting the surface water. **For example**, higher levels of aluminium affect the nutrient uptake capability of plants leading to their death and decay.
- 2) **Eutrophication:** The major cause of eutrophication is nitrogen pollutants such as nitrogen oxides and ammonia. Increase in the amount of plant nutrients in water bodies encourages the growth of water plants such as algae and duckweed in large numbers. This growth of plants at the upper levels of water hinders the movement of sunlight deep below the water, thus leading to death of many deep water organisms.
- 3) **Smog:** Smog is a combination of smoke and fog. The term was introduced by **Des Voeux**, a Glasgow public health official. Smog consists of more than 200 chemicals from diverse sources like fires, water, automobiles treatment, oil production, industrial solvents, paints and coatings.
- 4) **Loss of Ozone Layer:** Within the stratospheric layer of the atmosphere lies the ozone layer which protects the living beings and the Earth from ultraviolet rays emitting from the Sun. The depletion of ozone may increase the occurrence of certain diseases like malaria, cancer and other infectious diseases.
- 5) **Greenhouse Effect:** Human activities lead to the generation of a number of harmful gases. These gases capture the energy which is distributed on Earth in the form of sunlight which increases the environment's temperature. Carbon dioxide is produced as a result of burning of fossil fuels, which leads to the "greenhouse effect", thereby increasing the Earth's surface temperature which is the major cause of global warming.

3.1.4.4. Control Measures for Air Pollution

There are four broad approaches for controlling the emission of pollutants into the atmosphere. They are:

- 1) **Minimising Air Pollutant:** This is accomplished through efficient distribution of land by making proper plans for establishing industries and building residential apartments.

- 2) **Diffusion of Source Locations:** To a large extent, pollution can be controlled by diffusing various sources of pollutants. Tall stacks should be used for industries and thermal power plants so that pollutants are released at relatively higher heights, where there are both horizontal and upward movement of air, with less chances of downward movement.
- 3) **Reduction at Source by Process Changes:** This is done through:
 - i) Replacement of raw materials; like using high-volatile coal with low-volatile coal leads to reduction in smoke and soot.
 - ii) Replacement of fuels; like desulphurisation and de-ashing of fuel leads to decrease in SO₂ emissions, SPM (Suspended Particulate Matter) and ash. Likewise, coal can be replaced with natural gas to reduce emission.
 - iii) Modification of process; while disposing combustible wastes, sanitary landfills can be used in place of incinerators.
 - iv) Modification of process equipment and proper maintenance of available equipment can also help in decreasing the overall pollution level.
- 4) **Reduction at Source by Using Control Equipment:** This is the most suitable method for controlling air pollution at source. Different types of control devices are used for controlling variety of pollutants emitted from variety of sources.

3.1.5. Water Pollution

Water is the another vital amenity which is mandatory for the maintenance of all life forms, as it is responsible for the flow, circulation and movement of nutrients in the biosphere. Thus, water is the most important component for life support system. Similar to other natural substances, water possesses self-purifying ability during its recycling, but due to the presence of undesirable foreign particles, such ability gets reduced thereby giving rise to water pollution.

Hence, water pollution can be defined as deterioration of chemical, biological and physical features of water by human and natural activities up to an extent which becomes a hazard for the sustenance of living organisms.

According to United States Public Health Services, "Water pollution means the presence of any toxic substance in water that degrades the quality to constitute a hazard or impair its usefulness".

3.1.5.1. Water Pollutants

Following are the various types of water pollutants that affect the environment:

- 1) **Biological Impurities:** Various types of micro-organisms that occur naturally in water and in other ecosystem can be a major source of many infectious diseases. But, the micro-organisms that are the greatest cause of concern are usually connected to human activities. In this context, non-point sources include run-off from agricultural operations and storm water run-off, particularly when combined with situations of sewer overflow.
- 2) **Inorganic Impurities:** Inorganic impurities consist of the following:
 - i) **Dirt and Sediment or Turbidity:** Generally, water contains some amount of impurities or suspended particles in the form of sand, clay, soil, etc. Though turbidity is not pleasant to look at, it can be a good source of food and lodging for many bacteria. However, it can interfere with the process of disinfection.

