Soil: Agricultural Microbiology

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Soil

- The word soil originated from the Latin word "Solum" which means the "floor" hence soil is earth's floor.
- The present day definition is '**Soil is a natural body of minerals and organic constituents differentiated into horizons which differ among themselves in morphology, physical make up, chemical properties and biological characteristics**'
- Soil is an integral part of the environment as it supplies the organisms with essential minerals, water and nutrients.

- **Composition of Soil**

  In the beginning the soil was considered as an inert material, but with detailed studies it has been proved that soil is vital for life forms.

  Soil comprises of:

  1. **Solid Phase**:- (i) Minerals derived from parent rock, (ii) organic matter from dead organisms

  2. **Liquid Phase**:- Water present between the soil particles.

  3. **Gaseous Phase**:- Soil air present between the soil particles.

  Besides these the soil has **microbial population** present in it and is a medium for anchorage of plants.

- **Soil Components**

  Soils have the following components:

  1. Mineral Matter
  2. Soil organisms
  3. Soil water
  4. Soil atmosphere
  5. Organic Matter or Humus.

(1) Mineral Matter:- It constitutes about 90% of the soil. It is formed by the disintegration of the parent rock which may be IGNEOUS, SEDIMENTARY OR METAMORPHIC ROCK.

- Theses rocks vary in their composition. The minerals present in soil may be essential (Macronutrients: N, P, K, Ca, S, Mg, C, O, H) or accessory (Micronutrients: Fe, B, Cl, Mn, Zn, Cu, Mo, Ni) for the soil organisms.
- These soil minerals can be grouped into two categories:

  a) Primary Mineral eg. Feldspar, Quartz and Mica etc.

  b) Secondary Minerals eg. Hydrated Silicates.
- Primary minerals are inherited from the parent rock.
- The decomposition of primary minerals results in the formation of secondary crystalline minerals which are essentially clay minerals

(2) **Soil Organisms**:- The soil organisms present cause changes in the nature and structure of soil, thus soil is said to be a living system, which was initially thought to be an inert matter.

- These comprise of both the **flora** and **fauna**. Among them are **bacteria, fungi, algae, lichens**, and **soil animals** like **Protozoa, nematodes, earth worm, insects, reptiles** and **burrowing mammals**.
- These organisms influence the soil property and help in the decomposition of dead organic matter, and aeration.

3**) Soil Water**:- It is an essential substance as it regulates all the physical/chemical and biological activities of the organisms.

Water present in soil could be:

a) **Hygroscopic**-This water forms very thin film around soil particles and is not available to plants (roots)

b) **Capillary –** It is available to plants

c) **Gravitation** – Water held in the macropores. It is not available to plants

d) **Water Vapour**

(4) **Soil Atmosphere**:- Air is present in the spaces between the soil particles along with water. It is necessary for the survival and growth of the organisms present in soil.

Soil air shows fluctuations in composition, and marked seasonal variations.

The air comprises of O_2, CO_2 and N_2. In soil, oxygen is in lower percentage, CO_2 is in higher percentage while N_2 is also in lower percentage when compared with atmosphere. The percentage of O_2 & N_2 is less since they are being utilized by the soil population.

(5) **Oragnic Matter or Humus**:- The organic matter is complex part of the soil which mainly consist of dead remains of the organisms belonging to **Flora & fuanna** in the soil.

The finally broken organic matter is a dark coloured homogenous amorphous, odourless complex substance which has lost its structure through decay and decomposition called as **HUMUS** and process of it's formation is called **Humification**.

Humus is not quickly mineralized in cold conditions while in moist and warm conditions it gets quickly converted to CO_2, water & minerals. This process is known as mineralisation.

Organic matter is the source of most of the nutrients required for the growth of organisms especially plants which needs to be mineralized.

- ***Formation of Soil***
- The formation of soil is called as pedogenesis which results from rocks. The formation of soil involves two processes which are as follows:

  1. Weathering

  2. Development of soil Profile.
- Weathering could be physical, chemical or biological.

  In physical weathering - The parent rock breaks into smaller pieces, creating crevices. Physical weathering also causes disintegration of the rocks. This is caused by mechanical forces acting on the rocks (parent rocks) for e.g. temperature fluctuations, beating rainfall etc.

- While, **chemical weathering** could be the result of hydration/hydrolysis/carbonation/ oxidation/reduction.
- Water plays an important part in this process because it can bring about changes due to dissolution or reaction of the rock material. Basically chemical weathering has two phases as follows:-

