

Soil Profile and Soil Microorganisms

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What is Soil?

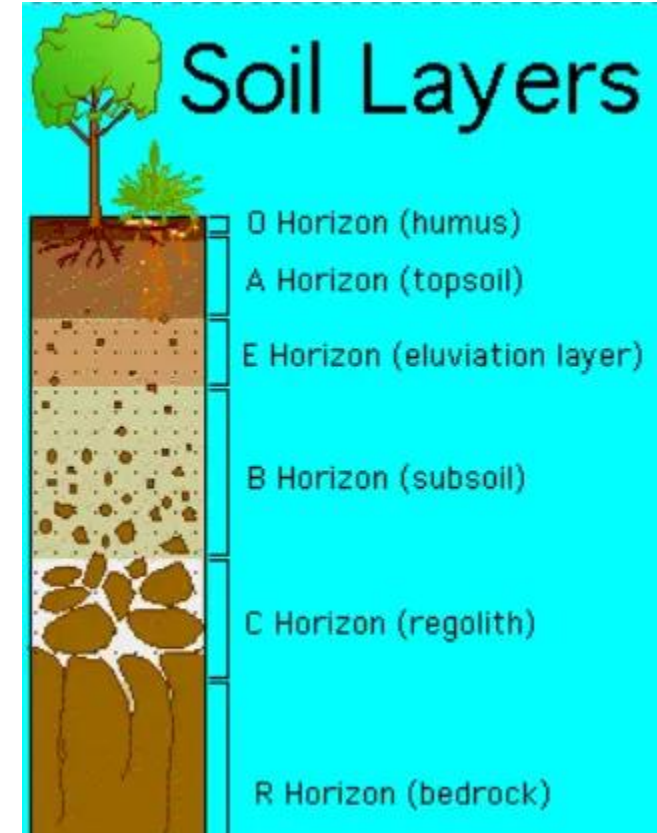
- **Soil is a natural resource that forms the Earth's surface layer through the interaction of organic matter, minerals, water, air, and living organisms.**
- It provides a medium for plants to grow, supports various ecosystems, and plays a crucial role in the Earth's
- biogeochemical cycles. Soil composition varies, but typically includes minerals, organic matter, water, and air. Different types of soil
- have varying levels of fertility, influencing their ability to sustain plant, animal life and microorganisms.

Soil Profile

- **Soil Horizons:** Soils are often organized into layers or horizons.
- The top layer, known as the topsoil, is rich in organic matter and is where most plant roots grow.
- Below this, there are subsoil layers that contain minerals leached down from the above layer.
- **A soil profile is a vertical cross-section of the soil that displays all of its horizons (layers) from the surface down to the bedrock.**
- It provides a detailed view of the soil's composition, structure, and other properties at a specific location.
- Soil profiles are typically studied by soil fertility, drainage capabilities, and suitability for various agricultural or construction purposes.
- **Soil profiles help scientists and farmers comprehend the soil's characteristics, including its texture, color, nutrient content, and depth of the different layers.**
- By analyzing the soil profile, experts can make informed decisions about land use, crop selection, irrigation practices, and soil management techniques.

Soil Profile Diagram

- A soil profile diagram is a visual representation of the layers (horizons) of soil from the surface down to the bedrock.
- In the soil profile diagram that we mentioned below, there is a brief description of almost all the layers of the soil such as Topsoil (A Horizon), Subsoil (B Horizon), Parent Material (C Horizon), and Bedrock.
- **These layers are depicted vertically, showing their relative thickness and characteristics.**
- Soil profile diagrams are essential tools for understanding the composition and quality of soil in a specific area, aiding in agricultural, ecological, and engineering assessments.



Different Layers of Soil

| Soil Layers | Description |
|------------------|-----------------------------------------------------------------------------------------|
| O Horizon | It is the topmost layer of the soil, rich in organic material. |
| A Horizon | The A horizon is also known as topsoil, which is rich in minerals and organic material. |
| E Horizon | Leached layer, light in color and nutrient-poor. |
| B Horizon | Subsoil accumulates minerals and nutrients. |
| C Horizon | Partially disintegrated rock lacks organic material. |
| Bedrock | The solid rock beneath the soil layers. |

