CHAPTER TWO: SOIL SCIENCE (PEDOLOGY)

Soil is a natural material on the upper most layer of the earth's crust that

supports plant growth. It is a medium providing anchorage, nutrients and water to plants.

IMPORTANCE OF SOIL

- Most elements essential for plant growth and development are obtained from soil. Only carbon being obtained from the atmosphere.
- It is a source of water for physiological processes in plants.
- It is a site for microbiological activity. Decomposition of plants and animals.

PEDOGENESIS (SOIL FORMATION)

This s the process by which soil is formed through the interaction of parent material, climate, topography, and organisms, overtime.

WEATHERING OF ROCKS

This is the gradual disintegration of rocks (parent rock) due to action of exterior forces like rainfall, solar radiation, living organisms to form soil.

Types of weathering

Chemical weathering. The main agents here are water and weak acid formed in water. Acids have free hydrogen ions (H^+). The common weak acid is carbonic acid formed in rain water, when the water reacts with carbon dioxide gas in the atmosphere. The hydrogen ions from the acid enter the crystal structure (rocks) resulting into rock break down.

Biological weathering. This s mainly due to biological agents. Micro-organisms like bacteria and fungi decompose organic matter, termites and earth worms feed on dead organic matter(DOM) adding humus to the soil. Roots of growing crops enter rock joints resulting to cracks and breakdown of rocks. Rodents for example moles that bu**r** ow into the soil hence ending in rock breakdown and man whose activities result into rock weathering.

Physical weathering. This is the type of weathering caused by physical agents like wind, water and glaciers. Large volumes of running water ca**r** y the debris down slope causing weathering. Moving ice (glacier) grind the rocks hence lead to weathering. Blowing strong winds, also ca**r** y abrasive material which hit against each other and make rock surfaces to disintegrate. More so water waves strike with great force the rock surfaces resulting to their breakdown.

However, the process of soil formation (weathering) is affected by the following factors;

Time. Soils change overtime, undergoing an aging process initially, and a thin layer of soil forms on the parent material. This immature soil takes hundreds of years to form well-weathered parent material. The time depends on the conditions available such as warmth and humidity.

Parent material. This is the mass from which the soil has to be formed. It is the underlying geological material (bed rock). It influences nutrient content and productivity of soil. The parent material

rich in calcium, magnesium, potassium, and sodium are easily dissolved in water.

Relief or topography. It refers to the steepness orgradient of a piece of land. This affects water movement. Water runs off a slope, it may ca**r** y away soil as fast as it is formed. Thus, soil layers may be thin on a slope and thick at the base of the slope.

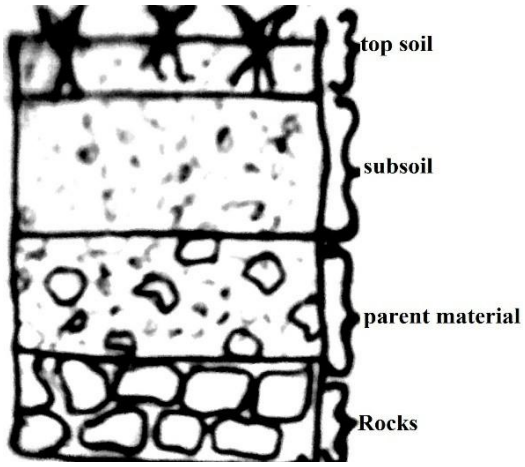
Climate. This is the average weather condition of a place recorded over a long period of time. The components of climate that affect soil formation include rainfall, temperature, wind, humidity, cloud cover and atmospheric pressure. For example temperature increases within limits resulting in increased rate of decomposition to form soil.

Living organisms. Living organisms include large (macro) and small (micro) organisms which may be plants or animals; found in the soil and have the following influence on soil formation.

- Vegetation cover breaks down and adds organic matter in the soil.
- Plant roots penetrate cracks in rocks and as they enlarge they widen the leading to disintegration of rocks.
- Soil micro-organisms feed on organic matter thereby decomposing it.
- Organisms like termites and earthworms help in profile mixing and nutrient recycling.

SOIL PROFILE

Soil profile is the vertical a**r** angement of soil layers from the top most layer to the bottom layer of soil. A mature profile (as shown below); is that one with clear horizons. A truncated profile is the one whose horizons are not clear due to erosion. Horizons develop as soils age.



Characteristics of various horizons

A. **Top soil**

- Contain fine particles.
- Contain much organic matter(humus).
- Contain numerous plants roots.
- Contain a fewstones.
- It is good forcrop growth.
- Contains the darkest part of the soil.
- Contains many soil livingorganisms.

B. **Sub soil**

- Contains soil which is

brown in colour.

- The soil is less fertile (contains fewnutrients).
- Contains a few air spaces and very few soil living organisms.
- Contains more fertile soil particles compared to top soil.

C. **Gravel**

- This layer contains many stones (gravel) and sand particles
- It contains biggerparticles than the soil in horizons A and B
- It is very acidic and contains numerous air spaces
- The soil is lose and continuous break down occurs.

D. **Parent material**

- This horizon is made up of the biggest stones called rocks.
- These are compacted together leaving very few spaces betweenthe rocks.
- It has very fewmineral salts.
- These rocks are the ones that give rise to upper layers during weathering.
- It is devoid of organic matterand soil living organisms.

NB. *The commonparent rocks in East Africa are granite, volcanic and sedimentary rocks.*

COMPONENTS OF THE SOIL

Six components make up the soil.

