

# e-Reading Manual

**NR1102**

## **GEOLOGY AND SOILS**



**Prepared by**

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**e-Reading Manual on**  
**Geology and Soils**

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## 1. Description of Geology and Soils

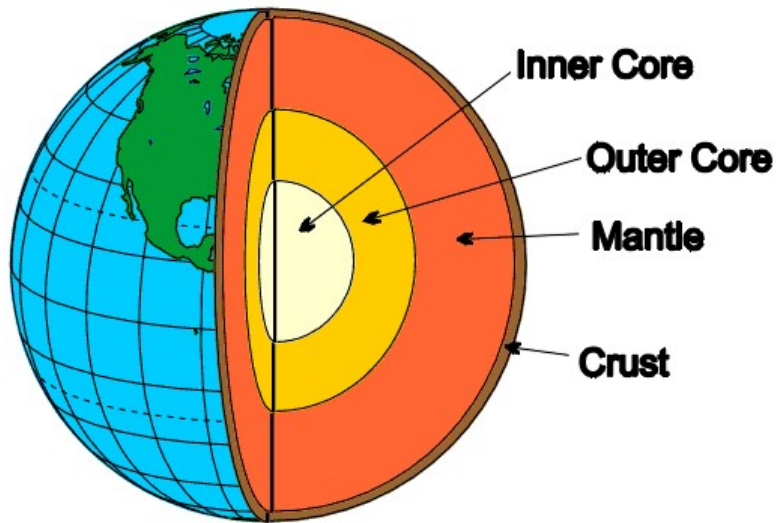
**Geology:** Study of earth is referred as Geology and it is also known as 'Geo-science' or 'Earth science'. Geology involves studying the materials that make up the earth, the features and structures found on Earth as well as the processes that act upon them. Typically, geology is divided into two categories:

- A. **Physical Geology:** Physical geology deals with the study of the physical features of the earth and the processes acting on them. This includes volcanoes, earthquakes, rocks, mountains and the oceans; just about any feature of the earth.
- B. **Historical Geology:** Historical geology is the study of the history of the earth. Historical geologists focus on what's happened to Earth since its formation.

### Interior of the Earth

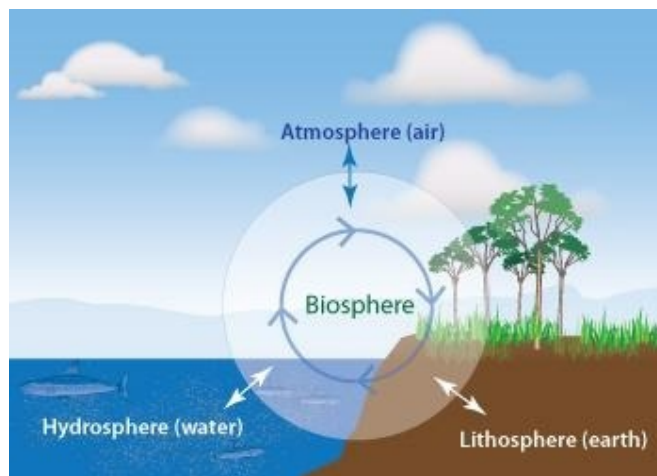
The Earth Ball consists of 3 concentric rings namely Crust, Mantle and Core.

- I. **Crust:** "Crust" describes the outermost shell of a terrestrial planet. The crust is made up of different types of rocks: igneous, sedimentary and metamorphic rock. The thickness of crust is about 5 to 11 km in the oceans and 35 to 56 km in the continents. It is dominated with silicon and aluminium.
- II. **Mantle:** A massive solid to semi solid layer below the earth crust. The mantle is about 2,900 kilometers (1,802 miles) thick, and makes up a whopping 84 percent of Earth's total volume. It comprises mixed metals and silicate minerals. In the mantle, temperatures range from approximately 500 K (227 °C; 440 °F) at the upper boundary. The average density of this layer varies from 3.0 to 4.5 g/cc. This layer is dominated with silicon and magnesium.
- III. **Core:** Earth's core is the innermost geologic layer of Earth. It is primarily a solid ball, very hot, very dense with a radius of about 3500 km. There are two layers of core:
  - a. **Outer core:** The outer core, about 2,200 kilometers (1,367 miles) thick, is mostly composed of liquid iron and nickel. The temperature of outer core is very hot, between 4,500° and 5,500° Celsius.
  - b. **Inner core:** The inner core is a hot, dense ball of (mostly) iron. It has a radius of about 1,220 kilometers (758 miles). Temperature in the inner core is about 5,200° Celsius. The average density of this layer varies from 9.0 to 12.0 g/cc.



### Exterior of the Earth

Geographically, Earth constitutes of three spheres corresponding to three states of matter, i.e. Solid, Liquid and Gas. The solid zone is called Lithosphere. The incomplete covering of water forming seas and oceans (liquidspheres) is called Hydrosphere. The gaseous envelop over the earth surface is called Atmosphere.



### Atmosphere –

1. The atmosphere forms an envelope is about 322 Km over the earth's surface.
2. This envelops of air that covers both lithosphere and hydrosphere is called atmosphere.
3. It contains water molecules and dust, which act as nuclei for the condensation of water vapour to form cloud or fog.

4. Atmosphere contributes only 0.03 %weight to the earth.

### Hydrosphere

1. It covers almost  $\frac{3}{4}$ <sup>th</sup> of earth crust.
2. The hydrosphere is 10 Km deep and it occupies 70 % of earth's surface.
3. Hydrosphere makes only 6.91 % of the earth mass.
4. It contains absorbed air and carries particles of rocks as sediments.
5. Most of it lies within the ocean basins and also appears on surface of land in the form of rivers, ponds, lakes and as ground waters.
6. The quality of different waters varies from place to place.

### Lithosphere

1. It is the solid sphere. It consists of continents, ocean basins, plains, plateaus and mountains, valleys, sand dunes, lava flows and fault scraps.
2. The interior of earth consists of rocks and minerals.
3. It is covered by gaseous and watery envelops. It amounts to 93.06 % of earth's mass.

### Composition of Earth's Crust

The Earth's crust is principally composed of mineral matter. This mineral matter is made up of various elements combined together to form compounds. Each element is in combination with one or more other elements to form definite chemical compounds known as **minerals**. Many of these minerals in turn combine together to form aggregates, which we know as **rocks**. Almost all the mineral matter is present in the form of rocks in the earth's crust. Rock is composed of elements, which in turn are made up of atoms.

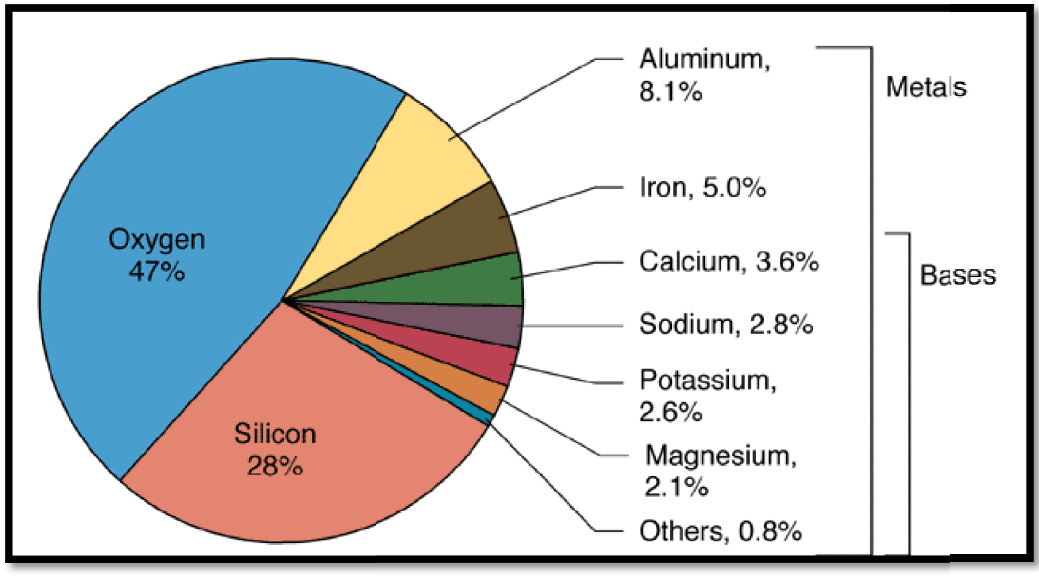
Out of 118 elements known, eight are sufficiently abundant as to constitute 98.6 % (by weight) of the earth crust (up to 16m). Out of eight elements, two are in great abundance (non metals) and comprise  $\frac{3}{4}$  of the total composition of the earth crust. The other six elements are metals.

