Middle-East Journal of Scientific Research 15 (3): 452-460, 2013
ISSN 1990-9233

DOI: 10.5829/idosi.mejsr.2013.15.3.11088

Transformations of Humus Carbon in *Aila* Affected Soils of Sunderban in Eastern Indian Mangrove Region

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Abstract: An incubation study was conducted to evaluate the effect of different treatments viz. lime, organic matter (vermicompost) and fertilizer, on changes of humic acid carbon and fulvic acid carbon of both upland and lowland mangrove soils collected from *Aila* (cyclone) affected village named Sandeshkhali, in South 24 Parganas district of West Bengal, Sunderban area of eastern India. N, P_2O_5 and K_2O was added @ 80: 40: 40 kg ha^{-1} in each of the treatment except the blank one Treatment combination was made using two doses of lime (0 and 17.54 t ha^{-1} for upland; 0 and 9.14 t ha^{-1} for lowland soil) and vermicompost (0 and 5 t ha^{-1} for both upland and lowland soil) each. The soil samples were collected and analyzed for evaluating the changes in humic acid carbon and fulvic acid carbon at 30, 60 and 90 days of incubation. Initially the Aila affected soil was tested for various physico-chemical parameters like particle size distribution, soil reaction (pH), electrical conductivity (EC), cation exchange capacity (CEC), oxidisable organic carbon (O.C), humic and fulvic acid carbon (HA_C and FA_C), total sulphur (S), inorganic sulphate (SO_4), total nitrogen, phosphorus and potassium (N, P and K) and water soluble and exchangeable potassium, calcium, magnesium and chloride (K, Ca, Mg and Cl). The soil samples were analyzed periodically for HA_C, FA_C and E_4:E_6 ratio of HA and FA. The data were statistically analyzed following the standard methods. Application of lime did not show appreciable changes in the content of HA_C and FA_C. But the application of vermicompost resulted to some extent better mobilization of HA_C and FA_C.

Key words: Transformation of humus Carbon · Aila affected soil · Mangrove region · Humic acid carbon · Fulvic acid carbon · Vermicompost application

INTRODUCTION

Tropical cyclones are major hazards in tropical coastal regions, both in terms of loss of life and economic damage. Many violent severe local storms occur over the Gangetic plain of West Bengal. Present study consists of the transformation of soil humus carbon due to a severe tropical cyclone Aila that passed across the Gangetic delta with a speed of 110 km/hr during 25th May 2009 [1]. Among the 12 districts of West Bengal the most affected ones are the 24 South Parganas and 24 North Parganas which are at the Sunderban region. The Sunderban mangrove forests is the largest single block of the tidal halophytic mangrove forest of the world. Mangroves are among the most productive coastal ecosystems in the world that protect coastal people from natural calamities and support livelihood [2]. The cyclone washed away a diameter as huge as 250-350 km of land, flooded most of the Sunderbans and left 10,00,000 helpless people with little or no access to food, safe drinking water, shelter or medi-cine (www.muktiweb.org).

Out of the total crop affected area of 2,56,750 ha in all the 12 districts, the share of North 24 Parganas is 55, 600 ha. According to the Government of West Bengal statistics, over 6.77 million people have been affected and 137 killed in North 24 Parganas and South 24 Parganas [3].

Saline water gushed in through breaches in the river dykes and inundated houses and lands. Under the present conditions, almost 60% of the area in the district of North 24 Parganas has been rendered uncultivable. It has caused a havoc in 5 blocks of North 24 Parganas, Sandeshkhali is one of them [4].

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It is apprehended that the overall physical, chemical and biological properties of the affected soil has been changing already considerably and rendering them unfavorable for cultivation. Along with other physical and chemical properties, soil organic matter will undergo considerable changes due to inundation with sea water for quite a long period of time. Since the soils collected for the present investigation are acidic sulphate soil, total and inorganic sulphate status of the soil and their transformation due to liming and organic matter application are considered relevant to study along with changes in humic and fulvic acid carbon.

