# A Comprative Study of Soil Analysis by Employing Chemical and Instrumental Methods

Dasharath P.Patel and Dr.Rajesh D. Modh

Gujarat Arts and Science college, Ahmedabad

## Abstract

The different elements are essentials for growth and fertilization of plants. Such as carbon, nitrogen, phosphorous, potash and some other materials are essential for plants in proper proportion. The qualities of soil are different at different area and it also fit for different crops. We analyzed thousands of soil samples by using various chemical and instrumental methods for Daskroi-taluka of Ahmedabad District, like pH metry, conductometry, colorimetric. Here action of soil measured by pH, amount of soluble salt measured by Electric conductivity, organic carbon and phosphorous measured by colorimetric and potash measured by flame photometer. These results also compare with the standard elemental data available for particular crops. Finally we explore excess or deficiency of carbon, nitrogen, phosphorous, potash and some other materials in the soil and discussed some important results for the land of Daskroi-taluka of Ahmedabad district.

## Introduction

Our research work was originally based on the soil health card programme which was followed by Department of Agriculture, Govt. of Gujarat. This programme introduced by the Govt. of Gujarat under the title of "Golden goal soil health card programme" Under this project it was decided that soil health cards furnished to all land holders of Gujarat state.

We have worked and analyzed 15592 soil samples for the land of Daskroi Taluka, Ahmedabad District at Department of Chemistry, Gujarat Arts and Science College, Ahmedabad. On the basis of our soil materials analysis farmers can add some extra inputs in proper proportion, so they can avoid extra excess use of fertilizers. They can also increase the agricultural product and decrease the cost of production. In addition to that, on the bases of our data, Department of Agriculture advised them for seasonal crops according to quality of their land.

The different elements are essential for growth and fertilization of the plants. Carbon, Nitrogen, Phosphorous, Potash and some other materials are essential for plants in proper proportion. The quality of soil is different at different area and it also fit for different crops [10]. The soil samples were analyzed by using various chemical and instrumental methods like pH metry, conductometry, colorimetric and flame photometry [8, 17].

Here, reaction of soil measured by pH, amount of soluble salt measured by electric conductivity, organic carbon and potash measured by colorimetric and potash measured by flame photometer.

## Experimental

### *Sample preparation*

First of all register the received samples and assigned laboratory number to each sample. We have taken working sample of nearly 100 gms. Having grind and sieved, the samples were arranged according to the lab. no. in the wooden tray having 30 boxes (10 x3 boxes) [4].

### *pH metry*

$$pH = - \log H+$$

pH indicates concentration of hydrogen or hydroxyl ions in the soil-water system [3]. The soil may be acidic, neutral or alkaline in reaction [9]. There are two electrodes, glass and reference electrode (calomel electrode). Both the electrode put in soil water suspension. The reference electrode will measure the difference of electric potential

*corresponding author. E-mail:dppatel_12@yahoo.com

 Printed in Kazakhstan

produces between 0.1N HCl solution kept in glass electrode and soil water suspension due to hydrogen ions different concentration [17].

*Procedure*

Arrange 30 beakers in an anamal trey then take 10 gm of soil sample in each beaker according to lab. number and add 20 ml distilled water in each beaker. Stair the soil mixture with the help of glass rod up to half an hour and then allow stabilizing it.

(a) Switch on the pH meter and warm up for 10 minutes.

(b) Standardized the pH meter with 4.0, 7.0 and 9.2 pH buffer solution in separate beaker.

(c) Clean the electrode with distilled water and deep it in each sample solution.

(d) Clean the electrodes with distilled water after measuring the pH of each sample solution.

***Conductometry***

The conductivity instrument is used to measure the ability of a solution to carry an electric current. The total soluble salt content is measured in a water extract of the soil, using a conductivity bridge. The value is usually expressed as conductivity in millimhos. The greater the concentration of soluble salts in the extract the greater will be the electrical conductivity. This measurement is particularly important in the case of crops sensitive to salt [4].

*Procedure*

(a) Switch on the conductometer and warm up for 10 minutes and also adjust 25° C temperature.

(b) Standardized the instrument with 0.1 N potassium chloride solution adjust 1.41 milimols/cm

(c) Clean the conductivity cell with distilled water. Take reading after deeping the conductivity cell in the sample solution and note the reading with distilled water after measuring the E.C. of each sample.