### Composition of Earth crust (% by weight)

Non-metallic	Oxygen	46.60	74.32% ( $\frac{3}{4}$ <sup>th</sup> )
	Silica	27.72	
Metallic	Aluminium	8.13	$\frac{1}{4}$ <sup>th</sup> of the total
	Iron	5.00	
	Calcium	3.63	

	Sodium	2.83	
	Potassium	2.59	
	Magnesium	2.09	
	Others	1.41	

Total weight of eight elements (%) – 98.59



**Exercise No - 01**  
**Identification of rocks and minerals**

**What is Rocks**

Rocks are the materials that form the essential part of the Earth's solid crust. "Rocks are hard mass of mineral matter comprising one or more rock forming minerals". Rocks are formed from the molten material known as **Magma**. The study of rocks is called **Petrology** (Greek, petra means rock, logos means science). Petrology deals with the description of rocks; Petrogenesis is the study of the origin of rocks.

**Formation of rocks**

1. Cooling and consolidation of molten magma within or on the surface of earth =

**Igneous or Primary rocks**

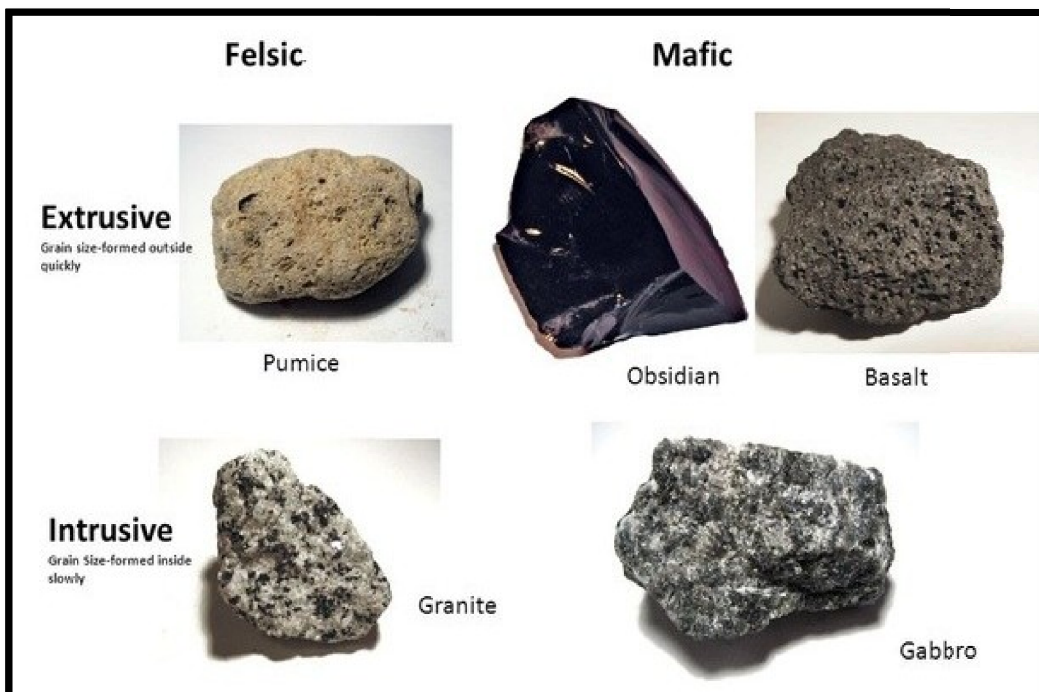
2. Transportation and cementation of primary rocks = **Sedimentary or Secondary**

**Rocks**

3. Alteration of the existing primary and secondary rocks = **Metamorphic rocks**

**1. Igneous rocks (Primary or Massive rocks):**

These rocks are formed due to cooling and solidification of molten magma. Based on the mode of formation, they are further classified as extrusive and intrusive rocks-



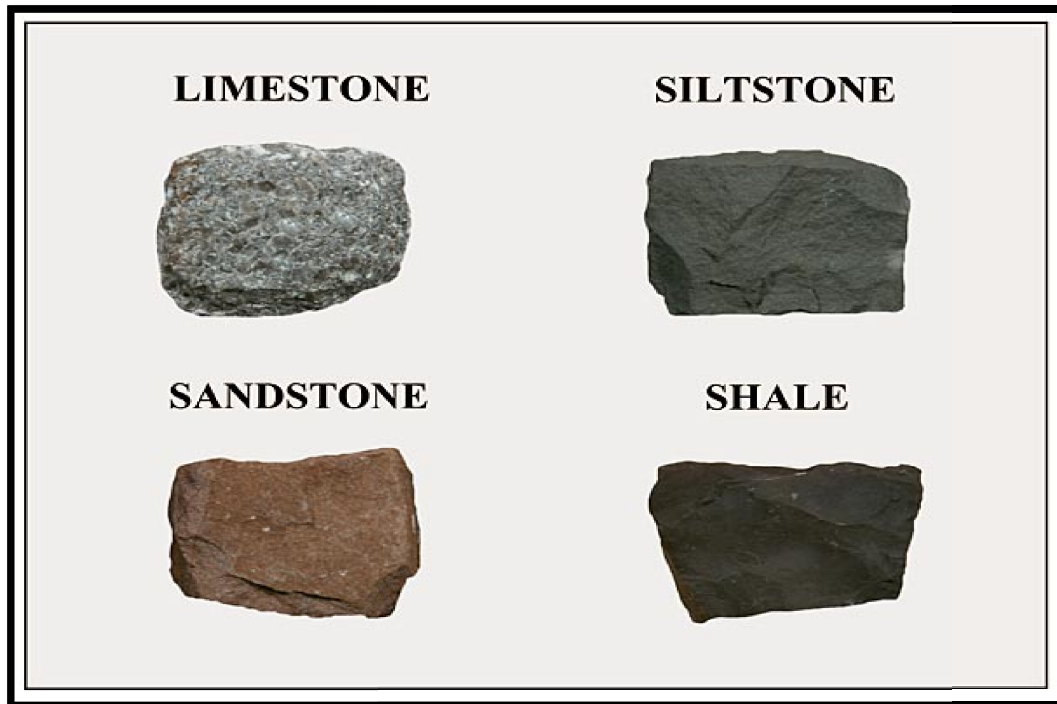
a) **Extrusive rocks or Volcanic rocks-** These rocks are formed due to the consolidation of magma on the surface of the earth. E.g. Basalt, Rhiolite, Pumic.



b) **Intrusive rocks or Plutonic rocks-** These rocks are produced due to solidification of magma below the surface of the earth. E.g. Granite, Syenite, Diorite, Gabbro *etc.*

**2. Sedimentary rocks (Secondary rocks or Stratified rocks):**

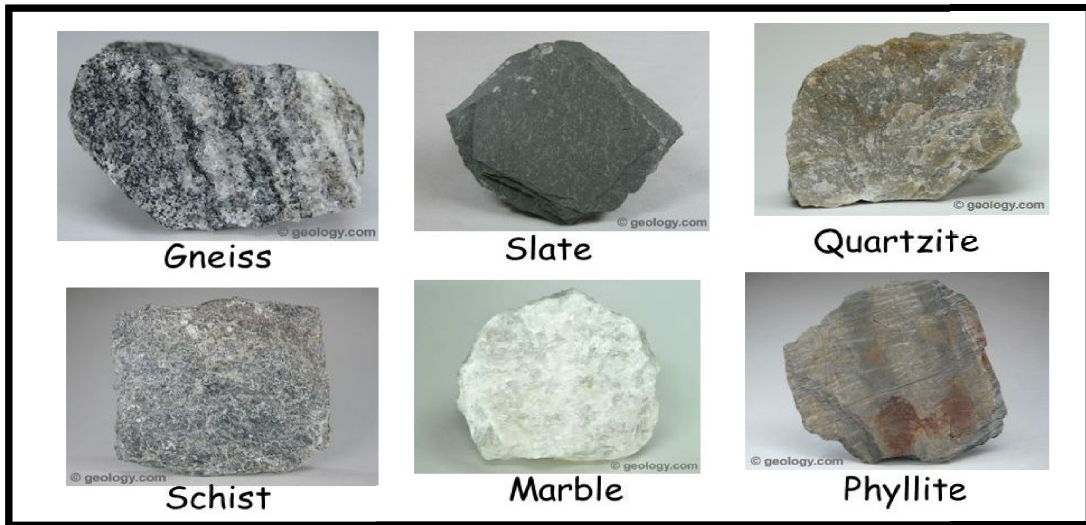
These rocks are formed from the consolidation of sediments accumulated through wind or water action at the surface of the earth. Many are deposited in layer or formed through chemical reactions as precipitates from aqueous solutions. Ex. Limestone



**3. Metamorphic rocks**

These are formed from igneous and sedimentary rocks under the influence of heat, pressure. Change may occur in mineral composition or texture or both. The change due to water is called **hydro metamorphosis** and due to pressure is called **dynamo metamorphosis**.

