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B.Sc. Forestry (First Semester)

Paper – Fundamentals of Geology and soil science

Note: Attempt any five questions in all. Question number 1 is compulsory.

Q1. State whether the following statements are true or false:

(a) Quartz and mica are an example of secondary minerals. **(False)**
(b) Sand, silt and Clay are known as solid soil particles. **(True)**
(c) The calculation formula for volume is πr^2h. **(True)**
(d) Soil porosity is the percentage pore space by volume in a soil. **(True)**
(e) The weight of 1 cc water is 1g. **(True)**
(f) Red color of soil is due to the presence of ferric oxide.**(True)**
(g) Sand particles are negatively charged. **(False)**
(h) Lime powder is used to correct the soil acidity. **(True)**
(i) The capacity of soil to hold maximum amount of total water against the pull of gravity is known as its water holding capacity. **(True)**

Q2:- What do you understand by Soil formation? Describe the role of soil factors and soil processes in soil formation.

Ans:-

SOIL FORMATION

Soil layers are approximately parallel to the land surface and several layers may evolve simultaneously over a period of time. The layers in a soil are genetically related; however, the layers differ from each other in their physical, chemical, and biological properties. In soil terminology, the layers are called horizons. Because soils as natural bodies are characterized by genetically developed horizons, soil formation consists of the evolution of soil horizons. A vertical exposure of a soil consisting of the horizons is a soil profile.

The Soil-Forming Factors

Five soil-forming factors are generally recognized:

Parent material, organisms, climate, topography, and time. It has been shown that Bt and Bhs horizon development is related to the clay and sand content within the parent material and/or the amount of clay that is formed during soil evolution. Grass vegetation contributes to soils with thick A horizons because of the profuse growth of fine roots in the upper 30 to 40 centimeters of soil. In forests, organic matter is added to soils mainly by leaves and wood that fall onto the soil surface. Small-animal activities contribute to some mixing of organic matter into and within the soil. As a result, organic matter in forest soils tends to be incorporated into only a thin layer of soil, resulting in thin A horizons. The climate contributes to soil formation through its temperature and precipitation components. If parent materials are permanently frozenor dry, soils do not develop. Water is needed for plant growth, for weathering, leaching, and translocation of clay, and so on. A warm, humid climate promotes soil formation, whereas dry and/or cold climates inhibit it. The topography refers to the general nature of the land surface. On slopes, the loss of water by runoff and the removal of soil by erosion retard soil formation. Areas that receive runoff water may have greater plant growth and organic matter content, and more water may percolate through the soil. The extent to which these factors operate is a function of the amount of time that has been available for their operation.

Soil-Forming Processes

Horizonation (the formation of soil horizons) results from the differential gains, losses, transformations, and translocations that occur over time within various parts of a vertical section of the parent material. Examples of the major kinds of changes that occur to produce horizons are:

(1) Addition of organic matter from plant growth, mainly to the topsoil; (2) transformation represented by the weathering of rocks and minerals and the decomposition of organic matter; (3) loss of soluble components by water moving downward through soil carrying out soluble salts; and,

(4) Translocation represented by the movement of suspended mineral and organic particles from the topsoil to the subsoil.

Q3. What do you mean by bulk density? Calculate the Bulk density using the following data:-

Cylinder height – 4cm.

Cylinder inside diameter -3 cm

Oven dry weight- 80g

Ans:-

Bulk density is the density of the bulk soil in its natural state, including both the particles and pore space. A soil is composed of mineral and organic particles of varying composition and density. Feldspar minerals (including orthoclase) are the most common minerals in rocks of the earth's crust and very common in soils. They have densities ranging from 2.56 g/cm^3 to 2.76 g/cm^3. Quartz is also a common soil mineral; it has a density of 2.65 g/cm^3. Most mineral soils consist mainly of a wide variety of minerals and a small amount of organic matter. The average particle density for mineral soils is usually given as 2.65 g/cm ^{3} must be exercised in the collection of soil cores so that the natural structure is preserved. Any change in structure, or compaction of soil, will alter the amount of pore space and, therefore, will alter the bulk density. The bulk density is the mass per unit volume of oven dry soil, calculated as follows:

$$\text{bulk density} = \frac{\text{mass oven dry}}{\text{volume}}$$

Where volume of cylinder($V = \pi r^2 h$)

