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SOIL BULK DENSITY AND ITS IMPACT ON SOIL TEXTURE, ORGANIC MATTER CONTENT AND AVAILABLE MACRONUTRIENTS OF TEA CULTIVATED SOIL IN DIBRUGARH DISTRICT OF ASSAM, INDIA

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ABSTRACT

Bulk density of a tea estate soil depends on the soil structure. It increases with soil depth due to the low content of total organic matter content. The principal objective of this work was to investigate the dependence of bulk density on texture, total organic matter content and macronutrients for the tea estate soil of Dibrugarh district. The relationship between some physical and chemical properties of soil such as, sand content, total organic matter content and macronutrients with bulk density were studied for sixty surface soil samples (0-15 cm) from ten tea estates. The sand, silt and clay content of soil samples ranges 74.87-88.24, 0.02-0.04 and 11.74-25.11 % respectively; the values of bulk density for the tea estate soil vary from 0.98-1.29 g $cm^{-}3$; soil pH varied from 4.60 to 5.57 ; electrical conductivity varied from 0.09 to 0.47 dS m^{-1} ; total organic matter content ranged 1.86 to 3.09 % ; available nitrogen status varied from 178 - 297 kg ha^{-1}; the average phosphorous content varied from 5.90 to 19.00 kg ha^{-1} and available potassium content in the soils ranged 214 to 291 kg ha^{-1}. Soil bulk density showed negative relationship with soil pH, electrical conductivity, total organic matter and macronutrients but showed positive relationship with sand content.

INTRODUCTION

Soil is the thin layer of the earth's crust in which biological activities take place. Soil is the "any part of earth's crust in which plants root". So soil is the natural medium for the growth of land plants. The soil is the most important part of the lithosphere as it is the source for creating plants, vegetation food materials, etc., needed for lives of men and animals. Soil is one of the most important ecological factors. All plants on the earth depend for their water supply, nutrients and anchorage upon the soil. Soil system is indeed very complex and dynamics, undergoing continuous change and the rates of such changes are influenced by physical, chemical, geographical and ecological factors. Soil belongs to lithosphere (A. K. De., 1993) – a very important segment of the gross environment. Bulk density is the mass (weight) per unit volume of a dry soil including pore space. It is a soil parameter, which is nothing but the ratio of the mass to the bulk or microscopic volume of soil particles plus pore spaces in the samples (Blake, 1965). It is now defined as the ratio of the mass, M of dry soil to its volume V. Therefore, it is calculated for the dried soil, moisture is not included in the sample weight. The volume with which bulk density is measured is that of the soil particles and pore spaces. Because of different soil texture, the bulk density of the soil varies. Loose and porous soils have low mass per unit volume and compact soil have high mass/volume ratio. For good plant growth, the bulk density of sand dominated soil is about 1.6 g cm^{-3} for clay soil, it is below 1.4 g cm^{-3} and in organic peat soil the bulk density is about 0.5 g cm^{-3}. Generally, in normal soil, the bulk density ranges from 1.0 –1.60 g cm^{-3}. Soil is the medium in which crops grow to provide food, cloth and shelter to the world. Soil is the major factor that limits types of vegetation and crops. The basic need of crop production is to maintain soil fertility and soil productivity. Soil fertility is the inherent capacity of soil to provide essential chemical elements for plant growth. Soil fertility in modern day agriculture is a part of a dynamic system. Nutrients are constantly being exported in the form of plant and animal products. Organic matter of plant and soil organisms immobilize, then release, nutrients throughout time. If agriculture production were a closed system, nutrient balance

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might be relatively stable. Bulk density is influenced by the amount of organic matter in soils, their texture, constituent minerals and porosity. Organic carbon influences many soil characteristics including colours, nutrient holding capacity, nutrient turnover and stability, which in turn influence water relations, aeration and workability. Soil organic matter plays a key role in nutrient cycling and can help improve soil structure. The bulk density depends on several factors such as compaction, consolidation and amount of soil organic carbon present in the soil but it is highly correlated to the organic carbon content (Morisada *et al*., 2004; Leifeld *et al*., 2005).

