May 2013- July 2013; Vol. 3, No. 3; 2051-2057. E- ISSN: 2249 –1929

Journal of Chemical, Biological and Physical Sciences

An International Peer Review E-3 Journal of Sciences

Available online atwww.jcbsc.org

Section C: Physical Science

CODEN (USA): JCBPAT Research article

Level of Significance of Various Physical and Chemical Parameters of Soils through Electrical Conductivity

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Received: 6 April 2013; **Revised:** 15 May 2013; **Accepted:** 24 May 2013

Abstract: In present study Physical and Chemical properties of soils and their relationship with electrical conductivity were studied. The soil samples were collected at a depth 20 cm from five different locations of ChalisgaonTehasil region. The soil samples were analyzed for pH, Electrical conductivity, organic carbon, Calcium Carbonate, Nitrogen, Phosphorous, Potassium, Iron, Manganese, Zinc, Copper, Calcium, Magnesium, Bulk density and texture. Electrical Conductivity had high degree positive correlation with silt content and negative significant correlation with sand content. Bulk density showed positive significant correlation with sand content and negative significant correlation with clay content of soil. Sand content of soil had higher effect on Electrical Conductivity (EC) and Bulk Density of soils. Electrical conductivity had positive significant correlation with organic carbon, Phosphorous, Potassium, Manganese and Copper.

Keywords: physical and chemical properties of soil, electrical conductivity, correlation coefficients

INTRODUCTION

Soil is comprised of minerals, soil organic matter, water and air. The composition and proportion of these components greatly influence soil physical properties like texture, structure and porosity. These properties affect air and water movement in the soil and thus the soils ability to function. A soil ability to provide plants with adequate water is based primarily on its texture. Processes such as fertility, water and solute movement and retention, and organic matter accumulation are all affected by soil properties, which subsequently affect plant growth and organism activity. Therefore understanding and recognizing soil properties and their interrelations is important for taking decisions regarding use of soil.

Soil fertility is determined by presence or absence of macronutrients and micronutrients. Out of sixteen plant nutrients Zinc (Zn), Copper (Cu), Iron (Fe), Manganese (Mn), Chlorine (Cl) and Boron (B) are referred as micronutrients. These elements required in minute quantities for plant growth. Essential elements used by plants in relatively large amounts for plant growth called macronutrients are Nitrogen (N), Phosphorous (P), Potassium (K), Calcium (Ca), Magnesium (Mg) and Sulfur (S).

The quality of soil is controlled by physical, chemical and biological components of a soil and their interactions Papendick and Parr[1] and Perveen *et. al.*[2] studied physical and chemical properties of soils of the Northwest Frontier Province, Pakistan. Robert Grisso *et. al*.[3] showed that the Electrical conductivity correlates with soil properties that affect crop productivity. Soil Electrical Conductivity is one of the simplest, least expensive soil measurements available for farmers today.

WajahatNazifet al[4] studied the status of micronutrients in soils of Bhimber district and their relationship with various physico-chemical properties. M. Kumar and A.L.Babel[5] evaluated the available micronutrients status and their relationship with soil properties of Jhunjhunu Tehsil (Rajsthan). The aim of this study was to understand the interrelations of physical and chemical properties of soil from Chalisgaon Tehsil region and especially to see the level of significance of these parameters through electrical conductivity.

Study Area: The present study was performed for five different sites in Chalisgaon Tehasil region. Chalisgaon Tehasil is located in Jalgaon District of North Maharashtra, India. The topology of Chalisgaon Tehasil is characterized by Sandy loam soils which do not retain water for long time. The soil samples were collected from regions of villages namely Ranjangaon, Patonda, Vaghadu, Vakadee and Bilakhed which are around Chalisgaon city.

Soil Sampling: The soil samples were collected from five different locations around ChalisgaonTehasil region. One representative soil sample was taken from each selected sites. Before sampling 20 mm topsoil was removed. Soil samples were collected from five different locations at the depth of 20 cm in zigzag pattern across the required areas. Five pits were dug for each sample. A composite sample about 2 kg was taken through mixing of represented soil sample. These soils were first sieved by gyrator sieve shaker with approximately 2 mm spacing to remove the coarser particles and allowed to dry in air for 1 hour.

