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# Correlations of Bulk Density with Various Physicochemical Parameters of Soils

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**ABSTRACT:** In present study Physical and chemical properties of soils and their relationship with Bulk Density were studied. Bulk Density of soil is dynamic property that varies with the soil structural conditions. Bulk Density is dependent on profile depth, organic matter content, porosity and compaction. The present study was carried out to investigate the relationship of Bulk Density with soil texture and available macro and micro nutrients for soils of Chalisgaon Tahasil region. The relationships between sand content (S), silt content (Si), clay content (C),  $\text{CaCO}_3$ , macro and micro nutrient content of soil with Bulk Density were studied for four surface soil samples (0-20 cm). Soil Bulk Density showed positive relationship with sand content and negative relationship with clay content, Organic Carbon (OC), Nitrogen (N), Iron (Fe), Calcium (Ca) and Magnesium (Mg).

**KEYWORDS:** Bulk Density, soil texture, macro and micro nutrient contents, correlation coefficients.

## I. 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 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).

## II. LITERATURE SURVEY

The quality of soil is controlled by physical, chemical and biological components of a soil and their interactions Papendick and Parr (1). Perveen et al (2) studied physical and chemical properties of soils of the Northwest Frontier Province, Pakistan.

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 behaviour of the soil. Generally, soils with low bulk densities have favourable physical conditions. Akgul and Ozdemir (3) studied relationships between soil bulk density and some soil properties.

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. A normal range of bulk densities for clay is 1.0 to 1.6 mg/m<sup>3</sup> and a normal range for sand is 1.2 to 1.8 mg/m<sup>3</sup> with potential root restriction occurring at >1.4 mg/m<sup>3</sup> for clay and ≥ 1.6 mg/m<sup>3</sup> for sand (4).

### III. METHODOLOGY

**Study Area:** The present study was performed for four different sites in Chalisgaon Tahasil region. Chalisgaon Tehasil is located in Jalgaon District of North Maharashtra, India. The topology of Chalisgaon Tahasil 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, and Bilakhed which are around Chalisgaon city.

**Soil Sampling:** The soil samples were collected from four different locations around Chalisgaon Tehasil region. One representative soil sample was taken from each selected site. 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 and Chemical properties:** The soil samples were analysed for sand, silt, clay, bulk density and particle density. These parameters of soil samples are represented in Table 1. Porosity was calculated from bulk density and particle density.

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

### IV. EXPERIMENTAL RESULTS

Sample No.	Particle Density (Mg/m <sup>3</sup> )	Bulk Density (Mg/m <sup>3</sup> )	Sand (%)	Silt (%)	Clay (%)	Porosity	Textural class
1	2.03	1.17	55.25	27.25	16.75	0.4236	Sandy loam
2	2.11	1.35	66.75	24.75	7.25	0.3602	Sandy loam
3	2.17	1.15	64.0	20.0	15.50	0.4700	Sandy loam
4	2.33	1.32	78.25	7.50	12.50	0.4334	Sandy loam

Table1: Physical Parameters of soil samples

The soil samples were also analysed for various chemical parameters by standard analytical methods. The nutrient concentrations of soil samples are represented in Table 2.

Soil Sam. No.	pH (1:2.5)	E.C. (dS/m)	Organic Carbon (%)	Calcium Carbonate (%)	N (kg/ha)	P (kg/ha)	K (kg/ha)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)
1	8.29	0.28	0.44	8.5	125.44	2.49	288.96	28.38	11.37	1.86	1.63
2	8.62	0.14	0.23	27.25	37.63	1.55	231.84	4.81	8.85	2.78	0.27
3	8.36	0.11	0.5	10.0	100.35	1.28	243.04	11.81	7.64	1.39	0.33
4	8.21	0.13	0.28	8.0	62.72	11.09	60.48	3.48	11.14	1.15	0.94

Table 2: Chemical parameters of soil samples

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

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

Where n= 4, is the number of pairs of data (x, y).

Simple correlation coefficients (r) between soil physical properties and chemical properties with bulk density are listed in Table 3.

