CHAPTER 11
Types, Composition and Properties of Soil

OBJECTIVES
At the end of this chapter, students should be able to:
â recognise the different types of soil.
â name the chemical elements in the soil that constitute plant food.
â name soil microbes and other soil inhabiting organisms.
â determine the pH of different soil types.

Introduction
Soil has been defined in the last chapter as the loose weathered material covering the earth surface which supports the growth of plants and sustains human and animal life.
Different factors such as the parent material, climate, topography, living organisms and geological time as well as the processes involved in the soil formation influence the type, composition and properties of any soil. These, in turn, determine the suitability of soil for agricultural production.

Types of Soil
Types of soil are as follows :
â Sandy soil
â Clay soil
â Loamy soil

Sandy soil: These are loose soils which consist of coarse grain particles. Their particle sizes are bigger than any other soil particles.
Properties of sandy soil
â It is coarse grained.
â It is gritty to feel.
â It is not sticky when wet.
â It has large pore spaces.
â It is highly aerated.
â It possesses different colours (brown, grey).
â It absorbs and loses water easily.
â It does not retain water.
â It is easily heated up during the day.
â It is low in plant nutrients.
â It is made up of quartz.
â Its percolation rate is high.
â It is easily eroded.
â It encourages leaching.
Ways of improving sandy soil
â **Application of organic manure:** The organic manure consists of compost and farming yard manure. When they are applied to sandy soil it helps to bind their particles together, thereby improving the texture and structure of the soil.
â **Planting of cover crops:** When cover crops are planted, it provides a cover to the soil. The leaves help to add organic matter to the soil when they die

and decay. With the cover crops rate of evaporation and erosion is reduced.
â **Mulching:** When the soil is mulched, the rate of evaporation is reduced. When the mulch decomposes, it adds organic matter to the soil.
â **Avoidance of bush burning:** When the bush is burnt, it kills the micro-organisms in the soil and chars the nutrients of the soil. Thus resulting in the reduction of soil fertility and erosion.

Clay Soil: This consists of the smallest, finest particles. It is made up of 40% clay and the rest consists of silt and fine sand.
Properties of clay soil
â It is fine in texture.
â It is sticky when wet.
â It has tiny pore spaces.
â It is poorly aerated.
â It has high water retention capacity.
â It is hard when dry with deep crevices during dry season.
â It can easily form ribbons or cast when moulded.
â It supports waterlogging.
â It is rich in plant nutrients.
â It has electrical charges which help to attract large number of mineral ions.
â The colour is usually light brown.
Ways of improving clay soil
Addition of organic manure: When organic manure is added to clay soil, it helps to improve the texture and structure of the soil. It also increases its nutrient content, and makes it readily available for absorption by the roots of plants.
Liming: This helps to make drainage more effective by improving the porosity of the soil.

Loamy Soil: This is a mixture of sand and clay particles with a higher proportion of organic matter (humus).
Properties of loamy soil
â It is rich in plant nutrients.
â It is dark in colour.
â It contains moderate air spaces.
â It can withstand moderate period of drought.
â It is easy to cultivate.
â It is slimy in texture and not plastic or mouldable but it sticks together.
â It is the best soil for agriculture.

11.3 Chemical Elements in the Soil that constitute Plant Food
Plant foods are the nutrients or mineral elements that a plant requires for growth, maintenance and development. The nutrients are classified into two groups :
1. Macro nutrients or major elements.
2. Micro nutrients or minor elements.
Macro nutrients or major elements: These are mineral elements that are required in relatively large quantities by plants. They include nitrogen, phosphorus, potassium, calcium, magnesium and sulphur.
Micro nutrients or minor elements: They are nutrients/mineral elements

required in relatively small quantities by plants. They include iron, Manganese, copper, zinc, boron, molybdenum and chlorine.

Soil water: This is the amount of water present within the soil that is available for the use of plants. Sources of soil water are ground water rainfall and irrigation. Excess water in the soil causes â€œwater loggingâ€ and lack of water in the soil for plant uptake results in permanent wilting. Water is necessary for carrying out some chemical, physical and biological activities in the soil.

Types of Soil water

â **Gravitational water:** This is the type of water drains from the top soil due to the force of gravity to deep layers of soil beyond the reach of plant roots. This water is not available to plants. It helps to prevent water logging in soil.

â **Hygroscopic water:** This is the water that forms a thin covering over the soil particles that is lost when soil is oven dried at 105Â°C. This water is not available to the plants for their growth.

â **Capillary water:** This water can rise to the root zones of plants especially in clay soils. Capillary water is very important to the plants.

