International Journal of Research in Agricultural Sciences
Volume 6, Issue 4, ISSN (Online): 2348 – 3997

Sorptivity and Organic Matter and its Humic Components Under Different Landforms in a Coastal Soil of West Bengal

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Date of publication (dd/mm/yyyy): 20/07/2019

Abstract **– Soil organic matter and its humic components namely, humic acid and fulvic acid for different soils coming under three different landforms namely, cultivated deltaic, depressed land and mudflats were analyzed for a coastal Block (Gosaba) of West Bengal (India). Results showed that organic carbon content of all soils were medium (0.54%) to high (1.28%), salinity was low to high (3.6-13.7dS/ m). The steady state cumulative infiltration of deltaic soils were higher than depressed low soils because of higher fulvic acid content in deltaic soil (0.14-0.15%) than depressed soils (0.09-0.1%). The humic acid: fulvic acid ratio decreased with soil depth. The relation between sorptivity and EC, pH and humic acid were highly significant, exponential and negative (r = -0.87, -0.89 and -0.86, respectively).**

Keywords **– Humic Acid, Sorptivity, Landforms, Salinity.**

I. Introduction

Climate change-associated sea level rise is expected to cause saltwater intrusion into many historically freshwater ecosystems. Of particular concern are tidal freshwater wetlands, which perform several important ecological functions including carbon sequestration. To predict the impact of saltwater intrusion in these environments, we must first gain a better understanding of how salinity regulates decomposition in natural systems. To help isolate salinity effects, sites should be selected to be highly similar in terms of plant community composition and tidal influence. Overall, salinity is found to be strongly negatively correlated with soil organic matter content (OM%) and C : N, but unrelated to the other studied environmental parameters (pH, redox, and above- and below-ground plant biomass). There is direct effect of salinity on the activity of carbon-degrading extracellular enzymes, i.e., salinity is having impact on decomposition of organic matter which could be due, at least in part, to its effect on the bacterial community. Soil salinity increases microbial decomposition rates in low salinity wetlands, and suggests that these ecosystems may experience decreased soil OM accumulation, accretion, and carbon sequestration rates even with modest levels of saltwater intrusion [1]. Cropping sequence under different landforms also have an important influence on soil organic matter. Soil infiltration and sorptivity are also affected by different components of SOM like humic acid, fulvic acid and humin. For an efficient management of SOM, it is necessary to study the influence of agricultural impact, soil salinity and cropping sequence on organic matter availability [2].

II. Materials and Methods

The study area covers 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, cultivated deltaic (CD), mudflat (MUD) and depressed lowland (DL). It covers approximately four sq. km area. Soil samples were collected for the *rabi* season from three different depths (0-20, 20-40, 40-60 cm). The season for collections was Feb.-March, 2017 (during rice cultivation). The area is mostly mono-cropped (rice cultivated). Soil samples were collected from three different locations (three replications) under each landforms.

The humic acid and fulvic acid fractions of organic matter were separated following the procedures of Kononova (1966) [3]. Sorptivity was determined using Philip's (1957) model [4], $I = St^{1/2}$ ---(1) where S is sorptivity, I is cumulative infiltration in equation (1). Sorptivity, $S= (\theta_o-\theta_i)(\check{D}/\pi)^{1/2}$ ---(2), where $\check{D}$ is weighted mean diffusivity, θ_i is initial soil water content, θ_o is saturated wetness and t is time in equation (2). Soil water diffusivity, D(θ) was calculated by using the equation (3) [5]: $D(\theta) = -1/2\ t.dx/d\theta + \int x d\theta$ ---(3) where, t is time; x is distance; the definite integral is solved between initial wetness (θ_i) and final wetness (θ_o). The weighted mean diffusivity was calculated according to equation (4) [4]:

$$\check{D} = 1.66 / (\theta_0 - \theta_i)^{5/3} + \int D(\theta)(\theta_0-\theta_i)^{2/3}\, d\theta \qquad (4)$$

where $\check{D}$ is weighted mean diffusivity, θi is initial moisture content, θ_0 is saturated moisture content, $D(\theta)$ is soil-water diffusivity in equation (4).

