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Study of soil physicochemical parameters and organic matter humic components in relation to salinity in different landforms in a coastal soil of West Bengal

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Abstract: ***An attempt is made to study soil organic matter and to correlate it with soil salinity in a coastal Block of West Bengal, India. The humic components of organic matter was related with soil infiltration. The study covered three different landforms namely, depressed low land, deltaic land and mudflat covering three villages of Gosaba Block in coastal West Bengal. The humic components of organic matter, namely, humic acid and fulvic acid, were also separated out. Steady state cumulative infiltration was highest (50-60 mm) in deltaic upland soil and lowest (8-10mm) in depressed soil. Organic C content of all soils were high (<=1.5 %) and EC values were also low to high (2.5-14.3 dS /m). Saturated soil moisture was high in low land soil. The deltaic upland soils contained higher fraction of fulvic acid (0.17-0.2%) which enhanced infiltration, whereas depressed soils contained greater fraction of insoluble humic acid (0.30-0.35%) and exhibited less cumulative infiltration. The humic acid fulvic acid ratio decreased with soil depth. Both the percentage of clay content and percentage of clay plus silt were significantly positively correlated with the percentage of organic carbon (r2 = 0.75 and 0.72, respectively). With an increase in soil salinity, in general there was a decrease in organic matter content for all soils. The relation between sorptivity and clay, pH, EC, porosity and HA were highly significant (r= -0.91, -0.85,-0.86, -0.87 and -0.90, respectively) and negative.***

Keywords: Physicochemical parameters, salinity, humic acid **.**

1. Introduction

Soil organic matter (SOM) being a storehouse of all essential plant nutrients, plays a pivotal role in crop production [1]. For sustainable utilization of soil resources, SOM should be maintained at a threshold level. The status of SOM of tropical countries like India is generally much below the threshold levels. The soil salinity and cropping behaviour under different landforms also have an important influence on soil organic matter. Infiltration is one of the major components of the hydrologic cycle [2]. Water that falls as precipitation may run over land eventually reaching streams, lakes, rivers and oceans or infiltrate through the soil surface, into the soil profile. Water that runs off over land causes erosion, flooding and degradation of water quality. Infiltration, on the other hand, constitutes the sole source of water to sustain the growth of vegetation, is filtered by the soil which removes many contaminants through physical, chemical and biological processes, and replenishes the ground water supply to wells, springs and streams. Soil infiltration and sorptivity are also affected by the various components of SOM like humic acid, fulvic acid and humin. Intensification of agriculture with adoption of multiple cropping systems and energy intensive cultivation practices, especially excessive tillage and imbalanced use of chemical fertilizers led to further deterioration of SOM. Hence for an efficient management of SOM, it is necessary to study the influence of agricultural impact, soil salinity and cropping pattern on organic matter availability. Study of the influence of salinity on organic matter in tidal wetlands showed that salinity was strongly negatively correlated with soil organic matter content (OM%).

2. Materials and Methods

Soil samples were collected for the kharif season from three different depths (0-20, 20-40, 40-60 cm) from three different villages of Gosaba Block (Lat. 22^{o} 09'-22^{o}10' N; Long. 88^{o}47'-88^{o}48' E) of South 24 Parganas district of West Bengal (India) coming under three different landforms namely, non-cultivated deltaic (NCD), mudflat (MUD) and depressed lowland (DL) (Figure 1). It covers approximately four

Figure 1: Study area showing sampling sites of Gosaba

sq. km area. The season for collections was June- July, 2016 (before rice cultivation). The area is mostly mono-cropped (rice cultivated).

Soil samples were collected from three different locations (three replications) under each landforms (Figure 1). The infiltration measurements were carried out in soil cores from the collected samples. Infiltration data was fitted to the Phillip's model [3], which is described by the equation no. 1:

$I = St^{0.5} + At$ (1)

where, I is the cumulative infiltration (cm), S is soil water sorptivity, A is parameter close to saturated hydraulic conductivity, and t is the time (min). The infiltration rate, I (cm) was divided by corresponding value of $t^{0.5}$ (min) in the entire infiltration measurement. The values obtained were then regressed against $t^{0.5}$ to obtain S as the intercept.