***Determination of organic carbon (O.C.)***

Generally 58% organic carbon presents in organic matter in the soil [18]. On the basis of the organic carbon, organic matter can be calculated by using “Van Bemmelen” formula as,

% of organic matter = 1.724 × 100/58

In organic matters of the soil have nitrogen, phosphorous and sulphur in amount of 5.0, 0.5 and 0.5 % respectively. Hence the ratio of N : P : S is 10 : 1 : 1

The amount of Nitrogen is also very closely related with organic carbon. The percentage amount of carbon and nitrogen present in the soil are 58% and 5% respectively, so the ratio of C: N is 11.6 : 1.

*Procedure*

(a) Arrange thirty 100 ml glass beaker in acid proof anamal trey.

(b) Take 1 gm soil samples in each thirty 100 ml beaker from anamal trey accordingly to lab no.

(c) Add 10 ml 1N Potassium dichromate solution in each beaker

(d) Add 20 ml conc. sulfuric acid and cooled it for half an hour.

(e) Add 20 ml distilled water.

(f) Prepare the blank solution as per above method without adding soil sample.

(g) Keep such samples solution for over night, take the reading next day and note down.

(h) We use 660 milli micron red filters for taking reading on photoelectric colorimeter.

Set the zero reading after each 30 samples with blank solution.

**% Organic Carbon = Reading** (on photoelectric colorimeter) × **Graph factor**

Graph factor can be obtained by using following method [15].

Graph factor: Refer Observation table1

Take 1.25 gm sucrose in 250 ml volumetric flask and make solution 250 ml with 1 N potassium dichromate.

Each 1 ml of this solution contains 0.005 gm of sucrose.

Take this solution 0, 1, 2, 3, 4, 5 and 6 ml in different seven 50 ml test tubes.

Add 10 ml of 1 N $K_2Cr_2O_7$ solutions and 20 ml. of conc. $H_2SO_4$. Keep it for 30 minute. Then add 20 ml of distilled water. Use First test tube for zero reading and take other reading. Sucrose contains 42% carbon.

*Calculation*

1 Reading = *Total amount of Sucros / Total reading* = 0.105 / 399 = 0.0002631 gm sucrose

Carbon value of 1 reading = 0.0002631 × 0.42 = 0.0001105 gm organic carbon

**Table 1**

| Test tube no. | Amount of Sucrose + $K_2Cr_2O_7$ Solution in ml | Amount of Sucrose in gm | Colorimeter reading (For e.g.) |
|---|---|---|---|
| 1 | 0 | ----- | 0 |
| 2 | 1 | 0.005 | 19 |
| 3 | 2 | 0.010 | 38 |
| 4 | 3 | 0.015 | 56 |
| 5 | 6 | 0.020 | 77 |
| 6 | 5 | 0.025 | 96 |
| 7 | 6 | 0.030 | 113 |
| TOTAL | | 0.105 | 399 |

1 Reading graph factor value = 0.0001105 × 100 = 0.01105 % graph factor value for 1Reading

***Available Phosphorous***

Phosphorous is required for the healthy growth of plants. The plant's root absorbs phosphorous form its different form of the orthophosphate and its compound. The amount of phosphorous absorbed by the plant's root is known as available Phosphorous [5]. It has been found that certain high energy phosphate bonds are involved in the respiratory and photosynthetic process. These bonds transfer energy in some of the plants metabolic processes without which the plant could not live. Phosphorous of Ca, Fe, and Al convert into water soluble phosphate with the treatment of 0.5 ml, 8.5 pH solution of sodium bicarbonate ($NaHCO_3$) .The soluble phosphate react with ammonium molyblade hydrochloride. Then the phosphate converts into phosphorous by reduction process with stannous chloride.

*Procedure*

(a) Take 2 gm soil sample in 100 ml conical flasks, 8.5 pH 40 ml sodium bicarbonate solution, 1 gm Phosphate free activated charcoal and than shake flasks for 30 minutes on shaking machine.

(b) Filter the mixture in 10ml funnel cum test tube and add 1.5%, 5.0 ml stannous chloride solution.

(c) Finally dilute the solutions up to 25 ml with distill water. Now immediately take the reading on colorimeter in other words measure the density of the blue colure with red filter paper.

(d) Set zero with blank solution before taking the reading.