Therefore, the incubation study was contemplated with a view to study the transformations of humic acid carbon and fulvic acid carbon, characterization of humic acid and fulvic acid by visible spectrometry, transformation of total and inorganic sulphate effect of liming, vermicompost application and fertilization on humus carbon transformation and effect of liming, vermicompost application and fertilization on the transformation of sulphur of the soil.

MATERIALS AND METHODS

The soil samples were collected from village Sandeshkhali under the district of South 24 Parganas, West Bengal. Sandeshkhali is located at longitude 88.90°E and latitude 22.36°N in the Sunderban area. Surface soil samples (0-15 cm) were collected, passed through a 2mm sieve and analysed for different physicochemical properties using standard methods as described by Black [5]. Organic carbon (O.C), humic acid and fulvic acid carbon (HA_C and FA_C), total sulphur (S) and inorganic sulphate (SO_4) were determined. The humic substances was extracted from soil following the rapid method of extraction using sodium pyrophosphate along with the dilute NaOH [6] and much higher amount of extracted dark coloured humic substances was found. The organic C, HA_C and FA_C content was determined by Tyurin's method. The total S was determined by the method of Bardsley and Lancaster [7] as described by Black [5] and the inorganic sulphate/or available sulphur was determined by extraction of soil with 0.15% $CaCl_2$ (soil:solution is 1:5) as described by Chesnin and Yien [8]. The incubation study was conducted in the net house of Faculty of Agriculture, Agricultural Chemistry and Soil Science Department, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia. The collected soils were kept in pots for incubation and submerged during whole period of experimentation (90 days). Treatment details are presented in the following table.

Treatments Number	Abbreviation	Description
I- Upland soil		
T_1	I (Bl)	Blank (No fertilizer + No lime + No vermicompost)
T_2	I (V_0L_0)	Control (80:40:40 of $N:P_2O_5:K_2O$) +(No vermicompost + No lime)
T_3	I (V_oL_A)	(80:40:40 of $N:P_2O_5:K_2O$) + (No vermicompost + 17.54 t ha^{-1} lime)
T_4	I (V_AL_o)	(80:40:40 of $N:P_2O_5:K_2O$) + (5 t ha^{-1} vermicompost + No lime)
T_5	I (V_AL_A)	(80:40:40 of $N:P_2O_5:K_2O$) + (5 t ha^{-1} vermicompost +17.54 t ha^{-1} lime)
II- Lowland soil		
T_6	II (Bl)	Blank (No fertilizer + No lime + No vermicompost)
T_7	II (V_0L_0)	Control (80:40:40 of $N:P_2O_5:K_2O$) + (No vermicompost + No lime)
T_8	II (V_AL_0)	(80:40:40 of $N:P_2O_5:K_2O$) + (No vermicompost + 9.14 t ha^{-1} lime)
T_9	II(V_AL_o)	(80:40:40 of $N:P_2O_5:K_2O$) + (5 t ha^{-1} vermicompost + No lime)
T_{10}	II (V_AL_A)	(80:40:40 of $N:P_2O_5:K_2O$) + (5 t ha^{-1} vermicompost + 9.14 t ha^{-1} lime)

[A=Upland, B=Lowland, V=Vermicompost, L=Lime, 0=Absent, Bl= Blank]

The design followed was Completely Randomized Design (CRD) and statistical analysis was done with the help of SPSS software (SPSS 7.5, 1997) and the mean effects of the variables were further subjected to Post-Hoc test like CD (Critical difference) test to identify homogeneous means 5% level of significance.

RESULT AND DISCUSSIONS

The physicochemical properties of the upland and lowland soils are presented in the Table 1.

Changes in Humic Acid Carbon (HA_C) and Fulvic Acid Carbon (FA_C) in Upland and Lowland Soils: Results of the effect of water logging on the changes in HA_C and FA_C in upland and lowland soils with fertilizer application, vermicompost application, liming and without such applications are presented graphically in figure 1.

Before initiation of incubation, HA_C of upland and low land soils were found to be 0.62 and 0.61% respectively. Simple submergence of the soil (without any treatment) HA_C value was found to increase up to 30 days of incubation and then reduces on 60 and 90 days in both upland and lowland soil.

