# Experimental Methods in Soil Analysis

**Useful for UG, PG and Research Scholar of Chemistry, Botany, Zoology, Microbiology, Agriculture, Environmetal Science etc.**


Authors

**Dr. Dasharath M. Chavhan**

**Dr. Kishor P. Suradkar**



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# Preface

Authors has great pleasure to present **Experimental Methods in Soil Analysis** for Under Graduate , Post Graduate and Research Scholar of Chemistry, Botany, Zoology, Microbiology, Agriculture, Environmetal Science etc. soil is made up by organic materials, gases, minerals, liquids and number of microorganisms. All these factors supports to life present on earth. Soil plays important role as plant growth promoter, storage and purification of water. In agriculture field soil analysis is means to test the soil samples to know the various ingredients like nutrients, pH value, water holding capacity, porosity, microbiota, contamination and other physiochemical characteristics.

This book is useful to performed the experiments like porosity test, water holding capacity test, particle density test, determination of pH value, conductivity test, to calculate the percentage of nutrients like phosphorous, magnesium, potassium, nitrogen, Cu, Fe, Zn, Mu etc. Authors have attempted to present subjects matter in most simple, lucid manner but exhaustive way so that it becomes easily understandable.

Authors are very much thankful to all those who helped directly or indirectly to make this book memorable. Authors are grateful to Vidhan Publication Pvt Ltd. for their timely co-operation to publish this book.

For the improvement of this book suggestions are highly appreciated from the various stakeholders.

**Authors**

# Content

# THE SCOPE OF AGRICULTURAL CHEMISTRY

There are the three main objects of agricultural chemistry ie. Fertilizer, Soil and Plant. These objects are interconnect to each other. The interrelation of these objects is suggested by Russian scientist Prayaniskov, which is called as Prayniskov triangle. (Fig.1)

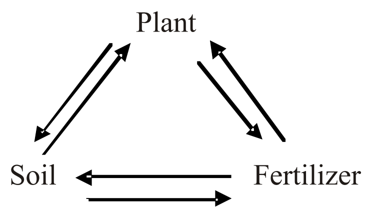



Fig.1- Prayniskov triangle

When studying the relation between the plants, soil and fertilizers all climatic factors should be consider. Use of fertilizers enhances the availability of nutrient in soil but it change the chemical and physical properties of the soil. Upgrading of inorganic nutrition enhance the rate of photosynthesis which brings the positive effect on plants growth. Fertilizers improves soils texture and physical properties which make the soil more fertile. Plants construct its own mass by using water, carbon Dioxide and Inorganic nutrients from soil. Plants root exudates convert the chemical compounds into useful forms.



In India agriculture field is widely affected by various factors like climate, soil topography, rainfall, soil erosion, temperature etc. To improve the total yield farmers should aware about following factors

a. Status of soil components
b. Status of Water availability
c. Nutrient requirements to the crop
d. Weather conditions

### Major Soil Types Occurs In India

Table: 2 Major soil types found in India

| Sr. No. | Soil type | Formation | Ingredients/ Fertility | Region |
|---|---|---|---|---|
| 1. | Mountain and hill soils (Forest soils) | - | Rich in organic matter (humus) but poor in potash | Northern hilly regions of the Himalayas. Central Indian HILLS, Western and Eastern Ghats |
| 2. | Alluvial Soils a) Khaddar b) Bangan | Very fine and new alluvium relatively coarse and old alluvium | Most Fertile Comparatively less fertile | Great-Northern Plains of India and Deltas of rivers in Peninsular India |
| 3. | Black Soils (regur or black cotton Soil ) | Volcanic Rocks of lava flows | Fertile clay sol | Deccan trap Region -Maharashtra, part of Madhya Pradesh, Gujrat, Tamilnadu |
| 4. | Red Soils | Developed on crystalline rocks specially under the moderate to poor rain fall condition in peninsular India | Comparatively less fertile and deficient in nitrogenous and organic matter | Plateaus of kerala, Tamilnadu, Karnataka, Andhra Pradesh, Orisa, Southern Bihar etc. |

| Sr. No. | Soil type | Formation | Ingredients/ Fertility | Region |
|---|---|---|---|---|
| 5. | Laterite soils | They are typical of the tropical rainy climate and are developed as a result of leaching | Invariably poor but support pastures and scrub forests | Western Ghats, Chhota Nagpur, Tamil Nadu, Assam, Orisa, Andhra Pradesh, Kerala |
| 6. | Desert Soils | Sand and Windblown loess | Arid Sandy Soils Humus and moisture content is low. | Western Rajasthan Southern Punjab,Haryana |

## Recommendation Based On Soil Testing

Table: 3 showing standard value of parameter of soils.

| Levels | Organic 'C' | Available Nutrient in Soil | | | Fertilizer Doses Per Hector |
|---|---|---|---|---|---|
| | | N | P | K | |
| Very low | >0.20 | >140 | >7 | >100 | 50% more for recommended |
| Low | 0.21-0.40 | 141-280 | 8-14 | 101-150 | 25% more for recommended |
| Medium | 0.41-0.60 | 281-420 | 15-21 | 151-200 | Recommended as it is |
| Moderately High | 0.61-0.80 | 421-560 | 22-28 | 201-250 | Recommended dose as it is |
| High | 0.81-1.0 | 561-700 | 29-35 | 251-300 | 25% less for recommended |
| Very high | <1.0 | < 700 | <35 | < 300 | 50% more for recommended |