(a) **Inorganic particles.** Inorganic particles are produced during weathering of rocks. Different soil types may be classified depending on the sizes of their particles. They are clay, silt, fine sand, coarse sand and gravel.

Estimated size of different soilparticles.

Soil particles	**Diameter(mm)**
Gravel	Greater than 2.0
Coarse sand	0.2 --- 2.0
Fine sand	0.02 – - 0.2
Silt	0.002 – 0.02
Clay	Less than 0.002

- In organic particles provide a surface for anchorage of plant roots hence providing support to the plants.
- They give a frame work/ skeleton to the soil
- They provide mineral elements to the soil

required by the plants

Experiment

Aim: To show that soil is made up of different particles.

Materials

-Measuring cylinder
- stir er

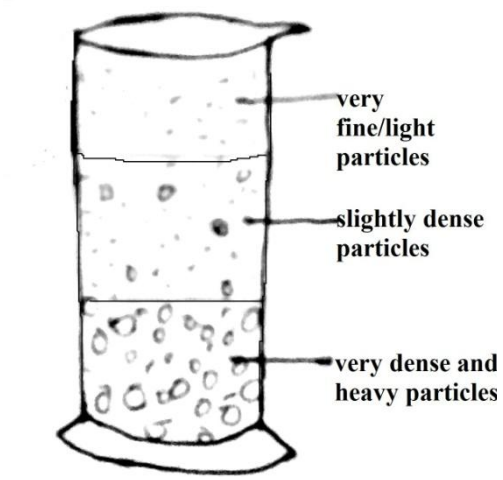
-Top soil

And beaker

Procedure

- Put water in a measuring cylinder.
- Pour soil (of a known volume) in water and stir thoroughly.
- Leave the experiment to stand forfive minutes.

Set up



Observation

Aftersettling of the soil particles,they ar ange themselves according to their size where the heaviest settle at the bottom and the smallest and lighter at the top as shown above.

Conclusion

Soil is made up of different particles, which have varying sizes and densities.

(b) **Soil air.** This occurs between soil particles. Total pore space is a measure of the soil volume that holds airand water. This value is usually expressed as a percentage and is known as porosity. It is mainly carbon dioxide as carbonic acid, oxygen and nitrogen. Air content of soil determines how deep the plant roots can penetrate. The more the porosity, the deeper the penetration.

Uses of soil air

- Oxygen is needed by some organisms to decompose organic matter.
- Oxygen is also needed for respiration by plant roots.
- Carbon dioxide dissolves in water forming carbonic acid for weathering.
- Nitrogen is fixed into the soil by nitrogen fixing bacteria. Hence forming nitrates and proteins.
- Carbonic acid also

reduces PH of the soil

which favors growth ofsome plants

EXPERIMENT

Aim: **To determine percentage ofair in the soil**

Materials required

-Dry soil sample -twomeasuring cylinders

-Water -glass rod

Procedure/ method

- Measure a known volume of dry soil in a measuringcylinder.
- Tap or shake the measuring cylinder to level the soil.
- Measure another known volume of water in another measuring cylinder.
- Add the two together, simultaneously observe carefully.
- Allow the mixture to stand until no more bubbling. Read and record the final level of water plus soil in the measuring cylinder.
- Calculate the aircontent in terms of percentage as shown below;

Example

-volume of soil=50 cc

-volume of water=50 cc

-Final volume of water + soil after mixing =85 cc

Percentage of airin a soil sample;

$$= \frac{\text{Volume of air}}{\text{Volume of soil}} \times 100$$

(c) **Soil water:** The ultimate source of soil water is rain. It sur ounds soil particles as a thin film. It serves the following functions.

- Plant cells are largely made up of water. Water makes plant cells turgid. This keeps stems upright and leaves expanded.
- Photosynthesis uses water as a raw material
- Evaporation of water from plant surfaces cools the plants
- Nutrients are made available to plants when dissolved in water.
- Water car ies materials such as nutrients and carbohydrates throughout the plants.
- It dissolves carbon dioxide produced by living organisms producing carbonic acid which causes chemical weathering.
- It moistens the soil keeping it humid for survival of micro-organisms.

EXPERIMENT

Aim: To determine the percentage (amount) of water inthe soil

Materials.

-Evaporating dish/ basin

-weighing scale

-Desiccator

-Fresh soil sample

-oven/ Bunsen burner

Procedure

- Weigh a clean evaporating dish and record its weight (say X g)
- Fill the evaporating dish with soil and record the total weight (say Y g)
- Dry the soil by heating it gently over a Bunsen flame for about 20 minutes.
- Repeat the heating and weighing until a constant mass. This should be done gently not to burn the soil (ensure that no smoke is produced)
- Re-weigh the soil and evaporating dish. Record the new weight (say Z g)
- Then calculate the water content as shown below;

NB. Cooling should be done in a desiccator before weighing, to ensure no fresh vapour enters the soil.

RESULTS

Weight of evaporating dish=X

Weight of soil + evaporating dish afterheating = Z

Weight of soil sample = Y- X

Weight of water in the soil sample;

= Y- Z.

%age of water;

$$= \frac{\text{weight of water}}{\text{Weight of soil}} \times 100$$

$$= \frac{(Y-Z)\ g}{(Y-Z)\ g} \times 100$$

WATER STRESS

Water stress is a condition when there is very little amount of water in the plant tissues than required for their normal growth. This is because as the soil dries, it becomes more difficult for plants to absorb moisture.