**Table 2**

| No. of test tube | $KH_2PO_4$ Solution | | Solution of $NaHCO_3$ | Solution of Ammonium molyblade hydrochloride | Solutions of Stannous chloride | Reading On colorimeter (For e.g.) |
|---|---|---|---|---|---|---|
| | ml | ppm | | | | |
| 1 | 0 ml | 0 | 5 ml | 5 ml | 1 ml | 0 |
| 2 | 1 | 2 | 5 ml | 5 ml | 1 ml | 25 |
| 3 | 2 | 4 | 5 ml | 5 ml | 1 ml | 42 |
| 4 | 3 | 6 | 5 ml | 5 ml | 1 ml | 58 |
| 5 | 4 | 8 | 5 ml | 5 ml | 1 ml | 76 |
| 6 | 5 | 10 | 5 ml | 5 ml | 1 ml | 93 |
| 7 | 10 | 20 | 5 ml | 5 ml | 1 ml | 151 |
| TOTAL | | **50 ppm** | **-** | **-** | **-** | **446** |

*Calculation*

$P_2O_5$ kg/hector = reading (on colorimeter) × 2.05

Where, 2.05 = graph factor × factor per hector [4]

For graph factor value:

Take 0.439 gm of dried potassium di-hydrogen orthophosphate, and make 1 liter with distill water. (Add 25 ml 7N $H_2SO_4$)

Take 10 ml solution in 50 ml volumetric flask and dilute up to 500 ml with distill water. (this 1ml solution = 2 ppm Phosphorous)

Take 0, 1, 2,3,4,5 and 10 ml solution in seven test tubes

Add the various solutions as given in Observation table 2.

Set zero with blank solution of first test tube.

***Available Potash***

Potash is also important for the growth of plant [7]. In the plant, it either occurs as a part of the anion of organic acid or as a soluble inorganic salt in the tissues. Formation and movement of carbohydrates in plant is contributed by potassium and a deficiency of potassium quickly reduces the carbohydrate contents. Potassium has also been found to contribute to the vigour and resistance of plants [13].

Procedure:

The soil sample shaking with the neutral ammonium acetate solution, Potassium ions released from soil particles.

Due to same radii of potassium and ammonium they substitute each other, The Potassium is measured in the filtrate by flame photometer.

Take 1.908 gm of potassium chloride in 1 liter volumetric flask and make 1 liter volume by distill water.

It is stock solution containing 1000 mgK/liter.

Take 5gm soil sample in 100 ml conical flask add 25 ml neutral ammonium acetate solution. Then shake for 5 minutes on shaking machine. Then filter the mixture in funnel cum test tube set zero reading with neutral ammonium acetate solution and 100 with 40 ppm Potash solution.

Then take the reading on flame photometer of the soil sample.

*Calculation*

$$K_2O = R \times 4.83$$

Kg/ hector Where, 4.83 = Graph factor value × factor per hector [4]

For Graph factor value: Refer Observation table 3.

Take 0, 1, 1.5, 2, 2.5, 3 and 4 ml stock solution of potash containing 1000 ppm in one to seven no. volumetric flasks.

Add neutral ammonium acetate solution and make 100 ml.

Now the solutions have 0, 10, 15, 20, 25, and 40 ppm of potash solution.

Switched on the flame photometer then set zero with ppm potash solution and 100 with 40 ppm potash solution check 0 and 100 twice or thrice. Then take the reading of above seven volumetric flasks.

**Table 3**

| No of VolumetricFlask | Stock volume of | Amount of Potash solution of potash | Reading (For e.g.) |
|---|---|---|---|
| 1 | 0.0 ml | - ppm | 0 |
| 2 | 1.0 | 10 | 40 |
| 3 | 1.5 | 15 | 50 |
| 4 | 2.0 | 20 | 55 |
| 5 | 2.5 | 25 | 70 |
| 6 | 3.0 | 30 | 75 |
| 7 | 4.0 | 40 | 100 |
| TOTAL = | | 140 ppm | 390 |

## Results and Discussion

The obtaining results also compared with the standard elemental data. Finally, we explore excess or deficiency of Carbon, Nitrogen, Phosphorous, Potash and some other materials in the agricultural land of Daskroi taluka of Ahmedabad District. We find out the how many samples are fit for fertile and in proper proportion shown in green belt and how many samples are out of green belt, i.e. in red belt.