  1. Disappearance of some minerals.

  2. Formation of new products.

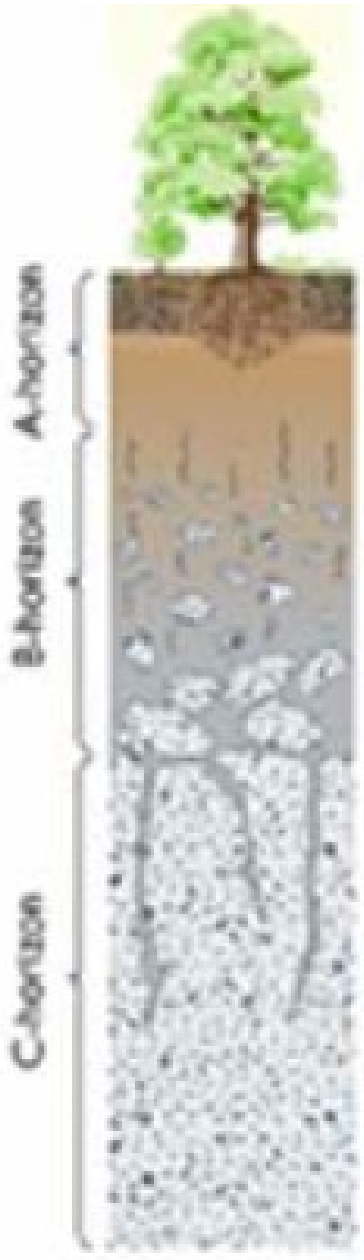
- **Biological weathering** - Strictly speaking, there is nothing like biological weathering. It is basically physical, chemical weathering by biological system or in other words by living organisms.
- The flora and fauna accelerate the weathering process. It starts with the growth of lichens on the rocks by their chemical secretions.
- Carbon dioxide liberated during respiration forms carbonic acid with the action of water. Lichens are followed by the growth of other lithophytes (e.g. Paphiopedilum orchids, ferns, many algae and liverworts) which corrode the rock through their secretions.
- Roots widen the cracks and the crevices of the rocks thus increasing the free percolation of water. The gliding action of the worms also helps in the reduction of stony particles in soil.

❖Soil Profile

- The process of soil formation results in the development of soil profile. Weathering of rocks results in soil formation that occurs over a period of time.
- Because of this, layers of strata's or horizons develop one over the other which may vary in thickness.
- These different horizons form the soil profile which can be defined as the vertical section of any soil from top to bottom.

- The different layer present in soil profile differ from each other in:
  1. Texture of mineral particles
  2. Colour of the soil
  3. Microbial activities
  4. Water holding capacity and
  5. Percentage of organic matter.

  The different horizons of soil are O1, O2 (topmost) followed by A, B, C, with finally bedrock at the bottom. These horizons are further subdivided as shown in the following Fig.



Topsoil (rich in organic matter)

Soil leached of soluble minerals rich in clay and insoluble minerals

Little organic matter, dissolved minerals from A-horizon precipitated

Bed rock cracked and weathered

Fig. Soil profile (vertical section of the soil showing different horizons)

Factors affecting Soil Formation

(1) Climate:-

- This affects directly as well as indirectly. **Rainfall** and **temperature** play a very important role.
- Rain water i.e. precipitation affects percolation and leaching since percolating water is responsible for dissolution and translocation of constituents of the parent rock material resulting in the their deposition at another region.
- Low temperature does not allow percolation in long winters.
- Percolation does not occur due to higher evaporation.
- No evaporation condition leads to the formation of lakes, swamps, peat and muck deposits.

(2) Organisms:-

- Plant roots penetrate the rocks creating space for movement of air and water.
- These dying roots produce many organic & inorganic acids.
- These substances produced react through the column of the parent material thus modifying the profile and soil constitution.
- Microorganisms play an important role in these reactions for example the burrowing animals dig the soil, thus mixing the material in horizons, as a result soil profile is disturbed.

(3) Parent Material:- This is a passive factor. Same conditions of decomposition will give rise to same type of soil profile.

- Once the factor of decomposition changes then same parent material may give a different type of soil profile.

(4) Time:- This also plays an important part but the age of the soil is judged in terms of maturity stage of development of the profile rather than the geological age of the parent material.

- Soil development in different climatic conditions varies.
- It is of the following types:-
  1. Laterization
  2. Podsolization
  3. Calcification
  4. Gleization

- **Laterization**: The terms Laterite has been derived from Latin word LATUS meaning brick.

  There soil are reddish brown in colour and are found in warm and humid climates including India
- **Podsolization**: This takes place in cool, humid climate. Leaching results into grey ash like surface leading to the term Podsol.
  - Which in Russian means:
  - Pod = Under, Zole = Ash ⟹ Under Ash

- **Calcification**: This is a common process in North India. It is a process in which accumulation of calcium carbonate occurs in the soil profile.

- **Gleization**: This takes place in predominantly ice covered regions like the arctic. Where soil is not saline, peat accumulates on the surface. Tundra soils are common example of gleization.

Soil Characteristics & Types of Soil

- Soil characteristic & types of soil very much depend on its physical properties mainly texture, porosity, colour, temperature etc
- Texture refers to different size of particles present in any soil type, this is given in the following table:
  - Gravel More than 2mm in diameter
  - Course Sand 2mm to 0.2mm in diameter
  - Fine Sand 0.2mm to 0.02mm in diameter
  - Silt 0.02mm to 0.002mm in diameter
  - Clay less than 0.002mm in diameter

- Apart from the physical properties certain chemical properties of soil are also important like pH, salts present in soil etc.
- The chemical nature of soil depends on parent rock which has provided the soil minerals after weathering and disintegration.
- Organic matter also contributes to the soil micronutrients present in soil.
- The nutrients depend on the decomposition of the dead remains of both the plants and animals.

Thanks