## Experiment No.1

Aim-Report writing of visit to Soil Testing Laboratory

Name of Soil Testing Laboratory-

Place -

Monitoring Body- Goveoment/Semi-Government/Private/NGO

Date of Visit-

Reports details-

Collecting and maintenance authority-

Technology used for storage-

Water Sources-

Reagents preparation and its Storage Methods -

Details of chemical parameter analyzed-

Details of Physical Parameter analyzed-

Method used for report preparation -

## Experiment No. 2

**Aim-**Visit to Farmers Fields for collection of Samples, Identification of nutrient deficiency symptoms in crop.

Name of Farmer_____________________________________________

Farm Size ______________________ Survey/Gat No. ____________

Permanent Address ________________________________________

________________________________Date _____________________

Region/Area ___________________ Location _________________

Sample Collected by _____________ Sample Id number __________

Water Source ___________________ Water PH _________________

Sample Depth __________________ Previous Crop _____________

Plot Size ______________________ Crop Height _______________

Leaf Color ____________________ Growth __________________

Nutrients Deficiency ______________________________________

Symptoms observed _______________________________________

Any other information collected from Farmer __________________

_________________________________________________________

_________________________________________________________



## Experiment No.3

**Aim-** Methods for different Chemical reagents preparation for soil testing

1. EDTA Solution 0.01 N:- Take 2.0 gm of versanate dissolved in distilled water and make volume upto 1 litre. Titrate it with 0.01 N calcium solution by the procedure discussed below and make necessary dilution so that its normality is exactly equal to 0.01N
2. Sodium Hydroxide 4N:-Prepare 16% soda solution by dissolving 160 grams of pure sodium hydroxide in water and make volume to 1 litre. This will give pH 12
3. Sodium Chloride Standard solution:-Dissolve 5.845 gm of sodium chloride in distilled water and make volume to one litre
4. Barium Chloride 5%:-25 gm of of BaCl2 is dissolved in distilled water and make volume to 500 ml.
5. Standard Sulphuric acid 0.05N:-Take 1.4 ml of concentrated sulphuric acid(36N) with automatic pipette and dilute to one litre with distilled water
6. 0.01M KCl:-0.7456gm of KCl is dissolved in double distilled water and make volume to one litre.it gives electrical conductivity of 1.413 mmhos/cm the instrument is calliberated with this solution.
7. Standard 0.01N Calcium Solution:-Take 0.50 gm of pure calcium carbonate and dissolve it in 10 ml of 3 HCl. Boil to expel $CO_2$ and then make the volume 1 litre with distilled water.
8. 0.05N Sodium Chloride:-2.935 gm of NaCl is dissolved in distilled water and make the volume to one litre.
9. 0.05N Silver Nitrate:-Dissolve 8.494 gm of $AgNO_3$ in distilled water and make the volume upto 1 litre. Standardise it against NaCl Solution(0.05N) and keep it in amber colored bottle away from light
10. Buffer solutions pH 4.0,7.0 or 9.2 :-Take the buffer tablet s of successive pH dissolved in freshly prepared doubled distilled water and make the volume of 100 ml
11. Ammonium chloride Ammonium hydroxide Buffer:-Dissolve 67.5 gm of ammonium chloride in 570 ml concentrated ammonia and make to one litre

12. Sodium cynide solution 2% or sodium diethyl dithiocabonate crystals:-This is used to remove the interference of copper, cobalt and Nickel.
13. Sodium Diethyl Dithiocarbamate Crystals:-Used to remove the interference of other metal ions
14. Eriochrome black T Indicator:-Take 100 ml of ethaol and dissolve 4.5 gm of hydroxyl amine hydrochloride in it. Now add 0.5 gm of the indicator and prepare solution. Hydroxyl amine hydrochloride remove the interference of manganese by keeping it in lower valancystate($Mn^{-}$) or mix thoroughly 0.5 gm of the indicator with 50 gm of ammonium chloride.
15. Murexide Indicator Powder:-Take 0.5 gm of murexide also known as ammonium purpurate and mix it with 40 gm of powdered Potassium sulphate. This indicator is not stored in the form of solution as it gets oxidized.
16. Potassium Chromate ($K_2CrO_4$) Indicator 5% Solution:-Dissolve 5 gm of $K_2CrO_4$ in about 75 ml distilled water and add a saturated solution of $AgNO_3$dropwise until a slight permanent red precipitate is formed. Filter and dilute to 100 ml.
17. Methyl Orange Indicator 0.5%:-Dissolve 0.5gm dry methyl orange powder in 100 ml of 95%of ethanol.
18. Phenolphthalein Indicator 0.25%:-Dissolve 0.25 gm of pure phenolphthalein powder in 100 ml of 60% ethanol



## Experiment No.4

**Aim-** Sample processing for soil analysis

Soil compositions is varies from region to region that's why samples should be collect in such a way that it is fully field representative. Samples should be collect from the depth of 10-30 cm below the soil surface. To collect the soil samples tools required are soil auger, clean bucket or tray or cloth or cloth bag of specific size. Pen or pencil and paper tag/sheet to write the soil details and to attach it on collected sample.

**Methods of Sampling-**

1. Select the region and marked the boundaries for sample collection.
2. Take the soil from surface layer from marked area. Obtain a uniformly thick slice of soil from the surface to the plough depth from each marked place
3. Made a V-shaped cut with a spade to remove 1 to 2 cm piece of soil and put in a clean bucket or bag prepared for sample collection.
4. Collected soil pour on a piece of clean paper or cloth and mix thoroughly.
5. Spread the soil evenly and divide it into four quarters.
6. Reject the opposite quarters and mix the rest of the soil again.
7. Repeat the procedure till left with about half kg of the soil, collect it and put in a clean cloth bag.
8. Marked each bag for sample identification. The bag used for sampling must always be clean and free from any contamination.
9. Write the details of the soil sample in the information sheet for further use.
10. Put a copy of this information sheet in the bag. Tie the mouth of the bag carefully.
11. Use the sample for testing or analysis.

## Experiment No.5

**Aim-** To Determine the pH of soil sample by pH Meter

Acidic or basic nature of soil is depends on the concentration or activity of $H^+$ ions or $OH^-$ ions. According to theory of dissociation or ionization of compounds into ions, the grater the degree of ionization the greater is the activity of ions. Pure water also show slight conductivity due to dissociation

$$H_2O \longrightarrow H^+ + OH^-$$

The result of dissociation of the two ions is a constant as represented by the equation.

$$K_w = [H^+][OH^-] = 10^{-14}$$

$K_w$ is the ionization constant for pure water at $22^0$ c.

Danish scientist Sorensen gives the term pH value and it is defined as the negative logarithm or reciprocal logarithm of $H^+$ ion activities or concentration by the equation.

$$pH = \log 1/H^+ = -\log_{10}[H^+]$$

'P' stands for log & 'H' stands for Hydrogen ion activity.

The soil and water ratio generally used in the determination of pH is of 1:2.5.

pH is the most important characteristic of soil. Whether it is basic or acidic has much to do bonding of ions on exchange area and activity of different microbes. Availability of nutrients is influence by soil pH. The ideal pH range for availability of nutrients are particularly informative. pH less than 4 indicates the presence of free acids generally from association of sulphides. pH below the 5.5 suggest the good presence of exchangeable Al. pH ranges from 7.8 to 8.2 indicates existence of $CaCO_3$.