Importance of soil water:

â It is the medium in which plants absorb nutrients.
â It promotes the activities of microorganisms.
â It is needed for germination of seeds.
â It aids weathering of rocks.
â It is the basic raw material for photosynthesis.
â It helps to maintain plant turgidity.
â It neutralizes the effect of temperature.

Soil Organisms: These are small microscopic organisms and other higher organisms living in the soil. They include plants and animals. Some of them are beneficial while some are harmful. Examples of micro-organisms are fungi, algae, bacteria nematodes and actinomyctes. Examples of higher organisms are earthworms, worms, millipedes, centipedes,insects, snails and rodents.

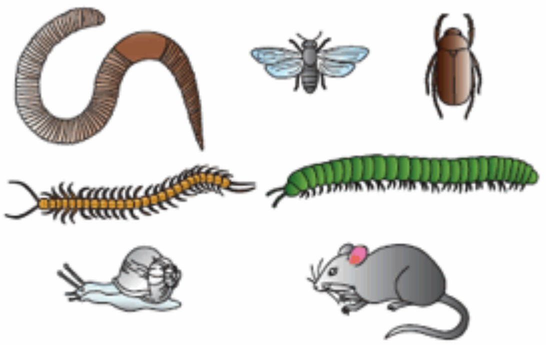


FIGURE 11.1 Some soil organisms

TABLE 11.1 Nutrients/mineral elements required by crop plants

Element	Form in which they are absorbed	Functions	Deficiencies
Nitrogen (N)	Nitrate anion ($NO3^-$) Ammonium cation ($N4_4^+$)	- For growth and development of plants - For Protein formation on plants - It imparts green colour in the leaves - Excess Nitrogen delays maturation in plants	- Retarded and stunted growth - Yellowing of leaf from the tip backwards with v-shape - Poor formation of flowers and fruits
Phosphorous (P)	Phosphate anion (PO_4^{2-})	Active maintenance of plant cells - For root formation and growth - Improved resistance to diseases - Early maturation of seed and Fruits - Helps in seed germination - It improves the palatability of Forage and vegetables	- Retarded and stunted growth - slow development of roots, flower and fruits - Dull greyish-green and purple leaves
Potassium (K)	Potassium cation (K^+)	- It aids the synthesis of Carbohydrates - It assists in the development of young plants - It controls stomata movement - It activates various plant enzymes - It helps in nitrate uptake - It helps in neutralizing organic acids in plants	- Premature loss of leaves - Dull bluish-green coloured leaves - Delayed growth - Brown colouration at the margin - Weak slender stems

TABLE 11.1 Continued

Element	Form in which they are absorbed	Functions	Deficiencies
Calcium (Ca)	Calcium cation (Ca^{2+})	❍ Formation of cell walls ❍ For the development of root tips and terminal buds ❍ Reduce soil acidity ❍ It controls toxicity of aluminium manganese and sodium ions ❍ It improves soil pH ❍ It helps in the translocation and storage of carbohydrates and proteins in seeds and tubers	❍ Low development of root tips and terminal buds ❍ There is appearance of pale yellow colour in the leaves
Magnesium (Mg)	Magnesium cation (Mg^{2+})	❍ For the formation of chlorophyll in plants ❍ It enhances plant growth ❍ It is required for synthesis of oil in plants ❍ It is required for plant growth ❍ It helps in cell division	❍ Chlorosis along leaf vein ❍ Stunted growth ❍ Premature leaf fall
Sulphur (s)	sulphate anion (SO_4^{2-})	❍ Constituent of protoplasm ❍ For protein formation ❍ It is needed for carbohydrate metabolism and nitrogen fixation in legumes	❍ Stunted growth ❍ Yellowing of leaves ❍ Poor rate of photosynthesis
		Micro Elements	
Iron (Fe)	Iron II ($Fe.^{2+}$) Iron III($Fe.^{3+}$)	❍ Chlorophyll formation ❍ For protein synthesis contained in chloroplast ❍ It is important in enzyme association with oxidation and reduction reaction	❍ Chlorotic condition in leaves which become pale green ❍ The veins too are green while the affected leaves curl in upward direction

