Theme: Soil

S2 New Curriculum Biology-Chapter 1 – Physical and chemical properties of Soil

Soil

The term soil is applied to a layer of material overlying the rocks of earth crust. Suitable nutrient contents and soil particle structure are essential for successful growth and production in ecosystem.

Importance of soil to living organisms

(i) **Plant Growth:** Soil provides essential nutrients, water, and support for plants, which are the foundation of most food chains. Without healthy soil, crops, forests, and natural vegetation wouldn't thrive.
(ii) **Habitat for Organisms:** Many creatures, from tiny microbes to insects and burrowing animals, depend on soil for shelter and food.
(iii) **Nutrient Cycling:** Soil helps recycle nutrients, breaking down organic matter and returning essential elements like nitrogen and phosphorus back to ecosystems.
(iv) **Water Storage & Filtration:** Soil absorbs, retains, and filters water, helping regulate the water cycle and ensuring clean groundwater for drinking and agriculture.
(v) **Carbon Storage:** Healthy soil captures carbon dioxide from the atmosphere, reducing greenhouse gases and combating climate change.
(vi) **Human Survival:** Agriculture, construction, and even medicine depend on soil. It supports food production, provides raw materials for buildings, and even contains microorganisms used in antibiotics.
(vii) It provides air for respiration of plant root.

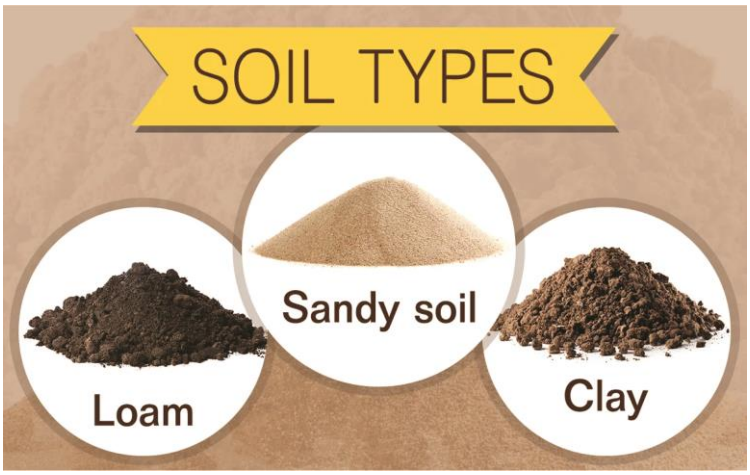
Components
Soil contains mainly

Component	Percentage of the soil
mineral salt (inorganic particle)	50 -60%
Organic matter	Up to 10%
Air	15 -25%
water	25 -35%

(i) Inorganic particles.

They are usually classified by the average size of particular shown below

Particle diameter (µm)	Particular name
<2	clay
2 - 20	silt
20 -200	fine sand
200- 2000	coarse sand
2 – 20 mm	gravel



Soil that contains a mixture of sand, clay, silt is the loam soil. Loams soil is mixture sand and clay soil in equal proportional with humus is the best soil for plant growth.

Physical properties of sand, clay soils are summarized below.

Properties	sand	clay
Texture	coarse	fine
Structure	light	heavily
Aeration	good	poor
Drainage	fast	slow
Water retention	poor	good
Nutrients	poor	good

(ii) Air and water

Water and air occupy the same space therefore the soil that contains more air will contain less water and vice versa. Aeration is the term used to describe the amount of air in the soil. Drainage is the ability of water to go through the soil. Oxygen is particularly required for respiration of microorganisms and plant roots; decomposition of organic matter, germination of seed, root hair formation and growth and water absorption.

Soil water is important

- As a source of water and dissolved mineral salt in plant.
- Promotes seed germination
- Excess water (water logging) slows down water absorption (by lowering the respiration of plant roots since it displaced air from the soil) and decay.
- Water softens soil for easy root penetration

Importance of soil air

- Oxygen is used to breakdown soil organic residue to less poisonous products such as carbon dioxide. In absence of oxygen organic residues are broken to pollutants like methane and organic acids

- Oxygen is used by microorganisms to oxidize nitrogen and sulphur into usable forms.
- Soil oxygen is used by plant roots to respire.
- Soil oxygen is used for respiration of microorganisms leading to oxidation of nitrogen and sulphur and recycling of nutrient,
- Poor aeration results in the development of toxins and other injurious substances such as ferrous oxide, H2S gas, CO2 gas, ethylene, organic acids, etc., in the soil.
- A deficiency of oxygen has been found to check the nutrient and water absorption by the plants
- Insufficient aeration of soil leads to the development of some diseases like, wilt of gram and dieback of citrus and peach.

