THE NEOTIA UNIVERSITY
ज्ञानम् आत्म प्रदीपाय

Fundamentals of Soil Science

PRACTICAL MANUAL

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EXERCISE NO.1
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) O_i : Organic horizon of the original plant and animal residues, only slightly decomposed.
2) O_e **:** Organic horizon, residues intermediately decomposed.
3) O_a : 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 silt sizes. An E horizon is generally lighter in colour than the A horizon and is found under the A horizon.

4) **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.

5) **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 B and C. They may be dominated by properties of one horizon but have prominent characteristics of another. Horizon wise 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, horizon wise 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.

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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
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EXERCISE NO. 2

Determination of soil colour by Munsell soil colour chart

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 Munsell notation. The three basic factors, which are the components of colour: Hue, Value and Chroma are used for the construction of the Munsell 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 Munsell 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 Munsell 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

Soil Survey Manual 1951 USDA Agriculture, hand Book.1

Reference

- https://www.youtube.com/watch?v=N6doCSP8T7I

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 place 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/iron 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/iron 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 ?

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2) Jackson, M.L. Soil chemical analysis (1973) prentice hall of India, Pvt. Ltd. New Delhi.
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EXERCISE NO.4

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

i) Igneous Rocks

1. Plutonic Rocks
2. Volcanic

ii) Sedimentary Rocks

1. Arenaceous
2. Argilaceous
3. Calcareous
4. Carbonaceous
5. Siliceous
6. Precipitated.

iii) Metamorphic Rocks

1. Dynamo metamorphic
2. Thermo metamorphic
3. Hydro metamorphic

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 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	Basic rock
SiO_2 = above 65%	SIO_2= below 55%
(e.g. granite)	e.g. Basalt (Trap)

Intermediate Rock

Sub acid	Sub Basic
SiO2 = 60 to 65%	SiO_2 = 55 to 60%
e.g. syenite	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.

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.

Reference:

1) A Text book of Geology by. V.D. Muthayya 4 th Edn. Oxford I B.H. Pushing Co. New Delhi.
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3) Practical manual of introductory courses in soils (1976) by .S.S Khanna and D.V. Yadav, HAU, Hissar : 11 –17.
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EXERCISE NO.5

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.
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. Monometric : The tree axis are of equal length and at right angle to one another, as in cube, e.g. Halite and Garnet.
2. Diametric : Two axis are equal and one unequal. All three axis are right

angle to one another e.g. Zircon.

3. Trimetric: All three axes are unequal but they are right angle to one another e.g. sulphur, olivine.
4. Monoclinic: 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. Triclinic: All three axis are unequal and none of them forms a right angle with one other e.g. Plagioclase.
6. Hexagonal: 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.

9) Fracture: 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.

10) Tenacity: 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.

11) Chemical nature: 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.

Questions:

1) Define mineral, primary, secondary, essential and accessory minerals.
2) List out important minerals found in different soils of West Bengal 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.
5) A text book of soil science J.A. Daji (1996)

Reference URL

https://www.youtube.com/watch?v=7MvXv66b5h4

EXERCIES NO.6

Determination of bulk density of soil

Bulk density of soil is expressed as the ratio of the mass (weight) of soil particle to their total volume including the pore space between the soil particles. Alternately, it is the weight of unit volume of dry soil. It is usually expressed in the unit of gram per cubic centimeter (g/cc) or mega gram per cubic meter (Mg/m^3). In fine textured soil bulk density vanes from 1.00 to 1.60 g/cc, whereas in coarse textured soil from 1.20 to 1.80 g/cc.

$$Bulk\ Density = \frac{Weight\ of\ soil}{Voliume\ of\ soil}$$

Here, the volume of soil means as it exists in situ i.e. in field condition.

Equipments and Materials

Core sampler consists of two cylinders fitted one inside the other (The inside cylinder is the sample holder; the outer core extends at both the ends; upper end to accept the hammer and lower end to form the cutting edge), knife, slide caliper, aluminium moisture box analytical balance, **oven, desiccators.**

Procedure

- Drive the sampler into a vertical soil surface slightly enough to fill the sampler but avoiding the compression of the soil in the confined space of sampler.
- Using spade dig out the sampler without disturbing the natural position of soil within the sampler.
- Separate the two cylinders retaining the soil mass undisturbed in the sample holder (inner core).
- Trim the soil extending beyond each end of sampler with the help of sharp knife. Now the volume of sample holder is equal to the volume of soil.
- Transfer the total soil from sample holder to a previously weighed moisture box and weigh it.
- Dry it in the oven at 105°C until a constant weight is reached (10 to 15 hours).
- Cool the moisture box and its content at room temperature in the desiccator and weigh

it again.

- Determine length and inner diameter of the sampler with the help of slide caliper.