Zinc (Zn)	Zn	❍ Enzymes activators ❍ Essential for the formation of some growth hormones ❍ Important for the reproduction process of certain plants ❍ Chlorophyll formation in conjunction with iron and magnesium	❍ Production of mottled leaves ❍ Production of reduced and small leaves ❍ Formation of fruit bud is reduced ❍ Dieback of twig
Molybdenum	(Mo) Molybdenum (MoO_4^{2-})	❍ To reduce excess nitrogen during synthesis of protein ❍ Enzymes activators ❍ Essential for nitrogen fixation in legumes ❍ Increase the pH level in the soil ❍ Promotes nitrate metabolism into amino acids and protein	❍ Retarded growth ❍ Necrosis of leaf tissue ❍ It causes premature flower drops. ❍ It promotes metabolism of nitrate in amino acids
Boron	Borate (BoO_4^{2-})	❍ It helps to promote the growth of tips of roots ❍ It assists in the formation of fruits and seeds ❍ It facilitates nodulation in leguminous plant ❍ It encourages cell division ❍ It encourages cell division in growing region of plants ❍ It increases yield	❍ Death of tips of roots and shoots ❍ Flower buds may fail to develop ❍ It causes lodging ❍ Dark spots on the thickest part of root ❍ Translocation of sugar in plant is reduced
Copper (Cu)	Copper II (Cu^{2++}) Copper III (Cu^{3++})	❍ Enzymes activators ❍ Necessary for photosynthesis ❍ It helps in respiration and in the utilization of iron ❍ Promotes the formation of vitamin A	❍ Pale greenish of leaves ❍ Yellow discoloration between veins ❍ Citrus juice is low with insipid test ❍ Results in reddish brown colouration of citrus fruit ❍ Causes dieback in tips of young leaves

Importance of soil micro-organisms

â They help in the decomposition of plants and animal materials to form humus.
â They help in breaking down of rocks.
â They are vectors of diseases.
â They help to improve soil structure.
â Bacteria like *Rhizobium leguminosarum* sp, Azotobacter, Nostoc, Nitrobacter, Nitrosomonas help in nitrogen fixation.
â They help to improve soil aeration by their burrowing activities.
â They help to improve the cation exchange capacity of soil.
â They help to stabilize the soil pH through the increase in soil organic matter and buffering.
â They increase the mineral or nutrient status of the soil.
â They help to influence chemical changes in the carbon and nitrogen cycles.

Soil air

This is the amount of gases found inside the soil. It is essential for respiration of soil micro-organisms.

Importance of soil air

â It is about 25% of the total volume of the soil.
â It promotes the growth and development of the seed.
â It is needed by micro-organisms for respiration.

â It helps in many reactions in the soil such as oxidation reaction.
â It is needed in nitrogen and carbon cycles.

11.4 Soil pH

The pH (pondus de Hydronum) is defined as the measure of hydrogen and hydroxyl ion concentration. They determine the acidity, alkalinity and neutrality of the soil. The hydrogen ion indicates the acidity while the hydroxyl ion indicates the alkalinity of the soil and it is measured with a pH scale. The pH scale is graduated within the range of 1–14.

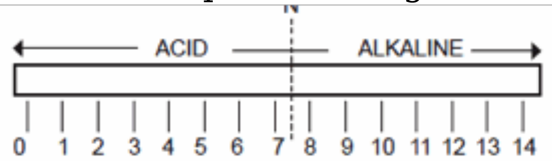


FIGURE 11.2 The pH scale

TABLE 11.2 Effects of pH on soil and plants

S/N	Effects on soil and plants
1	**Toxicity:** Excess acid or alkaline in the soil causes toxicity which affects plants growth.
2	**Nutrient availability:** It hinders the release of certain mineral elements to crops.
3	**Activities of soil organisms:** It hinders the performance and activities of useful soil organisms such as earthworms, bacteria.
4	**Nitrogen fixation:** It reduces the efficiency of soil micro-organisms such as the symbiotic and the free-living nitrogen fixing bacteria.
5	**Nutrient imbalance:** Some mineral elements present in the soil are made unavailable because they have been transformed into forms in which they are not available as a result of chemical reaction.
6	**Deterioration of soil:** Any soil with extremes of pH is poor for agricultural purposes especially aquaculture and crop production.

Acidity increases towards 0 and alkalinity increases towards 14. 7 is neutral. A pH range between 6.5 and 7.5 is optimum for most plants and soil organisms.

Problems associated with soil pH – causes

Soil acidity is usually caused by accumulation of excess hydrogen and aluminum ions
in the soil. The following factors cause soil acidity.
â **Crop removal:** Crops absorb nutrients from the soil during periods of active growth in the form of cations. The absorbed nutrients are taken away at harvesting, causing the soil to become acidic.
â **Leaching:** Elements in the soil like calcium, magnesium, sodium and potassium are normally absorbed to the surface of soil colloids in exchangeable manner. When there is excess water in the soil, some of these nutrients are leached away from the plant root zone into the subsoil. The pH is thereafter lowered and acidity results due to the presence of H^+ and Al^{3+} ions.
â **Organic matter decomposition** : Organic matter decomposition and mineralization increases the concentration of sulphur in the soil leading to acidity. Similarly, ammonium compounds which result from mineralization of organic matter may increase acidity of the soil due to oxidation reaction that liberates H^+ ions.
â **Use of acidic fertilizer:** Some fertilizers like ammonium sulphate and ammonium nitrate tend to release acid to the soil. This is because the nitrate and sulphate radicals in them combine with soil and water to produce acids.

