CHAPTER - 5

ENVIRONMENTAL POLLUTION

Pollution is defined as 'an addition or excessive addition of certain materials to the physical environment (water, air and lands), making it less fit or unfit for life'.

5.1. POLLUTANTS

- Pollutants are the materials or factors, which cause adverse effect on the natural quality of any component of the environment.
- For example, smoke from industries and automobiles, chemicals from factories, radioactive substances from nuclear plants, sewage of houses and discarded household articles are the common pollutants.

5.1.1. Classifications

(i) According to the form in which they persist after release into the environment.

- Primary pollutants: These persist in the form in which they are added to the environment e.g. DDT, plastic.
- Secondary Pollutants: These are formed by interaction among the primary pollutants.
- For example, peroxyacetyl nitrate (PAN) is formed by the interaction of nitrogen oxides and hydrocarbons.

(ii) According to their existence in nature.

- Quantitative Pollutants: These occur in nature and become pollutant when their concentration reaches beyond a threshold level. E.g. carbon dioxide, nitrogen oxide.
- Qualitative Pollutants: These do not occur in nature and are man-made. E.g. fungicides, herbicides, DDT etc.

(iii) According to their nature of disposal.

- Biodegradable Pollutants: Waste products, which are degraded by microbial action. E.g. sewage.
- Non-biodegradable Pollutants: Pollutants, which are not decomposed by microbial action. E.g. plastics, glass, DDT, salts of heavy metals, radioactive substances etc.,)

(iv) According to origin

- Natural
- Anthropogenic

5.1.2. Causes of pollution

- Uncontrolled growth in human population
- Rapid industrialization
- Urbanization
- Uncontrolled exploitation of nature.
- Forest fires, radioactivity, volcanic eruptions, strong winds etc.,

5.2. AIR POLLUTION

- Air pollution is aggravated because of four developments: increasing traffic, growing cities, rapid economic development, and industrialization.
- 'The presence in the atmosphere of one or more contaminants in such quality and for such duration as it is injurious, or tends to be injurious, to human health or welfare, animal or plant life.'
- It is the contamination of air by the discharge of harmful substances.
- Air pollution can cause health problems, damage the environment, property and climate change.

5.2.1. Major air pollutants and their sources

Carbon monoxide (CO)

- It is a colourless, odourless gas that is produced by the incomplete burning of carbon-based fuels including petrol, diesel, and wood.
- It is also produced from the combustion of natural and synthetic products such as cigarettes.
- It lowers the amount of oxygen that enters our blood.

- It can slow our reflexes and make us confused and sleepy.

Carbon dioxide (CO2)

- It is the principle greenhouse gas emitted as a result of human activities such as the burning of coal, oil, and natural gases.

Chloroflorocarbons (CFC)

- These are gases that are released mainly from air-conditioning systems and refrigeration.
- When released into the air, CFCs rise to the stratosphere, where they come in contact with few other gases, which lead to a reduction of the ozone layer that protects the earth from the harmful ultraviolet rays of the sun.

Lead

- It is present in petrol, diesel, lead batteries, paints, hair dye products, etc. Lead affects children in particular.
- It can cause nervous system damage and digestive problems and, in some cases, cause cancer.

Ozone

- It occurs naturally in the upper layers of the atmosphere.
- This important gas shields the earth from the harmful ultraviolet rays of the sun.
- However, at the ground level, it is a pollutant with highly toxic effects.
- Vehicles and industries are the major source of ground-level ozone emissions.
- Ozone makes our eyes itch, burn, and water. It lowers our resistance to cold and pneumonia.
- Nitrogen oxide (Nox)
- It causes smog and acid rain. It is produced from burning fuels including petrol, diesel, and coal.
- Nitrogen oxide can make children susceptible to respiratory diseases in winters.

Suspended particulate matter (SPM)

- It consists of solids in the air in the form of smoke, dust, and vapour that can remain suspended for extended periods and is also the main source of haze which reduces visibility.
- The finer of these particles, when breathed in can lodge in our lungs and cause lung damage and respiratory problems.

Sulphur dioxide (SO2)

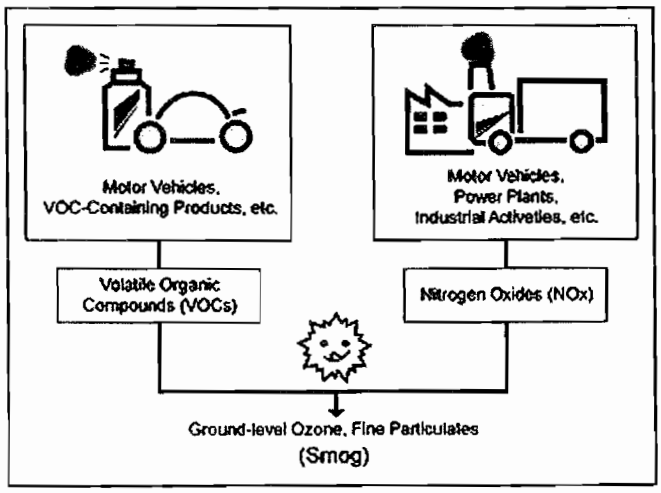
- It is a gas produced from burning coal, mainly in thermal power plants.
- Some industrial processes, such as production of paper and smelting of metals, produce sulphur dioxide.
- It is a major contributor to smog and acid rain. Sulfur dioxide can lead to lung diseases.

5.2.2. Smog

- The term smog was first used (1905) by Dr H A Des Voeux
- Smog has been coined from a combination of the words fog and smoke. Smog is a condition of fog that had soot or smoke in it.

The Formation of Smog

- Photochemical smog (smog) is a term used to describe air pollution that is a result of the interaction of sunlight with certain chemicals in the atmosphere.
- One of the primary components of photochemical smog is ozone.
- While ozone in the stratosphere protects earth from harmful UV radiation, ozone on the ground is hazardous to human health.
- Ground-level ozone is formed when vehicle emissions containing nitrogen oxides (primarily from vehicle exhaust) and volatile organic compounds (from paints, solvents, printing inks, petroleum products, vehicles, etc.) interact in the presence of sunlight.



Ground-level ozone is formed through a complex reaction involving hydrocarbons, nitrogen oxides, and sunlight. It is formed when pollutants released from gasoline, diesel-powered vehicles and oil-based solvents react with heat and sunlight.

- Smog refers to hazy air that causes difficult breathing conditions. It is a combination of various gases with water vapour and dust.
- Its occurrences are often linked to heavy traffic, high temperatures, and calm winds. During the winter, wind speeds are low and cause the smoke and fog to stagnate near the ground; hence pollution levels can increase near ground level.
- Smoke particles trapped in the fog gives it a yellow/black colour and this smog often settled over cities for many days.

The effects of smog

- It hampers visibility and harms the environment.
- respiratory problems
- deaths relating to bronchial diseases.
- Heavy smog greatly decreases ultraviolet radiation.
- Heavy smog results in the decrease of natural vitamin D production leading to a rise in the cases of rickets.

5.2.3. Indoor air pollution

- It refers to the physical, chemical, and biological characteristics of air in the indoor environment within a home, or an institution or commercial facility.
- Indoor air pollution is a concern where energy efficiency improvements sometimes make houses relatively airtight, reducing ventilation and raising pollutant levels.
- Indoor air problems can be subtle and do not always produce easily recognized impacts on health.
- Different conditions are responsible for indoor air pollution in the rural areas and the urban areas.

