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Analysis of Physical Properties of Soil Samples in Traditional Agricultural area in Purba Medinipur District, West Bengal, India

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Abstract

Bulk density of soil is an important dynamic property. This property varies with the soil structural conditions for any geographical area. Generally, the bulk density increases with profile depth increase, due to alteration or change of organic matter content, porosity and compaction of soil structure. The main objective of this study was to investigate the dependence of bulk density on texture, volumetric water content capacity and porosity. The study site has covered 25 selected sample points over the Purba Medinipur district. The samples have been collected during Pre-monsoon period (10th June to 20th June, 2015). Every soil sample has been collected from the maximum $12''$ depth from the top surface of the soil and carefully avoids the organic litter. After that, the "Core method" was applied for this analysis. The result reveals that, the bulk density of the collected soil samples are tends to little value for every sample point. More over the relation between the bulk density and volumetric water content capacity and porosity indicates strong negative relation ($r^2 = -0.99$). This result suggests that, proper maintain and pre-management are require for maintain the balance agro-ecological practice.

Keywords: *Agro-ecology, Bulk density, Physical properties of soil.*

1. Introduction

Soil is a natural substance that provides useful support for plant growth and agricultural production. The synthesized profile of the soil substance makes some variable improvement for agricultural production over any geographical area. Available mixture of broken and weathered minerals and decayed organic matter, which covers the earth in a thin layer and which supplies, when containing the amounts of air and water, mechanical support and imparts sustenance for plants (*Brady & Weil, 2000*). Partial heterogeneity in physical properties of soil affects not only the spatial patterning of vegetative cover but overall community structure and productivity *(Brady & Weil, 1990)*. The distribution of the soil substance has influenced distribution of vegetative cover over the world. The importance of the soil as a reservoir of nutrients and moisture for the production of forage and plant species has been recognized since the beginning of the forest management as a science (*Schlesinger et al., 1990*).

Vegetation distribution and development largely depends on the soil conditions (*De Deyn et al., 2004; Kardol et al., 2006*). The limitations of the physical properties occurring in the soil are important factors that affecting the structure of the plant community as well as agricultural practices. Practically the shift of the physical properties of the soil has been lead to bio-geochemical processes. So, it should be stated that, the soil is a complex formation which leads as a dynamic component for the agro-ecosystem. Alteration of its nature and inherent properties may drag meaningful signature in future. Moreover, the understanding of the soil ecosystem is a key part of designing and managing agro-ecosystem in which a long term fertility and productive capacity of the soil will be maintain. This understanding begins with knowledge of how soil is formed in a given ecological region and includes integration of all the components that contribute to the structure and function of the entire soil ecosystem (*Gliessmann, 1998*). Different researchers have been conducted regional analysis of agro-ecological parameters for estimating the regional fertility of soil. These types of analysis contribute to making agriculture more sustainable, it must establish a framework for measuring and quantifying sustainability (*Liverman et al. 1988, Gliessman 1990*). Such analysis of systems framework can measure the carrying capacity of a particular landscape or determine the probability of an agro-ecosystem being sustainable over the long term (*Fearnside 1986, Hansen & Jones 1996, Ellis & Wang 1997*). Our goal for this study is to establish the monotonic condition of agro-ecological balance of soil sub-state in respect of bulk density, volumetric water content capacity and porosity estimation for the Purba Medinipur district.

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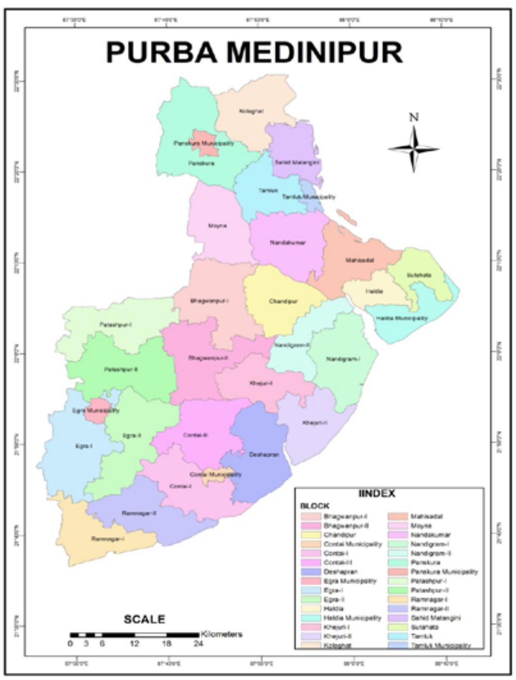
2. Study Area

The present study was conducted in and around the Purba Medinipur district where paddy cultivation is dominant. Mainly, this district administratively covers 25 Blocks. Tamluk is the district head quarter, which is located at the bank of Rupnarayan river.

