# 1. Rock and Soil

**Can you recall?**

The rocks are formed due to solidification of molten magma, derived from the volcano. Some rocks are formed at the surface whereas some deep below the earth surface. Some rocks are very massive while some are loose. They are composed of minerals combined with different salts.

## 1.1 Definition of Rock

A rock may be defined as a hard mass of mineral matter comprising of two or more minerals. Each rock possesses certain characteristics like colour, structure, specific gravity and minerological make up.

**Observe the stones and rocks**

Collect the pieces of marble, granite, shahbadi, chalk, etc. Study their colour, hardness, granulation, etc. Match the above with different types of rock.

## 1.2 Classification of rocks

### (A) According to mode of formation

1. **Igneous rocks** - These rocks were the first to be formed with the molten mass cooled and consolidated in to solid rock. They are also called as primary rocks.
   These are classified as follows :

(a) The rock formed by the slow cooling of molten magma beneath (deep) the surface is intrusive or plutonic rock e.g. Granite.

(b) The rock formed when the magma poured out on the surface of the earth and consolidated on cooling is extrusive or volcanic rock e.g. Basalt.

Plutonic and volcanic both rocks are known as igneous or primary rocks.

2. **Sedimentary rocks** - The sedimentary rocks are formed from sediments, derived from the breaking down of pre-existing rocks.

The sediments are transported by water, glaciers, etc. to new places, deposited in new arrangements and cemented to form a secondary rock.

3. **Metamorphic rocks** - The igneous and sedimentary rocks undergo considerable change known as metamorphosis and the rock formed by metamorphism is known as metamorphic rock. The metamorphosis is brought about by the action of water (hydrometamorphic rock), heat (thermometamorphic rock), pressure (dynamometamopphic rock) or by the combined action of all. eg : marble, slate, etc.

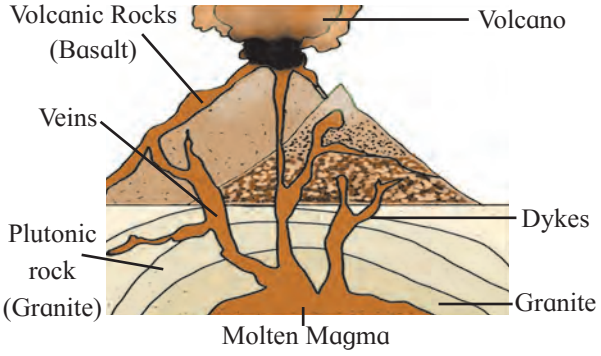



**Fig. 1.1 : Formation of Rocks**

**Do you know ?**

Igneous rocks can be transformed to others. They have different properties.

