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Programme: M.Sc., Environmental Science

Course Title: Water, Soil Pollution and management

Course Code : CC04

Unit-V
Soil Pollution

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Basics of Soil

Soil-Definition

- KNIGHT (1956) defined soil as the mineral material that exists in solid or unbroken form such as boulders and gravels or finely divided particles of mineral matter such as sand, silt or clay depending upon the texture.

- TRESHOW (1970) gave a more appropriate definition of soil. He defined soil as a complex physical-biological system providing support, water, nutrient and oxygen for the plants

Soil Formation

- Soil originates from rocks. It develops gradually by the fragmentation and corrosion of rocks and with the accumulation of organic matter. Soil formation may require 2,000 to 20,000 years but soil differentiation from the parent material may take place in a short time such as 30-50 years.)

1.Fragmentation

It is the mechanical breakdown of rock material into smaller pieces. The mechanical breakdown of rock is brought about by strong winds, extreme temperature fluctuations, shearing effect of ice sheets, running water and loot growth.

2.Corrosion

It includes the chemical processes of oxidation, reduction, hydration, hydrolysis and carbonation etc., by the action of these processes soil materials go into the solution with rain water.

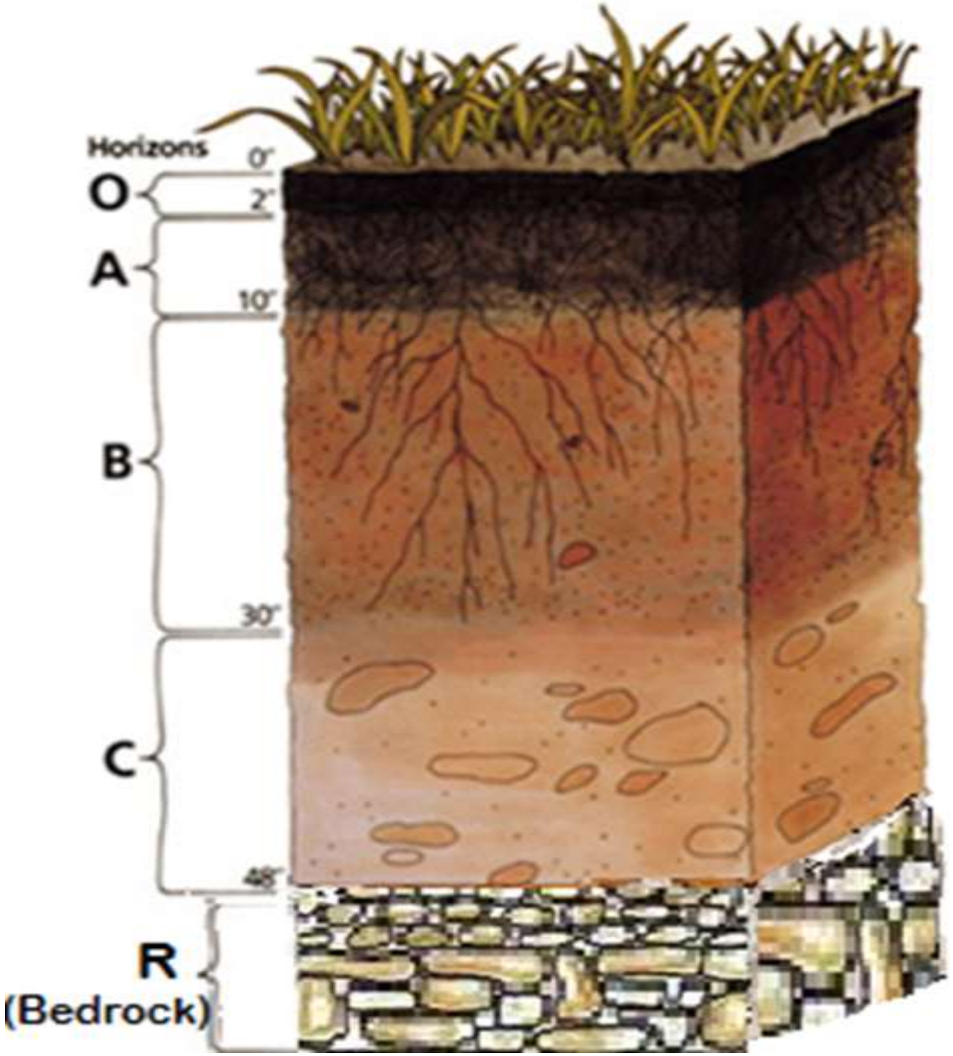
- This water percolates through the ground as soil- water combines with CO_2 to form carbonic acid which combines with calcium and magnesium of the rocks to form their carbonates.
- Aluminium and silicon minerals are converted into clay and iron compounds and are either reduced to ferrous state or are oxidised to ferric state. In this way rock is broken down into fine material which either remains at its place or may be transported to other places by wind and water.
- Plants are also responsible for soil formation. The roots secrete certain acids which mix with the ground water and cause the rocks to disintegrate much more rapidly.

3.Organic Matter

- Organic matter of dead and decaying organisms also contributes in soil formation. The lichens and big trees die and their dead parts—the roots, fallen leaves and dried twigs get mixed with the rock material.

- To this are also added the remains of animals and their excreta. The plant and animal remains are rich in organic matter. These provide suitable medium for the growth of bacteria, molds and other micro-organisms.
- The micro-organisms decompose the plant and animal remains and convert them into humus, the dark-black organic matter of the soil.
- Humus added to the soil tends to bind the grains together, reduces pore-size and separates the soil material into clumps. This allows aeration, increased percolation and easier root penetration.
- Since soil influences the flora and fauna of the area, its texture is of considerable ecological interest.
- Soils formed with various integrations of soil particles are of the following main types

- A cross-section of a well developed soil shows more or less distinct layers called horizons. The horizons may differ In thickness, color, texture, structure, porosity, acidity and composition.