â **Presence of clay minerals:** Clay minerals possess negative charges that attract and bind available cation. This results in the soil acidity. Also acid rain in most petroleum exploring region results in soil acidity.
â **Acidic parent materials:** Some parent materials are acidic in nature. When these parent rocks dissolve, they leave behind minerals that are rich in hydrogen ions.
â **Dumping of toxic waste:** Deliberate dumping of toxic wastes into the environment. A typical example is dumping of toxic waste from Europe into Nigeria in the 1980s, popularly known as the Koko toxic waste dump. Some of these contain radioactive substances that yield high concentration of H^+.
â **Use of agro-chemicals:** Some of these agro-chemicals react directly with mineral elements in the soil and increase soil acidity.
â **Flooding:** When organic materials are submerged and decomposed in water, the medium becomes acidic.
â **Heavy metal contamination of the environment:** Industrial effluent and toxic waste, when discharged directly into open field, can increase or decrease H^+ concentration through the introduced chemical substances.
â **Bush burning:** During burning organic materials are converted into ash. Some naturally occurring compounds such as calcium, potassium and magnesium salts are converted to their oxides. This increases the alkalinity of the soil.

Correction of soil pH

Lime/Liming

Liming is the application of liming materials like calcium oxide or quick lime CaO, calcium bicarbonate $Ca(HCO_3)_2$, limestone (calcium carbonate) ($CaCo_3$), slaked lime ($Ca(OH)_2$), dolomite or calcite ($CaCO_3$ Mg CO_3). Basic slag $Ca_3(OHSIO_3)_2$, wood ash (calcium phosphosilicate) Ca_4 (PO4)$_2$ SIO_4 when applied the Ca^{++} or mg $^{++}$ ion in the lime replaces the H^+ or AL^{+++} ions in the soil. This reduces the acidity of the soil.
â **Application of organic manure:** When the soil is alkaline organic manure is applied.
This helps to neutralize the alkalinity of the soil.
â **Application of acidifying fertilizer (ammonium sulphate):** It helps to reduce the alkalinity of the soil.
â **Irrigation by flooding:** When the soil is flooded using irrigation water, it helps to reduce the alkalinity of the soil.
â **Application of sulphur:** When the soil is alkaline, it can be reduced by the application of sulphur.

Methods of determining soil pH

1. Use of pH meter

The concentration of the pH is determined using the soil pH meter.

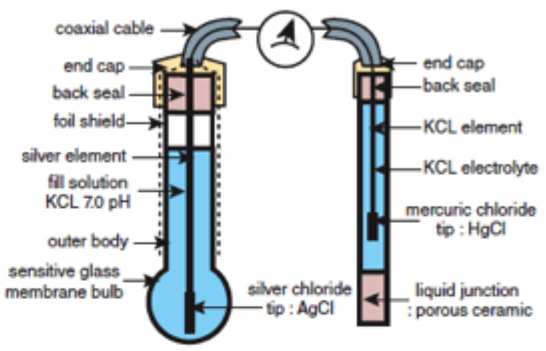


FIGURE 11.3 pH meter

2. The BDH Soil Test
This is used to determine the soil pH manually.
Procedure
(i) For sandy soil about 12 mm barium sulphate is placed on the bottom of the test tube, loamy 25 mm, and clay soil 40 mm.
(ii) The soil sample is added to give a total depth of 25 mm.
(iii) Distilled water is added to depth of the lower graduation on the tube.
(iv) The soil indicator solution is now added sufficiently to bring the level of the liquid to the upper graduation.
(v) The tube is closed with rubber band, well shaken and then allowed to stand until a clear-coloured solution above the soil can be readily compared with the colours on the chart.
3. Electrometeric Determination of Soil pH
This is the most accurate method where a pH meter is available. Laboratory and portable models are supplied. In each case, electrodes are placed in a soil suspension or soil paste, with modern instruments and the reaction is read directly from a scale.
Procedure
(i) Measure about 20 gm of soil into 50 cm_3 beaker.
(ii) Add sufficient distilled water to soak the soil.
(iii) Stir the soil with a glass rod.
(iv) If necessary, add a little more water to obtain a paste but not so wet that water stands on the surface.
(v) Set the pH with a buffer solution according to the makerâ€™s instruction.
(vi) Determine the reaction of the soil paste by placing the electrodes of the pH meter into the paste in at least four different places. The average value of these four determinations is taken as the soil pH.
4. Colourimetric Determination of Soil pH
In colourimetric methods, the colour developed by soil extracts and suitable indicators in various buffer solutions or permanent glass colour standards or with colours on printed card are observed and compared with a standard/chart.