Organic matter is an important source of nutrients for plants. Nitrogen, phosphorus and sulphur are considered macronutrients; iron, manganese, zinc, copper, boron, molybdenum and chlorine are essential micronutrients and beneficial but not essential elements are silicon, vanadium, cobalt and nickel (Chaudhari *et al*., 2013. The relationship between organic matter content and bulk density in arid-semi arid soils on Southeast Anatolia region was determined by (Sakin , 2012) . Similar studies were performed by following researchers for forest soils (Pe rie and Ouimet, 2007; Askin and Ozdemir, 2003). The variability in mineral nutrient concentration with bulk density of soil was studied by (Laiho *et al*., 2004). The effect of bulk density on macronutrients (N,P,K) assimilation with different levels of fertilization was reported by (Reitam *et al*., 2005). Soil productivity is the capacity of soil to produce crops and be expressed in terms of yield. It was found that increase in organic matter decreases the bulk density of tea estate soil. On the other hand increase in organic matter increases the macro and micronutrients concentration in soil. The available nutrients concentration in soil may play an important role in the change in bulk density in soil. Therefore, it was proposed to study the effect of texture, organic matter content and macronutrient content on bulk density of soils of tea estates of Dibrugarh district of Assam.

MATERIALS AND METHODS

Study Area

This study was conducted in tea plantation areas with high tea productivity. Ten tea estates selected for study in the Dibrugarh district of Assam. Dibrugarh district is situated in the eastern part of Assam. The district extends from $27^{0}05.38^{/}$ N to $27^{0}42.30^{/}$ N Latitudes and $94^{0}33.46^{/}$ E to $95^{0}29.80^{/}$ E Longitudes. The geographical area covered by Dibrugarh district is 3381 sq km. The area of the Dibrugarh district experiences subtropical monsoon climate with mild winter, warm and humid summer. Rainfall decreases from south to north and east to west in the area. The average annual rainfall in this district is 276 cm with a total number of 193 rainy days.

Physico-chemical properties of soil

The soils of the area are basically the products of the fluvial processes of the Brahmaputra and its tributaries. The plains are composed of alluvium which may be classified as new and old. The new alluvium varies mostly from clayey to sandy loam in texture and is slightly acidic in reaction. In certain parts, both the old and new alluvium are so combined that it is difficult to distinguish them. The pH ranges between 4.2 and 5.5. The new alluvium is less acidic as compared to the old alluvium. Its pH value varies from 5.5 to 9.9. Tea is abundantly grown in the old alluvium as it has high percentage of acid. The tea estates are located over relatively high lands with discernible slopes containing both old and new alluvium.

Soil sampling and physico-chemical analyses

This research was conducted in the tea estates in Dibrugarh district in the year 2012. Sixty soil samples were collected from the ten tea estates in the month of December, because no fertilization or compost was applied in this month in the tea estates. Composite soil samples and control soil were taken from 0 to 15 cm depth and prepared for necessary analysis in the laboratory (Jackson, 1995; Gupta, 2007). The locations of sampling stations were determined by using Global Positioning System (GPS) shown in Figure 1.