North –South extension of this district is $22°30'08"N, 87°51'42"E$ and $21°36'50"N, 87°28'33"E$ respectively. Agriculture is one of the most important practices for this district.

The southern part of the district is bounded by Bay of Bengal, western part is bounded by Paschim Medinipur district and northern part bounded by Howrah district. Maximum area of the study site is traditionally occupied by the monsoonal agro culture.

Figure 1: Study Area



3. Materials and Method

In this study we have selected some randomly ordered soil sample site covering each block of Purba Medinipur district. Moreover, the soil sample collection has been made throughout the 25 blocks over the district during pre-monsoon season (10th June to 20th June, 2015). The experiment has been carried out using soil sample

preparation from the layer depth of $12''$ maximum from the top surface of the soil layer and their sample points are given in Table-1. The collection of soil sample has been taken with the help of soil corer avoiding organic litter. These collected soil samples were stored in air tight polythene bags for subsequent laboratory investigations. The samples were air-dried, initially mashed using a pestle and mortar and passed through 2mm sieve before analysis.

Sl. No	Block	Sample Point	Latitude (ϕ)	Longitude (λ)
1	Ramnagar-I	Ramnagar	21° 42′10″	87°22′12″
2	Ramnagar-II	Depal	21°10′40″	87°20′13″
3	Contai-I	Dulalpur	21°44′55″	87°39′11″
4	Contai-II	Sarda	21°48′21″	87°46′26″
5	Contai-III	Durmuth	21°49′25″	87°43′43″
6	Egra-I	Dakshinchak	21°52′08″	87°33′46″
7	Egra-II	Sultanpur	21°53′56″	87°34′48″
8	Khejuri-I	Kamarda	21°42′20″	87°10′40″
9	Khejuri-II	Janka	21°54′23″	87°51′40″
10	Pataspur-I	Barhat	22°03′33″	87°38′14″
11	Pataspur-II	Argoal	21°58′01″	87°37′01″
12	Bhagabanpur -I	Bhagabanpur	22°04′38″	87°44′30″
13	Bhagabanpur -II	Bhupatinagar	21°56′12″	87°42′20″
14	Nandigram-I	Nandigram	22°01′30″	87°52′02″
15	Nandigram-II	Khodambari	22°01′42″	87°51′52″
16	Chandipur	Mathchandipu e	22°05′28″	87°51′18″
17	Haldia	Haldia	22°09′56″	88°09′58″
18	Sutahata	Sutahata	22°03′24″	88°03′26″
19	Mahishadal	Mahishadal	22°10′20″	87°54′02″
20	Moyna	Moyna	22°20′23″	87°20′40″
21	Tamluk	Tamluk	20°26′20″	87°20′24″
22	Sahid Matangini	Kharui	22°20′03″	87°52′30″
23	Panskura	Panskura	22°20′24″	87°42′28″
24	Kolaghat	Kolaghat	22°24′35′	87°52′41″
25	Nandakumar	Nandakumar	22°10′45″	87°53′15″

Table-1: Geographical location of sample points.

The weight of air dry sample was confirmed with $450 gram$ of soil from each sample point and for each case the weight of polythene bag was 5 gram. Than the container (Aluminum) weight has been subtracted from the total weight of collected soil sample. After that same amount of soil has been produced for drying to estimate the actual weight of dried condition at $\pm 105^{\circ}C$ and weight of dry soil has been confirmed. The estimation of the collected soil sample has been analyzed through the "Core" method. The numeric value has considered as standard or average Bulk Density of thumb based soil pore space area. Moreover soil water content (g/g^3) has been estimated by the following formula:

$$Volume\ of\ soil\ core\ (cm^3)$$

$$\pi r^2 \times h\,(Height) \ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

Where, $r = 1.5"$

$h = 3"$

$$Soil\ water\ content\ (W_c),$$

$$W_c = \frac{W_m - W_d}{W_d} \ldots\ldots\ldots\ldots\ldots\ldots \text{(2)}$$

Where,

$W_m = Weight\ of\ moist\ soil$

$W_d = Weight\ of\ oven\ dry\ soil$

After the estimation of soil water content, Bulk Density (*Bd*) also be calculated by the following formula:

$$Bd\,(g/cm^3) = \frac{Dry\ weight\ of\ bulk\ sample}{Volume\ of\ soil\ core} \quad \ldots \text{(3)}$$