Similar trend of increase in FA_C was found in both upland soil and lowland soil during 30 days period. But afterwards the reducing trend in FA_C was recorded in both 60 and 90 days of incubation. However, the reduction was very high (36%) in case of upland soil during 90 days of incubation. In only NPK fertilizer treated upland soil,

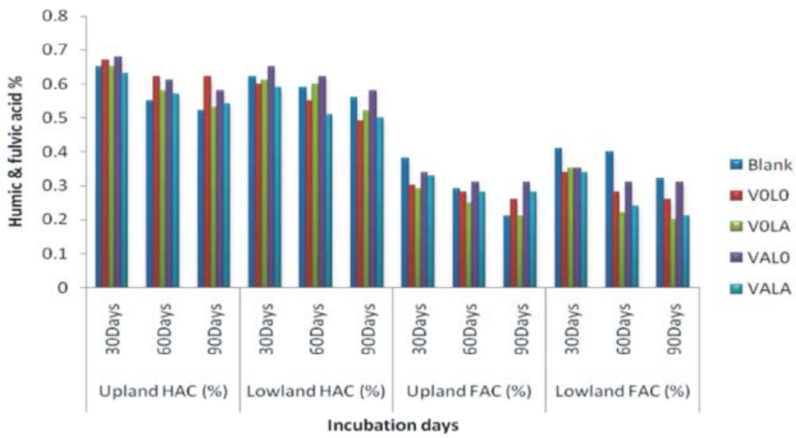

Fig. 1: Changes in humic acid carbon (HA_C%) and fulvic acid carbon (FA_C%) during incubation in upland and lowland soils.

Table 1: Physicochemical properties of investigated soils

Soil characteristics	Upland	Lowland
Physical Parameter (Particle Size Distribution, %)		
Sand	14.8	14.5
Silt	31.6	31.9
Clay	53.6	54.1
Textural class	Clay	Clay
Chemical Parameters		
pH (Soil: Water = 1: 2.5)	5.71	6.17
EC (in dS/m)	2.51	1.07
Cation Exchange Capacity [Cmol (P^+) kg^{-1}]	18.67	18.5
Oxidizable Organic Carbon (%)	0.58	0.631
Humic acid carbon (%)	0.62	0.61
Fulvic acid carbon (%)	0.33	0.36
Total S (mg/kg)	999.65	563.75
Inorganic sulphate S (mg/kg)	359.37	203.13
Total N (%)	0.198	0.182
Total P (mg/kg)	788.0	790.46
Total K (mg/kg)	21066	18533
Water soluble and exchangeable K (mg/kg)	576	473
Water soluble and exchangeable Mg (mg/kg)	6000	4200
Water soluble and exchangeable Ca (mg/kg)	4000	5000
Water soluble chloride (mg/kg)	240	142

Table 2: Effect of the interaction among soil, lime and organic matter on HA_C (%) of soils after submergence

	HA_C_1	HA_C _2	HA_C _3	Mean
SOIL				
Soil_1(Upland)	0.66	0.60	0.57	0.61
Soil_2(Lowland)	0.61	0.57	0.52	0.57
LIME				
Lime_0 (Absent)	0.65	0.60	0.57	0.61
Lime_1 (Present)	0.62	0.56	0.52	0.57
OM				
OM_0 (Absent)	0.63	0.59	0.54	0.59
OM_1 (Present)	0.64	0.58	0.55	0.59
SOIL*Lime				
Soil_1 * Lime_0	0.67	0.62	0.60	0.63
Soil_1 * Lime_1	0.64	0.57	0.53	0.58
Soil_2 * Lime_0	0.62	0.59	0.53	0.58
Soil_2 * Lime_1	0.60	0.55	0.51	0.55
SOIL*OM				
Soil_1 *OM_0	0.66	0.60	0.57	0.61
Soil_1 * OM_1	0.66	0.59	0.56	0.60
Soil_2 * OM_0	0.60	0.58	0.50	0.56
Soil_2 * OM_1	0.62	0.56	0.54	0.57
LIME*OM				
Lime_0*OM_0	0.63	0.59	0.55	0.59
Lime_0*OM_1	0.66	0.62	0.58	0.62
Lime_1*OM_0	0.63	0.59	0.52	0.58
Lime_1*OM_1	0.61	0.54	0.52	0.56
SOIL*Lime*OM				
Soil_1*Lime_0*OM_0	0.67	0.62	0.62	0.64
Soil_1*Lime_0*OM_1	0.68	0.61	0.58	0.62
Soil_1*Lime_1*OM_0	0.65	0.58	0.53	0.58
Soil_1*Lime_1*OM_1	0.63	0.57	0.54	0.58
Soil_2*Lime_0*OM_0	0.60	0.55	0.49	0.54
Soil_2*Lime_0*OM_1	0.65	0.62	0.58	0.62
Soil_2*Lime_1*OM_0	0.61	0.60	0.52	0.58
Soil_2*Lime_1*OM_1	0.59	0.51	0.50	0.53
GROUP				
SOIL 1	0.65	0.55	0.52	0.57
SOIL 2	0.62	0.59	0.56	0.59
TREATED	0.63	0.58	0.54	0.59