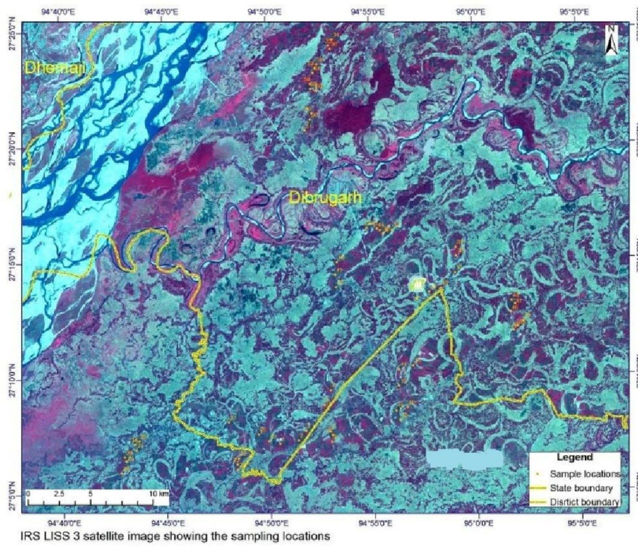

Figure 1. Locations of soil sampling stations

Texture in the present experiment is determined by the Hydrometer method (Bouyoucos, 1962). Bulk density was determined by using procedure (Chopra and Kanwar, 1986). Soil pH was determined by using procedure (Thomas, 1996). Organic matter was determined by the procedur (Walkley and Black, 1974). Macronutrients (N, P and K) were determined on each sample by using the procedure (Gupta, 2007).

RESULTS AND DISCUSSION

Texture and Bulk density

The sand, silt and clay content of soil samples ranges 74.87-88.24, 0.02-0.04 and 11.74-25.11 % respectively and these soils were categorized as sandy clay loam, sandy loam and loamy sand. The bulk density data for the soils of the tea estates are given in Table 1. The values for the tea estate soil vary from 0.98-1.29 g cm^{-3}. The soil of the tea estate T_9 is heavy with maximum bulk density of 1.29 g cm^{-3} while the bulk density is minimum for the soil of the tea estate T_8 (0.98 g cm^{-3}) indicating presence of light organic fractions. Under the same considerations, the soil of T_9 must have contained heavier inorganic fractions.

Soil pH and Electrical conductivity

Data presented in Table 2 show that soil pH varied from 4.60 to 5.57 with an average of 5.12. According to classification of

Table 1. Physico-chemical analysis of soil samples

S.No	Tea Estate	No. of samples	Sand (%)	Silt (%)	Clay (%)	Textural class	Bulk density (g cm^{-3})
1	T_1	6	79.81	0.02	20.17	Sandy clay loam	1.21
2	T_2	6	83.92	0.02	16.06	Sandy loam	1.08
3	T_3	6	83.20	0.02	16.78	Sandy loam	1.09
4	T_4	6	81.45	0.02	18.53	Sandy loam	1.13
5	T_5	6	79.04	0.02	20.94	Sandy clay loam	1.25
6	T_6	6	75.69	0.04	24.27	Sandy clay loam	1.27
7	T_7	6	86.52	0.02	13.46	Sandy loam	1.02
8	T_8	6	88.24	0.02	11.74	Loamy Sand	0.98
9	T_9	6	74.87	0.02	25.11	Sandy clay loam	1.29
10	T_{10}	6	85.69	0.02	14.29	Sandy loam	1.05
	Range		74.87-88.24	0.02-0.04	11.74-25.11		0.98-1.29
	Mean		81.84	0.02	18.13		1.14

Table 2. Physico-chemical analysis of soil samples

S.No	Tea Estate	No. of samples	pH	EC (dS m^{-1})	Total organic matter (%)	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})
1	T_1	6	4.98	0.22	2.16	207	11.00	248
2	T_2	6	5.26	0.35	2.67	256	15.00	278
3	T_3	6	5.20	0.32	2.66	254	14.80	270
4	T_4	6	5.08	0.27	2.59	248	12.00	256
5	T_5	6	4.90	0.19	2.12	202	10.50	240
6	T_6	6	4.72	0.10	1.96	184	6.00	219
7	T_7	6	5.46	0.43	2.89	265	18.00	288
8	T_8	6	5.57	0.47	3.09	297	19.00	291
9	T_9	6	4.60	0.09	1.86	178	5.90	214
10	T_{10}	6	5.38	0.40	2.84	268	17.00	285
	Range		4.60-5.57	0.09-0.47	1.86-3.09	178-297	5.90-19.00	214-291
	Mean		5.12	0.28	2.48	236	12.90	259

soil reaction suggested by (Brady, 1985) that all the soil samples were acidic in nature. The electrical conductivity of the soils varied from 0.09 to 0.47 dS m^{-1} and with an average of 0.28 dS m^{-1}. The limit suggested for the salt problem of soils, all the soil samples were found normal (EC < 1.0 dS m^{-1}) by Muhr *et al*., 1965.

