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Chemical and Morphological Characterization of Agricultural Soil Samples from Tirora Tehsil of Gondia District in Maharashtra, Central India

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ABSTRACT

Representative soil samples were collected for the chemical analysis in the laboratory, from the agricultural fields of different locations in villages of Tirora Tehsil. Chemical analysis of total 20 samples is done in order to gather information about soil nutrients and quality, so as to set the target of nutrient application in the soil of that particular area. The collected samples were analysed for various major morphological and chemical soil quality parameters like pH, Cation Exchange Capacity (CEC), Electrical Conductivity (EC), CaCO3 %, Organic Carbon, Available Nitrogen (N), available Potassium (K2O), Exchangeable Calcium, Magnesium, Sodium and Potassium. The present investigation is focused on experimental analysis of nutrients in soil samples with reference to agricultural land in different villages of Tirora, Maharashtra in Central India. The interpretation of the analytical data gives information that will help farmers to deal with the problems related to soil nutrient management and use of smart agricultural practices to increase the agricultural productivity.

Keywords : Soil sampling, chemical analysis, smart agricultural practices, soil nutrient management, Tirora, Gondia district.

I. INTRODUCTION

The primary source of mineral nutrients for crops is soil. Soil formation is a constructive as well as destructive process [1]. The predominant destructive processes are physical and chemical breaking down of materials, plants and animal structures which result in the partial loss of more soluble and volatile products. The nature of soil primarily depends upon its continued change under the effect of physical factors like the parent material, time, the climate, the organic activity in it etc. [2]. Soil is composed of mineral and organic matter and also provides support for plant growth in different ways. Soil health care is thus vital to ensure agriculture production in a sustainable manner. Soil properties that are sensitive and variable can be used to improve soil quality. The characterization of soil in the chemical laboratory by determining physical and chemical properties is helpful in understanding the evaluation of land use potential for agricultural practices and integrated nutrient management of soil. The only way to identify the available nutrient status in soil and to develop specific fertilizer recommendations is Soil testing. Soil analysis is also essential for the assessment of soil physical condition, availability of nutrients, soil acidity, alkalinity and for the judicious application of chemical fertilizer and irrigation water.

Soil sampling is the primary and most critical step for any soil analysis. Soils are sampled to determine physical conditions, available nutrient status, and chemical properties that affect their suitability as plant growing media. Hence, it becomes extremely important to get a truly representative soil sample of the field. Soil test based nutrient management has emerged as a key factor in efforts to increase agricultural productivity and maintain soil fertility. Crop specific optimal use of nutrients, based on soil analysis can maximize nutrient use efficiency and improve crop productivity. This is then used to calculate the rate of manure and fertilizer application.

It is thus very essential to assess physical properties such as soil texture and soil structure. Eswaran et. al. considered soil qualities like nutrient availability, effective soil volume, soil erodibility, soil depth, texture, slope condition and pH as important parameters for sustainable land use planning [3]. Many attempts have been made in characterization of soil resources using remotely sensed data in parts of basaltic terrain [4,5,6].

One more critical factor in determining soil health is the estimation of soil pH i.e. whether soil is Acidic, Neutral or Alkaline. Soil pH also has a considerable influence on the activity of soil microflora and on the availability of soil nutrients to crops. Most of the plants grow well in soils that have pH close to either side of neutrality. However, there are acid-loving crops and also crops that can withstand high soil alkalinity. Hence, good crop yields are possible in both acidic and alkaline soils depending on the crop. With proper amendments, still higher yields can be obtained in acidic and alkaline soils.

Soil analysis is necessary for the complete appraisal of soil. In the present study, we have done chemical and morphological characterization of soil samples from different villages of Tirora tehsil of Gondia district in Maharashtra state. Cultivation of Paddy by traditional methods constitutes the basic way of livelihood of farmers in this area. Earlier, Vishakha et. al. established landform and soil relationship in a geologically complex terrain of Tirora tehsil of Gondia district, Maharashtra using remotely sensed data and GIS techniques [7].

This soil quality survey was conducted in 2019-20. A representative soil sample collected from each village which represent soils of 5 to 10 farms depending upon area of village. The soil samples were collected in polythene bags using standard quadric procedure. In the laboratory, these samples were analysed for different chemical properties following standard methods [8]. For soil analysis, analytical grade reagents and double distilled water were used. Results obtained were compared with standard values to determine the nutrients content of the soil [9].

