J. Sher-e-Bangla Agric. Univ., 3(1): 80-88, January 2009 ISSN 1997-6038

ASSESSMENT OF NUTRIENT STATUS OF THE FOREST SOILS AS COMPARED TO CULTIVATED SOILS OF THE SUNDERBANS OF BANGLADESH

M. Maniruzzaman[1], M. W. Zaman[2] and M. K. Islam[3]

ABSTRACT

An investigation was carried out to determine the nutrient status of soils of the Sundarbans of Koyra Upazila under Khulna district. Forest soils of the Sundarbans receive seawater at a regular interval, but the cultivated land inside the embankment never receives seawater. To investigate the impact of seawater on nutrient status of the forest soils as compared to cultivated soils inside the embankment, soil samples from the above two areas were collected at two different depths, surface (0-15 cm) and sub-surface (15-30 cm). The chemical analyses included soil pH, EC, organic matter, N, P, S, K, Ca, Mg, Na, B, Zn, Cu, Fe and Mn content in soils. The soils of the mangrove forest of Koyra Upazila were saline, but the cultivated soils adjacent to the Sundarbans (inside the embankment) were acidic to saline. EC values were higher in mangrove forest soils than cultivated land and both the pH and EC were higher in surface soils. The organic matter, N, P and S contents were higher in surface soils than that of sub-surface soils. The status of Ca, Mg and K were higher in sub-surface soils than that of surface soils. The levels of N, Ca, Mg, Na, B, Cu and Mn were higher in forest soils than that of cultivated soils. But the concentrations of Fe, P, S and Zn were higher in cultivated soils than that of forest soils. The level of S in cultivated land was 401.4 mg kg^{-1}. The low pH (5.3 to 7.3) and higher amount of SO_4-S indicated that the soils of cultivated land were acid-sulphate. The concentrations of micronutrients were comparatively higher in surface soils than that of sub-surface soils.

Key words: Nutrient status, forest soils, cultivated soils

INTRODUCTION

The Sunderbans are the largest single tract of the mangrove forest in the world. Bangladesh shares about 62% of the total area of the Sundarbans. It is one of the valuable natural assets. It constitutes about 60% of Bangladesh natural forests and provides livelihood for at least 0.8 million people mainly wood cutters, fishermen, honey collector, *golpata* collector etc. In addition to forest resources, the Sunderbans forest is extremely important for the protective barrier against coastal erosion, cyclone, storms, and tidal surges, wildlife conservation, fish production etc. Unfortunately, the condition of this forest is deteriorating day by day. The biodiversity of the Sunderbans is in decreasing trend. We doubt that soil quality may be one of the reasons contributing to this deteriorating condition. Because soil is the storehouse of nutrient elements of plants. Obviously, floristic components are nourished by the soil and get support to withstand. The soil nutrient status is likely to govern the growth, development, and multiplication of this floristic composition, besides environmental influence. It is presumed that there is a close relationship between the existing condition of the floristic composition and soil nutrient status. Soil nutrient status is influenced somewhat by water nutrient status. Keeping this fact in mind this study was conducted.

MATERIALS AND METHODS

The soil samples were analyzed in the Laboratory of the Departments of Agricultural Chemistry, and

[1]Assistant Professor, [3]Research Officer, Dept. of Agricultural Chemistry, Patuakhali Science and Technology University, Patuakhali and [2]Professor, Dept. of Agricultural Chemistry, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Soil Science, Central Laboratory, Bangladesh Agricultural University (BAU), Mymensingh and the Division of Soil Science, Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh. In order to conduct the study, two forest stations Baniakhali and Kassiabad including five patrolposts (viz. Hadda, Koyra, Shakbaria, Hayathali and Bazbaza) of the Sundarbans under Koyra Upazila of Khulna range were selected with the help of the staff of forest division of Khulna. The soil samples were collected during the month of January 2003 from the selected areas. At two different depths, surface (0-15 cm) and sub-surface (15-30 cm), forty (20 x 2 = 40) samples were collected from mangrove forest of the Sundarbans (outside the embankments) and twelve (6 x 2 = 12) samples were collected from the cultivated land of Koyra Upazila adjacent to the Sundarbans (inside the embankment).

