Environmental Science

Unit –III Water and Soil Pollution

(Water Pollution: Pollutants in water, adverse effects. Treatment of Domestic & Industrial water effluent.
Soil Pollution – Soil Profile, Pollutants in soil, their adverse effects, controlling measures.)

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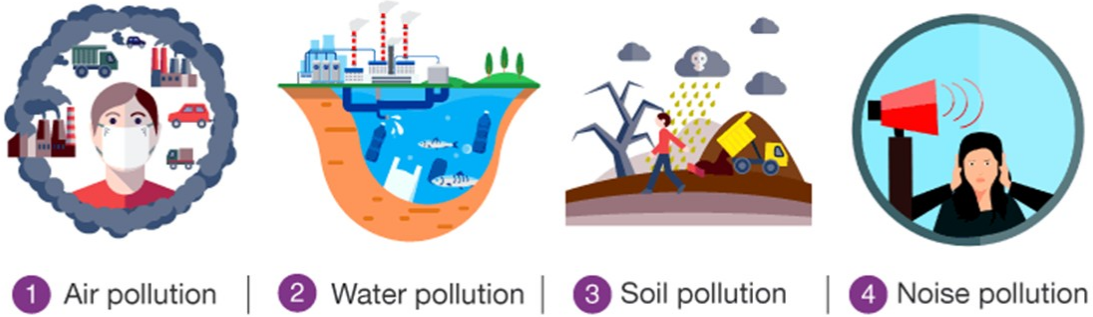
Environmental Issues



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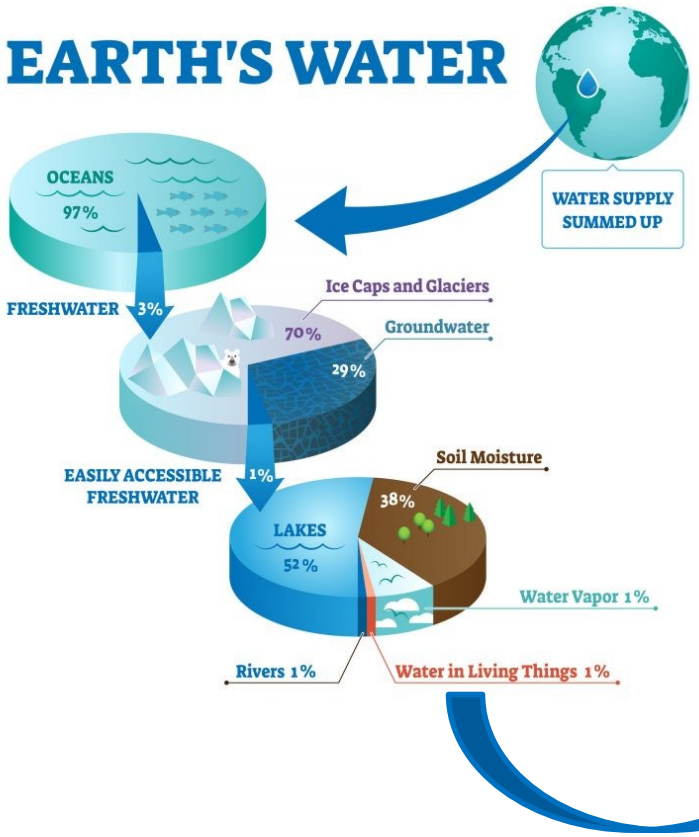
Water Pollution – Water Pollutants Categories



Contamination of water bodies is termed as water pollution

Causes of Water Pollution

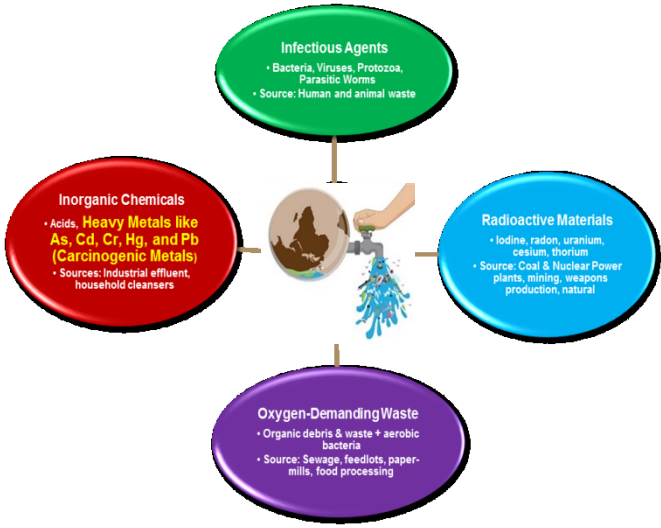
- **Marine dumping-** Water pollution occurs when harmful substances—often chemicals or microorganisms—contaminate a stream, river, lake, ocean, aquifer, or other body of water, degrading water quality and rendering it toxic to humans or the environment.
- **Sewage and Wastewater-** Domestic household, and agricultural practices release waste into water bodies.
- **Industrial waste-** like heavy metals, Pb, Hg, nitrates, oil, etc.
- **Radioactive waste-** mining and refining of Uranium, effluents released from nuclear power plants, etc.
- **Pharmaceutical substances such as antibiotics-** Medical industries

It occurs when pollutants (particles , chemicals or substances that make water contaminated) are discharged directly or indirectly into water bodies.