(a) Rural

- It is the rural areas that face the greatest threat from indoor pollution, where people rely on traditional fuels such as firewood, charcoal, and cowdung for cooking and heating.
- Burning such fuels produces large amount of smoke and other air pollutants in the confined space of the home, resulting in high exposure. Women and children are the groups most vulnerable as they spend more time indoors and are exposed to the smoke.
- Although many hundreds of separate chemical agents have been identified in the smoke from biofuels, the four most serious pollutants are particulates, carbon monoxide, polycyclic organic matter, and formaldehyde.

(b) Urban

- In urban areas, exposure to indoor air pollution has increased due to a variety of reasons, such as
- construction of more tightly sealed buildings,
- reduced ventilation,
- the use of synthetic materials for building and furnishing and
- the use of chemical products, pesticides, and household care products.
- Indoor air pollution can begin within the building or drawn in from outdoors.
- Other than nitrogen dioxide, carbon monoxide, and lead, there are a number of other pollutants that affect the air quality.

Pollutants

i) Volatile organic compounds

- The main indoor sources are perfumes, hair sprays, furniture polish, glues, air fresheners, moth repellents, wood preservatives, and other products.
- Health effect - imitation of the eye, nose and throat, headaches, nausea and loss of coordination.
- long term - suspected to damage the liver and other parts of the body.

ii) Tobacco

- Smoke generates a wide range of harmful chemicals and is carcinogenic.
- Health effect - burning eyes, nose, and throat irritation to cancer, bronchitis, severe asthma, and a decrease in lung function.

iii) Biological pollutants

- It includes pollen from plants, mite, and hair from pets, fungi, parasites, and some bacteria.

Most of them are allergens and can cause asthma, hay fever, and other allergic diseases.

iv) Formaldehyde

- Mainly from carpets, particle boards, and insulation foam. It causes irritation to the eyes and nose and allergies.

v) Radon

- It is a gas that is emitted naturally by the soil. Due to modern houses having poor ventilation, it is confined inside the house and causes lung cancers.

vi) Asbestos

vii) Pesticides

5.2.4. Fly Ash

- Ash is produced whenever combustion of solid material takes place.
- Fly ash is one such residue which rises with the gases into the atmosphere. Fly ash is a very fine powder and tends to travel far in the air. The ash which does not rise is termed as bottom ash.
- Nearly 73% of India's total installed power generation capacity is thermal, of which 90% is coal-based generation, with diesel, wind, gas, and steam making up the rest.

Composition

1. Aluminium silicate (in large amounts)
2. silicon dioxide (SiO_2) and
3. Calcium oxide (CaO).

- Fly ash particles are oxide rich and consist of silica, alumina, oxides of iron, calcium, and magnesium and toxic heavy metals like lead, arsenic, cobalt, and copper.

How it is collected?

- Fly ash is generally captured by electrostatic precipitators or other particle filtration equipments before the flue gases reach the chimneys of coal-fired power plants.

Environmental effects?

- If fly ash is not captured and disposed off properly, it can pollute air and water considerably.
- It causes respiratory problems.
- Fly ash in the air slowly settles on leaves and crops in fields in areas near to thermal power plants and lowers the plant yield.

Advantages:

- Cement can be replaced by fly ash upto 35%, thus reducing the cost of construction, making roads, etc.
- Fly ash bricks are light in weight and offer high strength and durability.
- Fly ash is a better fill material for road embankments and in concrete roads.
- Fly ash can be used in reclamation of wastelands.
- Abandoned mines can be filled up with fly ash.
- Fly ash can increase the crop yield and it also enhances water holding capacity of the land .

Policy measures of MoEF:

- The Ministry of Environment and Forests vide its notification in 2009, has made it mandatory to use Fly Ash based products in all construction projects, road embankment works and low lying land filling works within 100 kms radius of Thermal Power Station.
- To use Fly Ash in mine filling activities within 50 kms radius of Thermal Power Stations.

Do you know?

- Trees are an important part of our world. They provide wood for building and pulp for making paper. They provide habitats (homes) for all sorts of insects, birds and other animals. Many types of fruits and nuts come from trees -- including apples, oranges, walnuts, pears and peaches. Even the sap of trees is useful as food for insects and for making maple syrup – yum!
- Trees also help to keep our air clean and our ecosystems healthy. We breathe in oxygen and breathe out carbon dioxide. Trees breathe in carbon dioxide and breathe out oxygen. We're perfect partners!
- Trees do lots for us, our environment and other plants and animals in nature but we don't just love trees for practical reasons.

5.2.5. Effects of air pollution

➢ 1. health effect

Name Of Pollutant	Sources	Health Effects
Sulphur Oxides	Thermal power plants and industries	Eye and throat irritation, cough, allergies, impairs enzyme function in respiratory system. Reduces exchange of gases from lung surface.
Nitrogen Oxides	Thermal power plant, industries and vehicles	Irritation and inflammation of lungs, breathlessness, impairs enzyme function in respiratory system and causes bronchitis and asthma.
Suspended Particulate Matter (SOM)	Vehicular emissions and burning of fossil fuels	Lung irritation reduces development of RBC and cause pulmonary malfunctioning.
Carbon Monoxide	Vehicular emissions and burning of fossil fuels	Difficulty in breathing, severe headaches, irritation to mucous membrane, unconsciousness and death
Carbon Dioxide	Burning of fossil fuels	Impairs reflexes, judgment and vision, severe headaches and heart strain.
Smog	Industries and vehicular pollution	Respiratory problems and intense irritation to the eyes.
Ozone	Automobile emissions	Breathlessness, asthma, wheezing, chest pain, emphysema and chronic bronchitis.
Chlorofluorocarbons	Refrigerators, sprays, emissions from jets	Depletion of stratospheric ozone layer, global warming.
Hydrocarbons	Burning of fossil fuels	Carcinogenic effect on lungs, kidney damage, hypertension, respiratory distress, irritation of eyes, nose and throat, asthma, bronchitis and impairs enzyme function in respiratory system.
Tobacco Smoke	Cigarettes, cigars etc.	Chronic bronchitis, asthma and lung cancer, irritation of eyes, nose and throat.
Mercury	Industries	Nervous disorders, insomnia, memory loss, excitability, irritation, tremor, gingivitis and minamata disease.

Lead	Leaded petrol emissions	Damage to brain and central nervous system, kidneys and brains, impaired intelligence and interference with development of RBCs.
Cadmium	Industries	Affects the heart
Silica dust	Silicon quarries	Silicosis affects the lungs
Cotton dust	Cotton textile factories	Byssinosis involves destruction of lung tissues, chronic cough, bronchitis and emphysema.
Asbestos dust	Asbestos mining, asbestos sheet manufacturing	Asbestosis which involves severe respiratory problems and may lead to cancer.
Radioactive pollutants	Cosmic rays, x-rays, beta rays, radon and radium	Destroy living tissues and blood cells; affect cell membrane and cell enzyme functions, leukemia, and permanent genetic changes.
Coal dust and particles	Coal mines	Black lung cancer, pulmonary fibrosis which lead to respiratory failure.