	SE(m) (±)	CD(p<0.05)	SE(m) (±)	CD(p<0.05)	SE(m) (±)	CD(p<0.05)	SE(m) (±)	CD(p<0.05)
Soil / Lime / OM	0.002	0.006	0.003	0.009	0.003	0.008	0.002	0.005
Soil * Lime/ soil * OM/ Lime* OM	0.003	0.009	0.004	0.012	0.004	0.011	0.002	0.007
Soil * Lime* OM	0.004	0.013	0.006	0.017	0.005	0.016	0.003	0.010
Controls	0.004	0.013	0.006	0.017	0.005	0.016		
Fertilized vs. Non fertilized	0.003	0.007	0.005	0.010	0.004	0.009	0.003	0.006

HA_C did not show any appreciable change during the course of incubation in low land soil while in upland soil reduction of HA_C was more prominent up to 90th day of incubation. But the FA_C was found to reduce one third in case of upland soil and one tenth in case of lowland soil on 90th day of incubation. When vermicompost was applied along with NPK in upland and lowland soil the HA_C was found to increase up to 30 days and thereafter a steady decline of HA_C during 60 and 90 days. In case of FA_C both upland soil and lowland soil had same trend of results during three observations state.

Effect of liming on changes of HA_C (in both upland and lowland soil) did not show appreciable variation when compared with control. But in case of FA_C liming affected more reduction in 60 and 90 days of incubation in upland soil and lowland soil and the result was more striking in lowland soil. In case of both upland soil and lowland soil liming with and without vermicompost application have similar trend of reduction of HA_C during incubation period. But in case of FA_C, loss was more prominent in 60 and 90 days in lowland soil.

Table 3: Effect of the interaction of soil, lime and organic matter on FA_C(%) of soils after submergence

	FA_C _1	FA_C _2	FA_C _3	Mean
SOIL				
Soil_1 (Upland)	0.32	0.28	0.27	0.29
Soil_2 (Lowland)	0.35	0.26	0.25	0.28
LIME				
Lime_0 (Absent)	0.33	0.30	0.28	0.30
Lime_1 (Present)	0.33	0.25	0.23	0.27
OM				
OM_0 (Absent)	0.32	0.26	0.23	0.27
OM_1 (Present)	0.34	0.29	0.28	0.30
SOIL*Lime				
Soil_1 * Lime_0	0.32	0.30	0.28	0.30
Soil_1 * Lime_1	0.31	0.27	0.25	0.27
Soil_2 * Lime_0	0.35	0.30	0.29	0.31
Soil_2 * Lime_1	0.35	0.23	0.21	0.26
SOIL*OM				
Soil_1 *OM_0	0.30	0.27	0.24	0.27
Soil_1 * OM_1	0.34	0.30	0.29	0.31
Soil_2 * OM_0	0.35	0.25	0.23	0.28
Soil_2 * OM_1	0.35	0.28	0.26	0.29
LIME*OM				
Lime_0*OM_0	0.32	0.28	0.26	0.29
Lime_0*OM_1	0.35	0.31	0.31	0.32
Lime_1*OM_0	0.32	0.24	0.21	0.25
Lime_1*OM_1	0.34	0.26	0.25	0.28
SOIL*Lime*OM				
Soil_1*Lime_0*OM_0	0.30	0.28	0.26	0.28
Soil_1*Lime_0*OM_1	0.34	0.31	0.31	0.32
Soil_1*Lime_1*OM_0	0.29	0.25	0.21	0.25
Soil_1*Lime_1*OM_1	0.33	0.28	0.28	0.30
Soil_2*Lime_0*OM_0	0.34	0.28	0.26	0.29
Soil_2*Lime_0*OM_1	0.35	0.31	0.31	0.32
Soil_2*Lime_1*OM_0	0.35	0.22	0.20	0.26
Soil_2*Lime_1*OM_1	0.34	0.24	0.21	0.26
GROUP				
SOIL 1	0.38	0.29	0.21	0.29
SOIL 2	0.41	0.40	0.32	0.38
TREATED	0.33	0.27	0.26	0.29