11.5 Physical Properties of Soil
The physical properties of soil consist of:
(i) soil texture.
(ii) soil structure.

11.5.1 Soil Texture
Soil texture is defined as the degree of fineness or coarseness of soil as

determined by the size and distribution of the primary particles. In other words soil texture is the relative proportion of the various particles of soil. Texture is an important physical characteristic of a soil. Water and air movement depends partly on the soil texture.

The texture of the soil can be determined through the following ways :

(a) Field Method: **(i)** Feel method **(ii)** Moulding method

(b) Laboratory Method

Field Method

(i) Feel method: In this method, soil is held between the thumb and the index finger and rubbed together. If the feel is rough, gritty, or coarse, the soil is sandy soil. If smooth and powdery when dry and sticky when wet, it is clay. A fluffy and soapy feel connotes loamy soil.

(ii) Moulding method: The soil is adequately moistened and moulded into different shapes. The shape that forms depends on the texture of the soil. For instance, sandy soil does not form any shape when moulded. Light clay soil forms a ribbon that reacts as it bends into circle. Heavy clay forms a ribbon that makes a perfect circle.

TABLE 11.3 Soil textural classification

Soil fraction	Diameter of particles (mm)
Clay	Less than 0.002 mm
Silt	0.002–0.02 mm
Fine sand	0.02–0.2 mm
Coarse sand	0.2–2 mm
Gravel	2 mm and above

Loamy soil forms a ball, while light sand can be rolled out into a short flat cylinder.

Laboratory Method

(i) Sedimentation method: A known quantity of soil is poured into a glass cylinder and water four times the volume of the soil added. Then a known quantity of hydrogen peroxide is added. The mouth of the cylinder is covered with hand and vigorously shaken for about three minutes by turning and inverting. The cylinder kept on a table and the contents are allowed to settle. The particles will settle according to their sizes, the bigger ones settling first. Their relative volumes may be read from the cylinder.

(ii) Mechanical sieving method: Some quantity of soil is poured into sieves arranged in the order of mesh diameter with the smallest at the bottom. Thereafter the sieves are shaken.

The particles which can pass through a particular mesh belong to the corresponding grade of the soil.

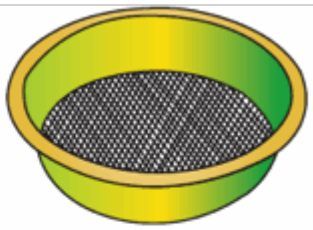


FIGURE 11. 5 A sieve

Importance of Soil Texture

Soil texture has great influence on crop production. It determines
â the type of crops to grow on any type of soil.
â the proportion of air and water in the soil.
â the nutrients availability in the soil.
â the type of farm operations.

11.5.2 Soil Structure

Soil structure is defined as the physical appearance of the soil according to the arrangement of the individual particles. In other words this is the arrangement of soil particles into various aggregate size and shapes.

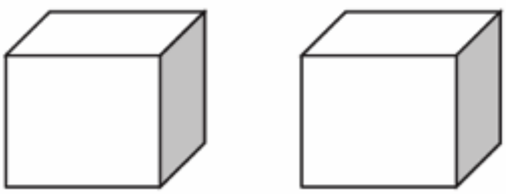
Types of Soil Structure

The common types of soil structures are as follows :

1. Granular form/spheroidal: They form granules or crumbs with a lot of pore spaces between them. These types of structures are found in the top soils that contain organic matter. There is good circulation of air and water.

Spheroidal/granular

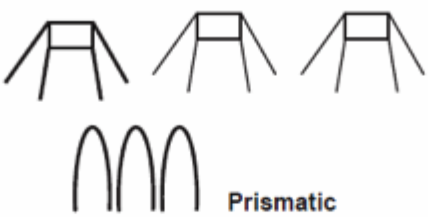
2. Block-like: The aggregate looks like block or cubes with irregular shapes. They are found in sub-soils that are rich in clay.



