EXERCISE NO.1
Study of soil forming minerals

Definition of Mineral :

      A mineral is a naturally occurring inorganic substance having a definite chemical composition and distinct physical properties. It usually consists of two or more elements in chemical combination in certain definite proportion e.g.

Calcite	$CaCO_3$	Magnetite	Fe_3O_4	Gypsum	$CaSO_4 .2H_2O$
Hematite	Fe_2O_3	Rock Crystal	SiO_2		

Minerals have certain definite physical properties by which they are identified.

Salient characteristic, properties of Minerals used for identification:

    1) Colour   2) Luster   3) Light Transmission   4) Hardness
    5) Streak   6) Specific gravity   7) Form and structure   8) Cleavage
    9) Fracture   10) Tenacity   11) Chemical nature.

1) Colour : The colour of mineral depends on reflection of certain colour vibrations, which are exhibited by ordinary light. Ordinary light contains number of colour vibrations like Red, Pink, Yellow, Green, White and Purple and these colours are absorbed by minerals, reflecting one of them which give colour to the minerals. Mineral may be colourless, white, yellow, pink, purple, green etc. e.g.

1) Calcite – White   2) Magnetite – Black   7) Quartz – Colorless
3) Orthoclase – Pink   4) Iron pyrite – Yellow
5) Apophylite – green   6) Amethyst – purple.

2) Luster : It is the appearance shown by each mineral e.g. shining of the mineral or the manner in which a substance reflects light. There are two types of lusters:

- Metallic luster: It is the luster resembling luster of metal e.g. Iron Pyrite.
- Non Metallic Luster:

    1. Adamantine luster : It is the luster resembling of diamond e.g. Diamond.
    2. Vitreous luster : Luster like ordinary glass e.g. Rock crystal.
    3. Sub-Vitreous luster : Luster like milky glass e.g. Milk quartz.
    4. Resinous luster : Luster like resin e.g. Talc.
    5. Pearly luster : Luster like pearl e.g. Zeolite.
    6. Earthy luster : Luster like earth e.g. Gypsum.
    7. Waxy luster : Luster like wax e.g. Apatite.
    8. Silky luster : Luster like silk e.g. Asbestos.

3) Light transmission : It is the property of mineral to judge whether a mineral is transparent, translucent or opaque.

    1. Transparent: The out line of the object appears distinct and clear through a mineral, it is called transparent e.g. Rock crystal, Muscovite Mica, calcite and biotite.

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2. Translucent: The outline of the object does not appear clear and distinct but it is indistinct then it is called translucent e.g. Milk quartz, Flint.
3. Opaque: When no light passes through a mineral, it is called opaque e.g. Magnetite, Iron pyrite, copper pyrite.

4. Hardness :   It is the resistance offered by a mineral to a scratching. Mohr has found a scale of hardness to determine the hardness of different minerals. This scale is called as Mohr's scale of hardness.

Relative hardness of some minerals in increasing order of hardness is given below.

1) Talc (Softest) 2) Gypsum 3) Calcite 4) Fluorite (Fluorspar) 5) Appetite 6) Feldspar 7) Quartz 8) Topaz 9) Corundum 10) Diamond (hardest)

Roughly the hardness of finger nail is = 2
Copper wire = 2
Glass place = 5.5 and
Sharp steel = 6.5

5) Streak : It is the colour of the powder of a mineral. It may be different from the colour of mineral. Generally white minerals have got white streak e.g.

Sr.No.	Name of Mineral	Colour of Mineral	Streak
1.	Rock Crystal	White	White
2.	Orthoclase	Pink	White
3.	Iron Pyrite	Yellow	Green
4.	Magnetite	Black	Black
5.	Hematite	Black	Cherry Red.

6) Specific gravity :
It is the ratio of weight of mineral to the weight of equal volume of water.

$$\text{Sp. gravity of mineral} = \frac{W_1}{W_1 - W_2}$$

Where W_1 = Wt. of mineral in air
W_2 = Wt. of mineral in water
$W_1 - W_2$ = Wt. of equal volume of water displaced.

7) Form and structure:
A] **Forms**: Minerals have got various forms. When a definite from is developed, it is called crystalline from and when no forms is developed, it is called massive or amorphous form.
The Forms are: 1) Massive or amorphous
2) Crystalline.

There are six basic systems of crystalline form:

i)   Monometric (Isometric, Cubic, Regular) ii)   Dimetric (Tetragonal, Octahedron)
iii) Tritmetric (Orthorhombic)   iv) Monoclinic
v) Triclinic   vi) Hexagonal.

1. <u>Monometric :</u>   The tree axis are of equal length and at right angle to one another, as in cube, e.g. Halite and Garnet.
2. <u>Diametric :</u>   Two axis are equal and one unequal. All three axis are right angle to one   another e.g. Zircon.
3. <u>Trimetric:</u>   All three axes are unequal but they are right angle to one another e.g. sulphur, olivine.
4. <u>Monoclinic:</u>   All three axis are unequal, two of which not right angle to one another, while third makes right angle with the plane of the other two. E.g. Orthoclase, Gypsum, Mica, Hornblende.
5. <u>Triclinic:</u>   All three axis are unequal and none of them forms a right angle with one other e.g. Plagioclase.
6. <u>Hexagonal:</u> There are three equal axis at 120^0 and one more fourth axis of a different length at right angle to the other three e.g. quartz, Calcite, Cinnabar.

B] Structure: The arrangement of crystals – give rise to several kinds of structures.

1] Granular: When in fine check grains.
2] Lamellar: Like plates or leaves.
3] Columnar or Fibrous: Needle like.
4] Reticulated or net like.
5] Stellated when radiating like a star.
6] Drusy when minute crystals implanted.

8) Cleavage: It is the tendency of some minerals to split along planes related to their molecular structure, sometimes parallel to crystal faces and yielding more or less smooth surfaces cleavage may be perfect or imperfect. Perfect e.g. Diamond.

<u>**9) Fracture:**</u> Not all minerals show good cleavage. Most show fracture or breakages in directions other than cleavage planes. The fracture may be even, uneven, earthy, (as in clay) and conchoidal.

<u>**10) Tenacity:**</u> Mineral may be :

i) Brittle when it falls to powder at the time of cuttings.
ii) Flexible when it can be easily bent .
iii) Malleable if its places flatten under a hammer.

<u>**11) Chemical nature:**</u> It refers to the chemical nature of the minerals like oxides, carbonates silicates etc. Identify important soil forming minerals in field stating their dominant properties. (Annexure 1)

Questions:

1) Define mineral, primary, secondary, essential and accessory minerals.
2) List out important minerals found in different soils of Maharashtra State with their chemical composition.
3) List out predominant minerals present in igneous, sedimentary and metamorphic rocks.
4) Select out the primary, secondary and accessory, minerals from the following. Montmorilonite , calacite, Zeolite, gypsum, talc, feldspars, tourmaline, Hornblendes, dolomite, apatite, kaolinite, magnetite and limonite's.
5) Give two examples from each category of the minerals given below : Phosphates, Oxides of silica, sulphates, carbonates, sulphides, oxides of iron, Aluminosilicates.
6) Mention two mineral containing the following nutrient elements. Zn, Cu, Mn, Fe, B, P, S, CI, K, Ca, Mg. and Mo.

References:

1) A Textbook of Geogby V.D. Muthayya, 4th Edn. Oxford and IBM publishing Co, New Delhi.
2) Minerals and rocks in colour (1976) by J.F. Kirkaldry Blandford press, Dhorset U.K.
3) Practical manual for introductory courses in Soils (1979) by S.S. Khanna and D.V. Yadav, HAU Hissar : 17-26
4) Physical properties of soils by C.C. Shah and N.Narayana (1966) Mankatalla Publishers, Bombay.
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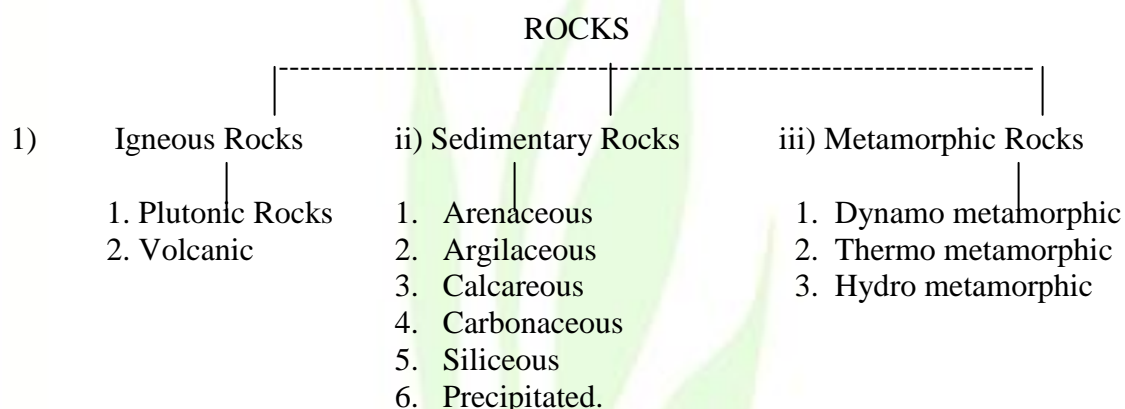.......................

Department of SSAC

EXERCISE NO.2
Study of soil forming rocks

Definition of Rock: A rock may be defined as an aggregate of one or more minerals called as rocks, for example an aggregate of the single mineral calcite is the limestone, while the granite rock is composed of several minerals, like orthoclase, mica, quartz with or without hornblende.

Rocks have no definite chemical composition or mineralogical composition nor do they possess any definite symmetrical form e.g. sand, marble, coal and building stone are all called rocks although they are so much unlike.

Classification of Rocks: - Rocks are classified into three main groups according to their origin.

ROCKS

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--------------------------------------------------------------------
       |                           |                              |
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1)   Igneous Rocks   ii) Sedimentary Rocks   iii) Metamorphic Rocks

1. Plutonic Rocks   1. Arenaceous   1. Dynamo metamorphic
2. Volcanic   2. Argilaceous   2. Thermo metamorphic
                      3. Calcareous   3. Hydro metamorphic
                      4. Carbonaceous
                      5. Siliceous
                      6. Precipitated.

I) Igneous Rock: (Fire rocks):

Igneous rocks are those rocks, which have been formed by the action of heat. These rocks were the first to be formed when the molten mass cooled and consolidated into solid rock. These rocks are massive and crystalline. They constitute nearly 95% of the earth's crust and about 16 km thick. Shale's account for about 4% Limestone 0.2% sandstone 0.7% and all the rest 0.1% they mostly consist of primary minerals like quartz, micas, feldspar, pyroxenes etc.

Igneous rocks are grouped into two groups.
1)   Intrusive or plutonic rocks   2) Extrusive or volcanic rocks.

1) Intrusive or Plutonic rocks: The Igneous rocks, which are formed by the cooling of the original magma beneath the surface, are called intrusive rock e.g. granite. They occur at greater depth in the earths crust. They are very compact.
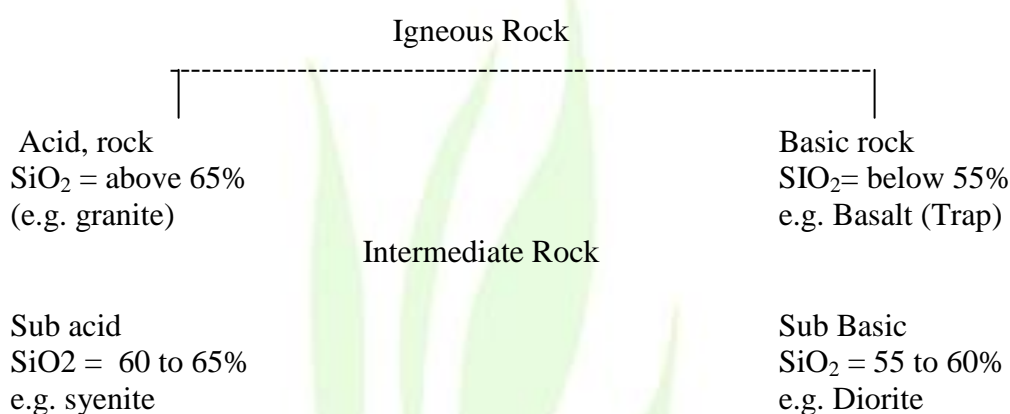
Intrusive rocks were formed as a result of the molten mass having been formed among the pre-existing solid rocks through the cracks and other planes of weakness. Some of these rocks consolidated in vertical cracks and formed wall like masses, called dykes. Other that consolidated in horizontal cracks or planes are known as sills.

2] Extrusive or volcanic rocks:

       Extrusive rocks are those that were formed when the molten mass was poured out on the surface of the earth where it is consolidated on cooling. They contain many gas cavities. The rocks, which contain gas cavities or vesicles are known as vesicular rocks.

       These cavities may be embedded by some minerals. Hence, such rocks are known as amygdaloidal rocks. The minerals so embedded are quartz, calcite, zeolite, glauconite.

       The igneous rocks are also classified into four groups according to their chemical composition (i.e. Silica content)

Igneous Rock

Acid, rock
SiO_2 = above 65%
(e.g. granite)

Basic rock
SiO_2 = below 55%
e.g. Basalt (Trap)

Intermediate Rock

Sub acid
$SiO2$ = 60 to 65%
e.g. syenite

Sub Basic
SiO_2 = 55 to 60%
e.g. Diorite

II)   **Sedimentary rock : (Aqueous, clastic, stratified rocks) :**

       Igneous rocks when exposed to the action of atmosphere break up into loose masses of crushed, crumbled and mellowed material. These are carried away by flowing water, into lakes and seas where they are deposited as sediments. The dissolved material from the rocks is also deposited when the water evaporates. These deposits remain as loose material or cemented consolidated into sedimentary rocks. The cementing material used for compacting the loose material are silica or lime or oxides or iron. Sedimentary rocks are also called classic rocks (Clastos broked.) They are also called aqueous rocks as water is the chief agency in their information and stratified rocks as the sediments are usually deposited in layers.

