

CHAPTER 6 SOILS

Objectives

After studying this chapter, students should be able to:

- define soils and describe their characteristics;
- describe the various components of the soil;
- describe the factors and processes of soil formation;
- describe the soil profile;
- describe the major types of soil;
- describe and enumerate the importance of soils to man;
- describe the effects of human activities on soils; and
- describe the various methods of soil conservation.

6.1 Definition

Soil is the upper layer of the Earth from where plants derive their food, water and mineral nutrients essential for their growth. It is the outermost layer of the Earth. It may be deep, (up to 3m) or very shallow about 2cm. The soil actually constitute only a few centimetres of the top layer of the Earth's crust, although the depth varies from place to place.

Characteristics of soils

These are the major attributes or features of every soil and they include:

1. **Colour:** This is the most striking feature of the soil and the first to be noticed. Soils have several colours ranging from white, yellow, red, brown, black, grey, etc. The colour of the soil provides information as to how the soil was formed. It changes from the surface downwards and from one place to the other.

2. **Texture:** This is the degree of roughness or fineness of the soil particles. This determines their ability to retain water and also support plant growth. It also determines the flow of water in the soil.
3. **Structure:** This is the physical arrangement of the soil particles in relation to one another. This is determined by the grain sizes of the rock and mineral particles from which soils are derived.
4. **Permeability:** This refers to the ability of soils to retain water. This is largely determined by the size of the soil particles and the size of pores or holes within the soil particles. This is concerned with the movement of water through the soil layers. Soils with rough structures are permeable while those with fine particles are impermeable.
5. **Porosity:** This is the ability of soil to allow water to pass through it. This is affected by the structure of the soil particles and the amount of pore spaces in a soil. Both the coarse and fine textured soils e.g. sand are porous as they have numerous pore spaces.

6.2 Components and Constituents of Soil

Soils are made up of several materials which are necessary and must be available in all soil types for them to be useful to man and other living organisms in the environment. Hence, the constituents must be examined to know how useful a particular soil will be. The five constituent materials are described below:

1. **Mineral or Inorganic matter:** These are the solid materials that are found in the soil. They are inorganic materials that are derived out of physical and chemical processes. The mineral matters are made up of rock and mineral particles that are derived from the weathered rocks that are found underneath the soil. This material is very

essential as it shows the mineral composition of the parent material from which soils are made. Indeed the parent material determines the mineral content of soils.

2. **Organic matter:** This consists of plant and animal wastes in the form of litter or humus which exists at various stages of decomposition. They help in binding together the mineral matter in soils. In addition, they serve as medium for retaining soil water and for providing additional soil minerals. They determine to a large extent, the fertility or otherwise of soils. Organic matter is formed from the decomposition of plant and animal organisms and consists of litter of dried and fallen leaves and the humus which is the matter formed out of the decomposition of dead animal and plant organisms.
3. **Air:** These are the gaseous substances that are found in the soil. It provides support through the presence of gases such as oxygen, carbon dioxide and nitrogen. Air is needed by plants to make their food in the form of sugar, starch and protein. The gases also help micro-organism to survive within the soil. Through the process of gaseous exchange, soil air is replenished from time to time.
4. **Water:** This is the medium through which plants and many micro-organisms obtain mineral elements from the soil. Water is also important for the process of weathering and leaching that occurs in soils. There are two types of water in the soil. First, is that water which occupies the soil pores during rainfall and drains the soil towards the water table. It is called the **FREE DRAINING** or **GRAVITATIONAL WATER**. It is of no use to plants as it washes away soil materials including plant nutrients. The second type of water is the **CAPILLARY WATER**. This water is often held within the tiny or small air pores in the soil. This is the water that is readily

available to plants. Another form of water that is readily available to plants through chemical exchange is the **HYGROSCOPIC WATER** which is attached to clay and humus particle.

Water ought to present in the soil in order for plant to grow. For this to be, the micropores must be completely filled with water, while the macropores are completely empty. The soil is then said to be in **FIELD CAPACITY**. Where there is excess of water relative to air, the soil is said to be in **POOR DRAINAGE**. When both the micropores and the macropores are filled with water, the soil is said to be **WATER LOGGED**.