Types of Water Pollutants – Major Categories

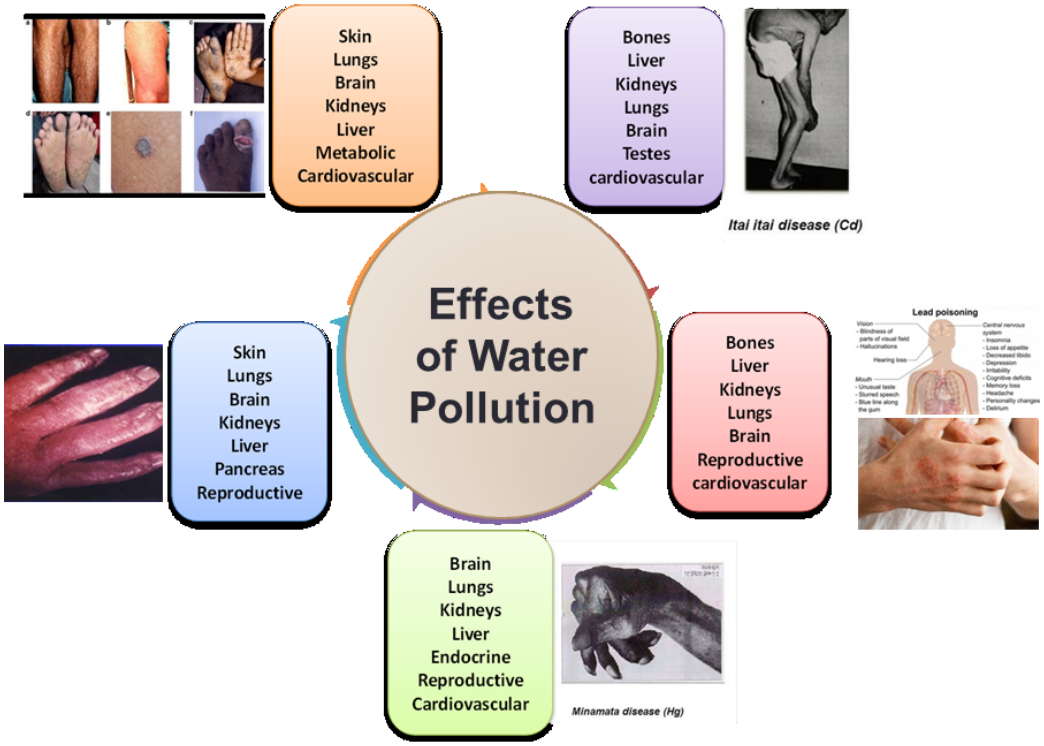
- Water pollutants can be divided into major categories:
  - **Infectious Agents-** Substances that harm humans or animals by causing disease or physical damage. Examples: Bacteria, Viruses, Protozoa, Parasitic Worms
  - **Oxygen-Demanding Waste-** Substances or situations that decrease the oxygen content of water, leading to anaerobic decay and the death of aquatic life. Examples: Organic debris & waste + aerobic bacteria
  - **Inorganic Chemicals-** Surface runoff, Industrial effluent, household cleansers. Examples: Acids, Metals, Salts
  - **Radioactive Materials-**Coal & Nuclear Power plants, mining, weapons production, natural. Examples: Iodine, radon, uranium, cesium, thorium
  - **Plant Nutrients-** Sewage, manure, agricultural and landscaping runoff. Examples: Nitrates, Phosphates,
  - **Organic Chemicals-** Industrial effluent, Household cleansers, runoff from farms and yards. Examples: Oil, Gasoline, Plastics, Pesticides, Solvents, detergents
  - **Eroded Sediment-** Examples: Soil, Silt
  - **Heat/Thermal Pollution**. Examples: Power plants, Industrial

Major Categories of Water Pollutants



Effect of Water Pollution

- Increased risk of respiratory illness and cardiovascular problems.
- Increased risk of skin diseases.
- May increase the risk of cancer.
- Hazards to wildlife.
- Destruction of biodiversity etc.



Government Steps to Prevent and Reduce Water Pollution

- Preparation of action plan for ***sewage management and restoration of water quality in aquatic resources*** by State Governments;
- ***Installation of Online Effluent Monitoring System*** to check the discharge of effluent directly into the rivers and water bodies;
- ***Setting up of monitoring network*** for assessment of water quality;
- ***Action to comply with effluent standards*** is taken by SPCBs to improve the water quality of the rivers;
- Financial assistance for ***installation of Common Effluent Treatment Plants*** for cluster of Small Scale Industrial units;
- Issuance of directions for implementation of ***Zero Liquid Discharge***;
- Issuance of directions under Section 5 of Environment (Protection) Act, 1986 to industries and under Section 18(1)(b) of Water (Prevention and Control of Pollution) Act, 1974;

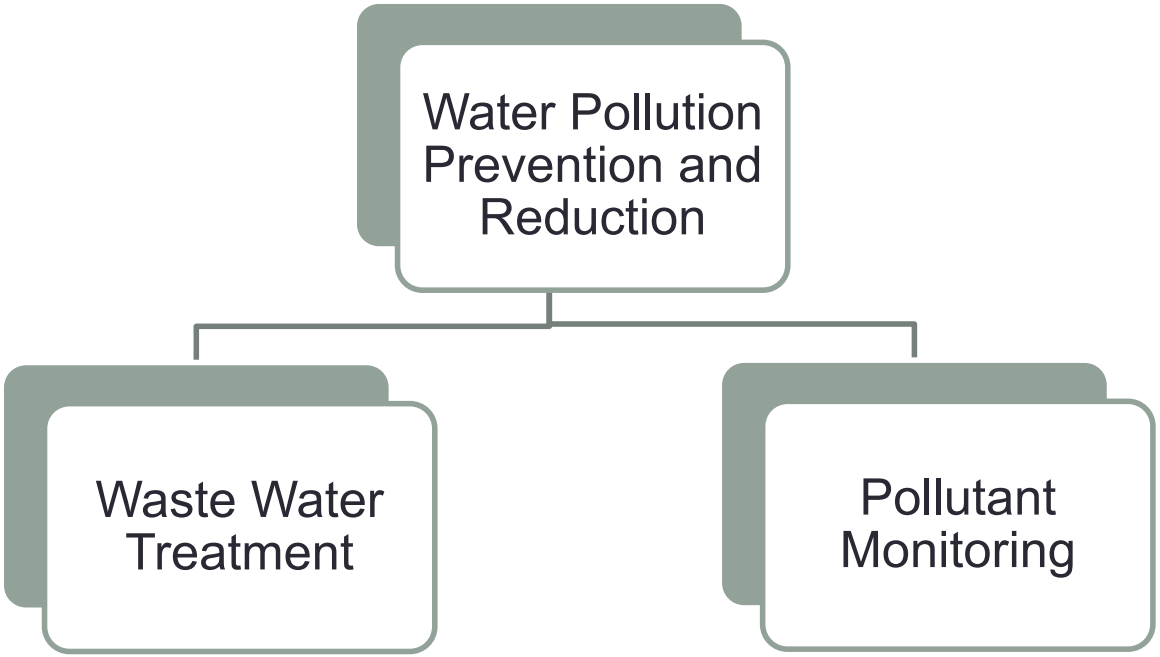
Government Steps to Prevent and Reduce Water Pollution…

- ***The National Water Policy (2012)*** Promotes rain water harvesting and conservation of water
- ***Mass awareness programmes***
- Implementation of ***National Plan for Conservation of Aquatic Eco-systems (NPCA)*** to undertake various conservation activities including interception, diversion and treatment of waste water, pollution abatement, lake beautification, biodiversity conservation, education and awareness creation, community participation etc.
- ***Mission Water Conservation*** includes water conservation and management, water harvesting, soil and moisture conservation, groundwater recharge, flood protection, land development, Command Area Development & Watershed Management

Government Acts to Prevent and Reduce Water Pollution contd..