The difficulty depends on the strength of the force between water molecules and the soil particles.

Effects of waterstress

- The plant loses water faster than it can be absorbed hence wilting
- Photosynthesis slows down and hence plant growth is inhibited
- Much periods of water stress can reduce plant growth and crop yields
- Plant leaves start falling off.
- Leaves of some plants curl due to lack of enough water
- During germination, the emerging seeding is easily injured by dry soil.
- As a plant becomes deficient of water, guard cells begin to close the stomata slowing down exchange of carbon dioxide and oxygen slowing the rate of respiration.

TYPES OF SOIL WATER

(i) **Gravitation water**

This is the water that is not attracted to soil particles, and drains through soil profile due to gravity.

(ii) **Hygroscopic water**

This is the water that is tightly held to soil particles and therefore it is not available to plants. It can only be removed by drying the soil in an oven.

(iii) **Capillarity water**

This is the water that remains su**r** ounding the soil particles and is mainly accessible to plant roots and other organisms. This water may be lost by evaporation.

NB. Field capacity is the amount of water retained when gravitational water has drained away from the soil.

The amount of water in soil depends on the structure of the sol and organic content. Coarse soils have lesser water than soils with finer textures. This is because finer texture increase surface area for attraction of water by soil particles.

Water retention refers to the ability of soil particles to keep water molecules attracted to them.

Water penetration refers to the movement of water through the soil particles to lower layers. It is also called percolation and is determined by amount of airbetween the soil particles.

(d) **Organic matter (Humus).** Portions of the soil that includes animal and plant remains at various stages of decay. It consists of complex carbon containing compounds. Humus is dark in colour and made up of very tiny particles of clay soil. It contains many elements including 50% carbon, 5%

nitrogen, and 0.5% phosphorous.

Functions of organic matter in the soil

- Prevents water logging in the soil; by making soil clumps bigger so that there are enough air spaces for water to drain easily.
- Humus binds soil particles together hence improving the crumb structure.
- The decomposition releases nutrients such as nitrates which are needed by plants.
- Humus improves the water holding capacity of the soil.
- Due to binding of particles, organic matter helps control soil erosion.
- Some nutrients like iron and zinc, react with other chemicals to form insoluble compounds.

(e) **Living organisms.** There are many living organisms which live in the soil. They help in decomposing organic matterand mixing minerals with organic components. Some may be macro-organisms such as earth worms, moles and insects while others may be micro-organisms such as bacteria, fungi, protozoa.

Importance of living organisms in the soil

- Fixing atmospheric nitrogen into nitrates by nitrogen fixing bacteria.
- They decompose litter and other wastes into humus such as termites.
- They feed on decaying plant material and add humus to the soil.
- Earth worms bur ow in soil and improve on the soil aeration and drainage.

NB. However some microorganisms also have harmful effects such as;

- ✓ Some bacteria cause diseases to man and crops
- ✓ Termites cause damage to crops
- ✓ Centipedes are poisonous on biting humans

EXPERIMENTS

(A) **Aim**: **To determine the percentage of humus in soil sample**

Materials

-Soil sample

-Bunsen burner

-Evaporating dish/ crucible

-thermometer

-tripod stand

Procedure

Weigh clean, empty crucible and record its mass. Let it be P g

Half fill the crucible with soil. Record the exact mass of the soil plus crucible on scale balance. Let it be Q g

Dry the soil by heating in an oven at 105 ^{0}c to a constant mass.

The loss in mass is due to water lost byevaporation

Re-weigh the dry soil and crucible and record the mass of crucible plus soil. Let this be S g. The weight reduces because humus is burnt to carbon dioxide and water.

Calculate the percentage of humus in the soil as shown below;

Results

Mass of crucible = P g

Mass of crucible and soil = Q g

Mass of crucible and soil after heating to constant mass = R g

Mass of crucible and red hot soil = S g

Calculations

Mass of soil sample used= (Q- P) gMass

of dry soil= (R- P) g

Mass of humus in the soil

= mass of dry soil – mass of soil after heating to red hot.

=(R-P) – (S-P)

= (R – S) g

Percentage of humus in the soil

$= \frac{\text{mass of humus in the soil}}{\text{Mass of soil}} \times 100$

$= \frac{(R - P)}{(Q - P)} \times 100$

(A) **Aim: To show that soil contains living organisms.**

Materials.

-2 test tubes; -lime water or biconcave indicator solution; -2 corks; - 2 muslin bags

Procedure.

Collect a handful of fresh top soil and divide it into two equal portions.

Sterilize one portion by heating it strongly on a crucible for 30 minutes. Leave it to cool and place it in a muslin bag.

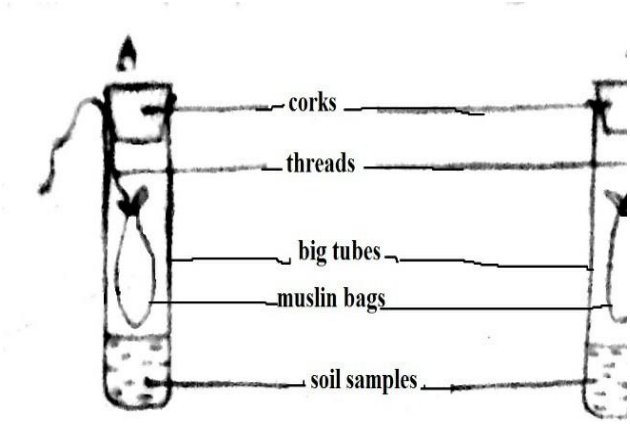
Place the remaining portion of soil in anothermuslin bag.