**Apparatus:-**pH Meter, Beaker, Measuring cylinder, Glass electrode

**Chemicals:-**0.1N KCl, Distilled Water, Buffer solution with pH=4, 7, 9



**Method:-**

1. Take 20 g of soil from collected sample and mixed with 40 ml distilled water in 1: 2 ratios.
2. Stirred the suspension intermittently with magnetic stirrer for 30 minutes and kept for one hour.
3. Insert the electrode into the supernatant and record the pH.
4. Wash the electrode with distilled water every time to record the new reading of the soil sample.

**Observation Table:-**

| Sample No./Id | Observed pH | Nature of soil |
|---|---|---|
| 1 | | Acidic/Basic |
| 2 | | Acidic/Basic |
| 3 | | Acidic/Basic |
| 4 | | Acidic/Basic |

**Result:-** pH of soil samples is____________________________

hence nature of soil given soil is___________________

## Experiment No.6

**Aim-** To determine the conductivity of soil by using electric conductivity meter.

Conductivity of soil is the determination of the capability of a soil solution to carry an electric current. The current flow in a conductor is directly proportional to the applied electromotive force and inversely proportional to the resistance (ohms) of the conductor. EC of water extract of soil gives a measure of the soluble salts content of the soil.
The conductivity is determined by electrical resistance between extract. In such system, the solution between the electrodes becomes an electrical conductor to which the electrical resistance(R) is directly proportional to the distance (L) between the areas (A) of the conductor. Thus,

$$R = r\ L/A$$

Where 'r' is a proportionality constant known as the electrical resistivity, the value is depend on the nature of the conductor. The units of 'r' are ohm/cm. To report the electrical conductivity measurement $25^0$c is standard temperature.
**Apparatus:-** Conductivity Meter, Electrode, Beaker, Measuring cylinder
**Chemicals:-** 0.01M KCl, Distilled Water
**Method:-**
1. Crushed the 10 g of dry soil sample (< 0.2 mm) of each type were mixed with 50 ml of deionized water in a bottle to make 1:5 ratio (w/v) slurry.
2. Shake the mixtures thoroughly for complete dissolution of soluble salts.
3. Allowed the soil to settle down and then insert the conductivity cell to take the readings.

**Observation Table:-**

| Sample No. | Observed E. C. |
|---|---|
| 1 | |
| 2 | |
| 3 | |
| 4 | |

**Result:-** Electrical conductance of given soil samples is observed

__________________m mho/cm

## Experiment No.7

**Aim-** Wet Oxidation Method for Determination of Organic Carbon Soil possesses 48-58 % of organic carbon among its total organic matter. Hence determination of organic carbon is often used as a basis for organic material estimation by multiplying the organic carbon value by a factor. The Varibemmelen factor of 1.724 has been used from many years based on the assumption of soil contain 58 % organic carbon in its organic part. Recently research suggested that organic carbon concentration factor of organic matter is 1.9-2.5 for surface and sub soil. The organic Carbon present in organic material is oxidized by known excess chromic acid ($K_2Cr_2O_7$+$H_2SO_4$). This excess chromic acid cannot reduce by organic matter is determined by back titration with standard FeSO4 solution (Redox Titration) with ferroin indicator. In normal soil nitrogen content is less than organic carbon, ideal ratio of organic carbon to total nitrogen is 10:1

**Apparatus:-**500 ml Conical Flask, Sieve, Measuring Cylinder, Burrete, Pippete.

**Chemicals:-**1 N Potassium Dichromate,Conc. $H_2SO_4$, Orthophosphoric acid,Diphenylamine indicator,ferrous ammonium Sulphate (FAS)

**Method:-**

The quantity of organic carbon of the soil can be estimated by the method given by Walkey and black (1934).

1. 1g finely ground soil passed through 0.5 mm sieve without loss and take into 500 ml conical flask, the add 10ml of 1 N Potassium Dichromate and 20 ml Conc. $H_2SO_4$ measuring cylinder.
2. Shake the contents for a minute and allowed to set aside for exactly half an hour.
3. Then add 200 ml distilled water, 10 ml Orthophosphoric acid and 1 ml Diphenylamine indicator.
4. Titrate the solution against standard ferrous ammonium Sulphate (FAS) or ferrous Sulphate, till color flashes from blue violet to brilliant green. Before this perform one blank titration without soil.



**Observation Table**

| Sr. No. | Volume of sample (ml) | Burette Reading | Constant Reading |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |

**Calculation:-**

1. Weight of soil taken =Wg
2. Volume of 1N Potassium Dicromate added =10ml
3. Volume of 0.5 N FAS required to neutralize10ml of 1N PoassiumDicromate solution (blank without soil) =Bml
4. Volume of 0.5 N FAS required for soil = Tml
5. Volume of 1N H2Cr2O7 solution used for the oxidation of Organic carbon present in the soil samples =10(B-T)

The organic carbon content (in%) of the soil was calculated as follows

$$\text{Organic Carbon\%} = \frac{10(B-T)}{B} \times 0.003 \times \frac{100}{\text{wt. of soil(g)}}$$

**Result**:- The percentage of organic carbon in given soil sample is

found_______________%

## Experiment No.8

**Aim-** Nitrogen determination from given soil sample

Plants require three major nutrients ie. Nitrogen (N), Potassium (K) and Phosphorus (P). Out of these major nutrients, plants require Nitrogen in the largest amounts. Nitrogen helps to promote the rapid growth and development because of Nitrogen is constitute of amino acids which plays important role in protein synthesis.

**Availability of Nitrogen in soil:**

There are three major forms of nitrogen in soil.

1) Soluble inorganic ammonium and Nitrate-Nitrogen.
2) Ammonium Nitrogen fixed by certain clay minerals
3) Organic Nitrogen associated with soil humus

In soil nitrogen is mostly associated with organic materials. In this condition it is protected from microbial release. In normal condition only 2to 3 percent can be mineralized per year.

Near about fifty percent of organic nitrogen is considered for amino compounds formation.

Inorganic nitrogen occurs in the soil in the form of ions such $N_2O$, NO, $NO_2$, $NH_3$ which give rise to $NH_4^+$, $NO_2^-$, and $NO_3^-$ respectively. The ability of soil of nitrogen supply can be determined by distilling soil with alkaline Potassium Permagnate solution. Utilizable and amino- N hydrolyzed Nitrogen liberated as ammonia after the distilling. This can be indicate the nitrogen status of soil.