II. MATERIALS AND METHODS

2.1 Geographical information about the study area

Tirora tehsil of Gondia district is bounded by North latitudes 21013'05" to 21033'30"and East longitudes 79047'50" to 80005'00". It is located in North-Western part of Gondia district in Maharashtra (India) with a total geographical area of 617.10 sq. km. Wainganga river flows from North to South in the Western part of the tehsil. It forms a major drainage system having the lower elevation ranging from 240 to 280 above MSL whereas, the higher elevation ranging from 350 to 500 above MSL. Tirora tehsil has a sub-humid, sub-tropical climate with well-defined summer (from March to May), rainy season (from June to October) and mild winter (from November to February). The mean annual temperature of the study area is 26.40C with mean maximum of 29.30C and a mean minimum of 24.120C. The mean annual precipitation of Tirora tehsil is 1400 mm of which nearly 85% is received during South-West monsoon period (i.e. from June to October).

2.2 Physical characteristics of soil in the study area

The particle size distribution shows that majority of the soils in the study area have high amount of clay. Soils developed on shallow weathered pediments, moderately weathered pediments, deeply weathered pediments and aggraded valley fills have high clay content (49.2 to 64.2 %).

2.3Methods The methods used to test soils vary depending on chemical properties of the soil. The utility of soil analysis depends mostly on the accuracy of soil sampling. The present study deals with the analysis of soil samples which were collected in a period 2019 from different villages of Tirora Tehsil of Gondia District. Soil was collected using a spade or khurpi [10] and for sampling V shaped holes were dug for collecting a uniform 2 cm thick slice of soil up to a depth of 15cm, which were collected in a plastic bucket. Samples collected were thoroughly mixed by rolling and turning on a piece of clean cloth, air dried in shade and the soil clods were crushed using wooden pestle and mortar [11]. Then the entire quantity of soil sample was sieved through 2mm stainless steel sieve. After sieving, the remaining coarse material was re-crushed and re-sieved. The remaining stones and organic residues were discarded. Total 20 soil samples were collected in clean polythene bags and brought to the Laboratory.

pH was measured using pH meter, Electrical Conductivity was measured using a conductivity meter, Organic Carbon was measured using Walkley and Black rapid titration method [12], available Potassium was measured using Flame photometer, available nitrogen is estimated by Kjeldahl's method [13], Exchangeable Calcium and Magnesium was measured using EDTA complexometric titration method (from ammonium acetate extract of soil). At pH 10, all exchangeable Calcium and Magnesium form complex with Versene to a bright blue end point in the presence of Eriochrome Black-T indicator. At pH 12, Calcium alone complexes with Versene in the presence of Murexide indicator. The orange-red colour that initially formed, turns finally into red-violet coloured end point. The amount of Magnesium can be determined by calculating the difference between first and second titrations. Exchangeable Sodium and Potassium was determined by Flame photometer. % CaCO3 was measured by Acid Neutralization method which is a rapid titration method [14].

III.RESULTS AND DISCUSSION

Soil testing is considered as a useful tool for identifying the causes of nutrient related plant growth problems and is beneficial to know the concentrations of various parameters present in soil samples. Present study is an attempt to find out the nutrient quantity of the soil in Tirora tehsil of Maharashtra state. This study of chemical and morphological parameters of soil samples showed differing values at different places of the study area, which may be due to the irregular distribution of different parameters present in soil (Table 1). The interpretation of analytical data for the 20 village samples is discussed below -

1. Sejgaon: This soil is non-calcareous 0.75 percent, low in organic carbon (0.31 %), non-saline, slightly acidic in reaction (pH 6.3). The exchangeable cations Na+, K+, Ca++, Mg++ is 0.11, 0.14, 7.50, 2.5 C mol (P+) Kg-1 respectively available in this soil. Exchangeable sodium percentage is 0.72 which is low and known to be slightly hazardous for most of the crop. The cation exchange capacity of soil is 15.20 C mol Kg-1. In these soils available nitrogen is low (151 kg ha-1) and available potassium is medium (175 kg ha-1).

2. Chikhali: This soil is non-calcareous 0.87 percent, low in organic carbon (0.18 %), non-saline, neutral in reaction (pH 6.99). The exchangeable cations Na+, K+, Ca++, Mg++, is 0.09, 0.04, 7.00, 3.5 C mol Kg-1 respectively in this soil. Exchangeable sodium percentage is 0.54 which is low and known to be slightly hazardous for most of the crops. The cation exchange capacity of soil is 16 C mol Kg-1 present. These soils have low available nitrogen (138 kg ha-1) and available potassium is medium (161 kg ha-1).