- ii) **Total Dissolved Solids:** These materials consist of dissolved rocks and other compounds from the Earth. It is difficult to mention all of them.
 - iii) **Toxic Metals:** Toxic metals present the greatest amount of threat to human health, especially when they are present in the drinking water. Metals like arsenic, cadmium, lead, mercury, and silver are inherently dangerous to human health. The maximum permissible limit for these metals is decided by Primary Drinking Water Regulations given by Environment Protection Agency.
 - iv) **Asbestos:** Asbestos is found in water as microscopic suspended mineral fibres. The main source of asbestos in water is asbestos-cement pipe, which was commonly used for supplying water in the cities post World War II. According to one estimate, there is around 200,000 miles of this pipe supplying drinking water at present.
 - v) **Radioactivity:** Small amounts of radioactive elements are found in almost all drinking water, but the levels that may affect health are rare. The biggest risk is posed by nuclear accidents, nuclear processing plants, and radioactive waste disposal sites.
- 3) **Organic Impurities:** It includes:
- i) **Tastes and Odours:** If the water has foul odour or taste, there are chances that it is due to the presence of some organic substance, which may be decaying vegetation or algae, hydrocarbons or phenols. The foul taste may also be due to the presence of TDS and other unwanted elements.
 - ii) **Pesticides and Herbicides:** Increased use of agricultural pesticides and herbicides leads to contamination of drinking water. These chemicals are carried down to the groundwater by rain and irrigation. Likewise, household use of herbicides and pesticides leads to the contamination of groundwater.
 - iii) **Toxic Organic Chemicals:** The most dangerous and widespread problem of water contamination is the presence of organic chemicals in freshwater released by industries.
 - iv) **Chlorine:** When chlorine, which is used to disinfect water, reacts with organic materials (decaying vegetation, algae, etc.) trihalomethanes (THMs) are formed. This further creates toxic organic chemicals like chloroform, and bromodichloromethane.

3.1.5.2. Causes of Water Pollution

Causes of water pollution include:

- 1) **Non-Point Sources:** Non-point sources are the sources which do not have any definite outfall. These sources contribute maximum volume of wastewater that mixes up with lakes and streams. Such sources includes agricultural run-off which contains pesticides and harmful fertilisers that pollute the water bodies.
- 2) **Domestic Sources:** Pollution of streams and lakes are mostly caused by domestic sources of wastewater which contributes considerably towards water pollution. Most of the towns do not regulate proper functioning of sewage treatment plant while other cities do not even have proper sewage facilities. Such scenarios worsen the situations of water pollution.

- 3) **Industrial Sources:** Wastewater originating from factories and industries contains toxic particles which are prone to industrial usage. Such toxic particles pollute lakes and rivers, and also cause harm to animals as they depend upon rivers for their livelihood.
- 4) **Mine Drainage Water:** During various mining operations, the groundwater trapped under mineral deposits is released, which is expected to contain important elements and heavy metals in geological form. This mine drainage water is acidic in nature and usually emerges from coal mines.
- 5) **Rural and Agricultural Factors:** Various rural and agricultural factors such as animal feeding operations, application of large amount of pesticides and fertilisers, etc., are also responsible for water pollutions.

3.1.5.3. Effects of Water Pollution

Following are the effects of water pollution:

- 1) **Effects on Human Health:** Water pollution has following effects on human health:
 - i) The toxic pollutants make the water unfit for consumption. Contamination of drinking water leads to a number of water-borne diseases like cholera, typhoid, diarrhoea, dysentery, polio, and hepatitis in humans.
 - ii) Nitrates reduce the amount of oxygen that should reach the brain, which leads to blue-baby syndrome (methemoglobinemia) in infants.
 - iii) Synthetic organic chemicals pose serious health hazard to humans, plants and animals and are categorised as carcinogens.
 - iv) Oil spills may lead to skin irritation and rashes.
- 2) **Effect on Ecosystems:** Water pollution has the following effects on ecosystems:
 - i) Water pollution leads to the reduction in the level of dissolved oxygen in water bodies leading to death of fish and other aquatic organisms due to scarcity of oxygen.
 - ii) Invasive species may replace native species and thus reduce the overall biodiversity of the region. Invasive species may add debris and biomolecules (allelopathy) to the environment that can adversely affect the soil and chemical composition of the environment. This may decrease the competitiveness of native species.
 - iii) Pollution affects the smooth flow of natural food-chain. Many of the toxic chemicals like lead, chromium, mercury, cadmium, etc., find their way into water bodies through water run-off or leaching. These chemicals are consumed by aquatic animals, which are further consumed by humans. In this way, harmful chemicals enter the food chain.
 - iv) Many of the organic nutrients like nitrates and phosphates may promote the growth of algae and other aquatic weeds in water bodies. The explosive plant growth leads to degradation of water bodies, making the water unsuitable for drinking, bathing, and other domestic purposes.
 - v) Heated effluents released by thermal power plants into the water bodies raise the temperature of water and imposes heat stress on aquatic life which results in their death.