Origin rocks	Metamorphic rocks
Sand stone	Quartzite
Shale	Slate
Lime stone	Marble
Granite	Gneiss
Peat	Coal
Basalt	Amphibolites



## Minerals

Minerals are naturally occurring solids with a definite chemical composition, inorganic in nature and crystal structure. “Solid substances composed of atoms having an orderly and regular arrangement”

### Physical properties of minerals for Identification

1. Color
2. Streak
3. Fracture/ cleavage
4. Hardness
5. Luster
6. Crystal form
7. Taste
8. Specific gravity
9. Magnetism
10. Effervescence (fizz)
11. Birefringence
12. Fluorescence

## 1. Colour:

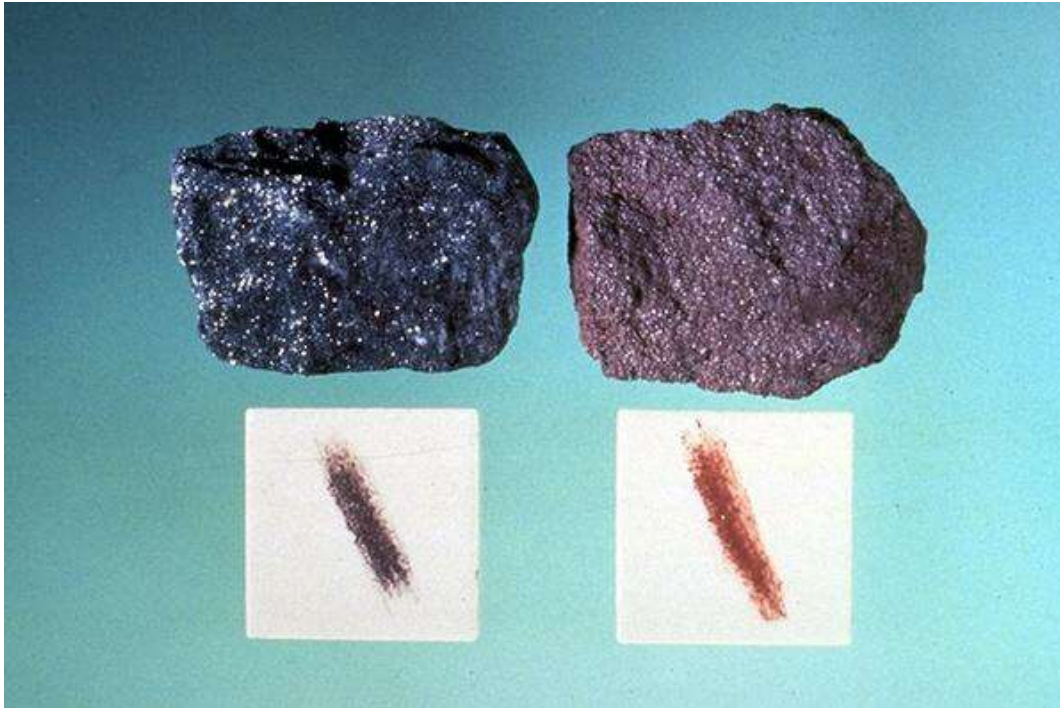
Minerals come in a variety of colours. Examples of common dark-coloured minerals (black, dark brown, dark green) are amphibole, olivine, pyroxene, biotite mica. Light-coloured minerals (white, pink, gray, translucent) are represented by quartz, feldspar (orthoclase, plagioclase), muscovite mica, gypsum, halite, and calcite.



## 2. Streak:

It refers to the colour of the powder form of the mineral when an unknown mineral is rubbed against a piece of unglazed porcelain (streak plate) it produces a coloured line.

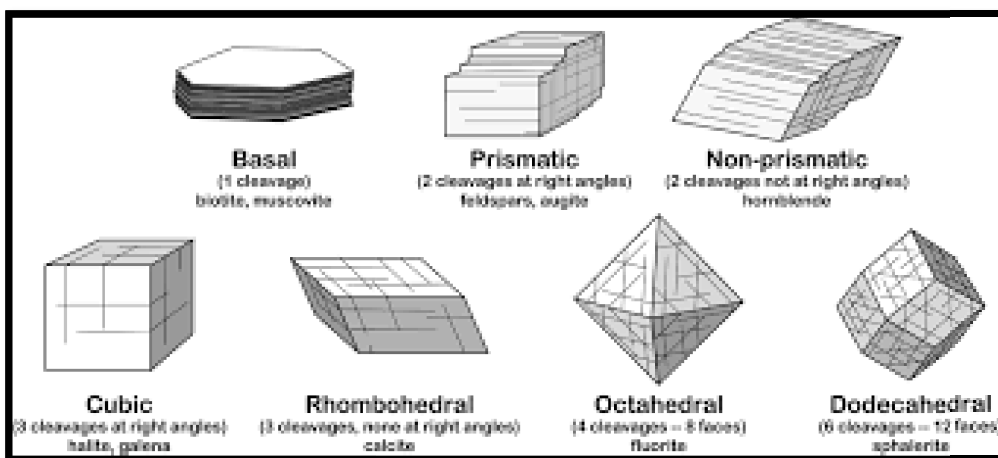
- Hematite - red
- Magnetite - Black
- Talc – white



### 3. Cleavage:


Minerals break along specific planes of weakness related to their atomic structure. Amphibole's cleavage planes intersect at 120 degrees; pyroxene has a distinctive 90 degree cleavage intersection. Quartz has no cleavage planes but fractures irregularly. Some minerals break along certain well defined planes called cleavage planes.

- Gypsum - 1 set
- Calcite - 2 sets
- Fluorite - 3 sets



#### 4. Moh's Hardness Scale:

Minerals are ranked from 1 to 10 based upon their relative hardness. Harder minerals can scratch softer minerals. For example, a mineral that could scratch feldspar but not quartz would have a hardness of approximately 6.5.

S.N.	Minerals	Hardness	Softest
1	Talc	1	
2	Gypsum	2	
3	Calcite	3	
4	Fluorite	4	
5	Apatite	5	
6	Feldspar	6	
7	Quartz	7	
8	Topaz	8	
9	Corundum	9	
10	Diamond	10	

#### 5. Luster:

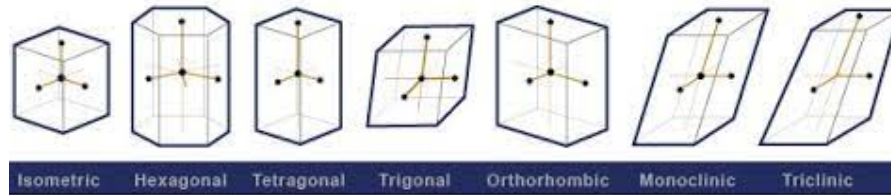
A characteristic of light reflected from mineral is luster. Types of luster include earthy, silky, glassy, and metallic.

#### 6. Crystal form:

Crystal structure is the result of regular grouping of atoms that are homogeneous. A crystal is a polyhedral form, which means it is a geometric solid. It has a specific set of faces, corners and edges, which is consistent with the geometric packing of the atoms

There are 6 basic crystal forms

1. Isometric
2. Tetragonal
3. Hexagonal
4. Orthorhombic
5. Monoclinic
6. Triclinic



### **7. Taste:**

This property is used to identify the mineral halite (salt).

### **8. Specific Gravity:**

This characteristic relates to the minerals density. If the mineral is heavy for its size, then it has a high specific gravity.