Acts	Thrust Areas
Water Prevention and Control of Pollution Act, 1974-	Maintenance of the water bodies and restoration of water
The Shore Nuisance Bombay and Kolaba Act	Facilitate the removal of nuisances below the high water mark in the islands Bombay and Kolaba
The Water Prevention and Control of Pollution Cess Act, 2003	Regulate the disposal of waste and effluents into the river by the factories and enable maintenance of the streams and water bodies
The Indian Penal Code and Pollution	Industries include any operation or process or sewage or disposal treatment or any industrial effluent Pay cess if consume water above the specified limit
The River Boards Act, 1956	Punishment to be given to the person who commits an offence of fouling of a public reservoir

Management of Fresh Water Resources



Wastewater Treatment

Wastewater treatment is the process of removing impurities from wastewater and converting it into effluent that may be recycled into the water cycle. When returned to the water cycle, the effluent either has an acceptable environmental impact or is used for a variety of applications (called water reclamation).

Management of Water Resources - Through Treatment

Physical & Mechanical Methods

- **Screening**- wooden pieces, metal pieces, paper, rags, pebbles, fibres etc.
- **Sedimentation**- settle down the solid particles
- **Aeration-** reduces the concentration of volatile organic compounds
- **Filteration**- Water filtration is the process of removing or reducing the concentration of particulate matter, including suspended particles, parasites, bacteria, algae, viruses, and fungi, as well as other undesirable chemical and biological contaminants from contaminated water.
- **Flotation**- Flotation pay is used in place of sedimentation, to remove oil fibers or contaminants having density comparable to water.
- **Degasification**-removal of dissolved gases from liquids.
- **Equalization**- for varying pH and varying quantity of suspended solids, dissolved solids etc.

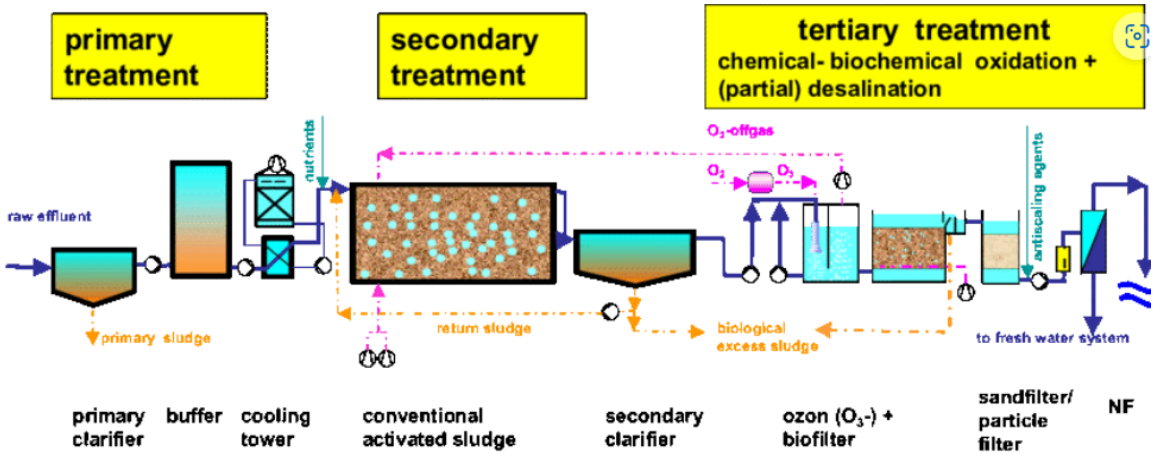
Chemical Methods

- **Chlorination-** kills germs and other bacteria.
- **Ozonation-** Ozone is considered more effective over chlorination and many other forms of disinfection because it can react with a wider range of viruses, bacteria, and protozoans
- **Neutralization-** pH should be neutralized using acid or alkali
- **Coagulation-** to remove suspended particles of size 0.0001mm.
- **Adsorption** – adhesion of atom , molecules on the surface of adsorbent.
- **Ion exchange**-Ion Exchange is a reversible chemical water treatment process for selective removal of charged inorganic species from water using an ion-specific resin and replacing them with other similarly charged ions.

Biological Methods

- **Trickling filter-** it is a mixture of various organisms which is responsible for the oxidation of organic matter present in the effluent.
- **Anaerobic digestion-**This treatment is in fact slow oxidative digestion process carried out in absence of air a closed container where ammonia and methane are released as the end products of the reaction.
- **Oxidation ditch-** It is a treatment generally carried out to reduce Biological Oxygen Demand to 85 to 95%.
- **Aerated lagoon-** These are big cement tanks having a depth of 4-6 metres. These tanks or lagoons are used for the oxidation of dissolved organics.
- **Activated sludge process**-It is an important biological oxidation method for the removal of suspended and colloidal solids and also reduces BOD of the effluent.
- **Oxidation pond-** It is a pond where oxidation takes place with the help of bacteria.

Various stages of Waste Water Treatment



- **Pre- Treatment-** It is done prior to discharge from industries or factories. Avoid discharge of chemicals and nutrients in surplus amount.
- **Preliminary Treatment-** it is done to remove large objects/ debris and non-biodegradable objects. Includes bar screen, mesh screen, grit chambers.
- **Primary Treatment-** It is a physical process that is done to remove any suspended sand particles from wastewater. The velocity of the water is reduced so that suspended particles settle down due to gravity force. The settled materials are called biosolids or sludge.

Various stages of Waste Water Treatment

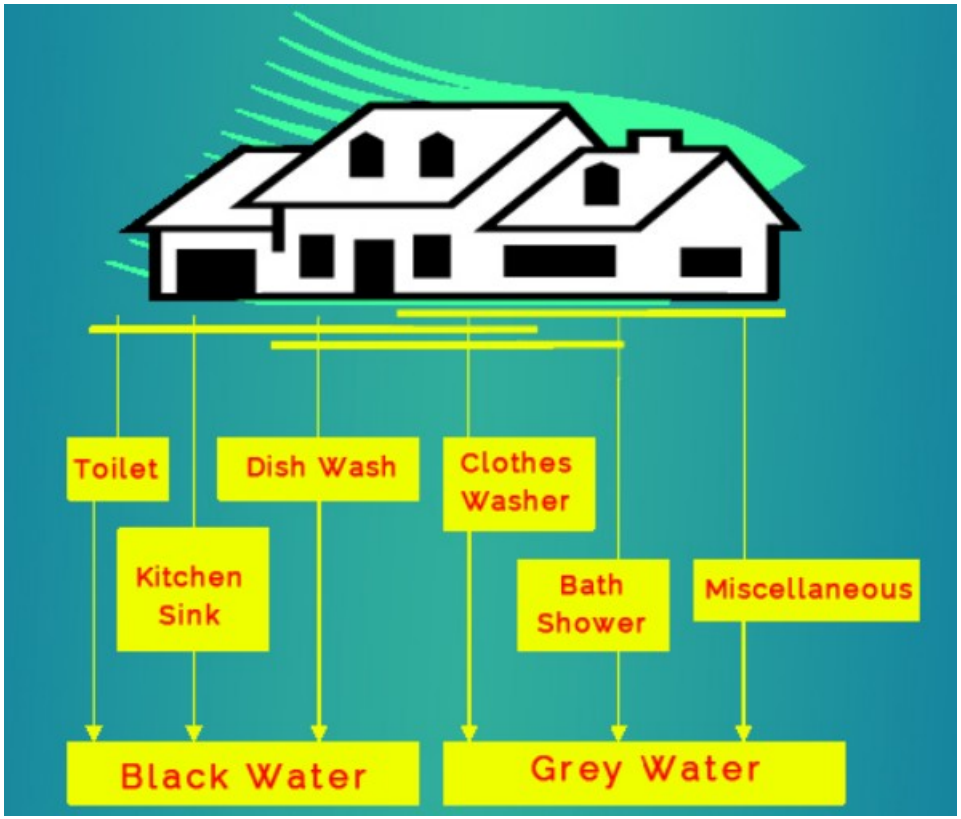
- Secondary Treatment- It is biological process that makes use of microbes/bacteria and algae to absorb the organic matter and convert into CO_2, water, energy for their own growth.