3. Garada: This soil is non-calcareous 1.48 percent, low in organic carbon (0.20%), non-saline, slightly alkaline in reaction (pH 7.60). The exchangeable cations Na+, K+, Ca++, Mg++, is 0.11, 0.06, 9.5, 5.0 C mol (P+) Kg-1 respectively. In the soil, exchangeable sodium

percentage is 0.41 which is low and is slightly hazardous for most of the crops. The cation exchange capacity of soil is 26.80 C mol (P+) Kg-1. These soils are having low available nitrogen (138 kg ha-1) and available potassium is medium (161 kg ha-1).

4. Sarandi: This soil is non-calcareous 1.11 percent, low in organic carbon (0.10%), non-saline, slightly alkaline in reaction (pH 7.84). The exchangeable cations Na+, K+, Ca++, Mg++, is 0.13, 0.08, 7.5, 4.0 C mol (P+) Kg-1 respectively in this soil. Exchangeable sodium percentage is 27.40 C mol (P+) Kg-1. This soil shows low value of available nitrogen (125 kg ha-1) and available potassium is medium (121 kg ha-1).

5. Bhiwapur: This soil is non-calcareous, medium in organic carbon (0.61%), non-saline, slightly acidic in reaction (pH 5.63). The exchangeable cations Na+, K+, Ca++, Mg++ is 0.11, 0.06, 9.5, 5.0 C mol (P+) Kg-1 respectively. The exchangeable sodium percentage calculated is 0.42, which is low and known to be slightly hazardous for most of the crops. The cation exchange capacity of this soil is 25.80 C mol (P+) Kg-1. In these soils, the available nitrogen is low (213 kg ha-1) and available potassium is medium (215 kg ha-1).

6. Bhajepar: This soil is non-calcareous, medium in organic carbon (0.54%), non-saline, slightly acidic in reaction (pH 5.82). The exchangeable cations Na+, K+, Ca++, Mg++ is 0.41, 0.19, 9.0, 3.0 C mol (P+) Kg-1 respectively available in this soil. Exchangeable sodium percentage is 1.58, which is low and known to be slightly hazardous for most of the crops. The cation exchange capacity of soil is 26.20 C mol (P+) Kg-1 present. These soils are having low available nitrogen (201 kg ha-1) and available potassium is medium (202 kg ha-1) in the soil.

7. Indora khurd: This soil is non-calcareous, low in organic carbon (0.24%), non-saline, slightly acidic in reaction (pH 6.17). The exchangeable cations Na+, K+, Ca++, Mg++ is 0.39, 0.13, 8.5, 2.5 C mol (P+) Kg-1 respectively in this soil. Exchangeable sodium percentage is 1.92, which is low and known to be slightly hazardous for most of the crops. The cation exchange capacity of soil is 20.40 C mol (P+) Kg-1 present. This soil is having low available nitrogen (151 kg ha-1) and available potassium is medium (161 kg ha-1).

8. Kawalewada: This soil is non-calcareous, low in organic carbon (0.16%), non-saline, neutral in reaction (pH 6.62). The exchangeable cations Na+, K+, Ca++, Mg++ is 0.24, 0.13, 7.0, 3.5 C mol (P+) Kg-1 respectively available in this soil. The exchangeable sodium percentage is 1.37, which is low and may be slightly hazardous for most of the crops. The cation exchange capacity of soil is 17.40 C mol (P+) Kg-1. This soil is having low available nitrogen (138kg ha-1) and available potassium is medium (175kg ha-1).

9. Navezari: This soil is non-calcareous, low in organic carbon (0.10%), non-saline, neutral in reaction (pH 6.72). The exchangeable cations Na+, K+, Ca++, Mg++ is 0.26, 0.10, 10.0, 3.0 C mol (P+) Kg-1 respectively. The exchangeable sodium percentage is 1.33, which is low and is slightly hazardous for most of the crops. The cation exchange capacity of soil is 19.60 C mol (P+) Kg-1. This soil is having low value of available nitrogen (125 kg ha-1) and available potassium is medium (134 kg ha-1).

10. Khairlanji: This soil is non-calcareous, low in organic carbon (0.05%), non-saline, neutral in reaction (pH 6.67). The exchangeable cations Na+, K+, Ca++, Mg++ present is 0.26, 0.09, 6.0, 1.5 C mol (P+) Kg-1 respectively. In this soil exchangeable sodium percentage is 1.69, which is low and is known to be slightly hazardous for most of the crops. The cation exchange capacity of soil is 15.40 C mol (P+) Kg-1. This soil has low available nitrogen (113 kg ha-1) and available potassium value is medium (121 kg ha-1) in soil.