II. Effects on Vegetation

- retard photosynthesis.
- Sulphur dioxide causes chlorosis, plasmolysis, membrane damage and metabolic inhibition.
- Hydrocarbons such as ethylene cause premature leaf fall, fruit drop, shedding of floral buds, curling of petals and discoloration of sepals.
- Ozone damage chlorenchyma and thus destructs the foliage in large number of plants.

III. Effects on Animals

IV. Detoriation of materials

V. Aesthetic Loss

5.2.6. Control Measures

1. Policy measures
2. Preventive measures:

- Selection of suitable fuel (e.g.fuel with low sulphur content) and its efficient utilization
- Modifications in industrial processes and/or equipments to reduce emission.
- Selection of suitable manufacturing site and zoning. e.g. setting of industries at a distance of residential areas, installation of tall chimneys.

Control measures:

(i) destroying the pollutants by thermal or catalytic combustion

(ii) conversion of the pollutants to a less toxic form

(iii) collection of the pollutant

- Different types of air pollutants can be eliminated / minimised by following methods:

a) Control of particulate matter: Two types of devices - arresters and scrubbers are used to remove particulate pollutants from air. These are arresters and scrubbers.

i. Arresters: These are used to separate particulate matters from contaminated air.

ii. Scrubbers: These are used to clean air for both dusts and gases by passing it through a dry or wet packing material.

b) Control of Gaseous Pollutants:

The gaseous pollutants can be controlled through the techniques of Combustion, absorption and adsorption.

c) Control of Automobile Exhaust

i. use of efficient engines (e.g. multipoint fuel injection engine).

ii. Catalytic converter filters in the vehicles can convert nitrogen oxide to nitrogen and reduce the potential hazards of NOx.

iii. use of good quality automobile fuels

iv. use of lead free petrol.

v. Use of compressed natural gas (CNG).

5.2.7. Government Initiatives

(1) National Air Quality Monitoring Programme

- In India, the Central Pollution Control Board (CPCB) has been executing a nationwide programme of ambient air quality monitoring known as National Air Quality Monitoring Programme (NAMP).
- The National Air Quality Monitoring Programme (NAMP) is undertaken in India
  - (i) to determine status and trends of ambient air quality;
  - (ii) to ascertain the compliance of NAAQS;
  - (iii) to identify non-attainment cities;
  - (iv) to understand the natural process of cleaning in the atmosphere; and
  - (v) to undertake preventive and corrective measures.
- Annual average concentration of SOx levels are within the prescribed National Ambient Air Quality Standards (NAAQS).
- This reduction from earlier levels is due to various measures taken, including the use of CNG in public transport in Delhi, the reduction of sulphur in diesel and use of LPG instead of coal as a domestic fuel.
- A mixed trend is observed in NO2 levels due to various measures taken for vehicular pollution control, such as stricter vehicular emission norms being partially offset by increased NOx levels due to the use of CNG in urban transport.
- Total suspended particulates, however, are still a matter of concern in several urban and semi urban areas.

(b) National Ambient Air Quality Standards (NAAQS)

- National Ambient Air Quality Standards (NAAQS) were notified in the year 1982, duly revised in 1994 based on health criteria and land uses.
- The NAAQS have been revisited and revised in November 2009 for 12 pollutants, which include

1. sulphur dioxide (SO2),
2. nitrogen dioxide (NO2),
3. particulate matter having size less than 10 micron (PM10),
4. particulate matter having size less than 2.5 micron (PM2.5),
5. ozone,
6. lead,
7. carbon monoxide (CO),
8. arsenic,
9. nickel,
10. benzene,
11. ammonia, and
12. benzopyrene.

5.3. WATER POLLUTION

- 'Addition of certain substances to the water such as organic, inorganic, biological, radiological, heat, which degrades the quality of water so that it becomes unfit for use'. Water pollution is not only confined to surface water, but it has also spread to ground water, sea and ocean.

5.3.1. Sources

Types of sources

1. Point Sources

- It is directly attributable to one influence. Here pollutant travels directly from source to water. Point sources are easy to regulate.

2. Diffuse or non-point source.

- It is from various ill defined and diffuse sources. They vary spatially and temporally and are difficult to regulate.
- The main sources of water pollution are as follows:

1) Community waste water: include discharges from houses, commercial and industrial establishments connected to public sewerage system. The sewage contains human and animal excreta, food residues, cleaning agents, detergents and other wastes.

> Putrescibility is the process of decomposition of organic matter present in water by microorganisms using oxygen.

2) Industrial Wastes: The industries discharge several inorganic and organic pollutants, which may prove highly toxic to the living beings.

Type of Industry	Inorganic pollutants	Organic pollutant
Mining	Mine Wastes: Chlorides, various metals, ferrous sulphate, sulphuric acid, hydrogen sulphide, ferric hydroxide, surface wash offs, suspended solids, chlorides and heavy metals.	
Iron and Steel	Suspended solids, iron cyanide, thiocyanate, sulphides, oxides of copper, chromium, cadmium, and mercury.	Oil, phenol and neptha
Chemical Plants	Various acids and alkalies, chlorides, sulphates, nitrates of metals, phosphorus, fluorine, silica and suspended particles.	Aromatic compounds solvents, organic acids, nitro compound dyes, etc.
Pharmaceutical	-	Proteins, carbohydrates, organic solvent intermediate products, drugs and antibiotics
Soap and Detergent	Tertiary ammonium compounds alkalies	Flats and fatty acids, glycerol, polyphosphates, sulphonated hydrocarbons.
Food processing	-	Highly putrescible organic matter and pathogens
Paper and Pulp	Sulphides, bleaching liquors.	Cellulose fibres, bark, woods sugars organic acids.

3) Agricultural sources:

- Fertilizers contain major plant nutrients such as nitrogen, phosphorus and potassium.
- Excess fertilizers may reach the ground water by leaching or may be mixed with surface water of rivers, lakes and ponds by runoff and drainage.
- Pesticides include insecticides, fungicides, herbicides, nematicides, rodenticides and soil fumigants.
- They contain a wide range of chemicals such as chlorinated hydrocarbons, organophosphates, metallic salts, carbonates, thiocarbonates, derivatives of acetic acid etc. Many of the pesticides are non-degradable and their residues have long life.
- The animal excreta such as dung, wastes from poultry farms, piggeries and slaughter houses etc. reach the water though run off and surface leaching during rainy season.

4) Thermal Pollution:

- The main sources are the thermal and nuclear power plants. The power plants use water as coolant and release hot waters to the original source. Sudden rise in temperature kills fishes and other aquatic animals.

5) Underground water pollution:

- In India at many places, the ground water is threatened with contamination due to seepage from industrial and municipal wastes and effluents, sewage channels and agricultural runoff.

6) Marine pollution:

- Oceans are the ultimate sink of all natural and manmade pollutants. Rivers discharge their pollutants into the sea. The sewerage and garbage of coastal cities are also dumped into the sea. The other sources of oceanic pollution are navigational discharge of oil, grease, detergents, sewage, garbage and radioactive wastes, off shore oil mining, oil spills.