- Tertiary Treatment or Disinfection-it uses chlorine and chloramines and UV rays for disinfecting the wastewater.

- Sludge Disposal- the final stage is to remove sludge and its by-product is utilized for agricultural processes.

Treatment of Domestic water effluent

- Wastewater derived from human activities in households such as bath, laundry, dishwashing, garbage disposal, toilets, etc is called as Domestic Wastewater.
- Contains relatively small amounts of contaminants like disease-causing bacteria, infectious viruses, household chemicals, and excess nutrients such as nitrate.
- Hence, a properly installed and maintained residential sewage treatment system for treating and disposing of household wastewater will minimize the impact on ground water and surface water.



Treatment of Domestic water effluent

- Domestic waste consists of two main fluxes: one is grey water which is from kitchen sinks, wash basins, laundry washing, showers, baths etc., and second one is black water which is from toilets and urinals. Household sewage treatment plant breaks down domestic wastes via three major stages:
  - Primary treatment
  - Secondary treatment
  - Tertiary treatment

Treatment of Industrial water effluent

- Primary Treatment of Industrial Effluents: It is of general nature and is used for removing suspended solids, odour, colour and to neutralize the high or low pH. It involves methods of:
  - **Screening**-It is a process through which large materials like wooden pieces, metal pieces, paper, rags, pebbles, fibres etc. are removed using rotary and circulation filters.
  - **Neutralization**- pH should be neutralized using acid or alkali.
  - **Equalization**-When effluent is discharged from the factory then its pH along with the quantity of suspended solids, dissolved solids etc. varies from the beginning to the last depending upon the dilution, velocity, and the amount of reactants etc. Hence as the character of the effluent does not remain the same throughout hence proper treatment is not possible. So equalization tank is necessary where effluent is kept for 10 hrs or more for the stabilization of pH and BOD.
  - **Sedimentation**- This technique is only used in the beginning to settle down the solid particles in a high suspension effluent.
  - **Coagulation-** water contains colloidal impurities which are even finer than 0.0001 mm and which also carry electrical charge on them. Due to electrical charges they remain in motion and never settle down. Therefore when water is turbid due to presence of such fine size and colloidal impurities, plain sedimentation is of no use. The coagulation becomes necessary when the turbidity is more than 40 — 55 ppm. For dealing waters with such impurities a chemical process was evolved. This process removes all these impurities within reasonable period of 3 — 4 hours. This chemical process is called coagulation and the chemical used in the process is called coagulant. Sodium aluminate, Sodium aluminate + Aluminium sulphate, Aluminium sulphate, etc

Treatment of Industrial water effluent

- Secondary Treatment of Industrial Effluents: It involves biological treatments as: biological treatments are given below:
  - **Trickling filter-** A trickling filter, also known as percolating filter or sprinkling filter, is an artificial bed of stone or broken brick material over which waste water or sewage is allowed to sprinkle or to trickle. It is then collected through the under drainage system. A zoolial film is formed on the filter media and oxidation of organic matter takes place under aerobic conditions. it is a mixture of various organisms which is responsible for the oxidation of organic matter present in the effluent.
  - **Anaerobic digestion**-This treatment is in fact slow oxidative digestion process carried out in absence of air a closed container where ammonia and methane are released as the end products of the reaction.
  - **Oxidation ditch-** It is a treatment generally carried out to reduce Biological Oxygen Demand to 85 to 95%.
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Treatment of Industrial water effluent

- Tertiary Treatment of Industrial Effluents: This type of treatment is needed for the effluent for the removal of bacteria and dissolved inorganic matter (metals, metal oxides, metal carbonates, metal sulphates etc.

  - **Reverse osmosis-**effluent containing dissolved solid is allowed to passed through semipermeable membrane at the pressure excess of osmotic pressure of feed waste (about 45-50 atm) leaving the dissolved solids on the surface. Thus through this technique the solid inorganic matter is separated from the water and the material can be recovered by using proper techniques.

  - **Chemical Precipitation**-It is a chemical technique by which metals are removed by precipitating them either as hydroxides at high pH or as sulphates etc.

  - **Evaporation-** This method is generally employed when waste solid/solids are reused in the industry. It is a method used for recovery of radioactive substances. Here the effluent is boiled and after the evaporation of the water, the concentrated solution is left out in the vessel which is again used in the recycle process of the industry

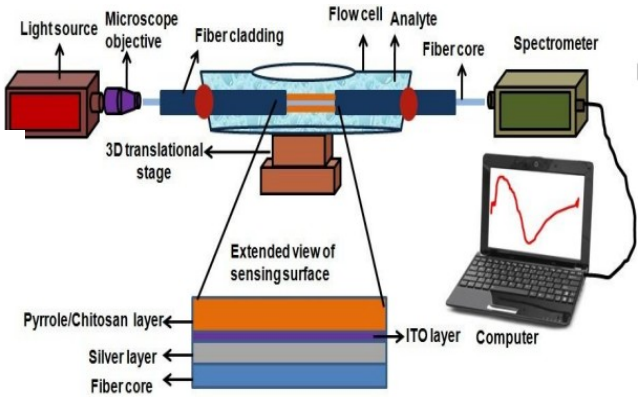
  - **Dialysis-** The process of separating crystalloid from colloid by diffusion or filtration through a membrane is called dialysis.

