B. SC. SEMESTER-II

BOTANY PAPER I

(PALAEOBOTANY, PTERIDOPHYTES, GYMNOSPERMS AND SOIL ANALYSIS)

UNIT-IV: Skill Development: Soil analysis:

1. Soil: Types of soil, method of collection of soil samples.

2. Physical properties of soil: Soil texture, soil colour, Water Holding Capacity (WHC). Water Rising Capacity (WRC), Bulk Density (BD) and Porosity (P).

3. Chemical properties of soil: pH, Carbonates as $CaCO_3$, Available Nitrogen, Available Phosphorous, Available Potassium.

Introduction of Soil

- Soil is complex mixture of minerals, water, air, organic matter and countless organisms that are decaying remains of once-living things. For soil to form from rocks, it takes an average of 500 years or more.

- It is the upper most weathered layer of the earth's crust, Soil also termed as "skin of the earth". Soil is capable of supporting plant life and is vital to life on earth.

- It is a complex physical-chemical biological system. It is formed of different grades, soil, air, water, decomposed organic matter and millions of living beings that together support life.

- Soil formation from the rocks involves two major steps, these are weathering and pedogenesis

1. Weathering:

The Breaking down and disintegration of solid rocks into small particles known as weathering The weathered particles are called regolith.

2. Pedogenesis:

In this process the soil weathered particles get differentiated into distinct profiles. It gives mature soil.

Definitions of Soil:

- Soil is loose material that lies on top of the land. It is a mixture of many different things including rock, minerals, water and air.Soil has also defined as a natural body consisting of layers

- Soil differs from its parent material in texture, structure consistency and colour, chemical, Biological and Physical characteristics.

- Soil holds water and nutrients it is an ideal place for plants to grow. It is important for life on earth.

- Soil is usually referred to as the naturally occurring organic materials found on the earth's surface, It is mainly composed of mineral, nutrients, water, other inorganic particles and some residues of plants and animals

Composition of Soil:

A typical soil is about 50% solid (45% mineral and 5% organic matter) and 50% voids (or pores) of which half in occupied by water and half by gas The biological influences on soil properties are strongest near the surface, while the geochemical influences on soll properties increases with depth.

Soil profile:

The sequential arrangement of different horizontal layers in soil in a locality is called soil profile. Each and every horizontal layer is said to be a horizon.

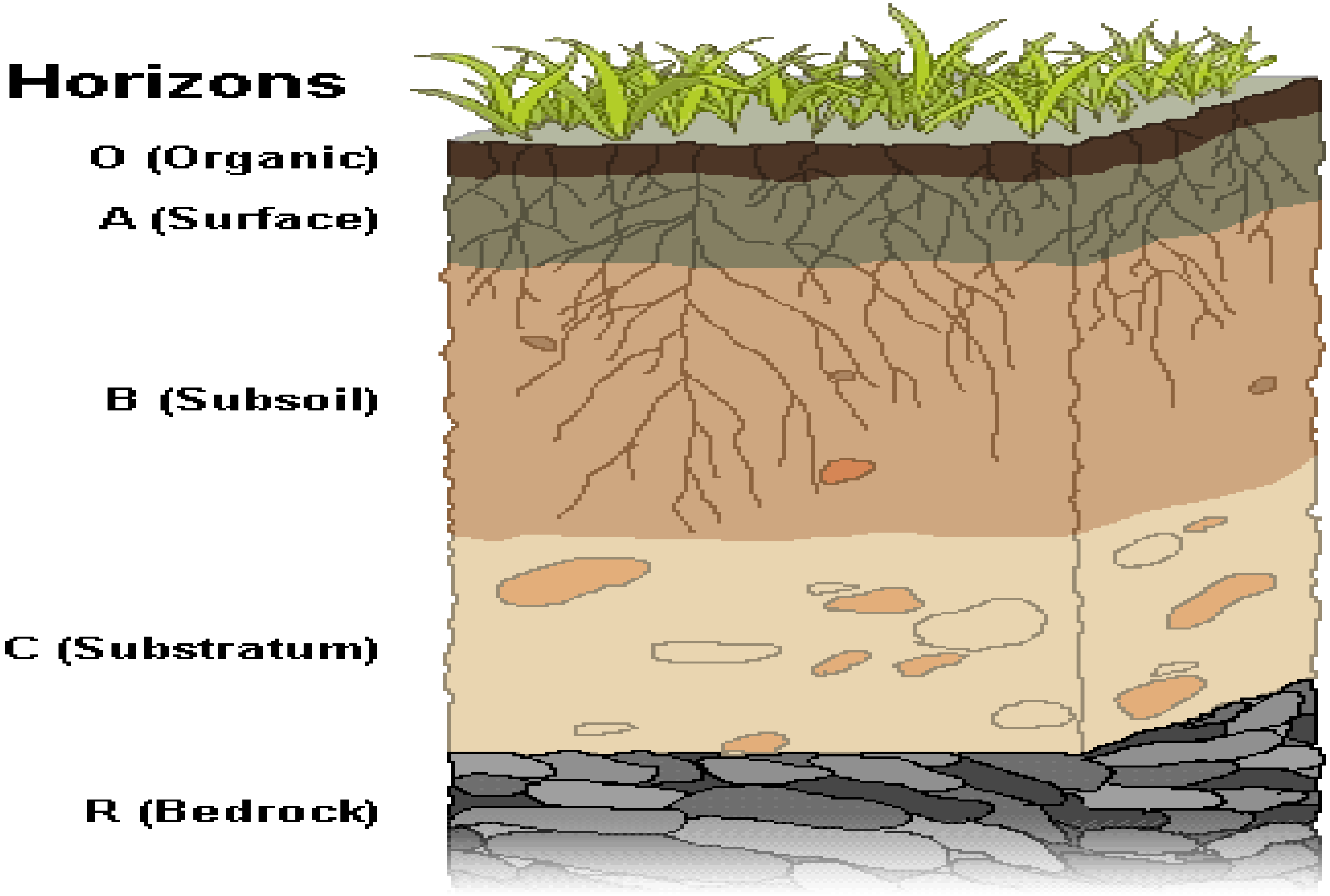
Soil has five main horizons, they are-O, A, B, C and R-horizons.

O-Horizons:

This is the surface layer of the soil. It is accumulated in the form of organic remains of plants, So, it is called Organic horizon. This horizon is more common in soils which are covered with luxuriant vegetation. This horizon is divided into top layer un-decomposed andbottom layer well-decomposed sub-layers

A-Horizons

This horizon lies below the O-Horizon, and forms the upper most or top layer of soil. As it is rich in humus, it is dark, brown, red or yellow in colour. This layer is also called humus horizon or of some of alluviation. This is the area of great importance for the growth of root and for the sarvival of barrowing animals.


Horizons
O (Organic)
A (Surface)
B (Subsoil)
C (Substratum)
R (Bedrock)

The organic matter is mised with mineral particles. It is further divided into three sub-layers-

Al horizon: This sub-layer is characterized by dark organic layer.