Block-like

3. Prism-like: The particles are arranged in prism-like manner in vertical axes.

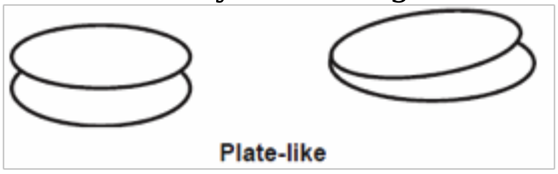
Where the edges are clear and sharp, the structure is termed prismatic. When the rounding of the tops of the particle has taken place, the particles are said to be columnar. They possess air spaces and are mostly found in sub-soils.



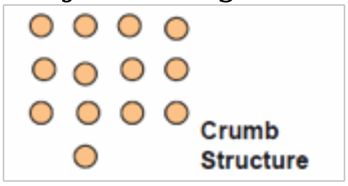
Prismatic

4. Plate-like: These structures are laid in thin flat layers that are plate-like.

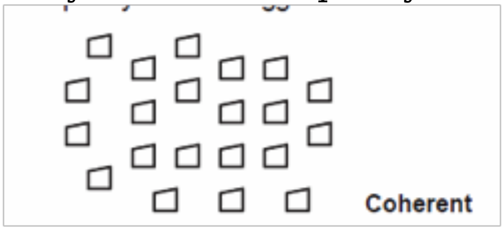
They are commonly found in soils whose parent materials have been deposited in layers by ice and water. They are found in sub-soil and also in surface layers of virgin soils.



5. Crumb structure: They are formed when grained particles coagulate and are joined together to form round aggregates. It is found in top soil.



6. Coherent: They are formed when the single grained particles are joined together by small binding factors. They cannot form large aggregates. They are found in paddy or water logged soils.



Importance of Soil Structure

â It facilitates seed bed preparation.
â It prevents water logging thus reducing erosion and allowing water percolation.
â It determines the level of soil fertility.
â It promotes the activities of soil microorganisms.
â It allows easy penetration of plant root and germination.
â It determines the tillage practices to be adopted by the farmer.

11.6 Soil Classification Systems

Soils are classified in different ways. The type of classification adopted depends on the physical characteristics of soil such as texture, its depth, fertility or even the amount of soluble salts it contains.

11.6.1 Classification of Nigerian Soils

Nigerian soils are classified into six classes as follows :

(i) Ferruginous Tropical Soils : These soils exhibit marked differentiation of horizons. They frequently have a leached A-horizon and contain a textural or structural B-horizon. The ferruginous soils are found in southern Nigeria which has two rainfall peaks. Examples of crops grown here are yam, maize, cassava, upland rice, oil palm and cocoa. Fertility can be maintained under continuous cropping by the use of green manure crops such as mucuna. The soils also respond generally to ready available phosphate and nitrogenous manure. Ferruginous soils are also found in the northern Nigeria where the rainfall rises to a single peak in August. It supports the growth of such crops as guinea corn, cotton, groundnut, millet, rice, sugar cane and tobacco. All crops respond to dressing of 25–50 kg of super phosphate, particularly if placed 4 cm or so from the seed/seedling.

(ii) The Ferrisols : These are generally considered as transitional soils. They resemble the ferrallitic soils, but with relatively retarded profile development due to erosion. The ferrisols are distinguished from ferralitic soils by their high exchangeable basic content, their better structure and higher biological activity. They have high organic matter content. This type of soil is deficient in available phosphates. It supports the growth of yam, cassava, guinea corn, benni seed, swamp rice and soya beans.
This type of soil is found in the South. It supports the growth of oil palm and maize. The soil is also found in Ogoja and Benue.
(iii) Ferrallitic Soils : The characteristics of soils in this category reflect the final effects of weathering and leaching. They are generally deep, exhibit slight differentiation of horizons and have bright colouration. They contain little or no reserve of wealtherable minerals and the clay fractions consist mainly of kaolinite. These soils are acidic and infertile except where there has been accumulation of vegetable matter due to heavy forest growth or secondary bush. Crops that grow in this soil type are yam, cassava, bambara groundnut, maize, oil palm and kola. Citrus and pineapple are also grown on these soils. The soil responds to manuring using sulphate of potash, super phosphateand sulphate of ammonia.
(iv) Eutrophic Brown Soil : This type of soil iswell structured and found in the B horizon. The clay fractions consist mainly of 2 :1 type of lattice clay. They areconsideredas relatively young soils. Eutrophic brown soils developed on volcanic ash which occurs in isolated particles in plateau and Adamawa areas of northern Nigeria. It supports crops like banana, oil palm, rubber, cocoyam, and plantain. Elephant grass (*Pennisetum purpureum*) does well as a fallow or forage crop.
(v) Calcimorphic Soil : This type of soil contains large quantities of relatively soluble compounds of calcium. Theyare generally rich in clay. They are badly eroded over a large area. To protect the soil adequate soil conservation should be carried out.
(vi) Vertisols : This type of soil contains more than 30 % clay. It has a cation exchange capacity in the excess of 30 mg per 100 g of soil. It is found in the northern part of the country precisely in Maiduguri and Gombe. They help in the production of cotton and sorghum.