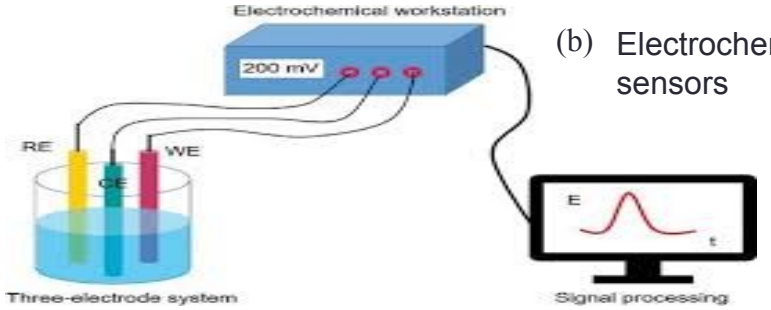
  - **Removal by algae-** algae require metals — cobalt, copper, zinc, manganese iron, molybdenum etc. in trace amounts and potassium, calcium magnesium, phosphorus, nitrogen and sulphur for the growth hence presence of algae in the effluent will reduce the above contents from the effluent.

  - **Activated carbon**-As activated carbon has high adsorption power hence it is utilized for the removal of pesticides such as DDT, hexachlorobenzene, Dieldrin, Heptachlor, Lindane, Aldrin, Chlordane, Toxophene, Methoxychlor, Heptachlor epioxide & others. The simple mechanism involves in this techniques is based on the phenomenon of adsorption.

Pollutant Monitoring – Precautionary Method

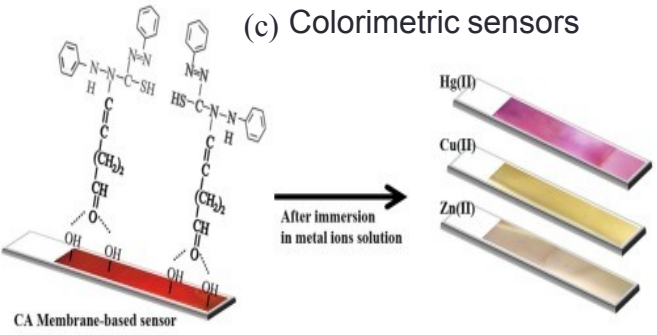
(a) Lab-based spectroscopic methods was used for detection

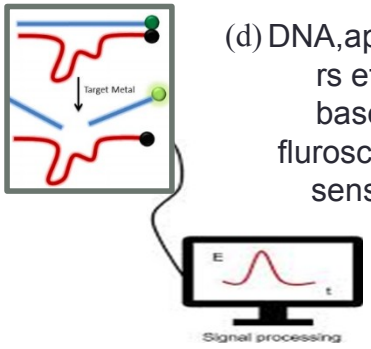




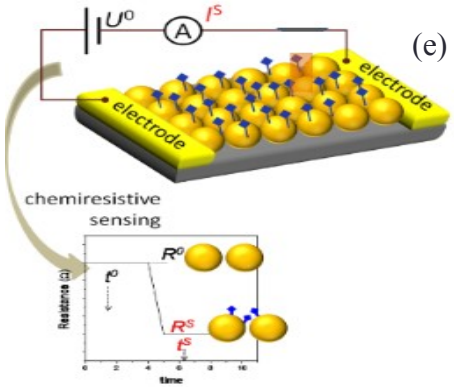
(b) Electrochemical sensors

(c) Colorimetric sensors





(d) DNA,aptamers etc. based fluroscence sensor



(e) Chemiresistors

- Different types of sensors are employed to detect the contaminants present in water.
- It's a precautionary method regulate the concentration of contaminants present in water within the permissible limit set by organization WHO, EPA etc.


Soil Pollution

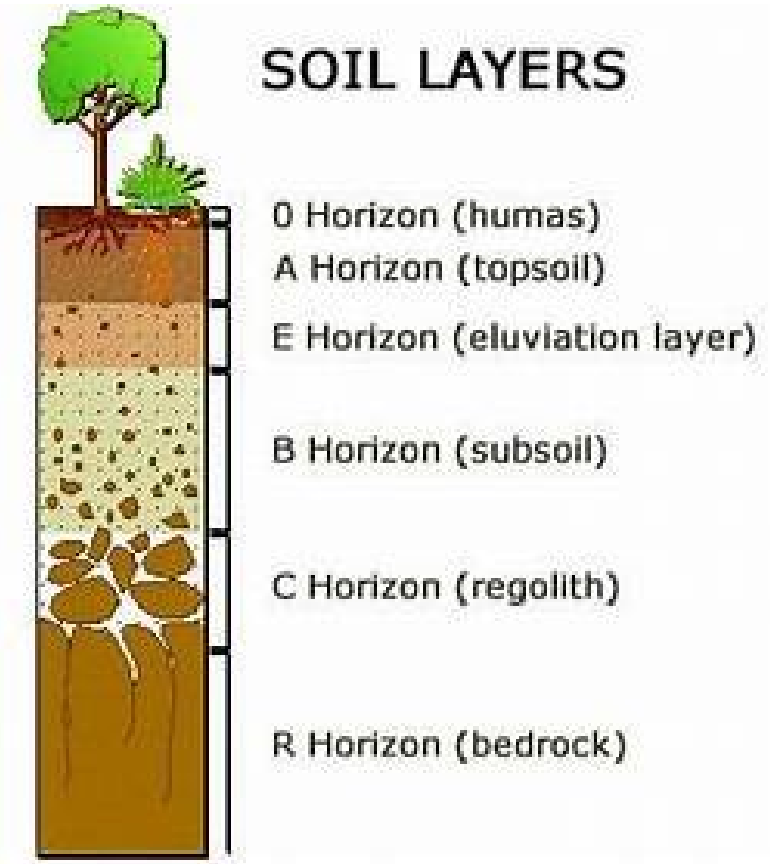
Soil

- Soil, the uppermost layer of the earth's crust is a mixture of many solid, liquid and gaseous substances having both living and nonliving matter such as mineral particles, decaying organic matter, microbes along with water and air contained in pore spaces.

