Soil.

Soil is the top most layer of earth's surface from which plants grow and obtain their nutrients. It consists of;

- ✓ Living organisms.
- ✓ Inorganic or mineral matter.
- ✓ Organic matter or humus,
- ✓ Air
- ✓ Water.

Soil formation.

Soil is formed from parent rocks through a process called **Weathering**. Weathering is the process of gradually breaking down hard rocks into smaller particles to form soil. The rate of soil formation depends on the;

1. nature of the parent rock.
2. type of weathering process.

Although there are many types of parent rocks, three major forms occur, namely; **igneous** rocks, **sedimentary** rocks and **metamorphic** rocks.

Igneous rocks are the hard volcanic rocks formed when molten lava from a volcano or crack in the earth's crust pours out over the land. The molten rock is called **magama** and as it cools it becomes very hard and solid.

Igneous rocks are hard to break down. They give rise to granite and basalts which are rich in potassium minerals.

Sedimentary rocks are formed as a result of deposition of particles like sand, mud by running water in water bodies. Over a long period of time, the sediment becomes compressed by earth movements and the particles become stuck together or cemented. Sediment rocks are ease to break down and give rise to sandstones and limestone which are rich in calcium.

Sedimentary rock is often found in the sea beds and beneath lakes and low-lying river valleys.

Metamorphic rocks are formed from either volcanic or sedimentary rocks which have undergone changes in formation beneath earth's surface by means of intense heat and pressure. The rock material is squeezed and stretched so that it becomes flattened.

Types of weathering.

Include;

- ✓ Chemical weathering.
- ✓ Physical weathering.
- ✓ Biological weathering

Physical weathering involves action of heat, frost, water, etc, on the parent rock which eventually break down.

Chemical weathering is due to action of chemicals such acids which weaken the rocks and cause them to eventually breakdown. Oxygen in the air may also cause oxidation of the iron in the rocks.

Biological weathering is due to the action of organisms on the rocks. E.g. plant roots, etc. As the plant roots penetrate and expand in the soil, they cause the rocks to split. Animals dig and burrow in the ground and so cause breakdown of rocks.

Importance/functions of soil components.

Air.

- ✓ Oxygen is used for tissue respiration of the roots and soil organisms, germination.
- ✓ Carbon dioxide increases soil acidity hence determining the distribution of soil organisms.
- ✓ Nitrogen is used in making proteins, amino acids, etc which are important for plant growth.

Water.

- ✓ It is a medium in which soil nutrients dissolve.
- ✓ Medium of transport in plants.
- ✓ Necessary for germination of seeds.
- ✓ Used in translocation of plant nutrients.
- ✓ Washes away accumulated salts and other toxic substances from the soil.
- ✓ Cools the plant when it evaporates from plant surfaces during transpiration.
- ✓ Is raw material for photosynthesis.
- ✓ Provides support in plant cells through turgidity.

Inorganic matter.

- ✓ Forms the frame work of the soil.
- ✓ Provides firm anchorage to plant roots hence support.
- ✓ Provides mineral salts to the plants.
- ✓ Have pores in between them which are occupied by air and water.

Organic matter.

- ✓ Is source of food for soil organisms.
- ✓ Is source of mineral salts when they decompose.
- ✓ is spongy hence allows water to percolate or drain through the soil.
- ✓ Forms a sticky coat around particles hence binding them together i.e. improves soil structure.
- ✓ Improves soil water holding capacity.
- ✓ Insulates the soil against extreme heat and cold i.e. moderate soil temperature.

Soil organisms.

- ✓ Improve soil aeration and drainage by construction of tunnels that are filled with air and allow water to pass through, e.g. tunnels of termites.
- ✓ Mix top soil with subsoil, e.g. termites when building their nests, earthworms, etc.
- ✓ Decompose organic matter.
- ✓ Weather parent rock particles to form soil.
- ✓ Some cause diseases to plants and animals, e.g. bacteria and fungi, etc.

Soil profile.

This is vertical section through the soil showing the different layers from the top to the parent rock.

Classification of soil.

Soil may be classified based on;

- Size of the particles/texture.
- Soil colour.

Based on the size of the particles, soil is divided into;

- Sand soil.
- Clay soil.
- Loam soil.

Relative size of soil particles.