A2 horizon: It is a light-coloured sub-layer

A3 Horizon: It is a transitional zone to B-horizon, and is more similar to the A-horizon

B-Horizon:

This horizon lies beneath the A-horizon. This horizon is also called Sub sell or illuvial horizon. It is rich

in iron, aluminium and manganese along with clay particles. It is formed due to the deposition of

minerals such as oxides of Fe, Al and Mn, humic substances and clay from O and A-horizons B-horizon is further divided into three sublayers, namely B1 horizon, 82 horizon and B3 Horizon

B1 horizon: It is a product of illuviation formed from A horizon, so it shares the properties of both A and B-horizons.

B2 horizon. This zone it characterized by high level of clay. It is accumulated with maximum silicatesclay, or iron, and small proportion of organic matter

B3 horizon. It is a transitional zone between B and C chorizone. It has more similarities to 8-Sorizon. It is a zone of weaker illuviation, so that the mineral cornent is low.

C-Horizon:

C-horizon is recent in its origin, and it lies below the B-horizon. It is characterized by the presence of weathered rock particles. It appears grey due to the anaerobic conditions of this layer. Since it contains certain amount of clay, it is known as C horiann (clay horizon)

D-Horizon:

This horizon consists of rocks which remain unaltered by soil forming processes or faces. It common of unwesthered rocks. The ground water remains stagnant on the rocky layer, All soils mat tot have all these five horizons Some soils have AlBC horizon alone. Some soil of brown forest have ABCD horizons, Some other soils have C and D horizons alone.

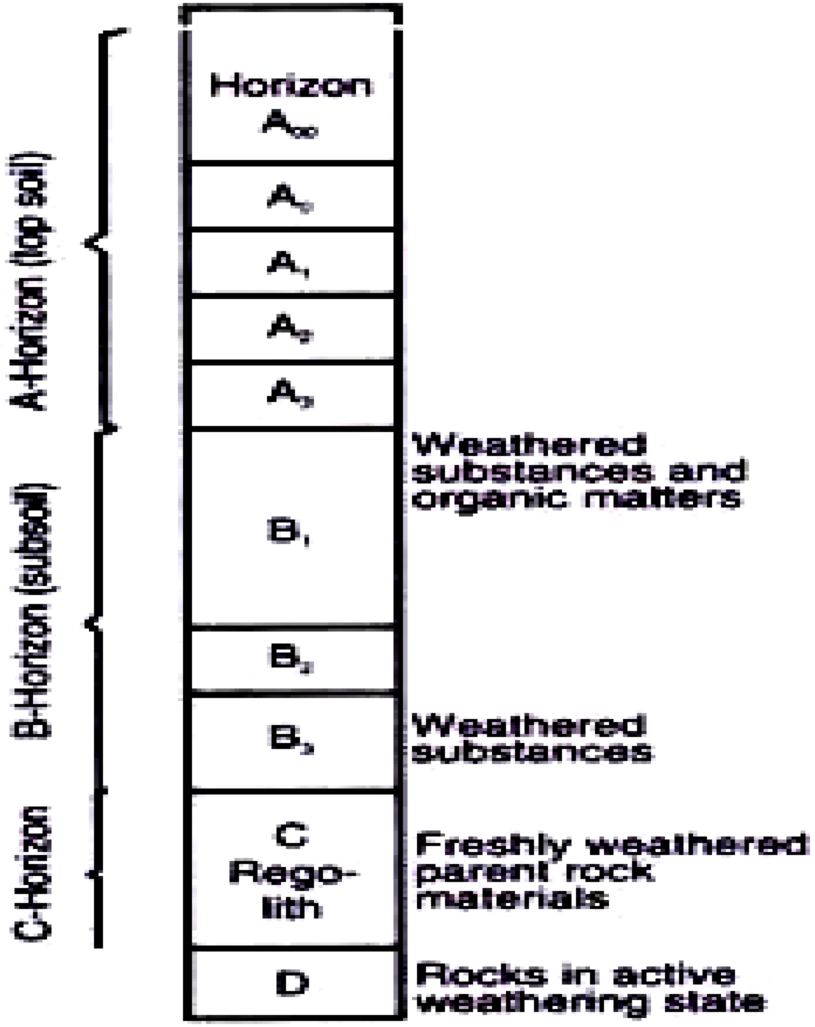
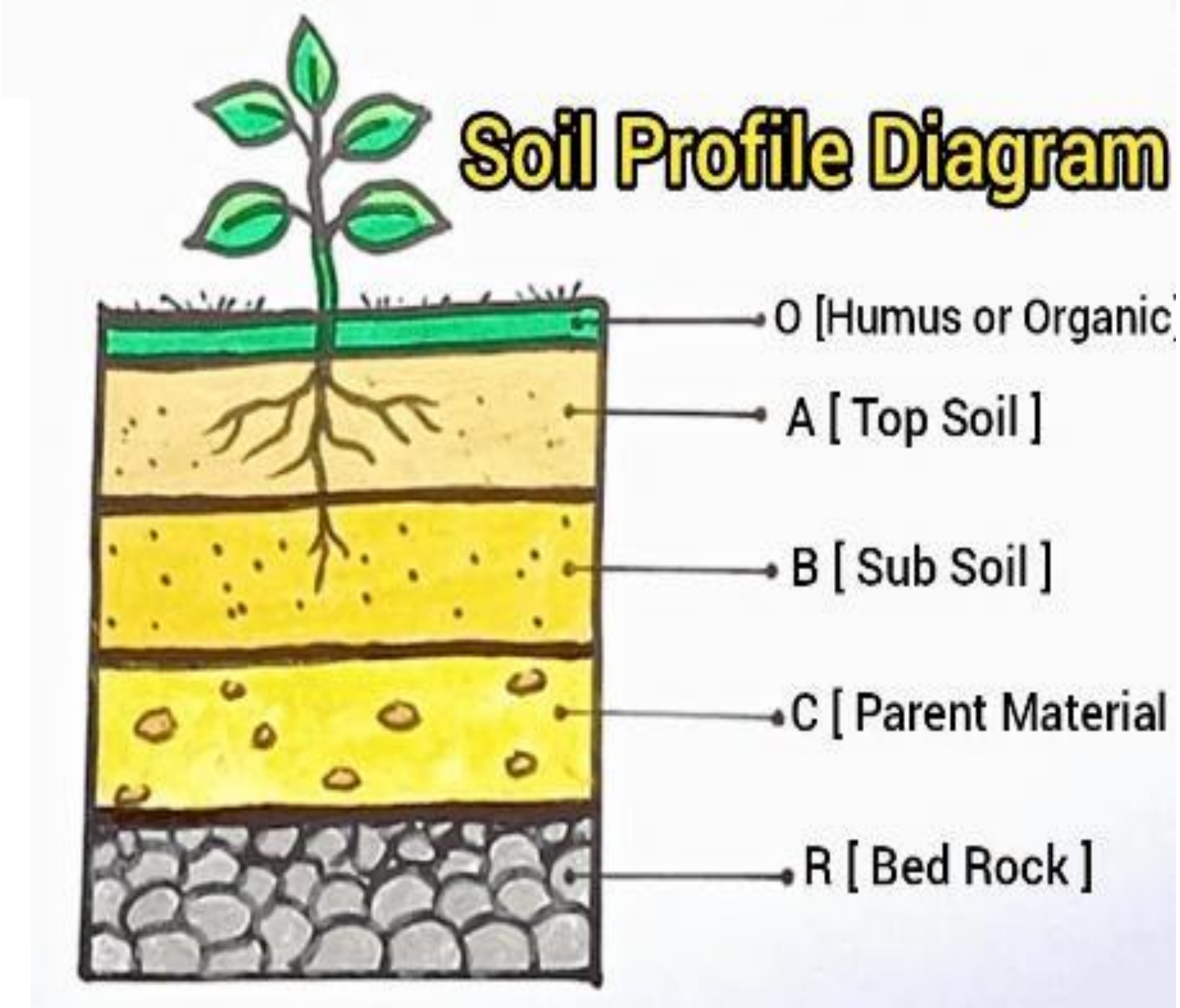