Sedimentary rocks are classified as:

1) **Arenaceous or sandy rocks:** These rocks mainly consists of course particles usually known as quartz and feldspar e.g. sandstone, grit, conglomerate and breccias.
2) **Argillaceous rocks:** Consists of small size particles usually known as clay e.g. clay mudstone shale and fullers earth.
3) **Calcareous rocks:** Usually consists of calcium carbonate and magnesium carbonate e.g. limestone, chalk, dolomite, etc.
4) **Carbonaceous rocks:** Formed from decomposing vegetation under anaerobic conditions, mainly consists of carbon e.g. coal, peat, lignite.

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5) **Siliceous rocks:** They are of organic origin having been formed from parts of minute plants and animals and deposited either from salts or fresh water. Mainly consist of SiO_2 e.g. diatomaceous earth.

6) **Precipitated rocks**: They are mainly deposits formed as rock masses either by cooling, evaporation or by direct chemical precipitation e.g. gypsum, rock salts.

Metamorphic rocks:

Igneous and sedimentary rocks undergo a change. When the change is considerable the rock is said to have undergone metamorphosis and the new rock is known as a metamorphic rock. The metamorphosis is brought about by the action of water heat or pressure.

1) Dynamo metamorphic rocks: Dynamo metamorphism is due to pressure brought about by the folding of rocks due to crust movement of the earth. As a result of this pressure, the crystals in rocks are flatted and they are called as folio e.g. thick in the middle and thin at edges. Such rocks is called foliated rock. When the foliation is sight and the folio are not separate, the rock is called the gneiss. If the crystals are very much flattered and the folio are easily separated, then the rock is called an schist e.g. Gneisses-Granite gneiss, Diorite gneiss.
Schist: Mica, Schist, Quartz, schist, Chlorite, schist, Talc schist.

2) **Thermo metamorphic rock:** Thermo –metamorphism may be caused by volcanic lava and the4 heat can fuse or melt the original rocks e.g. Sandstone is converted into quartzite and limestone is converted into marble.

2) **Hydro metamorphic rocks :** Water in combination with heat and pressure can bring about chemical changes as well. Hot water or stream converts feldspar into mica and potassium silicate e.g. Basalt and granite converted into literate.

Questions :
1) Define rock and classify the rocks according to their origin.
2) Differentiate between volcanic and plutonic rock.
3) What are acid and basic rocks
4) Explain in detail sedimentary rock
5) Classify the following rocks on the basis of their origin.
   List imp. Soil forming rocks in M.S.
   a) Trap b) Basalt c) Sand stone d) Literate e) Shale f) Limestone g) Marble h) Slate I) Quartzite ii) Schist k) Syenite. (Annexure-2)

Reference:
1) A Text book of Geology by. V.D. Muthayya 4 th Edn. Oxford I B.H. Pushing Co. New Delhi.
2) Minerals and rocks in colour (1976) by J.F. Kirkaldy Blandford press, Dorset.
3) Practical manual of introductory courses in soils (1976) by .S.S Khanna and D.V. Yadav, HAU, Hissar : 11 –17
4) Physical properties of soil by .C.C. Shah and N.Narayana (1966) Klarnaklala publishers, Bombay

EXERCISE NO.3

Study of soil sampling tools, collection of representative soil sample, its processing and storage

Soil sampling tools:

Soil Sampling Tools: Core Sampler, Posthole Auger, Tube Auger, Screw Auger, spade pickaxe, khurpi, bucket, cloth bag, scale.

AUGERS:

Auger is an instrument used for taking soil sample in the field. Whenever soil samples are to be collected by easy and quick method the augers are used. Select the crops from where the samples are to be collected and them work with auger.

In general when the soil is completely dry, it is difficult to work with auger, but if the soil is moist sampling is easy. There are various types of augers used, depending upon the type of the soil depth of sampling and such other conditions.

1) Screw auger :

It works like a screw in the field. The soil adheres in the grooves. Soil at any depth can be taken up by making mark on the stem and working the auger upto the mark. It is taken up straight way and the soil is collected from the grooves. This auger is useful even if there is a crop in the field.

This auger consists of three parts.
1) Handle   : It is a wooden portion.
2) Stem   : It is of iron-length 35 cm. or desired length.
3) Grooves   : It is of iron-distance between two grooves is 2.5 cm.

2. Dr.Leathers Auger :

It consists of a strong hallow steel cylinder with a sharp cutting edge. It is useful for taking surface sample only. Twenty-five cm. Column of soil is collected in the cylinder.

This auger : consists of three parts :
1. Handle   : It is a wooden portion.
2. Stem   : It is of iron
3. Cylinder   : It is of Iron.

3. American Soil Sampler :

The flank pointed out cuts the soil at the desired depth upto 20 cm. Then by turning the handle the soil enters into the cavity and accumulates there. Then by turning it in a reverse way, slit is closed and the auger is taken out. The soil collected in the cavity is not allowed to fall down. This auger is useful in sandy soil. It works better in rice field and in water logged field.

This auger consists of three parts :
1) Handle   : It is of Iron.
2) Stem   : It is of iron
3) Cylinder   : It is of Iron.
Cylinder consists of three parts :
1. Sliding covers   2. Flank,   3. Slit.

4. Lyalpur Auger :
      The point of the auger enters into the soil. The soil is collected in the cylinder. It can work upto the desired depth. The cutter piece at the end cuts the soil which is collected in the cylinder. Then the soil is removed from the cylinder. It is useful for taking the soil samples in irrigated conditions.
This auger consists of three parts :
1. Handle   : It is of Iron
2. Stem   : It is Iron
3. Cylinder   : It is of iron, length 13" (30 cm) dist.
      In the cylinder, there is a slit of cavity of length 6" (15cm) and breadth ½" (1.5 cm.)

5. **Post hole auger:**
      A chisel shaped point enters in the soil and the soil enters in the cylinder. While taking it out the tongue does not allow the soil to fall down. The auger works at any desired depth. It gives samples of surface, soil up to 25 cm. In case if the soil is sufficiently deep, the deeper layers sample a may also be collected.

      This auger consists of three parts :
      1) Handle   : It is of wooden portion.
      2) Stem   : It is of iron.
      3) Cylinder   : It is of iron consisting of side plates and tongue. The distance between two side plates is 6 cm.

The different soil sampling tools are used for soil sampling
1. Soil tube auger
2. Screw auger
3. Post hole auger
4. Spade
5. Khurpi/dager
6. Bucket/ghamela
   - For sampling of soft and moist soil tube auger, spade or khurpi can be used satisfactory .
   - A screw type of auger may prove more convenient on hard/dry soil
   - Post hole auger useful for sampling of wet area like rice field

- Tools for collecting the samples should be free from or any foreign materials which may contaminant the samples.
- Bucket or Ghamela are used for collecting and mixing the soil sample

Collection of soil samples :

Purpose of collection of soil sample: Soil samples are collected from the filed to study physical, chemical and biological properties of the soil.

Procedure: -

1) First divide the field according to the slope, colour of soil, depth, texture, management and cropping pattern, after demarcation of field into uniform portions each of which must be sampled separately.
2) Then divide each portion into two parts, draw the Zigzag line having about 8 to 10 corners on both the sides of middle line so that it will cover the whole area.
3) Where the crops have been planted, collect the soil samples between the lines.
4) Do not sample unusual area. Avoid area recently fertilized, old bunds, marshy spots, near trees, compost heaps or other than non-representative locations.
5) Use proper sampling tools like auger soils, tube, phawda (spade) or Khurpi (Trowel) crop sampler.
6) Before taking the sample scrap away surface litter or any stone etc. Collect the soil samples from 10 to 20 spots in the field depending upon the area. At each corner of the zigzag line take the samples by auger at the depth of 20-30 cm or with the help of trowel and spade by digging the "V" shaped pit up to plough depth. Then cut out uniform thick 2 cm. Slice of soil from top to bottom (0-30 cm) of the exposed soil surface of "V" shaped pit. Collect the sample on the blade or in your hand and place it in clean bucket. Collect all the samples from the uniform area into the same bucket
7) Pour the soil from the bucket on the piece of clean paper or cloth and mix thoroughly.   Discard by quartering, excess soil and collect approximately one kg. of soil. To quarter the sample, mix well, divide into four equal parts and reject opposite quarters.   Mix the remaining two potions and repeat the procedure as many times as necessary to arrive at the desired size of sample. If the sample is wet or moist, dry it in the shade before putting into a plastic bag. Fill the sample into a plastic bag and put the plastic bag into a cloth bag.
8) Fill out the information sheet completely and may be place inside the sample bag and put one outside the bag and send the sample to laboratory immediately for analysis.

Sample Information Sheet
1. Sample No.
2. Date of collection of sample
3. Name of the cultivator
4. Address: Village
5. Type of soil
6. Survey No.

7. Proposed crop / crops & Variety
8. History of the field for the last 3 years crop, kind of fertilizer and quantity applied.
9. Depth of sampling
10. Field condition: Dry / Wet.
11. Extent of sampled area in ha.
12. Number of samples taken to make a composite sample.

Preparation of Soil Sample :

1) When air dry, break the lumps with a wooden pestle in a wooden mortar so that the aggregate particles are crushed but no actual grinding takes place.
2) Shift the soil through a sieve with round holes of 2mm (10 meshes) diameter sieve. Use wooden pestle and mortar for further crushing. Repeat the screening till the aggregate particles are fine enough to pass through the sieve and only stones and gravels remain. Before discarding this residue, weigh it and report as gravel and stones (detritus)
3) For special determination, it is necessary to weigh out small amount of soil i.e. organic matter, $CaCO_3$ and chemical analysis, it is desirable to grind a representative sub sample and sieve it through 0.5 mm. Sieve (32 mesh)
4) For micronutrients like copper, iron, manganese and zinc, a brass sieve should be avoided and aluminum or plastic sieve with nylon netting should be used.
5) Nitrate, ammonia, bacterial count and moisture determination must be carried out on soils obtained straight from the field. Air-drying of these samples is not permissible and not desired.
6) The processed samples are analyzed for texture, carbonate content, pH, EC and available nutrients.

Storage of soil samples:
Collected soil sample should be store in well labeled cloth bag size 13cm X 25 cm or plastic bottle (1Kg)

Questions :
1) Explain the procedure of collection of representative soil samples.
2) State the importance of soil sampling.
3) What is auger? Give the name various types of augers.
4) What are the precautions to be followed during soil sampling?
5) Why do you dry the soil sample in shade?
6) Is it desirable to sample the field in each season?
7) What is the relation between mesh and pre size in mm in sieve ?

References :
1) Perur, N.G. Subramanian, C.K, Muhr, G.R. and Ray H.E. (1973): Soil fertility evaluation to serve Indian farmers.
2) Jackson, M.L. Soil chemical analysis (1973) prentice hall of India, Pvt. Ltd. New Delhi.
3) Gupta P.K. (2007) Soil Plant Water and Fertilizer analysis , Agrobios (India) Jodhpour

EXERCISE NO. 4
Determination of moisture content in soil by gravimetric method

Water plays a very significant role in soil-plant growth relationship. In fact, the soil water is a regulator of physical, chemical and biological activities in the soil.

Water in a soil may be measured in a number of ways, viz.

1. Gravimetric method (The standard method)
1. Neutron scattering
2. Gamma ray alternation,
3. Soil moisture tension, and
4. Electrical conductivity (Gypsum block).

Gravimetric Method

Principle : Weighed soil sample is placed in an oven at 105^0C and it is died to constant weight. The weight difference is considered to be water present in soil sample.

Apparatus :
Sampling auger
Moisture cans / Aluminium box
Oven
Balance
Desiccators

Procedure :
1. Weight the empty moisture boxes.
2. Used the sampling to take a soil sample of 40-50 g. from the required depth. Put the soil immediately in the moisture box and close it to prevent loss of moisture by evaporation.
3. Bring the boxes containing the moist soil to the laboratory and weight them immediately. Remove the lids and place the moisture boxes in oven at 105^0 C for 24 hours.
4. Allow the sample to cool for sometime in oven. Then close the boxes and put them in the desiccators for further cooling. After the completion of this step, weight the closed boxes with the oven dry soil.