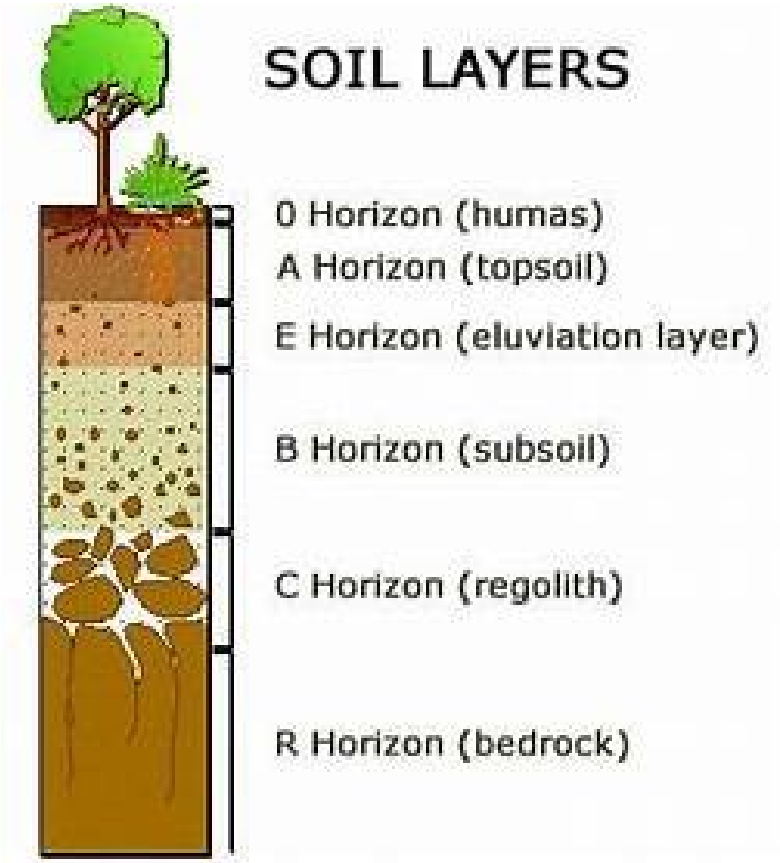
Components in Soil	Percentage
Organic mineral matter	45%
Organic matter	05%
Soil water	25%
Soil air	25%

Soil Profile

- Soil profile is defined as the vertical section of the soil from the ground surface downwards to where the soil meets the underlying rock.
- It is composed of a series of horizons or layers of soil stacked one on top of the other. These layers or horizons are represented by letters O, A, E, C, B, and R.
  - O Horizon- The top, organic layer of soil, made up mostlu leaf litter and humus (decomposed organic matter)
  - A Horizon- The layer called topsoil. Seeds germinate and plant roots grow in this dark-colored layer. It is made up of humus (decomposed organic matter) mixed with mineral particles.
  - E Horizon- This eluviation layer is light in color and is made up of mostly of sand and slit, having lost most of its minerals and clay as water drips through the soil.
  - B Horizon- Also called the subsoil, it contains clay and mineral deposits like iron, Aluminum oxides, and calcium carbonates, that it receives when the mineralized water drips from the soil above.
  - C Horizon-also called regolith, it consists of slightly broken –up bedrock, plant roots do not penetrate this layer. Very little organic material found in this layer.
  - R Horizon- the unweathered rock layer that is beneath all the other layers.



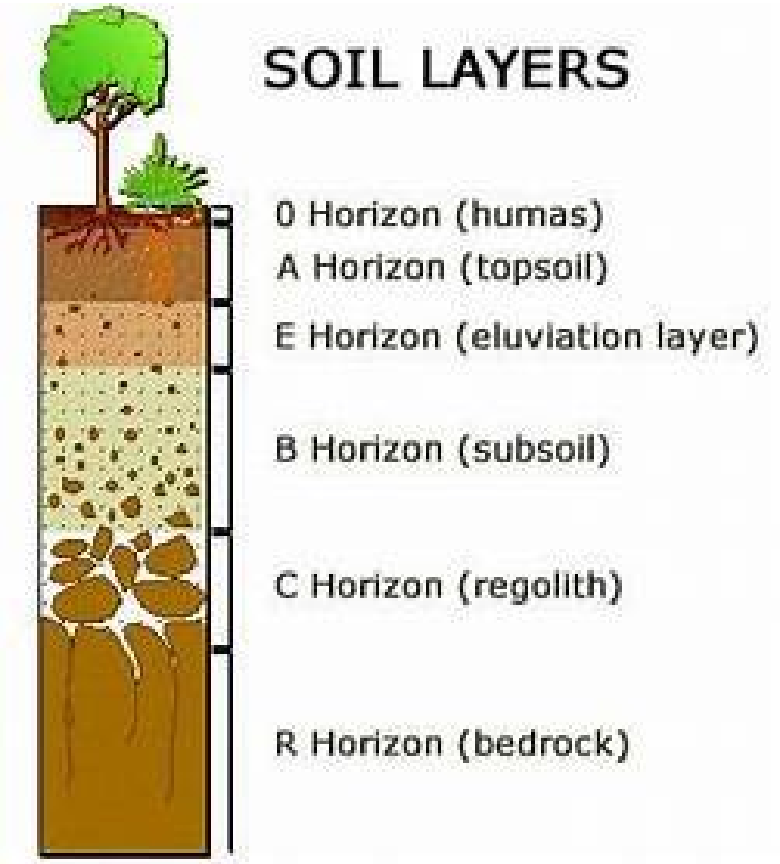
O-Horizon



The "Organic Matter" Horizon

- Surface-layer, at depths of 0-2 feet
- Dark in color, soft in texture
- **Humus** - rich organic material of plant and animal origin in a stage of decomposition
- **Leaf litter** – leaves, needles, twigs, moss, lichens that are not decomposing
- Several O-layers can occur in some soils, consisting only of O-horizons

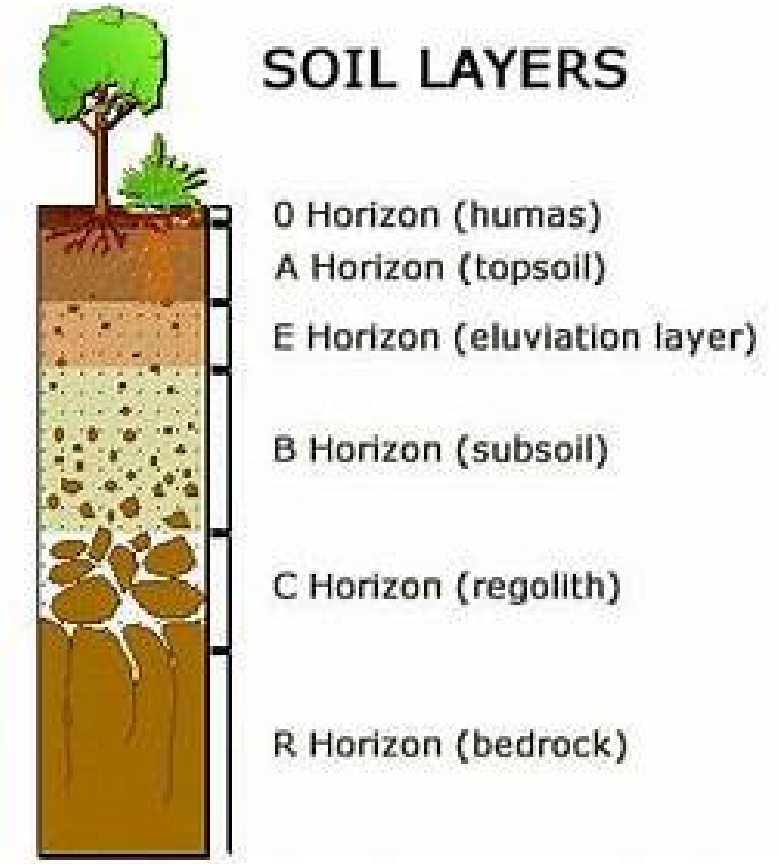
A - Horizon



"Topsoil" or "Biomantle" Horizon

- Topmost layer of **mineral soil**, at depths of 2-10 feet
- Some humus present, darker in color than layers below
- **Biomantle** - most biological productive layer; earthworms, fungi, and bacteria live this layer
- Smallest and finest soil particles