11. Ghatkuroda: This soil is non-calcareous (1.60 %), medium in organic carbon (0.61%), non-saline, neutral in reaction (pH 6.75). The exchangeable cations Na+, K+, Ca++, Mg++ is 0.15, 0.45, 11.50, 5.50 C mol (P+) Kg-1 respectively. In this soil, exchangeable sodium percentage is 0.54, which is low and is known to be slightly hazardous for most of the crops. The cation exchange capacity of soil is 28.40 C mol (P+) Kg-1. This

soil is found to have low available nitrogen value (201 kg ha-1) and available potassium is medium (215 kg ha-1) in this soil.

12. Gondmohadi: This soil is non-calcareous (1.97 %), low in organic carbon (0.37%), non-saline, neutral in reaction (pH 7.38). The exchangeable cations Na+, K+, Ca++, Mg++ is 0.11, 0.41, 16.0, 3,50 C mol (P+) Kg-1 respectively. In this soil, exchangeable sodium percentage is 0.34, which is low and is slightly hazardous for most of the crops. The cation exchange capacity of soil is 32.0 C mol (P+) Kg-1. This soil is having low value of available nitrogen (163 kg ha-1) and available potassium is medium (175 kg ha-1) in this soil.

13. Koylari: This soil is non-calcareous (1.60 %), low in organic carbon (0.18%), non-saline, neutral in reaction (pH 7.55). The exchangeable cations Na+, K+, Ca++, Mg++, is 0.12, 0.23, 12.50, 4.50 C mol (P+) Kg-1 respectively. In this soil, exchangeable sodium percentage is 0.34, which is low and considered slightly hazardous for most of the crops. The cation exchange capacity of soil is 34.40 C mol (P+) Kg-1. This soil is having low available nitrogen value (138 kg ha-1) and available potassium is medium (161 kg ha-1) in this soil.

14. Barbaspura: This soil is non-calcareous (0.99%), low in organic carbon (0.24%), non-saline, neutral in reaction (pH 7.47). The exchangeable cations Na+, K+, Ca++, Mg++ is 0.13, 0.18, 11.50, 2.5 C mol (P+) Kg-1 respectively. Exchangeable sodium percentage is 0.40 in this soil, which is low and is slightly hazardous for most of the crops. The cation exchange capacity of soil is 31.60 C mol (P+) Kg-1. This soil has low available nitrogen value (151 kg ha-1) and available potassium is medium (175 kg ha-1).

15. Dabbetola: This soil is non-calcareous (1.24%), low in organic carbon (0.22%), non-saline, neutral in reaction (pH 7.28). The exchangeable cations Na+, K+, Ca++, Mg++ is 0.12, 0.10, 7.5, 3.5 C mol (P+) Kg-1 respectively in this soil. The exchangeable sodium percentage is 0.45, which is low and is considered slightly hazardous for most of the crops. The cation exchange capacity of this soil is 26.80 C mol (P+) Kg-1. The available nitrogen is low in this soil (151 kg ha-1) and the available potassium is medium (188 kg ha-1).

16. Malpuri: This soil is non-calcareous, low in organic carbon (0.31%), non-saline, neutral in reaction (pH 6.67). The exchangeable cations Na+, K+, Ca++, Mg++ is 0.12, 0.04, 8.5, 1.0 C mol (P+) Kg-1 respectively in this soil. The exchangeable sodium percentage is 1.11, which is low and is considered slightly hazardous for most of the crops. The cation exchange capacity of soil is 10.40 C mol (P+) Kg-1. This soil is having low available nitrogen value (163 kg ha-1) and the available potassium is medium (215 kg ha-1) in the soil.

17. Indora: This soil is non-calcareous, medium in organic carbon (0.54%), non-saline, slightly acidic in reaction (pH 5.80). The exchangeable cations Na+, K+, Ca++, Mg++ is 0.41, 0.06, 5.0, 4.5 C mol (P+) Kg-1 respectively. In this soil, exchangeable sodium percentage is 3.04, which is low and known to be slightly hazardous for most of the crops. The cation exchange capacity of soil is 13.60 C mol (P+) Kg-1. The available nitrogen is low (201 kg ha-1) and available potassium is medium (242 kg ha-1) in this soil.