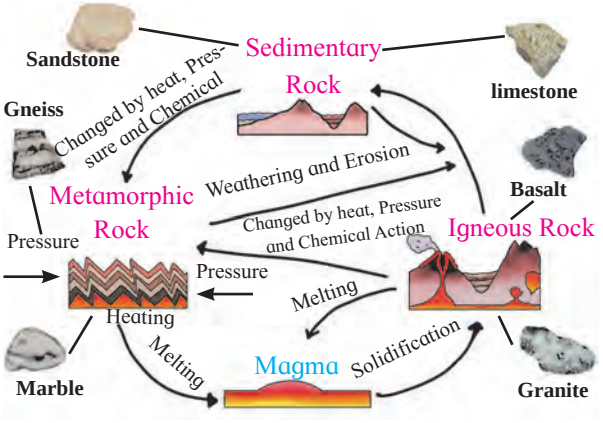



**Fig. 1.2 : The Rock Cycle**

**Table 1.1 : Characteristics and dominant mineral in different types of rocks with examples.**

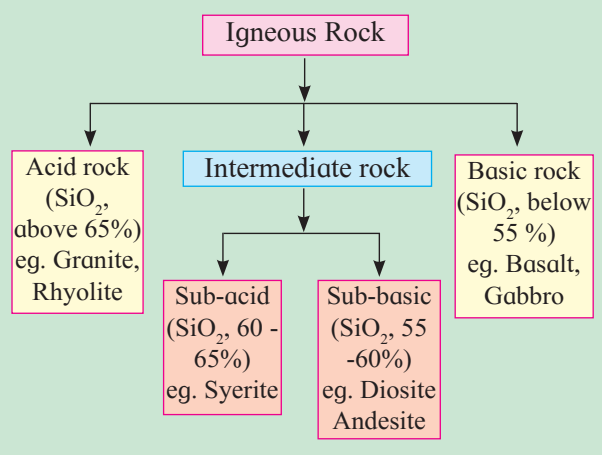
| Rocks | Dominant minerals | Characteristics | Availability |
|---|---|---|---|
| **(1) Igneous rocks** | | | |
| Granite | Feldspar, Mica | Acid rocks – $SiO_2$ 65 % and above light coloured, having big crystals of feldspar | Khanapur, Southern part of Belgaon dist. Vadodara |
| Diorite | Plagioclase, Feldspar, Augite, Magnetite | Sub-basic rock containing 55 to 60 % $SiO_2$ | Dharwad, Junagad |
| Basalt | Plagioclase, Feldspar, Augite, Magnetite | Basic rocks containing 55% or less $SiO_2$, less compact, dark coloured rocks. Micro crystalline texture. Smooth surface | Pune, Peninsular India |
| **(2) Sedimentary rocks** | | | |
| Limestone | Calcite ($CaCO_3$) | Quick effervescences (evolution of $CO_2$) when treated with dil. HCl | Porbandar, Kathiawad, Bagalkot, Shahabad |
| Dolomite | Dolomite $CaMg(CO_3)_2$ | Quick effervescences (evolution of $CO_2$) when treated with dil. HCl | As above |
| Sandstone | Quartz ($SiO_2$) | Excellent building material | Gokak, Badami, Gadag |
| Shale | Clays | Compact clay rocks. They are porous and soft | Dharwad, Hubali, Gadag |
| **(3) Metamorphic rocks** | | | |
| Gneiss | Various quartz, Orthoclase, Hornblende, Biotite | Foliated light coloured hard rocks | Khanapur, Gokak, Vadodara |
| Quartzite | Quartz ($SiO_2$) | Hard, compact, crystalline rock | Gadag, Bagalkot |
| Slate | Clays, mainly compacted clay | Medium, hard, fine grained rocks | Kaladigi, Vadodara |
| Marble | Calcite ($CaCO_3$) | Shining, thoroughly crystalline, hard rocks | Jabalpur |

### (B) Classification on the basis of chemical composition (Silica content)

The different rocks contain silica in different proportion. On the basis of silica content they are of different types.

**Do you know ?**

- ✓ Different rocks have different dominant mineral.
- ✓ They have specific character.
- ✓ They are available in different regions.




## 1.3 Definition of mineral

It is a naturally occurring inorganic substance having a definite chemical composition and distinct physical properties.

### 1.3.1 Classification of minerals

The minerals are classified on the basis of formation, component and specific gravity.

- **On the basis of formation they are**

  Primary – Principal constituent of Quartz, Feldsppar, Calcite, etc.

  Secondary – Deposited as a result of subsequent changes in rocks like Gypsum, Dolomite, etc.

- **On the basis of characteristic component they are** - Essential minerals : .e.g. Feldspar, Mica, etc.

  Accessory minerals : Magnetite, Tourmaline, etc.

- **On the basis of specific gravity they are**

  Heavy minerals : e.g. Haematite, Pyrite, etc

  Light minerals: e.g. Quartz, Muscovite, etc.

## 1.4 Definition of soil

According to Jenny (1941) soil is a naturally occuring body that has evolved owing to the combined influence of climate and organisms acting on a parent material conditioned by relief over a period of time.

According to the glossary of soil science (Soil science society of America 1970) the term soil is defined as

(i) The consolidated mineral material on the immediate surface of the earth that serve as a natural medium for the growth of plants.

(ii) The unconsolidated mineral matter on the surface of earth that has been subjected to an influence by genetic and environmental factor of parent material, climate (including moisture and temperature), macro and micro organisms and topography, all acting over a period of time and producing a product, that is soil. It differs from the material from which it is derived in many physical, chemical, biological and morphological chacteristics and properties.