- 3) **Other Effects:** The effects of water pollution can be seen on both the biotic and abiotic component of aquatic ecosystem. The effects of water pollution are also lethal for human health. Following are some of the effects of water pollution:
- i) **Production of Disease-causing Agents:** Water pollution leads to production of a number of bacteria, viruses, protozoa and parasites that are the main cause of many diseases like typhoid, fever, cholera, infections, hepatitis and such other similar diseases. These pathogens enter the ecosystem through the faeces and urine of diseased animals.
 - ii) **Oxygen Demanding Wastes:** Wastes like domestic sewage, manure, and other organic wastes reduce the dissolved oxygen content of the water bodies. The reduction of oxygen leads to the production of phosphates and a condition known as eutrophication in water bodies.
 - iii) **Inorganic Plant Nutrients:** Addition of inorganic plant nutrients like nitrates and phosphates leads to explosive growth of algae and other plants. When these plants die, they consume a lot of oxygen for decomposition. Death and the resultant decomposition of plants increase the overall level of carbon dioxide in the water, which affects the normal pH level of water.
 - iv) **Radioactive Substances:** The concentration of radioactive substances is enhanced in food chains. Such substances are extremely dangerous to human health and can cause birth abnormalities, genetic disorder or cancer.
 - v) **Heat:** Increased level of heat leads to many diseases and production of toxins in water bodies. With the rise in temperature, oxygen content of the water goes down.
 - vi) **Sediments:** Insoluble soil particles or sediments damages productive grounds of fishes, reservoirs and channels. These substances make water cloudy and disrupt the food web.

3.1.5.4. Control Measures for Water Pollution

Following measures should be adopted for controlling water pollution:

- 1) **Industrial Effort:** A number of legislations have been formed that force the industries to make efforts towards cleaning the waste generated by them or developing an efficient system for waste disposal. By reducing the total amount of waste produced by the industries, it is possible to reduce the amount of pollutants that may pass in the water cycle. Thus, proper treatment of wastes produced by the industries is important for controlling water pollution.
- 2) **Transportation:** Society can significantly reduce vehicular pollution by switching to hybrid and electric vehicles. Exhaust, being the major pollutant of the vehicular pollution, enters the water cycle and causes water pollution.
- 3) **Farming Solutions:** In farming, switching to organic farming methods can significantly reduce the adverse impact of agricultural operations on the water bodies. In organic farming, plants are grown without the use of chemical fertilizers. These chemicals are a major source of water pollution from agricultural operations. Whereas, organic fertilizers do no harm the water cycle.
- 4) **Waste Disposal:** Proper disposal of waste can significantly reduce the water pollution in the environment. Besides, an optimum method for handling city wastes can help in obstructing the flow of pollutants to the water bodies.

- 5) **Stopping the Cycle:** There are certain ways through which natural water cycle can be interrupted for preventing pollution. Filtering the water before it finds its way into the water bodies may be sufficient in some places. One of the most efficient and effective technique in this regard is rain garden which is designed specifically to hold and soak in the rainwater runoff.
- 6) **Groundwater Contamination Controls:** Controlling the ground water from being polluted is one of the effective method for reducing water pollution. It is also cheap as compared to several methods that involve cleaning the contaminated water. This can be done by properly managing the wastes and promoting organic farming.

3.1.6. Soil Pollution

Soil is a very important natural resource which is formed by the weathering of rocks and other various passive and active factors. It is responsible for fulfilling all the fundamental requirements of terrestrial and land-dwelling organisms. It is a core necessity for growing plants, food, fodder, etc., on which the living organisms depend either directly or indirectly. This soil gets polluted when foreign materials crossing the threshold proportion degrees are found in it which causes harm to living beings.

Soil pollution is caused by several human activities in urban, rural and industrial areas. Numerous toxic substances along with several harmful wastes are directly dumped at specific land areas which ultimately find their way in the soil and pollute the groundwater. These wastes and toxic substances usually come from industries and municipalities which also degrade the land and affect soil fertility. Moreover, the excessive use of pesticides, insecticides, fertilisers, herbicides, etc., leads to severe soil contamination. These hazardous particles are absorbed in the soil, and through food chain cause several diseases to living beings.