Volumetric water content (g/cm^3) also is estimated for the collected soil sample. The formula as:

$$V_{wc} = W_c\,(g/g) \times B_d\,(g/cm^3) \quad \ldots\ldots\ldots\ldots \text{(4)}$$

$V_{wc} = Volumetric\ water\ content$

$W_c = Water\ content\ (g/g^3)$

$Bd = Bulk\ Density\ (g/cm^3)$

Estimation of soil porosity (%) as per following formula:

$$Sp = 1 - (\frac{Bd}{2.65}) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(5)}$$

$S_p = Soil\ porosity\ (\%)$

$Bd = Bulk\ Density\ (g/cm^3)$

$2.65\, g/cm^3$ is default volume of average Bulk Density of thumb based soil pore space area.

4. Result and discussion

Bulk density is vital important property of a soil substrate that varies with the soil structural conditions in different region. Generally, compaction strength of soil layer is highly depends upon the bulk density of soil structure. This study has been conducted during Pre-monsoon season. The lower atmospheric temperature is very high during this season, by which the temperature of top soil layer contain maximum temperature value than the other seasons. The estimated bulk density is very low in this season. The results of the bulk density for this study have shown in Table-2. The sample numbers refers to the block-wise sample point distribution, that also given in Table-2. The bulk density for the study site for Nandigram-II and Haldia are very low and for both, the bulk density is 0.15 g/cm^3. The value of Bulk Density for Egra-I is showing 0.26 g/cm^3.

The average bulk density of this region is 0.20 g/cm^3. The substantive variation of the bulk density of the collected soil sample site for this study area refers small fluctuation. Physically, it has been observed that, the medium size grain (after passing 2mm sieve) particles like fine sand and silt are more common for these soil samples and their variation is minimum or negligible. Indeed the compaction and disruption of cohesive substance is mostly dry in this season.

The results for many additional sample points in this district reveals same result in respect of bulk density analysis for each g/cm^3 area of soil sample. Ramnagr-I, Contai-I, Contai-III, Egra-II, Khajuri-I, Pataspur-II, Bhagabanpur-I&II, Chandipur, Mayna, Tamluk, Panskura and Kolaghat are showing average amount of bulk density after the analysis.

Soil water content capacity (g/g^3) of those soil samples are also estimated. The results of those soil samples are shown in Table-2. The minimum water content capacity for these considered soil sample is 4.29 g/g^3 (Egra-I) and

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the maximum water content capacity is 8.27 g/g^3 (Haldia). The range of the water content capacity of these selected soil samples is 3.98 g/g^3. The variation of the soil water content capacity for this district is very low and the results have shown averagely distributed soil water content capacity in this season.

Table-2: Bulk density and soil water content (core method).

Sample No.	*Wt of field moist soil+ sample bag (grans)*	*Soil H_2O content (g/g^3)*	*Soil bulk density (g/cm³)*
1	450	5.45	0.21
2	450	6.83	0.18
3	450	5.00	0.23
4	450	6.25	0.19
5	450	5.30	0.22
6	450	4.29	0.26
7	450	5.64	0.21
8	450	5.68	0.21
9	450	7.88	0.16
10	450	7.06	0.17
11	450	4.80	0.24
12	450	4.80	0.24
13	450	5.30	0.22
14	450	4.62	0.25
15	450	8.13	0.15
16	450	5.71	0.21
17	450	8.27	0.15
18	450	6.47	0.19
19	450	6.94	0.17
20	450	7.00	0.17
21	450	4.73	0.24
22	450	5.81	0.20
23	450	6.89	0.18
24	450	5.90	0.20
25	450	5.95	0.20

Degree of compactness of the soil layer is determined by the bulk density analysis and this parameter is also an indicator of water content capacity of those soil layers. The volumetric water content generally increased linearly with bulk density over a wide range of densities. Dry hard compactness refers to the high amount of bulk density and this type of situation always decreases the water content capacity.

Conversely, the air capacity of compacted soils with large available-water capacities could be increased by reducing the bulk density to a value corresponding to an acceptable available-water capacity (*Archer J. R. and Smith P. D. 2006*). So, the decrease of bulk density will benefit both for available water capacity as well as good air capacity. The correlation between bulk density and water content capacity for the entire district indicates strong negative relation (r^2 =-0.99). This result is shown in Figure-2(a). The volumetric water content capacity is also indicate strong negative relation to the bulk density of the collected soil samples.