18. Berdipar: This soil is non-calcareous, high in organic carbon (1.07%), non-saline, moderately acidic in reaction (pH 5.32). The exchangeable cations Na+, K+, Ca++, Mg++ is 0.13, 0.06, 5.0, 1.0 C mol (P+) Kg-1 respectively in this soil. The exchangeable sodium percentage is 1.17, which is low and considered slightly hazardous for most of the crops. The cation exchange capacity of this soil is 11.20 C mol (P+) Kg-1. The available nitrogen in this soil is low (226 kg ha-1) and available potassium is medium (255 kg ha-1).

19. Sonegaon: This soil is non-calcareous, medium in organic carbon (0.50%), non-saline, moderately acidic in reaction (pH 5.01). The exchangeable cations Na+, K+, Ca++, Mg++ is 0.22, 0.05, 4.0, 1.5 C mol (P+) Kg-1 respectively present in this soil. The exchangeable sodium percentage is 1.70, which is low and is slightly hazardous for most of the crops. The cation exchange capacity of soil is 12.80 C mol (P+) Kg-1. The available

nitrogen is low (176 kg ha-1) and available potassium is medium (202 kg ha-1) in this soil.

20. Vihirgaon: This soil is non-calcareous, medium in organic carbon (0.54%), non-saline, moderately acidic in reaction (pH 5.43). The exchangeable cations Na+, K+, Ca++, Mg++ is 0.26, 0.05, 3.50, 2.0 C mol (P+) Kg-1 respectively in this soil. The exchangeable sodium percentage is 2.33, which is low and is considered slightly hazardous for most of the crops. The cation exchange capacity of soil is 11.20.40 C mol (P+) Kg-1. This soil is having low value of available nitrogen (188 kg ha-1) and medium value of available potassium (215 kg ha-1).

Soil series	CEC	pH	EC	OC	% CaCO3	Available N	Available K	Exchangeable bases				Base saturation
								Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	
Sejgaon	15.20	6.30	0.110	0.31	0.75	151	175	7.50	2.50	0.11	0.14	67.43
Chikhali	16.00	6.99	0.064	0.18	0.87	138	161	7.00	3.50	0.09	0.04	66.41
Garada	26.80	7.60	0.086	0.20	1.48	138	161	9.50	5.00	0.11	0.06	54.75
Sarandi	27.40	7.84	0.076	0.10	1.11	125	121	7.50	4.00	0.13	0.08	42.73
Bhiwapur	25.80	5.63	0.050	0.61	0.00	213	215	8.00	6.00	0.11	0.06	54.93
Bhajepar	26.20	5.82	0.046	0.54	0.00	201	202	9.00	3.00	0.41	0.19	48.11
Indora khurd	20.40	6.17	0.05	0.24	0.00	151	161	8.50	2.50	0.39	0.13	56.47
Kawalewada	17.40	6.62	0.101	0.16	0.00	138	175	7.00	3.50	0.24	0.13	62.45
Navezari	19.60	6.72	0.057	0.10	0.00	125	134	10.00	3.00	0.26	0.10	68.18
Khairlanji	15.40	6.67	0.046	0.05	0.62	113	121	6.00	1.50	0.26	0.09	50.98
Ghatkuroda	28.40	6.75	0.038	0.61	1.60	201	215	11.50	5.50	0.15	0.45	61.97
Gondmohadi	32.00	7.38	0.094	0.37	1.97	163	175	16.00	3.50	0.11	0.41	62.56
Koylari	34.40	7.55	0.097	0.18	1.60	138	161	12.50	4.50	0.12	0.23	50.43
Barbaspura	31.60	7.47	0.101	0.24	0.99	151	175	11.50	2.50	0.13	0.18	45.27
Dabbetola	26.80	7.28	0.096	0.22	1.24	151	188	7.50	3.50	0.12	0.10	41.88
Malpuri	10.40	6.67	0.049	0.31	0.00	163	215	8.50	1.00	0.12	0.04	92.82
Indora	13.60	5.8	0.063	0.54	0.00	201	242	5.00	4.50	0.41	0.06	73.36
Berdipar	11.20	5.32	0.064	1.07	0.00	226	255	5.00	1.00	0.13	0.06	55.31
Sonegaon	12.80	5.01	0.032	0.50	0.00	176	202	4.00	1.50	0.22	0.05	45.07
Vihirgaon	11.20	5.43	0.04	0.54	0.00	188	215	3.50	2.00	0.26	0.05	51.89