$V=22/7*((3/2))^2*4$

= 28.28 cm^3

Bulk density= 80/28.28

=2.83 g/cm^3

Q4. Write short notes about the following:

(a) Particle density:-

The solid (mineral and organic) particles that make up a soil have specific **particle density** (D_p), which is defined as the mass of solid particles in a unit volume.

$$D_p = \frac{mass\ of\ dry\ soil}{volume\ of\ solids}$$

The particle density of a soil is not affected by particle size or arrangement; rather it depends on the type of solid particles present in the soils. Because mineral soil particles are heavier than organic matter, they have a higher particle density on a unit volume basis. The average particle density of a mineral surface soil is about 2.65 g cm^{-3}, which is the average density of quartz.

(b) Bulk density:-

Bulk density (D_b) is a measure of the mass of soil per unit volume (solids + pore space) and is usually reported on an oven-dry basis.

$$D_b = \frac{mass\ of\ dry\ soil}{volume\ of\ solids\ \&\ pore\ spaces}$$

Unlike the measurement of particle density, the bulk density measurement accounts for the spaces between the soil particles (pore space) as well as the soil solids. Soils with a high proportion of pore space have lower mass per unit volume, and therefore have low bulk density. Typical mineral soils have bulk densities that range from 1.0 to 1.6 g cm^{-3}. A bulk density greater than 1.6 g cm^{-3} may indicate soil compaction, which means these soils have a low proportion of pore space and, therefore, low porosity. Alternatively, soils with a high proportion of organic matter tend to have bulk densities that are less than 1.0 g cm^{-3}.

The bulk density of different soils varies based largely on soil texture and the degree of soil compaction. Sandy soils with low organic matter tend to have higher bulk density than clayey or loamy soils. Soil bulk density is usually higher in subsurface soils than in surface horizons, in part due to compaction by the weight of the surface soil.

(c) Soil pores:

Soil pores is the gaps between particles and chunks of soil throughout a particular sample of soil. It can be classified into three main groups depending on the diameter of the individual pore. Macropores are large diameter pores ($\geq$ 0.1 mm) that tend to be freely draining and are prevalent in coarse textured or sandy soils. Mesopores are medium sized pores (0.03 mm – 0.1 mm) that are common in medium-textured soils or loamy soils. Micropores are small diameter pores (<0.03 mm) that are important for water storage and are abundant in clay soils. It is sometimes helpful to envision soil pore space as a network of tiny tubes of varying diameter. Imagine how the diameters of those tubes would impact the movement of gasses and liquids relative to aeration, drainage, and infiltration.

(d) Soil porosity:

Soil porosity is the ratio of the volume of soil pores to the total soil volume. In general, clayey soils have an abundance of very small pores (micropores) that give them a higher total porosity compared to sands, which are dominated by larger, but fewer pores. Consider the relative sizes of a single sand grain and several clay particles existing as an aggregate (Figure 1). Low porosity tends to inhibit root penetration, water movement, and gas movement.