1) pH (reaction of the soil): Refer Observation table 4

**Table 4**

| pH | Nature | No. of soil samples | soil samples in % |
|---|---|---|---|
| Below 6.5 | Acidic | 283 | 01.82 |
| 6.5 to 8.2 | Neutral | 13340 | 85.55 |
| More than 8.2 | Basic | 1969 | 12.63 |
| total | - | 15592 | 100.00 |

We have analyzed 15592 soil samples for pH measurement out of these 1.82% sample shows acidic nature and 12.63% soil samples shows basic nature which is not advisable for healthy crops [14]. The rest of 85.55% soil samples shown pH in the range 6.5 to 8.2, it means towards the neutral nature. These soil samples are fit for healthy crops.

2) Electric conductivity (amount of salt): Refer Observation table 5.

**Table 5**

| Electric conductivity | Nature | No. of soil samples | soil samples in % |
|---|---|---|---|
| Below 1.0 | Normal | 14205 | 91.10 |
| 1.0 to 3.0 | Harmful | 1387 | 08.90 |
| More than 3.0 | Very Harmful | 0000 | 00.00 |
| total | - | 15592 | 100.00 |

Here we measure the electrical conductivity of the soil samples; it means how much amount of soluble salt present in the given sample. The presence of excess amount of salt prevents the growth of plant as a result decrease in production. The most noticeable thing is not a single sample shown conductivity beyond 3.0 means it is not very harmful for a growth of plant [11]. But only 8.90% soil samples shown conductivity in the range 1.0 to 3.0 which can be reduced by taking proper care [12]. The 91.10% sample lies in the normal range. (Table 5)

3) Organic carbon: Refer Observation table 6

**Table 6**

| Organic carbon | proportion | No. of soil samples | soil samples in % |
|---|---|---|---|
| 0.0 to 0.25 | Very less | 151 | 00.97 |
| 0.26 to 0.50 | Less | 2084 | 13.36 |
| 0.51 to 0.75 | Medium | 6422 | 41.19 |
| 0.76 to 1.25 | High | 6835 | 43.83 |
| More than 1.26 | Very High | 100 | 00.65 |
| total | - | 15592 | 100.00 |

The proper proportion of organic carbon is very important because it is very closely related with proportion of nitrogen. The experimental results shown in above table reveals that 98.38% soil samples are fit for fertile land and only 1.62% soil samples shows either very high or very low proportion of organic carbon. The experimental value of organic carbon lies in the range of 0.76 to 1.25 indicates that the presence of organic carbon is higher side than medium range. 43.83% soil samples lies in this category and also almost equal amount of soil samples towards the medium range.

4) Available phosphorous: Refer Observation table 7

**Table 7**

| Available phosphorous | proportion | No. of soil samples | soil samples in % |
|---|---|---|---|
| 0 to 10 | Very less | 3 | 00.02 |
| 11 to 25 | Less | 565 | 03.62 |
| 26 to 60 | Medium | 11553 | 74.10 |
| 61 to 70 | High | 1779 | 11.41 |
| More than 70 | Very high | 1692 | 10.85 |
| total | - | 15592 | 100.00 |

Phosphorous is required in much lesser amounts than nitrogen [13]. It is a constituent of nucleic acids, phytins and phospholipids. It has also been found to contribute to the formation of the reproductive parts in the early life of the plant [16]. Here it is found that 89.13% soil samples contain phosphate in the normal range, so the deficiency of phosphorous is not a big problem for this land. But if we worried about the rest of 10.87% of the soil samples then by controlling the use of phosphate fertilizers in the proper proportion makes the soil productive.

5) Available potash: Refer Observation table 8

**Table 8**

| Available potash | proportion | No. of soil samples | soil samples in % |
|---|---|---|---|
| 0 to 75 | Very less | 556 | 03.56 |
| 76 to 150 | Less | 3166 | 20.30 |
| 151 to 300 | Medium | 7755 | 49.74 |
| 301 to 450 | High | 3254 | 20.87 |
| More than 450 | Very High | 861 | 05.53 |
| total | - | 15592 | 100.00 |

Potash is available in natural deposits such as biotite, muscovite and illite [13]. It is soluble and readily available to plants without further treatment. From the above results it is found that 90.91% soil samples lies in the green belt means in proper proportion, so it can be fit for healthy crops. Where 9.09% samples lies in red belt means not fit for the normal soil. Among them 49.74% samples are in exactly proper range. Both the sides of this range equal amount of slightly less and high proportion of potash is present.

