Soil Microbiology:

It is branch of science/ microbiology which deal with the study of soil microorganisms and their activities in the soil.

Soil: Is crucial for sustaining life, like water and air, because it is the source of most of our food. Soil can be defined as; the outer region of earth crust, consist of loose material formed by series of various processes called soil – forming factors(SFF), includes topography of land, the organisms present in the environment, the climate under which the soil was formed, the parent material or the original minerals that give rise to the soil, and the time that all of these processes have been occurring.

Soil Profile

Soil profile refer to the layers of soil develops over a long period of time, the soil profile consist of horizons, each with a distinctive features. The following horizons are listed by their position from the top to the bottom**:**

1. Horizon A (Top Soil)

Surface layer, is the top about 25cm of soil profile, with a darker in color than deeper layers and contain highest percentage of organic matter accumulation, this horizon also known as the biomantle because most biological activity occurs. The layer was likely formed from decomposing plant and mineral materials. It has a large amount of sand, and less clay.

2. Horizon B (Subsoil)

This horizon is found from 25 – 40cm, has a lighter color than the horizon A, with increase in clay and mineral salts such as deposits of silicates or aluminum that wash down through the top soil to create this layer, a process referred to as alleviated zone, It also contains less microbial population, but some biological activity extends into this layer

3. Horizon C (Parent Soil)

This third horizon has gray mottles, or patches of gray colors throughout the soil matrix. With strong increase in clay percentage, it's thickness of 45cm and more

may it reach the rocky layer. The layer indicated with the absence of organic matter and microbial activities.

4. Horizon D (Rocky bed)

This layer is found from 75cm and beyond, represent the parent material sitting on bedrock, may be weathered to form part of soil profile.

Soil Texture and Soil Structure

Soil texture and soil structure are both unique properties of the soil that have a profound effect on the behavior of soil, such as water holding capacity, nutrient retention and supply, drainage, and nutrient leaching. The combination influence of soil texture and structure may be best described by the term "**Soil bulk density**", is a measure of percent pore space and solid in soil.

Soil texture; referred to the proportion and distribution of mineral particles, sand, silt, and clay present, the texture of soil can be determined when the percentage of these three soil constituents are known. Table.1 illustrated soil particles size,

Table (1) Soil Texture Particles size

Type of Soil Particles	**Size range/mm**
Sand	2.0 – 0.05
Silt	0.05 – 0.002
Clay	Less than o.oo2

Physicochemical feature of soil depends mainly on its texture, because it influences plants growth by its direct effects on soil, aeration, water infiltration, and cations exchange capacity (CEC).

Sand, has large particle size with small surface area in comparison with same mass of silt and clay, in accordance to this little surface area the sand proportion of any soil has an importance as organizing skeleton for other constituents, in case of reasonable sand proportion the soil has enough pores which facilitate aeration and water drainage. Sandy soils are less productive than other.