Experiment to Determine Capillary Action of Soil Types

Apparatus: Three long glass tubes, cotton wool trough, stop clock, dry sand, dry clay, dry loam, water.

Method: Plug one end of the glass tube with cotton wool. Fill the tubes with dry sand, dry clay and dry loam separately. The three tubes containing the grounded soils are immersed at one end into the trough containing water.Allow the experimental set-up to stand for one to two hours in the laboratory.

Observation: Note that water rises faster in sandy soil than the other two samples. At the end of one hour, clay and loamy soil experienced higher rise in water but very low rise in sandy soil.

Conclusion: Clay soil has the highest capillary action followed by loam, due to the tiny pore spaces. Sandy soil has poor capillary action due to large pore spaces and large particle sizes.

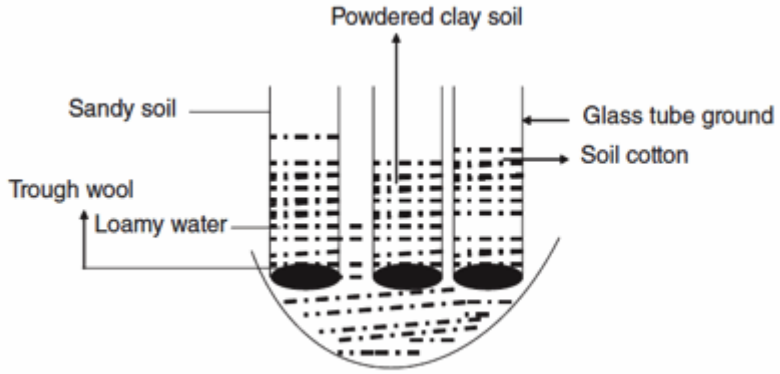


FIGURE 11.6 Capillary action of soil types

Experiment to Determine the Water-Holding Capacity of Soil

Aim: To determine the water-holding capacity of different types of soil.

Apparatus: Three measuring cylinders, cotton wool, three funnels, sand, loam, clay.

Method: Plug the three funnels with cotton wool and place each separately on a measuring cylinder. Weigh equal quantity of soil (50 gl) and pour it inside the funnels. Add equal volume of water (100 ml) to each set-up. Allow the water to drain into the measuring cylinders for 2 to 3 hours.

Observation: Note that water drains faster in sand, followed by loam and slowly in clay. Smallest amount of water is obtained in the cylinder containing clay soil. The amount of water in the cylinder with loam is less than that under sandy soil but greater than clay.

Conclusion: Clay soil has the greatest capacity to hold water. Loam soil retains moderate water, while sandy soil has very low water retention capacity. Therefore, clay holds too much water and does not drain easily. It can become waterlogged and so is not good for agriculture.

Loamy soil holds and drains water moderately and therefore is ideal for agriculture.

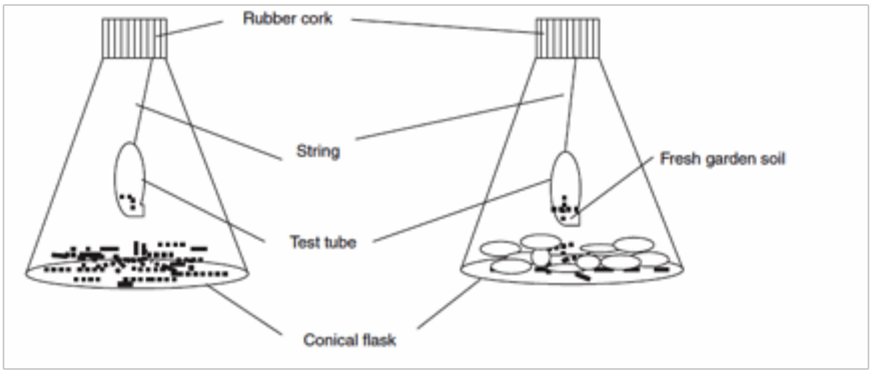
Experiment to Show That Living Organisms are Present in the Soil

Apparatus: Lime water, garden soil, 250 ml conical fl ask, rubber cork, petroleum jelly,
string, test tube.