Soil	Size in diameter (in mm).
Gravels(small stones)	20-2.0

Coarse sand.	2.0 - 0.2
Fine sand.	0.2-0.02
Silt.	0.02-0.002
Clay	Less than 0.002

Characteristics/properties of the different types of soils.

Clay soils.

- Very small particles which are closely packed together, hence limited air spaces in between the particles.
- Poorly drained/water logged/high water retention.
- Fertile due to high nutrient retention capacity and low leaching.
- Difficult to work on.

Silt.

- Good drainage.
- Easy to cultivate.
- Very high fertility.
- Very small quartz particles mainly silicon dioxide.
- Particles are smooth and powdery.
- Very high water holding ability.

Sand soil.

- Very good drainage due to large air spaces in between the particles.
- Poor water holding capacity.
- Easy to work on.
- Poor fertility due to rapid leaching out of mineral salts.
- Not good for cropping unless fertilized.
- High rate of leaching.
- Good aeration due to large air spaces between the particles.

Loam soil.

- Good drainage.
- Easy to cultivate.
- Fertile soil with sufficient supplies of soil moisture, air and plant nutrients.
- Best arable soil.

Importance of soil texture.

- ☞ It influences water holding capacity of the soil.
- ☞ Influences root penetration.
- ☞ Affects soil temperature, e.g. clay soils are colder than sandy soils.
- ☞ Determines the ability of the soil to retain water and nutrients.
- ☞ Influences soil aeration.
- ☞ Influences movement of water in the soil.

Experiment to determine the percentage of water in a soil sample.

Apparatus.

Wet soil sample, evaporating dish, stirring rod, source of heat, thermometer.

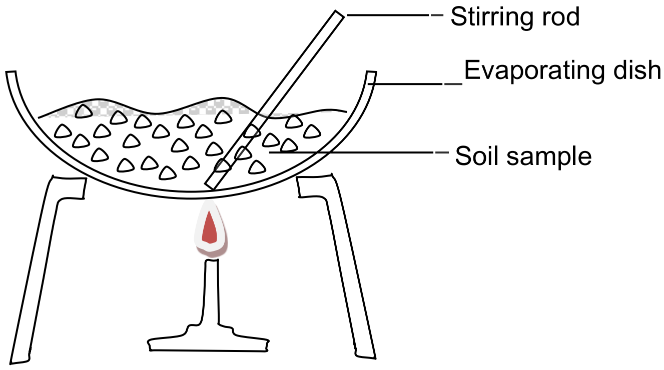
Procedure.

Weigh the evaporating dish when empty. Record its weight.

Place wet soil sample in the evaporating dish and weigh. Record the weight of the dish and wet soil.

Heat the soil while stirring it at 100°C to dryness. Cool and reweigh.

Repeat heating, cooling and reweighing until when a constant weight is obtained. Record this final weight of the dish and the dry soil.



Results.

Mass of empty dish = **a** gm.

Mass of wet soil +dish = **b** gm.

Mass of dish + dry soil = **c** gm.

Mass of water in soil sample = (**b-c**) gm.

Mass of soil + water = (**b-a**) gm.

Therefore percentage of water in the soil

$= \frac{(b-c)}{(b-a)} x\ 100\%$

Experiment to determine soil porosity or drainage and water retention of soil samples A, B and C.

Apparatus.

3 Measuring cylinders, cotton wool, 3 funnels, water, soil samples **A (**sand soil**), B (**clay soil**)** and **C (**loam soil**).**

Procedure.

Obtain dry soil samples **A** (sand), **B** (clay) and **C** (loam). Obtain equal volumes of soil samples and measure them separately. Plug the three funnels with cotton wool. Place the funnels in the mouth of three measuring cylinders. Pour sample **A** into the funnel 1, sample **B** into funnel 2 and sample **C** into funnel 3. Tap the funnels gently so that the soil particles settle completely.

Pour quickly a known volume of water, e.g. 50cm^3, into each funnel. Start timing. Note the time taken for the first drop of water to drain into the measuring cylinder in each set.

Allow the water to drain the through the soil samples until no more water drains through into the cylinder. Record the volume of water collected in the cylinders for the different soil samples.

Observation.

Shortest time taken for the first drop of water to drain through occurred in sample A, followed by sample C and longest time in sample B.

Results.

Volume of water poured into each funnel = V_1 cm^3.