MEASUREMENT OF ELECTRICAL CONDUCTIVITY AND PH OF SOIL SAMPLES

A pH and Electrical Conductivity of soil samples were measured by Soil Testing Kit Model 161E. A 20 gm of collected soil was weighed out into a 150 ml plastic jar and 100 ml distill water was added to it. Lid of jar was packed tightly and stirred continuously for 5 minutes. Then it was kept overnight and stirred again. Allowed to set for 15 minutes and strained sample into clean measuring cup. A pH and Electrical conductivity readings were taken.

Soil Physical properties: The soil samples were analyzed for sand, silt, clay, bulk density and Electrical conductivity. These parameters of soil samples are represented in **Table 1.**

Table-1: Physical Parameters of soil samples

Sample No.	Particle Density (mg/m^3)	Bulk Density (mg/m^3)	Sand (%)	Silt (%)	Clay (%)	WP	Wt	Porosity	Textural Class
1	2.03	1.17	55.25	27.25	16.75	0.1125	0.2201	0.4236	Sandy loam
2	2.11	1.35	66.75	24.75	7.25	0.0597	0.1942	0.3602	Sandy loam
3	2.11	1.20	72.0	20.0	7.75	0.0587	0.1937	0.4313	Sandy loam
4	2.17	1.15	64.0	20.0	15.50	0.1009	0.2144	0.4700	Sandy loam
5	2.33	1.32	78.25	7.50	12.50	0.0774	0.2029	0.4334	Sandy loam

Soil texture can have an effect on physical properties of soils. Texture is proportion of three mineral particles sand, silt and clay in a soil. The collected soils were categorized as sandy loam. The sand, silt and clay percentage of soil samples ranged from 55.25 to 78.25, 7.50 to 27.25 and 7.25 to 16.75 respectively. Particle density of soil samples ranged from 2.03 to 2.33. Bulk density of soil samples ranged from 1.15 to 1.35 g / cm^3. The bulk density of a soil is always smaller than its particle density. The bulk density of sandy soil is about 1.6 g / cm^3, whereas that of organic matter is about 0.5 g / cm^3. Bulk density normally decreases, as mineral soils become finer in texture. The bulk density varies indirectly with the total pore space present in the soil and gives a good estimate of the porosity of the soil. Very high bulk density is therefore undesirable for plant growth, since infiltration, aeration and root development are below the optimum level. Bulk density is of greater importance than particle density in understanding the physical behavior of the soil. Generally, soils with low bulk densities have favorable physical conditions.

Since bulk density relates to the combined volume of the solids and pore spaces, soils with high proportion of pore space to solids have lower bulk densities than those that are more compact and have less pore space. Fine textured surface soils such as silt loams, clays and clay loams generally have lower bulk densities than sandy soils. This is because the fine textured soils tend to organize in porous grains especially because of adequate organic matter content. This results in high pore space and low bulk density. However, in sandy soils, organic matter content is generally low, the solid particles lie close together and the bulk density is commonly higher than in fine textured soils. More the organic matter content in soil results in high pore space there by shows lower bulk density of soil and vice-versa. Porosity is a measure of the void i.e. empty spaces in soil, and is a fraction of the volume of voids over the total volume; it ranges from 0 to 1. Porosity is influenced by sizes, shapes and degree of packing of the soil particles. Porosity can be calculated from bulk density and particle density.

$$\text{Porosity} = 1 - \text{Bulk Density} / \text{Particle Density} \qquad ...(1)$$

The Wilting Point (WP) and Transition Moisture (Wt) of the soils are calculated by using the J.R. Wang and T. J. Schmugge[6] model as follows:

WP = 0.06774 – 0.00064 x Sand (%) + 0.00478 x Clay (%) ... (2)

Wt = 0.49 x WP + 0.165 ... (3)

