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EXPLORING ORGANIC MATTER PRESENCE IN SOILS AND ITS EFFECT ON ENGINEERING PROPERTIES OF GOPALGANJ DISTRICT

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Abstract

The presence of organic matter (OM) in soils changes its behavior in engineering practice. The design engineer should take concern for this and that's why it is important to ensure the presence of either OM is in soil or not. So, laboratory investigation of presence of OM in soils is of great importance for designing structures. In Bangladesh, Gopalganj district is one of the low lying depression areas where OM presents in the sub-surface soil. Under these circumstances this paper has been attempted to explore the presence of OM in soil in Tungipara, Gopalganj sadar and Kotalipara upazila of Gopalganj district. Soil samples have been collected from Bangladesh Water Development Board (BWDB) and the engineering properties of soils have been determined at the Geotechnical Research Directorate of River Research Institute (RRI). After the analysis of data, organic matter has been found up to 32´ at Tungipara, up to 17´ at Gopalganj sadar and up to 22´at Kotalipara upazilla. It has also been observed that the natural moisture content, liquid limit and plasticity have been increased with the increases of organic matter content. Here it is remarkable that organic matter contents in Tungipara are 5% to 32% and their corresponding SPT values are 1 to 6, organic matter contents in Gopalganj sadar are 5% to 20% and their corresponding SPT values are 2 to 4 and Kotalipara 5% to 16% and their corresponding SPT values are 2 to 4. Though effect of organic matter presence in soils on SPT has been demonstrated here but not remarkable effect has been observed.

Keywords: *liquid limit, natural moisture content, organic matter content, plasticity index, standard penetration test.*

Introduction

Bangladesh is a small country occupying 56,977 square miles. However, it has wide varieties of soils both in surface as well as sub-surface. There are 500 soil types in Bangladesh which has been classified in ranging from juvenile alluvium or man-made soils at one extreme to old and deep weathered red soils. The extensive range of environmental situation has generated many kinds of soils and its strata.

The most comprehensive soil classification of Bangladesh with complete information on soil characteristics has been envisaged. The formation of soil with its structural phenomena such as factors, processes as well as spatial coverage of different soil types have provided by this classification. According to this coverage, a total of 21 general soil types have been recognized where peat is one of the important soil type (Sajjad, 2008).

Peat Soils are partially or fully decomposes of organic matter which constitutes more than half of the uppermost 80cm of the profile in these soils. Peat soils occur extensively in the wet depressions of flood plain areas like the Gopalgonj and Khulna beels and some perennially wet sites in the Sylhet Basin. It has limitations such as deep flooding and low natural fertility (Sajjad, 2008).

The soils contain organic matter at the surface or buried under a mineral soil layer below at a depth of up to 40 cm. The organic material that forms the Histic horizon known as Histosol and it is varies from dark brown, fibrous peat to semi-liquid black muck (Banglapedia).

The organic soil is also found in the marsh land. The marsh lands all over the country have clay soils highly rich in organic materials. Its colour is blackish. The marshlands are found in Gopalgonj, Khulna, Narail, Netrokona and Sunamgonj areas and have black peat soils (Inamul, 2008).

In Bangladesh, the floodplains of the rivers are covered with sandy, or silty, or silt mixed sandy soils. It has some clay soils at patches, carried and deposited by the rivers. But, the all season wetlands have thick deposit of clay mixed organic soils. This happens because of carrying finer particles and clay soils from distant sources, and accumulating in deep inland, away from the rivers. The all season wetlands also accumulate suspended organic solids, and have deposition of the fossils of aquatic plants. At certain areas, where the fossil percentage is higher, the soil is called peat. These are unconsolidated deposits of semi-carbonized plants, containing about 60% carbon, and about 30% oxygen (Inamul, 2008).

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Madaripur, Gopalganj, Narail, Khulna, Bagerhat, Pirojpur, Sunamgonj, Netrokona, Kishoregonj and Habigonj districts have peat soils near the ground or just few meters below the ground. Peat soils are also found at the fringes of some other lowlands, under a layer of silt or sandy topsoil. All these happened because of morphological changes in the adjacent rivers, when they started carrying sand and silt during floods, and deposited them over the subsiding fossil soil (Inamul, 2008).