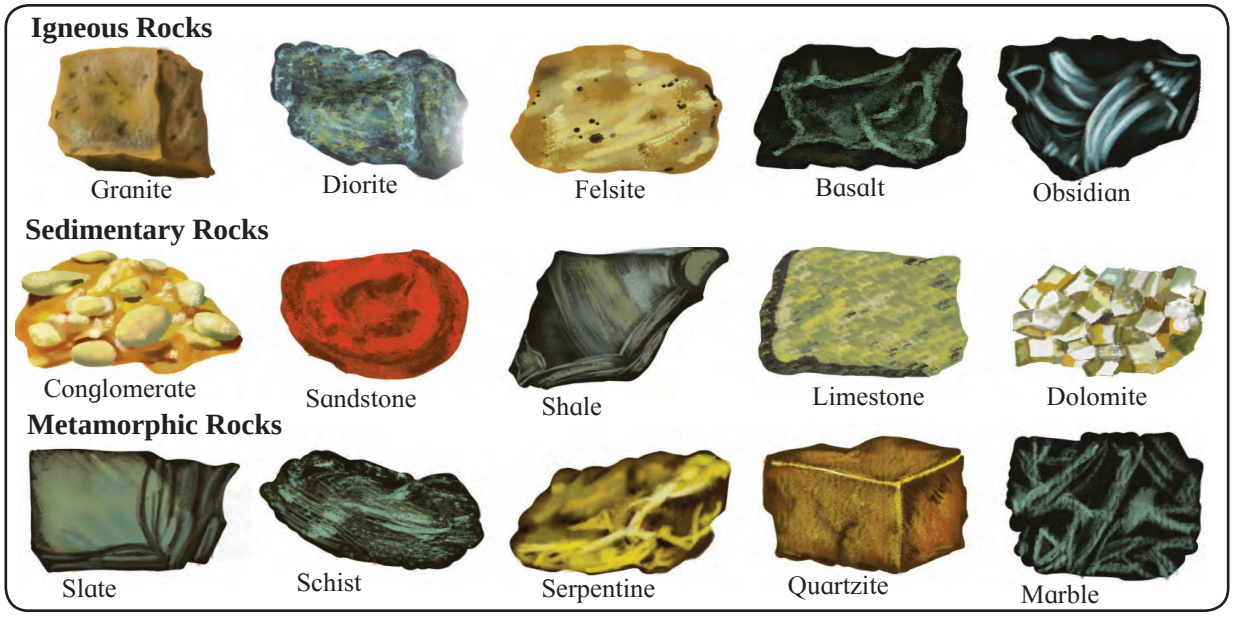



Fig 1.3 : Rock Specimens

### Use your brain power

The approximate proportion of essential minerals in the earth crust.

Earth crust contains (approximately) Feldspar 58.7 %, Quarz 13%, Amphiboles and pyroxenes 10 % , Mica 4%.

### Do you know ?

That soil is a non renewable resource and it takes few hundred years for building 1 cm layer of soil. But it can be lost within a year beacause of negligence of man.

### Observe and Discuss

Observe the soil in the fields. Find whether it is coarse or fine, its colour, nature, etc. Do you know that it is necessary for growing any plant. It is the most important natural resource for every country, because it not only grows variety of food, fodder and fibre crops which are required for mankind and animals, but also provide raw materials for various agro-industries viz., sugar, jute, starch, textile, canning and processing units.

### Mind and understand

It became evident that all soils share a number of characteristics. All have three phase open system to which substances may be added and lost. All have profile, some with more distinct horizons or layers than others.

Thus, soil is three dimensional, dynamic unconsolidated, natural body consisting of phases (solid, liquid and gaseous) and composed of mineral material and organic matter formed on the surface of earth crust under the set of soil forming factors such as climate, vegetation, topography, parent material and it acts as a medium for plant growth and processes.

### Know the Sceientist

Hans Jenny was born in Basel, Switzerland. He earned a diploma in agriculture from the Swiss Federal Institute of Technology (ETH Zurich) in 1922, and a D. Sc. degree in 1927 for a thesis on ion exchange reactions.

Following an appointment at the University of Missouri, he joined the faculty at Berkeley in 1936. International recognition came to Jenny after the 1941 publication of Factors of Soil Formation: A System of Quantitative Pedology. His synthesis of field studies with the abstract formalism of physical chemistry set down the generic mathematical relationship that connects the observed properties of soil with the independent factors that determine the process of soil formation.

## 1.5 Soil formation

### Do you know ?

That weathering of rocks is necessary for soil formation. Material undergoes physical, chemical and biological processes. It converts complicated mass into simpler one.

Weathering means physical disintegration and chemical decomposition of rocks and minerals which takes place naturally at or near the surface of earth crust. Means the process of transformation of solid into soil is known as weathering.