Place the remaining portion of soil in anothermuslin bag.

Add equal amounts of lime water or bicarbonate indicator into each of the test-tubes, A and B and then suspend a muslin bag with soil.

Leave the test tubes to stand for a few days and observe the appearance of lime water.

Experimental set up



Results

Lime water turns milky in test tube A but no observable change in test tube B. if the bicarbonate indicator is used it would turn yellow. This is because carbon dioxide is an acidic gas

Conclusion.

Carbon dioxide was produced in A during respiration indicating the presence of living organisms.

(f) **Mineral salts**

Mineral elements in the soil are obtained by the weathering of parent rock. They occurin form of ions needed forthe plant growth and development.

They may be added to the soil by activities of aerobic bacteria and fungi on humus. They dissolve in a film of water sur ounding the soil particles. Examples are sulphur, phosphorous, nitrogen, silicon etc.

TYPES OF SOIL

Soil is categorized into three main types depending on the size of the particles making up a soil sample.

Sandy soil

Soil is said to be sandy when sand exceeds 70 % of the soil particles. It constitutes light soils. When held between fingers, it feels gritty and dry.

Properties

- Particle sizes range between 0.02mm and 2.0 mm.
- The soil particles are largely spaced (highly aerated).
- It has a coarse texture.
- It has a low water holding capacity. Water penetration is high.
- Rate of leaching is higher than othersoils.
- Lowmineral salt content.
- Has a low capillarity extent.

NB. Sand soil can be improved by adding humus to it.

Clay soil

This is the type of soil that contains over 30% clay and less than 40% sand. Clay particles are less than 0.002 mm in

diameter.

Properties of clay.

Has a smooth texture

Sticky when wet and difficult to plough

Poorly aerated and poorly drained because of small pore spaces.

It has the highest extent of capillarity

Clay soil is not well drained and is therefore water logged

This type of soil can be improved by adding humus and lime. Lime flocculates the soil (clamps the soil particles together).

Loam soil

Loam soil has 40% - 70% sand, 20% - 30% silt and 10% - 30% clay i. e it is a mixture of different particles of the soil.

Properties of loamsoil

Well drained and aerated and retains enough water

It has a good mineral content (both trace and macro elements)

It has a good water holding capacity due to large quantities of humus

It has good aeration and better water retention

NB. The above properties make loam soil a better soil for the growing of crops

Physical properties of soil

Physical properties are those that can be observed by a person on individual encounter. They are due to texture and size of soil particles. The a**r** angement of soil particles into different layers s called **soil structure**. The different physical properties of soil include;

- Water retention. Ability to keep water in between the particles
- Porosity and drainage
- Amount of space between soil particles
    - Organic mattercontent
    - Soil components
    - Soil colour. Loam soil isdarker than othertypes
    - Soil texture

FEEL	***TYPE***
Gritty	*Sand*
Smooth when dry	*Clay*
Sticky when wet	*Clay*
Smooth	*Loam*

Soil structure helps to determine soil aeration and sol water retaining capacity.

N.B. The chemical properties of soil are those that are due to the mineral composition which include; Mineral salts and Flocculation. Flocculation is the ability of the soil particles to aggregate form large clumps. This process involves addition of lime (calcium oxide)

SOIL EROSION AND CONSERVATION

Soil erosion is the removal of a thin layer of soil from the top layer by agents like water and wind. This is a common observation in areas with less plant cover. The type of soil erosion is determined by the agents of erosion and the uniformity of the layer removed.

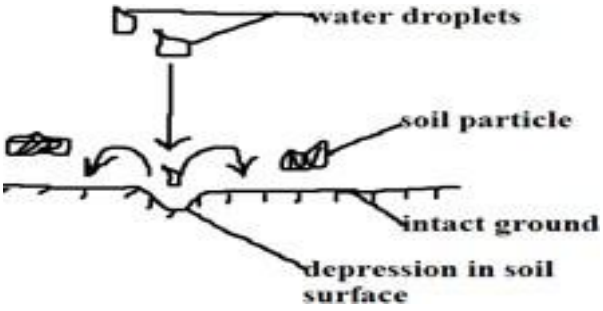
Soil fertility is the ability of the soil to supply mineral salts ornutrients in right proportions to plants. The loss of soil fertility is due to loss of adequate concentrations and availability of nutrients in soils to plants. This loss may be due to; erosion, soil exhaustion and leaching.

SOIL EROSION, TYPES AND EFFECTISON SOIL FERTILITY

Splash erosion.

This is the washing away of soil particles due to rain drop impact on an open area where there is a bare ground.

Illustration of splash erosion



Sheet erosion.

This type of soil erosion is where the soil particles over a land surface are eroded uniformly.

Gulley erosion.

If erosion is not controlled, deep and wide depressions called gullies will be formed. This is called gulley erosion. This is the most dangerous type because it removes a lot of soil that is most favorable foragriculture.

Stream bank erosion.

Running water along streams/ rivers erodes soil which is deposited in the

reservoirs such as dams leading to silting which also decreases water storage capacity.

Wind erosion.