Calculation

Say,

Weight of aluminium box = W_1 g

Weight of aluminium box + field moist soil = W_2 g

Weight of aluminium box + oven dry soil = W_3 g

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

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

Thus,

$$\text{Bulk Density of soil (g/cc)} = \frac{Y}{\frac{\pi d^2 h}{4}} = \frac{4Y}{\pi d^2 h}$$

Where, d = inner diameter of the sampler, in cm h = height of the sampler, in cm

Questions:

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

Reference URL

- https://www.youtube.com/watch?v=qcm1WTGlric

EXERCIES NO.7

DETERMINATION OF PARTICLE DENSITY OF SOIL BY PYCNOMETER METHOD

Principle :

Particle density of soil is the ratio of mass (weight) of solid particles t(their total volume, excluding the pore space between particles. Like bull density, -it is also usually expressed in the unit of gram per cubit centimeter (g/cc) or mega gram per cubic meter (Mg/m^3). For mineral soils the value usually varies from 2.60 - 2.75 g/cc. For general calculation average particle density of arable soil is considered to be 2.65 g/cc Particle density of organic matter (1.2 -1.7 g/cc) is much less than tha of mineral soil.

$$Particle\ Density = \frac{Mass\ of\ soilid\ particles\ of\ soil}{Voliume\ of\ solid\ particle\ of\ soil}$$

Volume of solid particles is calculated indirectly by volume of fluid (usually water) displaced by the solid particles. Again, volume of water is calculated from the mass and density of water.

Equipments and Materials

Pycnometer fitted with a glass stopper having a vertical capillary opening (Fig. below), analytical balance, hot plate.

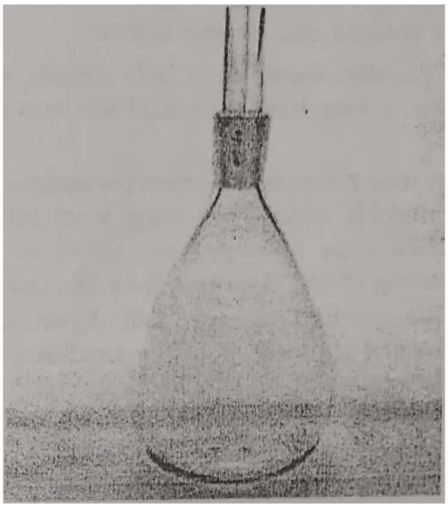


Fig. Pycnometer

Procedure

- Weigh a clean, dry pycnometer and pour oven dry soil to nearly one quarter of its volume.
- Weigh the pycnometer with soil after properly cleaning the outside of the pycnometer with dry cloth duster.
- Fill about half of the volume of pycnometer with distilled water.
- To expel entrapped air within the suspension gently boil the water for few minutes (5 minutes).
- Cool the pycnometer and its content to room temperature.
- Fill the total volume of pycnometer with preboiled cooled distilled water.
- « Insert the stopper carefully and clean outside of pycnometer with dry cloth.
- Weigh the pycnometer with its content.
- Remove soil from pycnometer and fill it with preboiled cooled distilled water and weigh it.
- Record the room temperature.

Calculation

Weight of empty pycnometer = W_A g

Weight of pycnometer + oven dry soil = W_sg

Weight of pycnometer + soil + water = W_{sw} g

Weight of water filled pycnometer = W_w g

Density of water at room temperature = D_{vv} g/cc

$$\text{Particle Density of soil}\left(\frac{\text{g}}{\text{cc}}\right) = \frac{W_S - W_A}{\left\{\frac{(W_W - W_A) - (W_{SW} - W_S)}{D_W}\right\}}$$

$$= \frac{D_W(W_S - W_A)}{(W_W - W_A) - (W_{SW} - W_S)}$$

Questions :

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

Reference URL

- https://www.youtube.com/watch?v=-PcD2XoBcA8&t=206s

EXERCIES NO.8

Determination of Porosity of Soil by Indirect Method

Porosity or total pore space of soil is the fraction of soil volume not occupied by soil particles. Mathematically, it is the ratio of volume of pore space to total volume of soil. It is governed by the orientation of the soil solids. Porosity gives idea about the storage capacity of fluid (air and water).

$$\%\text{Pore Space(f)} = 100 - \left(100\frac{D_b}{D_p}\right) = \left(1 - \frac{D_b}{D_p}\right)100$$

Where, D_b and are the bulk density and particle density of soil respectively.

Procedure

- Determine bulk density and particle density of soil as Exp no 5 and 6
- Calculate the porosity of soil using the above equation

Result

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.