- This sequence of horizons from the surface downwards is called the soil profile. In a typical soil profile following horizons or layers can be recognized.
- **1. A-horizon**
  - This is the topmost soil in which the vegetation grows and is the area of biological activities. It is darker in colour and rich in humus. Its thickness varies upto 10 ft. It can be further differentiated into several layers.
  - A-oo—This is the top layer consisting of freshly fallen litter i.e. leaves and organic debris which is still intact or partially decomposed.
- A-o--Below A-oo lies this layer. **It contains** organic matter in variable stages of decomposition. The upper portion of A-o layer contains organic matter in the initial stages of decomposition. This is also known as **F layer or fermentation level.** The lower portion of A-o horizon is also know as **H** or **humus level. A-o** horizon is very rich in life.
- This layer is known as the zone in which the most biological activity occurs. Soil organisms such as earthworms, arthropods, nematodes, fungi and many species of bacteria are seen associated with the plant roots. Thus the A horizon may be referred to as the biomantle. **A-o** and **A-oo** layers of A-horizon are found under thick forests but may be absent under grasslands.

2. B-horizon

- The B horizon is commonly referred to as the "subsoil". In humid regions, B horizons are the layers of maximum accumulation of materials such as silicate clays, iron (Fe) and aluminum (Al) oxides, and organic material.
- These materials typically accumulate through a process termedilluviation, wherein the materials gradually wash in from the overlying horizons. Accordingly, this layer is also referred to as the "illuviated" horizon or the "zone of accumulation".
- The B horizon may also have stronger colors (higher chroma) than the A horizon.
- In arid and semiarid regions, calcium carbonate or calcium sulfate may accumulate in the B horizon.

C-horizon

It is often thick consisting of large masses of weathered mineral material. The upper portion of C-horizon may become glued due to accumulation of water.

In dry regions, carbonates and gypsum may be concentrated in the C horizon. While loose enough to be dug with a shovel, C horizon material often retains some of the structural features of the parent rock or geologic deposits from which it formed.

The A and B layers usually originated from the C horizon. The upper layers of the C horizon may in time become a part of the solum as weathering and erosion continue. The C Horizon may contain lumps or more likely large shelves of unweathered rock, rather than being made up solely of small fragments as in the solum.

D-horizon

This is the lowest horizon of the soil profile. It is comprised of un weathered parent rock material.

R horizon

This is the layer of partially weathered bedrock at the base of the soil profile. Unlike the above layers, R horizons are composed largely of consolidated masses of hard rock that cannot be excavated by hand.

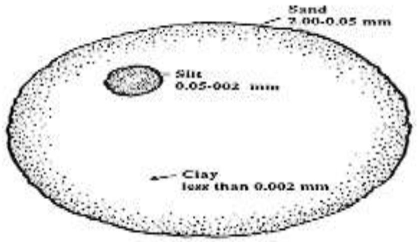
Soil Characteristics

- Physical properties of soils include texture, structure, porosity, permeability, color, and temperature.
- Soil Color:
- The color of a soil is an indication of its mineral, humus, and water content.
- Reddish soil: location is generally dry with seasonal wetting, darker red means higher iron content.
- Grey, blue, or green soil: location is poorly drained and if waterlogged for long periods of time, spots (or mottles) of blues, greys, and greens often result, indicating lack of oxygen.
- Dark brown soil: within a small geographical area, darker brown often means higher organic matter content, although darker colors do not always mean a fertile soil.
- White soil: lime or salts are present, pH is high.

- Soil Texture
- Since soil influences the flora and fauna of the area, its texture is of considerable ecological interest.
- Soils formed with various integrations of soil particles are of the following main types.

1.Sandy soils mainly consist of sand particles. These are loose, dry and poor in nutrients. The water holding capacity of such soils is poor.

2. Clay **soils** chiefly consist of clay particles. The clay particles are of colloidal dimensions. They have high plasticity **and** possess high water holding capacity. Clay particles have small interspaces between them so that neither water nor air can circulate freely. Such soils on getting water become water-logged. Thus they **are** not suitable for plant growth



3. **Loam soils** have sand, silt and clay particles in more or less equal proportions. Such soils are most suitable for plant growth.

4. **Sandy loam soils** are those soils in which sand particles predominate.