Sr. No.	Soil parameter	Correlation Coefficient ‘r’	Sr. No.	Soil Parameter	Correlation Coefficient ‘r’
1	BD-Sand%	0.6857	10	BD-P	0.4493
2	BD-Silt%	-0.3648	11	BD-Fe	-0.7436
3	BD-Clay%	-0.8957	12	BD-Mn	0.1601
4	BD-PD	0.4189	13	BD-Zn	0.4021
5	BD-pH	0.3897	14	BD-Cu	-0.3222
6	BD-EC	-0.3635	15	BD-Ca	-0.8951
7	BD-OC	-0.9928	16	BD-Mg	-0.3721
8	BD-CaCO3	0.6140	17	BD-Porosity	-0.7372
9	BD-N	-0.9293	18	BD-K	-0.5848

Table 3: Correlation coefficients (r) between soil properties

**Discussion:** 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 mg/m<sup>3</sup>. Bulk density of soil samples ranged from 1.15 to 1.35 mg/m<sup>3</sup>. The bulk density of a soil is always smaller than its particle density.

The pH values (8.21-8.62) indicated that all four soil samples were moderately alkaline. The three soil samples were calcareous (8.0-10.0%) and remaining one were highly calcareous (27.25%). According to Methods Manual of Soil testing in India (5) 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 (1.28-11.09) indicated that soil samples 1 and 2 were contain very low amount of Phosphorous and soil samples 3 and 4 were contain slightly high amount of Phosphorous. The available Potassium (60.48-288.96 kg/ha) showed that soil sample 4 contain very low amount of Potassium and three soil samples were containing high amount of Potassium.

According to Lindsay and Norvell (6) 4.5 ppm of Iron is considered as the critical limit for normal growth. Considering the limit three soil samples were contain high amount of Iron (4.81-28.38 ppm) one soil samples were contain low

amount of Iron (3.48 ppm). Sukla et al (7) and Anonymous<sup>8</sup> reported 3.00 ppm and 4.7 ppm respectively as critical limit for available Manganese and Lindsay and Norvell (8) suggested critical limit of Zinc as 0.5-1.00 ppm. Considering these limits all soil samples were contain high amount of Manganese (7.64-11.37 ppm) and Zinc (1.15-2.78). Sakal et al (9) reported critical limit of Copper as 0.66 ppm, considering this two soil samples contain high amount of Copper (0.94 and 1.63 ppm) and remaining two samples contain low amount of copper (0.27 and 0.33).

**Results:** Soil bulk density showed positive significant correlation ( $r = 0.6857$ ) with sand content and strong negative correlation ( $r = -0.8957$ ) with clay content of soil. Similar results were reported by T.Askin (10). Soil bulk density was mostly influenced by sand content of soil. Soil porosity is ratio of the volume of soil pores to the total soil volume. Thus, bulk density is inversely related to porosity. We also found strong negative correlation ( $r = -0.7372$ ) between bulk density and porosity of soil samples.

Soil bulk density showed positive significant correlation ( $r = 0.6140$ ) with  $\text{CaCO}_3$ , this shows bulk density is dependent on calcareous soils. Correlation between bulk density and pH ( $r = 0.3897$ ) was positive but not significant. While correlation between bulk density and electrical conductivity ( $r = -0.3635$ ) was negative but not significant.

E. Sakin (11) determined strongest correlation between bulk density and organic carbon. The similar results were obtained with strong negative correlation ( $r = -0.9928$ ) between bulk density and organic carbon of soil samples. This result shows that as organic carbon increases bulk density of soil decreases which is required for proper growth of the plants.

The bulk density depends on primary (N, P and K) and secondary (Ca and Mg) macronutrients in the soil. Bulk density decreases as macronutrient contents of soil increases. This study showed strong negative correlation of bulk density with Nitrogen ( $r = -0.9293$ ), Potassium ( $r = -0.5848$ ) and Calcium ( $r = -0.8951$ ). But correlation of bulk density with Phosphorous ( $r = 0.4493$ ) was positive but not significant and with Magnesium ( $r = -0.3721$ ) was negative but not significant.

Statistical correlation study showed strong negative correlation between bulk density and available Iron ( $r = -0.7436$ ) of soil samples. The correlation of bulk density with Manganese ( $r = 0.1601$ ) and Zinc ( $r = 0.4021$ ) were positive but not significant.

## V. CONCLUSION

Following conclusions can be drawn for soil samples around Chalisgaon Tahasil-

- 1.The sand content of soil more affects the bulk density rather than silt and clay content of soil.
- 2.Bulk density was dependent on calcareous nature of soils.
- 3.Bulk density gave high degree negative correlation with Nitrogen, Potassium and Calcium content of soils.
- 4.There was high degree negative correlation bulk density and Iron contents of soil samples.

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