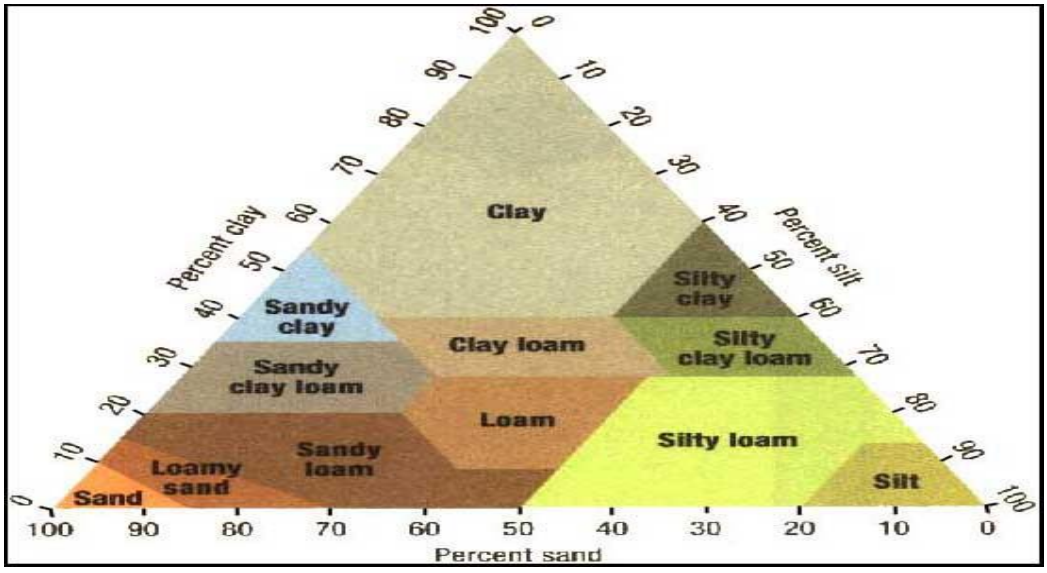
Silt, produced from fragmentation of rocks, also has small surface area, but in this character it's larger than those of sand particles, with smooth appearance look like cosmetic powders, and with low adherence capacity.

Clay, fraction made up tiny particles, despite their small size the particles have very large surface area relative to their volume, may be more than thousand times the total surface area of sand particles with same mass, resulting from the plate _ like shape of individual particles.

The increase in surface area is highly reactive and has the ability to attract and hold positively charged nutrient ions, clay particles are somewhat flexible and plastic because of their lattice – like design, this feature allow clay particles to absorb water and provides many places for soil particle to retain and supply nutrients, soil containing clay is the most productive and use fertilizers most effectively.

Textural class a grouping of soils based upon this relative proportion. Soil with the finest texture is called clay soil, while soil with coarsest texture is called sands. However, a soil that has a relatively even mixture of sand, silt, and clay and exhibits the properties from each separate is called loam.

There are different types of loams, based upon which soil separate is most abundantly present. Once the sand, silt, and clay percentage of a soil are, known, the textural class can be read from the textural triangle used to determine the soil type (**Fig-1**)



(Figure – 1) Soil texture triangle for determination of soil

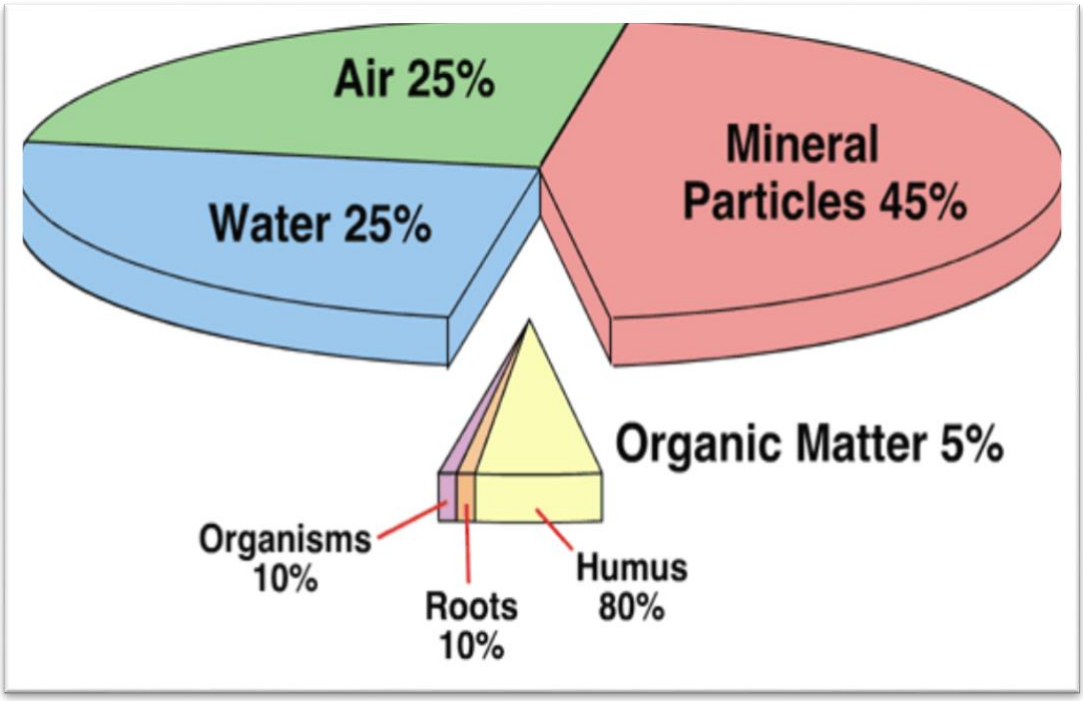
Soil structure; is the arrangement of soil particles into grouping. These grouping are called pads or aggregates, which often form distinctive shapes typically found within certain soil horizons. For example, granular soil particles are characteristic of surface horizon.