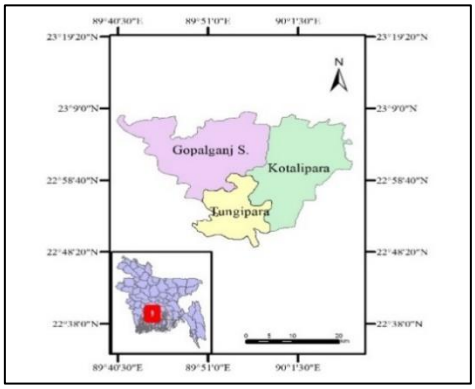

Fig. 1. Study area using ArcGIS 10.3

Peat and organic matter content have significant effect on engineering properties of soils as well as on its structure. So, considerable design should be done through duly study of organic matter of soil. No doubt, some scientists and engineers have studied. The following authors' studies could be taken for this case.

Ekwue (1990) studied Organic-matter effects on soil strength properties. He showed organic matter reduced bulk density and increased moisture retention of soil. Effect of Organic Content on the Index Properties and Compaction Parameters of Soil was investigated by Sen *et al.* (2014). The test results indicated that the organic content significantly alter the geotechnical properties of soil.

Abdi *et al.* (2016) tried to assess the influence of organic matter on the physical properties and mechanical behaviors of Hyrcanian forest soil, Iran. They also explored the relation between the amount of organic matter and the behavior of forest soil as road material. The results showed that soil plasticity increased linearly with increasing organic matter. Increasing the organic matter from 0% to 15% resulted in an increase of 11.64% of the plastic limit and15.22% of the liquid limit after drying at 110°C. Also, increasing the organic matter content reduced the soil maximum dry density and increased the optimum moisture content.

Develioglu and Pulat (2017) studied on geotechnical engineering properties and compressibility behavior of dredged soil. They obtained the samples with four different organic matter contents. From this study they has shown that OMC has an important effect on the engineering properties of dredged soils. Moreover, Rabbee and Rafizul (2012) have found that the shear strength has decreased with the increase of organic content and the stress-strain behavior is similar for all the reconstituted soils.

The Gopalgonj Sub-Region covers the areas of Gopalgonj District and north of the Perojpur and Barisal districts. The Gopalgonj sub region has many low-lying depressions, good for shallow tube well and subsoil irrigation. The ground elevation varies from 5m to 2m above mean sea level. The land is sloping at an average rate of 0.06m/km from north to south. The total area covered by this sub-region is about 1600sq.km out of which 1400 sq.km is vulnerable to flood (Inamul, 2008).

Though Gopalganj district is an organic prone area however, no dominant study has been carried out to investigate the relationship among soil properties of Gopalganj District in Bangladesh. Aim at this point, this study was attempted to reveal the relationship between organic matter content (OMC) (as independent variable) and engineering properties (as dependent variables) of soil including natural moisture content (NMC), plasticity index (PI), liquid limit (LL) and standard penetration test (SPT) of Goplaganj district. It is sanguine the study will bring help for design engineers for construction purposes who will work at low lying areas such as Gopalganj district.

Methodology

In context of organic matter presence in soils, Gopalganj district has been selected for this study as this area's soil contains highly rich organic matter. In search of organic matter content, only three upazillas of Gopalganj district namely Tungipara, Gopalganj sadar and Kotalipara have been selected as a study area which has been shown in Fig-1.

Soils including boring logs have been collected from Ground Water Hydrology Division of Bangladesh Water Development Board (BWDB). The samples were received by River Research Institute (RRI) up to 72 ft from the existing ground surface for each location. However, only organic matter content layer were considered along the soil profile in this study.

Soil samples have been tested at Geotechnical Research Directorate (GRD) of RRI. In order to detect organic matter content soils, the soils have been selected through its characteristics such as odour and dark colour (Lambe, 2004). Soil OMC, NMC, LL and PL has been quantified following ASTM procedure. SPT values have been taken from boring logs supplied by BWDB. Statistical analyses have been done between parameters using SPSS software (version 21).

Results and Discussion

This study has been carried out to reveal the relationship between OMC and NMC, PI, LL and SPT of the soil of the Upazilas of Gopalganj District. The data have been presented in the tabular form in Table-1 and the graphical presentation has been illustrated in Fig-2 and Fig-3 respectively.

In Tungipara upazila, soils of three locations namely, Char Boyria Gonapara, North Basuria and Kuchimara Khal have been identified containing organic matter presence up to 9.32% and the organic matter was observed up to the maximum depth of about thirty two feet (32´) from the existing ground surface. The sequence of presence of organic matter is not continuous for all the holes and their corresponding depth. These discontinuities have been occurred due to the percentage of the fossils of aquatic plants were accumulated in deep and light inland at variable range as the theory and practical concern.