5. **Living organisms:** These are organisms such as bacteria, algae, fungi, termites and worms that live in the soil. Through their activities, they help to build up the structure of the soil, maintain its fertility and help improve the flow of air and water in the soil. These organisms also assist in breaking down plant tissues in order to convert them to carbon dioxide and water. Through this, gases such as nitrogen and other plant nutrients are released into the soils. When the organisms die, their remains add to the organic substance in the soils.

6.3 Factors Affecting Soil Formation

The type and quality of soil formed in a particular place depend on some factors which include:

1. **Parent material:** This is the material from which the soil is formed. It may be in the form of a weathered material or it may be a material deposited in a particular area by agents such as rivers, waves, winds or moving ice. The kind of material significantly determines the nature especially the texture of the soil that will be formed from it. Also the parent material influences the depth, texture and the water-

holding capacity of a particular soil. Similarly, the parent material is responsible for the chemical content of the soil and the mineral content.

2. **Climate:** This is the most important factor in the formation of soil. This is because it controls to a large extent the depth of the soil, the degree of leaching, the amount of organic matter and several others. Soils formed in dry climates tend to be shallow but are deep in the humid areas. Also soils suffer from serious leaching in places with heavy rainfall unlike places with light rainfall. In essence, climates affect soils through the influence of rainfall and temperature and through its effect on vegetation such that, rock pieces are either broken down or dissolved through the action of the climatic elements.
3. **Topography and landform:** The shape of the land is very vital in soil formation. This is because places with steep slope experience erosion which will help in wearing and moving tiny rock pieces and sediments down the slope. Hence, soils are likely to be shallow and indeed may be stony because the fine grains have been washed away. In contrast, areas of gentle slope will however have deeper soils because the rate of erosion is less. Also, the soil may not be as stony as on steep slopes because weathering is more intense here. In all, it can be seen that hilly areas possess less soil than fairly sloping areas that possess deep soils. Equally, reliefs have been known to influence soil in the distribution of parent material, the amount of organic matter and soil solution.
4. **Vegetation:** This influence soil formation in the following ways: The root of plants penetrate rocks which later break them down into tiny pieces. Also, the fallen leaves of plants often decay which later result in their decomposition into litter which is the major source of

organic matter in soils. Lastly, different types of vegetation are associated with different types of soils.

5. **Biotic or living organisms:** They also contribute to the formation of soils. Burrowing animals which live underground, penetrate and break rocks down into tiny pieces, so also do they assist in the decomposition of plant and animal organisms which aids soil formation.
6. **Human activities:** There are several human activities that promote soil formation particularly those that interfere with the land surface such as agriculture, mining, road and building construction, grazing, etc. This is because these activities often disturb and destroy the vegetation cover thereby exposing them to the activities of erosion, weathering, etc.
7. **Time or age:** This refers to the time element in the formation of soils. This is because the time required for the formation of soils varies from one place to the other. The duration can be influenced by the rate at which environmental conditions of each area are changed. It is the change in these environmental conditions which to a large extent determines how long it may take particular processes of soil formation to operate before complete soil profiles or mature soils will develop. Equally, it takes some time for plant and animal organisms to decay and become part of the soil.

6.4 Processes of Soil Formation

This is the process by which the parent material is converted to soil through the various processes involved. These are the basic steps which take place when the parent material is being turned to soil. There are mainly five processes involved in soil formation. They are:

1. Leaching

2. Eluviation
3. Illuviation
4. Humification
5. Mineralization

All these processes depend largely on climate for effective operation.

1. **Leaching:** This is the process by which water removes readily soluble substances from the upper part of the soil parent material. The substances include the carbonates as well as salts which are produced when rocks decompose. Oftentimes, these substances are removed completely into a nearby stream once they are dissolved. This phenomenon is very common in wet climates as in the forest areas of Nigeria. However, in drier climates, the dissolved materials are deposited lower down the soil being formed. Hence, climate is a crucial factor in the process of leaching.
2. **Eluviation:** This is very similar to leaching. The only difference lies in that fact that it involves solid particles. This is a process that involves the removal through suspension of fine particles especially clay from the soil. Like leaching, materials may be removed into a nearby stream and then carried away. This is the situation of things in humid and very wet climates. In drier climates such as the savanna areas of Nigeria, the material may be deposited lower down in the soil being formed.
3. **Illuviation:** This is the process whereby leached or eluviated materials from the upper part of a soil are deposited lower down in the same soil. Illuviation is very important in climates which are neither too wet nor too dry.