Fig. 22.3 Soil profile



Factors affecting soil formation

The soil formation is affected by the following factors

1 The porous rocks weather more rapidly than the non-porous rocks.

2. Along the steeper slopes of rocks, rain, water drains off rapidly and corrodes the rock rapidly. But, soil development does not take place the slopes because of erosion.

3. Moderate rainfall favors for the translocation of minerals from the upper layer to the lower layers. The heavy rainfall causes erosion. The low rainfall is ineffective in mineral translocation.

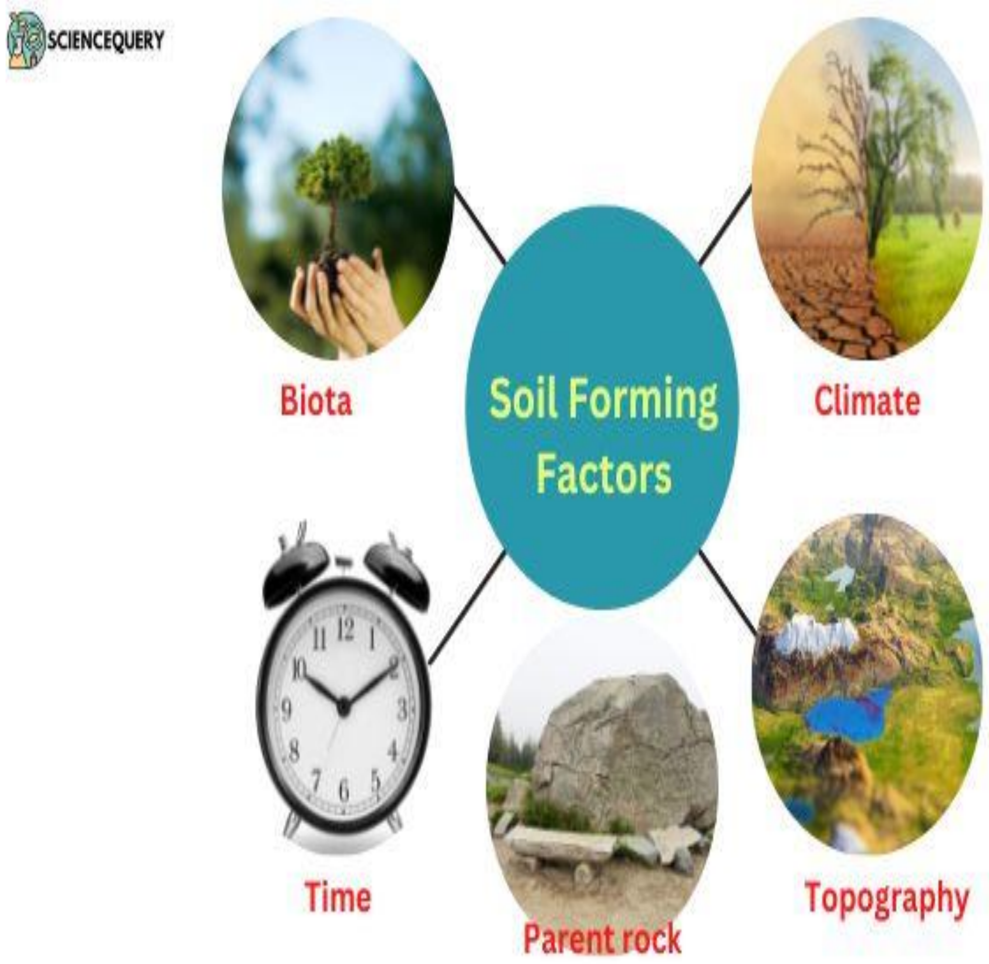
4. Low température accelerators the growth of primitive plants on weathered rock particles and favors the humus formation. High temperature reduces the rate of humus formation.

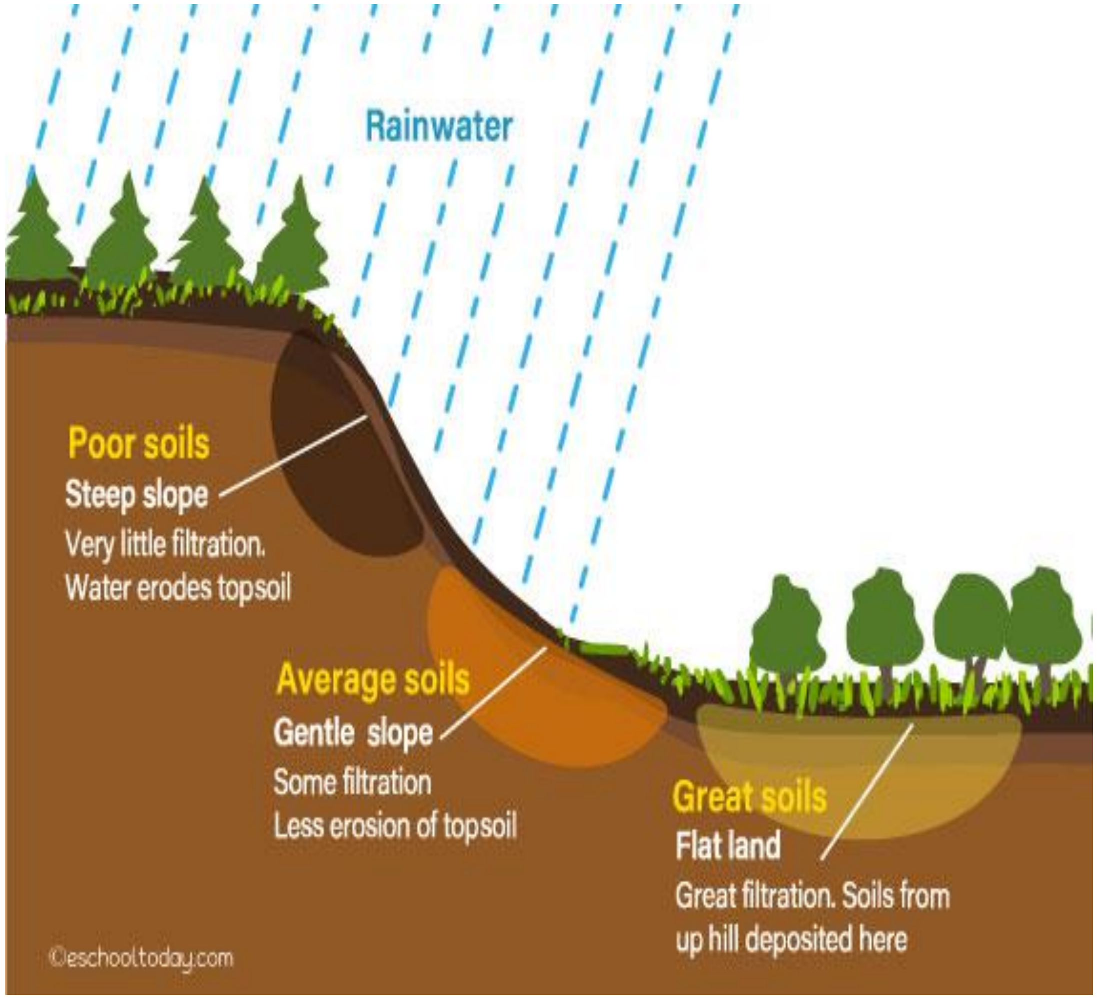
5. Soil development is more rapid when the microflora is rich.