Oil Spills

- Oil spills is one of the most dangerous of all water pollutants.
- Oil spills from tankers at sea or leaks from underground storage tanks on land are very difficult to control as oil tends to spread very fast, affecting a large area in a very short time.
- On land crude is transported through pipelines or tankers which can get damaged and spew out crude oil over the land, thereby contaminating it.
- Since crude oil is lighter than water, it floats on the surface and poses the threat of swift-spreading fire.
- Oil spills at sea decrease the oxygen level in the water and cause harm to the organisms.
- Oil spills are also a source of air and groundwater pollution.

5.3.2. Effects of Water Pollution

1. Effects on aquatic ecosystem:

i) Polluted water reduces Dissolved Oxygen (DO) content, thereby, eliminates sensitive organisms like plankton, molluscs and fish etc.

However a few tolerant species like Tubifex (annelid worm) and some insect larvae may survive in highly polluted water with low DO content. Such species are recognised as indicator species for polluted water.

ii) Biocides, polychlorinated biphenyls (PCBs) and heavy metals directly eliminate sensitive aquatic organisms.

iii) Hot waters discharged from industries, when added to water bodies, lowers its DO content.

Do you know?

The Environmental Performance Index, is conducted and written by environmental research centers at Yale and Columbia universities with assistance from outside scientists.

Different parts of the tree grow at different times of the year. A typical pattern is for most of the foliage growth to occur in the spring, followed by trunk growth in the summer and root growth in the fall and winter. Not all the trees follow the same pattern.

DO , BOD, COD

- Presence of organic and inorganic wastes in water decreases the dissolved Oxygen (DO) content of the water. Water having DO content below 8.0 mg L-1 may be considered as contaminated. Water having DO content below. 4.0 mg L-1 is considered to be highly polluted. DO content of water is important for the survival of aquatic organisms. A number of factors like surface turbulence, photosynthetic activity, O2 consumption by organisms and decomposition of organic matter are the factors which determine the amount of DO present in water.
- The higher amounts of waste increases the rates of decomposition and O2 consumption, thereby decreases the DO content of water. The demand for O2 is directly related to increasing input of organic wastes and is empressed as biological oxygen demand (BOD) of water.
- Water pollution by organic wastes is measured in terms of Biochemical Oxygen Demand (BOD). BOD is the amount of dissolved oxygen needed by bacteria in decomposing the organic wastes present in water. It is expressed in milligrams of oxygen per litre of water.
- The higher value of BOD indicates low DO content of water. Since BOD is limited to biodegradable materials only. Therefore, it is not a reliable method of measuring pollution load in water.
- Chemical oxygen demand (COD) is a slightly better mode used to measure pollution load in water. It is the measure of oxygen equivalent of the requirement of oxidation of total organic matter (i.e. biodegradable and non-biodegradable) present in water.

2. Effects on human health:

- The polluted water usually contains pathogens like virus, bacteria, parasitic protozoa and worms, therefore, it is a source of water borne diseases like jaundice, cholera, typhoid, amoebiasis etc.
- Mercury compounds in waste water are converted by bacterial action into extremely toxic methyl mercury, which can cause numbness of limbs, lips and tongue, deafness, blurring of vision and mental derangement.

A cripling deformity called Minamata disease due to consumption of fish captured from mercury contaminated Minamata Bay in Japan was detected in 1952.

- Water contaminated with cadmium can cause itai itai disease also called ouch-ouch disease (a painful disease of bones and joints) and cancer of lungs and liver.
- The compounds of lead cause anaemia, headache, loss of muscle power and bluish line around the gum.

3. **Hazards of ground water pollution:**

i. Presence of excess nitrate in drinking water is dangerous for human health and may be fatal for infants.

- Excess nitrate in drinking water reacts with hemoglobin to form non-functional methaemoglobin, and impairs oxygen transport. This condition is called methaemoglobinemia or blue baby syndrome.

ii. Excess fluoride in drinking water causes neuro-muscular disorders, gastro-intestinal problems, teeth deformity, hardening of bones and stiff and painful joints (skeletal fluorosis).

- High concentration of fluoride ions is present in drinking water in 13 states of India. The maximum level of fluoride, which the human body can tolerate is 1.5 parts per million (mg/1 of water). Long term ingestion of fluoride ions causes fluorosis.

iii. Over exploitation of ground water may lead to leaching of arsenic from soil and rock sources and contaminate ground water. Chronic exposure to arsenic causes black foot disease. It also causes diarrhoea, peripheral neuritis, hyperkerotosis and also lung and skin cancer.

- Arsenic contamination is a serious problem (in tube well dug areas) in the Ganges Delta, west bengal causing serious arsenic poisoning to large numbers of people. A 2007 study found that over 137 million people in more than 70 countries are probably affected by arsenic poisoning of drinking water.

4. Biological Magnification
5. Eutrophicaiton

5.3.3. Control Measures

1) Riparian buffers
2) Treatment of sewage water and the industrial effluents should be done before releasing it into water bodies.
3) Hot water should be cooled before release from the power plants
4) Domestic cleaning in tanks, streams and rivers, which supply drinking water, should be prohibited.
5) Excessive use of fertilizers and pesticides should be avoided.
6) Organic farming and efficient use of animal residues as fertilizers.
7) Water hyacinth (an aquatic weed) can purify water by taking some toxic materials and a number of heavy metals from water.
8) Oil spills in water can be cleaned with the help of bregoli – a by-product of paper industry resembling saw dust, oil zapper, micro-organisms.

5.4. SOIL POLLUTION

- Soil is a thin layer of organic and inorganic materials that covers the Earth's rocky surface. Soil pollution is defined as the 'addition of substances to the soil, which adversely affect physical, chemical and biological properties of soil and reduces its productivity.'
- It is build-up of persistent toxic compounds, chemicals, salts, radioactive materials, or disease causing agents in soil which have adverse effects on plant growth, human and animal health.
- A soil pollutant is any factor which deteriorates the quality, texture and mineral content of the soil or which disturbs the biological balance of the organisms in the soil.

5.4.1. Causes

- Indiscriminate use of fertilizers, pesticides, insecticides and herbicides
- Dumping of large quantities of solid waste
- Deforestation and soil erosion.
- Pollution Due to Urbanisation

5.4.2. Source

i. Industrial Wastes:

- Industrial waste includes chemicals such as mercury, lead, copper, zinc, cadmium, cynides, thiocynates, chromates, acids, alkalies, organic substances etc.

ii. **Pesticides:**

➢ Pesticides are chemicals that include insecticides, fungicides, algicides, rodenticides, weedicides sprayed in order to improve productivity of agriculture, forestry and horticulture.

iii. **Fertilizers and manures:**

➢ Chemical fertilizers are added to the soil for increasing crop yield. Excessive use of chemical fertilizers reduces th e population of soil borne organism and the crumb structure of the soil, productivity of the soil and increases salt content of the soil.

iv. **Discarded materials:**

➢ It includes concrete, asphalt, rungs, leather, cans, plastics, glass, discarded food, paper and carcasses.

v. **Radioactive wastes:**

➢ Radioactive elements from mining and nuclear power plants, find their way into water and then into the soil.

vi. **Other pollutants:**

➢ Many air pollutants (acid rain) and water pollutants ultimately become part of the soil and the soil also receives some toxic chemicals during weathering of certain rocks. [in box]