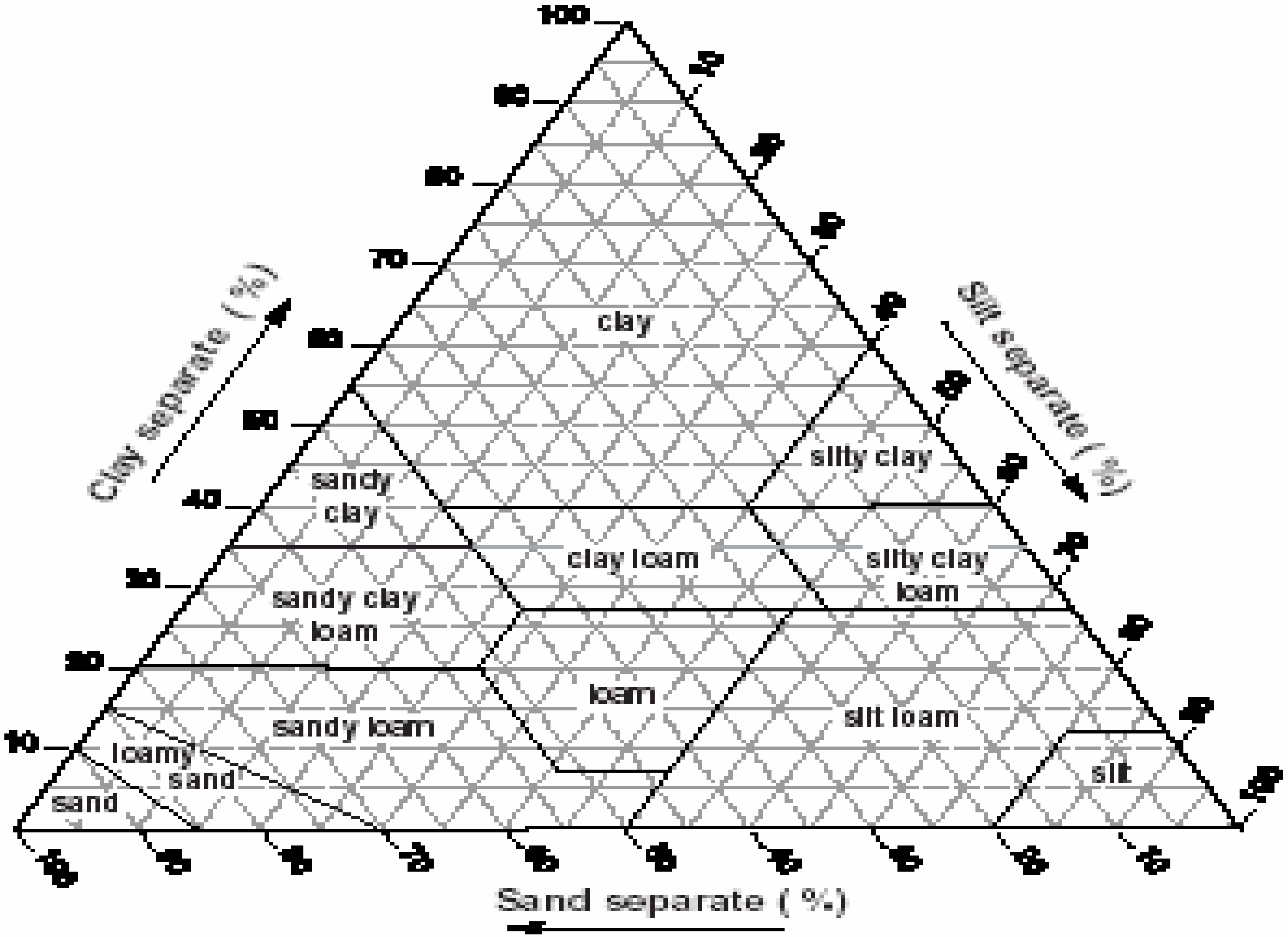
5. **Clay loam soils** have predominance of clay particles. Both sandy and clay loam soils are suitable for plant growth.

6. **Silt Loam soils** have predominance of silt. On getting water, silt loam becomes water- logged with poor air circulation. Such soil are not suitable for plant growth.

Texture

S.NO	Name of Particles	Diameter of Particles
1	Gravel	2.00 mm and More
2	Coarse sand	2.00 mm to 20 mm
3	Fine sand	0.20 mm. to 0.02 mm
4	Silt	0.02 mm.to 0.002 mm
5	Clay	Below 0.002 mm

- ***Soil structure*** is the way in which sand, silt, and clay are grouped together in the soil to form aggregates or clusters of soil particles.
- Humus is made up of material from the breakdown of organic matter and clay, two of the most important sources of cementing materials that help create aggregates. A good soil structure for gardens is one with many aggregates that create spaces in the soil for the movement of the water and air needed for healthy roots and plants.


100
70
40
20
10
Clay separate (%)
Silt separate (%)
Sand separate (%)
clay
silty clay
sandy clay
clay loam
silty clay loam
sandy clay loam
loam
silt loam
sandy loam
loamy sand
sand
silt

Soil structure

- By definition, type of structure are rated from 1 to 4 as follows:
- 1 Granular and crumb structures are individual particles of sand, silt and clay grouped together in small, nearly spherical grains. Water circulates very easily through such soils. They are commonly found in the A-horizon of the soil profile;

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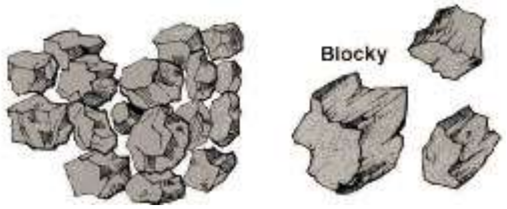
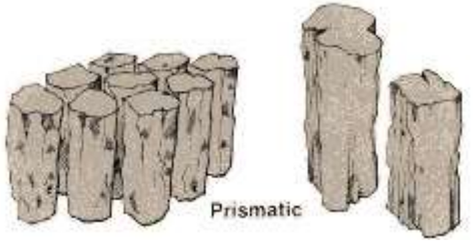
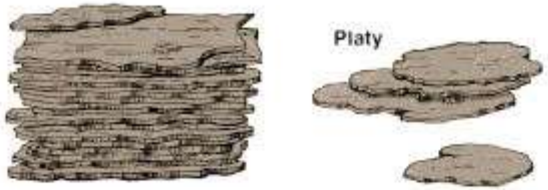
- 2 Blocky and subangular blocky structures are soil particles that cling together in nearly square or angular blocks having more or less sharp edges. Relatively large blocks indicate that the soil resists penetration and movement of water. They are commonly found in the B-horizon where clay has accumulated;



- 3 Prismatic and columnar structures are soil particles which have formed into vertical columns or pillars separated by miniature, but definite, vertical cracks. Water circulates with greater difficulty and drainage is poor. They are commonly found in the B-horizon where clay has accumulated;





- **4 Platy structure** is made up of soil particles aggregated in thin plates or sheets piled horizontally on one another. Plates often overlap, greatly impairing water circulation. It is commonly found in forest soils, in part of the A- horizon, and in **claypan*** soils.