### **9. Magnetism:**

Some minerals are magnetic or attracted by a magnet. This property is characteristic of Magnetite mineral.

### **10. Effervescence:**

When some minerals are exposed to acids, they begin to fizz (calcite).

### **11. Birefringence:**

This is also known as double refraction. Birefringent minerals split the light into two different rays which gives the illusion of double vision in this Iceland Spar Calcite

### **12. Fluorescence:**

Some minerals display the phenomenon of photoluminescence. They "glow" when exposed to UV light. Ex. Opal and Fluorite.

**Work sheet**

**Date:** .....

**Instructor's Signature**

## Exercise No - 02

### Collection and preparation of soil samples

The analysis can be no better than the sample. Soil being heterogeneous in nature, it is important to devise a satisfactory method of sampling to get a uniform sample. There is a considerable opportunity for sampling error and hence it is essential that the field be sampled correctly. For efficient evaluation of soil fertility, a representative soil sample of the area is the most important aspect. Practically, soil sampling is a two step process which includes: (i) Collection of soil from homogenous unit and (ii) Preparation of soil samples includes drying, grinding, sieving, mixing, partitioning and storing. During taking of a composite soil samples following points must be considered:

1. Equal amount of soil should be taken from each pit.
2. Each sample must be taken from equal depth (cross section)
3. Variation in slope, colour, texture, crop growth and management practices are the important factors that should be taken into account during sampling. Separate samples are required from these areas.
4. Larger area must be divided into appropriate number of smaller homogenous unit for better representation.
5. Soil sampling should be avoided from recently added fertilizer, bund, irrigation channels, depression areas, well, area under tree and manure dumping site.
6. The sample should be taken at random in zigzag direction.

#### **Soil sampling tools:**

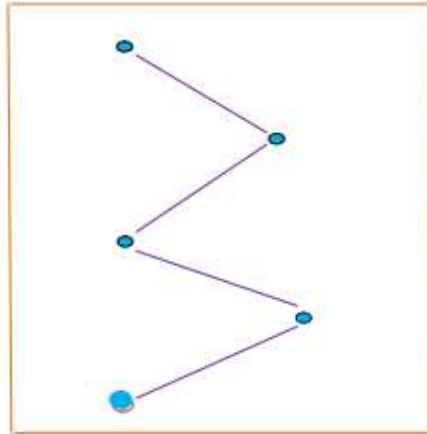
1. Khurpi
2. Spade
3. Augur
4. Sieve
5. Polythene/paper/cloth bag
6. Labels
7. Marker

#### **Soil sampling procedure:**

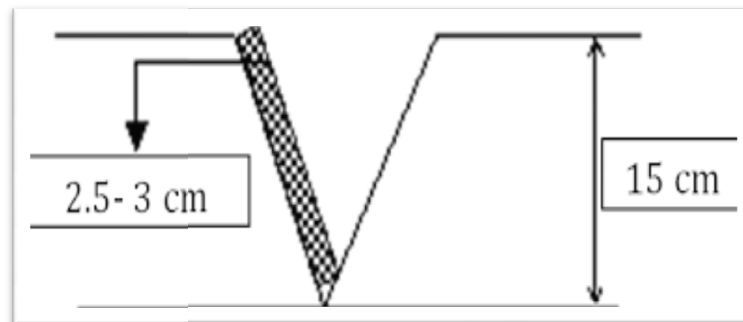
1. Depending on field condition, select the proper sampling tool and objective.
2. Keeping variability in soil texture (feeling by finger), topography (visual observation), soil organic matter (usually indicated by soil colour), fertility status (based on crop growth) determine homogenous area for sampling.



3. Separate samples should be taken from abnormal spot which developed by  $\text{CaCO}_3$  content, high salinity & sodicity or acidity or presence of hard pan.
4. At the sampling site, remove the surface litter with *khurpi* or phawda. Make a 'V' shape cut up to 15 cm (vertical) depth and collect the soil in a zigzag manner.



5. Depth of sampling depends on rooting pattern of the crop grown. Usually, 15 cm soil depth remains restricted for field crop and 180 cm for plantation crop. For mobile nutrients like nitrates and sulphates, samples should be taken upto a depth of 60 cm. Similarly for the site of garden, the subsoil samples are more important than surface soil.



6. Thoroughly mix soils collected from various spots by hand on a clean piece of cloth or polythene sheet.
7. Put the labels inside the polythene bag and another paste on outside the bag. Labels should contain following information-
  - i) Name of the farmers
  - ii) Geo-reference of the field
  - iii) Date of sampling
  - iv) Field/plot number
  - v) Cropping pattern
  - vi) Source of irrigation, if any

8. Under intensive cultivation, sampling should be done every year at same time. If one crop per year is raised sampling once in 3 years is sufficient. For preparation of soil, frequent testing is necessary fertility index / map of village or block level, sampling once in 5 years is more efficient.

#### **Preparation of soil samples:**

Preparation of soil samples involves several procedures which are follows

1. **Drying:** the soil samples are air dried in shade at room temperature.
2. **Grinding:** Remove large stones, stubbles, straw and glasses before grinding. Samples are grinded by wooden mortar, roller to break the soil aggregate.
3. **Mixing:** Grinded soils should be mix thoroughly
4. **Partitioning:** After mixing, keep the soil at middle of the cloth or paper in the form of dome, divide into four equal parts with the help of knife or spatula. Discard any two diagonal quarters. Mix other two quarters left on the paper, again follow the same process until you get 500 g of soil left on the paper.
5. **Sieving:** For routine soil testing and other chemical analysis pass the soil through 2 mm sieve.
6. **Storage:** the soil samples should be stored in air tight jar properly labelled on and inside it. The jars are kept in rack.

#### **Precautions:**

1. Soil samples should not be taken from recently fertilized field.
2. Take other samples from abnormal spot like, area nearby tree, old manure pit, depressed area etc.
3. Avoid contact of the samples with chemicals, fertilizers or manure.
4. Use stainless steel augurs instead of rusted iron khurpi/Fawda for sampling.
5. For grinding never use iron mortar-pestle.
6. Dry the samples in shade only.
7. Do not collect the sample from below or near the trees.

**Work sheet**

**Date:** .....

**Instructor's Signature**

### Exercise No: 03

#### Determination of gravimetric soil moisture content

The method described here is the 'Gravimetric method' in which gravimetric water can be converted into volumetric water content, provided the bulk density of the soil is known. The gravimetric method is simplest, accurate and most widely used method for the determination of water content of soil.

#### **Equipments and materials:**

- Soil augur
- Aluminium moisture box with air tight lid,
- Balance,
- Hot air oven

#### **Procedure:**

1. With the help of soil augur dig out 10-100g soil samples from the desired depth.
2. Immediately keep it into a previously weighed aluminium box with tight fitting lid to avoid any evaporation loss.
3. Weigh the box with wet soil samples and keep it noted.
4. Place the aluminium box in the oven with lid off and dry it at 105°C for 24 hours.
5. Do not put any other wet sample in the oven during this period.
6. Weigh of the dry soil till the weight become constant.

#### **Calculation:**

Let,

Weight of empty aluminium box with its lid = x g

Weight of aluminium box with its lid plus wet soil sample = y g

Weight of aluminium box with its lid plus dry soil sample = z g

Percent moisture in soil =  $\frac{y-z}{z-x} \times 100$

**Work sheet**

**Date:** .....

**Instructor's Signature**

## Exercise No: 04

### Determination of soil colour

Soil colour indicates many soil features. A change in soil colour from the adjacent soils indicates a difference in the soil's mineral origin (parent material) or in the soil development. Soil colour varies among different kinds as well as within the soil profile of the same kind of soil. It is an important soil property through which its description and classification can be made.

#### **Kinds of soil colour**

Soil colour is inherited from its parent material and that is referred to as **Lithochromic**, e.g. Red colour of red soils developed from red sandstone.