**Reaction:-**

1. $2\,KMNO_4$……………..$K_2O + 3O$ (Nascent oxygen)
   The oxygen evolved from the $KMNO_4$ Oxidizes the organic matter.
2. Organic matter + 3O……………….. $R\text{-}NH_2$(Amines)
3. $R\text{-}NH_2 + H_2O$ …………. $R\text{-}OH + 3\,H_2O$
4. $NH_4OH + H_2O$ …………. $NH_4OH$
5. $H_3BO_2 + 3\,NH_4OH$ ---------- $(NH_4)_3BO_3$
   green colour during absorption

**Apparatus:-**Round bottom flask, Conical flask, Burette, Pipette, beaker

Chemicals:-Potassium Permagnate, Sodium Hydroxide, Baric acid, Distilled Water,

$H_2SO_4$ 0.02 N



**Methods:-**

1. Take 20 % of sieved soil into a litter round bottom flask
2. Add distilled water with the help of jet in such a way that the particle of soil does not remain stuck to the side of flask.
3. Add 2 to 3 glass beds to prevent bumping & 1 ml of liquid paraffin to prevent frothing.
4. Add 100 ml Potassium Permagnate of Sodium Hydroxide solution to the flask.
5. Distil & Collect the distillate in a beaker contain 20 ml of baric acid working solution.
6. Take approximately 150 ml of distribute
7. Titrate the distillate with standard $H_2SO_4$ 0.02 N till the colour changes from green to red and record the burette reading.
8. Take one blank Titration without soil. Ammonium borate formed is further titrated with standard $H_2SO_4$.

**Observation Table**

| Sr. No. | Volume of sample (ml) | Burette Reading | Constant Reading |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |

**Calculation:-**

Calculate the available nitrogen by using following formula,

$$\text{Percentage of available N} = (A-B) \times (\text{N of acid}) \times 0.014 \times \frac{100}{\text{Wt. of soil(g)}}$$

$$\text{Available nitrogen (Kg/hec)} = \%N \times \frac{2240000}{100}$$

Where,

1. Wt. of soil sample - Wt.
2. Volume of std. acid required for soil - A ml
3. Volume of std. acid required for blank - B ml.
4. Normality of Sulphuric acid.

**Result:-** Available nitrogen in given soil sample is

___________________ kg/hec

## Experiment No.9

**Aim-** Available phosphorus determination from soil sample.

In soil phosphorus present as orthophosphate in various form and combinations. Only small amount may be available to plants which is direct relevance in determination of Phosphorus fertility status of soil. Without phosphorus plants cannot achieve the normal growth. Phosphorus is a main constituent of nucleic acids, phospholipids, the coenzymes DNA and NADP, and most importantly ATP.

Following are some factors influencing phosphorus in soils are;

**1) Clay type:** Soil containing large amount of clay (high in kalonite clay) will retain more phosphorus (P) than other type of soil.

**2) Soil reactions:** Ideal phosphorus availability in most of the soil is at pH ranges from 5.5 to 7.0. Changes in this pH values decreases the availability of phosphorus.

**3) Temperature:** Soil from temperate region fixes more phosphorus. Soil from warmers environment possesses higher contents of the hydrous oxides of Fe and Al.

**4) Organic matter:** Organic materials enhance the quality of soil and added phosphorus. Decomposition of organic matter is accompanied by the evolution of appreciable quantities of $CO_2$.

**5) Time of reaction:** If the added phosphorus remains in soil for long duration it will enhance the process of phosphorus fixation.

**Apparatus:-**150 ml Erlenmeyer flask, Electrical shaker, Calorimeter

**Chemicals:-**0.5 M $NaHCO_3$, 20 % NaOH, Olsen's reagent, Whatman filter paper (No.41)., 1: 4 $H_2SO_4$, Paranitrophenol as indicator, stannous oxalate.

**Methods:-**

Available phosphorus can be estimate by Olsen's method (Olsen, *et al.*, 1954).Modified by Watanbe (1965).

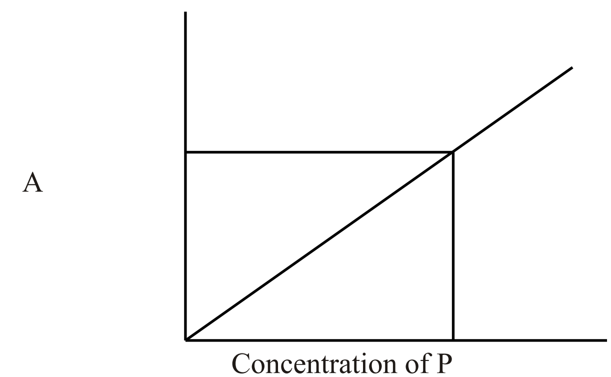
1. Prepare the reagent for Olsen's P 0.5 M $NaHCO_3$ (pH 8.5) by dissolving 42 g $NaHCO_3$ in distilled water and made up to 1 lit. The pH was adjusted at 8.5 with 20 % NaOH solution.
2. Weighed 2.5 g of air dried soil and pour into 150 ml Erlenmeyer



flask, added 50 ml of Olsen's reagent (0.5 M $NaHCO_3$ Solution , pH 8.5) and one teaspoonful of activate charcoal.
3. Shake the flasks for 30 minutes on the electrical shaker and filter the contents immediately through Whatman filter paper (No.41).
4. Pipette out 5 ml of the filtrate into 25 ml of volumetric flask and neutralized with1: 4 $H_2SO_4$ using Paranitrophenol as indicator.
5. Make the volume by adding distilled water. Color developed when few crystals of stannous oxalate were added.
6. Shake the solution well and read the intensity of blue color in photoelectric calorimeter within 10 min. at wavelength of 730 to 840 µm. Run a blank without soil.

***Standard curve**:*

Dry analytical grade ($KH_2PO_4$) Potassium Dihydrogen Orthophosphate in hot air oven at 60 C for 60 minutes and cool it. Dissolve 0.439 gm $KH_2PO_4$ in 500 ml of distilled water. Add 25 ml of 7N $H_2SO_4$ and make up volume to 1000 ml with distilled water. This called 100 ppm standard stock solution of $KH_2PO_4$. Prepare 2ppm solution by diluting this stock solution. For the preparation of standard curve take different concentrations of P 0,2,4,6,8 and 10 ml of 2 ppm P solution in 25 ml volumetric flask separately, which corresponds to 0, 0.16, 0.32, 0.48, 0.64 and 0.80 ppm P respectively. Add 0.5 ($NaHCO_3$) to these 5ml of the extracting reagent to each flask and adjusted pH as above. Dilute the content with 20 ml water and 4ml reagent (Dickman and Brays reagent). Make up the volume and read the intensity of blue color in photoelectric calorimeter using 730- 840 m filter or using red filter (660nm). Construct the graph by plotting reading on X-axis and concentrations of P on Y-axis.