Soil Porosity and Permeability

- Soil ***porosity*** is a measure of the amount of spaces or ***pores*** in the soil that can be filled with either air or water.
- ***Permeability*** is a measure of the ease with which water and air move through the soil pores . A combination of texture, structure, and organic matter content determine the porosity and permeability of soils. For a good balance between small pores that retain a lot of water, and large pores that allow easy movement of air and water, medium- textured loam soils with good structure and plenty of organic matter are best.
- While clayey soils have higher porosity, and so can hold more water than sandy soils, they also have lower permeability because the pores are so small. Soils with a small pore size (less than 0.03 mm; 0.0012 in), characteristic of clay soils, retain water by attraction forces and if most pores in the soil are of this size waterlogging can occur. Large pore size, and thus poor water-holding capacity, is a problem only in very sandy soils. Both situations can be improved by adding organic matter to the garden soil.
- Soil porosity can also be improved by animals such as earthworms or termites living in the soil.

Soil Bulk density

- **Bulk density** is **defined** as the dry **weight of soil** per unit volume of **soil**. **Bulk density** considers both the solids and the pore space.
- The soil bulk density (BD), also known as dry bulk density, is the weight of dry soil (M_{solids}) divided by the total soil volume (V_{soil}). The total soil volume is the combined volume of solids and pores which may contain air (V_{air}) or water (V_{water}), or both (figure 1). The average values of air, water and solid in soil are easily measured and are a useful indication of a soils physical condition.
- Bulk density is the weight of soil in a given volume.
- Soils with a bulk density higher than 1.6 g/cm3 tend to restrict root growth.
- Bulk density increases with compaction and tends to increase with depth.
- Sandy soils are more prone to high bulk density.
- Bulk density can be used to calculate soil properties per unit area (e.g. kg/ha).

Soil Temperature

- Soil temperature affects seed germination and root growth, and is the result of many factors:
- Direction of slope: determines exposure to the sun. In the northern hemisphere north-facing slopes receive less sun than south-facing ones; in the southern hemisphere the opposite is true
- Depth: with increasing depth below the soil surface, the less the soil temperature changes daily and seasonally, and the more changes in soil temperature lag behind changes in air temperature.
- Color: dark-colored soils absorb more solar radiation (heat) than light soils.
- Water content: water in the soil moderates temperature; large amounts of heat are used to evaporate water, keeping soil cool on hot days, and, large amounts of heat are given off when water freezes, keeping soil warm on cold nights.
- Surface cover: covering the soil surface with a mulch slows heating and cooling both seasonally and daily, and can be used to regulate soil temperature according to the time of year and crop .

Soil Water

- Soil retains large quantities of water. An ordinary garden soil contains about 25% water by volume. The principle source of soil water is rain. After a heavy rainfall, the water is retained by soil in various forms. On the basis of water retained by_ soil, it has been classified as *gravitational water*, *capillary water*, *hygroscopic water* and *combined water.*

1. Gravitational Water

- This is the free water which due to the action of gravity moves downwards into the soil until it reaches the water-table. This water is of little direct value to the plants.

2. Capillary Water

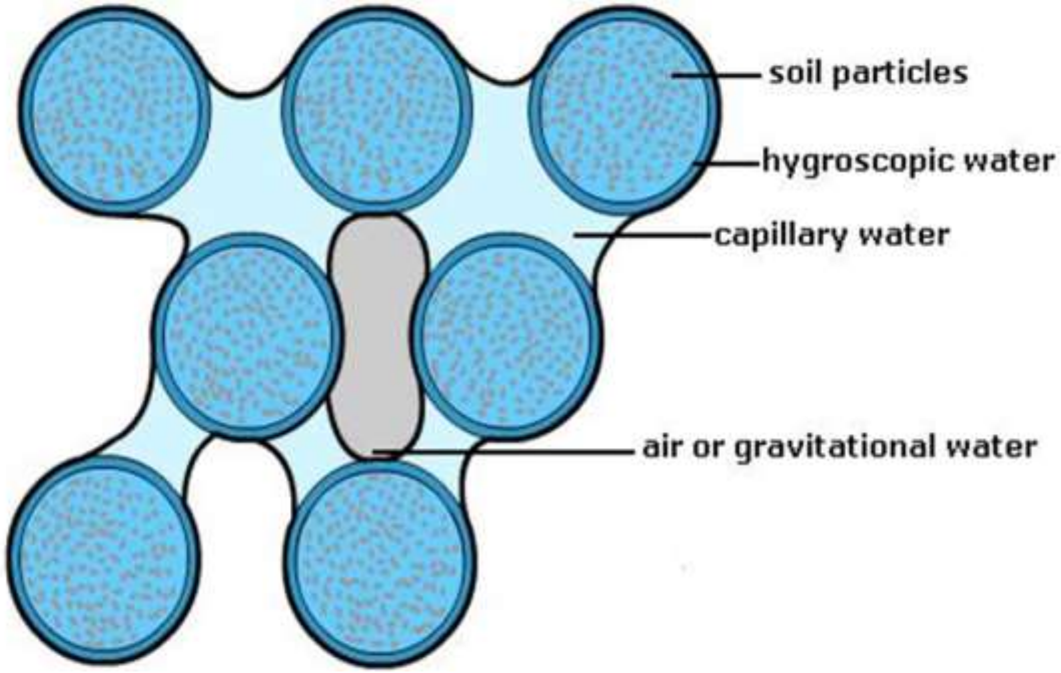
This water fills the spaces between colloidal soil particles or forms films around them. This water is held by the capillary forces around and between the particles and is of greatest importance to plant life

3. Hygroscopic Water

- The water that occurs in the form of thin film on the soil particles is termed as hygroscopic water. This water is not available to the plants.

4.Combined Water

A small portion of the soil water is chemically bound with soil materials. It is known as combined water.