Observations :
1. Weight of empty box   - A
2. Weight of box + moist soil   - B
3. Weight of box + oven dry soil   - C
4. Moisture content in soil   - B-C
5. Weight of oven dry soil   - C-A
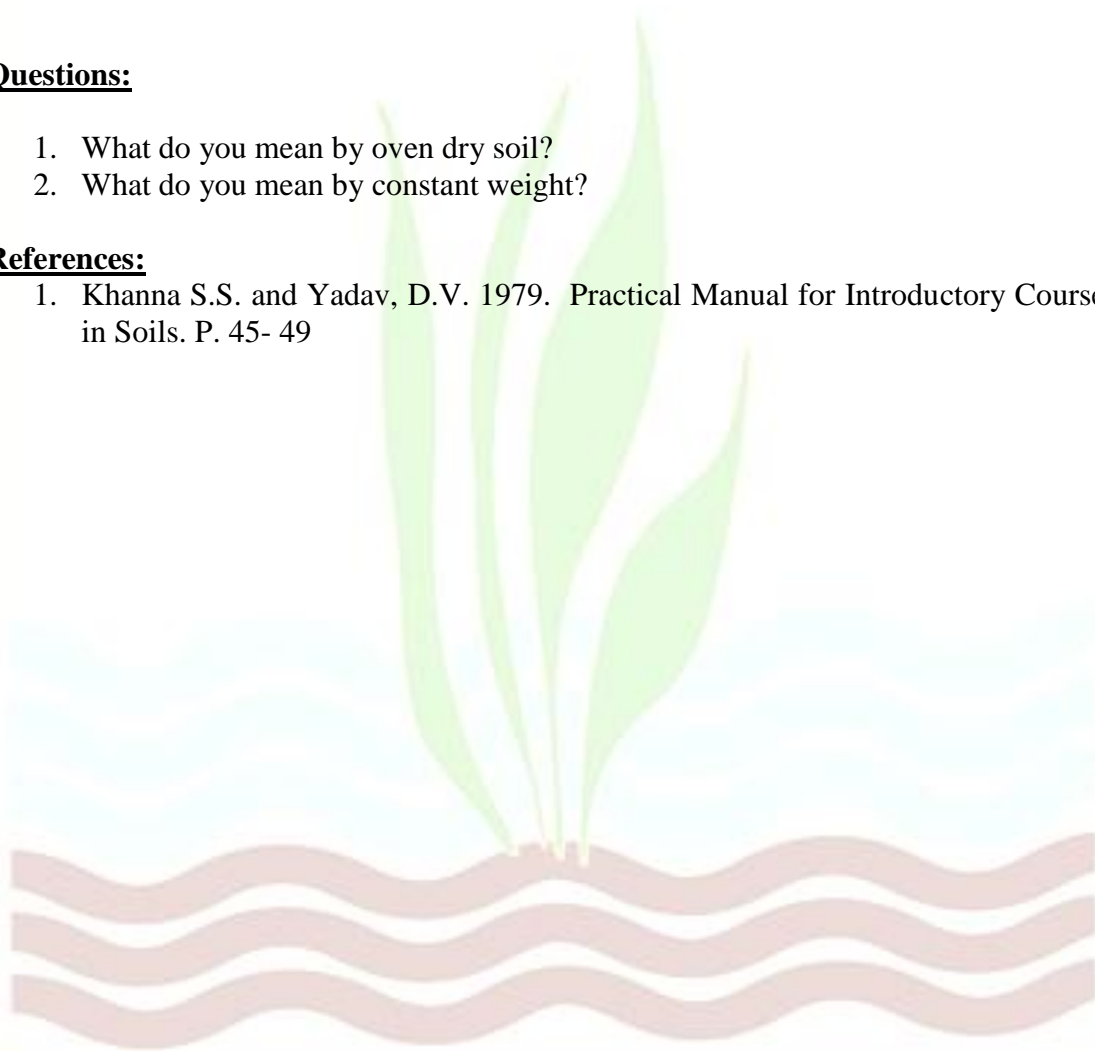
Calculations :

$$\text{Per cent moisture in soil} = \frac{(B-C)}{(C-A)} \times 100 \quad \text{i.e.} \quad \frac{\text{Loss in wt.}}{\text{Oven dry wt. of soil}} \times 100$$

Questions:

1. What do you mean by oven dry soil?
2. What do you mean by constant weight?

References:
1. Khanna S.S. and Yadav, D.V. 1979. Practical Manual for Introductory Courses in Soils. P. 45- 49

EXERCISE NO. 5

Dertermination of soil colour by Munsell soil colour chart in field

The soil colour depends on the kind of light (Wave length 380 to 750 um) that is reflected by soil to the eye. The soil colour of most conveniently determined by comparison with standard colour chips systematically arranged according to their Muncell notation. The three basic factors, which are the components of colour: Hue, Value and Chroma are used for the construction of the Muncell colour charts.

Hue :It refers to the dominant spectral colour or quality which distinguishes red from yellow etc.

Value : It expresses apparent lightness as compared to absolute white.

Chroma : It indicates the gradation of purity of colour

MUNSELL SOIL COLOUR CHART

The soil colour chart generally used with soil is a modified version of the collection appearing in the pocket edition of the Muncell book of colour and includes only that portion needed for soils about one-fifth of the entire range found in the complete edition of the book of colour. The seven charts in the soil collection display 196 different standard colour chips systematically arranged according to their Muncell notations, on cards carried in a loose-leaf notebook. The arrangement is by the three simple variables that combine to describe all colours and is known as the Munsell system as Hue, value and Chroma.

Colour display on individual colour chart is of constant Hue. Designated by a symbol in the as upper right hand corner of the card vertically. Colour become successfully lighter from the bottom of the card to the top of the visually equal steps, their value increases. Horizontally they increase in the chrome to the right and grayish to left. The value notation of the each clip is indicated by the vertical scale in the far left coloum of the chart. The horizontal scale indicates the chroma notation across the bottom of the chart

In writing the Munsell notation, the order is Hue, Value and Chroma with a space between the Hue letter and the sccceeding value number and a virgule between the two number for value and chroma. If expression beyond the whole number is desired, decimals are always used, never the fraction. Thus, the notation for a colour of hue 5YR, value 5, chroma 6 is 5YR 5/6 a yellowish red.

Procedure:

Select the appropriate hue card and place the soil sample directly behind the aperture separating the closest matching colour chips and determine soil colours. Record the Munsell colour notation as well as the name of the colours.

Rarely will be colour of the sample be perfectly match by any colour in the chart. The probably of the perfect matching of the sample colour is less than one in one hundred. It should be evident, however, which colour the sample lies between and which is closest match. The principal difficulties encounter in using the soil colour chart while deterring colour that are intermediate between the hues in the chart and in the distinguish between value and chroma are strong in addition the chart does not include some extreme dark colours which chroma colours occasionally encountered in the most soil.

Assignment:

Collect different soil and measure the soil colour

Question:

1) State the factors, which effect the colour of the soil.
2) Define hue, value and chroma.
3) How colour component are arranged in Munsell colour chart book?

Reference :

1) Munsell colour chart book 1954, Published by Munsell colour Co. Inc. USA
2) Soil Survey Manual 1951 USDA Agriculture, hand Book.18

EXERCIES NO.6

Determination of bulk density (clod coating method) and particle density by pyconometer method and porosity of soil

A) DETERMINATION OF BULK DENSITY OF SOIL:

Principle: Bulk density of soil is defined as mass per unit bulk volume of soil in undisturbed condition. It is determined by clod coating method, core method, pit method and gravimetric moisture content at crack initiation stage in the field.

1. Cold coating method:
A. Bulk density: Soil bulk density is defined as the oven dry weight of soil per unit of its bulk volume.

Material: Paraffin wax, twin thread, physical balance, 250 ml measuring cylinder and soil clod of at least 3 cm diameter.

Procedure:
1. Select a firm clod of minimum 3 cm in diameter. Round off the sharp edge and brush off loose soil particles from its surface.
2. Weigh 25 cm long thread and tie the clod on its one end firmly.
3. Weight the clod on the balance and weight it precisely up to 0.01 g.
4. Heat the wax slightly above its melting point and plug the cold in it for one second.
5. Let the wax harden on the clod surface and dip it again in molten wax for few seconds.
6. Repeat the preceding step till a thin layer of the wax around the clod makes it waterproof and weigh it.
7. Place the cylinder with ¾ filled with water.
8. Suspend the wax coated clod into water, without touching bottom or wall of measuring cylinder and record the rise in level of water.
9. Take a similar clod of soil and keep it in oven at 105 ^{0}C for determination of water content of soil.

Observations:
1. Weight of thread   =
2. Weight of thread + clod   =
3. Weight of thread + clod + wax in air   =
4. Volume of water displaced by coated clod   =
5. Volume of wax = weight of wax 0.91 (sp.gr)   =
6. Water content in soil   =

Calculations:

$$\text{Bulk density of soil in g cm}^{-3} \quad = \quad \frac{\text{Over dry weight of clod}}{\text{Volume of soil clod}}$$

Questions:
1) Define bulk density of soil and state its significance.
2) State the average bulk density of clay, sandy and silt soils of Maharashtra.
3) State reasons for variation in density of soil.

B) DETERMINATION OF PARTICLE DENSITY OF SOIL BY PYCNOMETER METHOD

Principle :
      A given amount of dry soil when immersed in a definitive volume of water, expels air, and results in the displacement of equal volume of water. The volume of soil particles is determined by measuring the volume of water displaced in pycnometer bottle.

Apparatus :
      A pycnometer, a pipette (20 ml. cap.) analytical balance, hot plate or water bath, filter paper.

Procedure :
1. Fill-up clean, dry pycnometer with de aerated water. Note its temperature.
2. Replace the stopper and wipe out the surface of the pycnometer and weigh it.
3. Empty it and put into it 10g oven-dried soil (in the absence of oven dried soil, a duplicate sample may be placed into oven for the determination of its water content.)
4. When the bottle is half filled, wash the soil particles sticking to the inner side of the neck into it by using the pipette.
5. Boil the contents to remove the entrapped air (leave the soil overnight in the case of heavy clay, so that all soil pores become water saturated).
6. Cool the contents at room temperature and fill the pycnometer with de aerated water.
7. Insert the stopper, wipe the surface of the pycnometer, dry and weigh it.

Observations :

1.	Weight of water filled pycnometer	=	WPW g
2.	Weight of dry soil	=	10 g
3.	Weight of pycnometer + water + soil =		WPSW g
4.	Volume of water displaced (volume of soil solids)	=	WPW + 10 – WPSW cm^3

Calculations :

Particle density of soil (g cm^{-3})
$$= \frac{10}{WPW + 10 - WPSW}$$

Questions :

1) Define particle density.
2) What is the significance of particle density

C) DETERMINATION OF POROSITY OF SOIL

Total porosity is defined as the ratio of the volume of the pores to the soils bulk volume, i.e. the volume of the solids plus voids. It is calculated from the formula given below.

$$\text{Porosity of soil} = \left(1 - \frac{D_b}{D_p}\right) \times 100$$

Where, D_b = Bulk density
         D_p = Particle density.

$$\text{Void ratio} = \frac{\text{Particle density}}{\text{Bulk density}} - 1$$

Questions : 1. State the significance of porosity of soil in relation to plant growth.
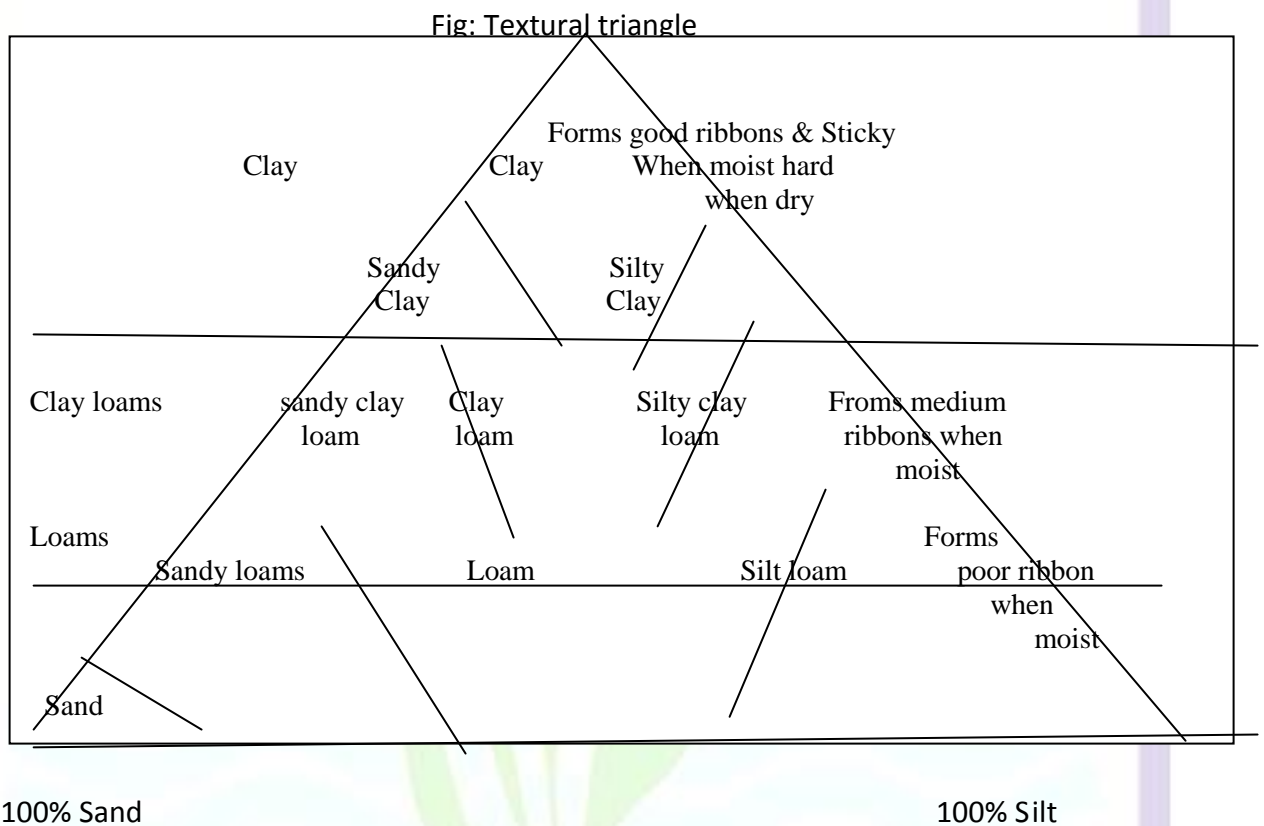   2. State the types of soil pores.

Reference:

1) A textbook of Soil Analysis by T.C. Baruah. H. P. Barthakar, Vikas publishing House Pvt. Ltd. 1997. Pp.11-12.
2) Soil Physical Analysis by R.A. Singh, 1980. pp. 62-63.