EXERCIES NO.9

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, Hot air oven, Balance

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 :

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

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- 4

Reference URL

- https://www.youtube.com/watch?v=AHD0G15kwvQ

EXERCISE NO. 10

Determination of soil texture by feel method and by Bouyoucos hydrometer 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.

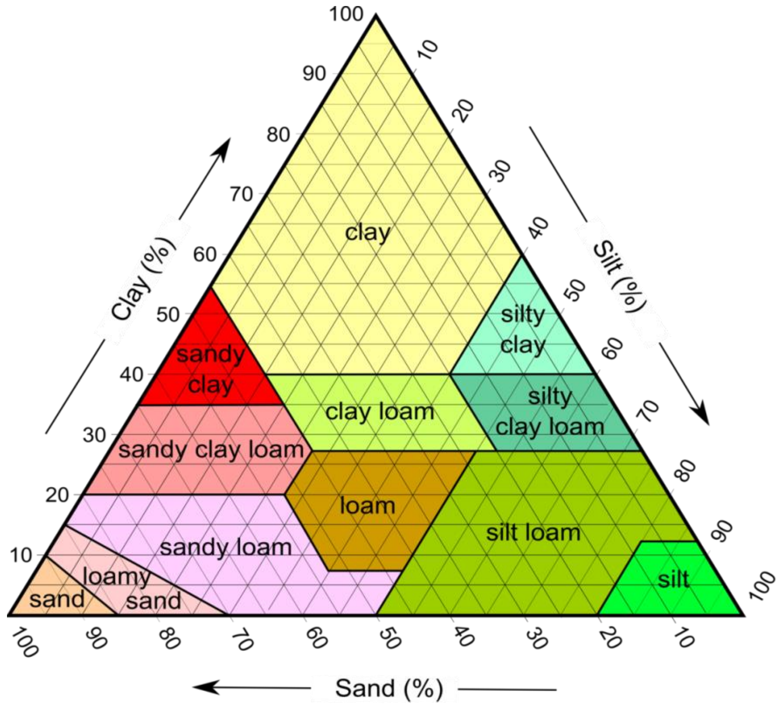


Fig: Soil Textural triangle

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 :

The textural class of the soil is

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

Reference URL

- https://www.youtube.com/watch?v=GWZwbVJCNec

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.

$$V = \frac{2}{9}\left(\frac{d_p - d}{\eta}\right) g r^2$$

Where

V = Velocity of settling particle
dp = density of particle
d = density of liquid
g = acceleration due to gravity
r = radius of particle
η = 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 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:

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

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

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 of the soil is

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.

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.

Reference URL

- https://www.youtube.com/watch?v=GfDW3Fw9cL0

EXERCIES NO.11

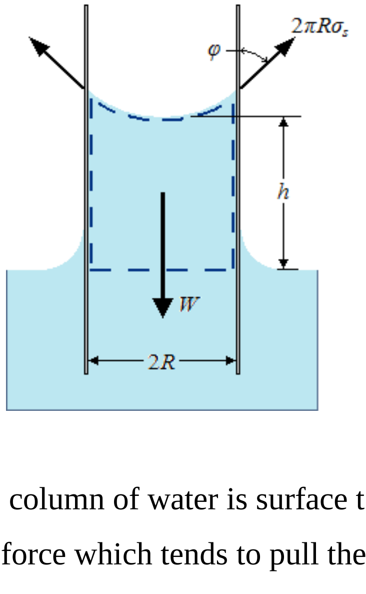
Demonstration of capillary rise phenomenon of water in soil column

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, 2πR, 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.

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

Reference URL

https://www.youtube.com/watch?v=5waNTa2b-yg

EXERCISE NO. 12

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.

Reference URL

- https://www.youtube.com/watch?v=PYvfTxQhbOQ

EXERCISE NO.13

Determination of soil pH

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 and note down the reading.
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.

Result:

The pH of given soil sample is …………

Questions:

What p and H stand for?

What is the soil: water ratio used in the determination of soil pH?

What is the utility of soil pH?

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
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EXERCIES NO.14

Determination of 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 x 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 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 Erlenmeyer (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.

Conversion factors:

TDS (m.eq/L) = EC (dS/m) ×10
TDS (ppm) = EC (dS/m) ×640
TDS (%) = EC (dS/m) ×0.064
Osmotic pressure (bars) = EC (dS/m) ×0.36

Result : The given soil sample contains,

EC (dS/m)	
TDS (m.eq/L)	
TDS (ppm)	
TDS (%)	
Osmotic pressure (bars)	

Inference: The given soil sample is……………………………………………………..

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. ?

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EXERCISE NO: 15

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

Principle :-

Soil is first saturated with normal ammonium acetate (pH 7.0). Excess ammonium (NH_4^+) ions and displaced cations are then removed by washing with alcohol. The amount of NH_4^+ ions retained by the soil is measured by steam distillation of NH4-saturated soil with MgO. During distillation evolved ammonia is absorbed in a boric acid solution as ammonium borate and the amount ammonium borate formed is determined by titration with standard sulphuric acid in presence of mixed indicator.