Wind is also an agent of erosion. Moving air blows loose material and takes it to other places. Wind can car y dust from fields or volcanoes high into the atmosphere and deposit it faraway.

CAUSES OF SOIL EROSION

These are practices that may lead to exposure of the soil to agents of erosion. They are not agents of soil erosion. They include among others, the following.

Over grazing. This leaves the soil bare hence exposed to agents of soil erosion.

Uncontrolled bush burning. This exposes the soil making it easy to be blown away by wind as dust. Furthermore it decreases the water retention capacity of the soil. Because direct exposure to intense heat increases evaporation of water from the soil.

Ploughing up and down slopes ; creates routes for water to run when it rains hence increases surface runoffs.

Over cultivation. Destroys thear angement of soil particles and humus. Soil properties are easily removed. This encourages soil erosion.

Cultivation of crops on slopes increases the surface runoffs hence speeding up soil erosion.

Factors that determine erosion extent

Amount and intensity of rainfall. If rainfall is too much and heavy, much of the soil will be removed from the top layers by flowing water.

Slope or topography of the land. Low lands are not highly affected by agents of soil erosion. Steep areas provide a gradient for wash away of soil by wind and water.

Type of the soil. Some soils such as sand soils have widely spaced particles which are lose. These allow water and otheragents to remove the upperlayers. Compact soils such as clay are not highly affected by erosion agents.

Soil depth. Thin layers of the soil particles can easily be washed away in presence of strong winds and rains.

Deforestation. If trees are cut on a large scale, most pieces of land are left bare, hence exposed to erosion agents.

Poorfarming methods. Such as digging down slopes and over cultivation which accelerate the action of erosion agents and leave the soil bare, respectively.

Excessive use of inorganic fertilizers. If fertilizers are used for a long period on the same piece of land; the soil particles become lose due to lack of organic material for binding them together.

Other human activities like open cast mining, road construction also accelerate the rate of soil erosion in a given area.

Effects of soil erosion

- It leads to loss of soil fertility
- It results in damage of crops
- It exposes plant roots hence reducing mineral uptake by plants
- It results in degradation of the land
- It reduces the depth of rivers due to silting
- It make soils unproductive

SOIL EXHAUSTION

This is the condition where the soil is

depleted of nutrients and therefore it cannot support proper plant growth. Poorfarming methods like monoculture (growing the same crop seasonally) depletes the soil of mineral salts. Different crops require different types and/ or amounts of mineral nutrients. Therefore over cultivation leads to soil exhaustion.

LEACHING

This is the movement of mineral salts from top to deeper layers of the soil. Leaching causes loss of mineral salts because plant roots cannot reach them. It is commonly due to heavy rainfall.

As rain water moves through the soil, it car ies soluble minerals especially the soluble nitrates with it from top soil to sub soil, reducing fertility of the top soil.

Heavily leached soils become brown in colour for example gravel used in construction of mur am roads. Leaching occurs more in sandy soils than clay soils because of the large pore spaces between the soil particles. This may lead to increased acidity of the soil therefore reducing fertility.

Methods of soil conservation

Soil conservation; refers to all practices

or methods that are carried out to maintain the productivity and fertility of the soil.

Soil productivity; is the ability of the soil to provide high yielding crops while fertility is the ability to support proper plant growth depending on the amount of nutrients.

This includes all the methods to prevent soil erosion and to maintain the fertility of the soil. All methods of preventing soil erosion can conserve the soil but not all methods of soil conservation can prevent soil erosion.

(a) Preventing soil erosion

Contour ploughing. Ploughing across a slope and not up and down. It allows furrows to trap water rather than channeling it away.

Strip cropping. This consists of alternate bands of cultivated and uncultivated soil, following contours. Untilled soil is covered with grass. The soil builds its structure underthe grass.

Terracing. This is cultivation along contours in horizontal strips supported by stones or walls, so breaking up the step down water rush of the surface run -off. The steeper the slope, the closer the terraces must be.

Correct crop for soil. Steep slopes which should not be ploughed are covered with pasture crops, their roots hold the soil.

Afforestation. This is the planting of trees on large areas of land. They may act as wind breakers, hold the soil particles together, and prevent rain drops from hitting the soil directly.

Mulching. Covering the soil with plant material such as dry grass, banana leaves, or maize stems after harvest. It protects the top soil and conserves the water in the soil. It prevents growth of weeds that would complete with crops. Mulches when rotten add humus in the soil. Holds the soil particles together preventing soil erosion

(b) Othermethods include

Intercropping. Here plants are alternately planted in a systemic or even random manner for example coffee, beans, and banana can be intercropped.

Fallowing. Land is left to rest and grow back to bush. This helps to add more green manure. The soil structure is restored and soil living organisms survive and dominate the soil.

Crop rotation. The farmer carefully rotates his crops season after season, so that the plants make different demands on the soil. Deep rooted crops are rotated with shallow rooted crops.

Application of organic manure. This helps in restoration of the fertility of the soil. It involves use of manures (manuring). These are natural organic fertilizers from plant wastes and animal wastes. Also artificial fertilizers may be applied. These are salts containing plant nutrients in high and definite concentrations. These should be applied with care because they may alter the soil PH and cause pollution of water bodies if used in large quantities.

Examples of manures include;

Farmyard manure. This is obtained from animals' waste products like cowdung and urine.

Compost manure. This is made by collecting all the available organic materials like weeds, fresh leaves, and chicken waste into a pit with soil leaving them to rot.