Besides soil colour also develops during soil formation through different soil forming processes and that is referred to as **Acquired or Pedochromic** colour, e.g. Ash colour of podzol soil developed from Podzolization process

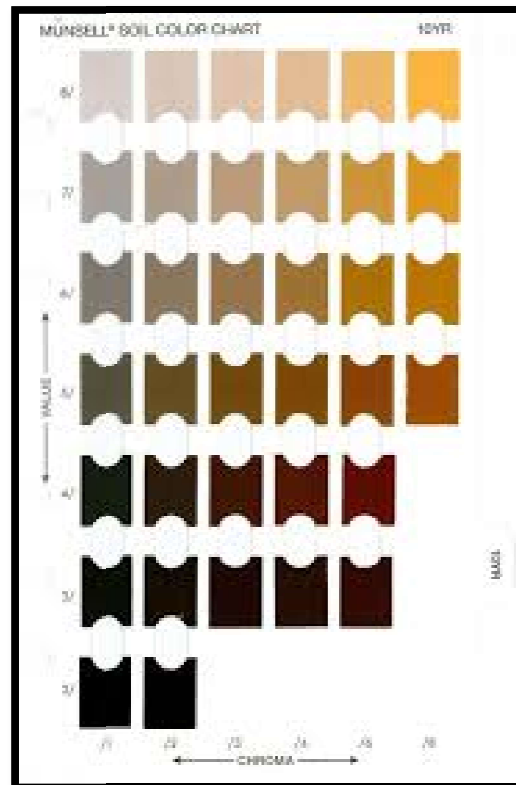
#### **Factors affecting soil colour**

There are various factors or soil constituents that influence the soil colour which are as follows:

1. **Organic matter:** soils containing high amount of organic matter show the colour variation from black to dark brown.
2. **Iron compounds:** soil containing higher amount of iron compounds generally impart red, brown and yellow tinge colour.
3. **Silica, lime and other salts:** Sometimes soils contain either large amount of silica and lime or both. Due to presence of such materials in the soil the colour of the soil appears like white or light coloured.
4. **Mixture of organic matter and iron oxides:** Very often soils contain a certain amount of organic matter and iron oxides. As a result of their existence in soil, the most common soil colour is found and known as brown.
5. **Alternate wetting and drying condition:** During monsoon period due to heavy rain the reduction of soil occurs and during dry period the oxidation of soil also takes place. Due to development of such alternating oxidation and reduction condition, the colour of soil in different horizons of the soil profile is variegated or mottled. This mottled colour is due to residual products of this process especially iron and manganese compounds.

6. **Oxidation-reduction conditions:** when soils are waterlogged for a longer period, the permanent reduced condition will develop. The presence of ferrous compounds resulting from the reducing condition in waterlogged soils impart bluish and greenish colour.

Therefore, it may be concluded that soil colour is indirectly indicative of many other important soil properties. Besides soil colour directly modifies the soil temperature e.g. dark coloured soils absorb more heat than light coloured soils.



### Determination of soil colour

The soil colours are best determined by Munsell colour chart. This chart is given by 'Hansworth Munsell'. The Munsell colour notations are systematic numerical and letter designations of each of these three variables (Hue, Value and Chroma). For example, the numerical notation 2.5 YR5/6 suggests a hue of 2.5 YR, value of 5 and chroma of 6. The equivalent or parallel soil colour name for this Munsell notation is 'red'. The colour of the soil is a result of the light reflected from the soil. This colour chart is divided into 3 groups which are following-

<b>Hue</b>	<b>Value</b>	<b>Chroma</b>
Hue appearance on apex of the chart	Appear in vertical of the chart	Appear in the horizontal of the chart
Hue indicate dominant spectral colour or rainbow colour i.e. Red, Yellow, Blue	Value indicates relative whiteness, lightness, blackness, amount of reflected light	Chroma indicates purity or strength of soil colour
Hue related to wavelength of light	Value related to quality of light	Chroma related to intensity of light
Range of Hue varied from 0-10, 0 denotes absolute red & 10 denotes absolute yellow	Range of Value varied from 0-10, 0 denotes absolute black & 10 denotes absolute white	Range of Chroma varied from 0-8, 0 denotes neutral & 8 denotes brilliant colour



**Work sheet**

**Date:** .....

**Instructor's Signature**

### Exercise No: 05

#### Determination of Bulk density (BD)

Bulk density of soil is expressed as ratio of the mass (weight) of soil to their total volume including pore space between the soil particles. Alternately, it is the weight of per unit volume of dry soil. It is generally expressed as g/cc or Mg/m<sup>3</sup>. In fine textured soil bulk density varies from 1.00 to 1.40 g/cc, in course textured soil from 1.40 to 1.60g/cc, whereas organic soils is low as 0.5 g/cc.

$$\text{Bulk density(g/cc)} = \frac{\text{Weight of soil}}{\text{Volume of soil}}$$

#### **Equipments and materials:**

- Core sampler,
- Knife,
- Hot air oven,
- Balance,
- Aluminium moisture box
- Polythene bag

#### **Procedure:**

1. Drive the core sampler vertically into level ground, deep enough, to fill the sampler can in the sampler.
2. Dig out the sampler using spade or khurpi without disturbing the natural position of soil within the sampler.
3. Trim off the extra soil from both ends of the sample can with a sharp knife.
4. Transfer the total soil from sample to a previously weighed moisture box and weigh it.
5. Dry it in the oven at 105°C until a constant weight is reached.
6. Measure the length and inside diameter of the sample cane.
7. Volume of soil = inside volume of the can =  $\pi r^2 l$



Core sampler

**Calculation:**

Say,

Weight of aluminium box =  $W_1$ g

Weight of aluminium box + field moist soil =  $W_2$ g

Weight of aluminium box + Oven dry soil =  $W_3$ g

Weight of oven dry soil =  $(W_3 - W_1)$ g =  $Y$  g

Weight of water in soil =  $(W_2 - W_3)$ g =  $Z$  g

Thus water content of soil (%) =  $\frac{Z}{Y} \times 100$

Bulk density of soil (g/cc) =  $\frac{Y}{\pi r^2 l}$

Whereas,  $r$  = inner radius of the sampler, in cm

$l$  = height of the sampler, in cm

**Work sheet**

**Date:** .....

**Instructor's Signature**

## Exercise No: 06

### **Estimation of Soil Organic Carbon and Organic matter content in soil**

Soil organic matter is defined as a whole series of products which range from undecayed plant and animal tissues to fairly stable amorphous brown to black material bearing no trace of the anatomical structure from the material it was derived. In addition, soil organic matter also contains products of microbial synthesis. Thus soil organic matter includes: a) fresh plant and animal residues capable of rapid decomposition b) humus which represents the vast bulk of resistant organic matter and c) inert form of elemental C such as charcoal or coal.

#### **Principle**

Soil organic matter is directly correlated to the nitrogen availability to the plant and its determination is often carried out as an index of nitrogen availability as well as soil quality.

There are two methods:

(A) Titration method (Walkley and Black 1934)

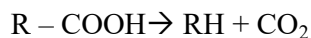
(B) Colorimetric method (Datta *et al* 1962)

In both the method organic matter is oxidized with chromic acid (Potassium dichromate + con. H<sub>2</sub>SO<sub>4</sub>). Known excess of potassium dichromate is added to the soil sample. After the reaction residual dichromate is titrated back with ferrus sulphate or ferrus ammonium sulphate (redox titration). Carbon is not only the element that is oxidized by chromic acid (H<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub>) but

H<sup>+</sup> also reduce. Reactions are as follows:

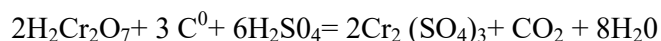
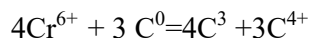


The presence of H<sup>+</sup>, therefore, increases the amount of dichromate required for oxidation. However, the carbon present in the carboxylic group does not require dichromate to get oxidized and thus lowers the amount of dichromate required for oxidation.



It is generally accepted that opposite effects of H and carbon (in carboxylic group) balance each other.

#### **Reactions:**



In the oxidation of organic C the change in valence is from 0 to + 4 (in CO<sub>2</sub>). The equivalent weight of C in this oxidation reaction is 12/4. Thus 1 ml of 1 N K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> will oxidize 3 mg or 0.003 g of C. This explains the factor 0.003, used in calculation.

Colorimetric method the intensity of green colour of chromic acid obtained due to reduction is measured colorimetrically. This intensity is directly proportional to the amount of organic carbon present in the soil.