5.4.3. Types of Soil Pollution

I. Agricultural Soil Pollution

II. Pollution due to industrial effluents and solid wastes

III. Pollution due to urban activities

5.4.4. Effects of soil pollution on

i) Agriculture
- Reduced soil fertility
- Reduced nitrogen fixation
- Increased erosion
- Loss of soil and nutrients
- Reduced crop yield
- Increased salinity
- Deposition of silt in tanks and reservoirs

ii) Health
- Dangerous chemicals entering underground water
- Bio magnification
- Release of pollutant gases
- Release of radioactive rays causing health problems

iii) Environment
- Reduced vegetation
- Ecological imbalance
- Imbalance in soil fauna and flora

iv) Urban areas
- Clogging of drains
- Inundation of areas
- Foul smell and release of gases
- Waste management problems

➢ Control measures
- Reducing chemical fertilizer and pesticide use
- Use of bio pesticides, bio fertilizers.
- Organic farming
- Four R's: Refuse, Reduce, Reuse, and Recycle
- Afforestation and Reforestation
- Solid waste treatment
- Reduction of waste from construction areas

FOUR R'S

1. Refuse

➢ Instead of buying new containers from the market, use the ones that are in the house. Refuse to buy new items though you may think they are prettier than the ones you already have.

2. Reuse

➢ Do not throw away the soft drink cans or the bottles; cover them with homemade paper or paint on them and use them as pencil stands or small vases.

3. Recycle

➢ Use shopping bags made of cloth or jute, which can be used over and over again. Segregate your waste to make sure that it is collected and taken for recycling.

4. Reduce

➢ Reduce the generation of unnecessary waste, e.g. carry your own shopping bag when you go to the market and put all your purchases directly into it.

5.5. NOISE POLLUTION

- Noise pollution is an unpleasant noise created by people or machines that can be annoying, distracting, intrusive, and/or physically painful.
- Noise pollution comes from sources such as "road traffic, jet planes, garbage trucks, construction equipment, manufacturing processes, leaf blowers, and boom boxes."
- Sound is measured in decibels (dB). An increase of about 10 dB is approximately double the increase in loudness.
- A person's hearing can be damaged if exposed to noise levels over 75 dB over a prolonged period of time. The World Health Organization recommends that the sound level indoors should be less than 30 dB.

5.5.1. Ambient Noise Level Monitoring

- Noise Pollution (Control and Regulation) Rules, 2000 define ambient noise levels for various areas as follows:

Category of Area/ Zone	Limits in dB(A) Leq	
	Day Time	Night Time
	6 a.m. to 10 p.m.	10 p.m to 6 a.m
A. Industrial Area	75	70
B. Commercial Area	65	55
C. Residential Area	55	45
D. Silence Zone	50	40

- The Government of India on Mar 2011 launched a Real time Ambient Noise Monitoring Network. Under this network, in phase- I, five Remote Noise Monitoring Terminals each have been installed in different noise zones in seven metros (Delhi, Hyderabad, Kolkata, Mumbai, Bangalore, Chennai and Lucknow).
- In Phase II another 35 monitoring stations will be installed in the same seven cities. Phase III will cover installing 90 stations in 18 other cities.
- Phase-III cities are Kanpur, Pune, Surat, Ahmedabad, Nagpur, Jaipur, Indore, Bhopal, Ludhiana, Guwahati, Dehradun, Thiruvananthpuram, Bhubaneswar, Patna, Gandhinagar, Ranchi, Amritsar and Raipur.
- Silence Zone is an area comprising not less than 100 metres around hospitals, educational institutions, courts, religious places or any other area declared as such by a competent authority.

5.5.2. Impacts of noise

- Annoyance: It creates annoyance to the receptors due to sound level fluctuations. The a-periodic sound due to its irregular occurrences causes displeasure to hearing and causes annoyance.
- Physiological effects: The physiological features like breathing amplitude, blood pressure, heart-beat rate, pulse rate, blood cholesterol are affected.
- Loss of hearing: Long exposure to high sound levels cause loss of hearing. This is mostly unnoticed, but has an adverse impact on hearing function.
- Human performance: The working performance of workers/human will be affected as it distracts the concentration.
- Nervous system: It causes pain, ringing in the ears, feeling of tiredness, thereby effecting the functioning of human system.
- Sleeplessness: It affects the sleeping there by inducing people to become restless and loose concentration and presence of mind during their activities
- Damage to material : The buildings and materials may get damaged by exposure to infrasonic / ultrasonic waves and even get collapsed.

5.5.3. Control

- The techniques employed for noise control can be broadly classified as

1. Control at source

- Reducing the noise levels from domestic sectors
- Maintenance of automobiles
- Control over vibration
- Prohibition on usage of loud speakers
- Selection and maintenance of machinery

2. Control in the transmission path

- Installation of barriers
- Design of building
- Green belt development (planting of trees)

3. Using protective equipment.

- Job rotation
- Reduced Exposure time
- Hearing protection

➢ Documentation of noise measurements, continuous monitoring and awareness are the need of the hour.

5.6. RADIO ACTIVE POLLUTION

5.6.1. Radioactive Pollution

➢ Radioactivity is a phenomenon of spontaneous emission of proton (a-particles), electrons (ß-particles) and gamma rays (short wave electromagnetic waves) due to disintegration of atomic nuclei of some elements. These cause radioactive pollution.

Radioactivity:

Radioactivity is a property of certain elements (radium, thorium, uranium etc.) to spontaneously emit protons (alpha particles) electrons (beta particles) and gamma rays (short-wave electromagnetic wave) by disintegration of their atomic nuclei (nuclides).

5.6.2. Types of Radiations

1. Non-ionising radiations affect only those components which absorb them and have low penetrability.
2. Ionising radiations have high penetration power and cause breakage of macro molecules.

5.6.3. Types of radiation particles

1. Alpha particles, can be blocked by a piece of paper and human skin.
2. Beta particles can penetrate through skin, while can be blocked by some pieces of glass and metal.
3. Gamma rays can penetrate easily to human skin and damage cells on its way through, reaching far, and can only be blocked by a very thick, strong, massive piece of concrete.

5.6.4. Sources

Natural

➢ They include cosmic rays from space and terrestrial radiations from radio-nuclides present in earth's crust such as radium-224, uranium-238, thorium-232, potassium-40, carbon-14, etc.

Man – made

➢ Nuclear power plants
➢ Nuclear weapon
➢ Transportation of nuclear material
➢ Disposal of nuclear waste
➢ Uranium mining
➢ Radiation therapy

Atomic explosion (Nuclear fallout):

➢ The nuclear arms use uranium-235 and plutonium-239 for fission and hydrogen or lithium as fusion material. Atomic explosions produce radioactive particles that are thrown high up into the air as huge clouds. These particles are carried to long distances by wind and gradually settle over the earth as fall out or are brought down by rain. The fall out contains radioactive substances such as strontium-90, cesium-137, iodine – 131, etc.

5.6.5. Effects

➢ The effects of radioactive pollutants depend upon

i. half-life
ii. energy releasing capacity
iii. rate of diffusion and
iv. rate of deposition of the pollutant.
v. Various environmental factors such as wind, temperature, rainfall also influence their effects.