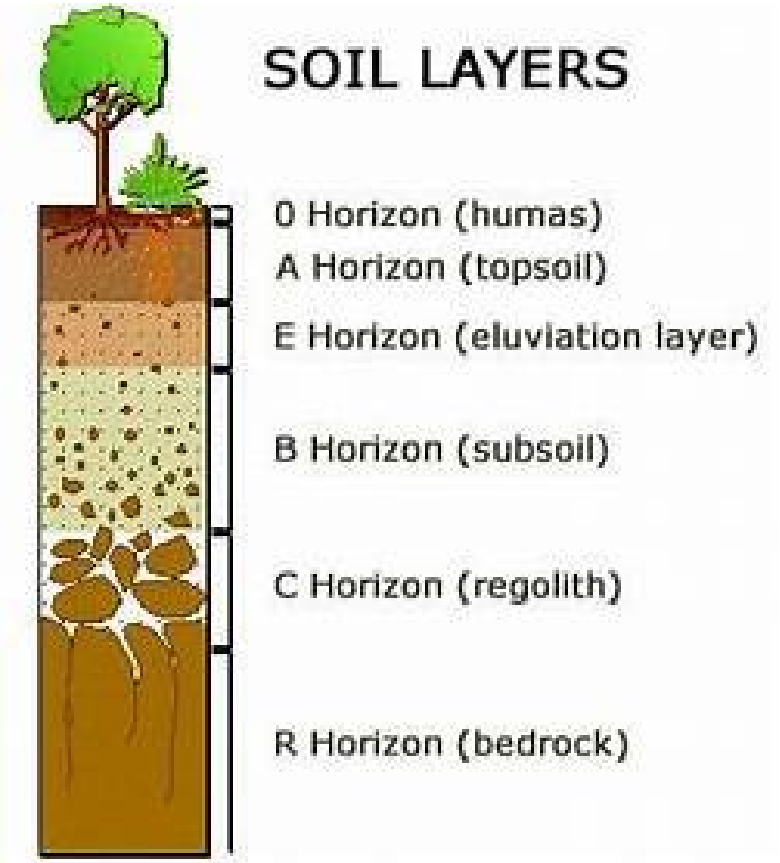
E - Horizon



The "Leaching Layer" Horizon

- Small layer between A & B horizons
- At depths of 10-15 feet
- Light in color, mainly sand & silt
- Poor mineral and clay content due to **leaching** – the loss of water-retaining plant nutrients to the water table
- Soil particles larger than in A horizon but smaller than in B horizon

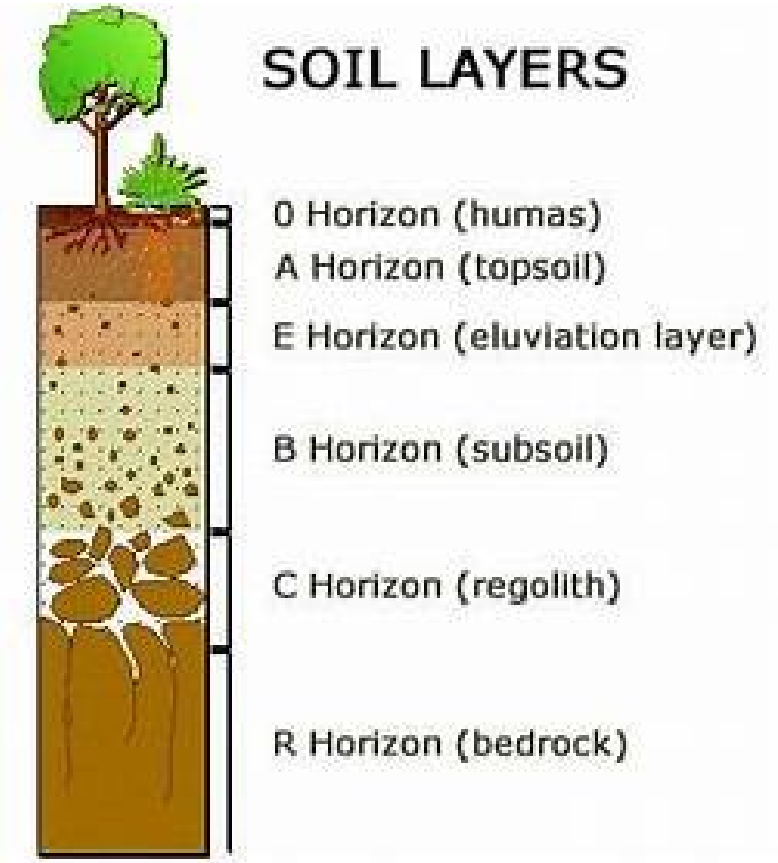
B - Horizon



The "Subsoil" Horizon

- At depths of 10-30 feet
- Rich in clay and minerals like Fe & Al
- Some organic material may reach here through leaching
- Plant roots can extend into this layer
- Red/brown in color due to oxides of Fe & clay