Physicochemical characteristics like soil texture, pH, EC, organic C etc. were also studied. Cumulative infiltration was plotted as a function of time (Figure 2). The physicochemical characteristics of the soils were determined using Black [4] and Jackson [5] methods. Particle size analysis was done using a Buoycous hydrometer [6]. Organic carbon was determined by conventional [7] method, pH and electrical conductivity (E:C) were measured in 1: 2 soil : water ratio. Saturated water content of the soils was determined by using Keen's box [8]. The humic acid and fulvic acid fractions of organic matter were separated following the procedures of Kononova [9]. Relationship between sorptivity and other soil parameters were also determined. Correlation between clay and organic C as well as clay plus silt and organic carbon for the soils was studied.

Table 1: Physicochemical characteristics of Gosaba soil (S: sand, Si: Silt, C: clay, and l: loam; NCD: non-cultivated deltaic, MUD: mudflat/mangrove, DL: depressed low land)

Name of soil	Particle size (%)			Tex class	Org C	pH	EC (dS/m)	Θ_{s} ($m^3 m^{-3}$)
	S	Si	C					
0-20 cm								
NCD	16	55	29	Scl	1.19	5	3.7	0.59
MUD	26	22	52	C	1.19	6.9	9.3	0.54
DL	26	24	50	C	0.85	5.9	13.2	0.59
20-40 cm								
NCD	24	47	29	cl	1.13	5.7	3.6	0.56
MUD	26	20	54	C	0.71	6.9	6.9	0.55
DL	20	28	52	C	0.8	6.2	8.3	0.61
40-60cm								
NCD	25	45	30	cl	0.78	5.7	2.8	0.53
MUD	26	20	54	C	0.71	7	6.9	0.55
DL	28	20	52	C	0.8	6	8	0.6

3. Results and Discussion

3.1 Physicochemial characteristics of soil

Mud flat (MUD) and depressed low (DL) soils were clay, with a clay content of 50-52 % in the surface layer (Table 1). Clay content in non-cultivated deltaic soil (NCD) was 29 % and was sandy clay loam. In the 20-40cm and 40-60 cm soil layer for MUD and DL soils clay content did not differ much (52-54 %, clayey). All three soils were medium to high in organic C content (0.71-1.19 %). The 20-40 cm layer of NCD soil contained higher (1.13) % of organic carbon. The highest porosity or saturation water content was found in DL soil (0.59-0.61 cm^3cm^{-3}) and the lowest was in MUD (0.54-0.55 cm^3cm^{-3}).The NCD and DL surface soils were slightly acidic to neutral (pH 5.0 to 6.2). The EC values of NCD soils were low for all depths (2.8 to 3.7 dS /m); other soils were having higher EC values (6.9-13.2 dS/m) (Table 1). Water content of air dried soil before initiation of infiltration (Θi), final water content (Θ_s) and saturated hydraulic conductivity (K_s) are presented in Table 2. The highest steady state cumulative infiltration was observed in non cultivated deltaic (NCD) soil (5.5 cm) followed by mudflat (MUD) soil (3.5 cm) and depressed low land soil (DL) (2.0 cm). This result can be verified from the slope of the cumulative infiltration and time curves (Figure 2). In 50 minutes time only 1.5 cm water infiltrated in DL soil. For the same period 3.5 cm water infiltrated in NCD soil. Infiltration in MUD soil was medium (2.5 cm). Average water content in soils before infiltration varied from 0.08-0.09 cm^3cm^{-3} in MUD and 0.091-0.94 cm^3cm^{-3} in DL soils, whereas values were 0.09-0.11 cm^3cm^{-3} in NCD soils. Saturated hydraulic conductivity values for NCD soil varied from 0.018 -0.02 cm/min and that for depressed soil the values were lowest (0.005-0.012 cm/min). Highest sorptivity (3.4-3.5 mmmin-1/2) was observed in NCD soil, followed by 2.2-2.5mmin$^{-1/2}$ in MUD soil and 0.90-1.0 mmmin$^{-1/2}$ in DL soils. Sorptivity values differ significantly for three different landforms for different depths. These results can also be verified from the slope of the cumulative infiltration versus square root of time relationship curves (Figure 2). The slope of NCD soils in the present study were higher than the MUD and DL soils. In our study the cumulative infiltration of NCD soils was about 3 times higher than that of DL soils . This result is in agreement with those reported by Singh and Bhargava [10]. Organic C content of coarse soils are usually lower than clayey soils [11] for all depths. In the present study, for all landforms , organic carbon percentages in general, decreased with soil depths (Table 1) and organic carbon content of MUD soils (0.71-1.19%) were less than that of DL (0.80-0.85%) and NCD (0.78-1.13%) soils. The porosity values of different layer did not differ much because of their similar clay content (Table 1). Similarly, the high porosity of DL soils were associated with high clay content for all the three layers. E.C. values for NCD soils were low (<4 dS / m) and high for DL and MUD soils (6.9-13.2 dS / m), which decreased slightly with soil depth. This might be due to accumulation of salts at the surface soils.