4. **Humification:** This is the process by which dead organic materials are broken down or decomposed to form humus. Humus is a gum-material which sticks to soil particles especially clay. It is derived from the remains of plant organisms and for that reason contains plant nutrients. Humification is a common occurrence in wet and warm areas that is either dry or cold areas. For this reason, soils form rapidly in the humid tropics than in arid or cold environment.
5. **Mineralization:** This is the process whereby organic matter is broken down further into mineral or inorganic substance. In essence, a dead leaf is transformed to form gases (such as carbon dioxide) under mineralization. This process is very important because it helps to release nutrients into the soil so that growing plants can use them again. This process is most rapid in hot and warm climates.

Note that the above processes are important in soil formation, although they are more effective when they act together on the parent material such that soil can be formed. In essence, soil formation is a process by which the parent material is converted into soils through leaching, eluviation and illuviation, humification and mineralization. All these processes largely depend on climate as different climates produce different types of soil.

6.5 The Soil Profile

This may be defined as a vertical section through the soil to the underlying rocks showing the various layers of the soil. These layers are referred to as **HORIZONS**. These layers are distinct and possess attributes that are peculiar to each. A layer within the soil can be distinguished from another because of differences in terms of colour; texture and consistency.

A well developed soil usually consists of three main horizons called:

- (i) the A horizon
- (ii) the B horizon
- (iii) the C horizon

These horizons as can be seen above are designated by the letters of the alphabet. In certain parts of the world where there is consistent accumulation of raw humus on the soil surface, the first layer of the soil is the organic layer designated O or AO horizon. Elsewhere, the surface layer of the soil is the A – horizon.

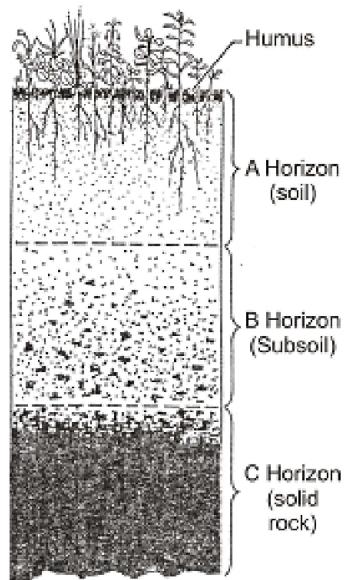


Fig. 6.1: Soil profile

The A – horizon

This layer is otherwise known as the top soil and it has the following characteristics:

- (i) This is the layer that has a direct contact with the atmosphere and serves as the platform that holds the plants and animals.
- (ii) It is dark in colour because it contains humus which is the main organic content.

- (iii) It is the zone of eluviation where minerals are moved down the soil profile.
- (iv) This is the zone where all biological activities involving plants and micro-organisms take place.
- (v) It loses fine humus, clay and silt particles in the horizons below.
- (vi) It is generally coarse in texture and more loose in structure than the layer below because of the eluviation of fine materials.

The B – horizon

This layer is called the sub-soil. It has the following characteristics:

- (i) It is the second layer of a typical soil profile.
- (ii) It is an illuvial horizon because most of the fine materials transferred from the A – horizon are usually deposited in it, a process which is known as illuviation.
- (iii) It is more compact and fine textured than the A – horizon.
- (iv) It is otherwise known as the zone of enrichment or accumulation of soil minerals. Here, humus and other organic matter are converted into inorganic compound.

The C – horizon

This layer is known as the parent material. Its characteristics include:

- (i) It is made up of a parent material, that is, the **REGOLITH** or weathered material.
- (ii) It has little or no organic matter.
- (iii) It is compact due to the effect of precipitation on accumulated materials over time.
- (iv) It is underlain by hard unweathered rock.
- (v) Due to its depth, it is least affected by the soil forming process.

On the whole, the soil profile is considered important in that, it:

- (i) determines the level of fertility of the soil, for instance, a thick top soil represents high level of soil fertility in the sense that it is likely to be rich in soil nutrients and organic matter (humus).
- (ii) assists farmers to know the specific types of crops to grow on a particular soil type.
- (iii) determines the extent to which plant roots can penetrate the soil in search of soil nutrients and the effects of drainage and aeration on soils.
- (iv) influences the rate of water percolation in soils and to some extent the level of soil erosion in a particular place.