Volume of water collected in cylinder = V_2 cm^3.

Volume of water retained by each soil sample = V_1-V_2 cm^3

Explanation.

Loam soil retains the highest amount of water because it contains organic matter that holds water firmly since it is sticky. Sand soil does not contain organic matter and has coarse structure hence a lot of air spaces between the particles. This allows water to easily drain through it. Small size particles in clay soils help in holding water which may lead to water logging.

Conclusion.

Sample **A** (sand soil) is the most porous, followed by sample **C** (loam soil) and then **B** (clay soil).

Experiment to determine the proportion of air in a soil sample.

Apparatus.

Soil sample, 3 measuring cylinder, water, and stirrer.

Procedure.

Put a known volume of soil in measuring cylinder, record its volume,

Measure a certain volume of water in the second measuring cylinder, and record it.

Mix the two volumes, stir the mixture until when all the air bubbles are given off. Allow the mixture to settle. Record the volume of the mixture after stirring.

Observation.

Bubbles of air escape from the mixture and the final volume of the mixture of water and soil after stirring is less than the sum total of soil and water

Results.

Volume of water = **m** cm^3.

Volume of soil = **n** cm^3.

Volume of mixture after stirring = **p** cm^3.

Expected volume of soil + water = (**m+n**) cm^3.

Therefore volume of air in the soil = **(m+n) - p** cm^3.

Percentage of air in the soil = $\frac{(\mathbf{m+n})-\mathbf{p}}{\mathbf{n}} \times \mathbf{100}\%$

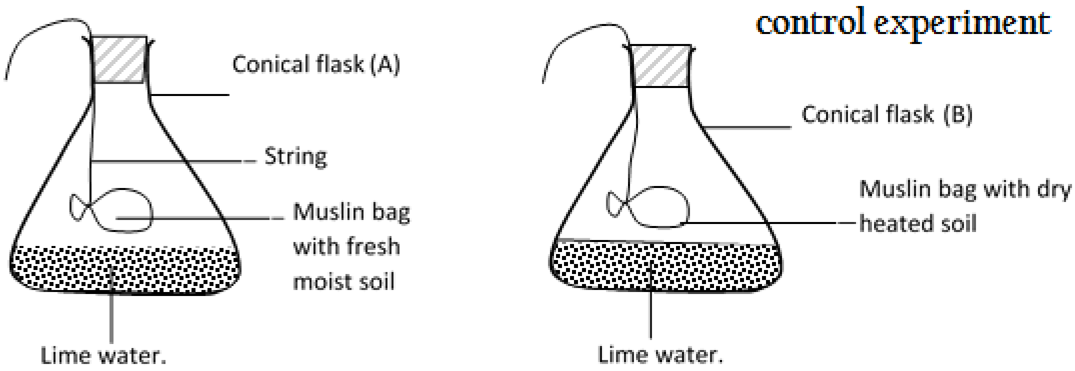
Experiment to show that soil contains living micro-organisms.

Basis for the experiment.

1. Living organisms respire.
2. During respiration, carbon dioxide is produced.
3. Carbon dioxide turns lime water milky.
4. Heat kills micro- organisms.

Procedure.

Set the experiments as below. Leave the setups to stand for 4 hours.



Lime water turns milky in the flask A and remains clear in flak B (the control experiment).

Explanation.

Lime water turns milky because of the carbon dioxide released by the living organisms in fresh soil. The carbon dioxide reacts with lime water to form calcium hydrogen carbonate which is insoluble. This causes the limewater to appear milky.

Heating killed micro- organisms in the control experiment, and so could not respire.

Conclusion.

Fresh, moist garden soil contains living organisms.

Experiment to determine the humus content of the soil.

Apparatus.

Crucible, dry soil sample, heat source, stirrer.

Procedure.

Weigh the crucible and record it. Place some dry soil sample in a crucible. Weigh the soil and the crucible. Heat the soil strongly. Note any change(s) that may occur in terms of colour, smell, and smoke. Note that the humus burns off into carbon dioxide and water vapour.

When there is no further change, allow the crucible and soil to cool. Repeat the heating and weighing until a constant weight is reached. Calculate the change in weight.

Results.

Mass of crucible = $\mathbf{M_c}$ gm.

Mass of crucible + dry soil = **M** gm.