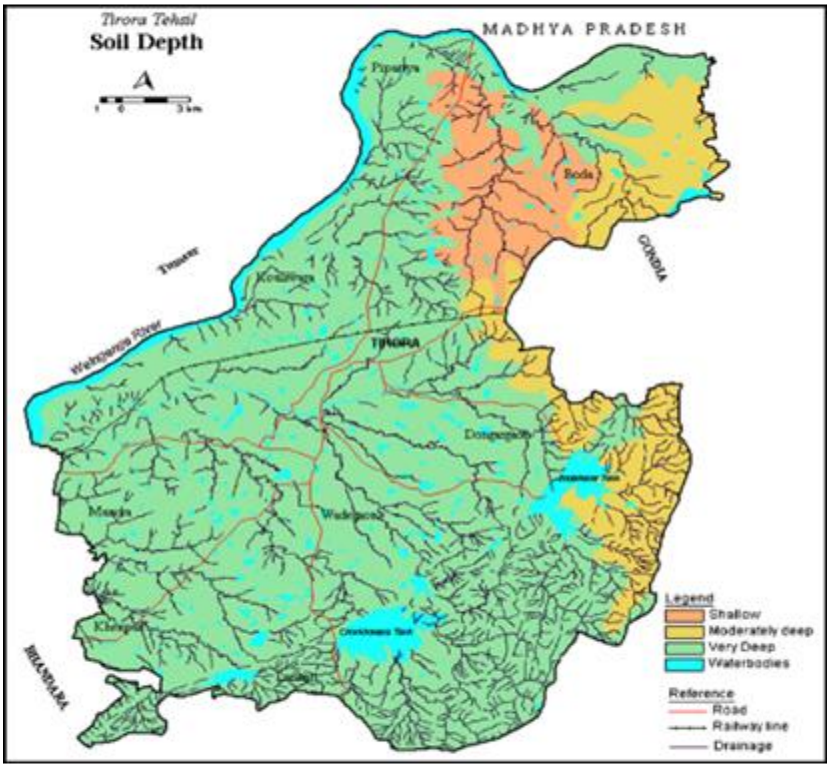

Figure 1 : Soil map of Tirora tehsil

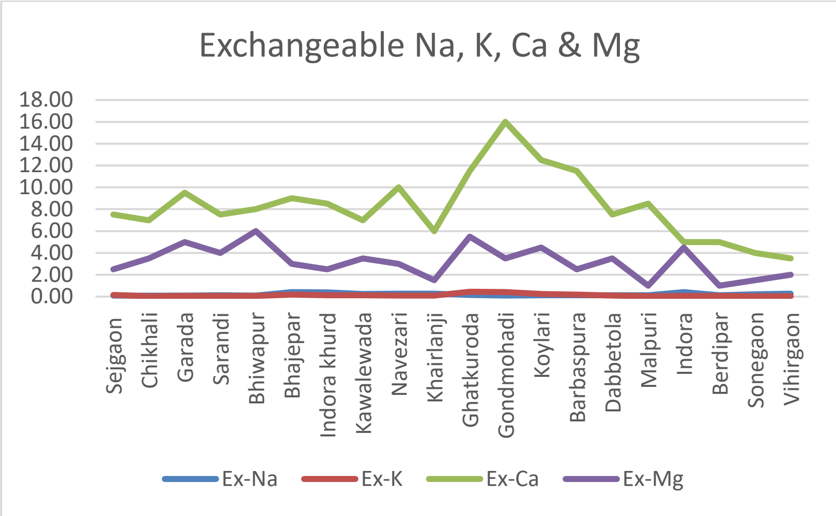

Figure 2 : Comparison of Exchangeable Na, K, Ca and Mg in 20 villages soil samples

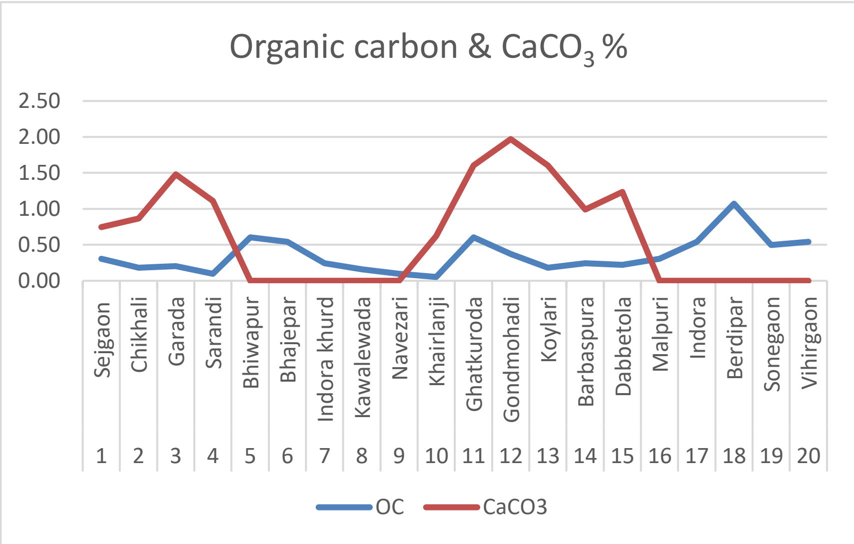

Figure 3 : Comparison of Organic carbon and $CaCO_3$ % in 20 villages soil samples