6.6 Types of Soils

On a general note, there are four major types of soils namely:

- (a) Clayey soils
- (b) Loamy soils
- (c) Sandy soils
- (d) Gravely soils

However, only the first three are widely recognized.

Clayey soils

These are soils whose clay content is usually more than 50%. The clay particles have a diameter which is less than 0.02mm. The soils are generally fine. They are sticky when wet and very hard when dry. By their nature, they have poor or no structure and the particles are generally loose. Water cannot move through clayey soils rapidly due to their structure. Thus water stays on the surface for a long time. Due to their sticky nature and the high acidic content, they are not suitable for crop cultivation.

Sandy soils

These soils are highly permeable, that is, they allow water to pass through. Hence, water does not stay on the surface for a long time, rather water moves through it very rapidly. The soil contains a lot of sand more than 50% in content, that is particles are having diameters between 0.02 and 2mm.

Loamy soils

These soils combine the good characteristics of clayey and sandy soils without having any of their limitations. Hence, the soil is very suitable for agriculture than clay or sandy silts. Loamy soils have equal proportion of sand and silt combined together. In specific terms, silt has diameters between 0.002 – 2.02 while sand has diameters between 0.02 – 2.0mm. They are made up of both coarse grains and fine grains. Loamy soils are fairly sticky when wet but not as sticky as clay. Water moves through them at a moderate rate.

Importance of soils

1. It helps plants to grow since it provides the platform, medium and nutrients for their sustenance and existence. Agriculture and lumbering owe their existence and practice to soil.
2. Soil provides platform for buildings and raw materials for the construction of houses, roads and other physical structures.
3. Soil stores nutrients and materials needed by plants and crops for their continuous existence.
4. It serves as habitat for most micro-organisms especially bacteria and some animals such as earthworms, termites and rodents.

5. It also serves as reservoir for water and air especially underground water from where man gets parts of his water supply.
6. Soil contains mineral resources which man over the years have exploited for his use and benefit.

Effects of human activities on soil

Indeed soil is important to man and in the process of exploiting it, there are some human activities carried out that exert some negative influences. The influences exert some effects, some of which are:

1. The contamination of soil particles as a result of the introduction of toxic materials with its attendant problems. For instance, in 1988, a large consignment of radio-active materials were dumped in Koko, Delta State which affected adversely the local soil and its immediate ecosystem.
2. Increased activities of soil erosion due to constant destruction of the vegetation cover and the washing away of the top soil, as a result of multi-cropping.
3. Occurrence of leaching in most humid climates and their effect on the level of soil fertility as a result of indiscriminate destruction of vegetation cover, which makes a lot of water to travel down the soil layers during torrential downpour.
4. Impoverishment of soils due to certain harmful practices such as bush burning, indiscriminate animal grazing, covercropping, etc.
5. Increased incidents of flooding and subsequent washing away of soil particles due to increased rainfall pattern in the last twenty years coupled with mining activities that has resulted in removal of huge soil particles has affected the fertility and amount of soil available for use. In addition to this, flooding has resulted in the

- blockage of river channels by erosional deposits and the increased sedimentation of reservoir and lakes.
6. Occurrence of famine as a result of mass destruction of arable land, farm and agricultural production due to persistent soil erosion.

6.7 Soil Conservation

This refers to the process of preventing, controlling and curtailing of soil erosion. It is aimed at ensuring a profitable use of soils so that they can be of immense benefits to man for a long period of time.

There are measures taken to prevent soil erosion and at the same time preserve the soil for man's use. The measures include:

1. The practice of contour ploughing, which is the cultivation of crops along the natural contour lines of sloping ground such that crops are planted at right angles to the downslope lines on which surface run off will normally move. This will help reduce movement of soil particles and help retain enough water in the soil.
2. The practice of terrace farming which is the cutting of steep slopes into a series of wide steps on which crops can then be grown. Along each step are ditches and embankments which are to help direct overland flow to the edges of the field.
3. Crop rotation which is a system of farming where the same piece of land is kept under cultivation every year and still made to produce good crops. This method ensures that all appropriate crops are planted, thus covering of the land and shielding it from erosion. Cover crops such as legumes are often planted as they spread all over a given piece of land and through that prevents the top soil from being washed away.
4. The practice of strip cropping, which is the cultivation of different crops side by side in a narrow, parallel belts such that no strip is laid

bare for ploughing and by so doing, ensures that no area is left open to erosion.