	SE(m) (±)	CD(p<0.05)	SE(m) (±)	CD(p<0.05)	SE(m) (±)	CD(p<0.05)	SE(m) (±)	CD(p<0.05)
Soil / Lime / OM	0.003	0.010	0.003	0.009	0.003	0.009	0.002	0.005
Soil * Lime/ soil * OM/ Lime* OM	0.005	0.014	0.004	0.012	0.004	0.012	0.002	0.007
Soil * Lime* OM	0.007	0.020	0.006	0.018	0.006	0.017	0.003	0.010
Controls	0.007	0.020	0.006	0.018	0.006	0.017		
Fertilized vs. Non fertilized	0.005	0.011	0.005	0.010	0.005	0.010	0.003	0.006

Statistical Analysis: Combined effect of different treatments viz. lime and OM on upland and lowland soil HA_C and untreated soil are statistically analysed and found to be significant relationship on 30, 60, 90 days of incubation (Table 2). Effect of fertilizer, lime and OM on HA_C against unfertilized was found to have significant relationship.

The changes of FA_C with the different treatments like lime, OM showed significant (P=0.05) result at all three observation period. Significant variation is also found for FA_C when interrelated with soil, lime, OM individually at 30, 60 and 90 days of incubation. When the results for FA_C were analysed with the combined effect of lime, OM with untreated were also showed the significant result which are presented in the (Table 3) in case of both upland and lowland soil. The effect of fertilizer application in both soil when compared with respect to unfertilized treatment also showed significant at 30, 60 and 90 days of incubation.

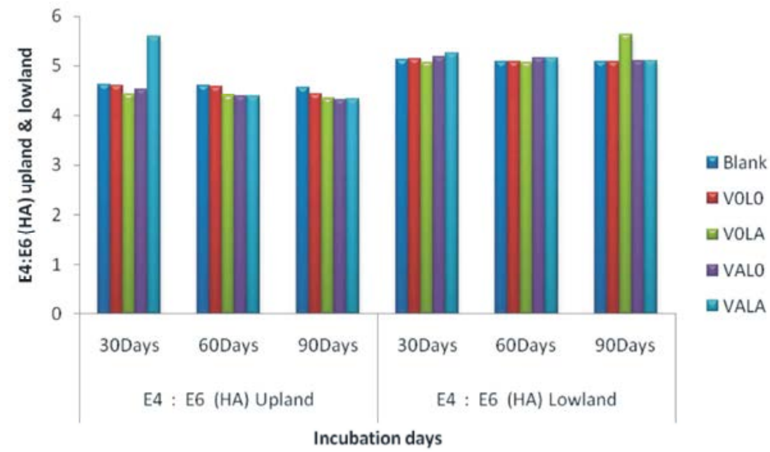

Fig. 2: Changes in E_4: E_6 ratio of humic acid (HA) during incubation in upland and lowland soils.