Green manure. This is obtained from crops after being grown on a piece of land and then ploughed into the soil to improve on properties of the soil.

NB. The most common elements lacking in highly cultivated soils are nitrogen, phosphorous, and potassium. These can be supplied in form of Potassium sulphate, Ammonium sulphate, and calcium sulphate which lead to high yields.

THE BIOGEOCHEMICAL CYCLES

These are cycles that involve the existence of an element and its movement from non-living components like rocks and water to the living components like plants and animals and vice versa. The most important andcommon elements in all forms of life are carbon, nitrogen and water cycles.

THE CARBON CYCLE

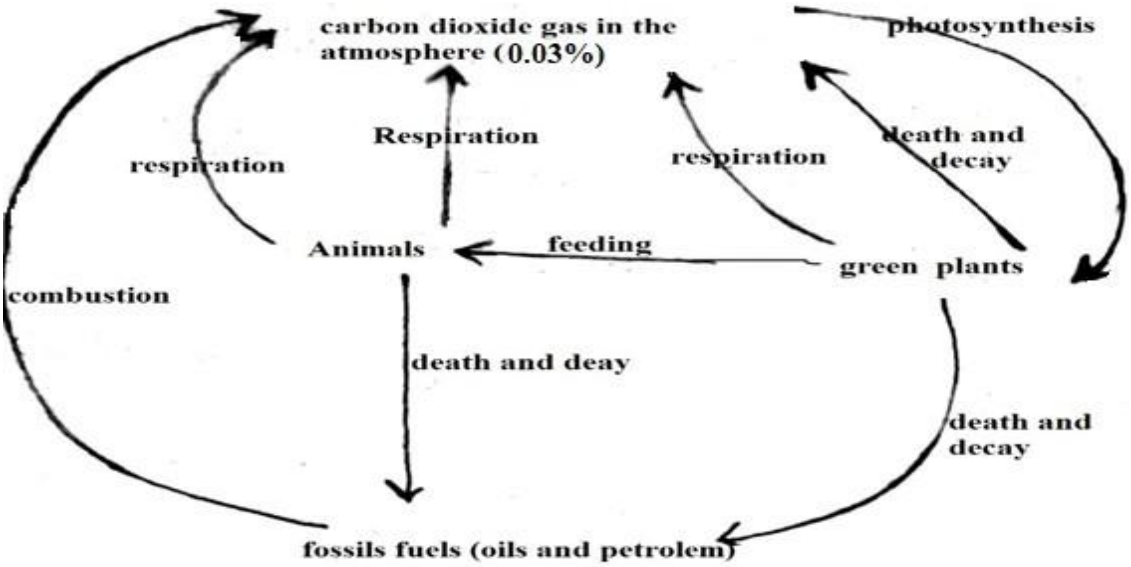
Carbon is the basic element that constitutes all living organism. It exists in organic compounds like proteins, carbohydrates, lipids, and nucleic acids. The cycle shows circulation of carbon

in nature among plants, animals and

the atmosphere. atmosphere is 0.03%.

The approximate normal concentration of carbon dioxide gas in the

The carbon cycle



Carbon dioxide is removed from the atmosphere by photosynthesis. Carbon dioxide may also dissolve in water bodies to form carbonic acid. Through respiration, combustion, death and decay, carbon dioxide is returned to the atmosphere.

Human activities like burning, deforestation and industrialization have greatly increased carbon dioxide release into the atmosphere. This leads to increased surface temperature, a process called global warming.

Influence of man's activities on the carbon cycle

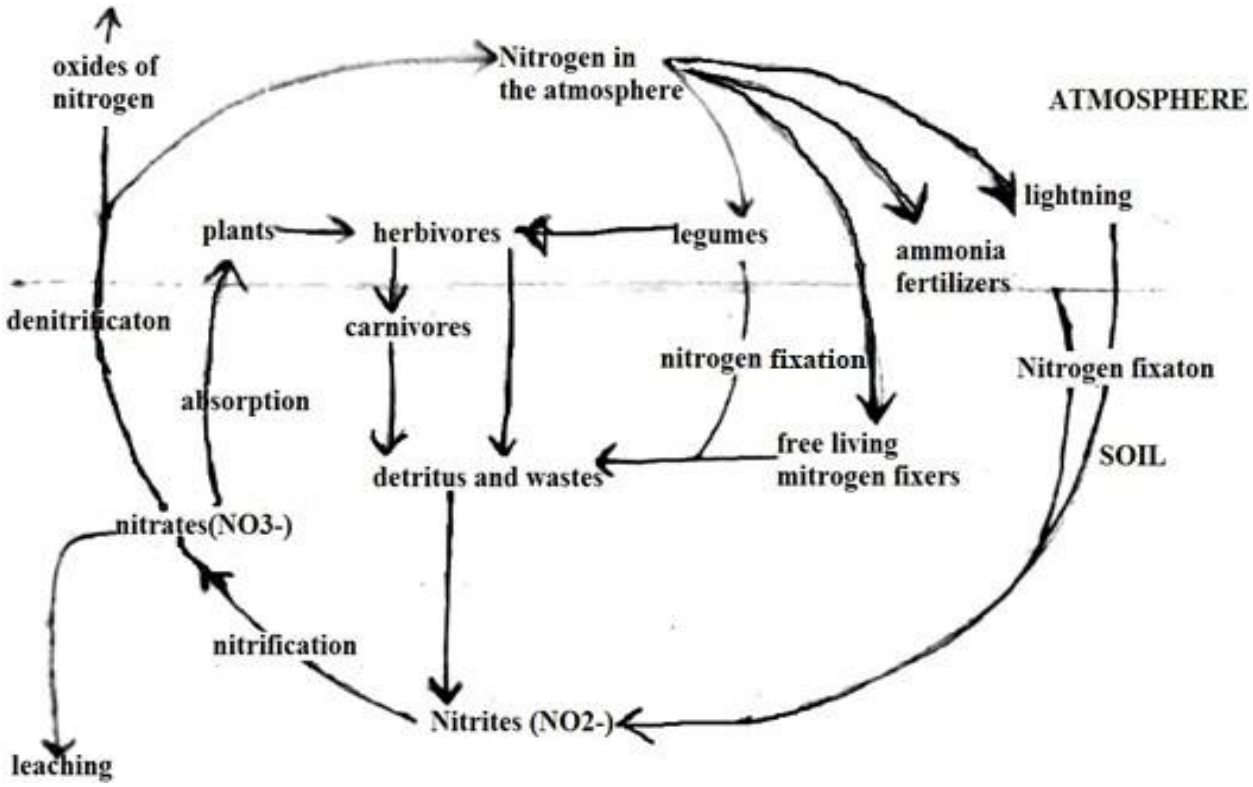
- Deforestation reduces rate of photosynthesis leading to global warming
- Afforestation increases carbon dioxide uptake hence reducing its concentration.
- Burning fossil fuels releases more carbon dioxide into the atmosphere.