5. The practice of stubble mulching which involves leaving the base of plants with its root intact and also allowing plants leaves and stems to remain on the ground. This help prevent soil erosion and evaporation of soil moisture.
6. The use of agroforestry, which is a land use system whereby farmers combine tree shrubs with other perennial crops with annual crops and livestock on the same land. Agroforestry help in ensuring that tree roots stabilize along the fragile slopes thereby maintaining soil moisture and nutrients and at the same time prevent erosion. The diversity of crops produced protect farmers against natural hazards as well as stabilize farmers' income.
7. Controlled grazing of domestic and commercial livestock thereby reducing the rate at which vegetation cover is being lost.
8. Public enlightenment on the adverse effects of soil erosion and the need to embrace and practise soil conservation.
9. Planting of shelter belts and windbreakers in places liable to wind erosion such that trees will help reduce the speed of the wind and its ability to lift soil particles.
10. The establishment of a government agency to manage and prevent incidents of soil erosion. This agency will among other things prescribe, implement and monitor ways and means of soil conservation. The work of this agency will also be to design programmes aimed at managing soil resources and rehabilitating areas that have been ravaged and degraded by soil erosion. In its operation, there is need to embark on the observation and monitoring of erosion by establishing field experimental stations for research purposes and the analysis of ecological problems arising

from the occurrence of soil erosion. It should also concern itself with mobilizing people for better land management methods and classify land according to their capabilities and vulnerability or susceptibility to erosion.

11. Allocating areas liable to erosion to other special users such as recreation and tourism purposes.

Summary

Soil is an important resource to man and life depends on it.

The soil is made up of mineral materials, organic matter, air, water and micro-organisms.

The properties of soil include colour, texture, structure and porosity.

The soil is divided in layers known as horizons and can be shown through the soil profile.

The soil is important to man as a medium for plant growth and a platform for hold buildings and practicing certain activities such as agriculture, lumbering and construction.

The practice of some human activities impacts on the soil in a negative way, one of which is the occurrence of erosion.

The consequences of soil erosion include soil infertility, weakening of the soil structure, loss of top soil, occurrence of flooding and destruction of lives and properties.

The soil can be conserved by embarking on some measures aimed at retaining its fertility and ensuring its optimal use.

Revision Questions

Objectives

1. Which of the following does not contribute to the character of a soil?
 - A. Prevailing wind
 - B. The nature of the underlying rock
 - C. The relief
 - D. Rainfall
2. A soil will develop most quickly under
 - A. cold dry conditions.
 - B. the influence of continuous heavy rain.
 - C. hot, dry conditions.
 - D. wet, humid conditions.
3. Which is the odd one out?
 - A. Podsol
 - B. Tropical
 - C. Brown forest
 - D. Laterite
4. The frozen subsoil of the tundra regions is known as
 - A. iron pan
 - B. permafrost
 - C. leached layer
 - D. lateritic zone
5. The top of the saturated zone in soil is called the
 - A. water table
 - B. iron pan
 - C. laterite
 - D. dry point

6. Which of the following is not a type of soil?
- Esker
 - Podsol
 - Chernozem
 - Clay
7. Which of the following is not a method of controlling soil erosion?
- Contour ploughing
 - Transhumance
 - Terracing
 - Shelter belts
8. The method of ploughing, planting, cultivation and furrowing along natural contour lines of sloping ground is referred to as
- crop rotation .
 - terracing.
 - contouring.
 - shelter belts.
9. Areas that are highly vulnerable to soil erosion may be better allocated to
- residential uses.
 - industrial uses.
 - special uses.
 - commercial uses.
10. The general process of detaching and transporting the top layer of the Earth's crust by weather and wind is called
- weathering.
 - physiography.
 - soil erosion.
 - lithology.

Answers

1. A 2. D 3. C 4. B 5. A 6. A 7. B 8. C 9. C 10. C

Essay

- 1(a.) Define soil.
- (b.) Describe three properties of the soil.
- 2(a.) List and describe the components of the soil.
- (b.) Describe two characteristics of the soil.
- 3(a.) Give two similarities between soil texture and soil structure.
- (b.) Describe two processes of soil formation.
- 4(a.) Describe three factors of soil formation.
- (b.) Enumerate four importance of soil.
- 5(a.) Describe a typical soil profile.
- (b.) Describe two problems affecting soil as a result of the effects of human activities.