Concentration of P 0.32

Factor (F) = ---------------------------------- = -------- = 0.01

Corresponding reading of 30

Above concentration

= 1 Calorimeter reading =0.01 ppm(P) phosphorus

***Calculations:-***

The amount of phosphorus can be estimated by using formula,

*Total volume of extract 1*

*P(ppm in soil) = ppm P in aliquot x ------------------- x --------------(RxF)*

*Aliquot taken (ml) Wt. of soil (g)*

*P (Kg/ha) = ppm P in soil x 2.24*

*$P_2O_5$ (Kg/ha) = P (Kg/ha) x 2.29*

*Conversion factors = P x 2.29 = $P_2O_5$*

*P = $P_2O_5$ x 0.437*

**Result: -** The amount of available Phosphorus in given soil samples

is ______________________ ppm



## Experiment No. 10

**Aim-** Determination of the available percentage of Potassium from given soil sample

Available potassium in given soil sample can be determine by using Flame photometer.

it works on the measurement of the intensity of characteristic line emission provided by the element to be determined. the salt gets separated into its component atoms when sprayed into a flame due to the high temperature. The energy comes from flame excite the atoms to high level of energy. Intensity of radiation is proportional to the concentration of elements in the particular solution measured by flame photometer.

**Apparatus and Reagent**

1. Flame Photometer
2. Volumetric flask (100 ml)
3. Standard solution of Potassium Chloride

   Take 191 mg of KCl salt and dissolve in distilled water and make up the volume upto 1000ml. This is called 100 ppm or mg/Litre K stock solution. Pipette out 0,2,4,6,8 and 10 ml of 100 ppm of K into 100 ml volumetric flask and dilute up to the mark.

**Procedure :**

1) Take 25 ml of NH4OAC extracting solution to a conical flask containing 5 gm air dry soil sample.
2) Put on reciprocating shaker at 200 to 220 oscillations per minute for 5 min and then filter.
3) Determine potassium as indicated in preparation of standard curve.

**Observation Table :**

| Sr. No. | Sample No./Id | Reading on flame photometer for potassium | Potassium in ppm |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

**Calculation :**

K (ppm) = Reading from graph µg K / ml in extract (R) x 5 x Dilution Factor (Df)

K (kg/ha) =Reading from graph µg K / x Aliquot used 25 ml
ml in extract (R) Soil used 5 g
x 1 Kg soil 1000 g x 1
1 1000 to convert µg into mg
x 1 x 1
1000 to convert mg to g 1000 to convert gm to Kg

x wt of soil 2240000 kg/ha x Dilution Factor (Df)
1

K (kg/ha) = R x (25/5) x (1000/1) x (1/1000) x (1/1000) x (1/1000) x (2240000/1)

= R x 5 x 2.24 x Dilution Factor (Df)

$K_2O^+$ (kg/ha) = R x 11.20 x 1.2

To convert K to K2O multiplied by 1.2 and to covert K2O to K multiply by 0.83.

**Result**

| | |
|---|---|
| Very low | Less than 120 |
| Low | 121 – 180 |
| Moderate | 181 – 240 |
| Moderately high | 241 – 300 |
| High | 301 – 360 |
| Very high | Above 360 |



## Experiment No. 11

**Aim:-** To Determine the calcium carbonate from given soil sample.

**Apparatus:-** Glass beaker 100 ml.,Conical glass flask 250 ml.,Glass funnel,Volumetric flask (100 ml),Erlenmeyer flask (150 ml)

**Chemicals:-**

1) Hydrochloric acid (1N HCL) : Dissolve 89 ml of conc. HCL in distilled water and make upto 1000ml.
2) Hydrochloric acid (0.2N HCL) : Take 25 ml of 1N HCL and dilute it up to 100 ml.
3) Sodium hydroxide (0.2N) : Dissolve 8.0 gm of sodium hydroxide in distilled water and make up the volume upto 1000 ml.
4) Potassium hydrogen phthalate (0.2N) : Dissolve 4.084 gm of KHP in distilled water and make up the volume upto 100 ml.

**Procedure:**

1) The primary tests can be carried out on soil to know the amount of carbonate present from the degree of effervescence with dilute acid.
2) On the basis of the degree of effervescence the soil is taken for analysis as per the following table.

| Degree of effervescence | Weight of air dry soil (g) W |
|---|---|
| No effervescence | 10.0 to 20.0 |
| Moderate | 5.0 |
| Fairly vigorous | 2.0 |
| Vigorous to very vigorous | 1.0 |

3) Take (W) g air dried soil of 0.5 mm sieve to a 250 ml plastic conical flask and carefully add 25 ml of 1N HCl down from the side of the flask. Place a watch glass on it and wait for 60 minutes.
4) Take the mixture in a 100 ml volumetric flask and make up the volume by distilled water. Filter it by filter paper.
5) Take Erlenmeyer flask of 150 ml and add 20 ml of the clear liquid into it and add some amount of distilled water and heat upto the boil then cool it.

6) Add few drops of bromothymol blue and titrate with 0.2 N NaOH till blue color persists for 30 seconds.
7) Prepare the blank by taking 25 ml 1N HCL in 100 ml volumetric flask and diluting with distilled water. Take 20 ml of this solution as a blank for titration with 0.2N NaOH.
8) 10 ml of 0.2N NaOH titrate with 0.2N KHP using phenolphthalein indicator and determine the factor of NaOH.

**Observation Table :**

| Sr. No | Sample Id. | Reading1 (Blank) | Reading 2 Burette (Sample) | Diffe-rence | Std. HCl in ml. | % CaCO3 |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |
| | | | | | | |

**Calculations:**
Let W be the moisture corrected weight of the soil in gm.
'T' is the volume in ml of the titration with 0.2 N sodium hydroxide.
Since 20 ml of liquid, after reaction with soil contains excess acid equivalent to "T" ml of 0.2N NaOH, so 100 ml contains T ml of 1N excess acid.
Thus, the acid neutralized in reaction with the soil is (Blank – T) ml of 1N.
Thus W gm soil contains 0.05 (Blank – T) gm calcium carbonate.

$$CaCO_3\ \%\ \text{in soil} = \frac{5(\text{Blank-T})}{W} \times F$$

Where,
F = factor of 0.2N NaOH and
W = wt. of air dry soil after correcting the moisture percentage.

$$F = \frac{\text{Exact normality of NaOH}}{0.2}$$

This may be reported as an apparent $CaCO_3$ % or as a neutralizing value.