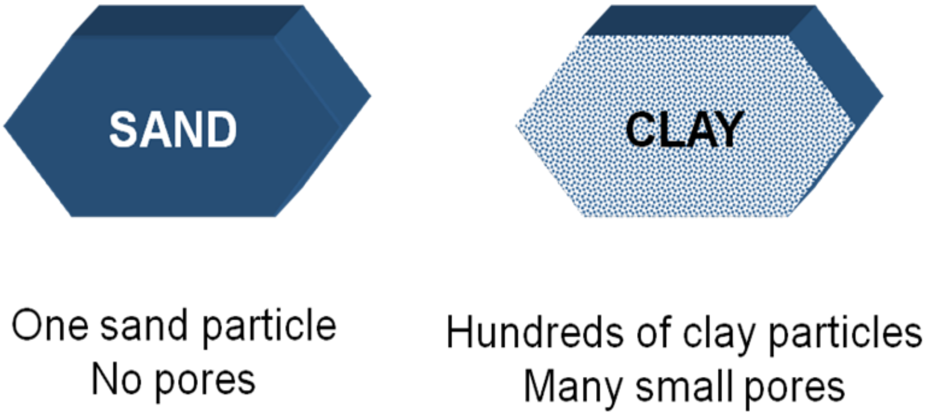


Figure 1. The relationship between soil particle size and soil porosity.

There are more pore spaces between the clay than sand particles because clay particles are much smaller. Thus, clay soils tend to have a higher total porosity than sandy soils—all else being equal. However, the relationship between texture and bulk density is tenuous and depends on a variety of factors such as organic matter content and depth in the soil profile.

Q5. Write short notes on:-

(a) Normal capacity moisture:-

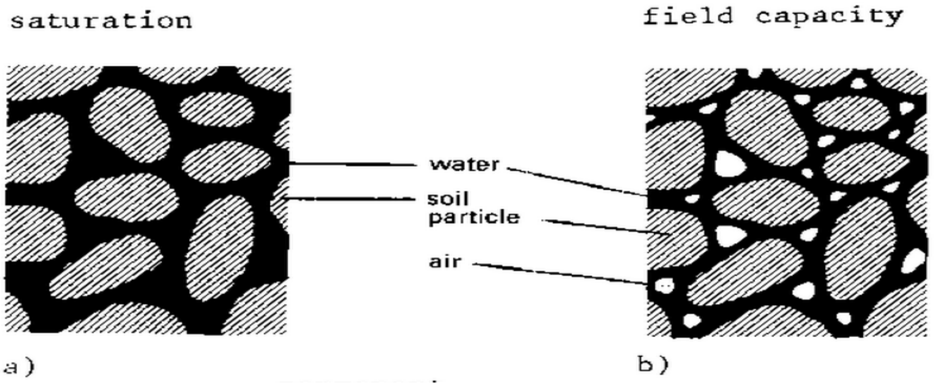
Normal capacity moisture /Field capacity moisture is the amount of soil moisture or water content held in the soil after excess water has drained away and the rate of downward movement has decreased i.e. after the drainage has stopped, the large soil pores are filled with both air and water while the smaller pores are still full of water. At field capacity, the water and air contents of the soil are considered to be ideal for crop growth (Fig. 2). This usually takes place 2–3 days after rain or irrigation in pervious soils of uniform structure and texture.

Calculation of Normal capacity moisture:-

1. Take a perforated earthen vessel
2. Fill the vessel with dry soil. Add water slowly so that soil gets homogenously. Stop water when water starts coming out from the bottom hole.

3. Allow the water completely drained out.
4. When water stops coming out from the mouth of vessel it is sealed with polythene bag to stop evaporation.
5. Take 10 gm of fresh soil and keep to drying in order to know dry weight.
6. Calculate the % moisture content with the following formula:- $\frac{Fresh\ weight\ of\ soil-Dry\ \ weight}{Dry\ weight\ of\ soil}$*100

Fig. 2 Some soil moisture characteristics



(b) Gravimetric method of soil moisture determination:-

The gravimetric method involves collecting a soil sample weighing the sample before and after drying it, and calculating its original moisture content i.e:-

a. Collect soil sample.
b. Take 10g weight of the soil and place in pertidish
c. Keep the petridish in hot air oven for drying at 105 ±1 ^{o}C
d. Continue drying till the constant weight is achieved
e. Take the dry weight of the soil

Calculate moisture % by given formula:-

$$\frac{Fresh\ weight\ of\ soil-Dry\ \ weight}{Dry\ weight\ of\ soil}*100$$

The gravimetric method is the oldest (other than the ancient method of feeling the soil) but still continues to be the most widely used method for obtaining data on soil moisture. Because it is the only direct way of measuring soil moisture, it is required for calibrating the equipment used in the other methods. Russell (1950) reporting on work completed in 1843 and Whitney (1894), describe some of the first scientific investigations of soil moisture using gravimetric methods. Since that time many types of sampling equipment, as well as special drying ovens and balances, have been developed for use with the gravimetric methods.