Method: Oven dry 100 g of garden soil at 80Â°C and allow to cool for 24 hours. Get two 250 ml conical flasks and two test tubes. Place 100 g oven-dried soil and 100 g of garden soil separately in each conical flask. Pour 50 ml of lime water into two test tubes and suspend each carefully with a string inside each conical flask stand containing each soil sample and hold the string firmly with petroleum jelly to make it airtight and prevent entry of micro-organisms.

Observation: Note that the lime in the set up A with garden soil turns milky indicating carbon iv oxide has been released due to respiratory activities of the living organisms. The lime water in conical B remains clear, indicating that the organisms are not present.

Conclusion: Living organisms are an integral component and are present in fresh garden soil.



Experiment to Determine the Organic Matter Content of Garden Soil

Apparatus: Garden soil, evaporating dish, weighing balance, bunsen burner, stirring rod and desiccator.

Method: Weigh a known quantity of garden soil into an evaporating dish. Heat the sample at 105Â°C continuously until a constant weight is obtained for about 1 to 2 hours. The garden soil and the dish are heated and placed in a desiccator to cool and are weighed again.

Results

Weight of evaporating dish = 20 g(A)

Weight of evaporating dish+ garden soil = 60 g (B)

Weight of fresh garden soil (B âˆ’ A) = 40 g

Weight of dish + heated soil (C) = 50 g

Weight of organic matter burnt (B âˆ’ C) = 10 g

Percentage of organic matter in soil sample

$$\frac{(B-C)}{(B-A)} = \frac{\text{Weight of organic matter removed } (B-C)}{\text{Weight of fresh soil } (B-A)} \times \frac{100}{1}$$

$$= \frac{10}{40} \times \frac{100}{1} = 25\%$$

Conclusion: Soil contains some quantity of humus soil.

Summary

- Soil is defined as the loose weathered material covering the surface of the earth which supports the growth of plants and sustain human and animal life.
- There are three types of soil, namely, sandy, loamy and clay soil and each has its basic characteristics.

- The chemical elements in the soil that constitute plant food consist of micro and macro nutrients.
- The soil is made up of organic and inorganic matter, soil air, soil water and soil living organisms.
- The soil pH determines the type of crop to be grown on a piece of land.
- Soil classification is normally based on their physical characteristics such as texture, fertility and soluble salts they contain.
- The classification of Nigerian soil is based on the texture and chemical composition of the soils.

Revision Questions

Essay Questions

1. (a) In an experiment on soil porosity, the following measurements were taken and recorded.

Volume of dry soil = 50 cm^3

Volume of water = 50 cm^3
Total volume of soil and water = 74 cm
Use the above information to
(i) Find the volume of air space in the soil sample.
(ii) Calculate the porosity of soil sample.
(b) Mention three reasons why soil porosity is important in agriculture.
(c) State four characteristics each of igneous and sedimentary rocks.
(WASSCE June 2005)
2. (a) (i) State six uses of lime in agriculture.
(ii) List four liming materials.
(b) (i) State three examples of nitrogenous fertilizer.
(ii) Three examples of phosphorous fertilizer
(WASSCE June 1997)
3. Write short notes on the following :
(a) Soil pH
(b) Soil texture
(c) Soil organisms
(d) Soil profile
(WASSCE June 1996)
4. (a) Describe briefly six ways in which soil organisms aid the formation of soils.
(b) State four ways in which soil organisms improve soils for crops growth.
(WASSCE June 1999)
5. (a) In a tabular form, state five differences between sandy and clayey soils.
(b) List two physical properties of soil.
(c) Mention four important factors of soil texture in agriculture.
(NECSSCE June 2010)
â—† The chemical elements in the soil that constitute plant food consist of micro and macro nutrients.

Objective Questions

1. The horizon of a soil profile which encourages the greatest level of microbial activity is
(a) A-horizon.
(b) B-horizon.
(c) C-horizon.
(d) D-horizon.
2. The easiest method of determining soil texture in the field is by
(a) moulding.
(b) sieving.
(c) feeling.
(d) sedimentation.
3. The components of soil include the following except
(a) living organism.
(b) moisture.
(c) mineral matter.
(d) light.
4. A soil pH_2 can be described as
(a) highly acidic.
(b) moderately alkaline.
(c) neutral.
(d) highly alkaline.

5. Which of the following soil water is tightly held to the surface of soil particles ?
(a) Hygroscopic water
(b) Gravitational water
(c) Capillary water
(d) Superfluous water
6. What is the percentage of water content of a soil sample which weighs 180g when fresh and 120 g when oven-dried ?
(a) 66.7%
(b) 60%
(c) 15%
(d) 33.3%

Answers to Objective Questions
1. (a) 2. (c) 3. (d) 4. (a) 5. (c) 6. (d) 7. (a)