3.1.6.1. Soil Pollutants

Soil pollutants are the result of improper disposal of industrial and domestic waste products. Some of the commonly known soil pollutants are:

- 1) **Heavy Metals:** Soil pollution by heavy metals like cadmium, lead, chromium, copper, zinc, mercury and arsenic raises serious health concerns. Though, heavy metals are present in the soil, their concentration in the soil is increased by:
 - i) Industrial activities (non-ferrous industries, power plants, iron, steel and chemical industries);
 - ii) Agricultural activities (irrigation with polluted water, use of mineral fertilizers);
 - iii) Waste incineration;
 - iv) Combustion of fossil fuels; and
 - v) Road traffic.
- 2) **Pesticides and Organic Contaminants:** Pesticides adversely affect the properties of the soil by interfering with the functioning of many micro-organisms that are part of soil. On the other hand, soil is an important transmitter of surface and groundwater pollution. Organic pollutants enter the soil through atmospheric deposition, distribution over land, contamination by wastewater and waste disposal.

- 3) **Nitrates and Phosphorus:** Nitrogen and phosphorus are elements that are essential for life, which makes them important for soil and food systems. Nitrates and phosphorus are vital plant nutrients but their over-utilisation may create conditions of saturation and subsequent contamination of groundwater.
- 4) **Artificial Radionuclides:** There is an increased concern, particularly after the Chernobyl incident, over contamination of soil with artificial radionuclides like cesium-137, strontium-90 and some plutonium isotopes. Radionuclides present in upper layers of soil may expose plants and animals to radiation. In some cases, humans may also be exposed to ionising radiation.

3.1.6.2. Causes of Soil Pollution

The causes of soil pollution are as follows:

- 1) **Urban Waste:** Excessive amount of urban waste products such as paper, glasses, containers, fuel residues, batteries, garbage, metals, fibre, plastics, etc., severely contribute towards soil pollution. Every day an enormous amount of urban waste is generated, which is unmanageable and riotous.
- 2) **Industrial Waste:** It is one of the most significant soil pollutants whose disposal is increasingly becoming a serious challenge. Industrial wastes are mainly discharged from factories and industrial areas containing toxic particles. These pollutants originate mainly from oil industries, paper mill, sugar factories, tanneries, refineries, distilleries, pesticides and fertilisers plants, etc.
- 3) **Radioactive Pollutants:** These pollutants mainly originate due to the explosions between nuclear devices, penetrations and accumulation of radioactive wastes in soil and atmospheric fall out from nuclear dust. Some of the radioactive substances commonly found in rocks, soil, air and water are Radium, Uranium, Carbon (C-14) and Thorium.
- 4) **Fertilisers:** Chemical compounds containing one or more plant nutrients such as phosphorous, potassium, nitrogen, etc., are known as fertilisers. Though they increase the fertility of soil but when used excessively cause soil pollution.
- 5) **Pesticides:** With the devastating increase in population, it is becoming extremely essential to increase the production of food which has led to the manipulation of land resources. Pesticides and insecticides used for controlling insects and pests cause significant stress in natural environment by polluting soil and water.
- 6) **Soil Conditioners and Other Chemical Agents:** Various soil conditioners and fumigants are used for increasing and protecting the fertility of soil, and to kill dangerous insects. These soil conditioners cause soil pollution and alterations in horticultural and agricultural soil areas.
- 7) **Farm Wastes:** Increasing amount of farm wastes resulting from growing population of cattle, cows, etc., has been a major contributor in polluting soil. Also, the groundwater gets polluted when the slurry of these farm wastes deposits over the upper layer of soil seeps in the ground.
- 8) **Metallic and Chemical Pollutants:** Hazardous effluents from a large number of industries manufacturing dyes, soaps, textiles, drugs, synthetic detergents, paper, pulp, rubber, etc., along with the metal industries are poured directly in the soil and water bodies, thereby creating devastating effects on living beings.