**a) Walkley and Black method:**

**Apparatus**

1. Conical flask 500 ml (wide mouth)
2. Pipette 1 and 10 ml
3. Safety Pipette 10 ml
4. Automatic burette —50 ml (with 21 container)

**Reagents**

1. Ortho-phosphoric acid 85% or Sodium fluoride (NaF) solution 2%
2. Sulphuric acid 96%
3. Standard 1 N K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub>: Dissolve 49.04 g of analytical grade K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> (dried at 105<sup>0</sup>C) in distilled water and make the volume dilute it to 1 litre.
4. Standard 0.5 N FeSO<sub>4</sub> (NH<sub>4</sub>)<sub>2</sub> SO<sub>4</sub>.6H<sub>2</sub>O solution (Mohr's salt). Dissolve 196.1 g ferrous ammonium sulphate in about 800 ml of distilled water. Add 20 ml concentrated H<sub>2</sub>SO<sub>4</sub> and dilute to 1 litre.
5. Diphenyl amine indicator —Dissolve 0.5 g reagent grade diphenyl amine in 20 ml water and add 100 ml concentrated H<sub>2</sub>SO<sub>4</sub>. Store in an amber colour bottle.

**Procedure**

Measure 1.0 g of the prepared soil sample in 500 ml conical flask. Add 10 ml of 10 N K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> solution and 20 ml of conc. H<sub>2</sub>SO<sub>4</sub>. Mix gently and allow the reaction to complete for 30 minutes. Dilute the reaction mixture with 200 ml water. Add 10 ml H<sub>3</sub>PO<sub>4</sub>, 1.0 ml of sodium fluoride solution and 2 ml of diphenylamine indicator. Titrate the solution with standard FeSO<sub>4</sub> solution to a brilliant green colour. A blank without soil is run simultaneously. Organic carbon in soil is given by the following equation:

$$\text{Organic carbon (\%)} = \frac{(F-T) \times 10}{5 \times \text{Weight of soil}}$$

Since one gram soil is used, this equation simplifies to:

$$\text{Organic carbon (\%)} = \frac{3(F - T)}{F}$$

Where, F = ml FeSO<sub>4</sub> solution required for Blank

T = ml FeSO<sub>4</sub> solution required for soil sample.

### ***b) Colorimetric method***

#### **Apparatus**

Colorimeter or spectrophotometer, conical flask, 100 ml centrifuge, pipette, etc.

#### **Reagents**

- 1N Potassium dichromate : Dissolve 49.04 of K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> in distilled water and make to 1000 mL
- Conc. Sulphuric acid (36 N)
- Anhydrous sucrose (AR grade)

#### **Procedure**

1. Weigh 1 g of 0.2 mm soil sample into a 250 mL conical flask.
2. Add 10 mL of 1N K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> and 20 mL of conc. H<sub>2</sub>SO<sub>4</sub> while swirling the flask slowly.
3. Swirl a little and keep on an asbestos sheet for 30 minutes and let it attain room temperature.
4. Decant about 15 to 20 mL of the supernatant liquid carefully into a centrifuge tube, retaining soil particles in the flask as far as possible.
5. Centrifuge for about 5 minutes to ensure the complete settling of soil particles, if any,
6. Carefully decant the clear liquid into the colorimeter/spectrophotometer tube and read the colour intensity using red filter/660 nm wave length.
7. Simultaneously run a blank without soil and a series of standards as follows:
  - a) Accurately weigh 5, 10, 15, 20 and 25 mg anhydrous sucrose crystals into 100 mL conical flasks.

- b) Proceed as above for oxidation of sucrose and colour intensity measurement.
- c) Plot the colorimeter/spectrophotometer readings against quantity of sucrose or carbon.
- d) Find out a factor to be multiplied by sample reading to get organic carbon content (%) of soil, If the standard curve is prepared accurately and repeatedly, the average value of this factor comes to be 0.0042 with little possible variation.

**Calculation**

**Organic carbon (%) = Calorimeter reading X0.0042.**

**Caution:** The centrifuge may be damaged due to accidental spilling of chromic acid during centrifuging the contents. Keeping overnight is suggested as an alternative. Appearance of chromic acid crystals is sometimes observed even before 30 minutes of keeping for oxidation. Dilution of the contents by adding 10 mL of distilled water after 30 minutes reaction followed by keeping overnight is useful if the soil texture is light. For fine textured soils it is, however, necessary to centrifuge.

**Estimation of Organic matter = 2 x % carbon or %OC x 100 or OC x 1.724**

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**Note:** Formerly a conversion factor of 1.724 was used, but there are indications that a factor 2 is more appropriate.

**Table:** Limits of Soil Organic Carbon and Organic Matter (%) as a measure of available N. (Subba Rao 1995)

Range	%OC	%OM
Low	<0.5	<0.86
Medium	0.5—0.75	0.86-1.29
High	>.75	V >129

**Precautions:**

1. Add K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> very carefully so that it not touch the neck of the flask.
2. Be careful while adding sulphuric acid as it can injure the skin and burn the clothes. The acid should be added through tilt measure only.
3. Read upper meniscus of solution in the burette.



4. If content of the flask turn green with the addition of indicator before titration, repeat the sample with double the volumes of standard potassium dichromate solution and sulphuric acid.
5. Do not place the hot flask on a wet surface as it can break.

**Work sheet**

**Date:** .....

**Instructor's Signature**

### Exercise No: 07

## **Determination of Soil pH**

Soil pH is an important property that indicates whether soil is acidic, neutral or alkaline. The term pH was suggested by S.P.L. Sorenson (1909) which means power of hydrogen. pH defines as negative logarithm of hydrogen ion activity.

Soil pH influences to a great extent the availability of nutrients to crops. It also affects microbial population in soils. Most nutrient elements are available in the pH range of 5.5 to 6.5.

### **Apparatus:**

- pH meter with a range of 0-14 pH
- Pipette/dispenser
- Beaker
- Glass rod

### **Reagent:**

- Buffer solutions of pH 4, 7 and 9.2
- Calcium chloride solution (0.01M): Dissolve 14.7 g  $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$  in 10 litre of water to obtain 0.01M solution.

### **Procedure**

1. Take 20 g air dry soil sample in 50 ml beaker.
2. Add 40 ml distilled water (1:2) in Erlenmeyer flask.
3. Stir the soil water suspension with glass rod for about 30 min.
4. Calibrate the pH meter with at least 2 buffer solution, one should be the buffer solution with neutral pH (7.0) and the other should be chosen based on the range of pH in the soil.
5. Immerse the electrode in soil water suspension.
6. Note down the reading of pH meter

Based on soil pH values, following types of soil reactions are distinguished:

<b>PH Range</b>	<b>Soil Reaction Rating</b>
< 4.6	Extremely acid
4.6 – 5.5	Strongly acid
5.6 – 6.5	Moderately acid
6.6 – 6.9	Slightly acid
7.0	Neutral
7.1– 8.5	Moderately alkaline
8.5	Strongly alkaline

**Work sheet**

**Date:** .....

**Instructor's Signature**

## Exercise No: 08

### **Determination of Electrical Conductivity (EC)**

The electrical conductivity (EC) of a soil is measured the salt concentration of a solution with conductivity meter called 'Solu bridge'. It is based on mainly Ohm's law.

EC mainly depends on the number of ions present in the soil solution, it is important to know the soil/water ratio used. The EC of a soil is measured from saturated soil paste at particular temperature.

#### **Apparatus:**

- EC meter
- Beakers (50 ml)
- pipettes
- Filter paper
- Glass rod

#### **Reagent:**

- 0.01M Potassium chloride solution: Weight 0.7456 g of potassium chloride and dissolve in distilled water and make the volume up to one litre. This solution gives an electrical conductivity of 1.412 dS/m at 25<sup>0</sup>C.

#### **Procedure:**

1. Weigh 20 g of air dry soil sample in 100 ml beaker.
2. Add 50 ml distilled water (1:2.5) in a beaker
3. Stir the solution for 30 min with glass rod and leave it for obtain a clear supernatant solution
4. Rinse and fill the conductivity cell with standard 0.01 m potassium chloride (KCl) solution.
5. Adjust the conductivity meter to read 1.412 dS/m, at 25<sup>0</sup>C for standard conductivity
6. Wash the electrode and dip it in the soil extract
7. Record the reading of electrical conductivity meter that measure the soluble salt content in the soil.

**Work sheet**

**Date:** .....

**Instructor's Signature**

### Exercise No: 09

#### Determination of soil texture by Hydrometer method

##### **Principle:**

Basically, hydrometer method of soil texture analysis is based on Stock's law. A hydrometer is used to determine the density of suspension at any given time. The measured density actually exists at a settling depth or effective depth within the zone of measurement. The hydrometer is based on the fact that the suspension at a given depth decreases as an initially homogenous dispersed suspension settles. The rate of decrease in density, at any given depth, is related to the settling velocities of the particles, which in turn are related to their size. The hydrometer reading indicated, 4 min after sedimentation will be silt+clay particles, while after 2hour will be clay particles in the suspension.