6. High humidity favors the plant growth and humus formation.

7. The soil development is more rapid, if the vegetation is luxuriant.

8. Animals add organic matter to the developing soil and favor for soil development.

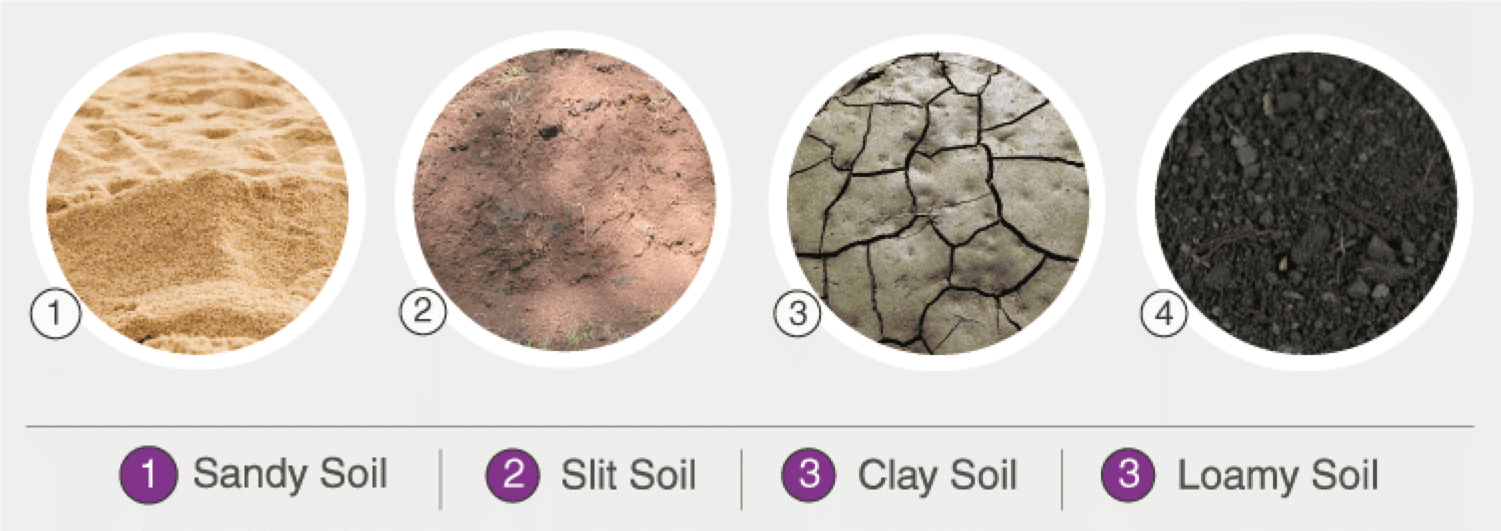

SCIENCEQUERY
Soil Forming Factors
Biota
Climate
Time
Parent rock
Topography


Rainwater
Poor soils
Steep slope
Very little filtration.
Water erodes topsoil
Average soils
Gentle slope
Some filtration
Less erosion of topsoil
Great soils
Flat land
Great filtration. Soils from
up hill deposited here
©eschooltoday.com

1. Soil: Types of soil

Soil is classified into four types:

1. Sandy soil.
2. Silt Soil.
3. Clay Soil.
4. Loamy Soil.
5. Laterite or Lateritic Soils or Latosols



1. Sandy soil.

- The first type of soil is sand.
- It consists of small particles of weathered rock.
- Sandy soils are one of the poorest types of soil for growing plants because it has very low nutrients and poor water holding capacity, which makes it hard for the plant's roots to absorb water.
- This type of soil is very good for the drainage system.
- Sandy soil is usually formed by the breakdown or fragmentation of rocks like granite, limestone and quartz.

2. Silt Soil.

- Silt, which is known to have much smaller particles compared to sandy soil and is made up of rock and other mineral particles, which are smaller than sand and larger than clay.

- It is the smooth and fine quality of the soil that holds water better than sand.

- Silt is easily transported by moving currents and it is mainly found near the river, lakes and other water bodies.

- The silt soil is more fertile compared to the other three types of soil. Therefore, it is also used in agricultural practices to improve soil fertility.

3. Clay Soil

- Clay is the smallest particle among the other two types of soil. The particles in this soil are tightly packed together with each other with very little or no airspace.

- This soil has very good water storage qualities and makes it hard for moisture and air to penetrate into it.

- It is very sticky to the touch when wet but smooth when dried.

- Clay is the densest and heaviest type of soil which does not drain well or provide space for plant roots to flourish.

4. Loamy Soil.

- Loam is the fourth type of soil.
- It is a combination of sand, silt and clay such that the beneficial properties of each are included.
- For instance, it has the ability to retain moisture and nutrients; hence, it is more suitable for farming.
- This soil is also referred to as agricultural soil as it includes an equilibrium of all three types of soil materials, being sandy, clay, and silt, and it also happens to have humus.
- Apart from these, it also has higher calcium and pH levels because of its inorganic origins.

Laterite or Lateritic Soils or Latosols:-

- Laterite is generally reddish or yellowish red in colour which turns black on exposure to sun.
- This group of soil occupies belts of various widths around the peninsular zone.
- Such soils occur on the plateau of Malwa, Madhya Pradesh, Central India, Bihar, Orissa, Tamil Nadu, Eastern and Western Ghats, Assam, Bengal, Hyderabad covering a total area of about 2,48,000 square kilometers.
- Lateritic soil is usually poor in lime, magnesia, nitrogen, phosphate, and potash. Humus is present in abundance in this soil. Base exchange capacity is low.
- Soil is good for agriculture purpose. Valley soils can produce good crops of rice and sugar cane whereas at higher elevations such soils favour the growth of coffee, rubber, tea, cinchona etc

METHOD OF COLLECTION OF SOIL SAMPLE

Soil is a heterogeneous body The vast area of land generally shows heterogeneity. It is not possible to collect a soil sample which would be representative of the heterogeneous land, if sample is collected from only one spot of the soil unit, it would not represent it. So, first of all the heterogeneity of the land is minimized by dividing the land. By making division of the vast land, soil unit is determined. The heterogeneity of the soil unit is minimum. Each sample collected must be a true representative of the area being sampled.