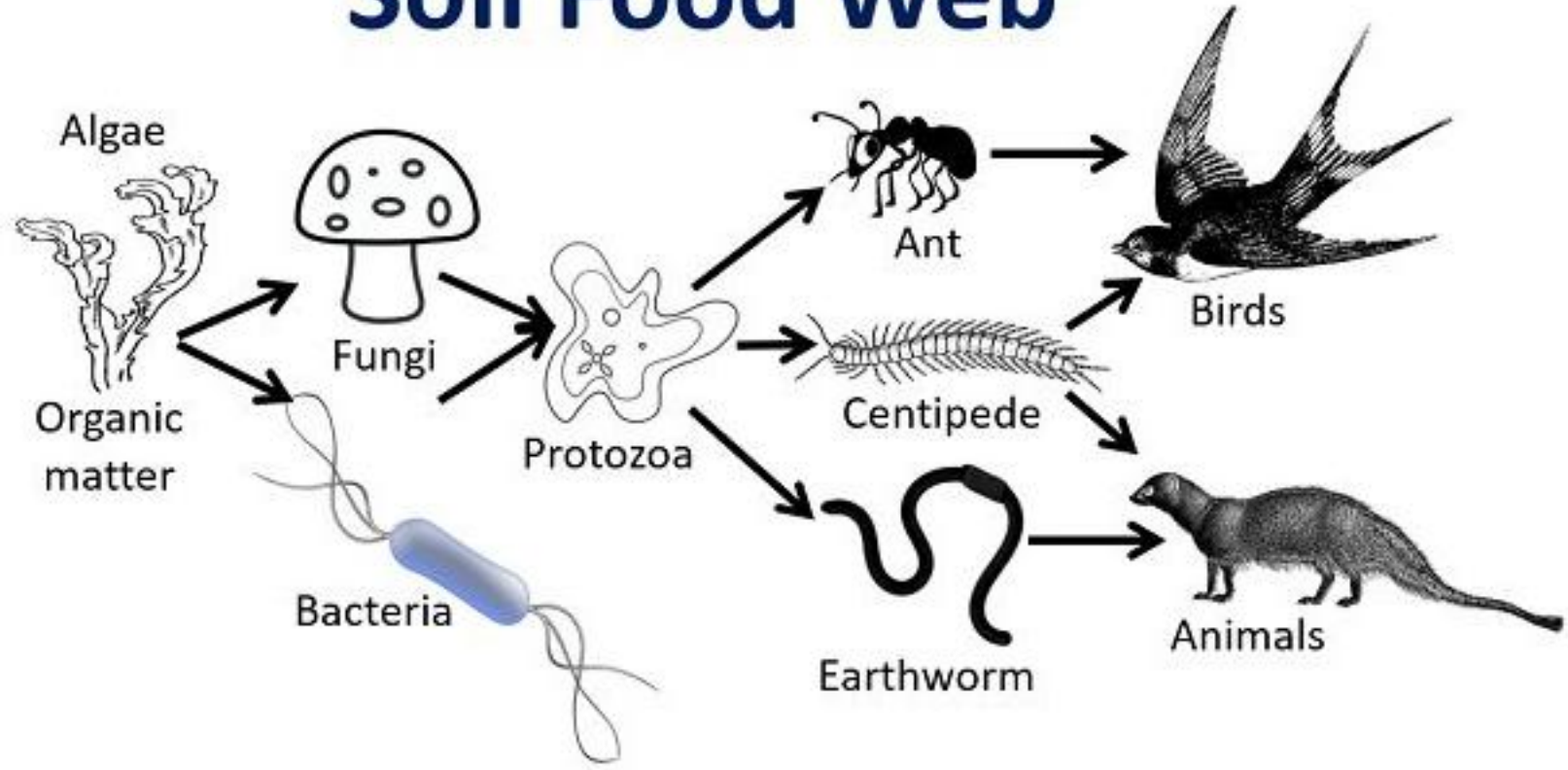
Layers of Soil

- **O Horizon:** This is the topmost layer of the soil, composed mainly of organic material like decomposed leaves and plant matter.
- **A Horizon (Topsoil):** This layer is rich in minerals and organic material. It's where most plant's roots grow and where many biological and chemical activities occur.
- The germination of seeds takes place in the Topsoil.
- **E Horizon:** This layer is light in color and leached of minerals and nutrients.
- It's often found in forest ecosystems.
- **B Horizon (Subsoil):** This layer accumulates minerals and nutrients leached down from the topsoil.
- It contains minerals like iron, aluminum, and clay.
- **C Horizon:** This layer consists of partially disintegrated and weathered rocks.
- It lacks the organic material found in the upper layers.
- **R Horizon (Bedrock):** This is the solid rock beneath the soil layers. Roots do not penetrate this layer, and it is not considered part of the soil profile in terms of plant growth.

Soil Microflora

- Soil microflora refers to a group of soil microorganisms, which primarily constitute the portion of the soil organic matter and some colloidal portion of the soil humus.
- Five major groups of microorganisms (bacteria, fungi, algae and protozoa) are part of soil microflora.
- They constitute the soil microbial population, in which each group has a significant role in promoting soil and plants health.
- Microbial community living within or on the soil system form a soil food web.
- Like the food web, the **soil food web** also represents the complex living system where all the soil microorganisms interact with the biotic components of the ecosystem, including plants, animals and humans.
- The **organic matter** of the soil, i.e. plant's and animal's wastes, serve as the **producers** or contribute to the first trophic level of the soil food web.
- Then comes the category of primary consumers, which includes decomposers and mutualists (like bacteria and fungi) and contribute to the second trophic level.
- Afterwards, the secondary consumers include shredders and predators (like nematodes, arthropods and protozoans), which make up the third trophic level of the soil food web.
- The tertiary consumers have higher predators like birds and animals, which form the fourth trophic level of the soil food web.