##### **Equipments and materials:**

- Hydrometer,
- Electric stirrer,
- Water bath,
- Beaker(500 ml capacity) with watch glass,
- Thermometer,
- Graduated cylinder (1litre) with rubber stopper

##### **Reagents:**

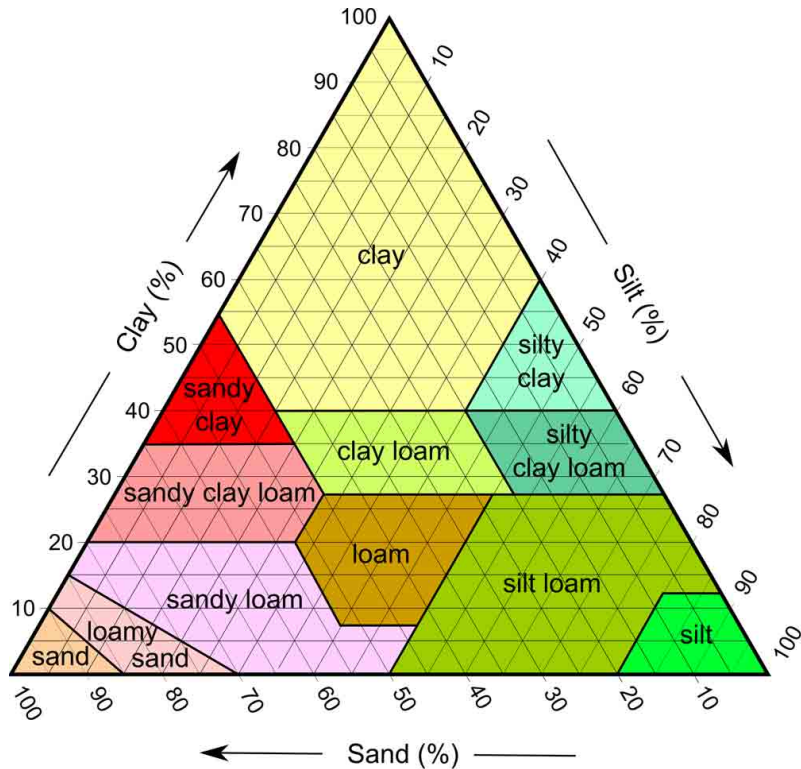
1. 6 % hydrogen peroxide ( $H_2O_2$ )
2. 5 % Calgon solution – Dissolve 50 g of calgon solution (sodium hexametaphosphate: sodium carbonate – 4:1) in water and make the volume upto 1 litre.
3. Amyl alcohol



**Procedure:**

1. Take 50 g air dry soil (passed through 2 mm sieve) in a 500 ml beaker.
2. Moisten the soil with water and add 50 ml of 6 %  $H_2O_2$ , cover with watch glass and leave it for some time.
3. Place it on hot water bath at 65-70°C, stir it occasionally until organic matter is completely oxidised (as indicated by absence of effervescence).
4. Remove the beaker, cool and transfer the content in a dispersing cup.
5. Add 100 ml of 5% calgon and about 400 ml of distilled water.
6. Stir the content for 10 min with the help of an electric stirrer.
7. Transfer the suspension from dispersing cup into the hydrometer cylinder and make up the volume up to 1 litre with distilled water.
8. Place a rubber stopper over the mouth of cylinder, and shake it upside down and back for several times.
9. Place the cylinder on a table and note the time immediately.
10. Record the temperature of the suspension.
11. Put 2 drops of amyl alcohol if the surface of the suspension is frothy.
12. Dip the hydrometer into the suspension 30 seconds before the appropriate time and take reading. For ISSS scheme of classification take reading at 4 min (silt plus clay) and 2 hour (clay).





13. To calibrate the hydrometer follow same steps but without soil and note the reading ( $R_1$ ).

[**Note:** the hydrometer is calibrated at 67°F. If the suspension temperature is above or below 67°F, then for each degree above or below 67°F, the correction will be added or subtracted. The correction is equal to the difference of temperature between suspension and 67°F multiplied by 0.2.]

14. Calculate the sand, silt and clay composition in percent and determine the texture, using the ISSS textural triangle.

**Calculation:**

Hydrometer reading at 4 minutes and 2 hours are  $X_1$  and  $X_2$  respectively. Temperature of the suspension is  $T^\circ\text{F}$ , then-

- I) Corrected hydrometer reading at 4 min =  $(X_1 - R_1) + (T - 67) \times 0.2$
- II) Corrected hydrometer reading at 2 hr =  $(X_2 - R_1) + (T - 67) \times 0.2$

If weight of soil taken =  $W$  g

Percent silt plus clay in the soil =  $[(X_1 - R_1) + (T - 67) \times 0.2] \times 100 / W = A$

Percent clay in the soil =  $[(X_2 - R_1) + (T - 67) \times 0.2] \times 100 / W = B$

So, percent silt in the sample =  $A - B$

Percent sand in the sample =  $100 - A$

**Work sheet**

**Date:** .....

**Instructor's Signature**

**Exercise No: 10**  
**Study of Soil Profile**

A vertical section of soil through all its horizons and extending in to the parent material. A vertical exposure of the horizon sequence is termed as “soil profile”.

A soil horizon is a layer of soil, approximately parallel to the soil surface, differing in properties and characteristics from adjacent layers below or above it. Soil profile shows past and present condition of soil.

Five master horizons are recognized in soil profile and are designated using capital letters O, A, E, B and C. These horizons are formed mainly due to through percolation and infiltration.

**A) O Horizons:**(Organic) it comprises of organic horizons that form above the mineral soil. They result from litter derived from dead plants and animals. ‘O’ horizons usually occur in forested areas and are generally absent in grassland regions.

- This horizon contains more than 30% organic matter if mineral fraction has more than 50 % clay (or) more than 20 % organic matter if mineral fraction has less clay.
- **Oi-** Organic horizon in which the original forms of the plant and animal residues can be recognized through naked eye.
- **Oe-** Organic horizon in which the original plant or animal matter can not be recognized through naked eye.
- **Oa** – Organic matter completely change to dark black colour material is called Humus.

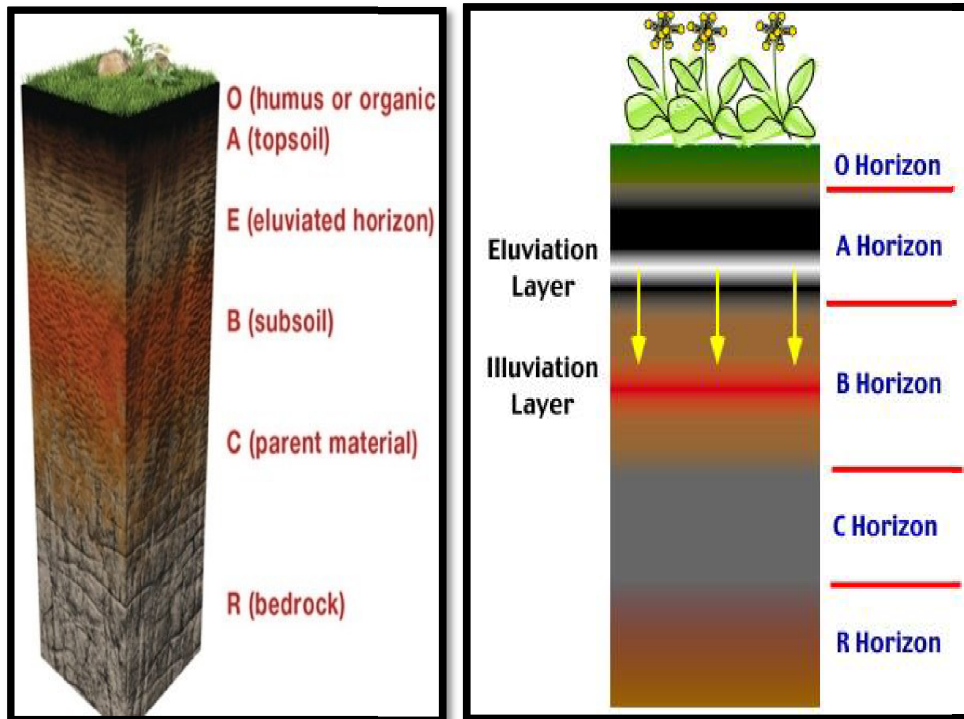
**B) A - Horizon:** It is the top most mineral horizon. It contains a strong mixture of decomposed (humified) organic matter, which tends to impart a darker colour than that of the lower horizons.