Wilting point (WP) is the minimal point of soil moisture the plant requires not to wilt. The electrical conductivity (EC) is the ability of soil to conduct an electrical current. The measured EC of soil samples ranges from 0.11 to 0.36. The soil samples were also analyzed for various chemical parameters by standard analytical methods. The nutrient concentrations of soil samples are represented in **Table2.**

Table- 2: Chemical parameters of soil samples

Sam-ple No.	Ca meq/ 100 gm	Mg meq/ 100 gm	pH	E.C. (dS/m)	OC (%)	Ca CO3 (%)	N (kg/ha)	P (kg/ha)	K (kg/ha)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)
1	43700	15700	8.29	0.28	0.44	8.5	125.44	2.49	288.96	28.38	11.37	1.86	1.63
2	32000	7900	8.62	0.14	0.23	27.25	37.63	1.55	231.84	4.81	8.85	2.78	0.27
3	30500	14500	8.31	0.36	0.63	22.25	75.26	13.89	499.52	4.44	15.93	1.87	1.25
4	43800	17200	8.36	0.11	0.5	10.0	100.35	1.28	243.04	11.81	7.64	1.39	0.33
5	24300	20400	8.21	0.13	0.28	8.0	62.72	11.09	60.48	3.48	11.14	1.15	0.94

STATISTICAL ANALYSIS

The relationship between these different soils parameters were determined using correlation coefficient ‘r’, given by equation

$$r = \frac{n\sum xy-(\sum x)(\sum y)}{\sqrt{n(\sum x^2)-(\sum x)^2}\sqrt{n(\sum y^2)-(\sum y)^2}} \quad \text{... (4)}$$

Where n= 5, is the number of pairs of data (x, y).

Simple correlation coefficients (r) between soil physical properties and chemical properties with electrical conductivity are listed in **Table 3 and 4** respectively.

Table- 3: Correlation coefficients (r) between soil physical properties and electrical conductivity

Soil parameters	EC	PD	BD	Sand	Silt	Clay	WP	Wt	Φ
EC	1	-0.6825	-0.3636	-0.7117	0.5633	0.4618	0.5783	0.2630	-0.1231
PD		1	0.4190	0.9465	-0.9878	-0.1634	-0.3816	0.1912	0.3046
BD			1	0.6857	-0.3648	-0.8957	-0.9416	-0.7171	-0.7372
Sand				1	----	----	-0.6532	-0.1219	-0.0152
Silt					1	----	0.2812	-0.3005	-0.3529
Clay						1	0.9736	0.9353	0.8212
WP							1	0.8305	0.7053
Wt								1	0.8965

Table-4: Correlation coefficients (r) between soil chemical properties and electrical conductivity

Sr. No.	Soil parameters	Correlation coefficient 'r'	Sr. No.	Soil parameter	Correlation coefficient 'r'
1	EC-Ca	0.0305	7	EC-P	0.5003
2	EC-Mg	-0.0870	8	EC-K	0.8329
3	EC-pH	-0.2713	9	EC-Fe	-0.2542
4	EC-OC	0.6855	10	EC-Mn	0.8862
5	EC-$CaCO_3$	0.2139	11	EC-Zn	0.1433
6	EC-N	0.3209	12	EC-Cu	0.7776

RESULTS AND DISCUSSION

The soil sample 1 had very low sand content, maximum silt and clay content. Soil sample 5 had maximum sand content and very low silt content. All soil samples were categorized as sandy loam. The electrical conductivity of soil samples ranged from 0.11 to 0.36 ds/m i.e. all soil samples were non saline in nature. Bulk density of soil samples ranged from 1.15 to 1.35 mg/m^3. The Wilting point of soil samples ranged from 0.0587 to 0.1125, transition moisture ranged from 0.1937 to 0.2201 and porosity of soils ranged from 0.3602 to 0.4700. The WP, Wt and Φ of soil sample 3 were lowest value as compared to other soil sample. The transition moisture content is found to be dependent on the sand and clay content in the soil. For the soils having higher sand content the transition moisture has lower value, whereas for soils having high clay content the transition moisture has large value.