EXERCISE NO. 7
Determination of soil texture by feel method

Determination of texture by feeling of the soil with the fingers requires considerable practices and experience. However, one can do fairly well if the following steps are followed carefully.

Fig: Textural triangle

Clay	Clay Forms good ribbons & Sticky When moist hard when dry
Sandy Clay	Silty Clay
Clay loams	sandy clay loam	Clay loam	Silty clay loam	Froms medium ribbons when moist
Loams				Forms
Sandy loams	Loam	Silt loam	poor ribbon when moist
Sand			

100% Sand   100% Silt

Procedure:

1. Determination whether the soil fits into a clay, clay loam and loam class based upon ribbon formation as good, medium or poor ribbon. To do this, place about ½ teaspoonful of soil in pour hand, Add water very slowly drop by drop, from a water bottle or the tap. Knead the soil all the while and bring it to the consistency of a moist, workable condition. When the soil is at the proper consistency try to press it into a ribbon between your thumb and fore-finger.
2. Once it has been determined whether the ribbon is good, medium or poor, the soil may be classified as a clay, clay loam or loam, respectively, as indicated in above fig.
3. When it has been determined that the given sample of soil is clay, clay loam or loam, re-examine the sample. If it has a gritty feeling indicating the presence of sand. Call it sandy clay, a sandy clay loam or sandy loam, depending upon a tube of ribbon it makes. If grittiness can be detected by the teeth but not the fingers, call it a silty clay

loam or silt loam. If it is neither sandy nor silty but has exceptionally smooth feeling, call it clay or a clay loam depending the tube of ribbon it produces.
4. Soils that are loose and single-grained when dry and form a fragile cast when moist are called sand.
5. Determine texture of the sample provided and record the results on the data sheet.
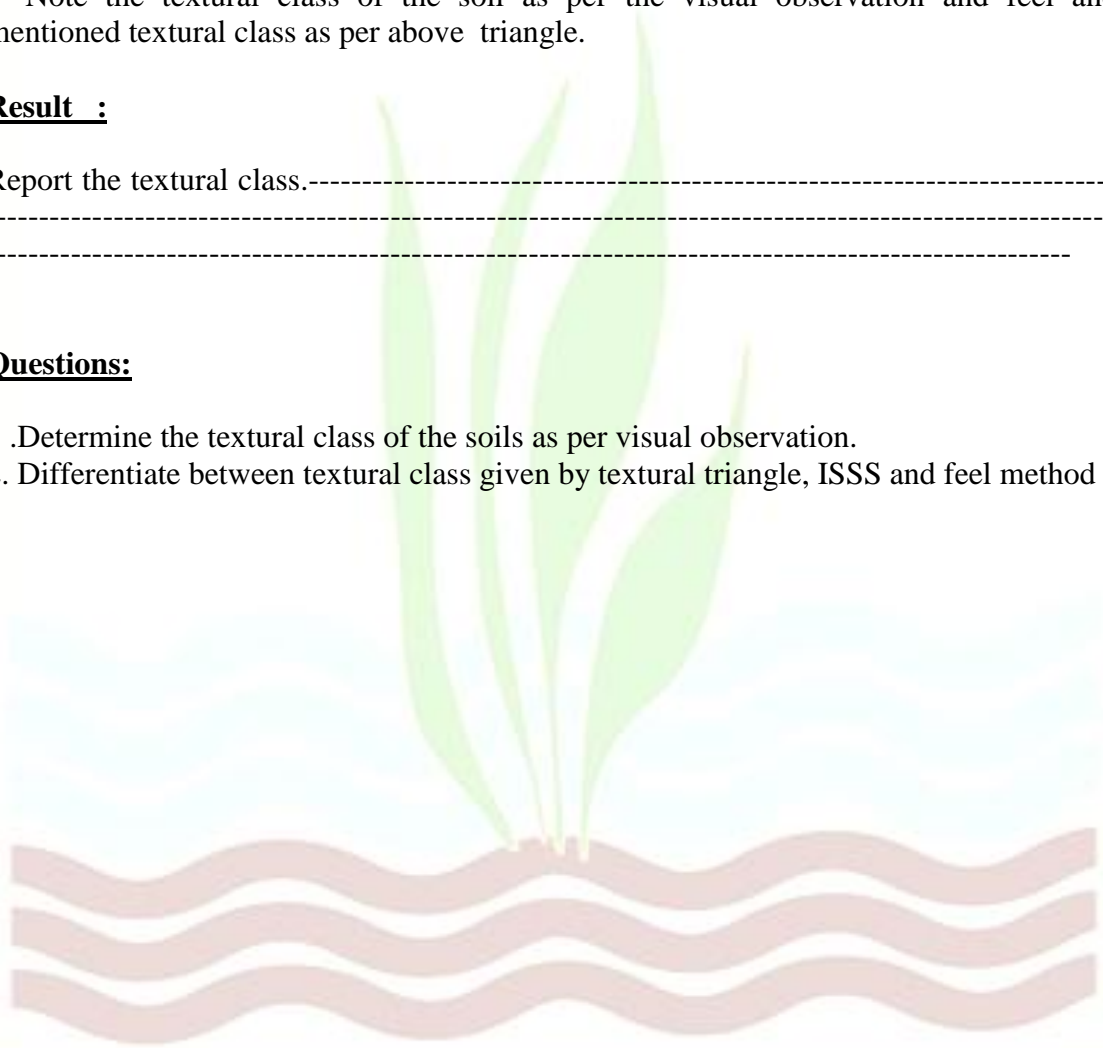
Observations:

Note the textural class of the soil as per the visual observation and feel and mentioned textural class as per above triangle.

Result :

Report the textural class.---

Questions:

1 .Determine the textural class of the soils as per visual observation.
2. Differentiate between textural class given by textural triangle, ISSS and feel method

EXERCISE NO. 8
Determination of soil texture by Bouyoucos hydrometer method.

The process of determining the amount of individual soil separates below 2 mm in diameter i.e. sand, silt and clay is called particle size analysis. It consists of determination of the percentage of various sized particles. (Sand, fine sand, silt and clay) as they exist in the soil. An essential first step is to separate the particles so that they function as individuals. This is called dispersion. The completely dispersed individual primary particles are usually referred to as textural separates.

Method of particle size Analysis. :
Principle :

The hydrometer method is based on the principle that the density of the suspension at the given depth decreases as an initially homogeneous dispersed suspension settles. The rate of decreases in density at the given depth is related to the settling velocities of the particles, which in turn, are related to their sizes. The time required by the particles of a given size to settle can be calculated by using strokes Law.

Stroke's Law :

Strokes (1851) stated that the velocity of a falling particle is proportional to the radius square and not to its surface. Equationally.

$$V = \frac{2}{9} \frac{g\, r^2\, (dp-d)}{n}$$

Where V = Velocity of settling particle
      dp = density of particle
      d = density of liquid
      g = acceleration due to gravity
      r = radius of particle
      n = Viscosity of liquid

Apparatus and Equipments
1) Dispersing machine　　　- Mechanical stirrer
2) 1000 ml cylinders without spout with rubber stoppers/spout
3) Thermometer (Fahrenheit scale)
4) Wash bottle.
5) 600 ml beaker with cover
6) Hot plate or water bath.
7) Bouyoucos hydrometer.
8) Watch glass.
9) Chemical balance.
10) Oven

Reagents :

1) 5 per cent sodium hexametaphosphate (dispersing agent)
2) 30 per cent Hydrogen peroxide
3) Amyl alcohol.

Procedure :

1) Weight 40 g sample of air-dry soil passed through 2 mm sieve in duplicate. Dry one of the samples in the oven at 105^0 C to determine the moisture content of soil. Meanwhile transfer the other sample to a 600 ml beaker and add to it 200 ml of distilled water.

2) Add 4 to 5 ml of 30 per cent H_2O_2 cover the beaker with watch glass and place it on water bath until most of the organic matter is destroyed, then remove the beaker from water bath and allow it to cool.

3) Repeat the process until the colour of the suspension ceases to become lighter or until frothing stops. 15 ml of H_2O_2 will usually be sufficient for a 40 g sample but more may be needed for soils high in organic matter. After the last addition of $H_2 O_2$ the beaker with soil is placed on the water bath for two hours to remove the excess $H_2 O_2$.

4) While waiting for the oxidation of the organic matter, put 10 ml of sodium hexametaphosphate solution in 1000 ml cylinder and fill the cylinder with distilled water to make exactly one litre. Mix the suspension thoroughly and bring it to room temperature. Insert the hydrometer into the solution carefully and determine the scale reading. Record this reading as RL, the calibration correction.

5) Transfer the organic matter-free soil sample to the dispersing cup, fill it with distilled water to the level of 4 cm from the top and add 10 ml sodium hexametaphosphate solution. Allow the soil to soak it for at least 15 minute. Then stir the soil suspension in the cup with the help of high-speed electrical stirrer for 10 minutes.

6) Pour and wash the contents of the dispersing cup into the special one litre cylinder with distilled water up to one-liter mark. Place a rubber stopper over the mouth of cylinder and shake it mechanically end-over-end for one minute.

7) Place the cylinder on the table and note the time immediately. Take the first hydrometer reading after 4 minute when the particles larger than 0.02 mm in diameter have settled (start inserting the hydrometer 10 seconds in advances of reading time). If the surface of the suspension is frothy, add one drop of amyl alcohol.

8) Remove the hydrometer carefully and wash it with distilled water. Measure and record the temperature of the suspension. The hydrometer is calibrated at 67^0F at any other temperature a correction must be applied if the working temp is above 67^0F the correction is added, if below 67^0F the correction is subtracted. The correction is equal to the difference between working temperature and 67^0 F multiplied by 0.2

9) Allow the suspension to remain undisturbed and re-insert the hydrometer at the end of two hours after the initial shaking was stopped. Now the particles larger than 0.002 mm. I.e. sand + silt will have settled. Record the hydrometer reading.

10) Calculate the percentage of sand, silt and clay in soil sample.

Observations :
1. Hydrometer reading at 4 minutes   - R_4
2. Hydrometer reading at 2 hours   _ R_{120}
3. Oven dry weight of soil sample   -   W
4. Temperature correction   -   r
5. Calibration correction   -   RL.

Observations
1. Hydrometer reading at minutes   - R_4
2. Hydrometer reading at 2 hours   - R_{120}
3. Oven dry weight of soil sample   -   W
4. Temperature correction   -   r
5. Calibration correction   -   RL.

Calculations:

$$P_4 = \frac{R_4 - R_2 + r}{W} \times 100$$

$$P_{120} = \frac{R_{120} - RL + r}{W} \times 100$$

Calculate P_4 from the 4 minute reading and P_{120} from the 2 hours since P_{120} = % Clay and P_4 = % silt + % clay, then we may say that.

% Sand   = 100- P_4
% Silt   = P_4 - P_{120}
% Clay   = P_{120}

Results :   Textural class using triangular diagram.

Questions :
1. Define particle size of analysis.
2. Explain Stokes Law and how is it applied in soil particle analysis?
3. Explain the role of H_2O_2 in the particle size analysis.
4. Why organic matter is destroyed?
5. What is the role of Sodium hexametaphosphate?
6. Mention the size of different soil particles.
7. Why do we use temperature correction factor?

Reference:
1) Khanna, S.S. and Yadav, D.V. 1979. Practical Manual for Introductory courses in soils. pp. 33-43.
2) Piper C.S. Soil and Plant analysis 1966.

EXERCISE NO. 9
Demonstration of capillary rise phenomenon of water in soil column

Importance:

A knowledge of the capillary phenomenon in soils helps in deciding the depth to which water table should be lowered during reclamation in soils, in maintaining favourable air-water regime for crop growth and in several engineering applications. It is of considerable significance in the determination of pore-size distribution of a soil.

Principle

Water hangs around the perimeter of a capillary tube by virtue of adsorption forces between the tube surface and the liquid as well as the cohesive forces from the liquid surface, also called 'surface tension'. As a result of these forces, water is drawn into a capillary tube inserted into beaker, containing water. Water moves from the surface where the pressure is zero to a height 'h' in the capillary. The surface tension force acts all along the circumference, $2\pi R$, tangent to the surface and is inclined at an angle θ.
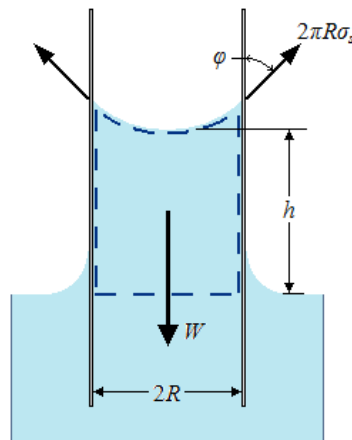
The upward force supporting the column of water is surface tension, while the weight of water column is the opposing force which tends to pull the water column down.

Upward force = $2\pi R.\ \sigma\ .\cos\theta$

Downward force = $\pi R\ .\ h.\ \rho.\ g$

At equilibrium, both the forces are equal.

Thus, $2\pi r.\ \sigma\ .\cos\theta = \pi r\ .\ h.\ \rho.\ g$

Therefore, $h = \dfrac{2.\ \sigma.\cos\theta}{R.\rho.\ g}$

considering the contact angle between the glass surface and water (and for that matter, between the soil surface and water) equal to zero, it follows:

$$h = \dfrac{2.\ \sigma}{R.\ \rho.\ g}$$

This equation applies to water rise in soils as well, where individual soil pore channels are treated as capillaries. This equation can be used to calculate the minimum size of soil pores and, then pore-size distribution, provided the height of water rise is known.

Equipment and Materials
Glass tubes of 2.5cm diameter and 70-80cm long with paper strips graduated in centimeters pasted over them; stands for holding tubes; water tray; spoon and rubber hammer to fill soil in glass tubes; cheese cloth or muslin cloth and string; filter papers, etc.

