For agriculture engineers

Understanding Soil

Done by Dr: Djamai Soumia

The Content

01. **What is Soil?**

02. **The Soil Profile: Layers of Soil**

03. **Soil Types**

I. What is Soil?

Soil is a mixture of **minerals, organic matter, air, and water** that serves as a medium for plant growth.

What is Soil?

It forms the upper layer of the Earth's surface

It is formed through the weathering of rocks and the decomposition of organic material over thousands of years.

II. The Soil Profile: Layers of Soil

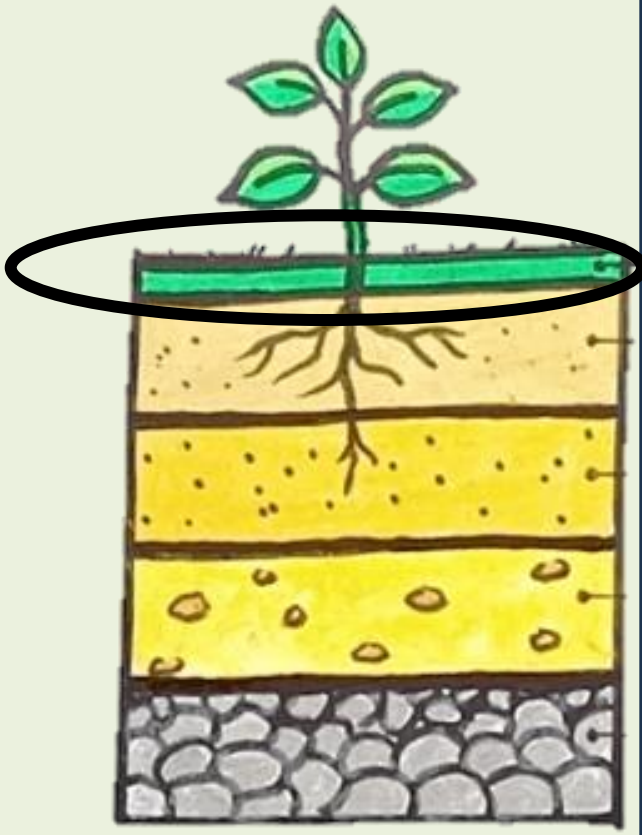
Soil is made up of several distinct layers, each with its own characteristics. These layers are referred to as the "soil profile." There are typically four main layers:

1. O Horizon (Organic Layer)

- It is the topmost layer of the soil profile, primarily made up of organic matter.

- It consists of :

  - decomposed leaves,
  - plant material,
  - and sometimes dead animals.



Key Characteristics of the O Horizon:

- **Organic Matter**

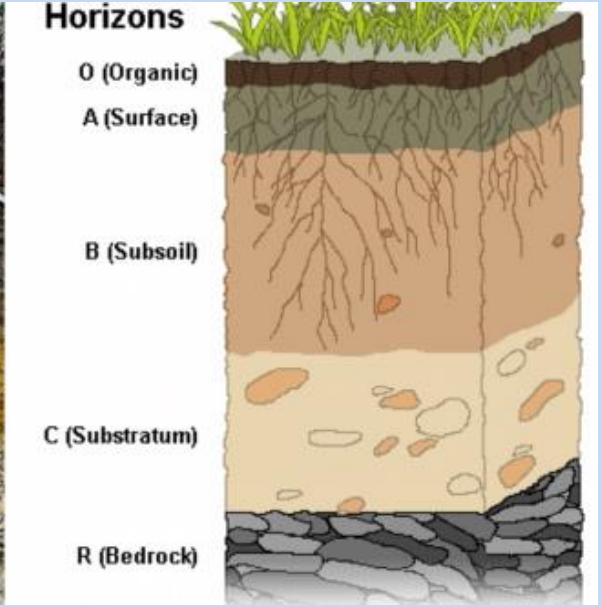
This horizon is rich in **organic material**, such as decomposed plant material, fallen leaves, and other organic residues.

It is the source of most of the nutrients that plants use for growth.

Key Characteristics of the O Horizon:

- **Dark Color**

Due to the high concentration of organic material, the O horizon tends to be **dark in color**, **often brown or black.**


Horizons
O (Organic)
A (Surface)
B (Subsoil)
C (Substratum)
R (Bedrock)


20
40
60
80
100

Key Characteristics of the O Horizon:

- **Biological Activity**

It is a hotspot for microbial activity, where bacteria, fungi, earthworms, and other decomposers break down organic material in **humus**.