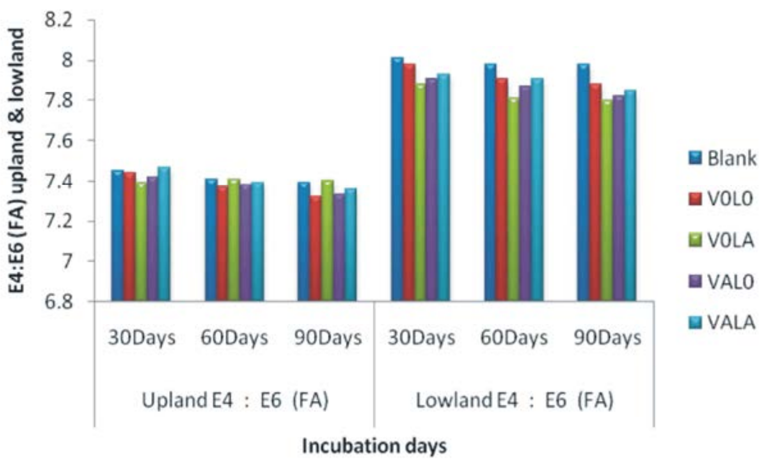

Fig. 3: Changes in E_4: E_6 ratio of fulvic acid (FA) during incubation in upland and lowland soils.

Changes in E_4: E_6 ratio of HA in-upland and Lowland Soils: E_4: E_6 ratio of HA of both upland and lowland soil showed the similar trend in the changes with respect to various treatments applied. The result has been graphically represented in the figure 2. No significant changes were found due to the application of lime, vermicompost and fertilizer in case of both upland and lowland soil. But in case of upland soil, due to application of both lime and vermicompost with fertilizer showed a small increase in the E_4:E_6 ratio of humic acid in the 30 days of intervals. Another change was found in the E_4:E_6 ratio in low land soil due to application of lime at 90 days of interval.

Changes in the E_4: E_6 ratio of FA in Upland and Lowland Soils: The data illustrated in Figure 3 show the same trend of decrease of E_4: E_6 ratio for FA in upland and lowland soils during the incubation period. In both cases, the effect of application of lime, vermicompost and fertilizer was negligible. It was also found that the E_4: E_6 ratio was decreasing in both upland and low land soils in the following order according to the different treatments:

Upland soil – Initial > Control > V_0L_0 > V_0L_A > V_AL_0 > V_AL_A

Lowland soil – Initial > Control > V_0L_0 > V_0L_6 > V_BL_0 > V_BL_B

Results of correlation matrix of HA, FA and E_4:E_6 ratio of HA and FA are presented in the table 4. Fulvic acid carbon (FA_C) is found to be significantly correlated with humic acid carbon (HA) at 1% level. E_4:E_6 ratio of FA is also found to be significantly correlated (1%) with E_4:E_6 of HA. Statistical analysis of the results of the effect of soil, lime and OM on E_4:E_6 ratio of HA and FA are presented in table 5, 6.

Combined effect of soil and lime; soil and OM; lime and OM and soil, lime and OM on E_4:E_6 ratio of HA and E_4:E_6 ratio of FA are presented in table 5, 6.

Table 4: Correlation matrix between E_4:E_6 ratio of HA and FA and between HA_C and FA_C

	HA_C	FA_C	E_4:E_6(HA)	E_4:E_6(FA)
HA	1.000			
FA	0.612	1.000		
E_4:E_6 (HA)	-0.035	0.074	1.000	
E_4:E_6 (FA)	-0.009	0.083	0.618	1.000

Bold coefficients are significant at 1% level

Table 5: Effect of the interaction among soil, lime and organic matter on E_4: E_6 ratio of HA of soils after submergence