The electrical conductivity of soil varies depending on the amount of moisture held by soil particles. Consequently electrical conductivity correlates strongly to soil particle size and texture, reported by Robert Grissoet al[3]. Simple correlation studies showed positive relationship (r = 0.56) of electrical conductivity with silt and negative significant relationship (r = - 0.712) with sand content. The correlation coefficient between electrical conductivity and clay content is (r = 0.4418). This is because of sandy nature of soil samples. The positive significant correlation (r = 0.58) was found between electrical conductivity and WP. Negative significant correlation (r = -0.68) was observed between electrical conductivity and bulk density of soil samples.

Soil bulk density showed positive significant correlation (r = 0.6857) with sand content and strong negative correlation (r = -0.89) with clay content of soil. Similar results were reported by T.Askin[7]. Soil bulk density was mostly influenced by sand content of soil. High degree negative correlation of bulk density (r = -0.8958, -0.942, -0.7171 and -0.7372) was observed with clay content, WP, Wt and porosity of soil respectively. Sand content of soil gave negative significant correlation (r = -0.6531) with WP of soil and negative but not significant correlation with Wt and porosity of soil.

The pH values (8.21-8.36) indicated that four soil samples were moderately alkaline and one (8.62) was strongly alkaline. The three soil samples were calcareous (8.0-10.0%) and remaining two were highly calcareous (22.25, 27.25%). According to Methods Manual of Soil testing in India[8] the critical limits of Nitrogen, Phosphorous and Potassium for normal growth of plant were 280 kg/ha, 10 kg/ha and 108 kg/ha respectively. With this consideration the available Nitrogen content (37.36-125.44 kg/ha) of all soil samples was found to be very low. The phosphorous content (1.28-13.89) indicated that soil samples 1, 2 and 4 contain very low amount of Phosphorous and soil samples 3 and 5 contain slightly high amount of Phosphorous. The available Potassium (60.48-499.52 kg/ha) showed that soil sample 5 contain very low amount of Potassium and four soil samples were containing high amount of Potassium.

According to Lindsay and Norvell[9] 4.5 ppm of Iron is considered as the critical limit for normal growth. Considering the limit three soil samples contain high amount of Iron (4.81-28.38 ppm) two soil samples were contain low amount of Iron (3.48,4.44 ppm). Shukla et al[10] and Anonymous[11] reported 3.00 ppm and 4.7 ppm respectively as critical limit for available Manganese and Lindsay and Norvell[9] suggested critical limit of Zinc as 0.5-1.00 ppm. Considering these limits all soil samples contain high amount of Manganese (7.64-11.37 ppm) and Zinc (1.15-2.78). Sakal et al[11] reported critical limit of Copper as 0.66 ppm, considering this all soil samples contain high amount of Copper (0.27-1.63 ppm).

The positive significant correlation (r = 0.5003) was found between EC and Phosphorous. High degree correlation was observed of EC with available Organic Carbon (r = 0.6855), Potassium (0.8329), Manganese (r = 0.8862) and Copper (r = 0.7776) of soil samples. While positive but not significant correlation was observed of EC with Calcium (r = 0.0305), Calcium carbonate (r = 0.2139), Nitrogen (r = 0.3209) and Zinc (r = 0.1433). EC gave negative but not significant correlation with Magnesium (r = -0.0870), pH (r = -0.2713) and Iron (r = -0.2542).

CONCLUSION

From this study of different types of soils from Chalisgaon Tehasil region following conclusions can be made.

- Soil had higher effect on electrical conductivity and bulk density because of its sandy loam nature.
- Positive significant correlation of electrical conductivity was observed with silt and clay content of soil.
- Electrical conductivity gave high degree negative correlation with sand content of soil.
- High degree positive correlation of bulk density was observed with sand content of soil.
- Electrical conductivity showed high degree positive correlation with Organic Carbon, Potassium, Manganese and Copper.

ACKNOWLEDGEMENTS

The authors are thankful to Head of Physics Department and Principal, Z.B. Patil College, Dhule for providing research facilities. We are also very much thankful to the Principal, NanasahebY.N.Chavan Arts, Science and Commerce College, Chalisgaon for his valuable guidance and kind co-operation.

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