Mass of crucible + soil after heating to constant weight = $\mathbf{M_h}$ gm

Therefore mass of humus= ($\mathbf{M - M_h}$) gm

Percentage of humus in the soil

$$= \left(\frac{M - \mathrm{M_h}}{\mathrm{M - Mc}}\right) \mathrm{x} \mathbf{100\%}$$

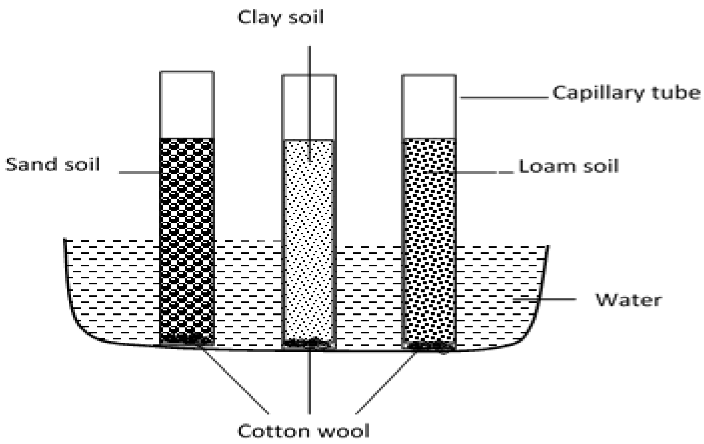
Experiment to compare rise of water through different types of soils (Capillarity).

Apparatus.

Three long capillary tubes, cotton wool, dry soil types e.g. loam, clay and sand, water trough, clamps, water, ruler and clock.

Procedure.

1. Plug one end of the capillary tubes with cotton wool.
2. Fill the first capillary tube with dry sand soil, second with clay soil and the third with loam soil to the same height.
3. Place the tubes vertically in a water trough. Support the capillary tubes with claps.



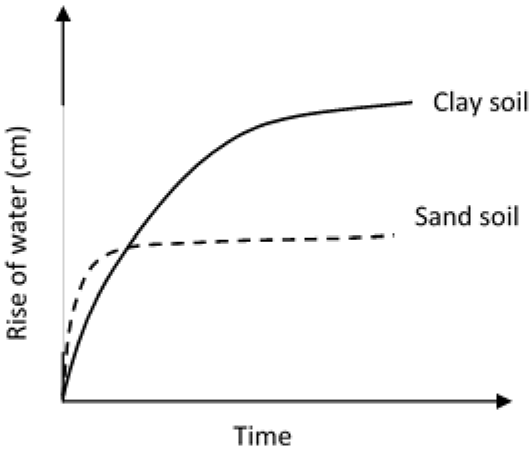
4. Start timing.
5. At regular intervals, e.g. 10 minutes, record the rise of water in each capillary tube above the level of water in the trough.
6. Plot the results on a graph paper for each sample.

By comparing the three graphs, we can deduce the relationship between the soil size and capillary action of the soil samples.

Observation.

Water rises up the capillary tubes by capillarity action, fastest in both loam and sand soils, slow in clay soils in the first 10 minutes. After 2hours, water rises higher in clay soils, least in sandy soils.

Graph showing capillarity rise of water against time.



Conclusion.

Clay and loam soils have greater capillarity action due to their fine pore spaces. Loam contains some quantity of organic materials which absorb water very fast. Sand soils have poor capillary attraction due to wide pores spaces.

SOIL FERTILITY.

This is the ability of the soil to supply plants with nutrients in appropriate quantities to sustain their growth. Soil fertility may be sustained through crop rotation, manuring, addition of fertilizers, fallowing, reducing soil erosion, etc.

Loss of soil fertility.

Soil fertility may be lost through;

1. Monocropping.
2. Continous cultivation/ploughing.
3. Leaching.
4. Soil erosion.
5. Crop removal from the soil/harvesting.

SOIL EROSION.

This is the removal of top soil by agents of erosion e.g. running water, air,

Factors aiding/promoting/influencing soil erosion.

a) Topography.
b) Burning of surface vegetation.
c) Construction/mining/brick making/quarrying.
d) Deforestation.
e) Over grazing.
f) Amount and intensity of rainfall.
g) Type of soil e.g. sand soils are more easily detached and carried away than clay soils.

Types of soil erosion.

- ✓ Sheet erosion.
- ✓ Rill erosion.
- ✓ Gulley erosion.