- Industrial extraction and releases also affect the amount of carbon dioxide in the atmosphere
- Raising more animals increase carbon dioxide concentration through increased respiration.

THE NITROGEN CYCLE

Nitrogen as an element exists naturally in either gaseous form about 78% in the atmosphere or in all living things as a component of their proteins. Living organisms do not take up gaseous nitrogen into theirbody fluids because it is inert (unreactive).

Nitrogen promotes rapid growth and development of a dark green colour(chlorophyll). Plants obtain nitrogen in elemental form from absorbed nitrates. During the nitrogen cycle, nitrogen undergoes the most movement and change involving a series of gains, losses, and changes. The basis of this cyclic movement is attributed to the role of soil living micro-organisms.



The nitrogen cycle constitutes of four main processes that is nitrogen fixation,

nitrification, ammonification, and denitrification.

Plants are fed on by animals as their main source of nitrogen in proteins (from essential amino acids). With time both plants and animals die, decay and their remains also decompose. The compounds containing ammonium ions are converted to ammonia gas in a process called ammonification. These compounds commonly are in faeces, urine and dead organisms.

Putrefaction. The process by which certain bacteria act on organic matter for respiration and nutrition to release nitrates. Bacteria and fungi act on ammonium compounds to release nitrates.

Nitrification. This is done by nitrifying bacteria called Nitrosomonas which convert ammonium compounds into nitrites. Nitrobacter transforms nitrites into nitrates which can be absorbed by green plants.

Nitrogen fixation. Nitrogen is converted into absorbable nitrogen compounds. Little fixation occurs during thunderstorms. Nitrogen is oxidized to nitrogen oxides, which dissolve in water to form dilute acids. These acids dissociate to form nitrates absorbed by green plants. Also free living bacteria in the soil for example azotobacter and clostridium convert atmospheric nitrogen into nitrates. Symbiotic bacteria for example rhizobium are also found in root nodules forthe same process.

Denitrification. This is a process by which nitrates are transformed into atmospheric nitrogen. This is by denitrifying bacteria for example thiobacillus. These bacteria convert nitrates to nitrites then to free nitrogen gas hence reduce the nitrate content of the soil.

NB. *Nitrates may move from the top soil to the sub-soil in form of a solution through a process called* ***leaching****. This is commoninareas which receive heavy rainfall.*

THE WATER CYCLE (HYDROLOGICAL CYCLE).

This refers to the processes involved in the movement of water from the water bodies

into the atmosphere and then back to the eater bodies. The point during the cycle in

which water spend much of the time is a water body, but from the atmosphere, it is constantly being removed by organisms.

Water is removed from the water bodies such as lakes, rivers, ponds, e. t. c, into the atmosphere in form of water vapour, due to strong sun light energy heating the water surfaces. Evaporation also takes place when surfaces of plants, animals and the soil are heated up by sun rays. A combination of the vapor from the surfaces of living and non-living things is called evapo-transpiration. Transpiration is the evaporation from the surfaces of plants mainly leaves.

The warm air rise up over the cold air in the atmosphere. This is because warm air is less dense than cold air. The warm air continues to rise as condensation (vapour molecules coming closer) until it reaches a saturation level. At this point the vapour forms an intense mass full of water (clouds), which splits to release precipitation in form of rain, hails, storms orflakes.

The precipitation may erode the surface of the soil or move (Seep) through the upper layer into the water ways and finally into a water body. Droplets falling on to leaves and stems may flow to the ground then into the soil. In presence of strong sun light. The surface water molecules from animals, plants (mainly) evaporate into the atmosphere in form of gaseous vapour which condenses as it rises higher in the atmosphere. The cycle is repeated again.

Some experiments on soil properties

(a) **Aim.** To compare rates of water retention in the three types of soil.