**Visit different sites and observe the weathering process**

How the weathering is going on? You will find that physical, chemical and biological processes are going on simultaneously ?

In physical process due to temperature the rocks expand and during cooling it produces cracks. Ultimately the rocks are broken into big pieces, then to small and smaller particles. Water also apply tremendous pressure, hence, rock splits and disintegrates. The running water also acts mechanically and chemically on rocks. The waves, winds and glaciers also help in the process of disintegration of rocks.

Chemically, decomposition of rocks and minerals is brought about by water and due to the gases ($CO_2$) and salts which are dissolved in water. The chemical reactions involved are hydrolysis, oxidation, reduction, carbonation, hydration, solution, etc. The hydrolysis forms hydroxides, the oxidation oxides, the reduction reduces the salts, carbonation forms the carbonates and bicarbonates. In hydration and solution the complex compounds are changed to simpler ones.

In biological weathering man, animals, higher plants, macro and micro organisms due to their action and secretions hastens the process of decomposition.

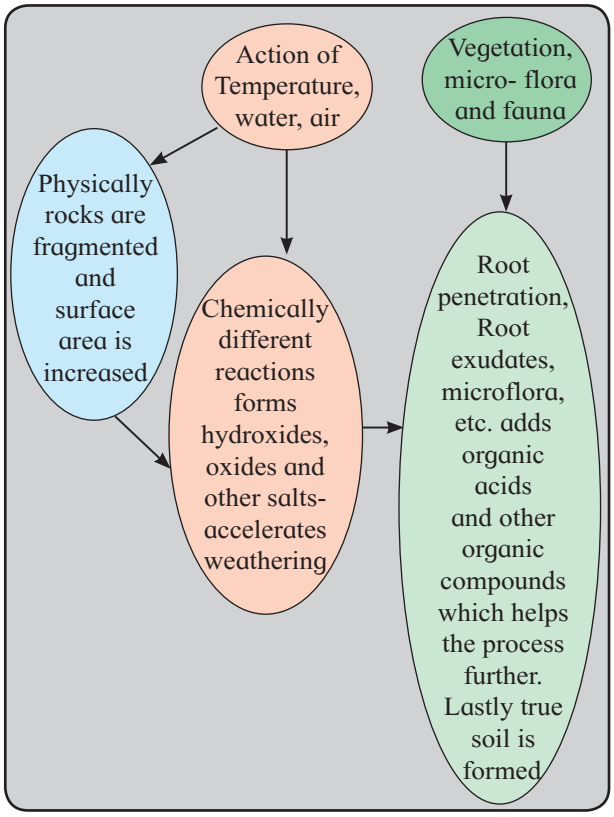



**Fig. 1.4 : Process of weathering**

**Use your brain power**

Mere weathering does not produce the soil. It is the result of the action of various agencies. It is a long time process. Weathering is a destructive process whereas soil formation is constructive process resulting into soil profile.

The natural agencies which are responsible for soil formation are called as soil forming factors. Soil formation is diversified and complex process which is considerably affected by five factors which are interacting with each other.

The soil forming factors are expressed by the Jenny's equation…

$$S = \Sigma f (Cl, b, r, p, t)$$

Where, S = Soil
$\Sigma f$ = sum of functions
Cl = Climate
b = biosphere or vegetation & micro organisms,
r = relief / topography
p = parent material
t = time / age

They are grouped into two classes as :

a) passive and b) active

**Can you think**

Parent material, topography and time do not have a dominating role in soil formation. They are only the source and conditions. Therefore, they are called as passive factors.

Whereas climate and biosphere i.e. Vegetation and microorganisms play a most dominating role. They can change the nature of soil formed. In climate rainfall and temperature are important. The vegetation and micro organisms affects the amount of organic matter addition to soil. These helps in various decomposition processes.

**Do you know the processes :**

A set of soil reactions leading to the formation of soil are known as soil forming processes.The book references will reveal that calcification, podzolization, laterization, salination / alkalinization are the important soil forming processes.

The percolation of rain water accumulates the carbonates of Ca and Mg in soil profile and is known as **calcification**.