Soil aggregation is an important indicator of the workability of the soil. Soil that are well aggregated are said to have "god soil tilth

Soil Composition

Soils are made up of four basic components: mineral particles, air, water, and organic matter.

Solid materials (organic and inorganic) , which represent around half of soil content and spaces filled with air and water, each of them are important to life, four basic components: minerals, air , water, and organic matter



(Figure - 3) Soil composition

Inorganic materials

In most soil types inorganic materials (mineral particles) represent about 45% of total soil volume. The mineral portion formed from the rock bed by weathering and biogeochemical factors, mineral portion consist of three distinct soil particles sand, silt, and clay Particles.

Based on chemical nature the mineral portion of soil can be divided into two groups,:

***Non – Silicate**

Includes; Oxides, hydroxides, sulfates, chlorides, carbonates, and phosphates.

***Silicate group**

Are very complex in structure, vary in its stability and resistance to decomposition, among these group **SiO2** is the most abundant one. It may contain about 70% of total soil mass, except of organic soil.

Most soil influential particles are clay, it play a significant role in determining the availability of nutrient and water to different life forms

Clay particles are negatively charged, due to exchange of SiO_2 and Al^{3+}

$$Al^{3+} + SiO_2 \longrightarrow AlO^{2-} + Si^{4+}$$

Net particles charge depends on soil microorganisms metabolic activities and pH of soil solution.

• Water and Air

Soil particles pack loosely, forming a soil structure filled with pore spaces, these pores contain soil solution (water) and gas (air). Water and air in soil vary significantly with soil texture, weather, and plants uptake of water, but their percentage together in most of soil types is about 50 % of total soil volume. Soil pore space doesn't change depends on soil texture and structure , but after rain the soil pore space will have a high percentage of of water in relation to air, once the

***Soil water*:** Comes from rain, snow, dew or irrigation. Soil water serve as solvent and a carrier of nutrient for plant growth. The microorganisms inhabiting in the soil also require water for their metabolic activities. Soil water thus, indirectly affects plant growth through its effects on soil and microorganisms. Percentage of soil – water is about 25 % total volume of soil.

Soil water amount affected by many factors;

- ***Porosity:***

Soil porosity refers to the space between soil particles, which consists of various amounts of water and air, porosity depends on both soil texture and structure, for example, a fine soil has small but numerous pores than coarse soil. A coarse soil has bigger particles than a fine soil, but it has less porosity. Water can be held tighter in small pores than in large one, so fine soils can hold more water than coarse soil.

- ***Infiltration:***

  Water infiltration refers to the movement of water from soil surface to the soil profile. Soil texture – structure, slope, and gravitation has the largest impact on filtration rate, water move by gravity into the open pore space in the soil, the size of soil particles and their spacing determines how much water can flow in.

- ***Permeability:***

Soil permeability refers to the movement of air and water through the soil, which is important because it affects the supply of root – zoon.