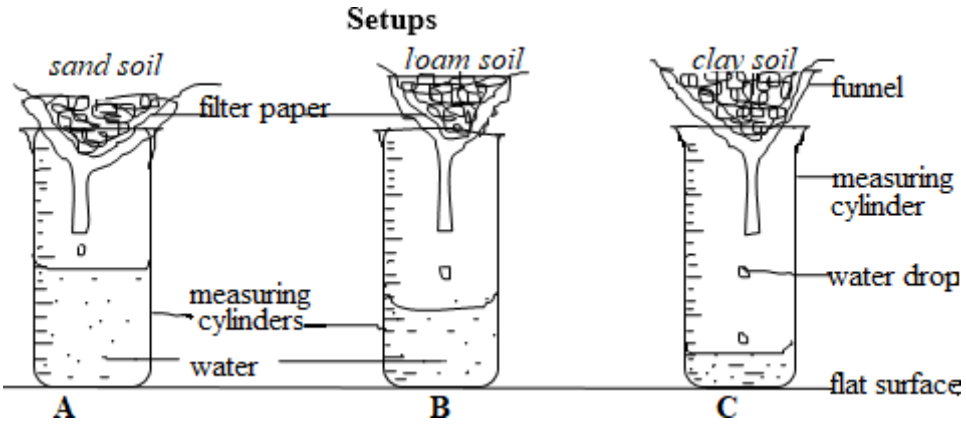
Materials used

Loam soil; clay soil; and sand soil. Water of known volume (such as 100 cm^3); three filter papers; three 50 cm^3 measuring cylinders; three small filter funnels; a timersuch as a stop clock.

Procedure

- Equal amounts of each soil type are each placed on a filter paper in the order; sand, loam and clay.

- The three filter papers containing soil; are each placed gently into the filter funnel as shown in the figure below.
- Each of the three filter funnels with its contents is placed on the brim/ mouth ofmeasuring cylinderas shown in the figure below.
- A known amount of water is poured in one of the setups and a stop clock simultaneous started. This procedure is repeated forthe othertwo setups.
- The experiment is left to stand for some time (such as 30 minutes) as observations are made and the amount of water collected in the measuring cylinders recorded.



Observation

In set up **A,** the water drops are observed to come out of the soil at a fast rate. In set up **B,** water drops at a slow rate and then at the slowest rate in set up **C.** After thirty minutes, much water is found to have been collected in measuring cylinder **A** than in **B**and more water in **B** compared to **C.**

Conclusion

Soil sample in set up **A** has a lowest water retention capacity. Soil **B** has a high water retention capacity and soil **C** has the highest water retention capacity.

Explanation

In set up **A;** sand soil contains the biggest particles hence cannot be packed so closely. The numerous and large air spaced left between soil particles allow a lot of water to percolate (drain) through the soil. However this reduces in loam and is least in clay where soil particles are closely packed with the least amount of airspaces.

(b) **Aim.** To demonstrate capillarity in the three types of soil

Materials required

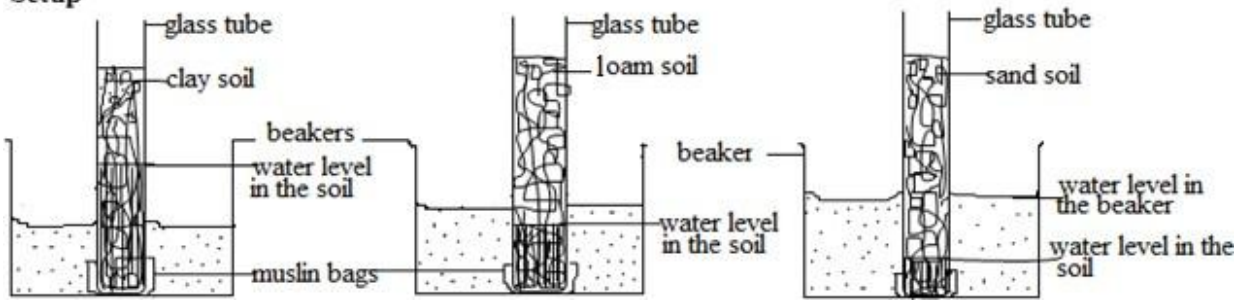
- Three glass tubes of equal size
- Three beakers/ troughs
- Water and three muslin bags
- Clay soil, loam soil and sand soil

Procedure

- Three beakers of the same size are half-filled with pure water.

- A sample of clay soil is placed into a glass tube whose one end has been tied with a muslin bag. This procedure is repeated with the same amount of loam and sand soils using the remaining two glass tubes.
- The three glass tubes with their contents are vertically placed in water in the beakers with the closed ends to the bottom as shown in the setup below.
- The experiment is left to stand for some time (such as 30 minutes) and observations are made.

Setup



Observation

Water is seen to rise very fast but soon stops to a lower level in sand soil than in loam soil. In clay soil rises slowly and to a higherlevel than in loam soil. The level of water in the beaker is found to have greatly reduced in setup with clay soil than in setups withloam soil and sand soil.

Conclusion

The capillarity rate can then be concluded to be in this order from the highest to lowest: in clay soil, higherthan in loam soil, higherthan in sand soil.

Explanation

Clay soil contains the smallest soil particles. These can be packed closed together. This increases the surface area over which water molecules can slowly spread from the lower particles to the higher particles hence highest rate of capillarity. However in loam soil, the soil particles are relatively bigger and very big in sand soil leaving large airspaces hence reduced capillarity.