	E_4:E_6_(HA)1	E_4:E_6_(HA)2	E_4:E_6_(HA)3	Mean
SOIL				
Soil_1 (Upland)	4.79	4.44	4.36	4.53
Soil_2 (Lowland)	5.15	5.11	5.23	5.16
LIME				
Lime_0 (Absent)	4.86	4.80	4.73	4.80
Lime_1 (Present)	5.08	4.75	4.86	4.90
OM				
OM_0 (Absent)	4.81	4.79	4.88	4.82
OM_1 (Present)	5.13	4.77	4.71	4.87
SOIL*Lime				
Soil_1 * Lime_0	4.57	4.48	4.37	4.47
Soil_1 * Lime_1	5.01	4.40	4.35	4.59
Soil_2 * Lime_0	5.15	5.12	5.09	5.12
Soil_2 * Lime_1	5.16	5.10	5.37	5.21
SOIL*OM				
Soil_1 *OM_0	4.52	4.50	4.39	4.47
Soil_1 * OM_1	5.06	4.39	4.33	4.59
Soil_2 * OM_0	5.10	5.08	5.36	5.18
Soil_2 * OM_1	5.21	5.15	5.10	5.15
LIME*OM				
Lime_0*OM_0	4.87	4.84	4.76	4.82
Lime_0*OM_1	4.85	4.77	4.71	4.77
Lime_1*OM_0	4.75	4.73	4.99	4.82
Lime_1*OM_1	5.42	4.77	4.72	4.97
SOIL*Lime*OM				
Soil_1*Lime_0*OM_0	4.60	4.59	4.43	4.54
Soil_1*Lime_0*OM_1	4.53	4.38	4.31	4.41
Soil_1*Lime_1*OM_0	4.43	4.41	4.35	4.40
Soil_1*Lime_1*OM_1	5.59	4.39	4.34	4.77
Soil_2*Lime_0*OM_0	5.13	5.09	5.09	5.10
Soil_2*Lime_0*OM_1	5.17	5.15	5.10	5.14
Soil_2*Lime_1*OM_0	5.06	5.06	5.63	5.25
Soil_2*Lime_1*OM_1	5.25	5.15	5.10	5.17
GROUP				
SOIL 1	4.62	4.60	4.57	4.60
SOIL 2	5.12	5.09	5.09	5.10
TREATED	4.97	4.78	4.79	4.85

	SE(m) (±)	CD(p<0.05)	SE(m) (±)	CD(p<0.05)	SE(m) (±)	CD(p<0.05)	SE(m) (±)	CD(p<0.05)
Soil / Lime / OM	0.288	0.849	0.291	0.857	0.293	0.863	0.289	0.853
Soil * Lime/ soil * OM/ Lime* OM	0.407	1.200	0.411	1.212	0.414	1.221	0.409	1.207
Soil * Lime* OM	0.575	1.697	0.581	1.714	0.585	1.727	0.579	1.707
Controls	0.575	1.697	0.581	1.714	0.585	1.727		
Fertilized vs. Non fertilized	0.455	0.949	0.459	0.958	0.463	0.965	0.457	0.954

Table 6: Effect of the interaction among soil, lime and organic matter on E_4:E_6 ratio of FA of soils after submergence

	E_4:E_6_(FA)1	E_4:E_6_(FA)2	E_4:E_6_(FA)3	Mean
SOIL				
Soil_1 (Upland)	4.79	4.44	4.36	4.53
Soil_2 (Lowland)	5.15	5.11	5.23	5.16
LIME				
Lime_0 (Absent)	4.86	4.80	4.73	4.80
Lime_1 (Present)	5.08	4.75	4.86	4.90
OM				
OM_0 (Absent)	4.81	4.79	4.88	4.82
OM_1 (Present)	5.13	4.77	4.71	4.87
SOIL*Lime				
Soil_1 * Lime_0	4.57	4.48	4.37	4.47
Soil_1 * Lime_1	5.01	4.40	4.35	4.59
Soil_2 * Lime_0	5.15	5.12	5.09	5.12
Soil_2 * Lime_1	5.16	5.10	5.37	5.21
SOIL*OM				
Soil_1 *OM_0	4.52	4.50	4.39	4.47
Soil_1 * OM_1	5.06	4.39	4.33	4.59
Soil_2 * OM_0	5.10	5.08	5.36	5.18
Soil_2 * OM_1	5.21	5.15	5.10	5.15
LIME*OM				
Lime_0*OM_0	4.87	4.84	4.76	4.82
Lime_0*OM_1	4.85	4.77	4.71	4.77
Lime_1*OM_0	4.75	4.73	4.99	4.82
Lime_1*OM_1	5.42	4.77	4.72	4.97
SOIL*Lime*OM				
Soil_1*Lime_0*OM_0	4.60	4.59	4.43	4.54
Soil_1*Lime_0*OM_1	4.53	4.38	4.31	4.41
Soil_1*Lime_1*OM_0	4.43	4.41	4.35	4.40
Soil_1*Lime_1*OM_1	5.59	4.39	4.34	4.77
Soil_2*Lime_0*OM_0	5.13	5.09	5.09	5.10
Soil_2*Lime_0*OM_1	5.17	5.15	5.10	5.14
Soil_2*Lime_1*OM_0	5.06	5.06	5.63	5.25
Soil_2*Lime_1*OM_1	5.25	5.15	5.10	5.17
GROUP				
SOIL 1	4.62	4.60	4.57	4.60
SOIL 2	5.12	5.09	5.09	5.10
TREATED	4.97	4.78	4.79	4.85