Table 2: Water content of soil samples, hydraulic conductivity and sorptivity

Name of soil	Θ_i	Θ_s	K_s (cm/min)	Sorptivity (mmmin$^{-1/2}$)
0-20 cm				
NCD	0.09	0.59	0.02	3.5
MUD	0.08	0.54	0.014	2.5
DL	0.09	0.59	0.012	1
20-40 cm				
NCD	0.1	0.56	0.02	3.4
MUD	0.08	0.55	0.008	2.3
DL	0.09	0.61	0.005	0.09
40-60cm				
NCD	0.11	0.53	0.018	3.4
MUD	0.09	0.43	0.008	2.2
DL	0.09	0.6	0.005	1

NCD: non-cultivated deltaic, MUD mudflat/mangrove, DL: depressed low land $F_{2,6} > F_{tab (1\%)}$; CD = 0.42; T_1 = 10.3, T_2 = 7.0, T_3 = 2.9

3.2 Soil sorptivities

The relationships between sorptivity and clay, pH, E.C., porosity and humic acid were highly significant (r = -0.91, -0.85, -0.86, -0.87 and -0.90, respectively), exponential and negative (Table 4). Percentage fulvic acid was positively correlated (r=0.95, significant at 1% level) with sorptivity. Table 3 shows that the clay content and clay plus silt content were significantly positively correlated with the percentage of organic carbon (r^2 = 0.79 and 0.75,

Table 3: Relation between % clay, % clay+silt and organic Carbon

Soil separates (X)	Square of correlation coeff.(r^2)	Regression equation
% Clay	0.79 *	Y=0.49+0.05X
% Clay+silt	0.75 *	Y=0.45+0.02X

*Significant at 1% probability level; Y is soil organic C (%)

Table 4: Relation between sorptivity (S) and other parameters (X) of soil

Soil parameter	Correlation coefficient (r)	Regression equation
% Clay	-0.91*	S= 6.25 $e^{-0.02x}$
pH	-0.85**	S= 6.70 $e^{-0.17x}$
EC (dS/m)	-0.86*	S= 3.93 $e^{-0.06x}$
Porosity (%)	-0.87*	S= 81.2 $e^{-6.29x}$
H.A. (%)	-0.90 *	S= 4.1 $e^{-2.37x}$
F.A. (%)	+0.95*	S= 81.2 $e^{-6.29x}$