The disadvantage of the gravimetric method is the time and effort required to obtain data. It is time-consuming work to collect the samples, especially from depths greater than a few feet, and to oven dry and weigh the many samples required for most projects. For many problems, such as the study of evapotranspiration by grasses, the sampling procedure alters the area of experiment owing to trampling of the vegetation or the making of numerous holes. Under these conditions, the sampling may have to be done from platforms, and the holes may have to be refilled and packed. Soils are normally variable within an experimental area and, as two samples cannot be collected from the same point; slight variations of moisture content may be noticed.

Q6. What do you know about the problem soils? How the soils become acidic in nature and describe control measures of acidic soil.

Ans:-

Problem soils are those soils whose physical, chemical and biological properties have undergone adverse change due to ecological and anthropological cause/factors. E.g.:-

Soil Problem No. 1: Soil is too dry.

Common to: sandy soils

Amendments to add: compost

Soil Problem No. 2: Soil is too wet.

Common to: clay soils, low-lying areas, areas with a high water table

Amendments to add: compost, sand, 78M pea gravel

Soil Problem No. 3: Soil is alkaline.

Common to: clay soils, arid and semi-arid climates

Amendments to add: elemental sulfur, iron sulfate

Soil Problem No. 4: Soil is acidic.

Common to: areas of high rainfall, poor drainage, heavy nitrogen-fertilizer use and high evergreen-tree population. Acidic soils are formed by removal of base elements like Ca, Mg, Na & K from the soil.

Amendments to add: dolomitic lime, wood ash

Soil Problem No. 5: Soil has excess salinity (salt content) or sodicity (sodium content).

Common to: arid and semi-arid climates, low-lying areas near salt water

Amendments to add: gypsum (calcium sulfate), elemental sulfur

Soil Problem No. 6: Soil lacks organic matter.

Common to: many soils, especially those that have been continually farmed using less-sustainable methods

Amendments to add: compost

Q7.Describe the following:-

a. Soil orders

TABLE 1. Names and Important Properties of the Soil Orders

S. No	Soil Orders	Important Properties
1	Alfisols	Mineral soils relatively low in organic matter with relatively high base saturation. Contains horizon of alluvial clay. Moisture is available to mature a crop.
2	Aridisols	Mineral soils relatively low in organic matter. Contain developed soil horizons. Moisture is inadequate to mature a crop without irrigation in most years.
3	Entisols	Mineral soils lacking developed soil horizons. Moisture content varies.
4	Histosols	Soils composed mostly of organic matter. Moisture content varies.
5	Inceptisols	Mineral soils containing some developed horizons other than one of alluvial clay. Moisture is available to mature a crop.
6	Mollisols	Mineral soils with thick, dark surface horizons relatively high in organic matter and with high base saturation.
7	Oxisols	Mineral soils with no weatherable minerals. High in iron and aluminium oxides. Contain no alluvial horizons.
8	Spodosols	Soils that contain an alluvial horizon of amorphous aluminium and organic matter, with or without amorphous iron. Usually moist or well leached.
9	Ultisols	Mineral soils with an alluvial clay horizon. Has low base saturation. Generally found in humid climates.
10	Vertisols	Clayey soils with deep wide cracks at some time in most years. Moisture content varies.

b. Land capability classification

USDA Land Capability Classification System

Class I: These soils do not have significant limitations for crop production

Class II: Soils with moderate limitations that restrict the range of crops or require moderate conservation practices

Limitations may be one of the following: adverse regional climate, moderate effects of cumulative undesirable characteristics, moderate effects of erosion, poor soil structure or slow permeability, low fertility correctable with consistent moderate applications of fertilisers and lime, gentle to moderate slopes, occasional damaging overflow, or wetness correctable by drainage but continuing as a moderate limitation.