Schrotus Apparatus Method :
Apparatus:-Glass Beaker, Conical Flask, Glass Funnel, Erlenmeyer Flask
Chemicals:- 3 N Hydrochloric acid
Procedure:-
Take 10 ml of HCL Hydrochloric acid into 50ml Erlenmeyer flask. Take the weight of Erlenmeyer flask with cork stopper. Take 1 to 10 gm of soil to the flask, after effervenscence loose the stopper. Reaction will be complete in two hours the carbon dioxide will be seen in the flask with air and weight the flask with the stopper.

**Calculations**
Wt. of $CO_2$ lost = (Initial wt. of flask + acid + soil) – ( Final wt. of flask + acid + soil)

**Ratings :** Percentage of $CaCO_3$

**Procedure:-**
Take 10 ml of HCL Hydrochloric acid into 50ml Erlenmeyer flask. Take the weight of Erlenmeyer flask with cork stopper. Take 1 to 10 gm of soil to the flask, after effervenscence loose the stopper. Reaction will be complete in two hours the carbon dioxide will be seen in the flask with air and weight the flask with the stopper.

**Calculations :**
Wt. of $CO_2$ lost = (Initial wt. of flask + acid + soil) – ( Final wt. of flask + acid + soil)

**Ratings :** Percentage of $CaCO_3$

| Sr.No. | Value | Rating |
|---|---|---|
| 1 | Less than 1 | Low |
| 2 | 1-5 | Medium |
| 3 | 5-10 | High |
| 4 | 10-15 | Very High |

## Experiment No.12

**Aim:-** To Determine the lime requirement of soil.

The amount of lime required to acquire the desired pH value of soil is called as lime requirement of soil. There are so many methods to measure the lime requirement of soil. Out of which the best method is involves the use of hydroxide in serial potentiometric titration with calcium hydroxide using glass electrode.

Chemicals:- Calcium Hydroxide Solution.— prepare the solution by dissolving approximately 1.5 grams of reagent grade calcium hydroxide in 1000ml distilled water. Mixed the solution and allowed to precipitated the excess calcium hydroxide. Determine the normality and pH of saturated solution of calcium hydroxide and record it. Standard normality of solution is approximately 0.04.

**Procedure:**

1. Take 10 gm of soil sample into 41/4-ounce paper cups.
2. Add 25 ml distilled water and 2.5ml 0.04 normal calcium hydroxide solution to each soil sample.
3. Stirred the soil sample thoroughly and keep to stand approximately 24 hours and then stirred again.
4. Determine the pH of samples after 48 hours the add calcium hydroxide solution with calibrated automatic vial filler to bring, with each stroke of the filler, a volume of solution that is equivalent to 1000 pounds of pure calcium carbonate per acre.
5. The number of increments of calcium hydroxide in the titration is depend on various factors like the initial soil reaction, the soil reaction desired, the crop that is to be produced, and the soil texture.
6. Increments of calcium hydroxide in the soil sample, calcium carbonate equivalents, and conversions of agricultural limestone used to interpret the outputs occurs in estimating the lime requirement of a soil are given in Table 1.



**TABLE l.-** Increments of calcium hydroxide in the soil sample, calcium carbonate equivalents, and conversions of agricultural limestone used to interpret the outputs occurs in estimating the lime requirement of a soil

| Sr. No. | Increments of 0.04N $Ca(OH)_2$ Ml. per 10 g. soil | CaCO3 Equivalent[1] Pounds per acre | Agricultural Limestone Conversions[2] Pounds per acre |
|---|---|---|---|
| 1 | 2.5 | 1,000 | 2,000 |
| 2 | 5.0 | 2,000 | 4,000 |
| 3 | 7.5 | 3,000 | 6,000 |
| 4 | 10.0 | 4,000 | 8,000 |

[1]Values shown are based on reagent-grade calcium hydroxide and calcium carbonate

[2]Values are calculated from calcium carbonate equivalents, assuming that agricultural liming materials are 50 per cent as effective as pure calcium carbonate.

Remarks: this method is not considered as rapid method know the lime requirement of the soil, because it takes approximately three day to complete reactions. Near about 97 percentage of the complete reaction can be process in three days true equilibrium can be attain after 5-7 days.

## Experiment No.13

**Aim:-** To Determine the Gypsum Requirement of Soil

If alkali soil treated with the known amount of excess saturated gypsum solution can determine the gypsum requirement of soil. Gypsum requirement of soil can be determine by the Versenate method given by Schoonover (1952).

**Apparatus:-** Mechanical shaker.

**Chemicals:-**

Saturated gypsum solution : Add 5 g of chemically pure $CaSO_4.2H_2O$ to 1000 ml distilled water. Shake vigorously for 10 minutes by using a mechanical shaker and filter through Whatman No. 1 paper.

0.01N $CaCl_2$ solution : Take 0.5 g of AR grade $CaCO_3$ and dissolve in 10 ml of 1:3 diluted HCl. After completely dissolved, transfer to 1000ml volumetric flask and make up the volume by distilled water. $CaCl_2$ salt being highly hygroscopic should not be used.

0.01N Versenate solution : Take 2.0 g EDTA-disodium salt and 0.05 g of magnesium chloride (AR) dissolve in 50 ml of water and dilute upto 1000 ml. performed the titration against 0.01N $CaCl_2$ solution to standardize.

Erichrome black T indicator : Take 0.5 g of EBT dye and 4.5 g of hydroxylamine hydrochloride dissolve in 100 ml of 95% ethanol and keep in a stoppered bottle or flask.

Ammonium hydroxide - ammonium chloride buffer : Take 67.5 g of pure ammonium chloride and dissolve in 570 ml of concentrated ammonia solution and dilute up to the 1000ml. By using dilute HCl or dilute $NH_4OH$ adjust the pH value at 10.

**Procedure :**

1. Take 5 g of air dry soil in 250 ml conical flask.
2. Then add 100 ml of the saturated gypsum solution and shake for 5 minutes. Filter it through
   Whatman filter paper No. 1.
3. Take 5 ml filtrate into a 100 or 150 ml porcelain dish and add 1 ml of the ammonium hydroxide – ammonium chloride buffer solution and 2 to 3 drops of Erichrome black T indicator.