Soil pH,acidity, alkalinity

- Soils of different places vary in their **pH** value. Soils with pH of 7 are neutral while the pH above 7.0 indicates alkalinity and that below 7.0 indicates acidity.
- Generally the pH value of soils lies between 2.2 and 9.6. Depending upon the pH value, soils may be neutral, acidic or alkaline.
- For example, the soils are alkaline in arid areas and acidic in tropics. Plants and animals in different soils vary with regards to their pH tolerance.
- pH affects Nutrients, Minerals and Growth
- The effect of soil pH is great on the solubility of minerals or nutrients. Fourteen of the seventeen essential plant nutrients are obtained from the soil. Before a nutrient can be used by plants it must be dissolved in the soil solution. Most minerals and nutrients are more soluble or available in acid soils than in neutral or slightly alkaline soils.
- Phosphorus is never readily soluble in the soil but is most available in soil with a pH range centered around 6.5. Extremely and strongly acid soils (pH 4.0-5.0) can have high concentrations of soluble aluminum, iron and manganese which may be toxic to the growth of some plants. A pH range of approximately 6 to 7 promotes the most ready availability of plant nutrients.

Soil pH

- But some plants, such as azaleas, rhododendrons, blueberries, white potatoes and conifer trees, tolerate strong acid soils and grow well. Also, some plants do well only in slightly acid to moderately alkaline soils. However, a slightly alkaline (pH 7.4-7.8) or higher pH soil can cause a problem with the availability of iron to pin oak and a few other trees in Central New York causing chlorosis of the leaves which will put the tree under stress leading to tree decline and eventual mortality.
- The soil pH can also influence plant growth by its effect on activity of beneficial microorganisms Bacteria that decompose soil organic matter are hindered in strong acid soils. This prevents organic matter from breaking down, resulting in an accumulation of organic matter and the tie up of nutrients, particularly nitrogen, that are held in the organic matter.

Soil Air

- Soil air is essential for the respiration of soil micro-organisms and underground parts of the plants. Compared to atmospheric air, soil air is slightly poorer in oxygen. This is due to the metabolic activities of roots and soil organisms.
- The oxygen present in the soil air is an important factor in soil fertility since it is necessary for the breaking down of insoluble minerals into soluble salts.
- It is essential for soil organisms whose activity increases the soil fertility. In the absence of oxygen seed germination, root growth, water absorption by root hairs etc. are slowed down and ultimately altogether cease.
- Under deficient supply of oxygen, due to anaerobic respiration, production of toxins takes place. Well aerated soils are free from such toxic substances

Soil EC

- Soil electrical conductivity affects yields, crop suitability, plant nutrient availability and soil microorganism activity such as emission of greenhouse gases and respiration.
- Excess salts hinder plant growth by affecting the soil-water balance.
- Arid and semi-arid climates naturally have a higher salt content.
- Salinity is influenced by humans through cropping, irrigation and land management practices.

Factors affecting Soil EC

- Climate
  - Salts are more easily flushed through soil located in areas of high rainfall
  - Salts are flushed below the root zone into groundwater or streams
  - Salts accumulate in soils found in dry areas
- Soil Texture
  - Clay with high cation-exchange capacities have high electrical conductivity
  - Clay with lower cation-exchange capacities have low electrical conductivity
  - Salts can’t leach through restrictive layers and therefore accumulate

Soil organic matter

- Organic matter is made up of different components that can be grouped into three major types: 1. Plant residues and living microbial biomass. 2. Active soil organic matter also referred to as detritus. 3. Stable soil organic matter, often referred to as humus.
- The living microbial biomass includes the microorganisms responsible for decomposition (breakdown) of both plant residues and active soil organic matter or detritus.
- Humus is the stable fraction of the soil organic matter that is formed from decomposed plant and animal tissue. It is the final product of decomposition.
- The first two types of organic matter contribute to soil fertility because the breakdown of these fractions results in the release of plant nutrients such as nitrogen, phosphorus, potassium, etc.
- The humus fraction has less influence on soil fertility because it is the final product of decomposition (hence the term “stable organic matter”).

- Benefits of Stable Soil Organic Matter :
- There are numerous benefits to having a relatively high stable organic matter level in an agricultural soil. These benefits can be grouped into three categories:
- Physical Benefits :
- Enhances aggregate stability, improving water infiltration and soil aeration, reducing runoff.
- Improves water holding capacity. Reduces the stickiness of clay soils making them easier to till. Reduces surface crusting, facilitating seedbed preparation. C
- Chemical Benefits : Increases the soil's CEC or its ability to hold onto and supply over time essential nutrients such as calcium, magnesium and potassium.
- Improves the ability of a soil to resist pH change; this is also known as buffering capacity .
- Accelerates decomposition of soil minerals over time, making the nutrients in the minerals available for plant uptake.
- Biological Benefits : Provides food for the living organisms in the soil.
- Enhances soil microbial biodiversity and activity which can help in the suppression of diseases and pests. Enhances pore space through the actions of soil microorganisms. This helps to increase infiltration and reduce runoff.

- Organic Materials
- Over time, the application and incorporation of organic materials can result in an increase in stable soil organic matter levels. Sources of organic materials include:
- Crop residues.
- Animal manure.
- Compost
- Green manure

Cation exchange capacity

- Cation exchange capacity (CEC) is a measure of the soil's ability to hold positively charged ions.
- It is a very important soil property influencing soil structure stability, nutrient availability, soil pH and the soil's reaction to fertilisers and other ameliorants (Hazleton and Murphy 2007).
- The clay mineral and organic matter components of soil have negatively charged sites on their surfaces which adsorb and hold positively charged ions (cations) by electrostatic force. This electrical charge is critical to the supply of nutrients to plants because many nutrients exist as cations (e.g. magnesium, potassium and calcium). In general terms, soils with large quantities of negative charge are more fertile because they retain more cations (McKenzie *et al.* 2004) however, productive crops and pastures can be grown on low CEC soils.