Organic carbon was determined by Walkley and Black (1934) [5] 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 [6].

III. Results and Discussions

A. *Humic Acid and Fulvic Acid*

The humic acid (H.A.) and fulvic acid (F.A.) fractions of organic matter in the present study were separated by Kononova (1966) method and are given in Table 1. The results showed that the fraction of H.A. was highest (0.30%) in DL soil and the fraction of F.A. was lowest (0.10%) in the surface layer of the same soil. On the other hand, the F.A. fraction was highest in CD soil (0.15%). MUD soils showed intermediate values (0.14%). In the lower soil depths H.A. % was higher in the DL soils (0.25 to 0.30). The H.A. / F.A. ratio decreased with depth (0.7 to 0.4 for CD and 3.3 to 2.8 for DL land soils).

The relationships between sorptivity and EC, pH and humic acid were highly significant (r = -0.87, -0.89 and -0.86, respectively), exponential and negative (Table 3). These were in agreement with the findings of Singh and Kundu (2001) [7] for Odisha soils. Percentage fulvic acid was positively correlated (r = +0.90, 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 ($r^2 = 0.77$ and 0.76, respectively). Humus is the major soil organic matter component making up 75-80% of the total (Kononova, 1966). The humic acid fulvic acid ratio in the present study was 0.7, 1.2 and 3.3 in the surface layers of CD, MUD and DL soils, which decreased with soil depth (0.40, 1.1, & 2.8, respectively in 40-60 cm layer). This finding is in agreement with that of Weil (1993) [8]. The CD soils in the present study had higher fraction of fulvic acid (0.14-0.15%) for which these were more capable of infiltration, whereas DL soils with greater fraction of insoluble humic acid (0.25-0.30%) were water repellent and exhibited less cumulative infiltration. MUD soils showed intermediate humic acid and fulvic acid contents [9].

Table 1: Humic acid and fulvic acid content of Gosaba soil.

Soils	Total organic matter (%)	H.A. (%)	F.A. (%)	H.A. / F.A. ratio
0-20 cm				
CD	2.21	0.10	0.15	0.7

Soils	Total organic matter (%)	H.A. (%)	F.A. (%)	H.A. / F.A. ratio
MUD	0.93	0.15	0.13	1.2
DL	1.48	0.30	0.09	3.3
20-40 cm				
CD	2.07	0.08	0.15	0.5
MUD	1.10	0.15	0.14	1.1
DL	0.93	0.30	0.10	3.0
40-60 cm				
CD	1.31	0.06	0.14	0.4
MUD	1.03	0.16	0.15	1.1
DL	1.03	0.25	0.09	2.8

Water content of air dried soil before initiation of infiltration (ϴi), final water content ($ϴ_s$) and gain in water content are presented in Table 2. The water content in soils before infiltration varied from 0.01-0.02 cm^3cm^{-3} in MUD and 0.02-0.03 cm^3cm^{-3} in DL soils, whereas values were 0.02-0.04 cm^3cm^{-3} in CD soils. Sorptivity was highest (2.2-2.5 mmmin-1/2) in CD soil, followed by 2.1-2.2 $mmin^{-1/2}$ in MUD soil and 1.0-1.5 $mmmin^{-1/2}$ in DL soils. Sorptivity values differ significantly for three different landforms for different depths. These results can also be reflected in the slope of the cumulative infiltration versus square root of time relationship curves.

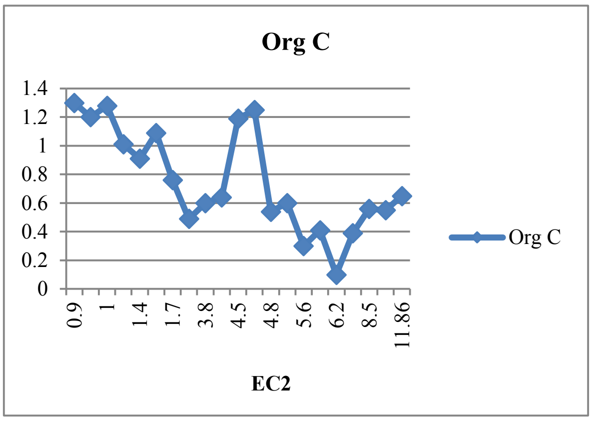

Fig. 1. Soil salinity and organic carbon relationship

In general, with increase in EC values, there was a decrease in organic carbon content. This may be attributed to the decrease in activity of organic matter sequestering organisms. The organic C % was high at EC values 4-4.5 (dS /m) may be because of addition of F.Y.M.