Procedure
- Tie the muslin cloth or the cheese cloth over the bottom of glass tubes with the string.
- Pack the soil of varying texture in some tubes (leaving two tubes) with the spoon, while gently tapping the sides by the rubber hammer. Ensure compact filling, without leaving any layering effect at any stage.
- Of the two tubes, pack the lower half of one tube with one soil and the top with the other soil, while reversing the order in the other tube. Care must be taken that there is an abrupt boundary between the two textural distribution in one tube thereby simulating the condition existing in the field.
- Place a piece of filter paper at the top of tubes, and dip their lower ends in water and support the tubes.
- Record the height of water rise in the tubes after the lapse of 10 minutes, 30 minutes, 1 hour, 3-4 hours and then 24 hours for seven days.
- Note down the time and date with each reading.

Observations

Sr.No.	Date/time of observation	Cumulative time from zero hour	Cumulative height of water rise (cm)			
			I	II	III	IV
1						
2						
3						
4						
5						
6						

Calculations

- Plot height of water rise versus time for each case.
- Calculate the minimum pore radii from the height of water rise in column of homogeneous ad layered soils as well.
- Make histogram of the height of water rise for each soil and layered columns

Reference:

Baruah T. C. and Barthakur H. P.1997. A textbook of Soil Analysis pp72-73

EXERCISE NO. 10
Determination of infiltration rate of soil by double ring infiltrometer

Infiltration is defined as downward movement of water from the surface below either through rains or irrigation. It is measured in the field itself as a function of time by double ring infiltrometer method.

Apparatus: Double ring infiltrometer. Cylinder of 28 to 35 cm in diameter and 40 cm long and made from 16 gauge sheet of iron,(Large 35 cm and small 28 cm diameter) scale, hook,guage,hammer,iron plate.

Equipments and Material:

Cylinders made of 14 to 16 gauge iron sheet, rolled in circular fashion and joints ground to a smooth finish. One end of the cylinders should be sharpened from outside keeping the inside completely smooth. This will facilitate easy drive of the cylinders in the soil. Galvanize cylinders after fabrication. For easy of transportation, cylinders can be made with different diameters so that they will fit one within another.

Inner diameter of the central ring should be between 30-35 cm and that of outer ring, it should be 40-45 cm. The height of each of these rings should be 40-45 cm.

1. Circular driving caps to fit over each of the rings.
2. Hammer of sufficient weight to drive the rings into the soil.
3. Watch
4. Hook gauge or staff gauge.
5. Field source of water and
6. Rubber or plastic sheet to be used as splashed guard.

Procedure:

Drive first the central cylinder vertically downwards into the soil (at a suitable spot selected in the field) to a depth of 15 to 20 cm by hammering on the central guide rod of the circular cap taking care that the soil is disturbed to a bare minimum and the ring is driven into the soil straight downwards from all sides. Tap soil into space between the soil-column and the cylinder to bring the soil inside the ring to its natural condition as far as practicable. Drive the outer ring into the soil is diametrically with the central ring. Take same precautions as in the first case. Cover the soil with a splash guard and apply 10-15 cm water in the central as well as in the space between central and outer rings. Remove the splash guard and place the hook gauge or staff gauge in the central ring. Record receding water level against time at suitable intervals in the central ring. Plot the curve. Express infiltration rate in cm/hr or inches/hr, using values averaged over time intervals.

Observations:

Note the level of water infiltering devising suitable time intervals.

Time	Time Interval	Water Level	Infiltration	Cumulative infiltration
	Initial – 5 min. -10min - 15 min			

Calculations:

$$\text{Infiltration rate} \quad i = \frac{di}{dt} \quad \text{Where,}$$

di = Change in cumulative infiltration.

dt = Time interval.

Questions:

1. Define infiltration, infiltration rate and cumulative infiltration.
2. What is the importance of infiltration?

Reference:

1. Soil Physical Analysis by R.A. Singh (1980) PP 77-78.

EXERCISE NO. 11
Determination of hydraulic conductivity of soil by constant head method

An important soil properly involved in the behavior of the soil water flow systems is the conductivity of the soil to water. Quantitatively the conductivity is the ability of the soil to transmit water. Hydraulic conductivity (k) is defined by Darcy's equation.

$$Q = K.h/L \quad \text{or} \quad K = \frac{Q \times L}{A \times t \times h}$$

Where: Q = Volume of water passing in time 't'
A = Cross section area of the soil sample.
h/L = Hydraulic gradient. 'h' is the head of water and 'L' is the length of sample.

Principle:

Air-dry sieved soil is placed in brass cylinder (Permeanmeter) and water is then applied to the surface at known head. Water is allowed to drip from the soil base. The effluent is measured at regular intervals. Tests are run until the volume of water that has passed through the soil corresponds to approximately 12 cm. depth of water on the soil surface. The hydraulic conductivity has the dimension of velocity, cm/hr.

1. Brass cylinder (20 gage) of 5.5 cm diameter and 23.5 cm height. The bottom of the cylinder is made from 20 gage brass sheet and are counter bore in the cylinder. Cylinder should has inflow and outflow for maintaining water head.
2. Constant head water supply siphon.
3. Stop watch.

Procedure :

Air dried soil passed through 2 mm sieve is taken for this experiment. Put the filter paper or glass wool at the bottom of cylinder. Dump the entire soil in one motion into the cylinder that has been fitted with a screen and filter paper.

This method or transfer of soil is used to prevent particle size segregation. The cylinder containing the soil is dropped 20 times through a distance of 2.5 cm on to the packing block. Place a filter on the surface of the soil and introduce water into the cylinder with minimum of soil disturbance. The ratio between h / L should be at least 2 to 2.5 i.e. approximately half soil and standing water head and record the time of application of water

Collect the percolate into a suitable receptacle and measure the volume at convenient time intervals. That is run until the volume of water that has passed through the soil corresponds to approximately 12 cm of depth of water on the soil surface. Calculate hydraulic conductivity and plot against accumulated equivalent depth of percolate (Generally the readings are continued until an equilibrium value of percolate is reached.)

Observations

Sr.No.	Observations	Values
1.	Type of Soil	------------------------
2.	Cross section area of soil surface = $(2.75)^2$ x 22 /7 =23.75 cm (dia of cylinder 5.5 cm so radius is 2.75 cm)	23.75 cm^2
3.	Length of soil sample	10 cm
4.	Water head	13.5 cm
5.	Time intervals and quantity of percolated water	------------------------

Calculations : Hydraulic conductivity cm/hr.

$$K = \frac{Q \times L}{A \times t \times h} = \frac{Q \times L}{23.75 \times t \times 13.5} = \frac{Q \times 10}{23.75 \times t \times 13.5}$$

Questions :

1) State Darcy's law
2) Define hydraulic conductivity.

Reference :

1. Diagnosis and improvement of saline and alkali soils by Richards (1954). Hand book No.60 pp.40.

EXERCISE NO: 12

Determination of soil temperature by using soil thermometer
(0-15 and 15-30cm)

Apparatus:
  Soil thermometer with steel jacket at the bottom and screw auger.

Procedure:
  1] Bore a whole in soil by means of screw auger upto desired depth.
  2] Insert the soil thermometer in the hole and keep it in the soil for 10 minutes.
  3] Take out the thermometer and note down the readings.

Observations:

  The temperature of soil is highest in the afternoon i.e. at. 15.00 hrs. We can record the temperature of soil with this kind of thermometer up to depth of 15 cm. For further depths special instruments are used. They are fixed in the soil and temperature from various depths is recorded.

1. Soil depth (cm.) 5, 10, 15 and 25 cm.
2. Soil temp. ------- -^{0}C --------------------^{0}C ---------------------^{0}C and ------------ -^{0}C

Questions:

1) Explain the role of soil temperature in agriculture with special reference to biological activities chemical reactions, seed germination and growth.

Reference:

1) Methods of soil analysis part – 1 (1965) edited by C.A. Black. American Soc. Of Agro. Madison, USA pp. 341-344.

Department of SSAC

EXERCISE NO.13

Determination of soil pH and electrical conductivity of soil

A) Soil pH

One of the most enlightening attributes of a soil is its pH. Whether a soil is acidic or basic has much to do with the solubility of various components the relative bonding of ions on exchanges sites and activity of various microorganisms. The plant nutrient is 6.5 to 7.5. Thomas (1957) noted that the three-soil pH availability is influenced by soil pH. The ideal pH range for availability of nutrients is 6.5 to 7.5. Thomas (1957) noted that three soil pH ranges are particularly informative pH less than 4 indicates the presence of free acid generally from association of sulphides: a pH below 5.5 suggests the likely occurrence of exchangeable Al and pH from 7.8 to 8.2 indicates the presence of $CaCO_3$.

I]   Equipment for measurement of soil pH :

The pH meter consists of two electrodes viz. (i) Glass electrode and (ii) Calomel electrode
(reference electrode)

A.   Glass electrode:

1.   The glass electrode consists of thin-walled bulb of pH sensitive glass, sealed to a stem of high resistance glass. It is better to choose a lower resistance electrode 9 (pH range 0 to 12) with a more repaid response and to tolerate the possibility of small   errors caused by reaction between the electrode surface and the film of soil suspension in contact with it.
       New electrodes should be checked in at least three standard buffers, say near pH 4,7 and9 for linearity of response.

2.   The useful life of glass electrode is extended if it is kept most when not in use. Combined glass and reference electrode should also be stored in a buffer solution, but separate reference electrodes should have their liquid junctions immersed in nearly saturated KCl solution protected from evaporation.

3.   With continued use, the performance of glass electrode gradually worsens. Electrode with poor performance should be replaced.
       Erratic off scale readings indicate very high electrical impedance in the electrical circuit. Air bubbles interrupt the path between the glass bulb and the internal reference electrode. Gentle tapping and shaking usually dislodge these bubbles.

B. **Reference electrode:**

a. These electrodes are usually the calomel type with saturated KCl electrolyte. But Ag-AgCl electrodes give quite satisfactory service and have an advantage in being easily repaired or even constructed in a laboratory.

b. Calomel electrodes must not be heated above 70 ^{0}C . They should be closely inspected regularly to see that no air gaps have developed.

c. The liquid junction between the reference electrode and the test liquid usually made with KCl solution, which is also the reference electrolyte. The liquid junction potential with soil suspensions is not the same with other electrolytes. The KCl solution used should not be saturated at any temperature above the minimum to which the electrode will be subjected. For example, a solution of 32 g KCl in 100ml water, is just undersalurated at 15 ^{0}C.

d. The KCl solution should flow through the liquid junction at a very low but detectable rate.

e. The liquid junction of reference electrode should just enter the surface of the soil suspension in order to be in a zone of minimum clay concentration. This makes the junction potential as small as possible and closest to that in the standardizing buffer solution. The difference in the junction potential in buffer and suspension is included in the pH shown by the meter.

II] **Reagents:**

A. Standard buffer solution, pH 4.00. Prepare stock solution of 0.3 M potassium hydrogen phthalate by dissolving 15.3g of the analytical grade salt in about 225 ml of hot water. cooling the solution, and diluting it to 250 ml .Add a drop of toluene to discourage growth of micro organisms. For the standard buffer pH.4.0 mix 100 ml of the stock solution with 500ml water. Prepare the fresh solution every week.

B. Standard buffer solution, pH 9.2 : Dissolve 3.81g sodium tetraborate (A.R) in water and dilute to 1000 ml.

C. 1.0 N Potassium Chloride solution (A.R)

III] **Apparatus** :
Electrometric pH meter with glass and calomel electrodes.

IV] **Procedure :**

1. Weight 20g air dry soil in to breaker and add 50 ml distilled water. Stir at regular intervals for one hour.

----

2. In the mean time turn the pH meter on, allow to warm up, and standardize the glass electrode using both the standard buffers. Remember to adjust the temperature compensation knob to the temperature of the solution. Measure the pH of the sample suspension, stirring the suspension well just before introducing the electrodes.

3. Rinse the electrodes after each determination and carefully blot them dry with filter   paper before the next determination. Standardize the glass electrode after every ten determinations.

D] To determine pH in 1.0 N KCl use 50mL. 1.0 KCl instead of water. Stir at regular intervals for one hour. Let it settle and measure the pH of the clean supernatant solution.

Questions:

Q.1. What p and H stand for?
Q.2. What is the soil: water ratio used in the determination of soil pH?
Q.3. What will happen to the soil pH if the soil: water ratio is increased from 1:2:5 to 1:5?
Q.4. What is the utility of soil pH?
Q.5. What are the factors affecting soil pH?

Reference:

1. Hesse. P.R. 1971. A textbook of Soil chemical analysis. John Murray. Pubi Ltd.50 Albemarle, Street, London
2. Jackson, M.L.1967. Soil chemical analysis. Practice-Hall of India Pvt. Ltd. New Delhi.

B) Electrical conductivity of soil

Principle :

The method is based upon the principle that conductivity of soil is nearly proportional to salts concentration.

Reagents :

Standard potassium chloride solution: 0.7456g of dry reagent grade potassium chloride is dissolved in freshly prepared double distilled water and made to one litre. At 25 ^{0}C it gives an electrical conductivity of 1411.8×10^{-4} (0.0014118) mhos/cm or 1.41 mm hos/cm . The conductivity bridge is to be calibrated and cell constant determined with the help of this solution. Even if the scale is marked directly in mhos/cm (as in solubridge) it is necessary to check and calibrate the instrument with the KCl solution.