- The main ions associated with CEC in soils are the exchangeable cations calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^{+}) and potassium (K^{+}) (Rayment and Higginson 1992), and are generally referred to as the base cations.
- In most cases, summing the analysed base cations gives an adequate measure of CEC ('CEC by bases').
- However, as soils become more acidic these cations are replaced by H^{+}, Al^{3+} and Mn^{2+}, and common methods will produce CEC values much higher than what occurs in the field (McKenzie *et al.* 2004).
- This 'exchange acidity' needs to be included when summing the base cations and this measurement is referred to as effective CEC (ECEC).

Soil Macro nutrients

- Sixteen plant food nutrients are essential for proper crop development. Each is equally important to the plant, yet each is required in vastly different amounts. These differences have led to the grouping of these essential elements into three categories; primary (macro) nutrients, secondary nutrients, and micronutrients.
- PRIMARY (MACRO) NUTRIENTS
- Primary (macro) nutrients are nitrogen, phosphorus, and potassium. They are the most frequently required in a crop fertilization program. Also, they are need in the greatest total quantity by plants as fertilizer.
- NITROGEN
- · Necessary for formation of amino acids, the building blocks of protein
- · Essential for plant cell division, vital for plant growth
- · Directly involved in photosynthesis
- · Necessary component of vitamins
- · Aids in production and use of carbohydrates
- · Affects energy reactions in the plant

PHOSPHORUS

- Involved in photosynthesis, respiration, energy storage and transfer, cell division, and enlargement

· Promotes early root formation and growth

· Improves quality of fruits, vegetables, and grains

· Vital to seed formation

· Helps plants survive harsh winter conditions

· Increases water-use efficiency

· Hastens maturity

POTASSIUM

Carbohydrate metabolism and the break down and translocation of starches

· Increases photosynthesis

· Increases water-use efficiency

· Essential to protein synthesis

· Important in fruit formation

· Activates enzymes and controls their reaction rates

· Improves quality of seeds and fruit

· Improves winter hardiness

· Increases disease resistance

Micro nutrients

- MICRONUTRIENTS
- The micronutrients are boron, chlorine, cooper, iron, manganese, molybdenum, and zinc. These plant food elements are used in very small amounts, but they are just as important to plant development and profitable crop production as the major nutrients. Especially, they work "behind the scene" as activators of many plant functions.
- BORON
- Essential of germination of pollon grains and growth of pollen tubes
- Essential for seed and cell wall formation
- Promotes maturity
- Necessary for sugar translocation
- Affects nitrogen and carbohydrate
- CHLORINE
- Not much information about its functions
- Interferes with P uptake
- Enhances maturity of small grains on some soils

- COPPER
- · Catalyzes several plant processes
- · Major function in photosynthesis
- · Major function in reproductive stages
- · Indirect role in chlorophyll production
- · Increases sugar content
- · Intensifies color
- · Improves flavor of fruits and vegetables
- IRON
- · Promotes formation of chlorophyll
- · Acts as an oxygen carrier
- · Reactions involving cell division and growth
- MANGANESE
- · Functions as a part of certain enzyme systems
- · Aids in chlorophyll synthesis
- · Increases the availability of P and CA

- MOLYBDENUM
- Required to form the enzyme "nitrate reductas" which reduces nitrates to ammonium in plant
- Aids in the formation of legume nodules
- Needed to convert inorganic phosphates to organic forms in the plant
- ZINC
- Aids plant growth hormones and enzyme system
- Necessary for chlorophyll production
- Necessary for carbohydrate formation
- Necessary for starch formation
- Aids in seed formation
- The secondary nutrients are calcium, magnesium, and sulphur. For most crops, these three are needed in lesser amounts that the primary nutrients.

Soil Pollution and remediation

- Soil Pollution may be defined as direct or indirect alteration of the physical, chemical, biological and radioactive properties of the soil due to the deposition of domestic, commercial, industrial, vehicular and hazardous wastes.
- **Sources and effects of Soil Pollution –**
- **Agricultural sources**
- Synthetic Fertilizers: They are employed to increase the soil fertility and crop productivity. These fertilizers concentrate the essential nutrients in the layer of top soil. However, the soil enriched by chemical fertilizers cannot support the microbial flora which are essential to enrich the humus that helps in plant growth. Excessive and indiscriminate use of chemical fertilizers may result in the following undesirable effects.
- Wheat, maize, corn etc., grown on soils fertilized with NPK fertilizers may result in considerable reduction in protein content of the crop.
- Excessive use of nitrogenous fertilizers leads to the accumulation of nitrates in the soil which may contaminate the ground water.
- Vegetation grown in nitrate rich soils may exert toxic effect to the cattles.
- Excessive use of chemical fertilizers may enter the water bodies and contribute to Eutrophication.
- Excessive use of chemical fertilizers may reduce the ability of plants to fix nitrogen.
- Excessive quantities of potassic fertilizers in soils may reduce the quantities of ascorbic acid (Vitamin-C) and carotene in fruits and vegetables grown in such soils.
- The large sized fruits and vegetables grown in highly fertilized soils may be more vulnerable to attack by pests and insects.

- Pesticides: As per the reports of the World Health Organization (WHO), about 50,000 people in developing countries are poisoned and about 5,000 people die because of improper use of pesticides and other chemicals in modern agricultural practices.
- Pesticides including herbicides, fungicides and rodenticides are persistent pollutants. Owing to interactions between lithosphere and biosphere, pesticides may enter the food chain and pose serious health hazards. Some of them under go metabolic transformation and degradation. The degradation products of some of the pesticides are more dangerous than their respective parent compounds.
- Pesticides pose potential hazard to animals, human and aquatic life. They cause deleterious effect to the soil fertility and crop productivity.
- Pesticides applied to crop are retained in the soil in considerable quantities.
- Pesticides enter into cyclic environmental processes such as absorption by soil. leaching by water, etc., and contaminate both lithosphere and biosphere.
- Some of the pesticidal residues are carcinogenic while their metabolic products too are toxic.
- Some arsenic pesticides may render the soil permanently infertile.
- Pesticides such as DDT, endrin, dieldrin, heptachlor etc., may seep through the soil and contaminate the crops grown, (eg. fruit, vegetable, rice, wheat, barley, maize) ground water and surface waters. They may eventually contaminate the drinking water supplies too.
- Poly Chlorinated Biphenyls (PCB) having half-life periods of about 25 years in soil are among the most hazardous soil pollutants.