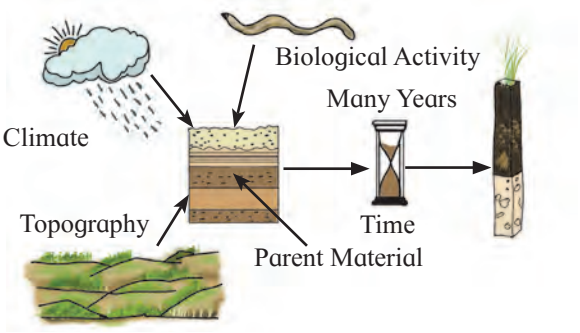



**Fig 1.5 : Soil forming factors**

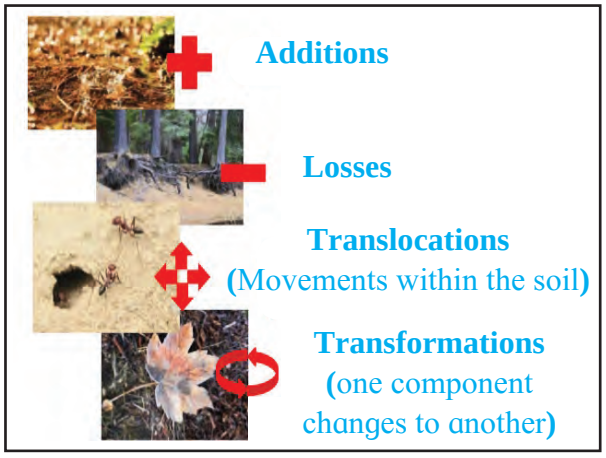



**Fig 1.6 : Basic soil forming processes**

In humid region large amount of organic matter is accumulated at the surface. The decomposition of the oraganic matter releases organic acids which removes Fe from upper layers and is fractionated at different horizons and this is known as **podzolization**.

**Laterization** means the hydrolysis of minerals and in this there is loss of aluminium oxides, silicates and soluble nutrients due to leaching. This process is prominent in tropical condition.

The accumulation of soluble salts of Na, Ca and Mg as chlorides, sulphates and bicarbonates is termed as **salinization**. After rainfall or irrigation these are removed from upper layer is known as **desalination**.

### 1.5.1 Soil profile :

Definition : It represents succession of layers/horizons differentiated from one another but genetically related. Vertical section through the soil gives the clear picture of profile.

**Try this**

Dug a large pit (1×1×1.5 meter) and observe the sides of this pit and find the difference. You will observe different layers, some are distinct while some are mixed which are known as horizons.

**Observe and draw a diagram :** This will look like -

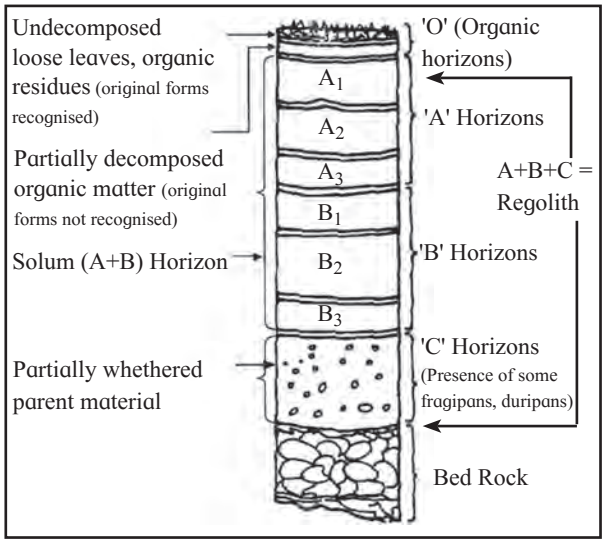



**Fig 1.7 : Theoretical soil profile consisting of all horizons**

### 1.5.2 Properties of soil :

Every soil has some important properties i.e. physical, chemical and biological.

**I. Physical properties :-** It indicates the coarseness or fineness of soil as determined by relative proportion of the various soil separates i.e., sand, silt and clay particles.

**(a) Texture :** Soils have different amount of sand, silt and clay particles which imparts coarse or fineness. Depending on the amount of a particular particle the soil is said to be sandy, loamy or clayey. In a clay soil, the percentage of clay particles is more, whereas in sandy, sand particles are in higher percentage. The soil textural class can be determined from the following triangle.