Period of Radioactivity

➢ Each radioactive nuclide has a constant decay rate. Half-life is the time needed for half of its atoms to decay. Half-life of a radio nuclide refers to its period of radioactivity. The half-life may vary from a fraction of a second to thousands of years. The radio nuclides with long half-time are the chief source of environmental radioactive pollution.

➢ Radiations are of two types with regard to the mode of their action on cells.

1. Non-ionising radiations:

➢ They include short-wave radiations such as ultraviolet rays, which forms a part of solar radiation.
➢ They have low penetrating power and affect the cells and molecules which absorb them.
➢ They damage eyes which may be caused by reflections from coastal sand, snow (snow blindness) directly looking towards sun during eclipse.

- They injure the cells of skin and blood capillaries producing blisters and reddening called sunburns.

2. Ionising radiations.

- They include X-rays, cosmic rays and atomic radiations (radiations emitted by radioactive elements).
- Ionising radiations have high penetration power and cause breakage of macro molecules.
- The molecular damage may produce short range (immediate) or long range (delayed) effects.
  i. Short range effects include burns, impaired metabolism, dead tissues and death of the organisms.
  ii. Long range effects are mutations increased incidence of tumors and cancer, shortening of life-span and developmental changes.
  iii. The mutated gene can persist in living organisms and may affect their progeny.
- The actively dividing cells such as Embryo, foetus, cells of skin, intestinal lining, bone marrow and gamete forming cells are more sensitive to radiations.
- Some species of animals and plants preferentially accumulate specific radioactive materials. For example, oysters deposit 65Zn, fish accumulate 55Fe, marine animals selectively deposit 90Sr.

5.6.6. Control Measures

- Prevention is the best control measure as there is no cure available for radiation damage.
  i. All safety measures should be strictly enforced. Leakage of radioactive elements should be totally checked.
  ii. Safe disposal of radioactive waste.
  iii. Regular monitoring through frequent sampling and quantitative analysis.
  iv. Safety measures against nuclear accidents.
  v. Nuclear explosions and use of nuclear weapons should be completely banned.
  vi. Appropriate steps should be taken to protect from occupational exposure.

5.7. E – WASTE

- The discarded and end-of-life electronic products ranging from computers, equipment used in Information and Communication Technology (ICT), home appliances, audio and video products and all of their peripherals are popularly known as Electronic waste (E-waste).
- E-waste is not hazardous if it is stocked in safe storage or recycled by scientific methods or transported from one place to the other in parts or in totality in the formal sector. The e-waste can, however, be considered hazardous if recycled by primitive methods.

5.7.1. Source and its health effects

S.NO	PARTICULARS	SOURCE	HEALTH EFFECTS
1.	Lead	Used in glass panels and gaskets in computer monitors Solder in printed circuit boards and other Components	Lead causes damage to the central and peripheral nervous systems, blood systems, kidney and reproductive system in humans. It also effects the endocrine system, and impedes brain development among children. Lead tends to accumulate in the environment and has high acute and chronic effects on plants, animals and microorganisms.
2.	Cadmium	Occurs in SMD chip resistors, infra-red detectors, and semiconductor chips Some older cathode ray tubes contain cadmium	Toxic cadmium compounds accumulate in the human body, especially the kidneys.

Do you know?

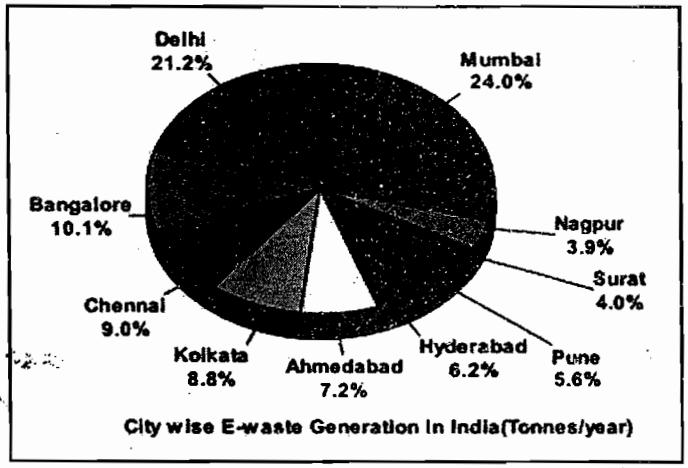
Diesel engine exhaust fumes can cause cancer in humans and it belong in the same potentially deadly category as asbestos, arsenic and mustard gas - World Health Organization (WHO) (June, 2012).

3.	Mercury	It is estimated that 22 % of the yearly world consumption of mercury is used in electrical and electronic equipment Mercury is used in thermostats, sensors, relays, switches, medical equipment, lamps, mobile phones and in batteries Mercury, used in flat panel displays, will likely increase as their use replaces cathode ray tubes	Mercury can cause damage to organs including the brain and kidneys, as well as the foetus. The developing foetus is highly vulnerable to mercury exposure. When inorganic mercury spreads out in the water, it is transformed to methylated mercury which bio-accumulates in living organisms and concentrates through the food chain, particularly via fish.
4.	Hexavalent Chromium/ Chromium VI 29	Chromium VI is used as corrosion protector of untreated and galvanized steel plates and as a decorative or hardener for steel housings Plastics (including PVC): Dioxin is released when PVC is burned. The largest volume of plastics (26%) used in electronics has been PVC. PVC elements are found in cabling and computer housings. Many computer moldings are now made with the somewhat more benign ABS plastics	Chromium VI can cause damage to DNA and is extremely toxic in the environment.
5.	Brominated flame retardants (BFRs):	BFRs are used in the plastic housings of electronic equipment and in circuit boards to prevent flammability	
6.	Barium	Barium is a soft silvery-white metal that is used in computers in the front panel of a CRT, to protect users from radiation	Studies have shown that short-term exposure to barium causes brain swelling, muscle weakness, damage to the heart, liver, and spleen.
7.	Beryllium	Beryllium is commonly found on motherboards and finger clips It is used as a copper-beryllium alloy to strengthen connectors and tinyplugs while maintaining electrical conductivity	Exposure to beryllium can cause lung cancer. Beryllium also causes a skin disease that is characterised by poor wound healing and wartlike bumps. Studies have shown that people can develop beryllium disease many years following the last exposure.

8.	Toners	Found in the plastic printer cartridge containing black and color toners.	Inhalation is the primary exposure pathway, and acute exposure may lead to respiratory tract irritation. Carbon black has been classified as a class 2B carcinogen, possibly carcinogenic to humans. Reports indicate that colour toners (cyan, magenta and yellow) contain heavy metals.
9.	Phosphor and additives	Phosphor is an inorganic chemical compound that is applied as a coat on the interior of the CRT faceplate.	The phosphor coating on cathode ray tubes contains heavy metals, such as cadmium, and other rare earth metals, for example, zinc, vanadium as additives. These metals and their compounds are very toxic. This is a serious hazard posed for those who dismantle CRTs by hand.

5.7.2. E – Waste in India

- Survey was carried out by the Central Pollution Control Board (CPCB) during 2005 estimated that 1.347 lakh MT of e-waste was generated in the country in the year 2005, which is expected to increase to about 8.0 lakh MT by 2012.
- In India, among top ten cities, Mumbai ranks first in generating e-waste followed by Delhi, Bangalore, Chennai, Kolkata, Ahmadabad, Hyderabad, Pune, Surat and Nagpur.