- ✓ Splash erosion.

Soil and water conservation.

Conservation is preservation or restoration of the natural environment (or sustainable use of a resource).

Preservation methods include;

- ☞ Afforestation/reafforestation.
- ☞ Contour farming.
- ☞ Terracing.
- ☞ Mixed cropping/Intercropping.
- ☞ Crop rotation.
- ☞ Strip cropping.
- ☞ Mulching.
- ☞ Cover cropping.
- ☞ Grassed water ways.
- ☞ Trash or stone lines.
- ☞ Barriers.
- ☞ Ridging.
- ☞ Wind breaks.

Effects of soil erosion.

- ✓ Loss of plant nutrients and micro-organisms, hence reduce crop yield.
- ✓ Damage to crops.
- ✓ Silting of dams, lakes, rivers/water pollution.
- ✓ Degradation of the land.
- ✓ Shortage of water as soil displaces water in rivers.
- ✓ Increase cost of agricultural production through application of manures, artificial fertilizers, etc.

Ways of improving soil fertility.

Soil fertility may be improved through;

- ✓ Application of fertilizers/manures.
- ✓ Crop rotation.
- ✓ Fallowing i.e. leaving land uncultivated/to rest.
- ✓ Afforestation and reafforestation.

Nitrogen cycle.

Nitrogen is fixed into an inorganic form e.g. nitrates and ammonia before it is used by the plants and animals. Nitrogen may be fixed through;

1:<u>Nitrogen fixation</u>.

Through,

a) Thunderstorms.
The energy of lightening combines atmospheric nitrogen and oxygen together to form oxides of nitrogen. These oxides combine with rain water to form acidic solutions which reach the soil through rainfall. In the soil the acid combines with chemicals to form nitrates that can be availed to the plants.

b) Nitrogen fixing organisms.
These include symbiotic ***Rhizobia*** and free living bacteria like ***Azotobacter*** and ***Clostridium***. They fix the atmospheric nitrogen into plant roots and soil respectively which is used to make plant proteins and amino acids.

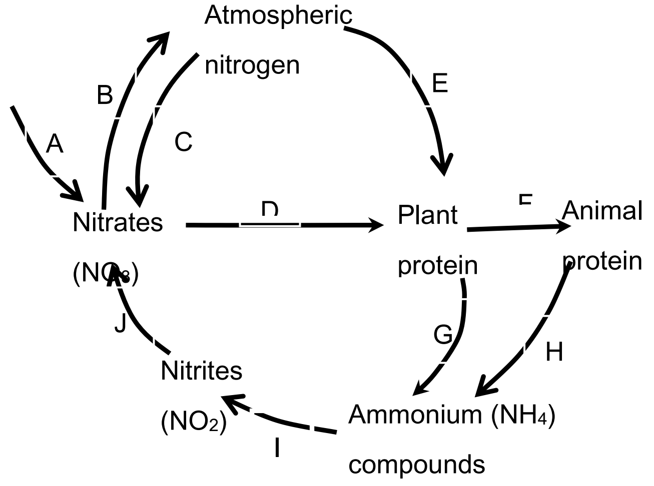
c) Ammonification.
This is where putrefying bacteria and fungi decompose the dead bodies of animals and plants into ammonia, carbon dioxide and water. Ammonia is also formed from faeces of animals.

2:<u>Nitrification</u>.

This is where ammonia is converted into nitrates from ammonium compounds by *Nitrobacter* and *Nitrosomonas*.

Denitrification.

Some organisms in the environment break down nitrates into nitrogen thus releasing nitrogen into the atmosphere. E.g. bacteria like pseudomonas and some fungi.



A-Nitrogen fixed by electrical discharge into the soil. B-Denitrifying bacteria. C-Nitrogen fixing bacteria (e.g. ***Azotobacter***). D-Nitrates absorbed by plants to make plant proteins. E-Nitrogen-fixing bacteria in root nodules of leguminous plants. F-Feeding by animals. G-Death and decay. H- Excretion and faeces. I- Nitrifying bacteria (e.g. ***Nitrosomonas***). J-Nitrifying bacteria (e.g. ***Nitrobacter***).

Carbon cycle.

Carbon dioxide is removed from the atmosphere by plants through photosynthesis. It is released into the atmosphere through combustion, decay and respiration.