Class III: Soils in this class have moderately severe limitations that restrict the range of crops or require special conservation practices

Limitations are a combination of two or more of those described under Class II, or one of the following: moderate climate limitations including frost pockets, moderately severe effects of erosion, intractable soil mass or very slow permeability, low permeability, low fertility correctable with consistent heavy applications of fertilisers and lime, moderate to strong slopes, frequent overflow accompanied by crop damage, poor drainage resulting in crop failure in some years, low water-holding capacity or slowness in release of water to plants, stoniness severe enough to handicap cultivation seriously and necessitate some clearing, restricted rooting zone or moderate salinity.

Class IV: Soils in this class have severe limitations that restrict the range of crops or require special conservation practices or both

Limitations in this class include the adverse effects of the combination of two or more of those described under Classes II and III, or one of the following: moderately severe climate, very low water-holding capacity, low fertility difficult or unfeasible to correct, strong slopes, severe past erosion, very intractable mass of soil or extremely slow permeability, frequent overflow with severe effects on crops, salinity severe enough to cause some crop failure, extreme stoniness requiring a lot of clearing for annual cultivation, or very restricted rooting zone, but more than one foot of soil over bedrock or an impermeable layer.

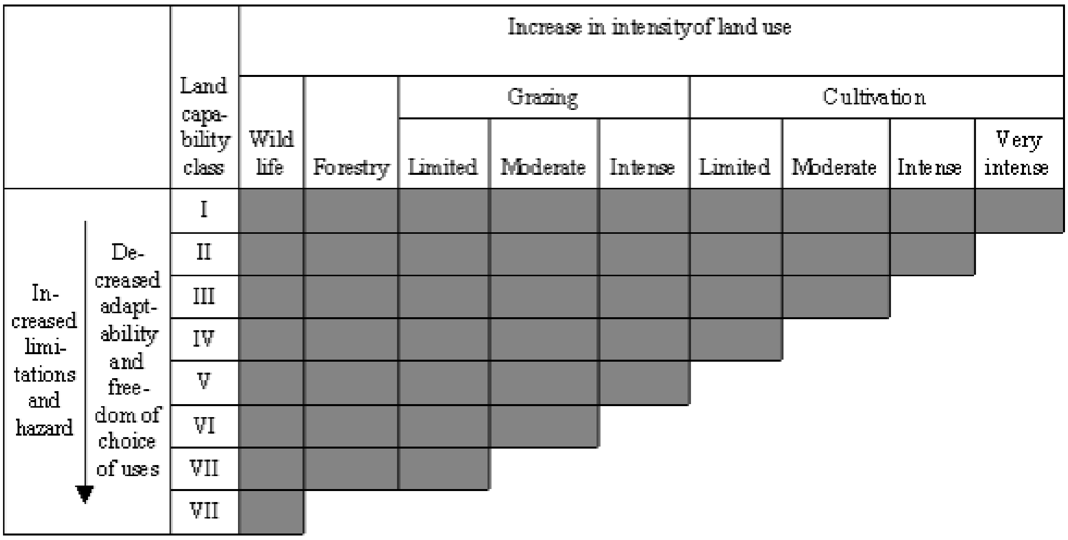
Class V: Soils in this class have very severe limitations that restrict their capability to produce perennial forage crops, but improvement practices are feasible

Limitations in this class include the adverse effects of one or more of the following: severe climate, low water-holding capacity, severe erosion, steep slopes, very poor drainage, very frequent overflow, severe salinity permitting only salt-tolerant forage crops to grow, or stoniness or shallowness to bedrock that make annual cultivation impractical.