The soil unit is determined based on the following-

1) Topography: The land is divided into high land, medium land or low land based on the level of the land

2) Colour: Dark colour of the land usually indicates high content of organic matter than that of light coloured portion of the land.

3) Texture: The land should be divided into different textural classes' like- clayey, loamy, sandy etc, because the properties of these textural classes would differ.

4) fertility Status: The land should be divided into two-one which yielded more and the other which yielded Jen

Materials required

1) Spade or auger (screw or tube or post hole type).

2) Khurpi

3) Core sampler

4) Sampling bags

5) Plastic tray or bucket

For collecting soil sample, the following steps are required

1) Cores (when auger is used) or furrow slice (when spade is used) shoul used) should have the same volume

2) Cores or furrow slice should be taken at random if the previous crops were grown broadcast or in a zig-zag way if the previoun crops were grown in rows. The cores of furrow-slice should not be positional regularly on the rows or the crop hills

3) Enough cores should be taken.

4) There should be no chemical interaction of soil material composited.

5) In practices, usually 8-10 cores are taken but this number may increase to 20-30 Increasing the number of as decreases variations in soil characteristics.

Samples from unusual or abnormal spots of the soil unit should not be collected. These spots may be

1) Near gates, buildings, highways etc. and along field boundaries, margins, etc In these sites, normal crop management practices cannot be followed.

2) If the fertilizers or manures were stacked on a site of the field for their application to the crops, this would enrich that sites with nutriens elements which would be higher than the rest of the field.

3) Shaded area

4) Crop hills and rows

5) Local abnormal sites: (acidic or alkaline pocket etc.)

2. Physical properties of soil:

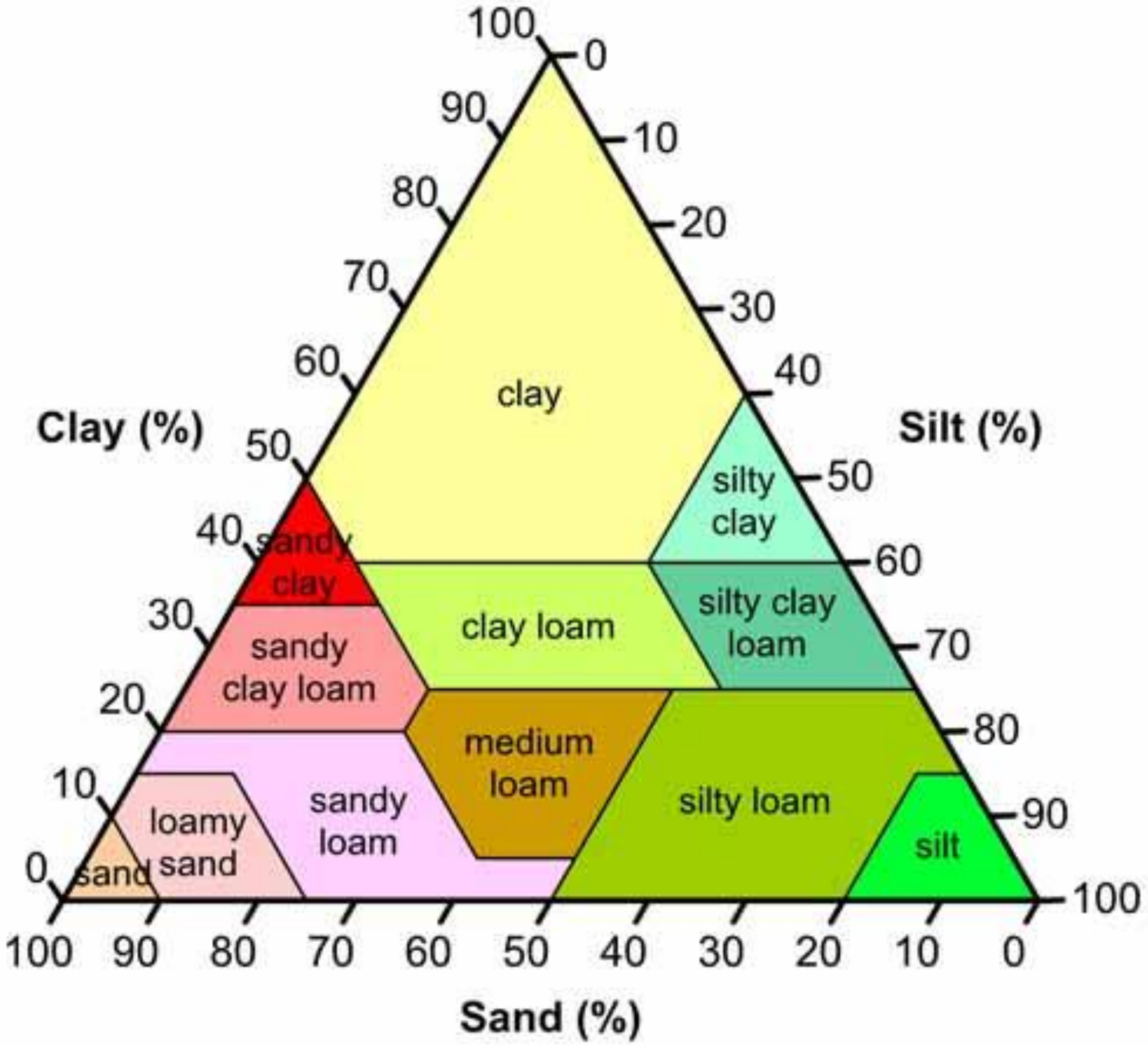
(1) Soil texture:

- Soil texture refers to the sense one can feel to touch the soil. It depends upon the size constituent soil particles. The particles that make up soil are categorized into following groups by size - Gravels, Coarse, Fine, silt, and clay.

- Gravels are larger than 2 mm size and unsuitable for plant growth. Coarse soil particles are between 2 mm 0.20 mm in size. Fine sand particles with 0.20-0.02 mm in size and can see with naked eye and it improves the diffusion of water and air through soil.

- Silt soil particles with 0.02-0.002 mm and it contain enough quantity of mineral nutrients for plant growth. Clay in whom individual particles are less than 0.002 mm size and it gives plasticity and smoothness to the soil

- Soil texture affects soil behavior, in particular its retention capacity for nutrients and water


Clay (%)
Silt (%)
Sand (%)
100
90
80
70
60
50
40
30
20
10
0
clay
silty clay
sandy clay
clay loam
silty clay loam
sandy clay loam
medium loam
silty loam
sandy loam
loamy sand
sand
silt

2) Soil colour:

- Soils are often named after their characteristic colour, eg black, red/yellow etc. Soils acquire characteristic colours from the parental rock or from the nature of soil forming process.