This process enriches the soil with nutrients that plants rely on.

Key Characteristics of the O Horizon:

- **Nutrient-Rich**

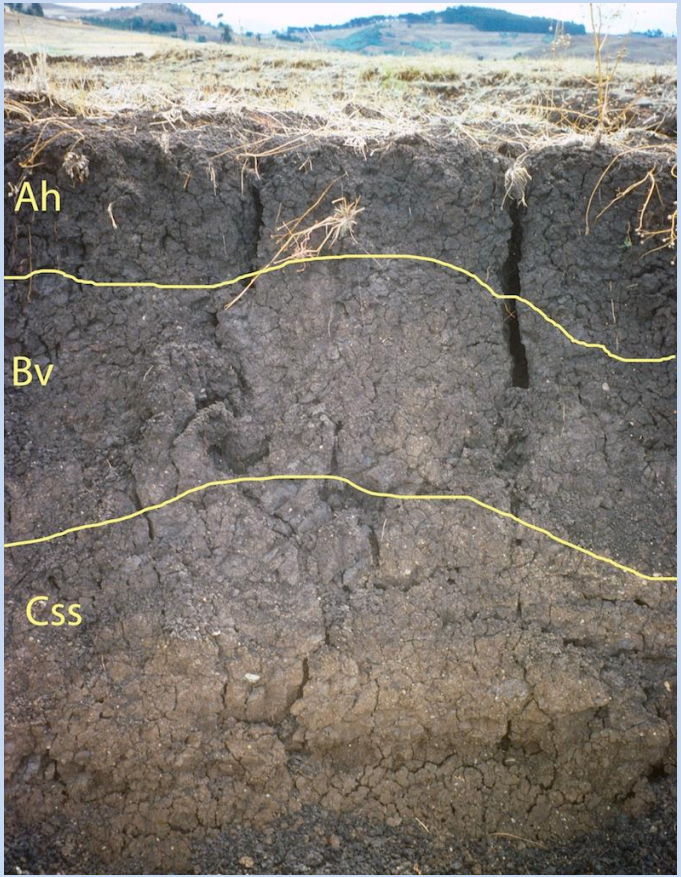
Key Characteristics of the O Horizon:

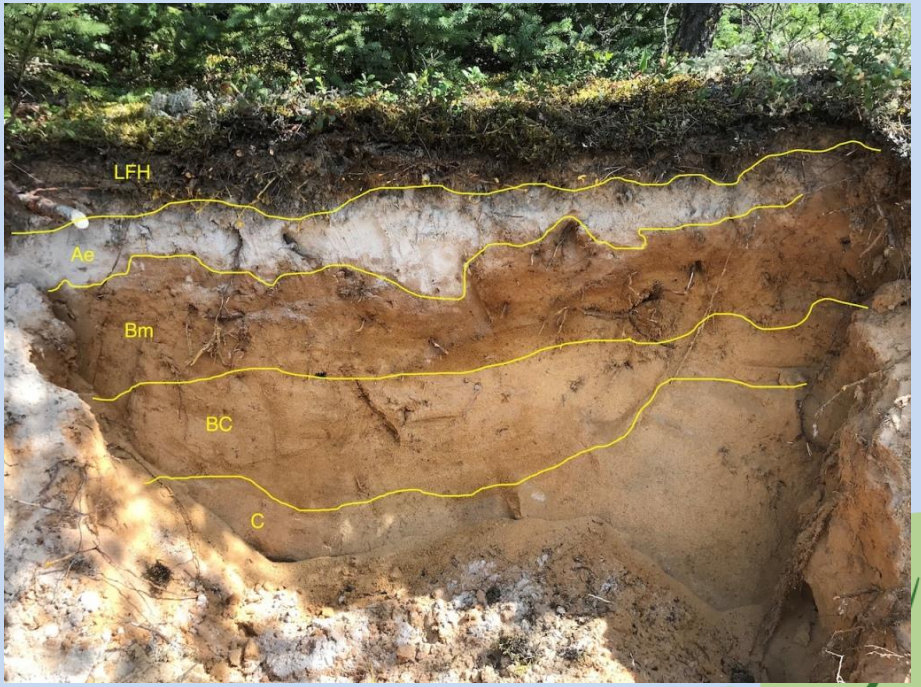
- **Thin Layer**

In many soils, the O horizon is relatively **thin**, especially in temperate or arid regions.