Water holding capacity is controlled permeability, by the combination effects of soil texture and organic matter, soil with smaller particle (silt and clay) have large surface area than those with large sand particles, so the first one has a high water holding capacity and allow a soil to hold more water than the second type.

Soil air: Apart of soil pores which not occupied with water are filled with air. Compared with atmospheric air, soil is lower in oxygen and higher in carbon dioxide, because CO2 is continuous recycled by microorganisms during the process of decomposition of organic matter. Soil air comes from external atmosphere and contains nitrogen, oxygen, CO2, and water vapor (CO2> O2).

CO2 in soil air is (0.3 – 1.0) more than atmosphere air (0.03%). Soil aeration plays important role in plants growth, microbial population, and microbial activity

in soil. A good aerated soil types lead to complete oxidation of organic matter, and characterized with high redox potential capacity, which offer e- and H+ donor and acceptors, results in thrive of aerobic and facultative microorganisms, but poor aerated soil types (saturated soils), which featured by low redox potential capacity cause continues release of NO3- and SO42+ and accumulation of some harmfully intermediates like CH4, that affected soil fertility and increase of anaerobic microorganisms population.

• Organic matter

Soil organic matter (SOM) is one of the most important components of soil ecosystem, in its broadest sense, and complex combination of living organisms and non – living organic matter (fresh organic residues, actively decomposing material, and humus). Generally the proportion of SOM in the soil ranging from 3 – 5 % of total soil volume.

Non – living organic matter can be considered to exist in two distinct pools:

Nonhumic Substances: Its particulate matter represents microbial metabolites products, all with identifiable structure, like polysaccharides , amino acids, organic phosphorus. This organic matter can constitute from a few percent up to 25% of total organic matter in soil**.**

Humic Substances: Carbon decomposition, successive decomposition of dead material, and modified organic matter results in the formation of undefined organic matter called humic substances or humus, by a process is called humification. Humus comprise both organic molecules of identifiable structure like proteins and cellulose, and molecules with no identifiable structure, like plants residues such as lignin, remains of animal carcasses (waxes, hair, nail, wool, and feather), also humin , humic acid, and fulvic acids are major components of humus. Humus is very stale, long – lived pool of organic matter in soil (with turnover rate of 100 – 500 years), which makes it a effective way to sequester excess carbon. Humus affects soil properties, as it slowly decomposes, it colors the soil darker, offer spongy appearance , encourages aggregate formation , increase water and nutrient retention and contributes to N, P, S, and other nutrients.

• Soil Living organic matter (Soil Biota) 5.**Soil microorganisms:**

Soil is an excellent culture media for the growth and development of various microorganisms. Soil is not an inert static material but a medium pulsating with

life. Soil is now believed to be dynamic or living system. Soil contains several distinct groups of microorganisms and amongst them bacteria, fungi, actinomycetes, algae, protozoa and viruses are the most important. But bacteria are more numerous than any other kinds of microorganisms. Microorganisms form a very small fraction of the soil mass and occupy a volume of less than one percent. In the upper layer of soil (top soil up to **10-30 cm** depth i.e. Horizon A), the microbial population is very high which decreases

with depth of soil. Each organisms or a group of organisms are responsible for a specific change /transformation in the soil. The final effect of various activities of microorganisms in the soil is to make the soil fit for the growth & development of higher plants.

Living organisms present in the soil are grouped into two categories as follows.

1. **Soil flora** (micro flora) e.g. Bacteria, fungi, Actinomycetes, Algae and

2. **Soil fauna** (micro fauna) animal like eg. Protozoa, Nematodes, earthworms, moles, ants, rodents .Relative proportion / percentage of various soil microorganisms are: Bacteria-aerobic **(70%),** anaerobic **(13 %)**, Actinomycetes **(13%),** Fungi /molds **(03 %)** and others (Algae Protozoa viruses) **0.2-0.8 %.** Soil organisms play key role in the nutrient transformations.