- Soil colour is mainly due to the accumulation of organic substance, iron compounds, silica, lime and inorganic substances.

- Soil colour can also tell us how a soil "behaves"-a soil that drain well is brightly coloured and one that is often wet and soggy will have a mottled pattern of gray's, reds, and yellows.

- Soil colour does not affect the behaviour and use of soil, however, it can indicate the composition of the soil.

- Black coloured soils absorb more solar radiations than brown coloured soils.

Black Cotton Soils or Regur (Regada = Black):

- These soils are black in colour and best suited for cotton cultivation. It is locally known as regur in some provinces.

- Black soils are distributed in Tamil Nadu, South-east Mumbai, Eastern Hyderabad, Maharashtra, Western M.P., parts of Mysore, Andhra Pradesh, Gujarat Southern districts of Orissa, Bundi and Tonk districts of north Rajasthan, and Bundelkhand region of UP. Covering total area of approximately 5, 46,000 square kilometres.

- Regur soils are mostly dark grey to black in colour. The soil is clayey

- (clay content 40-60%) or loamy or sandy loams.

- The soil is characterised by high percentage of calcium and magnesium carbonates, iron oxides and alumina

Red Soils Including Red Loam and Yellow Earth:-

- These soils are distributed in India mainly in the peninsular regions.

- The soils occur mainly in M.P., S.E. Mumbai, Mysore, Andhra Pradesh, West Bengal, Assam, Orissa,Nagpur covering a total area of about 3,50,000 square kilometres.

- These soils are characterised by absence of lime nodules (Kankars). Percentages of humus and other organic nutrients are very poor in red soils.

- The colour of red soil is due to high Proportion of iron compounds.

- The red soils are light, friable and porous.

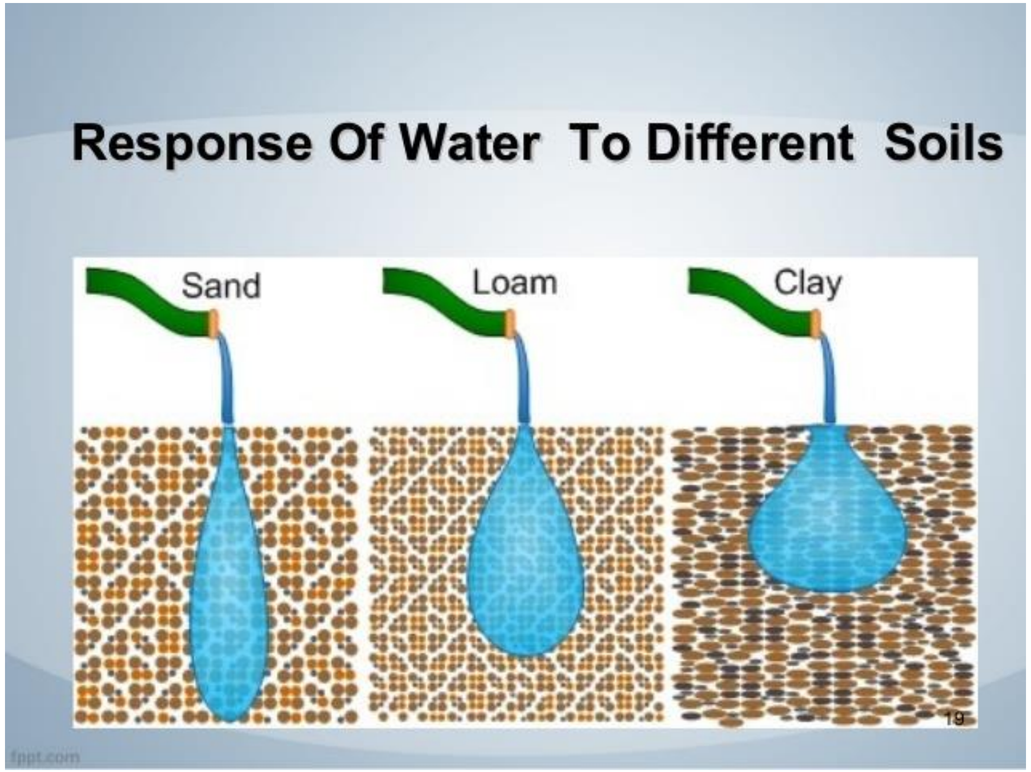
- Their water-absorbing capacity is very low Cultivation on such soils depends upon irrigation and rainfall

3. Water holding Capacity (WHC)

- Water Holding Capacity is the ability of a certain soil texture to physically hold water against the force of gravity.
- It does this by soil particles holding water molecules by the force of cohesion.
- As an example, a sandier soil has much less water holding capacity than a silt loam soil.
- Due to the size of the soil particles, the cohesive properties are much different between a sand particle and a clay or silt particle

Water Holding Capacity of Various Soil Textures

- Sand = 0.8”/ft
- Loamy Sand = 1.2”/ft
- Clay = 1.35”/ft
- Silty Clay = 1.6”/ft
- Fine Sandy Loam = 1.9”/ft
- Silt Loam = 2.4”/ft



4) Water Rising Capacity (WRC):

Available water capacity is the water held in soil between its field capacity and permanent wilting point. Field capacity is the water remaining in a soil after it has been thoroughly saturated and allowed to drain freely, usually for one to two days.

Density is the mass of unit volume of soil. It is measured in grams per cubic centimeter (g/cm^3). It varies from soil to soil depending on the size of the soil particles. Soil density is measured in two ways. They are - Bulk density and Particle density.

5) Bulk density

- The Bulk density is the net weight of unit volume of soil. It includes the weight of soil particles and pore spaces. It is estimated by the formula -

- Weight of soil Bulk density = $\frac{\text{Weight of soil}}{\text{Volume of soil}}$

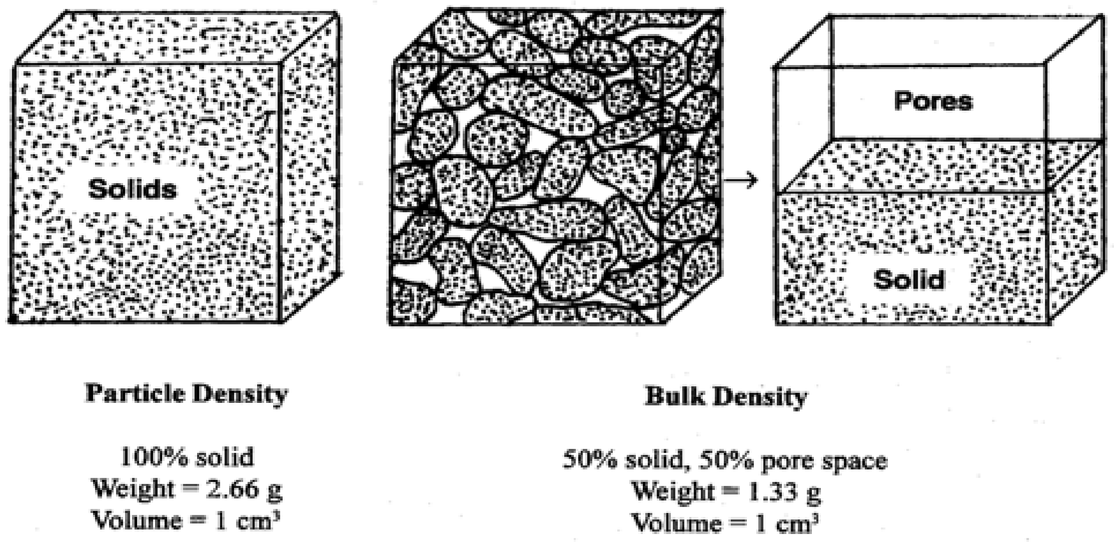
- Bulk density is not an intrinsic property of a material; the bulk density of soil depends greatly on the mineral make up of soil and the degree of compaction.