Experiment to determine the percentage of water in a soil sample

A sample of a known mass of soil is dried in an oven at 1050C to a constant mass. The difference in the initial and final mass is the mass of water in the soil

Results

Mass of crucible = a g

Mass of crucible + soil = b g

Mass of crucible + soil after drying to constant mass at 100^0C in an oven = c g

Mass of soil = (b – a)

Mass of dry soil = (c – a)

Mass of water = (b – a) – (c – a) = (b – c)

The percentage of water = $\frac{(b-c)}{(b-a)}\ x\ 100\%$

Experiment to determine the percentage of air in the soil

A given volume of soil is placed in a measuring cylinder followed by a given volume of water. The mixture is stirred to a constant volume.

Result

Volume of the soil added to measuring cylinder = a cm^3
Volume of water added to measuring cylinder = b cm^3
Volume of soil and water after stirring = c cm^3

Volume of air = ((a + b) – c)
The percentage of air in the soil = $\frac{(a+b-c)}{a}\ x\ 100\%$

(iii) Organic matter

Dead organic matter is derived from soil organisms and from organism that live above the soil surface. Fungi and bacteria in the soil decompose organic materials to humus. Humus improves the water retention in the soil and therefore the soils containing humus will resist leaching.

Experiment to determine the percentage of humus in the soil

A mass of a dry soil sample is heated to redness to a constant mass. The difference in the masses is the mass of humus.

Results

Mass of the dish = a g
Mass of dish + dry soil = b g
Mass of dish + soil after heating to redness = = c g

Mass of dry soil = (b – a)
Mass of dry soil without humus = (c – a)
Mass of humus = (b – a) – (c – a) = (b – c)

The percentage of humus = $\frac{(b-c)}{(b-a)}\ x\ 100\%$

(iv) Soil organism.

The soil organism range in size from bacteria and protoctist to fungi, Nematode, insect, worms and a few mammals such as screw:

Role of soil organisms

(i) Microorganisms such as bacteria and fungi.
(ii) Promote germination by breaking seed coats
(iii) Fix nitrogen in the soil
(iv) Decompose and recycle or organic matter
(v) Macro organism such as rodent, termite and worms.
(vi) Turn the soil and improve aeration and drainage
(vii) Promote decay by breaking big pieces into small pieces
(viii) When they die they decay and add humus to the soil

(v) Dissolved minerals

The nature of dissolved minerals in the soil depend on the parent rock, organism growing in and above the soil and whether aerobic conditions prevail chalk soil for example are high in calcium carbonate. However, are low in phosphate, nitrogen and iron, again as is the case with oligohophic lakes, species diversity is high.

(a) **Soil pH** is the acidity or alkalinity of the soil. It usually lies between 3 and 8.

Effect of soil pH

- Acidic soil with pH of less than 4.5 reduce the availability of nitrogen and phosphorus to plant on the other hand,
- the concentration of toxic Al^{3+} ions increase as the pH falls. These two factors enable a few plants to grow in acid bogs. Those that do are often carnivorous and this supplies them with extra nutrients.
- Affect the activity of microorganism which may increase of reduce the rate of decay and nutrient recycling

(b) Soil Structure

This is the arrangement of soil particles, it refers to the looseness or compactness of the soil particle.

Its effects are

- Drainage for loose soil is faster than that of compact soil
- Erosion for loose soil is faster
- Aeration is higher in loose soil

(c) **Soil temperature**.

High soil temperature increases the rate germination, decay, absorption of water

Soil fertility

This is the ability of the soil to supply plant nutrients in adequate amount and right proportion for better plant growth.

Characteristics of productive soil

- It should be well drained.
- It should be of a sufficient depth for good root penetration and growth.

- It should be well aerated.
- It should have a good water holding capacity.
- It should have enough nutrients which must be the right proportions.
- It should be fee from crop pests and diseases.
- It should have a right PH for the particular crop to be grown on it.
- It should have a good structure and texture.

The causes of low soil productivity/fertility

- Soil erosion leads to loss of crop nutrients
- Leaching leads to inaccessibility of soil nutrients
- Poor drainage may lead to water logging and hence poor soil aeration and unfavorable soil temperature.
- Poor tillage destroys soil structure leading to leaching
- Unfavourable pH
- Soil capping i.e. development of impervious layer on the soil surface
- Development of hard pans or impervious layers below the soil surface
- Lack of required soil nutrients
- Presence of pests and disease causing organisms in the soil
- Presence of weeds which compete which compete with plants for nutrients
- Lack of adequate soil moisture.
- Mono-cropping cause soil exhaustion and build up disease causing organisms
- Burning of vegetation destroys soil living organisms
- Excessive irrigation cause leaching
- Excessive drainage lead to loss nutrients
- Salinity of the soil

Thanks

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