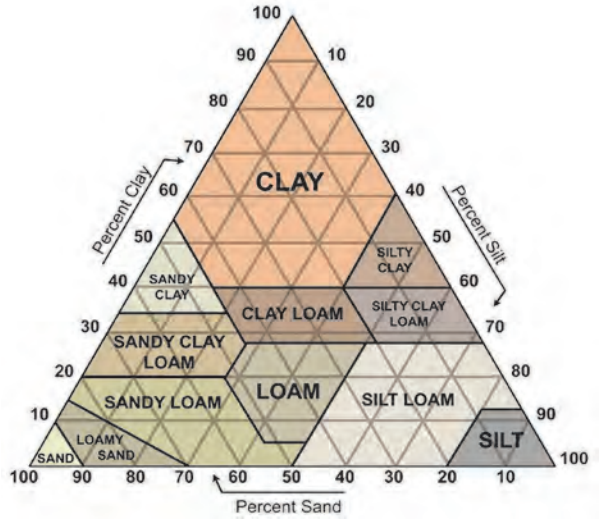



**Fig. 1.8 : Determination of textural class (Textural Triangle)**

Depending upon percentage of sand, silt and clay there can be intermediate classes of soil e.g. Sandy loam, clay loam, silty clay, loamy sand, etc.

Classification of soil separates as per International Soil Science Society System is as follows

| Name of soil separate | Diameter limit (mm) |
|---|---|
| Sand particle<br>(a) Coarse sand<br>(b) Fine sand | <br>2.00 to 0.20<br>0.20 to 0.02 |
| Silt particle | 0.02 to 0.002 |
| Clay particle | Less than 0.002 |

**(b) Structure :** On the basis of particle size the soil texture is determined, similarly on the basis of the arrangement of soil separates in the soil aggregate the structure of the soil is decided.

When the arrangement is plate like i.e. one above the other then it is called as platey, when it has angles it is angular or when it is grain like then it is granular and like wise.

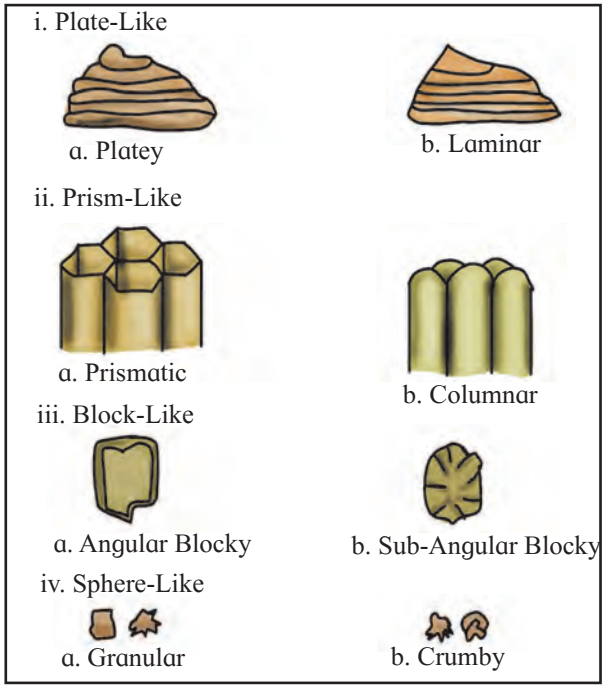



**Fig. 1.9 : Different soil structures**

**(c) Bulk density :** Depending upon the amount of pore spaces in the soil aggregate, the specific gravity of the soil is changed. As the amount of pore space is increased, the specific gravity of the soil decreases.

**(d) Soil colour :** Different soil have different colours. The colour of soil is mostly due to iron, manganese compounds and also the organic matter present in the soil.

**(e) Soil temperature :** Soil temperature is measured with the help of soil thermometer. The favourable limit of soil temperature for biologocal activites and growth is from 27 to 32°C.

**(f) Plasticity :** Plasticity is the property of a material which when subjected to an external force allows it to be deformed rapidly without rupture of a plastic rebond and without volume change. Plasticity of soil is depend on the amount of clay particles and the moisture percentage present in it.

**(g) Soil consistency :** It refers to the resistance of soil with various moisture contents to mechanical stresses. It is the best guide for tillage operations.

**II. Chemical properties :-** Soil pH, cation exchange capacity (CEC), organic carbon content are the chemical properties of soil.

**(a) Soil pH :** soil pH is defined as negative logarithm of hydrogen ion activity. Depending upon the concentration of hydrogen ($H^+$) or hydroxyl ($OH^-$) ions soil pH is determined. When the pH value is less than 7 the soil is said to be acidic and above 7 it is said to be alkaline.