Equipments and Materials

Kjeldahl distillation set, shaker, Buchner funnel, Whatman No. 42 filter paper, balance, 800 ml Kjeldahl flask, 250 ml conical flask, 50 ml measuring cylinder.

Reagents :

- 1N ammonium acetate (pH 7.0): Either dilute 57 ml of glacial acetic acid (99.5%) to 800 ml with water containing 70 ml concentrated ammonia solution or dissolve 77.08g ammonium acetate (NH_400CCH_3) crystal in about 800 ml water. Cool and adjust pH to 7.0 with dilute acetic acid or ammonia solution. Make up volume to 1 liter.
- Ethanol, 60%: Dilute 630 ml of absolute alcohol (95%) to 1 liter with distilled water.
- Ammonium chloride crystal
- Magnesium oxide powder (MgO)
- Mixed indicator: Dissolve 0.5 g bromo cresol green and 0.1 g methyl red in 100 ml of 95% ethanol. Adjust the solution to the bluish purple midcolour at pH 4.5 with dilute NaOH or HC1. This indicator is pink at pH 4.2 or lower and bluish green as pH rises to 4.9 and above.
- Boric acid- indicator solution, 2%: Dissolve 20 g boric acid in about 800 ml hot distilled water. Cool, then add 20 ml of mixed indicator and adjust the pH of the solution by dilute NaOH or HCl until the bluish colour of the indicator weakens

toward pink. Make up volume to 1 liter.

- Standard sulphuric acid, O.'IN: Dilute 2.8 rnl of concentrated sulphuric acid to I liter with distilled water and standardize against standard sodium carbonate (0.1 N) using methyl red indicator.
- Methyl red indicator, 0.5%: Dissolve 0.5 g indicator in 100 mi of 05% ethanol.
- Silver nitrate solution, 0.1 M: Dissolve 8.5 g silver nitrate ($AgN03$) in 500 ml distilled water and add 2 ml concentrated HNO_3 to it.

Procedure

- Take 10 g air dry processed soil in a 250 ml conical flask and add 50 ml of 1 N ammonium acetate solution.
- Shake the suspension for an hour and leave it for overnight.
- Filter the content through Whatman No. 42 filter paper fitted on Buchner funnel under suction. Transfer the soil completely to the filter paper.
- Leach the soil with neutral normal ammonium acetate solution for about ten times. Before adding fresh aliquot (20 ml) allow the leachate to be drained out completely.
- Leachate is preserved for determination of individual exchangeable cations.The soil left on the filter paper will be required for CEC determination.
- Wash the soil with 60% ethanol to remove excess ammonium acetate. To be confirmed add a pinch of ammonium chloride to the soil on the filter paper and continue washing until the leachate becomes free from chloride (test with $AgN0_3$).
- Transfer the soil with filter paper to an 800 ml distillation flask; add about 200 ml of water, little liquid paraffin and one spoonful of MgO.
- Distill and collect ammonia by absorbing in 50 ml of 2% boric acid mixed indicator solution taken in a 250 ml conical flask. Collect about 150 ml distillate.
- Titrate the distillate with standard sulphuric acid (0.1N) till pink colour appears.
- Run a blank distillation in a similar way without soil.

Calculations

Say,

Weight of soil taken = W g

Volume of standard sulphuric acid required for sample titration — V_s ml

Volume of standard sulphuric acid required for blank dtiation -$V_B$ml

Strength (N) of standard sulphuric acid - S

Cation exchange capacity, meq/100g = $(V_s - V_B) \times S \times (100/W)$

[As 1000 ml 1 N of any acid or alkali =1 equivalent of any cation

Or 1 ml 1 N of any acid or alkali = 1 milliequivalent of any cation]

Rating

Soil Class on CEC	**CEC** (meq/**100 g soil)**
Low	<10
Medium	10-25
High	25-45
Very high	>45

Result

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.

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EXERCISE NO . 16

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

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) Diphenyl amine indicator: Dissolve 0.5 g of DPA in 100mL of conc. H_2SO_4.
4) Concentrated sulphuric acid : (Note less than 96%)
5) Phosphoric acid H_3PO_4 (85%)
6) Sodium fluoride NaF, (Solid).

Procedure

Transfer without loss 1g of soil sample finely ground and passed through 0.5 mm sieve into 500 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.

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

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.	Vo1. of 0.5 N $FeSO_4$ required for Blank (B)	
6.	Vo1. of 0.5 N $FeSO_4$ required for sample (T)	

Calculations

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

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%

Result

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 ?

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