4. Take 0.01N versenate solution in a 50 ml burette and titrate the contents in the dish and observe the the wine red colour starts changing to sky blue.
5. Titrate a blank by using using 5 ml of the saturated gypsum solution

**Calculation:-**

Ca or Ca+Mg (me/L) in the aliquot = 2 V

Where, V stands for volume of versenate solution used.

Since, 1 litre extract = 50 g soil (5 g soil to 100 ml)

Ca retained (or Ca requirement) in me/100 g soil

= [2V for added gypsum solution – 2V for filtrate] x 2 ….. (A)

Gypsum requirement of soil in tons per hectare upto 30 cm soil depth

= A x 3.852

Apply correlation depending on purity of gypsum.

## Experiment No.14

**Aim:-** Test report preparation, result interpretation and recommendation of fertilizer

Name of Institute /Laboratory ________________________________

Sample Id/No. ______________________ Date _________________

### Soil Analysis Report

| Sr No. | Parameter/Perticulars | Test Value | Unit | Rating |
|---|---|---|---|---|
| | **Chemical** | | | |
| 1 | pH value | | | |
| 2 | Organic Carbon (OC) | | | |
| 3 | Available Nitrogen (N) | | | |
| 4 | Available Phosphorus (P) | | | |
| 5 | Available Potassium (K) | | | |
| 6 | Available Sulphur (S) | | | |
| 7 | Available Zinc (Zn) | | | |
| 8 | Available Boron (B) | | | |
| 9 | Available Iron (Fe) | | | |
| 10 | Available Manganese (Mn) | | | |
| 11 | Available Copper (Cu) | | | |
| 12 | Available Calcium (Ca) | | | |
| 13 | Available Magnecium (Mg) | | | |
| 14 | Carbonate | | | |
| 15 | Bicarbonate | | | |
| | **Physical** | | | |
| 1 | Percentage of Sand | | | |
| 2 | Percentage of Slit | | | |
| 3 | Percentage of Clay | | | |
| 4 | Percentage of Moisture | | | |
| 5 | M.W.H.C. | | | |
| 6 | Partical Density | | | |
| 7 | Bulk Density | | | |
| 8 | Porosity | | | |

Test by........................ Verified by.......................



## Experiment No.15

**Aim:-** To prepare soil fertility maps and soil test summaries. Recommendations Of Secondary & Micro Nutrients

### Recommendations Of Secondary & Micro Nutrients

| Sr No. | Parameter/ Nutrients | Recommendation for Soil Application |
|---|---|---|
| 1 | Sulphur (S) | |
| 2 | Zinc (Zn) | |
| 3 | Boron (B) | |
| 4 | Iron (Fe) | |
| 5 | Manganese (Mn) | |
| 6 | Copper (Cu) | |

General Recommendations

| | | |
|---|---|---|
| 1 | Organic Manure | |
| 2 | Biofertiliser | |
| 3 | Lime / Gypsum | |

### Fertilizer Recommendations For Reference Yield (With Organic Manure)

| Sr.No. | Crop & Variety | Reference Yield | Fertilizer Combination-1 for N P K | Fertilizer Combination-2 for N P K |
|---|---|---|---|---|
| 1 | Cotton | | | |
| 2 | Jawor | | | |
| 3 | | | | |

Prepared by.................. Verified by.....................

## Experiment No. 16

**Aim:-** To Prepare the Soil Health Card.

### SOIL HEALTH CARD

Soil Health Card Id/No. :____________________________________

Name Of Farmer :____________________________________

Adress. :____________________________________

Validity :From ______________to _______________

| | |
|---|---|
| Name | |
| Address | |
| Village | |
| Tahsil | |
| District | |
| PIN | |
| Aadhaar Number | |
| Mobile Number | |

SOIL SAMPLE DETAILS

| | | |
|---|---|---|
| Soil Sample Number | | |
| Sample Collected on | | |
| Survey No. | | |
| Khasra No. / Dag No. | | |
| Farm Size | | |
| Geo Position (GPS | | |
| | Latitude | Longitude |
| Irrigated / Rainfed | | |



## Experiment No. 17

**Aim:-** To Determine the Density of Given Soil Samples

**Soil Density-** Mass per unit volume is called as soil density. Ideal density of soil is 2.65 gm/ml, it may varies with the degree of weathering. It is divided into two categories particle density and bulk density.

1) Particle Density:- This is the density of soil particles excluding pore space it can measure in gm/ml. The weight of the soil can be measure in specific gravity. Absolute or true specific gravity is the gravity of soil particles.

Specific gravity of soil particle = Particle density/Density of water

2) Bulk Density:- It is the dry weight of soil including pore space is known as bulk density. Bulk density is always lower than particle density. It can change by alter in pore space. Bulk density is denpends on soil texture, soil structure, total pore space and organic content of the soil.

Apparatus: Pycnometer.

Chemicals:- Filter paper, Distil water.

**Procedure:-**

Particle Density- it is static property of soil (value of PD)…………gm/$Cm^3$

1. Take an empty weight of Pycnometer.
2. Fill the Pycnometer with the distil water up to the mark.
3. Note the Weight of pycnometer with distil water.
4. Remove the water from pycnometer.
5. Whip out pycnometer by using filter paper and Pour soil sample up to mark & the content.

**Calculations:-**

Mass of the soil taken, g = $M_s$ = 10

Mass of Water-filled pycnometer, g = $M_{pw}$

Mass of pycnometer + water + soil, g = $M_{psw}$

Volume of soil solids, Vs in $cm^3$ = Volume of water displaced

$= M_{pw} + M_s - M_{psw}$

$= M_{pw} + 10 - M_{psw}$

Particle Density, g $cm^{-3}$ or Mg $m^{-3}$ = $M_s/V_s$

**Observation Table:- Density of different soil samples.**

| Sample Id/No. | Site of Sample | Depth | Density |
|---|---|---|---|
| 1 | 10 | | |
| 2 | 20 | | |
| 3 | 10 | | |

**Result:-**The Density of given soil sample is found to be-----------gm/ml



# Experiment No. 18

**Aim:-**To determine the porosity of given soil samples

Soil Porosity-Soil porosity is the percentage pore space by volume. It can be measure by using following formula.

$$\text{Percentage of pore space} = 100 - \frac{\text{Apparent specific gravity}}{\text{Absolute specific gravity}} \times 100$$

Soil porosity provided the information about total pore space of the soil. Soil porosity reduces in the particle size in the pore space and soil depth. Total pore space is promote the plant growth due to the presence of enough air and moisture.