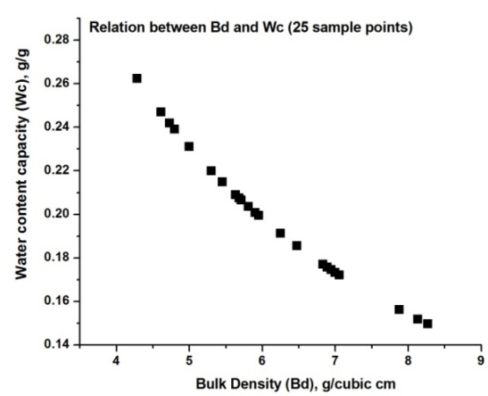
Variation of the volumetric water content capacity is very negligible (Table-3). Consistently, the volumetric water content capacity is equally distributed over the district. The result reveals that, the consistently decrease of bulk density has indicated increase of volumetric water content capacity.

Moreover the texture of soil samples over the entire district of Purba Medinipur refers to the good enough for water content capacity.

Porosity of soil samples has also been estimated by the core method. The result of this estimation is shown in Teble-4. The collected samples were very loose when collected from the field especially; it was the Per-monsoon period. So, maximum porosity has been observed after investigation.

Figure-2: a. Relation between bulk density (Bd) and water content capacity (Wc) b. Relation between bulk density (Bd) and volumetric water content (V_{wc})

(a)



(b)

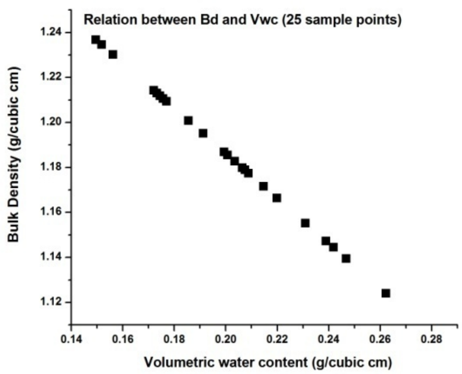


Table-3: Soil water content with volumetric measurement

Sample No.	*Soil water content (Wt) g/g^3*	*Bulk density (g/cm^3)*	*Volumetric Water content (g/cm^3)*
1	5.45	0.21	1.17
2	6.83	0.18	1.21
3	5.00	0.23	1.16
4	6.25	0.19	1.20
5	5.30	0.22	1.17
6	4.29	0.26	1.12
7	5.64	0.21	1.18
8	5.68	0.21	1.18
9	7.88	0.16	1.23
10	7.06	0.17	1.21
11	4.80	0.24	1.15
12	4.80	0.24	1.15
13	5.30	0.22	1.17
14	4.62	0.25	1.14
15	8.13	0.15	1.23
16	5.71	0.21	1.18
17	8.27	0.15	1.24
18	6.47	0.19	1.20
19	6.94	0.17	1.21
20	7.00	0.17	1.21
21	4.73	0.24	1.14
22	5.81	0.20	1.18
23	6.89	0.18	1.21
24	5.90	0.20	1.19
25	5.95	0.20	1.19

Table-4: Estimation of pore space (%) of sample soil.

Sample No.	*Bulk density (g/cm^3*	*(1-B_d) Actual (B_d)applied*	*Porosity (%)*
1	0.21	0.92	92
2	0.18	0.93	93
3	0.23	0.91	91
4	0.19	0.93	93
5	0.22	0.92	92
6	0.26	0.90	90
7	0.21	0.92	92
8	0.21	0.92	92
9	0.16	0.94	94
10	0.17	0.94	94
11	0.24	0.91	91
12	0.24	0.91	91
13	0.22	0.92	92
14	0.25	0.91	91
15	0.15	0.94	94
16	0.21	0.92	92
17	0.15	0.94	94
18	0.19	0.93	93
19	0.17	0.93	93
20	0.17	0.93	93
21	0.24	0.91	91
22	0.20	0.92	92
23	0.18	0.93	93
24	0.20	0.92	92
25	0.20	0.92	92

5. Concluding Remark

Soil bulk density is an independent dynamic character that helps to develop the volumetric water content capacity as well as porosity of the soil substance. This study reveals some undocumented result regarding the physical character of soil samples site. Actually, Purba Medinipur is one of the important geographical area which is combined by alluvial soil structure. Most of the sample site has indicated medium compact character of soil and the bulk density strongly refers to the fertile character of soil. Moreover, the proper management is required for progressive agricultural practice in this area.

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