	SE(m) (±)	CD(p<0.05)	SE(m) (±)	CD(p<0.05)	SE(m) (±)	CD(p<0.05)	SE(m) (±)	CD(p<0.05)
Soil / Lime / OM	0.288	0.849	0.291	0.857	0.293	0.863	0.289	0.853
Soil * Lime/ soil *								
OM/ Lime* OM	0.407	1.200	0.411	1.212	0.414	1.221	0.409	1.207
Soil * Lime* OM	0.575	1.697	0.581	1.714	0.585	1.727	0.579	1.707
Controls	0.575	1.697	0.581	1.714	0.585	1.727		
Fertilized vs. Non fertilized	0.455	0.949	0.459	0.958	0.463	0.965	0.457	0.954

The Change of HA_C/FA_C Ratio: In order to develop a possible relation between humic acid carbon and fulvic acid carbon with the different treatments applied, the HA_C/FA_C was done, which were presented in the table 12 and graphically represented in the figure 4. In upland soil HA_C/FA_C ratio was increased gradually after submergence of 90 days of period in case of control (none of the fertilizer, lime and vermicompost) which was around 44%. But in low land soil that ratio was decreased at 60 days of interval. The application of vermicompost resulted in the decrease in the ratio of HA_C/FA_C of both upland and low land soil as compared with previous treatment in both upland and lowland soil. After application of lime and vermicompost along with NPK fertilizer to soil, the change in the ratio of HA_C/FA_C was more or less same with the treatment where only vermicompost with fertilizer was applied. But in case of lowland soil that ratio was increased gradually at 30, 60, 90 days of interval which was also more as compared with control (36%).

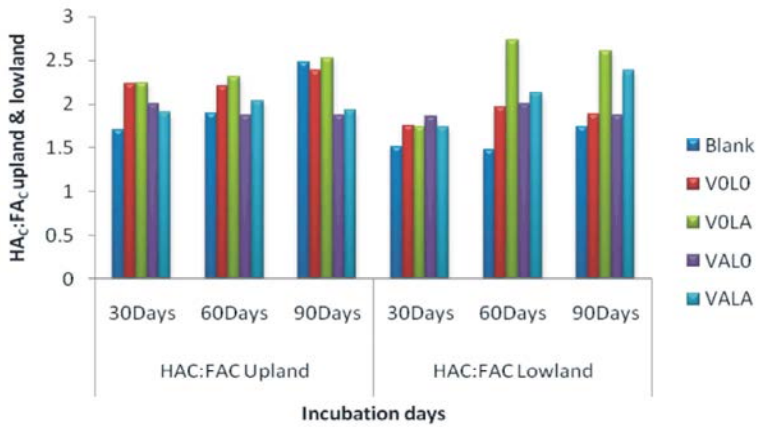

Fig. 4: Ratio of HA_C: FA_C in upland and lowland soils.

CONCLUSION

As expected the E_4/E_6 ratio was found to be much larger for the FA fractions than for the HA fractions. The larger E_4/E_6 values are associated with lower molecular weights [9], which is consistent with the average molecular weight values. This E_4/E_6 ratio is inversely related to the degree of condensation of the aromatic network [10], so that a high ratio would reflect a low degree of aromatic condensation and the presence of relatively large proportions of aliphatic structures.

It was found that in all of the cases submergence with water up to 30 days resulted in increased rate of humic acid carbon and it was subjected to decrease in case of further period of submergence.

The interaction effect of lime, organic matter (vermicompost) and fertilizer (NPK @ 80: 40: 40) on humic and fulvic acid carbon was found to be significant upon submergence.

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