However, in forested areas with lots of leaf litter, it can be **thicker**.

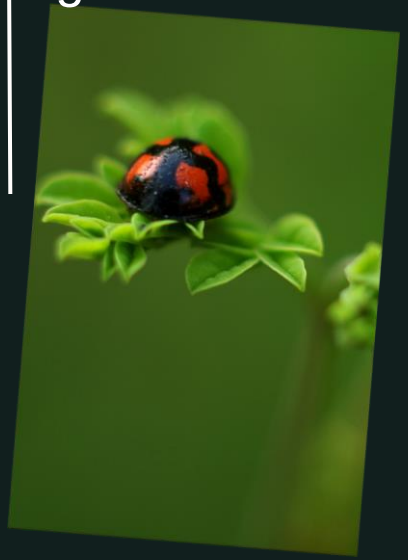
Key Characteristics of the O Horizon:





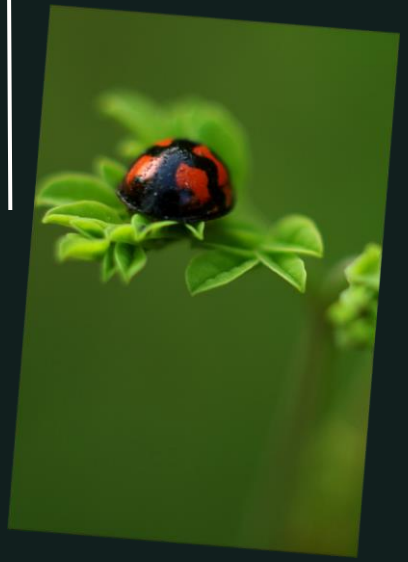
Functions of the O Horizon:

1- Nutrient Supply: By decomposing organic matter, this layer enriches the soil with essential nutrients, which plants depend on for growth.



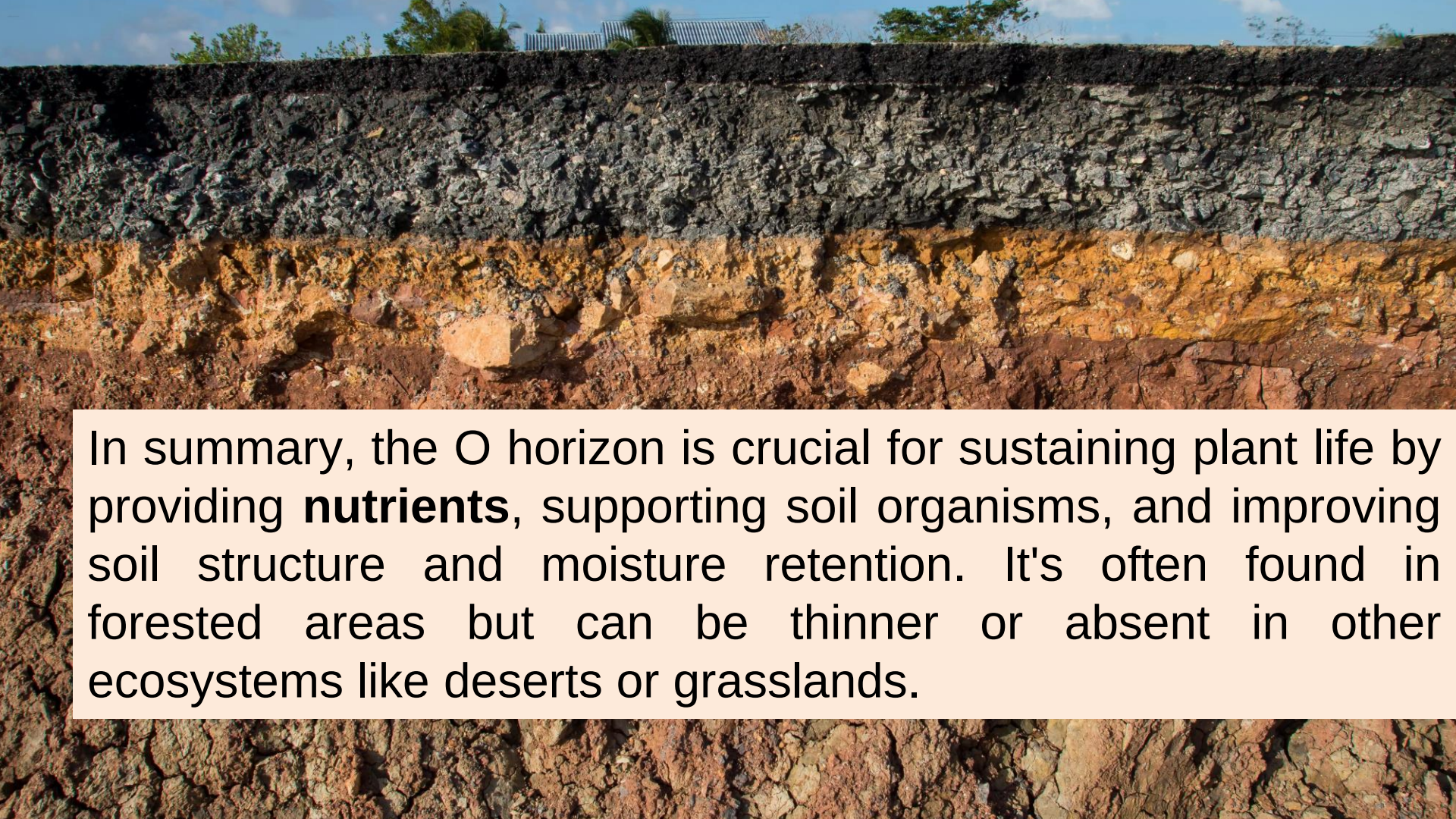
2- Soil Fertility: The humus in the O horizon enhances the soil's ability to retain moisture and nutrients, which improves soil fertility.