- They may accumulate in soil and plants and when they eventually enter the animal or human body, they may cause severe health disorders including eye damage, skin problem, nervous disorders, fetus deformities and liver or stomach cancer.
- The DDT can enter the food chain and accumulate in human fat and may lead to impotency.
- Chlorinated pesticides and herbicides are hazardous soil pollutants which can affect the soil texture and damage the ecosystem.
- Herbicides such as dioxide cause congenital defects in off springs.
- Contaminated soil may aid as potential carriers of pathogenic bacteria and other dangerous organisms which may endanger human.
- Volatile pesticide may cause pollution of air in the surrounding area.

- Cattle raising:
- Cattle manure is a major waste product of agricultural practice involving the breeding and rearing of cattle. Inappropriate disposal of manure can create environmental problems such as odours and leaching of nitrate ion and other pollutants into groundwater. Repeated annual application of manure with high salt content caused a build up of soluble salts in soils, sufficient to lower their productivity .
- Further manure, can harm soil and water quality.
- Manure varies in mineral composition depending on the type of animal and the ration fed. It was reported that cattle (Bos Taurus) manure contains 2.7 to 9.5% N, 0.5 to 0.8% O, 1.7 to 2.9% K, 1.4 to 20% Ca, and 0.61 to 0.76% Mg (% dry waste basis) . In addition, varying amounts of Al, Fe, Mn, S, Cl, Cu, Zn, and B and trace concentrations of Co, Cd, Cr, Ni, As and Se are present. Large fractions of these elements are present in a water-soluble form. With high precipitation, almost all regions where dairy farm facilities concentrate, great qualities of these elements are lost through surface runoff and leaching into groundwater.
- Manure contains a large amount of soluble and insoluble organic substances. Organic matter content ranges between 80% and 90% (dry weight basis) . Pyrolysis field ionization mass spectroscopy (Py-FIMS) was also used to analyse cow manure samples . The organic components that were identified include lignins, dimeric lignins, pesticides, lipids, monoesters, fatty acid, sterols, and heterocyclic nitrogen compounds.

- **Industrial wastes** – Disposal of Industrial wastes is the major problem for soil pollution
- 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. (a) **Effects of Industrial effluents:** Solid, liquid and gaseous chemicals from various industries such as paper and pulp, iron and steel, fertilizers, dyes, automobiles, pesticides, tanneries, coal-based thermal power plant etc., contain a variety of pollutants such as toxic heavy metals, solvents, detergents, plastic, suspended particulates and re-factory / non-bio degradable / restraint chemicals, if they are not properly treated at source, they give rise to water, air and soil pollution. Indiscriminate dumping of unwanted or inadequately treated domestic, mining and industrial wastes on land is an important source of soil pollution.
- Fall out of gaseous and particulate air-pollutants from mining and melting operations, smoke- stacks, etc are some of the major source of soil pollution in nearby area.

- Some soils are deficient in the heavy metals (such as Co, Cu, Fe, Mn, Mo, Ni, and Zn) that are essential for healthy plant growth , and crops may be supplied with these as an addition to the soil or as a foliar spray. Cereal crops grown on Cu-deficient soils are occasionally treated with Cu as an addition to the soil, and Mn may similarly be supplied to cereal and root crops. Large quantities of fertilizers are regularly added to soils in intensive farming systems to provide adequate N, P, and K for crop growth.
- The compounds used to supply these elements contain trace amounts of heavy metals (e.g., Cd and Pb) as impurities, which, after continued fertilizer, application may significantly increase their content in the soil . Metals, such as Cd and Pb, have no known physiological activity. Application of certain phosphatic fertilizers inadvertently adds Cd and other potentially toxic elements to the soil, including F, Hg, and Pb .
- Several common pesticides used fairly extensively in agriculture and horticulture in the past contained substantial concentrations of metals. For instance in the recent past, about 10% of the chemicals have approved for use as insecticides and fungicides in UK were based on compounds which contain Cu, Hg, Mn, Pb, or Zn.
- Examples of such pesticides are copper-containing fungicidal sprays such as Bordeaux mixture (copper sulphate) and copper oxychloride . Lead arsenate was used in fruit orchards for many years to control some parasitic insects. Arsenic-containing compounds were also used extensively to control cattle ticks and to control pests in banana in New Zealand and Australia, timbers have been preserved with formulations of Cu, Cr, and As (CCA), and there are now many derelict sites where soil concentrations of these elements greatly exceed background concentrations. Such contamination has the potential to cause problems, particularly if sites are redeveloped for other agricultural or nonagricultural purposes. Compared with fertilizers, the use of such materials has been more localized, being restricted to particular sites or crops.

- The application of numerous biosolids (e.g., livestock manures, composts, and municipal sewage sludge) to land inadvertently leads to the accumulation of heavy metals such as As, Cd, Cr, Cu, Pb, Hg, Ni, Se, Mo, Zn, Tl, Sb, and so forth, in the soil .
- Certain animal wastes such as poultry, cattle, and pig manures produced in agriculture are commonly applied to crops and pastures either as solids or slurries .
- Although most manures are seen as valuable fertilizers, in the pig and poultry industry, the Cu and Zn added to diets as growth promoters and As contained in poultry health products may also have the potential to cause metal contamination of the soil .
- The manures produced from animals on such diets contain high concentrations of As, Cu, and Zn and, if repeatedly applied to restricted areas of land, can cause considerable buildup of these metals in the soil in the long run.