Class VI: Soils in this class are capable of producing only perennial forage crops, and improvement practices are not feasible

Limitations in this class include the adverse effects of the combination of two or more of the following: very severe climate, very low water-holding capacity, very steep slopes, very severely eroded land with gullies numerous and deep for working with machinery, severely saline land producing only slat-tolerant native plants, very frequent overflow allowing less than 10 weeks effective growing, water on the surface of the soil for most of the year, or stoniness or shallowness to bedrock that makes any cultivation impractical.

Class VII: Soils in this class are not capable of supporting agriculture or permanent pastures
Soils in this class have limitations so severe that they are not capable of use for farming or pastures. These soils may or may not be able to support trees, native fruits, wildlife and recreation.



	Land capability class	Increase in intensityof land use								
				Grazing			Cultivation			
		Wild life	Forestry	Limited	Moderate	Intense	Limited	Moderate	Intense	Very intense
Increased limitations and hazard Decreased adaptability and freedom of choice of uses	I	▨	▨	▨	▨	▨	▨	▨	▨	▨
	II	▨	▨	▨	▨	▨	▨	▨	▨	
	III	▨	▨	▨	▨	▨	▨	▨		
	IV	▨	▨	▨	▨	▨	▨			
	V	▨	▨	▨	▨	▨				
	VI	▨	▨	▨	▨					
	VII	▨	▨	▨						
	VII	▨								

Note. The intensity with which each land capability class can be used with safety, and the limitations acting, increase as one moves from land capability Class I to Class VIII.

Figure 3. Relationships between the USDA (United States Department of Agriculture) land capability classes and potential utilisation of land

Q8. What are the various sources of organic matter? Describe the chemical composition of undecomposed organic matter.

Ans:-

Soil organic matter plays important role in the maintenance and improvement of soil properties. It is a dynamic material and is one of the major sources of nutrient elements for plants. Soil organic matter is derived to a large extent from residues and remains of the plants together with the small quantities of animal remains, excreta, and microbial tissues. Soil organic matter is composed of three major components i.e. plants residues, animal remain and dead remains of microorganisms. Various organic compounds are made up of complex carbohydrates, (Cellulose, hemicellulose, starch) simple sugars, lignins, pectins, gums, mucilages, proteins, fats, oils, waxes, resins, alcohols, organic acids, phenols etc. and other products. All these compounds constituting the soil organic matter can be categorized in the following way.

Chemical composition of Organic Matter (Undecomposed)

A. Organic:

- **Nitrogenous:**

  Water Soluble eg. Nitrates, ammonical compounds, amides, amino acids etc.

  Insoluble eg. Proteins nucleoproteins, peptides, alkaloids purines, pyridines chitin etc.

- **Non Nitrogenous:**

  Carbohydrates eg. Sugars, starch, hemicellulose, gums, mucilage, pectins, etc.

Micellaneous: eg. Lignin, tannins, organic acid, etc.

Ether Solube: eg. Fats, oils, wax etc.

B. Inorganic

The organic complex / matter in the soil is, therefore made up of a large number of substances of widely different chemical composition and the amount of each substance varies with the type, nature and age of plants. For example cellulose in a young plant is only half of the mature plants; water-soluble organic substances in young plants are nearly double to that of older plants. Among the plant residues, leguminous plants are rich in proteins than the non-leguminous plants. Grasses and cereal straws contain greater amount of cellulose, lignin, hemicelluloses than the legumes and as the plant gets older the proportion of cellulose, hemicelluloses and lignin gets increased. Plant residues contain 15-60% cellulose, 10-30 % hemicelluslose, 5-30% lignin, 2-15 % protein and 10% sugars, amino acids and organic acids. These differences in composition of various plant and animal residues have great significance on the rate of organic matter decomposition in general and of nitrification and humification (humus formation) in particular. The end products of decomposition are CO_2, H_2O, NO_3, SO_4, CH_4, NH_4, and H_2S depending on the availability of air.