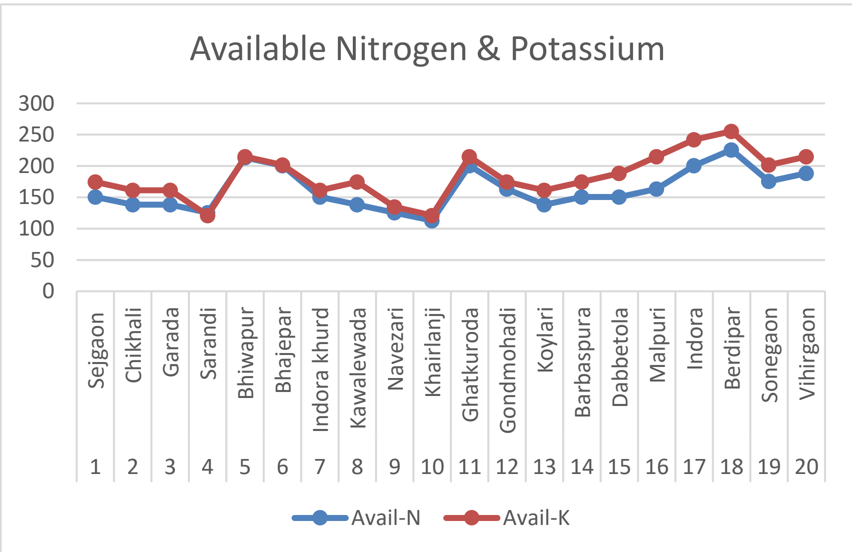

Figure 4 : Comparison of available Nitrogen and Potassium in 20 villages soil samples

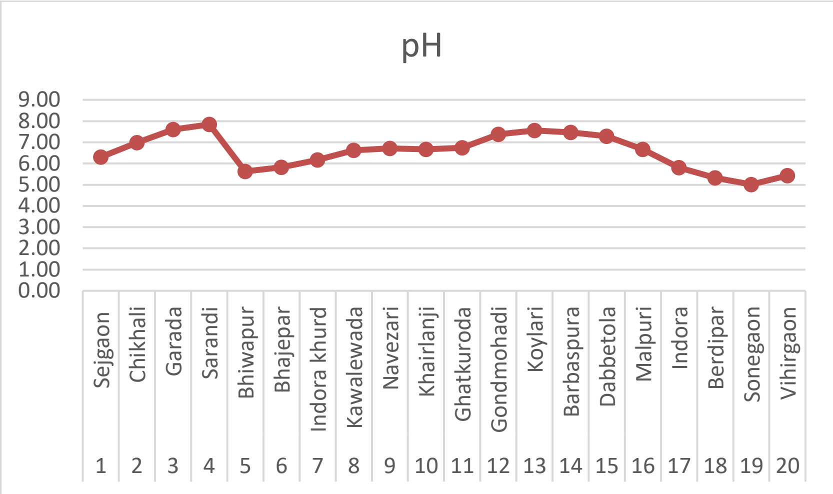

Figure 5 : Comparison of pH values in 20 villages soil samples

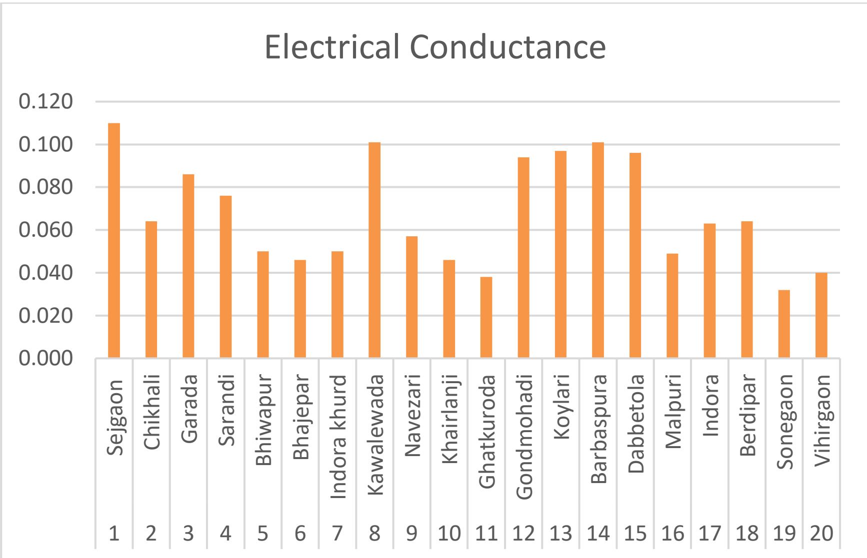

Figure 6 : Comparison of Electrical Conductivity values in 20 villages soil samples