Linear regression analysis has been done between organic matter content (independent variable) and natural moisture content (dependent variable) and it has showed linear relationship with a coefficient of determination, $R^2 = 0.804$. Similar relationships were obtained for the case of liquid limit and plasticity index. Both liquid limit and plasticity displayed linear relationship with organic matter content. The obtained coefficients of determination, R^2 for LL VS OMC and PI VS OMC are 0.8729 and 0.9079 respectively. These results have been shown in the Table-2. They have resemblance to that of Develioglu and Pulat (2017), where they found the liquid and plastic limits increased with increasing OMC. Different result has been observed from the analysis between SPT and OMC. Using SPSS software (version 21) correlation coefficient (Pearson) of SPT and OMC was obtained equal to -0.374, according to Evans (1996) which indicates a weak correlation between the two parameters. Effective diameter of the samples have been observed in the range 0.001mm to 0.007mm while organic matter content ranged from 5% to 9.32% and natural moisture content ranged from 48.27% to 64.55%. All the corresponding illustrations have been shown in Fig- 3.

In Gopalganj sadar upazila, Dattadanga Khal, Vogergati Khal, and Shibpur Khal had been identified regarding organic matter presence up to 11.95% and the organic matter is observed up to the maximum depth of about only fifteen feet (15´) from the existing ground surface in this three locations which is lower than Tungipara upazilla. However, the organic matter content have been found greater amount in Gopalganj upazilla than the Tungipara upazilla though there is no sequence of presence of organic matter content for all the holes and their corresponding depth as the same reasons as Tungipara Upazilla.

The highest organic matter was found in Kotalipara Upazila (Table-1). The three locations of this upazilla namely Depuar Khal, Pukuria Khal and Panchuramer Khal have been identified regarding organic matter presence up to 15.85%

and the organic matter is observed up to the maximum depth of about twenty two feet (22´) from the existing ground surface. There is also absent the sequence of continuous presence of organic matter for all the holes and their corresponding depth as the due same reasons as Tungipara upazilla.

Table 1. Soil organic matter according to soil profile and its corresponding NMC, LL, PI, SPT and soil texture including D_{10}, D_{30}, D_{60} in Tungipara, Gopalganj sadar and Kotalipara upazilla

Upazila	Location	Hole No.	Sample No.	Depth	OMC	N.M.C	LL	PI	Clay (%)	Silt (%)	Sand (%)	SPT	D_{10} (mm)	D_{60} (mm)	D_{30} (mm)
Tungipara	Char Boyria Gonapara	2	D1	5-7'	5.4	51.08	59	29	22	73	5	1		0.0375	0.00375
		3	D1	5-7'	9.32	64.55	76	38	15	83	2	1		0.0475	0.005
	North Basuria	2	D1	5-7'	6.96	55.03	66	32	16	81	3	2		0.016	0.0045
		3	D5	25'-27'	5.4	50.22	61	31	10	84	6	6		0.02	0.007
			D1	5-7'	6.08	48.59	60	30	16	76	8	2		0.018	0.0055
	Kuchiamara Khal	1	D1	5'-7'	6.8	51.86	65	32	4	77	19	2		0.0105	0.0035
		2	D1	5'-7'	6.4	50.13	63	30	18	80	2	2		0.0105	0.004
		3	D3	15'-17'	7.13	52.787	62	32	10	82	8	2	0.002	0.015	0.0058
			D4	20'-22'	5	48.27	55	27	18	75	7	2		0.012	0.004
			D6	30'-32'	8.54	56.01	68	35	16	77	7	2		0.014	0.0045
Gopalganj Sadar	Dattadanga Khal	1	D2	10'-12'	11.6	56.64	72	36	10	82	8	4	0.0025	0.055	0.009
					9.72	53.7	62	33	12	82	6	3	0.0014	0.016	0.0058
		3	D2	10'-12'	10.24	59.43	75	34	8.5	83.5	8	5	0.0025	0.0525	0.0075
	Vogergati Khal	3	D2	10'-12'	5.75	45.04	53	27	10	82	8	4	0.002	0.025	0.008
	Shibpur Khal	3	D3	15'-17'	11.95	66.38	85	42	11	84	8	4	0.0018	0.065	0.0075
Kotalipara	Depuar Khal	1	D1	5'-7'	5.82	50.31	55	27	21	78	1	2		0.0078	0.0031
		2	D2	10'-12'	15.85	74.86	86	45	11	80	9	4	0.002	0.025	0.0055
	Pukuria Khal	2	D3	15'-17	14.85	60.15	78	40	7	84	9	2	0.003	0.024	0.009
			D4	20'-22'	15	69.99	63	36	9.5	83.5	7	2	0.0021	0.016	0.006
	Panchuramer Khal	2	D1	5'-7'	7.65	49.12	58	30	17	80	3	3		0.009	0.00355

Note: Organic layer do not found in all holes or locations towards the whole soil profile (0´-72´). Here only consider the depth which contain organic layer in each hole/location. So, there is difference in hole no. sample no. and depth in each location.