- Biosolids (sewage sludge) are primarily organic solid products, produced by wastewater treatment processes that can be beneficially recycled . Land application of biosolids materials is a common practice in many countries that allow the reuse of biosolids produced by urban populations .
- The potential of biosolids for contaminating soils with heavy metals has caused great concern about their application in agricultural practices.
- Heavy metals most commonly found in biosolids are Pb, Ni, Cd, Cr, Cu, and Zn, and the metal concentrations are governed by the nature and the intensity of the industrial activity, as well as the type of process employed during the biosolids treatment .
- Under certain conditions, metals added to soils in applications of biosolids can be leached downwards through the soil profile and can have the potential to contaminate groundwater . Recent studies on some New Zealand soils treated with biosolids have shown increased concentrations of Cd, Ni, and Zn in drainage leachates

- **Urban centres:**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.
- **Effects of Urban Wastes:** Millions of tonnes of urban wastes are produced every year from polluted cities. The inadequately treated or untreated sewage sludge not only pose serious health hazards but also pollute soil and decrease its fertility and productivity. Other waste materials such as rubbish, used plastic bags, garbage sludge, dead animals, discarded medicines, hospital wastes, skins, tyres, shoes, etc, also cause land and soil pollution. Some solid waste may cause clogging of ground water filters. Suspended matter present in sewage can act as a blanket on the soil and interfere with its productivity.

- **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.

- Ex: Radio nuclides of Radium, Thorium, Uranium, isotopes of Potassium (K-40) and Carbon (C-14) are commonly found in soil, rock, water and air.

- Explosion of hydrogen weapons and cosmic radiations include neutron, proton reactions by which Nitrogen (N-15) produces C-14. This C-14 participates in Carbon metabolism of plants which is then into animals and human beings.

- Radioactive waste contains several radio nuclides such as Strontium90, Iodine-129, Cesium-137 and isotopes of Iron which are most injurious. Strontium get deposited in bones and tissues instead of calcium.

- Nuclear reactors produce waste containing Ruthenium-106, Iodine-131, Barium-140, Cesium-144 and Lanthanum-140 along with primary nuclides Sr-90 with a half life 28 years and Cs-137 with a half life 30 years. Rain water carries Sr-90 and Cs-137 to be deposited on the soil where they are held firmly with the soil particles by electrostatic forces. All the radio nuclides deposited on the soil emit gamma radiations.

- **Control 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.
- **Proper dumping of unwanted materials:** Excess wastes by man and animals pose a disposal problem. Open dumping is the most commonly practiced technique. Nowadays, controlled tipping is followed for solid waste disposal. The surface so obtained is used for housing or sports field.
- **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.

- **Proper hygienic condition**: People should be trained regarding sanitary habits.
- Ex: Lavatories should be equipped with quick and effective disposal methods.
- **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.
- **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.

- When examining alternatives for the treatment of contaminants in the soil, the method of treatment must be considered: if the designated technologies include use of a facility or insertion of substance to the soil – or a combination thereof; and whether the treatment will be undertaken on- or off-site (On Site/In-Situ or Ex Situ).
  There are three main methods to treat pollutants in the soil.
  • Biological treatment – in which the pollutant undergoes biological disintegration by a population of bacteria that exists in the soil or by ‘insemination’ of external bacteria and encouraging its development in the soil.
  • Chemical treatment – disintegration of the pollutant by means of oxidizing or reducing chemical agents.
  • Physical treatment – disintegration of the pollutant by physical methods such as heating, evaporation or washing.
  As mentioned, treatment technology is usually based on a facility, a substance or a combination thereof. Thus, physical treatment can be performed by gas suction facilities , heating facilities and incinerators. Chemical treatment can be performed by the insertion of various chemical materials, such as Permanganate, Persulfate, Peroxide and Ozone.
  Any treatment method can be executed by means of varying technologies, either on or off site.
  Additionally, there are methods for soil treatment which do not treat contaminants, and include excavation and removal of the contaminated soil, or the creation of a partition which prevents contact and transfer of pollutants.

- **What is Bioremediation of soils?**
- Bioremediation is the a biological degrading processes for the treatment of contaminated soils, groundwater and/or sediments, relying on microorganisms including bacteria and/or fungi to use the contaminant(s) as a food source with resulting degradation of the contaminant. Bioremediation is one of the most economic remedial techniques presently available for treating most organic fuel based contaminants such as coal tars and liquors, petroleum and other carcinogenic hydrocarbons such as benzene and naphthalene, and some inorganics.
- **Biostimulation**
- Natural attenuation of certain contaminants occurs in soils, biostimulation is a method of increasing the rate of the natural degradation processes. Techniques for this involve identifying limiting factors in the natural processes, for example oxygen availability for the bacteria which is often limited in soils at depth, and balancing that factor to increase the rate of degradation.

- **Bioaugmentation**
- Bioaugmentation is process where contaminant specific degrading bacteria are introduced to the contaminated media to promote / enhance degradation. This process is not as simple as it sounds as bacteria are in general suited to certain types of soils and pHsetc and therefore introduction to a new environment involves identifying the right bacteria for the new environment, and managing the contaminated materials once bioaugmentation has been undertaken.
- Bioremediation can be undertaken in-situ (i.e. with the soils / groundwater in the ground) or ex-situ (i.e. excavated soils or water pumped from the ground.

- **In-situ bioremediation**
- In-situ bioremediation causes minimal disturbance and avoids the necessity to replace the contaminated materials, however the limitations of in-situ bioremediation are that only certain types of soils can be bioremediated in-situ, and complete degradation is often difficult to achieve. Bioremediation is of course only undertaken if it is possible to reduce contaminants to below guideline levels.
- **Ex-situ bioremediation**
- Ex-situ bioremediation can involve bio-piles / windrows, where soils are manipulated in to structures to enhance temperature and aeration amongst other variables, and use of bioreactors to process the material in a highly controlled environment.

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