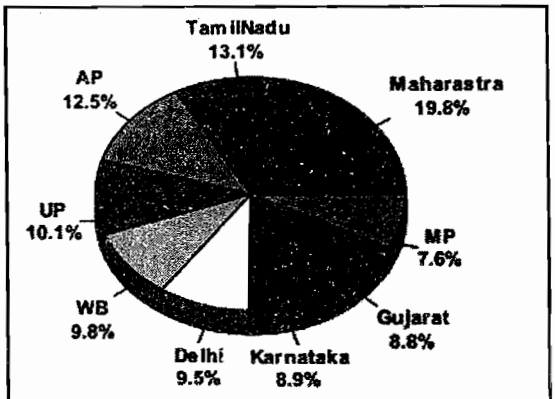


City wise E-waste Generation in India(Tonnes/year)

Do you know?

The sex of crocodilians is determined by the incubation conditions, particularly the temperature. Incubation at 30°C or less gives exclusively females, incubation at around 31°C gives both sexes, whereas incubation between 32°C and 33°C gives mostly males. Incubation at temperatures above 33°C gives males in some species, whereas in others, the sex reverts to females

- The 65 cities generate more than 60% of the total generated ewaste, whereas, 10 states generate 70% of the total e-waste.



State wise E-waste Generation in India (Tonnes/year)

- Most of the e-waste is recycled in India in unorganized units, which engage significant number of manpower. Recovery of metals by primitive means is a most hazardous act.
- The recycling process, if not carried out properly, can cause damage to human being through inhalation of gases during recycling, contact of the skin with hazardous substances and contact during acid treatment used in recovery process.
- Proper education, awareness and most importantly alternative cost effective technology need to be provided so that better means can be provided to those who earn the livelihood from this.
- A holistic approach is needed to address the challenges faced by India in e-waste management. A suitable mechanism needs to be evolved to include small units in unorganized sector and large units in organized sector into a single value chain.

5.8. SOLID WASTE

➢ Solid wastes are the discarded (abandoned or considered waste-like) materials. Solid waste means any garbage, refuse, sludge from a wastewater treatment plant, or air pollution control facility and other discarded materials including solid, liquid, semi-solid, or contained gaseous material, resulting from industrial, commercial, mining and agricultural operations, and from community activities. But it does not include solid or dissolved materials in domestic sewage, or solid or dissolved materials in irrigation return flows or industrial discharges.

5.8.1. Plastic Waste

➢ Plastics are considered to be one of the wonderful inventions of 20th Century. They are widely used as packing and carry bags because of cost and convenience. But plastics are now considered as environmental hazard due to the "Throw away culture".

5.8.2. Source of generation of waste plastics

- Household
- Health and medicare
- Hotel and catering
- Air/rail travel

5.8.3. Effects

➢ The land gets littered by plastic bag garbage and becomes ugly and unhygienic.

➢ Conventional plastics have been associated with reproductive problems in both humans and wildlife.

➢ Dioxin (highly carcinogenic and toxic) by-product of the manufacturing process is one of the chemicals believed to be passed on through breast milk to the nursing infant.

➢ Burning of plastics, especially PVC releases this dioxin and also furan into the atmosphere. Thus, conventional plastics, right from their manufacture to their disposal are a major problem to the environment.

➢ Plastic bags can also contaminate foodstuffs due to leaching of toxic dyes and transfer of pathogens.

➢ Careless disposal of plastic bags chokes drains, blocks the porosity of the soil and causes problems for groundwater recharge.

➢ Plastic disturbs the soil microbe activity. The terrestrial and aquatic animals misunderstand plastic garbage as food items, swallow them and die.

➢ Plastic bags deteriorates soil fertility as it forms part of manure and remains in the soil for years.

➢ These bags finding their way in to the city drainage system results in blockage causing inconvenience, difficult in maintenance, creates unhygienic environment resulting in health hazard and spreading of water borne diseases.

➢ Designing eco-friendly, biodegradable plastics are the need of the hour.

5.8.4. Types

➢ Solid wastes are classified depending on their source:

a) Municipal waste,

b) Hazardous waste and

c) Biomedical waste or hospital waste.

a) Municipal solid waste

➢ Municipal solid waste consists of household waste, construction and demolition debris, sanitation residue, and waste from streets.

➢ With rising urbanization and change in lifestyle and food habits, the amount of municipal solid waste has been increasing rapidly and its composition changing.

➢ In 1947 cities and towns in India generated an estimated 6 million tonnes of solid waste, in 1997 it was about 48 million tonnes. More than 25% of the municipal solid waste is not collected at all.

➢ 70% of the Indian cities lack adequate capacity to transport it and there are no sanitary landfills to dispose of the waste. The existing landfills are neither well equipped and are not lined properly to protect against contamination of soil and groundwater.

➢ Over the last few years, the consumer market has grown rapidly leading to products being packed in cans, aluminium foils, plastics, and other such nonbiodegradable items that cause incalculable harm to the environment.

b) Hazardous waste

➢ Industrial and hospital waste is considered hazardous as they contain toxic substances. Hazardous wastes could be highly toxic to

humans, animals, and plants and are corrosive, highly inflammable, or explosive.

- India generates around 7 million tonnes of hazardous wastes every year, most of which is concentrated in four states: Andhra Pradesh, Bihar, Uttar Pradesh, and Tamil Nadu.
- Household waste that can be categorized as hazardous waste include old batteries, shoe polish, paint tins, old medicines, and medicine bottles.
- In the industrial sector, the major generators of hazardous waste are the metal, chemical, paper, pesticide, dye, refining, and rubber goods industries.
- Direct exposure to chemicals in hazardous waste such as mercury and cyanide can be fatal.

c. Hospital waste

- Hospital waste is generated during the diagnosis, treatment, or immunization of human beings or animals or in research activities or in the production or testing of biologicals.
- These chemicals include formaldehyde and phenols, which are used as disinfectants, and mercury, which is used in thermometers or equipment that measure blood pressure.
- It may include wastes like soiled waste, disposables, anatomical waste, cultures, discarded medicines, chemical wastes, disposable syringes, swabs, bandages, body fluids, human excreta, etc.
- These are highly infectious and can be a serious threat to human health if not managed in a scientific and discriminate manner.
- Surveys carried out by various agencies show that the health care establishments in India are not giving due attention to their waste management.
- After the notification of the Bio-medical Waste (Handling and Management) Rules, 1998, these establishments are slowly streamlining the process of waste segregation, collection, treatment, and disposal.