Functions of the O Horizon:

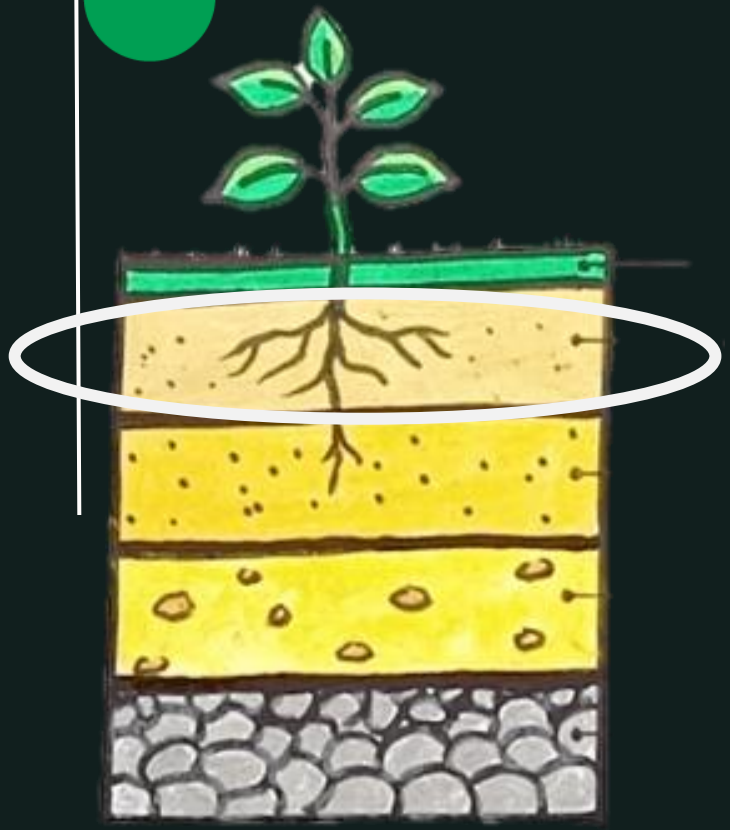


3- Soil Structure: The organic matter helps to bind soil particles together, improving soil structure and making it easier for plant roots to penetrate.

4- Water Retention: It helps the soil hold moisture, preventing water from draining too quickly, which is vital for maintaining plant health.



In summary, the O horizon is crucial for sustaining plant life by providing **nutrients**, supporting soil organisms, and improving soil structure and moisture retention. It's often found in forested areas but can be thinner or absent in other ecosystems like deserts or grasslands.