**Significant at 5% probability level, *significant at 1% probability level; S is sorptivity (mmmin $^{-1/2}$)

respectively). Humus is the major soil organic matter component making up 75-80% of the total. The humic acid fulvic acid ratio in the present study was 0.60, 1.6 and 3.1 in the surface layers of NCD, MUD and DL soils, which decreased with soil depth (0.50, 1.5, & 2.7, respectively in 30-45 cm layer) [15]. Presence of humic acid in soil generally decreases volumetric water content of soil. Decline in water repellency of soil is due to the presence of water soluble fulvic acid. The NCD soils in the present study had higher fraction of fulvic acid (0.11-0.14%) for which these were more capable of infiltration, whereas DL soils with greater fraction of insoluble humic acid (0.25— 0.31%) were water repellent and exhibited less cumulative infiltration. MUD soils showed intermediate humic acid and fulvic acid contents [12]. Regression equations in Table 4 showed that sorptivity decreased as the clay content, pH, EC, porosity and humic acid content of the soil increased (r values were -0.91, -0.85, -0.86, -0.87 and -0.90, respectively). These were in agreement with the findings of Singh and Kundu for Odisha soils. The clay content was found to be the best predictor of organic carbon. Table 5 shows that both the clay content and clay plus silt were significantly (+ve) correlated with the organic carbon content (r^2 = 0.79 and 0.75, respectively). This may be attributed to the decrease in C mineralization with increase in finer sized particles. Or in other words, pores of smaller sizes protect organic substrates against microbial decomposition in soils. Fractionation of organic matter showed that the fraction of H.A. was the highest (0.31%) in DL soil and the fraction of F.A. was the lowest (0.10%) in the surface layer of the same soil. On the other hand, the F.A. fraction was the highest in NCD soil (0.14%). MUD soils showed intermediate values (0.09%). In the lower soil layers also H.A. % was higher in the DL soils (0.25 to 0.30). The H.A. / F.A. ratio decreased with depth (0.5 to 0.6 for NCD and 2.7 to 3.1 for DL land soils).

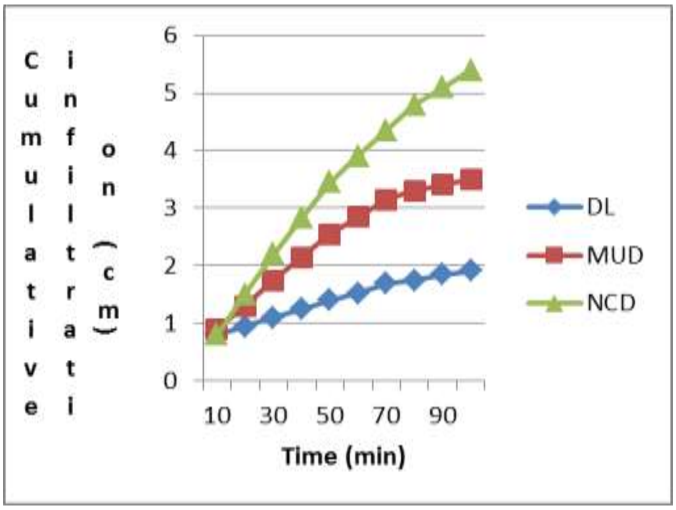

Figure 2: Cumulative infiltration as a function of time

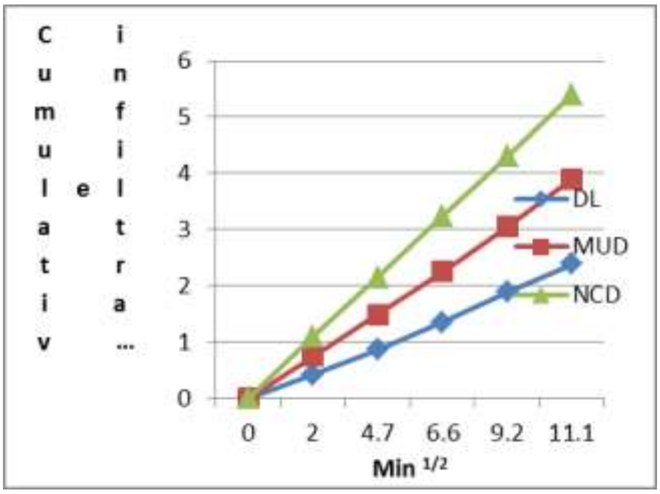

Figure 3: Cumulative infiltration as a function of square root of time

4. Conclusions

The relationships between sorptivity and clay, pH, E.C., porosity and humic acid were highly significant (r = -0.91, -0.85, -0.86, -0.87 and -0.90, respectively), exponential and negative. Percentage fulvic acid was positively correlated (r=0.95, significant at 1% level) with sorptivity. **T**he clay content and clay plus silt content were significantly positively correlated with the percentage of organic carbon (r^2 = 0.79 and 0.75, respectively). In general, there was a decrease in organic matter content with increase in salinity for all soils. Thus correction of soil pH and salinity with adoption of appropriate amendments (addition of organic matter and salinity tolerant rice varieties) were suggested for improving sorptivity of the soils of different landforms of the Block which will improve crop production of the area.

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