Procedure :

10 g of soil is shaken intermittently with 25ml of distilled water in a 150 ml Erievmeyer (conical) flask for one hour and allowed to stand. Alternatively, the clear extract after pH determination can be used for electrical conductivity measurement. The conductivity of the supernatant liquid is determined with the help of the salt (conductivity) bridge. The measurement of EC (expressed in mmhos/cm or ds/m.) is to be adjusted for known temperature (usually 25 ^{0}C) of the solution by setting the knob provided for this purpose.

1)   EC/T.S.S (mmhos/cm)= Reading x multiplication factor x cell constant x mhos (10^3)
2)   Total soluble salt (ppm) = E.C. mmhos/cm x 640
3)   % of total soluble salts   = T.S.S. or (p.p.m.) / 10000

Soil water suspension is kept as such for 3-4 hours to settle down the silt and clay particles .The clear liquid is used for measuring electrical conductivity. It is measured by soil bridge. Calculate EC and T.S.S. from the following data:

1)   Reading.   0.255
2)   Multiplication factor   = 10^{-3}
3)   Cell constant 1.41

E.C. (mmhos /cm)   = R x 1.41 x 10^{-3} x10^3
$$= 0.25 \text{ x } 1.41$$
Total soluble salt (ppm) = 0.3525 x 640 = 225.62

$$\text{Percent of total soluble salts } = \frac{\text{T.S.S. (ppm)}}{10000} = \frac{225.62}{10000} = 0.0225$$

Questions

1) Why it is essential to measure the electrical conductivity of soil?
2) How will you measure the E.C.?
3) Name the instrument used for conductivity measurement?
4) What precautions will you take while measuring the E.C. ?

References:
1.   Method of Soil Analysis : Part II (1965) Ed.C.A.Black Americal Socy of agronomy Madison , U.S.A.

EXERCISE NO: 14

Determination of Anion Exchange Capacity of soil

Principle:

The soil is leached with a solution of 1N ammonium phosphate (adjusted to pH 4.0) until all the exchangeable anions are replaced by phosphate ions. The excess of ammonium phosphate is then removed by alcohol. The adsorbed phosphate, after being displaced with sodium hydroxide, is determined calorimetrically.

Reagents

1N Ammonium phosphate pH 4.0: Dissolve 38.4 g of ammonium dihydrogen phosphate in deionized water, filter and dilute to 1 litres. Check the pH of the solution and if it does not correspond to pH pH4.0 adjust to this value by the careful addition of a small quantity of N phosphoric acid.

60% Alcohol

1N Sodium Hydroxide: Dissolve 40 g of NaOH in water and dilute to litre.

Standard phosphorus solution:

100 ppm P solution: Dissolve 0.4387 g potassium dihydrogen phosphate (KH_2PO_4) in distilled water and make up volume to one litre.

5ppm P solution: Dilute 5 ml of 100ppm P solution to 100ml with distilled water.

Procedure

- Weigh 1-5 g of soil, depending on its anion exchange capacity and transfer into a 50ml of centrifuge tube.
- Add 30 ml of 1N ammonium phosphate solution. Stopper the tube tightly and shake vigorously for 5 minutes in a reciprocating shaker. Then place it in a water bath, kept at a temperature of 50-60°C, shaking vigorously at intervals of 15 minutes. After 1-2 hours, remove the centrifuge tube from the bath and allow it to stand overnight.
- Centrifuge the tube for 10 minutes at about 2000rpm. The clear supernatant liquid should be decanted as completely as possible and discarded.
- Treat the sample in this manner with 33 ml portions of ammonium phosphate solution a total of three times, discarding the supernatant each time.
- Remove the excess of free ammonium salt by suspending the sample in 33 ml of 60% alcohol, shaking for 5 minutes in a reciprocating shaker, and centrifuging until the supernatant is clear. Decant and discard the supernatant.
- Wash the sample with 33 ml portions of alcohol a total of three times.
- Transfer the soil to a small beaker by washing with water to remove the last traces of soil. Dilute to about 200 ml, add 25-30 ml of N sodium hydroxide and boil for 5 minutes.
- Filter and transfer the suspension to a 250 ml volumetric flask, rinsing the beaker with hot water. When cold, dilute to the graduation mark, stopper and

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mix well. The phosphate in this solution is then determined calorimetrically using ascorbic acid method.

Determination of P using Ascorbic Acid Method

Principle

The soluble phosphate forms heteropoly complexes with molybdate ions liberated from ammonium molybdate, phosphorus being the central co-ordinating atom. The heteropoly complexes give a faint yellow colour, which on reduction with ascorbic acid gives blue colour. The intensity of blue colour , which is proportional to the concentration of phosphate is read on the colorimeter at a wavelength of 760 nm using red filter. The conc. of P in soil extracts is calculated from the standard curve prepared at the same time.

Reactions

$$H_2PO_4^- + 12\ H_2MoO4 \longrightarrow H2P\ (Mo_3O_{10})_4 + 12\ H_2O$$
$$\text{(light yellow)}$$
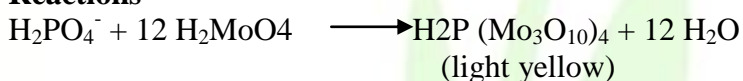
Phosphomolybdate (yellow) is reduced by ascorbic acid to phosphomolybdate (blue)

Reagents

A: Dissolve 12 g ammonium molybdate in about 300 ml distilled water. In another beaker 0.2908 g antimony potassium tartarate in 300 ml hot distilled water. Cool and mix the solutions and put it in a 2 litre volumetric flask. Then add 1 litre 5 *N* sulphuric acid and make the volume with distilled water.
B: Weigh 1.056 g L-ascorbic acid and dissolve in 200 ml reagent A.

Procedure

Pipette 5 ml extract in 25 ml volumetric flask. Add 0.5 ml of 5 N H_2SO_4 and shake the flask until evolution of carbon dioxide stops. Add about 10 ml distilled water washing the neck and sides of flask. Then add 4 ml of reagent B and make volume up to the mark.

Set the wavelength knob of colorimeter (760 nm) and swith it on. Let it warm for 15-20 minutes. Adjust the zero of galvanometer with the help of zero set knob. Rinse the colorimetric tube with blank solution and add suitable volume in it. Place the tube in the cuvette and adjust the 100 of galvanometer with the help of 100 set knob. Put test solution in another tube and record percent transmittance or absorbance.

Preparation of standard curve

The standard curve shows the relationship between the concentration of an element in the solution and intensity of its colour. This is used to calculate the amount of that element in the unknown sample. To prepare the standard curve pipette out 0, 0.2,

0.4, 0.6 ,0.8, 1.0, 1.5, & 2.0 ml of 5 ppm P solution in eight different 25 ml volumetric flasks. Then proceed to develop colour like the test sample. Note the absorbance or transmittance readings. Plot the graph of P concentration versus absorbance/ transmittance readings on a simple /semi-log graph paper.

Calculations:

Weight of the soil taken	= 5 g
Volume made (with 1N NaOH)	= 250 ml
First dilution	= 50 times
Volume of leachate taken for colour development	= 5ml
Volume made	= 25 ml
Second dilution	= 5 times
Total dilution	= 250 times
% T reading from colorimeter	= X
P concentration from standard curve (ppm)	= Y
P concentration in soil (ppm)	= Y x 250 = Z
P concentration (me/100g soil)	= Z / (31 x 10) = A
Anion exchange capacity (me/100 g soil or cmol (P^-) / kg soil	= A

Questions

1. Write down the most important exchangeable anions involved in anion exchange capacity.
2. Write down the principle of determining anion exchange capacity using phosphate adsorption method.
3. What happens to anion exchange capacity with the change in soil pH?

References

1. Willard, H.H., Merrit, Jr., and J. A. Dean, 1965. Instrumental Methods of Analysis. Pp. 54-80.
2. Jackson, M. L. 1967. Soil Chemical Analysis : pp. 429-451.
3. Black, C.A. (Editor-in-Chief). 1965. Methods of Soil Analysis. Chemical and Microbiological Properties, pp. 866-878.

EXERCISE NO: 15

Determination of Cation Exchange Capacity of soil
(by ammonium acetate method)

Principle :-

The adsorbed soil cations are displaced by NH_4^+ ions by leaching the soil with neutral ammonium acetate solution. The excess of ammonium acetate is removed with alcohol. Adsorbed ammonium (NH_4^+) of the soil is determined by steam distillation as ammonia using MgO. The distillate is collected in a known (excess) volume of std. acid and the excess being determined by a back titration with std. alkali.

Reagents :

1. Neutral ammonium acetate solution.
2. Ammonium Hydroxide. 2N : Dilute 108 ml. of conc. Ammonium hydroxide
    i. (sp. gr. 0.88) to one litre
3. Acetic acid 2N Dilute 115 ml of glacial acetic acid (sp. gr. 1.052) to 1 litre.
4. Mix equal volumes of (a) & (b) . If reagents accurately prepared, the mixture will have a pH of 7.0. If it is not 7, make necessary adjustment by addition of a little of 2N acetic acid or ammonia as the case may be.

OR

1. Neutral ammonium acetate solution: Dissolve 77.08 grams of ammonium acetate in
   Distilled water and dilute to 1 litre.
2. Alcohol: 60 % add 520 ml of water to 1 litre of absolute alcohol.
3. 0.1 N sulphuric acid and 0.1 N NaOH.

Procedure :

Transfer without loss 10 gm of soil to a 500 ml conical flask and add 250 ml of neutral ammonium acetate solution. Shake the contents occasionally for an hour and keep it overnight. Filter the contents through Whatman No. 44 receiving the filtrate in a 1000 ml measuring flask. Transfer the soil completely on to a filter paper and continue to leach the soil with neutral NH_4OAC solution (using 20 to 25 ml at a time)

Allow the leach ate to drain. Collect a leachate of 1 litre and reserved this for determination of individual cations. The residue left on the filter paper is used for a determination of total cation exchange capacity of soil.

Wash the soil left on the filter paper with 60 % alcohol to remove the excess ammonium acetate. This may be tested as follows: Add a pinch of solid ammonium chloride to soil on filter paper and wash with 60 % alcohol till filtrate runs free of chloride. When this is attained remove the soil with the filter paper and transfer into distillation flask and add about 200 ml. dist. Water Followed by 2 to 3 g of MgO. Carry out steam distillation, collecting the distillate in a known excess of 0.1 N H_2SO_4 to

which few drops of methyl red are added. Back titrate the excess of acid with 0.1 N NaOH.

Calculations:

Titrate Value = (ml of H_2SO_4 x N of H_2SO_4) – (ml of NaOH x N of NaOH) 1.0 ml of 0.1 N
acid is equal to 0.1 mili equivalent of any cation. Hence the cation exchange capacity is equal to :

$$C.E.C.(me/100g) = \frac{Titrate\ Value\ x\ 0.1\ x\ 100}{Wt.\ of\ soil\ taken\ (g)}$$

;CEC is expressed as $(cmol\ (p^+)\ kg^{-1})$ =meg/100g

Notes:

1) The object of using neutral alcohol is to remove the excess of ammonium acetate since the ammonium complex undergoes slight hydrolysis if water is the leaching agent. Futher ammonium saturated soil is highly dispersed when is contact with water and the fine particles of soil show a tendency to pass through the filter paper.

2) The process of leaching the soil on the filter paper if found to be slow may be accelerated by addition on coarse sand or macerated filter paper.

3) The leading of the soil is facilitated by use of leaching tubes or columns described by Metson(1956). Leaching on filter paper in funnies is fedious and is inclined to give lower value indicating less efficient method than by leaching column method.

4) The ammonia absorbed by soil on filter paper may by remove by washing with N K_2SO_4 to collect 1 litre of the filtrate. A suitable aliquot of this may be used for the estimation of ammonia using MgO.

5) Metson (1956) has also described special steam distillation apparatus, which has been found to be more convenient in every respect than the use of ordinary stem distillation.

6) A better method is to collect the distillate (ammonia) into a 250 ml conical flask containing 50ml of 4% boric acid using mixed indicator bromo Cresol-green methyl red. On titration with 0.1 N HCl the indicator changes from bluish green through bluish purple to pink at the end.

Rating

Result	Low	Medium	High	Very High
C.E.C.me/100g	10	10-25	25-45	45

Observations:

1. ml of 0.1 N H_2SO_4 taken in beaker for absorption of ammonia.
2. ml of 0.1 NaOH required for back titration.
3. Wt. of soil taken for analysis.

Questions :

1. Define CEC, Explain factors affecting it.
2. Explain the significance of soil CEC in agriculture.
3. Describe the role of Neutral normal ammonium acetate and 60% alcohol in determination CEC.

Reference:

1. Laboratory manual for agricultural chemistry – A.Sankaram.
2. Methods of soil analysis (1965) Part-II Ed. C.A. Blank, American Society of Agronomy Madison, U.S.A.

Department of SSAC

EXERCISE NO: 16

Study of soil map

There are different types of base materials used for mapping soils. They are mainly-
1. Cadastral map
2. Topographical and geographical map
3. Aerial photograph
4. Satellite imagery

Cadastral map

The cadastral maps are available on large scale mainly "16 to a mile or 8 " to a mile. In hilly areas they are on 32" to a mile. The cadastral map shows field boundaries/parceling with numbers. The ownership and land use deteils can be obtained from Khasra and Khatoni records maintained by partwari.

Survey of India Maps:

The Survey of India (SOI) is the national survey and mapping organisation of our country. The SOI publishes topographical and geographical maps on different scale.

Definition of Topographical and Geographical Maps:

A topographical map is on a sufficiently large scale to enable the individual features shown on the map to be identified on the ground by their shape and position. On the other hand a Geographical Map is on such a small scale that strict representation of individual features for identification on the ground is not possible. A geographical map is intended to give a picture of the country as a whole.

Maps on scale 1 inch to 4 miles or 1:250,000 and larger are classified as topographical maps while the maps on scales smaller than 1:250,000 are termed as geographical maps.