**C) E - Horizon:** It is an eluviated horizon. Clay and sesquioxides are invariably leached out, leaving a concentration of resistant minerals such as quartz. An ‘E’ horizon is generally lighter in colour than the ‘A’ horizon and is found under ‘A’ horizon.

**D) B – Horizon:** (Illuvial) these horizons are formed below an A, E or O horizons. The sub - surface ‘B’ horizons include layers in which illuviation of materials has taken place from above and even from below. In humid regions, the B horizons are the layers of maximum accumulation of materials such as sesquioxides and silicate clays. In arid and semi-arid regions Ca CO<sub>3</sub>, Ca SO<sub>4</sub> and other salts may accumulate in the B horizon. This horizon is also known as store house of nutrients.

**E) C – Horizon:** It is the unconsolidated material overlying the bed rock. It may or may not be the same as the parent material from which the solum formed. The ‘C’ horizon is outside the zones of major biological activities and is generally little affected by the processes that formed the horizons above it.

**‘R’- Layer:** Underlying consolidated rock, with little evidence of weathering.



**Transitional or combinational horizons:**

The horizons or layer between two master horizons is known as transitional horizons. These are dominated by properties of one master horizon but possess subordinate properties of another horizon also. Two capital letter symbols like AB, BA, EB, BE, BC or CB are used to present these horizons. The master horizons symbols which is given first, designates the kind of horizon whose properties dominate the transitional horizon i.e.

- AB- Transition to B, more like A than B
- BA- Transition to A, more like B than A
- BE- Transition to E, more like B than E
- BC- Transition to C, more like B than C
- CB- Transition to B, more like C than B

Horizons in which distinct parts have recognizable properties of the two kinds of master horizons are indicated by the capital letters. The two capital letters are separated by a virgule (/), such as E/B, B/E or B/C.

**Subordinate Distinctions within Master Horizons and Layers:**

Lower case letters used as suffixes to designate the specific kind of master horizons and layers are given in Table-

<b>S.N.</b>	<b>Suffix</b>	<b>Description</b>
1	i	Slightly decomposed organic matter
2	e	Partially decomposed organic matter
3	a	Fully decomposed organic matter
4	b	Burried genetic soil horizon
5	f	Frozen soil
6	p	Ploughed soil or cultivated land
7	c	Accumulation of concretion
8	h	Illuvial humus
9	k	Accumulation of carbonates
10	n	Accumulation of Na Salts
11	o	Residual accumulation of sesquioxides
12	q	Accumulation of quartz
13	s	Accumulation of sesquioxides
14	t	Accumulation of silicate clay
15	v	Accumulation of Plinthite
16	j	Accumulation of Jarosite
17	y	Accumulation of gypsum

**Work sheet**

**Date:** .....

**Instructor's Signature**

## Exercise No: 11

### **Determination of soil moisture by Tensiometer**

Tensiometers measure the matric potential of the soil moisture. The tensiometer consists of a porous cup made of ceramic material and a mercury manometer attached to the water filled cup through a water reservoir tube. When the porous cup is placed in soil and equilibrated, water tends to move out of the cup under the suction exerted by soil.

These suction readings are thus calibrated on the gauge to a specific soil to interpret the percent of moisture.

The use of tensiometer is confined up to the minimum matric potential of -0.8 bars, but much of the available water is retained by soil between -0.8 bars and -15 bars, particularly in fine textured soils. Beyond the tensiometric range, the matric potential is usually interpolated from the water retention characteristics curve using the measured soil moisture content.



**Work sheet**

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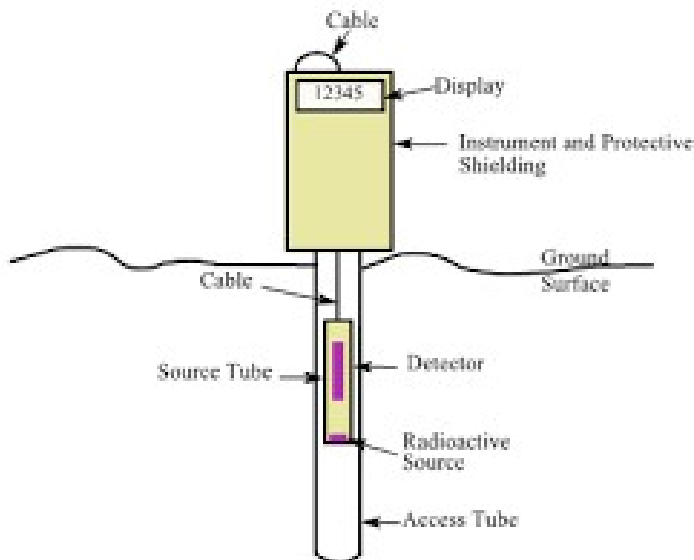
## Exercise No: 12

### **Determination of soil moisture by Neutron Probe method**

The neutron moisture meter consists of americium and beryllium or radium and beryllium as the neutron source and boron tri fluoride (BF<sub>3</sub>) gas as a detector.

The instrument works on the principle that when fast moving neutrons are emitted from the source into the soil, they undergo elastic collisions with hydrogen nuclei. The hydrogen nucleus contains a proton having mass equal to that of neutron causing an elastic collision in which neutron loses energy and gets scattered. Thus, its energy is reduced and speed is slow down. The process is called 'thermalization' and the slow neutron is called 'thermal neutrons'. The density cloud of thermal neutron so formed around the source (probe) is proportional to the concentration of hydrogen nuclei in the soil. Since water is the main source of hydrogen in soil, the density of slowed neutron is proportional to the volume fraction of water present in the soil. The thermalized neutrons are captured by detector (BF<sub>3</sub>) which is placed just behind the source.

This instrument has to be calibrated for each soil. This method is rapid, less laborious, non-destructive and repeated measurements can be made at the same depth. However, this method is not suitable for moisture determination of surface soil.



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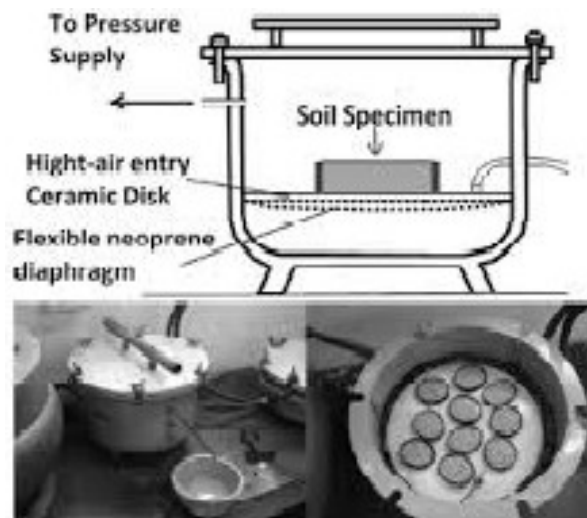
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### Exercise No: 13

#### Determination of soil moisture by Pressure Plate method

Laboratory measurement of soil water potential are usually made with pressure membrane and pressure plate apparatus. It consists of ceramic pressure plates of high air entry values contained in airtight metallic chamber strong enough to withstand high pressure of 15 bars or more. The apparatus enables development of soil moisture characteristics curves over a wide range of matric potential.

The porous plates are first saturated and then soil samples are placed on these plates. Soil samples are saturated with water and transferred to the metallic chamber. The chamber is closed with special wrenches to tighten the nuts and bolts with required torque for sealing it. Pressure is applied from a compressor and maintained at a desired level. It should be ensuring that there is no leakage from the chamber. Water start to flow out from saturated soil samples through outlet and continues to trickle till equilibrium against the applied pressure is achieved soil samples are taken out and oven dried to constant weight for determining moisture content on weight basis. Moisture content is determined against pressure value varying from -0.1 to – 15 bars. The value of moisture content so obtained at a given applied pressure are used to construct soil moisture characteristics curves.



**Work sheet**

**Date:** .....

**Instructor's Signature**