5.7.5. Treatment and disposal of solid waste

i) Open dumps

- Open dumps refer to uncovered areas that are used to dump solid waste of all kinds. The waste is untreated, uncovered, and not segregated. It is the breeding ground for flies, rats, and other insects that spread disease. The rainwater run-off from these dumps contaminates nearby land and water thereby spreading disease. Treatment by open dumps is to be phased out.

ii) Landfills

- Landfills are generally located in urban areas. It is a pit that is dug in the ground. The garbage is dumped and the pit is covered with soil everyday thus preventing the breeding of flies and rats. Thus, every day, garbage is dumped and sealed. After the landfill is full, the area is covered with a thick layer of mud and the site can thereafter be developed as a parking lot or a park.
- Problems - All types of waste are dumped in landfills and when water seeps through them it gets contaminated and in turn pollutes the surrounding area. This contamination of groundwater and soil through landfills is known as leaching.

iii) Sanitary landfills

- Sanitary landfill is more hygienic and built in a methodical manner to solve the problem of leaching. These are lined with materials that are impermeable such as plastics and clay, and are also built over impermeable soil. Constructing sanitary landfills is very costly

iv) Incineration plants

- The process of burning waste in large furnaces at high temperature is known as incineration. In these plants the recyclable material is segregated and the rest of the material is burnt and ash is produced.
- Burning garbage is not a clean process as it produces tonnes of toxic ash and pollutes the air and water. A large amount of the waste that is burnt here can be recovered and recycled. In fact, at present, incineration is kept as the last resort and is used mainly for treating the infectious waste.

v) Pyrolysis

- It is a process of combustion in absence of oxygen or the material burnt under controlled atmosphere of oxygen. It is an alternative to incineration. The gas and liquid thus obtained can be used as fuels. Pyrolysis of carbonaceous wastes like firewood, coconut, palm waste, corn combs, cashew shell, rice husk paddy straw and saw dust, yields charcoal along with products like tar, methyl alcohol, acetic acid, acetone and a fuel gas.

vi) Composting

- Composting is a biological process in which micro-organisms, mainly fungi and bacteria, decompose degradable organic waste into humus like substance in the presence of oxygen.
- This finished product, which looks like soil, is high in carbon and nitrogen and is an excellent medium for growing plants.
- It increases the soil's ability to hold water and makes the soil easier to cultivate. It helps the soil retain more plant nutrients.
- It recycles the nutrients and returns them back to soil as nutrients.
- Apart from being clean, cheap, and safe, composting can significantly reduce the amount of disposable garbage.

vii) Vermiculture

- It is also known as earthworm farming. In this method, Earth worms are added to the compost. These worms break the waste and the added excreta of the worms makes the compost very rich in nutrients.

viii) Four R's

5.7.6. Waste Minimization Circles (WMC)

WMC helps Small and Medium Industrial Clusters in waste minimization in their industrial plants.

- This is assisted by the World Bank with the Ministry of Environment and Forests acting as the nodal ministry. The project is being implemented with the assistance of National Productivity Council (NPC), New Delhi.
- The initiative also aims to realize the objectives of the Policy Statement for Abatement of Pollution (1992), which states that the government should educate citizens about environmental risks, the economic and health dangers of resource degradation and the real economic cost of natural resources.
- The policy also recognizes that citizens and non-governmental organizations play a role in environmental monitoring, therefore, enabling them to supplement the regulatory system and recognizing their expertise where such exists and where their commitments and vigilance would be cost effective.

5.8. BIOREMEDIATION

- Bioremediation is the use of microorganisms (bacteria and fungi) to degrade the environmental contaminants into less toxic forms.
- The microorganisms may be indigenous to a contaminated area or they may be isolated from elsewhere and brought to the contaminated site.

The process of bioremediation can be monitored indirectly by measuring the Oxidation Reduction Potential or redox in soil and groundwater, together with pH, temperature, oxygen content, electron acceptor/donor concentrations, and concentration of breakdown products (e.g. carbon dioxide)

5.8.1. Bioremediation Strategies

(a) In situ bioremediation techniques

- It involves treatment of the contaminated material at the site.
  - Bioventing – supply of air and nutrients through wells to contaminated soil to stimulate the growth of indigenous bacteria. It is used for simple hydrocarbons and can be used where the contamination is deep under the surface.
  - Biosparging - Injection of air under pressure below the water table to increase groundwater oxygen concentrations and enhance the rate of biological degradation of contaminants by naturally occurring bacteria
  - Bioaugmentation - Microorganisms are imported to a contaminated site to enhance degradation process.

Do you know?

The jaws of the snakes are not fused together. That means that unlike our jaws, snakes jaws are not hooked up at the back of their mouths. This makes it possible for them to eat very big meals, bigger than their own heads!

(b) Ex situ bioremediation techniques

- Ex situ -involves the removal of the contaminated material to be treated elsewhere.
  - Landfarming - contaminated soil is excavated and spread over a prepared bed and periodically tilled [] until pollutants are degraded.The goal is to

stimulate indigenous biodegradative microorganisms and facilitate their aerobic degradation of contaminants.

- Biopiles - it is a hybrid of landfarming and composting. Essentially, engineered cells are constructed as aerated composted piles. Typically used for treatment of surface contamination with petroleum hydrocarbons.
- Bioreactors – it involves the processing of contaminated solid material (soil, sediment, sludge) or water through an engineered containment system.
- Composting – dealt earlier in solid waste management

Using bioremediation techniques, TERI has developed a mixture of bacteria called 'oilzapper' which degrades the pollutants of oil-contaminated sites, leaving behind no harmful residues. This technique is not only environment friendly, but also highly cost-effective.

5.8.2. Genetic engineering approaches

Phytoremediation

- Phytoremediation is use of plants to remove contaminants from soil and water .

Types

- Phytoextraction / phytoaccumulation is the process by which plants accumulate contaminants into the roots and aboveground shoots or leaves.
- Phytotransformation or phytodegradation refers to the uptake of organic contaminants from soil, sediments, or water and their transformation to more stable, less toxic, less mobile form.
- Phytostabilization is a technique in which plants reduce the mobility and migration of contaminated soil. Leachable constituents are adsorbed and bound into the plant structure so that they form unstable mass of plant from which the contaminants will not re-enter the environment.
- Phytodegradation or rhizodegradation is the breakdown of contaminants through the activity existing in the rhizosphere. This activity is due to the presence of proteins and enzymes produced by the plants or by soil organisms such as bacteria, yeast, and fungi.
- Rhizofiltration is a water remediation technique that involves the uptake of contaminants by plant roots. Rhizofiltration is used to reduce contamination in natural wetlands and estuary areas.

The bacterium Deinococcus radiodurans has been used to de toxify toluene and ionic mercury which are released from radioactive nuclear waste.

Mycoremediation

- is a form of bioremediation in which fungi are used to decontaminate the area.

Mycofiltration

- is a similar process, using fungal mycelia to filter toxic waste and microorganisms from water in soil.

Advantages of bioremediation

- Useful for the complete destruction of a wide variety of contaminants.
- The complete destruction of target pollutants is possible.
- Less expensive.
- Environment friendly

Disadvantages of bioremediation

- Bioremediation is limited to those compounds that are biodegradable. Not all compounds are susceptible to rapid and complete degradation.
- Biological processes are often highly specific.
- It is difficult to extrapolate from bench and pilot-scale studies to full-scale field operations.
- Bioremediation often takes longer time than other treatment process.

Do you know?

Rattlesnakes are easily recognized by their rattle. The rattlesnake babies are born with what is called a pre-button. The baby snake loses this piece when it sheds its skin for the first time. With the shedding a new button appears. With every shedding after that another button, or rattle, will be added. These buttons are made up of a material called Keratin. The rattles are empty. The noise comes from each segment knocking together, so until a rattlesnake has two or more pieces it isn't going to make a sound! But when it does...you WILL hear it...and you WILL RUN!