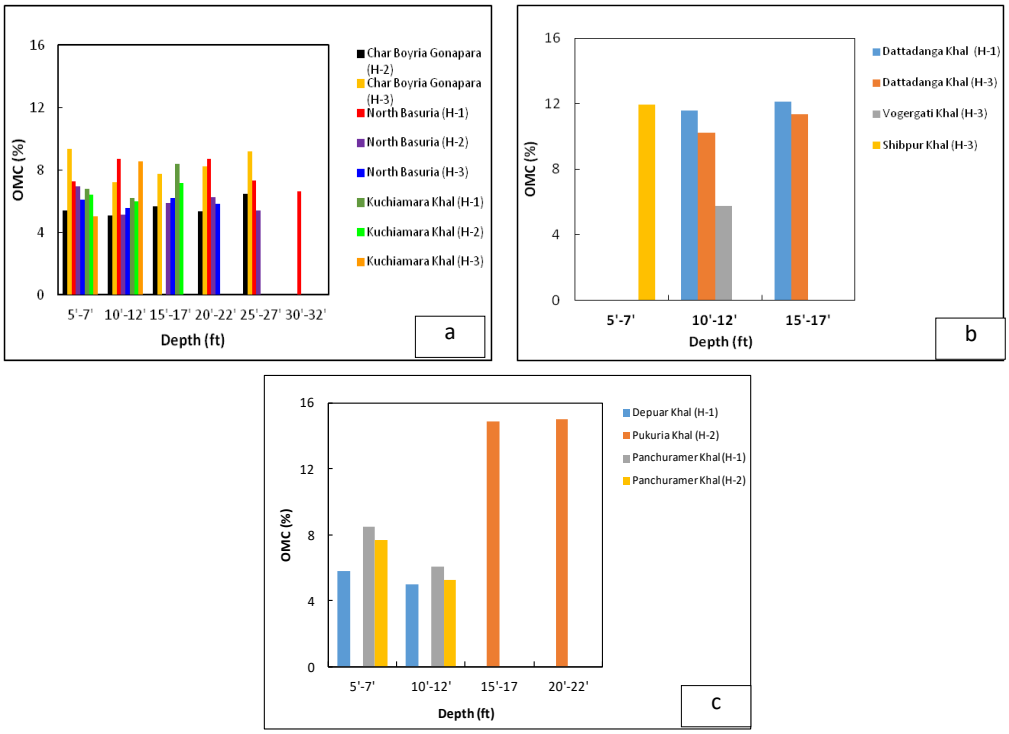

Fig. 2. The amount of OM (in %) according to depth a) for Tungipara, b) for Gopalganj Sadar, c) for Kotalipara. Note that here only consider the depth which contain organic layer in each hole/location. Organic layer do not found in all holes or locations towards the whole profile (0-72´).