## Conclusion

We have analyzed 15592 soil samples under various measurements like pH, electric conductivity, organic carbon, phosphorous and potash. Here our main emphasis towards the soil materials analysis and find out the excess or deficiency in the soil, particularly for the land of Daskroi taluka of Ahmedabad district.

From the pH measurements [table 4] it can be said that basicity of the soil samples is more rather than acidic nature. This is due to the excess use of fertilizers and other inputs. If we can control the basicity, fertility of the land increased.

In the E.C. measurements higher conductivity [table 5] is due to the presence of soluble ions in the soil. This excess amount of soluble ions prevents the growth of plants. So by removing soluble ions from the soil, we can reduce the cost and increase the production.

Nitrogen is the most important nutrient for the growth of plant. Because of the very close relation of nitrogen with carbon, we measure the percentage of organic carbon [table 6]. Accordingly we set the proper proportion of organic carbon in the soil.

It is also seen [table 7] 1692 soil samples contain very high proportion of phosphorous. It means these farmers are using phosphate fertilizers very extensively, so their cost of production is high. Here we concluded that proper proportion of phosphorous not only reduces the cost of production but also helpful to set the other parameters in the normal range and makes the soil fertile.

After finishing measurements for all the parameters, we had done comparative study of all the parameters (Table 9)

**Table 9**

| parameters | Samples in Lower- range | Samples in Higher-range | Total Samples |
|---|---|---|---|
| pH | 280 | 1969 | 2249 |
| Electric conductivity | 000 | 1337 | 1337 |
| Organic carbon | 151 | 100 | 251 |
| Available phosphorous | 003 | 1692 | 1695 |
| Available potash | 556 | 861 | 1417 |

From the Table 9 comparative study it can be seen, the number of soil samples lies higher range side is more than samples in the lower range side except organic carbon. This is due to the excess use of inputs fed to the soil as a results decreased in efficiency of the soil. This leads to the cost of production is very high. The amount of organic carbon in higher range side is very low indicates carbon is a major portion in the plant.

In the (Table 10) the number shown in green belt indicates the average range of all the parameters which is almost 84%. The farmers in this range are benefited by using this soil health card. But 16% farmers will be more benefited shown in red belt. With the help of our soil analysis, agriculture experts will suggest them how much inputs should be added in proper proportion to get the maximum advantage of their land and also cost effective.

**Table 10**

| Samples in Green belt | | Samples in Red belt | | Total samples | |
|---|---|---|---|---|---|
| In No. | % | In No. | In No. | % | In No. |
| 12168 | 83.80 | 2525 | 16.20 | 15592 | 100.00 |


## Acknowledgement

• First and foremost, we would like to express indebtedness to Department of Agriculture, Government of Gujarat for financial support.

• We are thankful to Commissioner of Higher Education, Block No. 12, second floor, Dr. Jivaraj Mehta Bhavan, Gandhinagar playing role of bridge between Department of Agriculture and Gujarat Arts and Science College, Ellis Bridge, Ahmedabad, where we carried out our soil analysis.

• Our thanks to Principal, Gujarat Arts and Science College, Ellis Bridge, Ahmedabad for providing infrastructure facilities for soil analysis project at Department of Chemistry. He always becomes constant source of inspiration for us.

• Our special thanks to Mr. K.R. Buch, State level co-ordinator, soil health card project, Commissionerate of Higher Education office, Gandhinagar. He is the real key co-ordinator among the Department of Agriculture, Commissioner of Higher Education, Dr.Jivaraj Mehta Bhavan ,Gandhinagar and with us. The great success of the project is due to him.

• We are grateful to Director of Agriculture, Gujarat State, Krishi Bhavan, Sector-10, Gandhinagar, Deputy Director of Agriculture, Sector-15, Gandhinagar (Land-coordinator), Joint Director of Agriculture (Explanation) Ahmedabad, Deputy Director of Agriculture, Sabarmati, Ahmedabad for their technical support and wholehearted co –operation throughout the work.

• Our thanks are also due to all the teaching and non-teaching staff members of my Department for helping hand.

• We are thankful to all the staff members of the Gujarat Arts and Science College, Ahmedabad helpful in the project for maintaining inner coordination.

• How can we forget our students those who are real pillar of my project, their hard work and dedication for this project leads us towards our goal.


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*Received 26 June 2010.*