Percentage of solids = Bulk density/Particle density X100

In cultivated soil the volume of pore space may varies from 30 to 60 percentage, and in cly soil it may be 50 percentage.

**Apparatus:** Pycnometer.

**Chemicals:-** Filter paper, Distil water.

**Procedure:-**

- Determine the soil bulk density (Db) and Particle Density (Dp).
- Put these values in equation
- Calculate the total porosity

**Calculations:-**

The soil bulk density is (Db) is define as

Db = Ms/Vt ………………………………………………….. (1)

Where Ms is mass of oven-dry soil at 105 c and Vt is total volume of soil sample.

Similarly the soil particle density ( Dp) is define as

Dp = Ms/Vs …………………………………………………….(2)

Where Vs is Volume of soil particles
From (1) and (2) above
Vt = Ms/Db and Vs = Ms/Dp
Threfore the Volume of soil pores (Vp), is given as
Vp = Vt – Vs
Porosity of soil is given by
F = Vp/Vt = (1- Vs/Vt) = (1- Db/Dp) ................................(3)

**Observation Table:-Variation of Porosity of various soil samples.**

| Sample Id/ No. | Site of Sample | Depth | Porosity |
|---|---|---|---|
| 1 | | 10 | |
| 2 | | 20 | |
| 3 | | 10 | |
| 4 | | 20 | |

**Result:-**The Porosity of given soil sample is found to

be________________gm/ml



## Experiment No. 19

**Aim:-** To Determine the Water Holding Capacity of Given Soil Samples.

**Soil Water Content:-**
It is define as the available mass of water in particular unit of soil. To know the water content availability in soil following factors should be study.

1. Measure the percentage of availability of water in soil.
2. Measure the water storage capacity of soils.
3. Soil water management system, depletion patterns and water requirement of different crops.
4. Irrigation system and to analyse requirement of deepness of water irrigation of soil.
5. Measure the water movement of soil.
6. Study the soil strength or the resistance to root penetration
7. Calculate the mechanical strength of soil.
8. Study the possible plant diseases related to availability of water in soil.

**Soil Moisture Content:- The information about the water holding capacity of soil is essential to know the soil water balance**(Juan, *et al.*, 2005). Water availability of soil greatly influences by soil texture. The sandy soil can easily recharge but it can not hold the water as compare to the soil having heavier texture. Soil having heavier texture due to narrow pore spacing hold water tightly than the soil having wide pore spacing (Samuel 1999-2009).

Moisture content of soil of depth between 0 and 20 cm can be calculated by two types.

Air dried soil and Saturated wet soil.

Take and measure the wet soil sample and then dry in oven at 105°C. Soil moisture can be calculated by using formula.

W1 = weight of cleaned and dried weighing container

W2 = About 100 g sample was placed in the weighing container and weighed.

W3 = Weight of the container and contents after dryness.

Apparatus:-thermostat controlled oven, desiccators

Chemicals:-soil

Procedure:- Take the soil sample in container and place in thermostat controlled oven to dry at 105 °C to take constant weight. Then placed in desiccators or cooling.

$$SMC = \frac{(Ww - Wd)}{Wd} \times 100$$

where:

SMC = Soil moisture content dry base

Ww = Weight of the wet soil (g) = W2 - W1

Wd = Weight of the dry soil (g) = W3 - W1

Observation Table:-Variation of MWHC of different soil samples.

| Sample Id/ No. | Locality | Depth | MWHC |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |

**Result:-** Soil Porosity of analyzed sample is found

to be_______________gm/ml



## Experiment No.20

**Aim:-** To study and determine the microbial content of Soil samples

Soil Microbiology-Bacteria and fungi are the important microbes found in soil that influence the decomposition in the terrestrial ecosystem (Bardgett RD. 2005).These microbiota ie. Bacteria and fungi play an important role to promote the growth of plants and some bacteria and fungi also helpful to control the plant diseases.

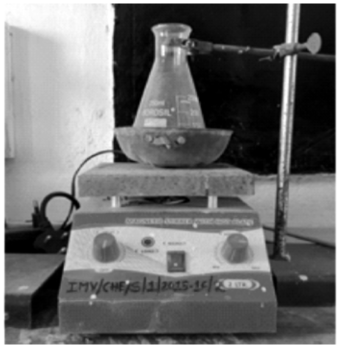
**Microbiological analysis:-**

Collect near about 1gm soil and carried out serial dilution ten time. Take 0.1 ml aliquots from last test tube. Inoculate this solution aseptically on petri plate containing culture medium. To isolate bacteria inoculate the solution on Muler and hinton agar medium and incubate the plate at 37 0 C for 24 hours. To isolate the fungi inoculate the solution on sabouraud dextrose agar (SDA) medium and incubate the plate at (28±2°C) for 72 hours.

After the particular incubation period colonies of bacteria and fungi will be seen on the culture plate then subculture it on fresh culture media plates. Then identify the bacteria and fungi by observing their microscopic characteristics like spore size, shape, colour and confirm the species.

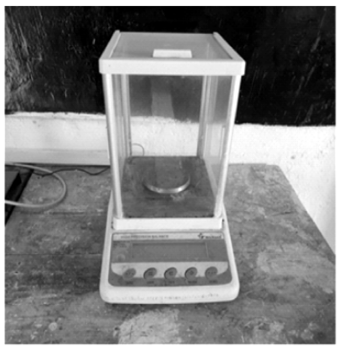
Common bacterial genera found in soil are *Bacillus, Arthrobacter, Pseudomonas, Agrobacterium, Alcaligenes, Clostridium, Flavobacterium, Corynebacterium, Micrococcus, Xanthomonas*. Fungi present in soil commonly are *Absidia*, *Alternaria, Aspergillus, Chaetomium, Fusarium*, *Mortierella*, *Mucor*, and *Penicillium*

## Introduction of Some Laboratory Instruments



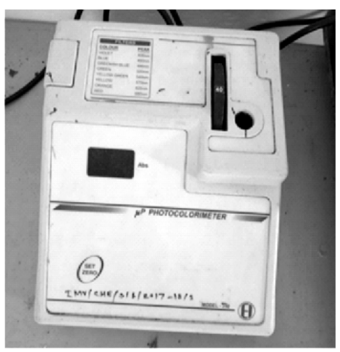
Magnetic Stirrer

Soil Analysis Kit



Weighing Balance


Digital pH Meter




Photocolorimeter


Conductivity Meter