Soil Food Web



Soil Microfauna

- They are less than **0.1 mm** in size.
- Nematodes and protozoans are the soil microfauna, which attacks the primary decomposers and mutualists (bacteria, mycorrhizal fungi and saprophytic fungi).
- Thus, they function as **predators** as well as parasites (cause crop diseases).
- They are generally root feeders and some feeding on the soil particles and the thin water film.

Soil Microflora

- It primarily includes bacteria and fungi.
- Bacteria are numerous, and they participate in various soil **transformation processes** like weathering of rocks, breakdown of organic matter and nutrient recycling.
- Fungi are also important for the decomposition process, and they also help in soil aggregation and restoring nutrients.

Bacteria

- The number and variety of bacteria predominate over the other groups of soil microorganisms.
- Their number exceeds several million to billions in one gram of soil.
- Direct microscopic and plate count methods are generally employed to enumerate the number and different groups of bacteria in the soil.

Decomposers

- They degrade the plant's and animal's wastes into accessible nutrients.
- Bacteria primarily decompose the dead organic waste before decomposition by fungi.
Examples: *Bacillus subtilis* and *Pseudomonas fluorescens* etc.

Nitrogen Fixers or Nitrifying Bacteria

- This group of bacteria fix the atmospheric nitrogen into the formulations, which the plants can access.
- Firstly, nitrite bacteria (*Nitrosomonas* spp.) convert the ammonia into nitrites (NO_2^-), and nitrate bacteria (*Nitrobacter* spp.) convert the nitrites (NO_2^-) to nitrates (NO_3^-).
- They prefer alkaline pH and increase soil fertility.

Denitrifiers

- They split nitrates back into the atmospheric nitrogen, thereby decreasing the nitrogen fertility of soils.

Mutualists

- Rhizobium is a mutualistic bacteria that associates with leguminous roots to fix atmospheric nitrogen within the soil by forming root nodules. *Azotobacter*, *Azospirillum* and *Clostridium* species are the free-living nitrogen fixer.

...Bacteria

Pathogenic Bacteria

- Few species of bacteria cause plant diseases like bacterial blight, bacterial canker and black rot. They can cause severe outbreaks in various crops, starting from the damage in leaves to the entire field.
Example: *Xanthomonas axonopodis* pv. *citri* causes [citrus canker](#), *Pseudomonas syringae* causes bacterial speck of tomato.

Disease suppressors

- Soil bacterial population also includes some species that produce antibiotics, which protect the plants from disease-causing or pathogenic organisms or plant pathogens.
- Diverse bacterial populations maintain the equilibrium in the soil ecosystem by competing for the same nutrients, minerals and water.

Sulfur oxidizers

- Some bacteria (like *Thermothrix*, *Thiobacillus* etc.) split sulfides (present as soil minerals) into sulfates. Plants cannot utilize sulfides, for which sulfides must be converted into the usable form that a plant can consume.

Actinomycetes or Actinobacteria

- They are the type of filamentous bacteria, which gives a characteristic smell, structure and texture to the soil by secreting compound geosmin. They decompose the organic residues like chitin, lignin etc., like fungi.

Fungi

Decomposers

- Fungi are the active decomposers that degrade the complex or woody organic matter (cellulose, chitin, lignin and pectin) that are hard to decompose by the bacteria.
- They also help play a crucial role in securing nutrients by immobilizing soil nutrients.

Mycelial fungi

- They are multicellular and expands their hyphae deep into the soil, forming a dense network called mycelium.
- The mycelium entangles to promote binding or aggregation of the soil particles. They form water-stable soil aggregates.
- **Disease suppressors**
- They produce fungal enzymes and some antibiotic-like substances, which restrict the growth of other fungi, other groups of soil microorganisms and pathogens.
- **Mutualists**
- Arbuscular mycorrhiza (VAM) are the fungi having arbuscles. These growths are formed inside the cortical cells of the plant's root that have many small projections into root cells.
- Their hyphae extend outside the root, which increases the soil-plant interaction. They improve the availability of water and nutrients and also protect the roots from pests and pathogens.
- **Pathogens**
- Some fungal spores of the members like *Phytophthora*, *Rhizoctonia* and *Pythium species* decompose the living tissue by showing visible symptoms like lesions, blisters, wilting etc. The spores of pathogenic fungi remain dormant in the soil.

Algae

- Among different groups of bacteria and fungi, the number of algae is somehow less (100-10,000).
- **Green algae** and **diatoms** predominates in the soil.
- They usually inhabit the ground surface or the layer below it, to carry out photosynthetic and other metabolic activities.

Protozoa

- Flagellated protozoans and amoebas are prevalently found in moist soils. They mainly feed on bacteria. They are unicellular, colourless, appear larger than the bacteria and exist predominantly in the surface soil.