**(b) Cation exchange capacity :** The capacity of soil to exchange the cations present in the surrounding medium is known as its CEC. Sandy soil have less CEC than silty and clayey soil.

**(C) Organic carbon**: The carbon present in the form of organic matter (O.M.) in soil is known as organic carbon. The O.M. may be present in different forms i.e. leaf litter, plant roots, crop residuals, microflora and fauna.

**III. Biological properties :-** In addition to physical and chemical properties the soil have also biological properties too. This is dependent on the amount of micro flora and fauna present in the soil. e.g. amount of bacteria, algae and fungi. This population is again dependent on the amount of organic matter because organic matter is the food of these micro organisms. The activities of some micro organisms are beneficial to each other. Some of the products of metabolism may serve as nutrients for plants / organisms. The organic acids liberated during boichemical changes are useful to solubilize the plant nutrients. Thus the association between different organisms influences the activities of the soil population and there by the soil properties.

### 1.5.3 Functions of soil

Each soil have to perform specific functions. It has three fold functions to perform such as physical, chemical and biological.

**Physical functions**

It gives mechanical support for growth of plants. The plant is able to stand erect because of the hold exerted by the soil on plant roots. The roots are remified and they thus, anchored in the soil mass. The soil acts as reservoir of water and air. The plant absorb water through their roots. The roots breath oxygen from the air around soil mass. Soil also stores sun heat and applies it to the growing plant.

**Chemical functions**

Chemically the soil may be looked upon as a store house of plant nutrients. It contains organic and inorganic compounds. The weathering material of rocks and minerals constitutes inorganic compounds, while the decaying plant and animal remains furnish the organic compounds. The plant obtains its nutrients from these compounds. The different reactions going on in the soil causes decomposition of organic matter thereby brings the nutrients in soil solution and make them available for the plant nutrition.

**Biological functions**

Soil is the habitat of a very large number of organisms of both plant and animal origin. Some of the organisms like rodents, worms, insects, etc. are big while others like fungi, bacteria, etc are of microscopic in size. Among the worms, nematodes and earthworms are important organisms. They aerate the soil and at the same time, disintegrate and mix its constituents by passing large quantities of soils through their bodies and ejecting the same on the surface as “worm casts”. The quantity of soil passed through their bodies is enormous. About 25 tonnes of earth per hectare per year is turned over by the earth worms.

The ejected material is in a more pulverized condition and possess better fertility than the original soil.

This activity of earthworms leads to the transfer (invertion) of soil from lower layer to the surface.

These functions impart a dynamic character to the soil, which makes the soil fit for plant growth.

## 1.6 Soil health

Similar to human beings soil also have a health. Soil health is depend on the amount of plant nutrient content (soil fertility), soil productivity and the population of microorganisms.

**Meaning**

**Remember this**

Supply of nutrients depends upon soil fertility. Sustainability depends on productivity.

Doses of fertilizers are decided on the basis of fertility and the package of practices.

The presence of optimum population of microflora and fauna particularly the beneficial microflora is supposed to be responsible for good soil health. The soil rich in organic matter particularly the humified one possesses good soil health. The factors which affects the organic matter content of soil ultimately influence the soil health.

The results of long term fertilizer experiments indicated that, intensive cropping has declined the organic carbon content in soil, which resulted in reduced productivity. Some phosphatic fertilizers contain varying amounts of heavy metals which may accumulate and cause adverse long term effects on soil health.

Therefore, soil organic carbon is supposed to be the key nutrient for maintaining good soil health. Hence, the most logical way to manage soil health is the use of the Integrated Plant Nutrient Supply (IPNS).

Organic recycling also helps to improve soil health. It broadly includes-

1. Recycling in-situ i.e. green manuring, growing green manure crop
2. Recycling through external inputs (addition of green leaf manures, foliage, organic mulching etc.)
3. Recycling through composting.

### 1.6.1 Soil fertility :

It is considered as the capacity of soil to provide essential nutrients, in adequate amounts and in a proper proportion for the growth of plants, when other factors such as light, water, temperature and the physical condition of the soil are favourable. Soil fertility is an effect of soil-plant relationship viz., plant growth with reference to nutrients available in soil. In short, it is the inherent capacity of soil to supply nutrients for plant growth in adequate amounts and in a suitable proportions. Soil test indicate soil fertility.