2. A Horizon (Top soil)

The **A Horizon**, also called **top soil**, is the second layer of the soil profile and one of the most important layers for plant growth

Key Characteristics of the A Horizon:

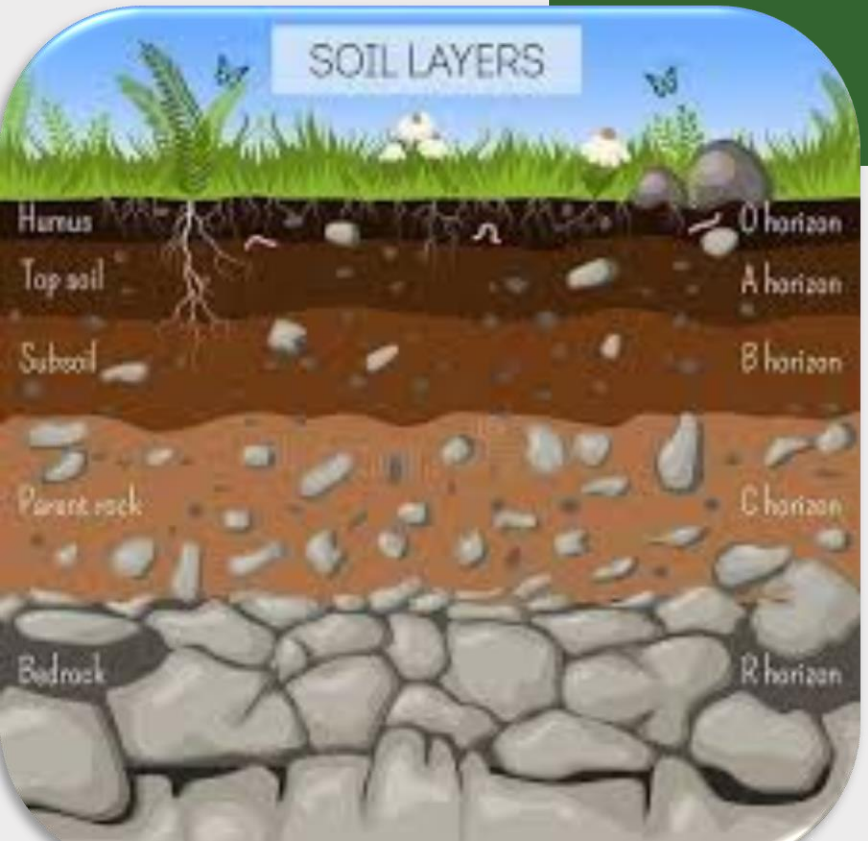
-Composition

-Color

-Texture

-Biological Activity

-Thickness



Composition

•A mixture of **organic material** (from the O Horizon) and **mineral particles** (like sand, silt, and clay).

•Contains **humus**, which gives it a rich, dark color.

•Nutrient-rich due to the decomposition of organic matter.

Color

- Generally darker than the layers below it because of the presence of organic matter.
- Its color can vary depending on the type of soil and the amount of organic content

Texture

- The texture depends on the proportions of sand, silt, and clay.
- Loamy soils (balanced mixtures) in the A Horizon are often ideal for farming.

Biological Activity:

- A hotspot for soil organisms such as earthworms, insects, fungi, and bacteria.
- These organisms help break down organic matter and recycle nutrients.

Thickness

Varies based on climate, vegetation, and land use:

- **In fertile regions**, it can be deep.
- While in **arid or heavily eroded areas,** it may be thin or even absent.

Function of the A Horizon:

1- Plant Growth: It is the primary layer where plants anchor their roots and absorb water and nutrients.

2- Supply for Plants: is rich in organic matter (humus) and minerals, providing essential nutrients like nitrogen (N), phosphorus (P), and potassium (K).

Functions of the A Horizon:

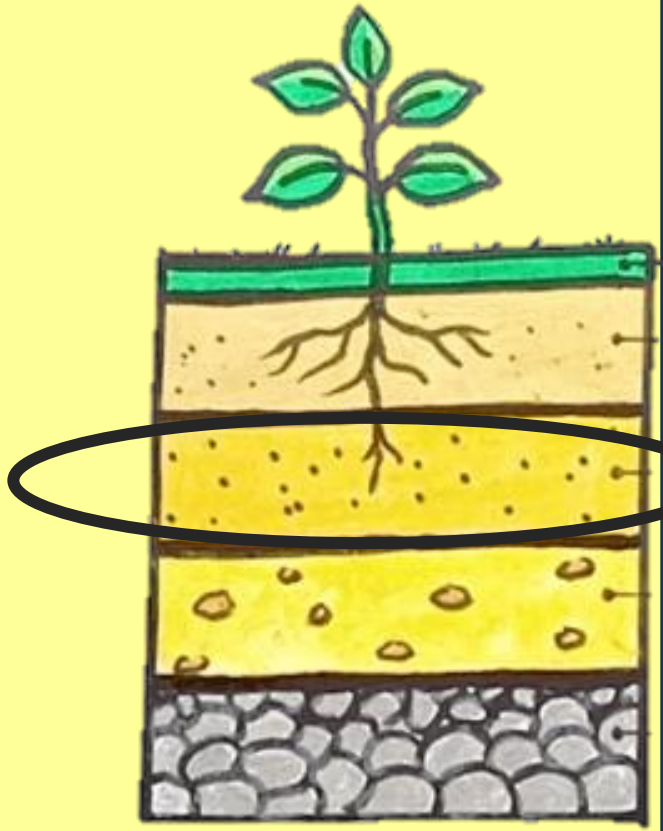
3- Water Retention: The organic material helps retain water, making it available to plant roots.

4- Support for Ecosystems: Acts as the base for plant growth and supports diverse ecosystems, from crops to natural vegetation.

3. B Horizon (Sub soil)

- The **B Horizon**, also known as the **sub soil**, is the layer beneath the A Horizon (topsoil) and above the C Horizon (parent material).

- It plays a crucial role in **soil development**, **nutrient storage**, and **water movement**.



Key Characteristics of the B Horizon

Composition:

- Contains minerals (such as iron, aluminum, and clay) that have been leached (washed down) from the A Horizon through a process called illuviation.
- Has less organic matter than the A Horizon but is richer in minerals.
- Sometimes referred to as the zone of accumulation because of the buildup of minerals from upper layers.

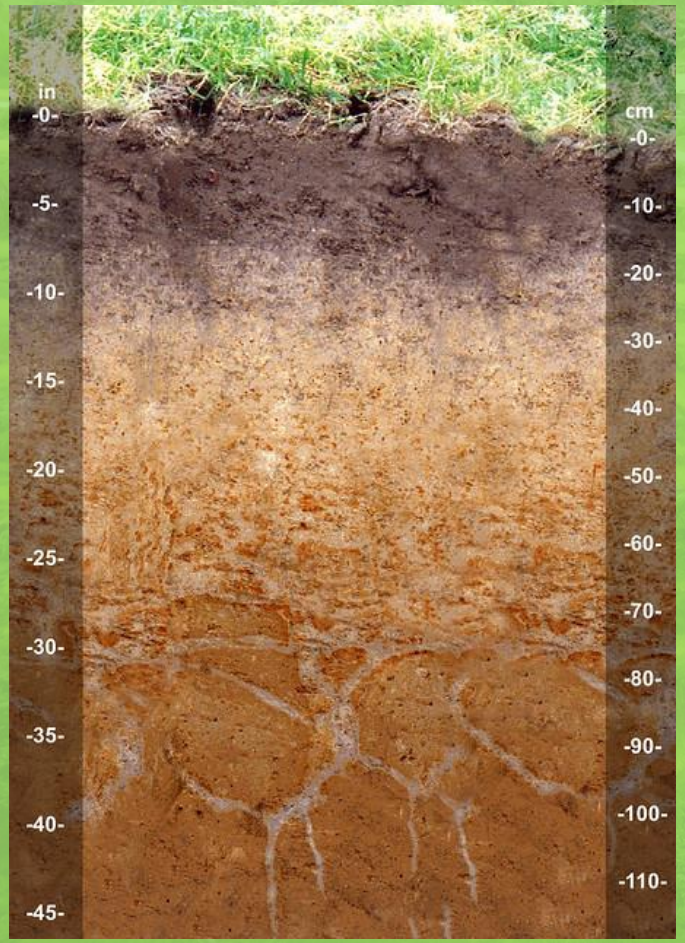
Key Characteristics of the B Horizon

Color:

- Usually **lighter** than the A Horizon but **darker** than the C Horizon.
- Can be **reddish, yellowish, or brown** due to the accumulation of iron oxides and clay.

Reddish or Reddish-Brown (Brick Red, Rusty Red):

- **Cause:** High iron oxide (Fe_2O_3) content due to oxidation.
- **Example Soils:** Tropical and subtropical soils, well-drained clay-rich soils.