Details regarding Topographical Maps

Topographical Maps:

The layout and numbering of all topographical maps (1",1/2", ¼",1:50,000 and 1:250,000) are based on 1:1,000,000 (1:M) India and adjacent countries series maps. Each 1:M map is divided into sixteen 1 inch to 4 miles (1/4inch) or 1:250,000 sheet, each ¼ inch or 1:250,000 sheet is divided into four 1 inch to 2 miles (1/2 inch sheet and each ½ sheet is further divided into four 1 inch to 1 mile (1 inch) or 1:50,000 sheets.

$$Gradient = \frac{Vertical\ distance}{Horizontal\ distance}$$

Vertical distance is the rise or drop between two points
Working out of the gradient
Height of A= 19m

Height of B =139m

$$\text{Gradient} = \left(\frac{\text{Vertical distance}}{\text{Horizontal distance}}\right) = \frac{120}{960}$$

$$= 1/8 \text{ or } 1 \text{ in } 8$$

Landforms:

Each landform has a fairly distinctive contour pattern. Contour patterns help us to identify and to explain how they were created. Some examples of the landform are given in figures.

The human landscape in maps:

SOI maps provide a wealth of information about the human landscape. They show the place, where people live (settlements), the roads and railways along which people and good travel (communications), how the land is used (land use) and some of man's activities (economic and non-economic activities).

Survey of India Maps.

Maps published by Survey of India are available for sale with authorised Maps Sale Agents in important cities and towns and can also be obtained from:

1. Officer-in-Charge, Map Records and Issue Office, Survey of India. Dehra Dun-248 001 (Main supplier of Maps).
2. Head Clerk, Map Sales Office, Survey of India, Janpath Barraks 'A', Janpath, New Delhi-110 001.
3. Director, Southern Circle, Survey of Indian, 8, Richmond Road, Banglore, 560 027.
4. Director, Eastern Circle, Sruvey of Undia, 13, Wood Street, Calcultta-700 016.
5. Incharge, Map Sales Office, Survey of India, 3-6-561/1, Himayatnagar, Hyderabad-500 029.
6. Director, South Eastern Circle, Survey of India, Lewis Road, Bhubaneshwar-751 014.

The recent maps are printed in about seven colours viz. Black for outline and typescript Blue for water features Red for roads and sites Yellow for cultivation Green for wooded area Brown for contours, cliffs etc. Grey for hill shading.

In addition, administrative boundaries are printed with ribands in various colours. Hills are shown by contours and more important ranges are emphasized by hill shading.

Scale: Is relationship between distance on the map and distance on the ground. Every unit of distance measured on the map represents a fixed number of units on the ground. There are three ways of showing scale on a map.

A **statement of scale** uses words to indicate the scale of the map. One centimeter to half a kilometer means that one centimeter measured on the map represents half a

kilometer measured on the land. The units of measurement are clearly stated in this kind of scale.

A **Linear scale** is the easiest kind to use. It is a straight line devided up into sections which are numbered according to the real distances on the land. Map distance can be red off a linear scale immediately.

The **ratio or representative fraction** is the third way of showing the scale of map. Here, the units must always be the same 1:50,000 (1/50,000) meant that 1 unit on the map represents 50,000 units on land. If the units are centimeters then a statement of the scale can be worked out like this.

  1 cm represents 50,000 cm
  1 cm represents 500 m
  1 cm represents 05 km

  Some of the older SOI maps have a scale of 1:63, 360. In this scale the units are inches so that one inch on the map represents 63,360 inches on the land. These symbols are called conventional signs and are kind of shorthand allowing cartographers to show may features without cluttering on the map.

Relief:

  Relief is shown of SOI maps **contour lines.** A contour is line that joins places that are the same height above sea level. On SOI maps contours are drawn as brown lines. The pattern and spacing of contours lines show the shape or relief of the land. Spot heights are also used to show the height of a place above sea level.

Land Use

  This refers to the main use to which land is put.

Communications

  This section includes roads, railways and paths

Water features: All water areas like the sea, lakes, rivers and canals are shaded or drawn in blue.

MAP READING

  Map reading is a skill which brings a map to life. This skill can best be achived by trying to imagine the map as a real landscape and not just a printed sheet of paper. Map reading may also identify physical and human aspect of landscape. The physical aspects includes the natural features of the landscape which are formed by physical forces such as earth movements, rives, ice and the sea. Human aspects include all those feature of the landscape that have been or modified by man. So a mountain, river and cliff are examples of physical features. A town, orchard and reservoir are human features. Sometimes the physical and human aspects are closely related.

The Physical Landscape in Maps

      The height and shape of the land is called relief. It is shown on maps by spot heights and lcontour lines. Sometimes the relief forms particular shapes known as landforms which can be detected form contour patterns.

Cross-Section

      On should be able to draw cross-section from the contours on SOI map. First, decide on the line of section. It should cross the features you want to show. Next, mark off and number contours that cross the line of section. Use the straight edge of a sheet of paper for this. Now transfer the marks and contour numbers to the correct position in the section box. The heights can be found on the left hand side on the box. Finally, join the marks together with a smooth curved line. Never use a ruler. Label both ends of the section with a letter or name from the map to show where the section was taken. The cross section is then complete.

Gradient means the slope or angle of the land. Suppose a hill has a gradient of 1 in 9. That means for every 9 meters we go along the road, we will also go down 1 meter. The gradient can be mapped in degress with the help of protector. There is a formula for working out gradients.

EXERCISE NO . 17

Estimation of organic carbon and organic matter content in soil (Walkley and Black's method)

The soil organic matter consists of a whole series of products which range from undeclared plant and animal tissues to fairly amorphous brown to black material i.e. humus. Carbon in soils occurs in two different forms viz inorganic form and organic form

1)   Inorganic form

a.   Insoluble compounds like calcite ($CaCO_3$) and dolomite ($MgCO_3, CaCO_3$).
b.   Dissolved gases as CO_2, and,
c.   Ions of soluble salts such as HCO_3 and CO_3
d.   Organic form
a.   Animal, plant and microbial residues,
b.   Elemental organic carbon (charcoal, coal, graphite's)

In the determination of organic carbon, the inorganic form must be removed. It is assumed that SOM contains 58% C. Percentage of organic carbon multiplied by 1.724 (i.e. 100/58) will give the percentage organic matter.

The percentage carbon as determined by Weakley and Black's method gives a result that has been shown to be about 75-80% of that determined by a dry combustion method. Therefore the result is multiplied by a correction factor of 100/77 (i.e. 1.3).

Principle

The organic carbon in organic matter is oxidized by known but excess of chromic acid ($K_2Cr_2O7 + H_2SO_4$). The excess chromic acid not reduced by organic matter is determined by back titration with std. $FeSO_4$ solution (redo titration), using diphenylamine or Ferro in indicator. The organic carbon content in soil is calculated from the chromic acid utilized (reduced) by it.
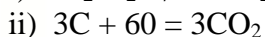
Reagents

1)   Potassium dichromate solution 1N : Dissolve 49.04 g of dried regent grade potassium dichromate in distilled water and dilute to 1 liter.
2)   Ferrous sulphate solution (0.5 N) : Dissolve 139g of reagent grade $FeSO_47H_2O$ in distilled water and add 15 ml of concentrated H_2SO_4 cool and dilute to 1 liter. Ferrous ammonium sulphate Fe $(NH_4)_2$ $(SO_4)_2$ $6H_2O$ can also be used by dissolving 196.19 g of salt in 800 ml of water containing 20 ml of concentrated H_2SO_4 and making up to one liter and standardize the solution.
3)   Ferries indicator – (Ortho-phenanthroline ferrous
4)   Concentrated sulphuric acid : (Note less than 96%) (For soils containing chlorides, add 15g Ag_2 SO_4 per liter of H_2SO_4)
5)   Phosphoric acid H_3PO_4 (85%)
6)   Sodium fluoride NaF, (Solid).

Procedure
a. Using Diphenylamine Indicator
Transfer without loss 1g of soil sample finely ground and passed through 0.5 mm sieve into 50 ml Erlenmeyer flask. Add by means of a pipette 10 ml of 1 N Potassium dichromate solution and swirl the flask gently. Add 20 ml of conc. H_2SO_4 by measuring cylinder. Swirl the flask by hand for a minute or two and set aside on an asbestos pad for exactly half an hour, *At the end of half an hour, add 200 ml of distilled water, 10 ml of H_3PO_4, 0.2 g of NaF and 1 ml of diphenylamine indicator and shake the content of flask. Titrate the contents of flask against 0.5 N ferrous sulphate or famous ammonium sulphate solution till the violet blue color changes to green. Note the burette reading at this point.

b. Using Ferro in indicator
At the end of half an hour, add 200 ml of distilled water, 10 ml of H_3PO_4, 0.2 g of NaF and 3-4 drops of Ferro in indicator. Titrate the contents of flask against 0.5N ferrous sulphate or ferrous ammonium sulphate solution till the color changes from brown – green – blue to finally red. Run the blank (without soil) simultaneously.

Reactions
Oxidation

i) $2K_2Cr_2O_7 + 8H_2SO_4$ --------------- $2K_2SO_4 + 2Cr_2(SO_4)_3 + 8H_2O + 60$

ii) $3C + 60 = 3CO_2$

iii) $K_2Cr_2 O_7 + 6FeSO_4 + 7H_2SO_4$ -------------- $K_2SO_4 + Cr_2(SO_4)_3 + 7H_2O$

i.e. every molecule of $K_2Cr_2O_7$ gives out 3 atoms of nascent oxygen in presence of H_2SO_4 and three atoms of carbon will require six atoms of nascent oxygen for oxidation which will be 2 molecules of $K_2Cr_2O7 = 6(O) = 3C$ 2 molecules x 294 g pot. Dichromate = 6x16 g Oxygen = 2 x 294 g K_2Cr_2O7

$$8 \text{ g of oxygen} = \frac{2 \times 294}{96} \times \frac{8}{1}$$
$$= 49 \text{ Equivalent Wt. of } K_2Cr_2O_7$$

2 X 294 g $K_2Cr_2O7 = (12)$ X 3 g carbon

49 g $K_2Cr_2O7 = 3$ g carbon

1000 ml of 1N $K_2Cr_2O7 = 3$ grams of carbon

1 ml of 1N $K_2Cr_2O7 = \dfrac{3}{1000} = 0.003$ g carbon

1 ml of 1N $FeSO_4 = 0.003$ g carbon

During oxidation only 77% carbon is oxidized hence it is necessary to multiply by correction Factor (100/77 = 1.3) to get exact amount of organic carbon.

Observation table to be recorded

Sr. No.	Observations	Value
1.	Name of the soil	
2.	Wt. of soil taken	
3.	Wt. of oven dry soil	
4.	Vol. of 1 NK_2Cr_2O7 added	
5.	Vol. of 0.5 N $FeSO_4$ required for Blank (B)	
6.	Vol. of 0.5 N $FeSO^-_4$ required for sample (T)	

Calculations

$$\text{Percent organic car bone} = (B - T) \times N \times 0.003 \times \frac{100}{\text{Wt. of soil (oven dry)}}$$

In this method recovery of organic carbon is 77% hence a correction factor of 100/77 = 1.3 is used to get correct value.

(Express results on oven dry basis)

Percent organic mater = % organic carbon x 1.724.

Rating of soil for organic carbon :

1. Very low   -   Less than 0.20%
2. Low   -   0.21 to 0.40%
3. Moderate   -   0.41 to 0.60%
4. Moderately high   -   0.61 to 0.80%
5. High   -   0.81 to 1.00%
6. Very high   -   Greater than 1.0%

Questions

1) Explain the principle involved in the estimation of organic carbon determination by Walk Ely and Black method.
2) Explain the role of the following regents in the estimation of organic carbon.
a) K_2Cr_2O7 b) Ferrous sulphate c) Conc. H_2SO_4
3) Why per cent of organic carbon is multiplied by 1.724 to get per cent of organic matter ?
4) Why is it necessary to multiply 1.3 to get exact amount organic carbon in soil ?
5) Which indicator is used in organic carbon estimation ?

References

1) Jackson, M.L. (1967). Soil Chemical Analysis. Prentice Hall of India, New Delhi, pp. 214-221.
2) Khanna, S.S. and D.V. Yadav, (1979). Practical Manual for introductory Courses in Soils. HAU, Hisser.
3) Hesse.P.R. (1971). A Text of Soil Chemical Analysis. John Murray, Publ Ltd. 50 Albemarle Street, London, WLX-4BD.

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EXERCISE NO.18

Study of soil profile in field

Definition of Soil profile : It is defined as a vertical section of the Soil through all its horizons and extending in to the parent material.

Soil morphology: It is defined as a constitution of the soil including the texture, structure, consistence, colour and other physical, chemical and biological properties of the various soil horizons that make up the soil profile.

Soil horizons : It is defined as a layer of soil approximately parallel to the soil surface, differing in properties and characteristics from adjacent layers below or above it.

The Master Horizons : For convenience in study and description, five master soil horizons are recognized. These are designated using the capital letters O, A,E,B and C.
        Figure : Draw Hypothetical soil profile showing horizons and sub horizons. (Brady 10th edition page 56)

A common sequence of horizons within a profile

1) **O HORIZONS** (Organic) :   The "O" group is comprised of organic horizons that from 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. The specific horizons are:
   1) Oi   : Organic horizon of the original plant and animal residues, only slightly decomposed.
   2) Oe   **:** Organic horizon, residues intermediately decomposed.
   3) Oa   : Organic horizon, residues highly decomposed.