### 1.6.2 Soil productivity :

Basically it is an economic concept and signifies the capability of soil to produce yield under specified system of management inputs and environmental conditions. This is not essentially a property alone, but a function of several factors. It is measured in terms of output i.e. production including management. It is the capacity of soil to produce per unit area under the given set of management practices. More simply it is the response to management in terms of yield per unit area.

All productive soils are fertile, but every fertile soil need not to be a productive. It may be due to some problems like water logging, salinity, alkalinity, adverse climatic conditions, etc. Soil test does not indicate soil productivity as a whole.

### 1.6.3 Difference between soil fertility and productivity

| | Soil fertility | Soil productivity |
|---|---|---|
| 1. | It is considered as an index of available nutrients in the soil | It is the term used to indicate the yield of crops per hectare of land |
| 2. | It is the property of soil to supply nutrients required by plants for their growth i.e. one of the factor of crop production | It is the inter relation of all these factors including soil fertility and the managerial techniques which determine the magnitude of yield. |
| 3. | It can be determined by analyzing the soil in the laboratory for the content of nutrients in it | It can be assessed by conducting an experiment on field itself under a given set of management |
| 4. | It is the potential / inherent status of the soil to produce crop which may or may not reflect in production. | It is the resultant of various factors influencing the production including the management skills. |
| 5. | All fertile soils may not be productive | All productive soils are generally fertile. |

**Remember this**

**How to improve productivity**

Fertility is the inherent property but productivity can be improved in various ways particularly with the sequestration of organic carbon. The maintenance of it should be considered both on a temporary and long term basis. The temporary measures include suitable cultural practices such as addition of organic manures, green manures, bio fertilizers, fertilizers, etc. Whereas longterm measures are the correction of problems such as reclamation, addition of amendments, adoption of suitable soil conservation practices, improved agricultural techniques, etc. All these will be helpful in improving fertility and there by the productivity.

**Mind and Understand**

**How soil fertility is affected :** There are many factors which if not handled properly, can adversely affect the soil fertility.

**Tillage :** If soil is not worked at the optimum moisture level, it may disturb soil structure, ill-drainage, etc. which will affect the soil fertility.

**Fertilizers :** The imbalanced use of fertilizers may hamper soil fertility.

Soil salinity/sodicity can affect the soil fertility.

**Erosion :** the runoff can form gullies and the fertile soil can be lost.

Water stagnation also affects the soil fertility.

Weed infestation can reduce the yield of crop.

# Exercise

**Q.1 A. Fill in the blanks.**

1. Hard mass of mineral matter comprising of two or more minerals is called as -------- .
2. Naturally occurring inorganic substance having a definite chemical composition and physical properties is known as ---------.
3. Acid igneous rocks contain --------- percent silica.
4. Earth crust contains ---------- percent feldspar.
5. Basalt is an example of --------- type of rock.

**B. Make the pairs.**

| 'A' Group | 'B' Group |
|---|---|
| 1. Igneous rock | a. Primary mineral |
| 2. Gabbro | b. Secondary mineral |
| 3. Feldspar | c. Basic rock |
| | d. Granite |
| | e. Dolomite |

**C. State true or false.**

1. The rock formed by metamorphism is known as metamorphic rock.
2. Magnetite is an example of accessory mineral.
3. Earth crust contain 13 % Quartz.
4. Soil texture indicates its coarseness or fineness.
5. Arrangement of soil separates in the form of aggregates is called as soil structure.

**Q. 2 Answer in brief.**

1. Give the examples of heavy and light minerals.
2. What is meant by soil texture?
3. List out the types of soil structure.
4. Name the factors affecting soil fertility.
5. Classify the soil separates as per international soil science society system.

**Q. 3 Answer the following questions.**

1. Explain chemical properties of soil.
2. Draw and label soil profile.
3. Complete the following chart

| Sr. no. | Mineral | Any two examples |
|---|---|---|
| 1 | Essential | |
| 2 | Accessory | |
| 3 | Secondary | |
| 4 | Primary | |

4. Describe with diagram the types of soil structure.
5. Explain biological functions of soil.

**Q. 4 Answer in detail.**

1. Define rock and give its classification.
2. What is meant by mineral and give its classification on the basis of different aspects.
3. What do you mean by soil ? Describe its physical properties.
4. Define soil and give its functions.
5. What is meant by soil fertility? Differentiate it from soil productivity.

**Activity :**

Collect soil samples from the field and label them with brief discription.