- 9) **Biological Agents:** Another major source of land and soil pollution is the biological agents containing excreta of living organisms. Digested sewage sludge along with heavy application of manures to soil without periodic leaching cause chronic salt hazards to plants within a few years. This sludge contains numerous live viruses and intestinal worms. These pathogenic organisms pollute the soil and are categorised as:
- i) Pathogenic organisms excreted by animals
 - ii) Pathogenic organisms excreted by human beings
 - iii) Pathogenic organisms occurring naturally under polluted soil

3.1.6.3. Effects of Soil Pollution

The effects of soil pollution can be studied under two broad heads:

- 1) **Impact on Health:** Following are the effects of soil pollution on human health:
 - i) **Chronic Health Conditions:** Extreme exposure to chromium, lead, petroleum, solvents, pesticides and herbicides formulations can be hazardous to human health. It can cause serious congenital disorders and other chronic health conditions.
 - ii) **Organ Damage:** The occurrence of heavy metals in soil in toxic quantity can lead to permanent developmental damage among kids. Some amount of lead and mercury are found naturally in soil. However, higher levels of these metals may damage the developing brains of children. Further, it also gives rise to a number of neurological problems.
 - iii) **Bioaccumulation:** Plants growing in polluted soil absorb pollutants from the soil. As these pollutants become part of plants, they accumulate in plants over time. This leads to increase in the concentration of pollutants in plants as compared to the soils. The concentration level is further enhanced when these plants are consumed by animals. This process goes on and is known as bioaccumulation.
 - iv) **Cancer:** Many of the soil pollutants are carcinogenic. Humans exposed to these pollutants have greater chances of developing cancer than those who are not exposed.
- 2) **Impact on Environment:** The effects of soil pollution on the environment can be discussed under following points:
 - i) **Fertilizers:** Chemical fertilizers, usually added to increase crop yield, remains one of the biggest sources of soil pollution. Rains carry these nutrients to nearby water bodies and from there, they goes down under the soil.

In the water bodies, these nutrients are responsible for the excessive growth of algae and other harmful plants. These nutrients increase the presence of microbes in the soil, thereby reducing the oxygen level of the water body.
 - ii) **Salts:** Salinisation is one of the general problems of soil pollution. The primary source of soil salinisation is irrigation, particularly in arid and semi-arid climates. Irrigation leads to accumulation of salts in the soil over a period of time. This makes the soil infertile and unsuitable for growing crops.

- iii) **Groundwater Pollution:** Leaching of soil pollutants leads to groundwater pollution. This further leads to pollution of nearby water sources, wells and springs.
- iv) **Heavy Metals:** Heavy metals like uranium, radium and plutonium can pollute the soil to a dangerous level. The pollution by heavy metals may be natural or due to human activity. These metals cause problems of plant infertility and are also poisonous to animals and humans.
- v) **Pesticides:** They are also responsible for soil pollution. They can reduce the fertility of the soil, make plants poisonous and reduce the carrying capacity of ecosystem. They can also lead to toxic reactions.

3.1.6.4. Control Measures for Soil Pollution

Following measures can be taken to control soil pollution:

- 1) **Reducing Usage of Chemicals:** Many of the pesticides, insecticides and fungicides are important for improving plant yield and growth. However, their overuse is one of the primary causes of soil pollution. As such, attempts should be made to gradually reduce the application of these chemicals and support organic farming.
- 2) **Weed Control:** Weed control is an effective method for controlling soil pollution. Weeds are useless plants that grow near to main plants and often consume a significant portion of soil minerals leaving nothing for the main plant. Controlling and removing such plants can foster the growth of crops and increase soil fertility.
- 3) **Reforestation and Recycling:** Other methods for reducing soil pollution are reforestation and recycling of waste materials. Deforestation leads to soil erosion, which ultimately contributes to soil pollution due to loss of fertile top soil.
- 4) **Solid Waste Management:** Solid waste management is another method for controlling soil pollution. This calls for the development of an efficient waste disposal system. Industrial wastes should be treated physically, chemically and biologically and only then it should be released into the environment.

3.1.7. Marine Pollution

Marine pollution is defined as the direct or indirect entrance of substances or energy into the marine environment by human activities creating harm to living beings, hazards to human health and intrusions to marine activities such as fishing, reduction of amenities, and impairment of sea water quality.

There are two major aspects of the above definition. First, the definition can be measured as the extent of marine pollution measurable.

Second, it is action-oriented. Marine pollution is hazardous, whose harmful effects can be identified in various manner. Marine pollution is usually conceptualised as human process, thereby eliminating all the natural process that could possibly damage the ocean ecosystem.