Brown or Dark Brown

- **Cause:** A mix of iron oxides and some organic matter leaching down from the A Horizon.
- **Example Soils:** Common in well-drained temperate soils

Key Characteristics of the B Horizon

Texture:

- **Denser and more compact** than the A Horizon, making it harder for plant roots to penetrate.
- High **clay content**, leading to reduced water drainage compared to the A Horizon.

Thickness:

- Varies depending on soil type, climate, and location.
- In some regions, it can be quite deep, while in others, it may be relatively thin.

Functions of the B Horizon

Mineral Storage:

Acts as a reservoir for minerals like **iron, aluminum, and clay**, which have leached from the A Horizon.

Water Retention:

Due to its compact structure and high clay content, it holds water well, making it important for plant roots during dry periods.

Root Support:

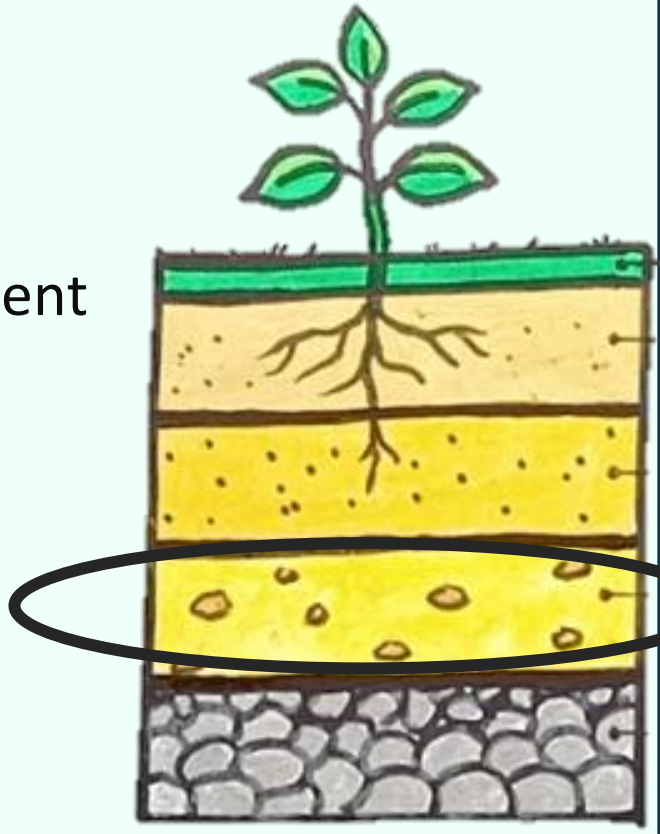
Some deep-rooted plants, like trees, can extend their roots into the B Horizon to access water and minerals.

Filtration and Water Movement:

Helps filter water as it moves downward toward the C Horizon and groundwater.

4. C Horizon (Parent Material)

- The C Horizon, also known as the parent material

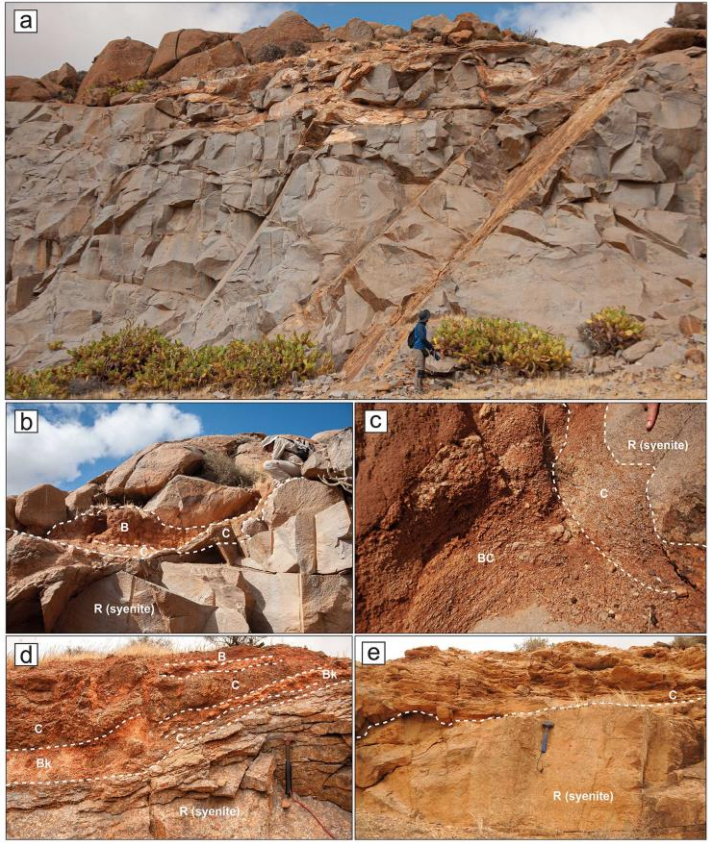


4. C Horizon (Parent Material)

It is the deepest layer of the soil profile

Weathered rock fragments and mineral deposits that serve as the foundation for soil formation.