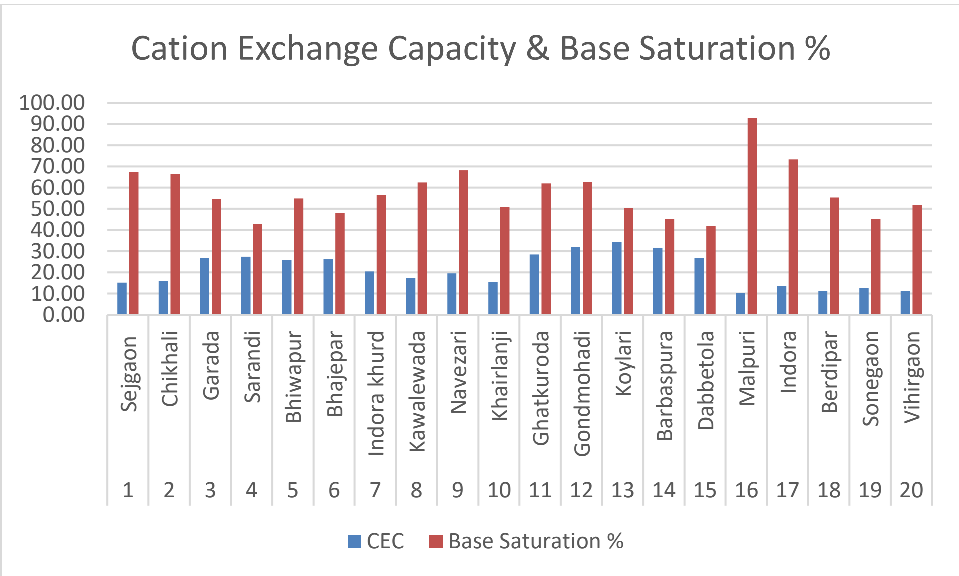

Figure 7 : Comparison of Cation Exchange Capacity & Base Saturation % in 20 villages soil samples

IV.CONCLUSION

Results in the study revealed that most of the samples are moderately well drained soils with moderate permeability. These soils are under multiple cropping systems. The common crops grown in the area are Paddy, legumes like Bengal gram, Green gram, Pigeon pea (Tur), Grass pea (lakhori) etc. These soils can be used for growing vegetables and fruit crops for higher productivity, if properly managed in terms of integrated nutrient and water management. The study concluded that the high sodium content in some of the soil samples may limit the availability of nutrients like calcium, magnesium because of high solubility sodium. Application of Gypsum as an amendment to correct Na+ and Farm yard manure will improve its physical condition and improve drainage. The incorporation of green manure (legumes) crop will be increase yield and increase fertilizer use efficiency. The soil under study is having low organic matter and available Nitrogen, which reduces the productivity of crops. Smart agricultural practices such as crop rotation, applying organic compost and manures, mulching, cover cropping etc. improve soil structure and properties through enrichment in soil organic Carbon and available Nitrogen.

Soil pH is a measure of the acidity or alkalinity in soils. It affects the nutrients available for plant growth. In highly acidic soil, aluminium and Manganese can become more available and more toxic to crops while Calcium, Phosphorous & magnesium are less available to the crop. In highly alkaline soil, Phosphorous and most of the micronutrients become less available. Near neutral to neutral range from 6.5 to 7.5 is acceptable for most of the crops for their growth. Organic matter decomposes releasing available Nitrogen more quickly in warm humid climates. This Nitrogen release is also quicker in well aerated soils and much slower on wet saturated soils.

This information will help farmers to make strategic use of fertilizers in the soil for economic production of crops. On the basis of these results, farmers are advised to use integrated nutrient management practices to maintain optimum concentration of all the essential nutrients for plants and to add bio-fertilizers containing organic carbon and nitrogen solubilising bacteria. The suggested agricultural practices enable the farmers to protect soil resources, which is one of their valuable resource.

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