- Bulk density reflects the soil's ability to function for structural support, water and solute movement, and soil aeration.

- Bulk density is also used to convert between weight and volume of soil.

- It is used to express soil physical, chemical and biological measurements on a volumetric basis for soil quality assessment.

- Particles density refers to the total density of solids in the soil. It does not include pore spaces



6) Porosity (P):

- The total volume of space unoccupied by soil particles in the soil is called Soil porosity. The space between thesoil particles is called soil pore.

- Sail porosity depends on the composition of different soil separates compactness between the soil particles.

- It increases with increase in the size of soil separates. It decreases with reduction in the size of soil separates. Organic content of soil increases the soil porosity.

- Soil pores are filled with air and water. Se, soil porosity improves the growth of plant roots.

- Porosity is usually measured in percentage basis. Porosity of the soil can be measured using the following formula-

- $$\text{Soil porosity} = \frac{\text{Total Volume of soil}}{\text{Specific volume of soil} \times 100}$$

Kachimkil (1965) divided soils into five groups on the basis of their porosity and of their usefulness to agriculture. They are

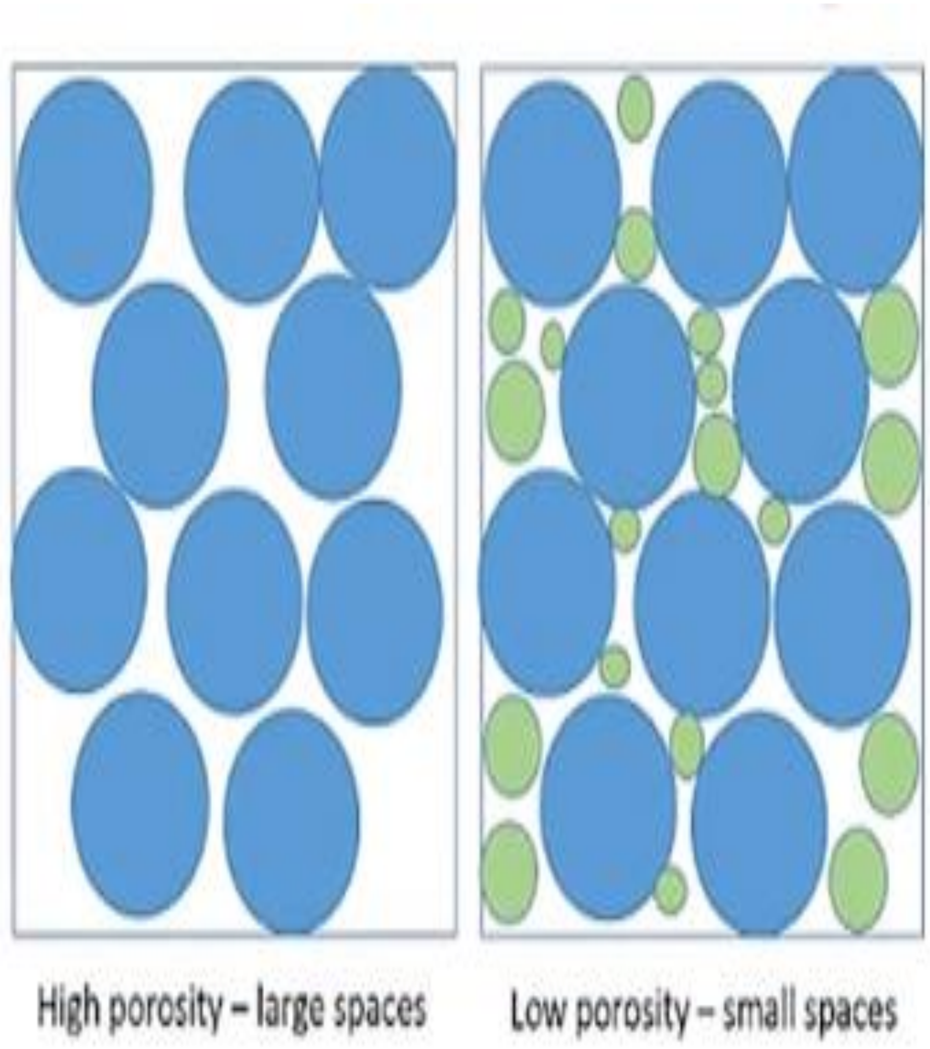
1) The best soil-Porosity of this soil exceeds 50% of its total volume.

2) Good soil-Porosity of this soil ranges from 45 to 50% of the total volume of the soil.

3) Satisfactory soil - Porosity of this soil ranges from 40 to 45% of the total volume of the soil