Table 2. Water content of soil samples and sorptivity

Name of soil	$ϴ_i$	$ϴ_s$	$ϴ_s$ - $ϴ_i$	Sorptivity ($mmmin^{1/2}$)
0-20 cm				
CD	0.02	0.44	0.42	2.5
MUD	0.02	0.38	0.36	2.1
DL	0.03	0.45	0.42	1.5
20-40cm				
CD	0.03	0.44	0.41	2.4
MUD	0.01	0.40	0.39	2.2
DL	0.03	0.46	0.43	1.0
40-60cm				
CD	0.04	0.45	0.41	2.2
MUD	0.01	0.42	0.41	2.1

Name of soil	Θ_i	Θ_s	$\Theta_s - \Theta_i$	Sorptivity (mmmin$^{1/2}$)
DL	0.02	0.46	0.44	1.0

CD: cultivated deltaic, MUD: mudflat/mangrove, DL: depressed low Land; $F_{2,6} > F_{tab\,(1\%)}$; CD = 1.1; $T_1 = 7.1$, $T_2 = 6.4$, $T_3 = 3.5$

Table 3. Relation between sorptivity (S) and other parameters of soil

Soil parameter	Correlation coefficient (r)	Regression equation
EC (dS/m)	-0.87*	$S= 3.2\ e^{-0.07x}$
pH	-0.89**	$S= 9.5\ e^{-0.26x}$
H.A. (%)	-0.86 *	$S= 2.9\ e^{-3.1x}$
F.A. (%)	+0.90**	$S= 0.65\ e^{7.9x}$

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

In this study, organic carbon percentages for all landforms decreased with soil depth. (Table 1) and organic carbon content of MUD soils (0.54-0.60%) were less than that of DL (0.54-0.86%) and CD (0.76-1.28%) soils. The saturation moisture content (porosity) of different layer did not vary much because of their similar textural content (Table 1). Similarly, the high porosity of DL soils was associated with high clay content for all the three layers. E.C. values for CD soils were low (<4 dS / m) and high for DL and MUD soils (5.2-13.7 dS / m), which decreased slightly with soil depth. This might be due to accumulation of salts at the surface soils. The fraction of H.A. was highest (0.30%) in DL soil and the fraction of F.A. was lowest (0.10%) in the surface layer of the same soil. On the other hand, the F.A. fraction was highest in CD soil (0.15%). MUD soils showed intermediate values (0.14%). In the lower soil depths H.A. % was higher in the DL soils (0.25 to 0.30). The H.A. / F.A. ratio decreased with depth (0.7 to 0.4 for CD and 3.3 to 2.8 for DL land soils).

Table 4 shows that both the clay content and clay plus silt were significantly (+ve) correlated with the organic carbon content ($r^2 = 0.77$ and 0.76, respectively).

Table 4. Relation between % clay, % clay+silt and organic Carbon.

Soil separates (X)	Square of correlation coeff.(r^2)	Regression equation
% Clay	0.77 *	Y = 0.59 + 0.03X
% Clay + silt	0.76 *	Y = 0.49 + 0.02X

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

IV. Conclusion

Decline in water repellency of soil is due to the presence of water soluble fulvic acid. The CD soils in the present study had higher fraction of fulvic acid (0.14-0.15%) for which these were more capable of infiltration, whereas DL soils with greater fraction of insoluble humic acid (0.25-0.30%) were water repellent and exhibited less cumulative infiltration. MUD soils showed intermediate humic acid and fulvic acid contents. The clay content was found to be the best predictor of organic carbon. Both the clay content and clay plus silt were significantly (+ve) correlated with the organic carbon content ($r^2 = 0.77$ and 0.76, 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. In general, with increase in EC values, there was a decrease in organic carbon content.

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