Total organic matter content of soil samples

The total organic matter content ranged 1.86 to 3.09 % with an average of 2.48 %. All the soil samples in study area contain sufficient amount of organic carbon (> 0.75%).

Available macronutrients (N, P and K) in soil samples

It was found that the critical limits nitrogen (N), phosphorous (P) and potassium (K) for normal growth of plant were 280 kg ha^{-1}, 10 kg ha^{-1} and 108 kg ha^{-1} respectively. Available nitrogen status varied from 178 -297 kg ha^{-1} with an average of 236 kg ha^{-1}. On the basis of rating suggested by soil testing in India 90 % of soil sample were found to be low (< 280 kg ha^{-1}) and remaining 10 % sufficient. The average phosphorous content varied from 5.90 to 19.00 kg ha^{-1} with an average of 12.90 kg ha^{-1}. The phosphorous content of soils indicated that the 20 % soil samples were contain low and remaining 80 % soil samples were contain very high amount of phosphorous. Status of available potassium content in the soils ranged 214 to 291 kg ha^{-1} with an average of 259 kg ha^{-1}. The available potassium content showed that all the samples were contained high amount of potassium.

Relationship between bulk density and texture of soil

According to the following workers (Gupta, 2007; Singanan *et al*., 1995) a good correlation is predicted if the linear regression co-efficient "r" is > 7. The simple correlation coefficient (r) between bulk density with soil parameters are given in Table 1. It was observed that the bulk density is dependent on texture of the soil. As the sand content of the soil sample increases the bulk density increases. High degree positive correlation of bulk density was observed with sand content (r = 0.92).

Relationship between bulk density with pH and Electrical conductivity of soil samples

It was observed that the bulk density is independent on whether the nature of the soil is acidic or alkaline. Statistical correlation studies showed significant negative correlations of bulk density with soil pH (r = - 0.73) and soil electrical conductivity (r = - 0.70).

Relationship between bulk densities with organic matter content of soil samples

It was obtained strong negative correlation between bulk density and total organic matter content of the soil samples (r = - 0.93), which indicate that as the organic matter increases the bulk density of soil decreases. The bulk density bears an inverse relationship with the soil organic matter (White, 1987). Similar results were reported many researchers (Askin and Ozdemir, 2003; Morisada *et al*., 2004; Leifeld *et al*., 2005 ; Pe rie and Ouimet, 2007; Sakin, 2012).

Relationship between bulk density available macronutrients content of soil samples

The bulk density of the soil samples dependence on available macronutrients in the soil. It was found that the bulk density decreases as the macronutrient contents in the soil increases. A significance negative correlation (r = 0.90) was found between bulk density and available nitrogen (Table 3). A significance negative correlation (r = 0.82) was found between bulk density and available phosphorous (Table 3). A significance negative correlation (r = 0.90) was found between bulk density and available potassium (Table 3).

Table 3. Simple correlation coefficient (r) between bulk densities with soil parameters

Related soil parameters	Correlation Coefficient (r)	Level of Significance
Bulk density—Sand (%)	0.92	High degree positive
Bulk density—pH	-0.73	Significance negative
Bulk density—Electrical conductivity	-0.70	Significance negative
Bulk density—Organic matter (%)	-0.88	Strong negative
Bulk density—N	-0.90	High degree negative
Bulk density—P	-0.82	Strong negative
Bulk density—K	-0.90	High degree negative

Conclusions

There was high degree of positive correlation between bulk density and sand content of the soil. Bulk density was reverse correlation with pH, EC, organic matter and macronutrient in the soil. The available macronutrient concentration depends on the organic matter content in the soil, therefore as the concentration of macronutrients increases the bulk density decreases.

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