2) **A HORIZONS :** The A horizons are the topmost mineral horizons, They contain a strong mixture of partially decomposed (humified) organic matter, which tends to impart a darker colour than that of the lower horizons

3) **E HORIZONS** : E horizons are those of maximum leaching or elevation of clay, iron and aluminum oxides, which leaves a concentration of resistant minerals, such as quartz, in the sand and slit sizes. An E horizon is generally lighter in colour than the A horizon and is found under the A horizon.

1)   **B HORIZONS (ILLUVIAL) :** The subsurface B-horizons include layers in which illuviation of materials has taken place from above and even from below. B-horizons are the layers of maximum accumulation of materials such as iron and Aluminium oxides and silicate clays. Calcium carbonate, calcium sulphate and other salts may accumulate in the B-horizon.

2)   **C HORIZON** : The C horizon is the unconsolidated material underlying the solum (A and B). 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 and is generally little affected by the processes that formed the horizon above it.

R Layers : Underlying consolidated rock, with little evidence of weathering.

Transition Horizons : These horizons are transitional between the master horizon (O.A.E.B and C) They may be dominated by properties of one horizon but have prominent characteristics of another.

Horizonwise Soil samples should be collected from typical profile as per procedure described below :
1) Locate sample site away from roads, houses and constructions sites, etc.
2) Dig a fresh rectangular pit at least 1.5 metres deep for master and other profile studies.
3) Dig a small pit 1 meter X 1 meter X 50 cm deep for grid points.
4) Clean the profile facing the sun with appropriate tool and demarcate horizons for their morphological descriptions.
5) After describing the horizons, collect the soil sample from the surface horizon with an appropriate implement and place it in a plastic coated bag for micro-nutrient analysis.
6) The soil samples, horizonwise may be collected from the bottom upwards using appropriate tools, Divide horizons thicker than 30 cm or variation in soil character and sample each half separately.
7) Discard fragments larger than 7.5 cm.
8) Collect in each cloth bag (3-4 kg capacity) with a slightly larger polythene bag.
9) Insert the label between the two bags.
10) Label the sample for micronutrient analysis prominently with as M on the bag. These samples have to be specially handled in a special laboratory for processing.
11) The other soil samples have to be sent to laboratories for their analysis.

Note : Collect two bags of samples from the surface horizon or layer, one for micronutrient analysis and the other for general analysis.

**The following soil macro morphological characteristics should be studies.**

1.The number of horizons in profile	2.	Thickness of horizon and profile depth
3.Colour of each horizon	4.	Texture of soil of each horizon.
5 Root penetration	6.	Concretions, nodules.
7.Natural vegetation	8.	Topography
9.Parent rock, solum depth	10.	Consistency.

Questions :
2) Define soil profile.
3) What is solum
4) Which are the master horizons?
5) Draw an ideal sketch of soil profile & name the different horizons.

Reference :
1) Practical manual for introductory courses in soils (1979) by S.S. Khanna & D.V. Yadav, Hisar pages. 5 to 10 51 to 54
2) Introductory pedology by J.L. Sehgal (1986) Kalyani publishers, New Delhi.
3) Nature and properties of soils 10th edition (1995) by N.C. Brady p.p. 56-57
4) Field manual Tech. Bull. No.13 NBSS & LUP Nagpur. 1989.
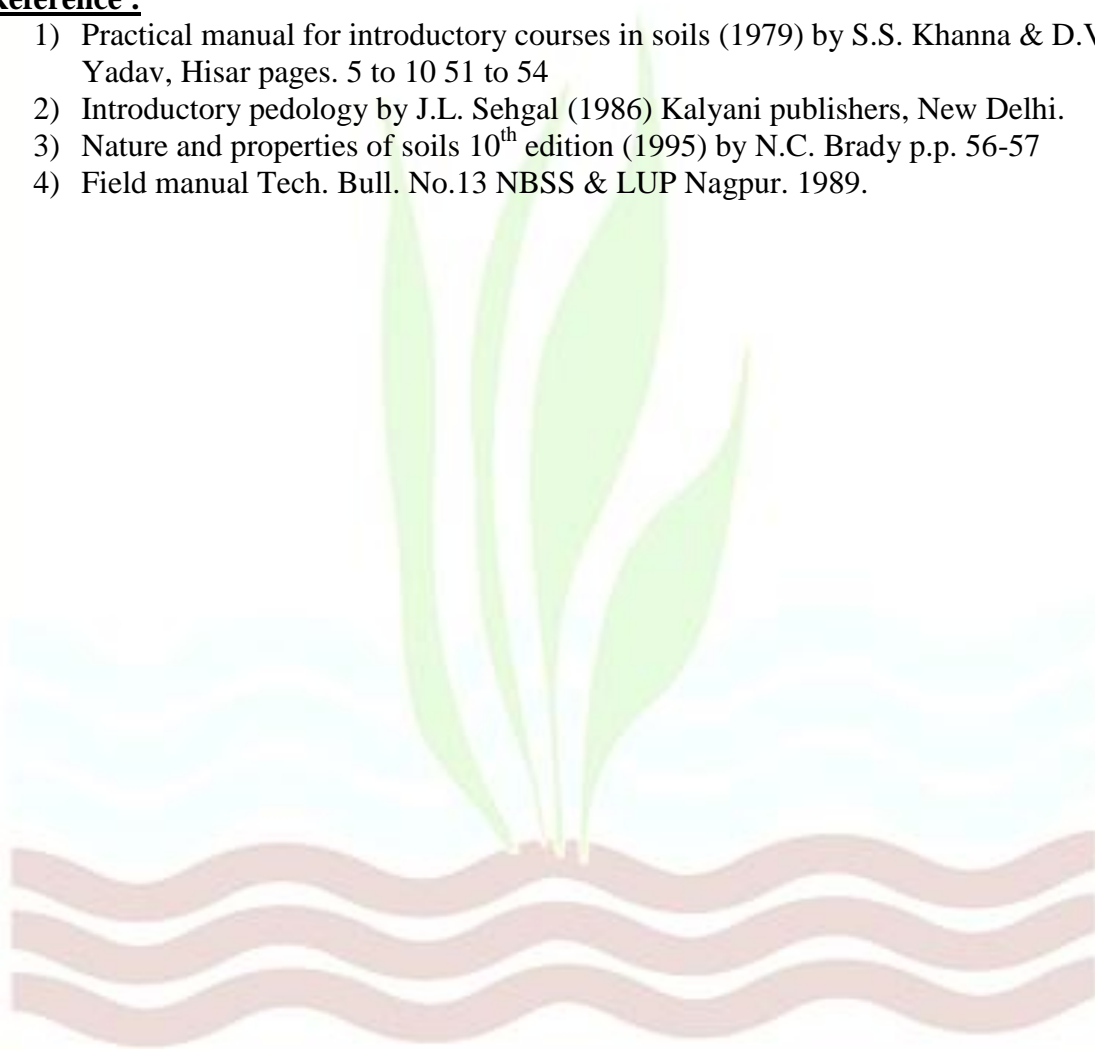
Department of SSAC

Course :	SSAC 111		Credit:	3(2+1)	Semester-I
Course title:	Fundamentals of Soil Science				

Syllabus

Theory

Soil as a natural body, pedological and edapholological concepts of soil. Soil genesis: soil forming rocks and minerals. Weathering, processes and factors of soil formation; Soil Profile, components of soil; Soil physical properties: soil-texture, structure, density and porosity, soil colour, consistence and plasticity; Elementary knowledge of soil taxonomy classification and soils of India; Soil water retention, movement and availability; Soil air, composition, gaseous exchange, problem and plant growth, Soil temperature; source, amount and flow of heat in soil; effect on plant growth, Soil reaction-pH, soil acidity and alkalinity, buffering, effect of pH on nutrient availability; soil colloids - inorganic and organic; silicate clays: constitution and properties; sources of charge; ion exchange, cation exchange capacity, base saturation; soil organic matter: composition, properties and its influence on soil properties; humic substances - nature and properties; soil organisms: macro and micro organisms, their beneficial and harmful effects; Soil pollution - behaviour of pesticides and inorganic contaminants, prevention and mitigation of soil pollution.

Practical

Study of soil profile in field. Study of soil sampling tools, collection of representative soil sample, its processing and storage. Study of soil forming rocks and minerals. Determination of soil density, moisture content and porosity. Determination of soil texture by feel and Bouyoucos Methods. Studies of capillary rise phenomenon of water in soil column and water movement in soil. Determination of soil pH and electrical conductivity. Determination of cation exchange capacity of soil. Study of soil map. Determination of soil colour. Demonstration of heat transfer in soil. Estimation of organic matter content of soil.

Teaching schedule

   a) **Theory**

Lecture	Topic	Weightage (%)
1 & 2	History and development of soil science, its scope and importance. Soil as natural body, pedological and edapholgical concept of soil.	5
3 & 4	Soil genesis: Soil forming rocks and minerals.	6
5 & 6	Weathering of Rocks and Minerals.	6
7 & 8	Processes and factors of soils formation.	5
9	Soil profile, components of soil.	5
10 & 11	Soil physical properties: Soil texture, structure, density and	5

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	porosity.	
12	Soil colour, consistency and plasticity.	3
13 ,14	Elementary knowledge of soil survey, soil taxonomy, classification, Land capability classification.	5
15	Soils of India and Maharashtra.	3
16 , 17& 18	Soil water : Soil water classification, soil water retention , soil water potential, soil moisture constants', Hydraulic conductivity, permeability, percolation, movement and availability in soil.	6
19	Soil air : composition, gaseous exchange and effect on plant growth.	6
20	Soil temperature: source, amount and flow of heat in soil and effect on plant growth.	6
21 &22	Soil reaction: pH, soil acidity and alkalinity, buffering capacity, effect of soil pH on nutrient availability.	6
23 & 24	Soil colloids: soil colloidal properties, inorganic and organic colloids.	4
25 , 26 & 27	Silicate clay: constituents and properties, sources of charge, ion exchange, cation and anion exchange capacity, base saturation.	6
28,29 & 30	Soil organic matter: sources, composition, properties, factors affecting SOM, its importance and influence on soil properties.	6
31	Humic substances-nature and properties	5
32 ,33 &34	Soil organisms : macro and micro organism, their beneficial and harmful effects on soil and plant. soil biological properties (SMBC, soil respiration, DHA etc.)	6
35 & 36	Soil pollution – sources of soil pollution*, behavior of pesticides and inorganic contaminants, prevention and mitigation of soil pollution.	6
	Total	**100**

b) Practical

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Experiment	Topic
1	Study of soil forming minerals.
2	Study of soil forming rocks.
3	Study of soil sampling tools, collection of representative soil sample, its processing and storage.
4	Determination of moisture content in soil by gravimetric method.
5	Determination of soil colour by Munsell soil colour chart in field.
6	Determination of bulk density (Clod coating method) and particle density by pycnometer and porosity of soil.
7	Determination of soil texture by feel method.
8	Determination of soil texture by Bouyoucos hydrometer method.
9	Demonstration of capillary rise phenomenon of water in soil column.
10	Determination of infiltration rate of soil by double ring infiltrometer.
11	Determination of hydraulic conductivity of soil by constant head method.
12	Determination of soil temperature by using soil thermometer (0-15 and 15-30cm).
13	Determination of soil pH and electrical conductivity of soil.
14	Determination of anion exchange capacity of soil.
15	Determination of cation exchange capacity of soil (By NH_4OAc Method).
15	Study of soil map.
16	Estimation of organic carbon and organic matter content in soil by Walkely and Black method.
17 &18	Study of soil profile in field.

Suggested Reading
1) SS. 2009. Fundamentals of Soil Science. 2nd Ed. Indian Society of Soil Science, New Delhi- 110 012. pp. 728.
2) Das D. K. 2011. Introductory Soil Science, 3rd revised and Enlarged Ed, Kalyani Publisher, Ludhiana. pp. 645.
3) Brady, N. C. 2016. The Nature and Properties of Soils. 15th edition Publisher: Pearson Education, ISBN: 978-0133254488
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5) Biswas, T.D.; Mukherjee, S.K.. 1995. Text Book of Soil Science 2nd sEd. Tata McGraw Hill Publisher, Delhi pp 433.

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Jakson, M.L. 1973. Soil Chemical Analysis. Printice Hall, India, Pvt. Ltd. New Delhi. pp 498.

5) Page et. al. 1982. Methods of Soil Analysis, Part 1 and 2. Chemical and Microbiological Properties . 2nd Ed. Soil Science Soc. of America Am. Soc. Agron., Madison, Wisconsin, USA.

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9) Hesse, P. R. 1971. a Text Book of Soil Chemical Analysis. John Murray, London.

10) Richards, L. A. 1968. Diagnosis and Improvement sof Saline Alkali Soils. Oxford andIBH Publication Co. Calcutta.

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14) Patil, V. D. and Mali C. V. 2007. Fundamentals of Soil Science, Aman Publication, Meerut.

15) Nirankari Lal Singh. 2000. Text Book of Soil Science. Aman Publication, Meerut.

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PRACTICAL MANUAL

Course No. : SSAC-111 Credits : 3(2+1)

Course Title : Fundamentals of Soil Science

Course   : B.Sc. (Hons.) Agriculture Semester   : I (New)

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VASANTRAO NAIK MARATHWADA KRISHI VIDYAPEETH, PARBHANI : 431 402

College of Agriculture, ...

CERTIFICATE

This is to certify that Shri / Miss ………………………
Reg.No………………….......... a student of Ist **(New)** Semester,
B.Sc. (Hons.) Agriculture has completed all the exercises
successfully for the Course : **Fundamentals of Soil Science**,
Course No. : **SSAC - 111,** during Monsoon Semester 201 - 201 .

Place :

Date :   **COURSE TEACHER**

Remarks :

Department of SSAC

Course No.   : SSAC-111
Course Title : Fundamentals of Soil Science
Course   : B.Sc. (Hons.) Agriculture
Semester   : I (New)

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