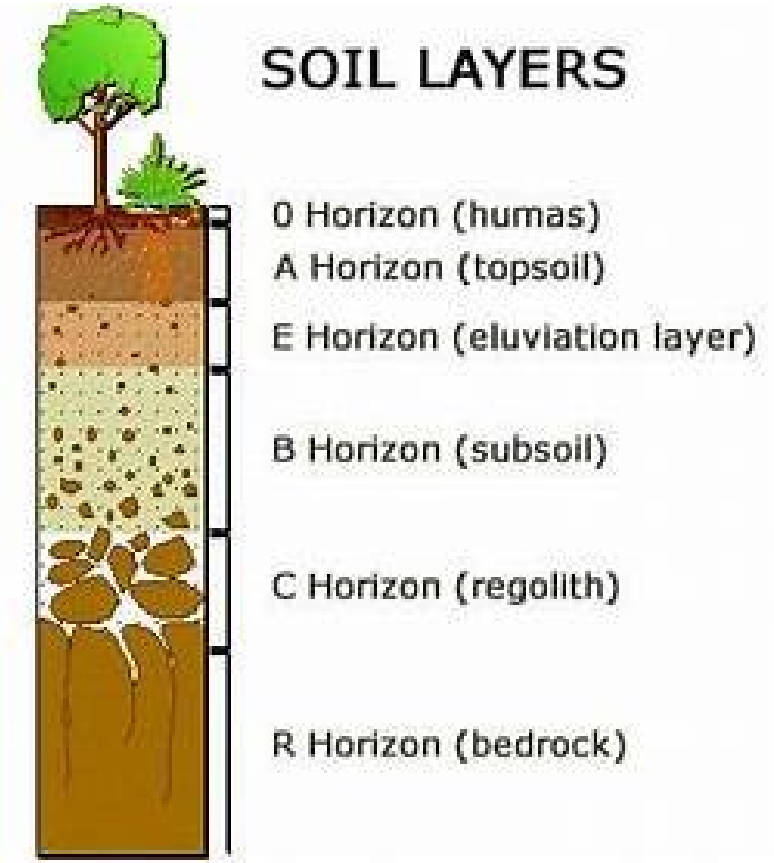
C - Horizon



The "Regolith" Horizon

- At depths of 30-48 feet
- Made up of large rocks or lumps of partially broken bedrock
- Least affected by weathering and have changed the least since their origin
- Devoid of organic matter due to it being so far down in the soil profile

R - Horizon



The "Bedrock" Horizon

- At depths of 48+ feet
- Deepest soil horizon in the soil profile
- No rocks or boulders, only a continuous mass of bedrock
- Colors are those of the original rock of the area

Soil Pollution

- Soil pollution is defined as, “contamination of soil by human and natural activities which may
- cause harmful effect on living organisms”

Sources of Soil Pollution

- Soil pollution mainly occurs due to the following:
- Industrial wastes
  - Sources: Industrial pollutants are mainly discharged from various origins such as pulp and paper mills, chemical fertilizers, oil refineries, sugar factories, tanneries, textiles, steel, distilleries, fertilizers, pesticides, coal and mineral mining industries, drugs, glass, cement, petroleum and engineering industries etc.
  - Effect: These pollutants affect and alter the chemical and biological properties of soil. As a result, hazardous chemicals can enter into human food chain from the soil or water, disturb the biochemical process and finally lead to serious effects on living organisms.
- Urban wastes
  - Urban wastes comprise of both commercial and domestic wastes consisting of dried sludge and sewage. All the urban solid wastes are commonly referred to as refuse.
  - Constituents of urban refuse: This refuse consists of garbage and rubbish materials like plastics, glasses, metallic cans, fibres, paper, rubbers, street sweepings, fuel residues, leaves, containers, abandoned vehicles and other discarded manufactured products. Urban domestic wastes though disposed off separately from industrial wastes, can still be dangerous. This happens because they are not easily degraded.

Sources of Soil Pollution

- Soil pollution mainly occurs due to the following:
- Agricultural practices
  - Modern agricultural practices pollute the soil to a large extent. With the advancing agro-technology, huge quantities of fertilizers, pesticides, herbicides and weedicides are added to increase the crop yield. Apart from these farm wastes, manure, slurry, debris, soil erosion containing mostly inorganic chemicals are reported to cause soil pollution
- Radioactive pollutants
  - Radioactive substances resulting from explosions of nuclear testing laboratories and industries giving rise to nuclear dust radioactive wastes, penetrate the soil and accumulate giving rise to land/soil pollution
- Biological agents
  - Soil gets a large amount of human, animal and bird excreta which constitute a major source of land pollution by biological agents. Ex: 1. Heavy application of manures and digested sludge can cause serious damage to plants within a few years

Pollutants in Soil

- Heavy metals (such as lead and mercury, at excessively high amounts) in the soil can make it very poisonous to humans.

- PAHs (polycyclic aromatic hydrocarbons) are a class of organic chemicals where only carbon and hydrogen atoms are present. Coke (coal) production, automobile emissions, cigarette smoke, and shale oil extraction are all sources of PAHs in the soil.

- Industrial Waste Soil contamination can come from the dumping of industrial waste into soils.

- Pesticides are chemicals (or chemical mixes) that are used to kill or prevent pests from reproducing.

Effect of Soil Pollution

- Decrease soil fertility
- Corrosion foundation and pipelines
- Reduce the Plant ability to take nutrients
- Poisoning of the Underground Water
- Reduce Quality of crops
- Increase Health Disorder
- Create toxic dust
- Loss of Habitat and so on.

Controlling Measures of Soil Pollution

Soil erosion can be controlled by a variety of **forestry and farm practices**.

Ex:

- Planting trees on barren slopes Contour cultivation and strip cropping may be practiced instead of shifting cultivation.
- Terracing and building diversion channels may be undertaken.
- Reducing deforestation and substituting chemical manures by animal wastes also helps arrest soil erosion in the long term.

Controlling Measures of Soil Pollution

- **Public awareness:** Informal and formal public awareness programs should be imparted to educate people on health hazards by environmental education.

  Ex:

  Mass media, Educational institutions and voluntary agencies can achieve this.

- **Production of natural fertilizers:** Bio-pesticides should be used in place of toxic chemical pesticides. Organic fertilizers should be used in place of synthesized chemical fertilizers.

  Ex:

  Organic wastes in animal dung may be used to prepare compost manure instead of throwing them wastefully and polluting the soil.

Controlling Measures of Soil Pollution….

- **Proper hygienic condition:** People should be trained regarding sanitary habits. Ex: Lavatories should be equipped with quick and effective disposal methods.
- **Recycling and Reuse of wastes:** To minimize soil pollution, the wastes such as paper, plastics, metals, glasses, organics, petroleum products and industrial effluents etc. should be recycled and reused.

  Ex:

  Industrial wastes should be properly treated at source. Integrated waste treatment methods should be adopted.
- **Ban on Toxic chemicals:** Ban should be imposed on chemicals and pesticides like DDT, BHC, etc. which are fatal to plants and animals. Nuclear explosions and improper disposal of radioactive wastes should be banned.

Projects

P. No.	Name of Project
1	Recycling and reuse of Building waste in construction. -- Roll No. (1-11))
2	Survey and documentation of methods disposal of hospital waste. -- Roll No. (12-18)
3	Air pollution monitoring (CO_2, CO, SO_2 , N_2O) in and around Nation. -- Roll No. (19-25)
4	Design simulation based model for air quality improvement. -- Roll No. (26-32)
5	Recycling and reuse of E-waste. -- Roll No. (33-39)
6	Waste water treatment and reuse (40-46)
7	Impact of Radiation on human life (47-53)
8	Impact of Noise pollution on human life (54-60)
9	Impact of Industrial Waste dumping on soil (61-67)
10	Impact of recent Climate change on Agriculture (68-74)
11	Impact of Indoor gases on the health of employees siting in centrally air conditioned buildings (75-80+ backlog)