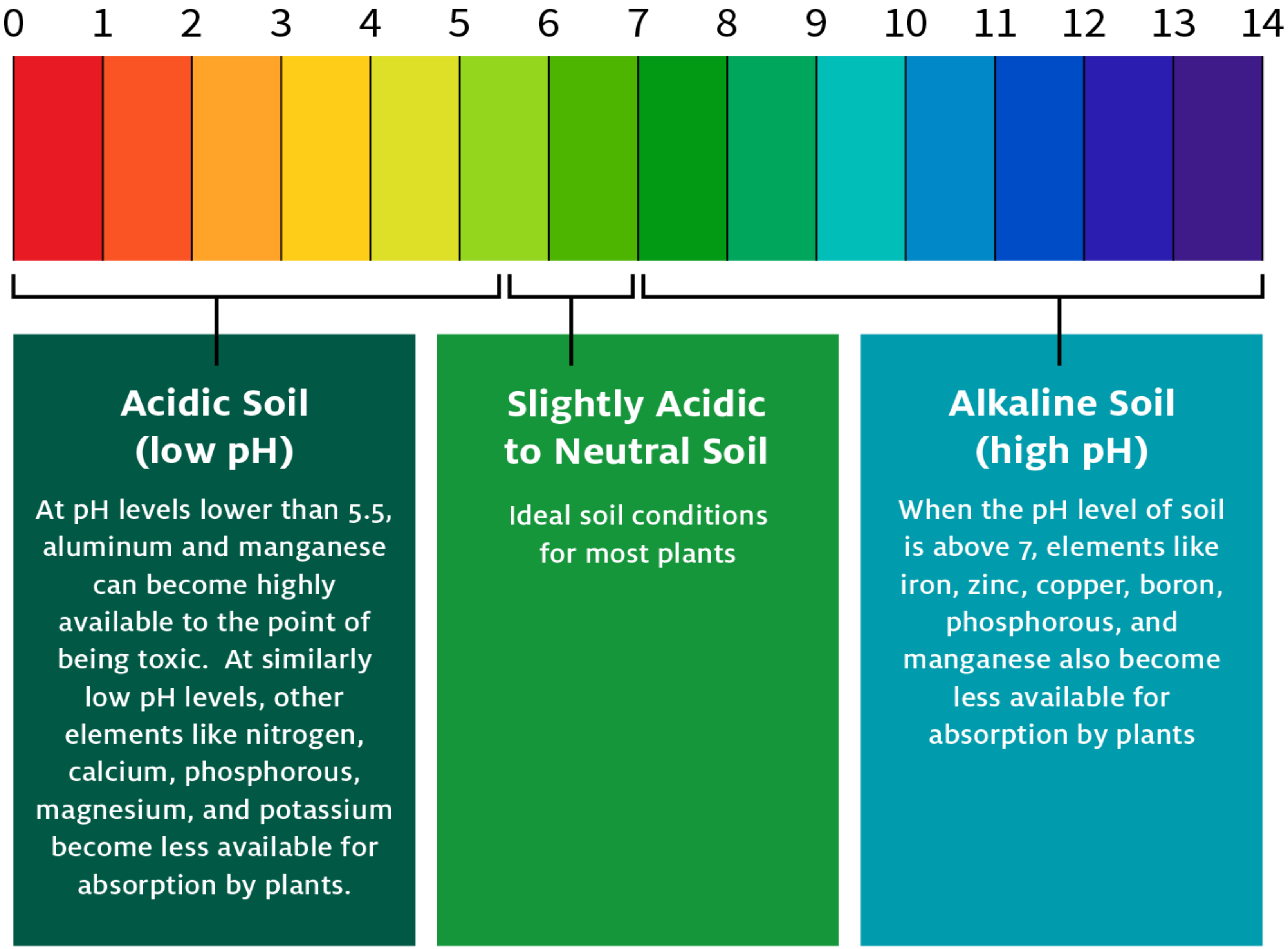
4) Unsatisfactory soil-Porosity of this soil ranges from 30 to 40 % of the total volume of the soil.

5) Poor Soil-Porosity of this soil is less than 30% of the total volume of the soil.



3. Chemical properties of soil: pH

- Soil pH is probably the most commonly measured soil chemical property and is also one of the more informative
- Soil pH is a measure of the number of hydrogen ions (H) present in a solution. In more common terms, it is a measure of alkalinity and acidity.
- The pH scale runs from 0 to 14. Seven is neutral, 0 is the most acidic value possible, and 14 are the most alkaline, or basic, value
- Soil pH has a profound influence on plant growth. Soil pH affects the quantity, activity, and types of microorganisms in soils which in turn influence decomposition of crop residues, manures, sludges and other organics.
- It also affects other nutrient transformations and the solubility, or plant availability, of many plant essential nutrients.
- The parent material of soils initially influences soil pH. For example, granitic soils are acidic, and limestone- based soils are alkaline. However, soil pH can change over time.
- Soils become acidic through natural processes as well as human activities. Rainfall and climatic conditions influence the pH of most soils.


0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Acidic Soil (low pH)
At pH levels lower than 5.5, aluminum and manganese can become highly available to the point of being toxic. At similarly low pH levels, other elements like nitrogen, calcium, phosphorous, magnesium, and potassium become less available for absorption by plants.
Slightly Acidic to Neutral Soil
Ideal soil conditions for most plants
Alkaline Soil (high pH)
When the pH level of soil is above 7, elements like iron, zinc, copper, boron, phosphorous, and manganese also become less available for absorption by plants

3. Chemical properties of soil: Carbonates as $CaCO_3$

- Calcium Carbonate is the carbonic salt of calcium ($CaCO_3$)
- Soils are dominated by calcium carbonates are referred to as calcareous soils. The most common carbonate found in calcareous soils is lime ($CaCO_3$).
- Calcium carbonate is one of the cementing agents participating in the binding of soil particles together through physico-chemical mechanisms and presumably creates a stable soil structure.
- The presence of carbonates in soil can affect soil productivity by influencing soil pH, structure, WHC (Water Holding Capacity) and water flow
- Calcareous soils have a high buffering capacity or resistance to changes in pH This is due to free carbonates being able to effectively neutralize acids in the soil
- Carbonates can alter soil structure by affecting texture and promoting aggregation. Carbonate deposits can be of varying size, ranging from very fine clay like powder to coarser, silt-like deposits, which can impact texture.

Plant Available Nitrogen (N):

- Nitrogen is the most critical element obtained by plants from the soil and when deficient is a bottleneck in plant growth. Plants can use the nitrogen as either the cation ammonium, NH, or the anion nitrate, NO, Nitrogen is seldom missing in the soil, but is often in the form of raw organic material which cannot be used directly.
- Nitrogen is also available in gas forms in the soil, however these quantities are very small and difficult to detect such as: nitrous oxide (N_2O), nitric oxide (NO), nitrogen dioxide (NO_2), ammonia (NH) and molecular nitrogen (N_1) present in the air space of the soil

Available Phosphorous (P):

- Phosphornn is found in the soil in organic compounds and in minerals. The types of phosphorus compounds that exist in the soil are mostly determined by soil pH and by the type and amount of minerals in the soil. Mineral compounds of phosphorus usually contain aluminum, iron, manganese and calcium. Soils with inherent pH values berween 6 and 7.5 are ideal for P-availability

- In acidic soils phosphorus tends to react with aluminum, iron and manganese, while in alkaline soils the dominant fixation is with calcium. Excess of phosphorus mostly interferes with uptake of other elements, such as iron manganese and zinc. Symptoms of phosphoras deficiency include stunted growth and dark purple colour of older leaves, inhibition of flowering and root system development

Available Potassium.

- Potassium is highly mobile in the soil, but leaching is minimized by cation exchange and by trapping within clay crystals. Potassium a major plant nutrient is the most abundant element in soils. Potassium exists in soils in natural, non-exchangeable, exchangeable and water soluble forms.

- Potassium has a role in large number of enzymatically catalysed reactions.

- The K^+ in soil solution, which is directly available to plants, comprises a minor proportion (0.1–0.2%) of total soil K^+, whereas the exchangeable (labile) K^+ adsorbed on clay and organic matter constitutes 1–2% of the total soil K (194).

- The total K content of soils frequently exceeds 20,000 ppm (parts per million). While the supply of total K in soils is quite large, relatively small amounts are available for plant growth at any one time.That's because nearly all of this K is in the structural component of soil minerals and isn't available for plant growth.

- The amount of K supplied by soils varies due to large differences in soil parent materials and the effect weathering has on these materials. Therefore, the need for K in a fertilizer program varies across the United States.Three forms of K – unavailable, slowly available or fixed and readily available or exchangeable – exist in an equilibrium in the soil system.

THE END