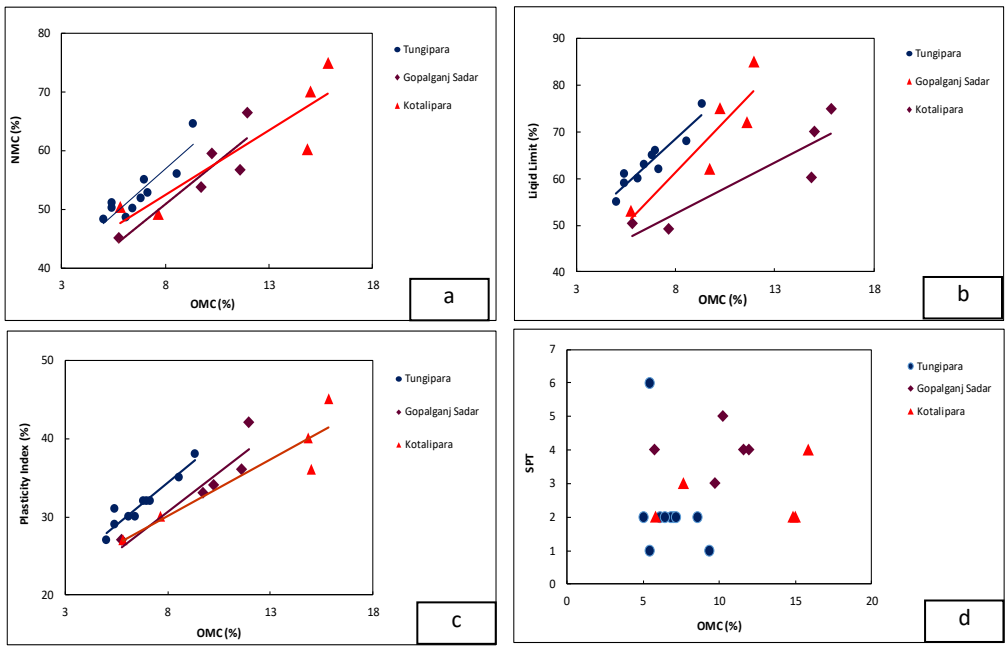

Fig. 3. Relationship between OMC and engineering properties of soils a) OMC vs NMC, b) OMC vs Liquid limit, c) OMC vs Plasticity Index, d) OMC vs SPT

Table 2. Obtained values of Coefficient of determination, R^2 and equation

Location	Parameter		Coefficient of determination, R^2	Equation
	Independent (x)	Dependent (y)		
Tungipara	OMC	NMC	0.8040	y = 3.1218x + 31.927
		LL	0.8729	y = 3.8857x + 37.454
		PI	0.9079	y = 2.132x + 17.309
Gopalganj Sadar		NMC	0.8059	y= 2.8419x + 28.24
		LL	0.7838	y = 4.4045x + 26.007
		PI	0.8422	y = 2.0091x + 14.606
Kotalipara		NMC	0.8254	y=2.1992x + 34.861
		LL	0.8130	y = 2.1992x + 34.861
		PI	0.8556	y = 1.4331x + 18.64

Table 3. Obtained values of Correlation coefficient (Pearson), R

Location	Parameter		Correlation coefficient (Pearson), R
	Independent (x)	Dependent (y)	
Tungipara	OMC	SPT	–0.374
Gopalganj Sadar		SPT	0.0743
Kotalipara		SPT	−0.228

Linear regression analysis between OMC and NMC showed that there is linear relationship with coefficient of determination ($R^2 =$ 0.0.8254).

Similar relationships were also obtained for the case of LL and PI. Similar to Tungipara and Gopalganj sadar Upazilla, both LL and PI displayed linear relationship with OMC. The obtained coefficients of determination, R^2 for LL VS OMC and PI VS OMC were $R^2 = 0.813$ and $R^2 = 0.8566$ respectively. Like as Tungipara and Gopalganj Sadar different results were observed from the analysis between SPT and OMC. The correlation coefficient (Pearson) of SPT and OMC was obtained equal to −0.228. These results have been shown in the Table-2 and Table-3 respectively. The amount of organic matter varied from 5.82% to15.85 % and NMC from 49.12% to 78.86%, effective diameter of the samples has been observed in the range 0.002mm to 0.025mm. Lower than this range of organic matter, the effective diameter of soil particles had not been identified in hydrometer test of grain size analysis. All the corresponding illustrations have been referred to Table-1.

After all the analysis of the data of the selected locations, it has been found that natural moisture content, plasticity and SPT value of soil samples have been varied with the variation of amount of organic matter content. However, the variation of organic matter content would not vary with effective diameter of the representative soil samples. Here it is clear that the variation of effective diameter has been varied due to the presence of percentage of clay, silt and sand particles.

Conclusions

In this study a number of areas of Gopalganj district have been selected to explore the presence and effect of organic matters in soils on its engineering properties. From this study it has been concluded that soils in all the locations of three Upazilas of Gopalganj District contain various amount of organic matter at the depth from ground level to the maximum depth of 12´. However exceptions have been observed at North Basuria and Kuchiamara of Tungipara Upazila where organic matter has been found depth up to 27´and 32´ respectively. The highest organic content (15.85%) has been found in Kotalipara Upazila and the lowest organic content (5.00%) has been found in Tungipara Upazila. The average organic content has been

found 6.70% for Tungipara, 9.85% for Gopalganj Sadar and 11.83 for Kotalipara. However, organic layer is absent in some of the boreholes. It is mentionable that the natural moisture content, liquid limit and the plasticity have been increases with the increases of organic matter content. The measurement of other properties has not been conducted due to various reasons. That's why only SPT values could not demonstrate the original phenomena in this study.

Recommendations

The study will be helpful for design engineer especially who will work on organic matter containing low-lying area like Gopalgonj. In this study, most of the layers content organic matter up to maximum depth of about 32´ and there is some effects on natural moisture content and plasticity even it is recommended that knowing engineering properties of soil through laboratory test is obligatory.

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