The C horizon has minimal biological activity and little to no organic matter.



Mountainous Regions

Desert Soils

Agriculture

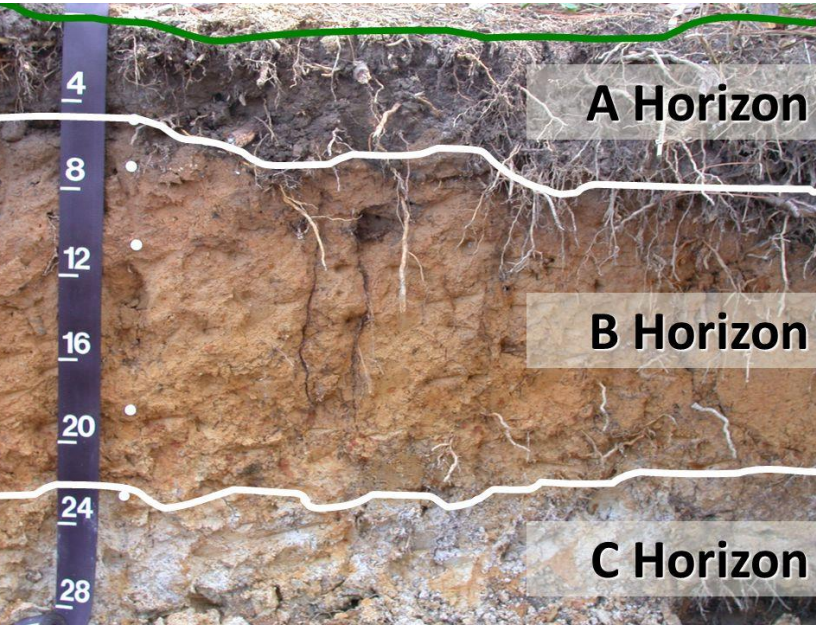
Key Characteristics of the C Horizon

Composition

Large rock pieces, minerals, and partially weathered bedrock.

Color

Varies depending on the type of rock; may be gray, brown, or reddish.


4
8
12
16
20
24
28
A Horizon
B Horizon
C Horizon


4
8
12
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24
28
32
36
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44
48

Key Characteristics of the C Horizon

Texture

Can range from loose and crumbly to hard and compact.

Moisture Content

Generally lower than upper layers but can store groundwater.

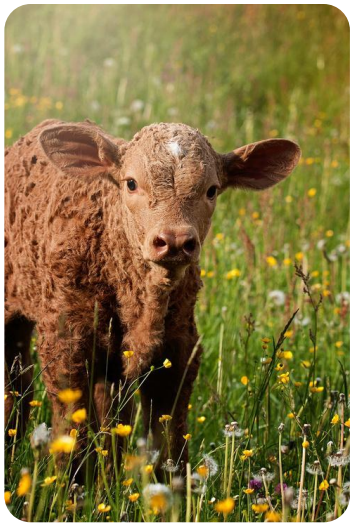
Key Characteristics of the C Horizon

Organic Matter

Very little to none compared to topsoil.

Root Penetration

Some deep-rooted plants, like trees, may reach this layer to access water and minerals.



Function of the C Horizon:

Function of the C Horizon:

Source of Minerals: Supplies minerals that slowly move upward to enrich the soil.

Foundation for Soil Development: Over time, weathering breaks down this layer, contributing to soil formation.

Function of the C Horizon:

Water Storage: Can hold groundwater, which may be accessed by deep plant roots.

5. Difference Between the soil Layers

Layer	Organic Matter	Minerals	Biological Activity	Texture
O Horizon	Very high	Low	Very high	Loose
A Horizon (Topsoil)	High	Moderate	High	Soft, crumbly
B Horizon (Subsoil)	Low	High	Low to moderate	Dense
C Horizon (Parent Material)	Very low	Mo ate to high	Very low	Rocky or loose