Preparation of soil samples

The collected soil samples were carried to the Laboratory of the Department of Agricultural Chemistry, BAU for chemical analysis. The soil samples were then dried at room temperature, ground to pass through twenty-mesh sieve and kept separately in polythene bag for chemical analysis. The soil samples were collected following the instructions reported by Allen *et al.* (1974).

Chemical analyses of soil

The soil samples were analyzed to determine i) pH ii) EC iii) Organic matter iv) Total nitrogen v) Available phosphorus vi) Exchangeable potassium vii) Available sulphur viii) Exchangeable calcium ix) Exchangeable magnesium x) Exchangeable sodium xi) Available boron and xii) Available zinc, copper, iron and manganese. pH of the soil samples were determined by glass electrode pH meter as described by Ghosh *et al.* (1983). The electrical conductivity of collected soil samples were determined electrometrically (1:2.5, soil: water ratio) by a conductivity meter as described by Anderson and Ingram (1996). Organic matter was determined titrimetrically following Walkley and Black (1934) method and modified by Ghosh *et al.* (1983). Total nitrogen content in soil was determined by macro Kjeldhal method (Jackson, 1973). Available soil phosphorus was determined by Olsen method (Olsen *et al.*, 1954) colorimetrically using $SnCl_2$ as reductant. Exchangeable potassium and sodium were determined with the help of flame emission spectrophotometer (Ghosh *et al.* 1983). Sulphur was determined by turbidimetric method with the help of a spectrophotometer (Page *et al.*, 1982). Calcium and magnesium were determined by complexometric method of titration using Na_2-EDTA as a complexing agent (Page *et al.*, 1982). Water-soluble B was extracted from soil by hot water and determined by Azomethine-H method (Page *et al.*, 1982). Available zinc, copper, manganese and iron were determined by atomic absorption spectrophotometer (McLaren *et al.*, 1984).

RESULTS AND DISCUSSION

Variation in pH values

The pH values of the surface and subsurface soils of twenty samples of mangrove forest of the Sundarbans varied from 7.2 to 8.0 and 7.1 to 7.9, respectively (Table 1). The pH values of surface and sub-surface soil of cultivated land of the same Upazila adjacent to the Sundarbans inside the embankment varied from 5.3 to 7.3 and 4.0 to 7.0, respectively (Table 2). The results indicated that the soils of mangrove forest of the Sundarbans were saline in nature and the soils of cultivated land adjacent to the Sundarbans were acidic to saline. Soil salinity might have developed due to the inundation of saline sea water into the forest.

Electrical Conductivity

The electrical conductivity (EC) values of surface and sub-surface soils of mangrove forest ranged from 3.3 to 5.0 and 2.8 to 4.8 ds m^{-1} with the mean values of 4.17 and 3.69 ds m^{-1}, respectively (Table 1). About 45 and 50 per cent EC values of surface and sub-surface soils were less than their respective means. But the EC values of the cultivated land adjacent to the Sundarbans inside the embankment ranged from 1.8 to 4.2 ds m^{-1} and 1.1 to 3.9 ds m^{-1}, respectively. The mean values of these soils were 3.13 ds m^{-1} and 2.46 ds m^{-1} in surface and sub-surface soil, respectively (Table 2). The average result of EC of mangrove forest of the Sundarbans both surface and sub-surface was close to that of Gunasekaran *et al.* (1992). The mean EC value of mangrove forest (4.17 ds m^{-1}) of the Sundarbans was greater than that of cultivated land (3.13 ds m^{-1}) adjacent to the Sundarbans. The result indicated that the EC of the both soils were greater in surface soil than sub-surface soil.

Table 1. pH, EC, organic matter, nitrogen and phosphorus levels of surface and sub-surface soils of the mangrove forest outside the embankment of the Sundarbans of KoyraUpazila

Sample No.	pH		EC dsm^{-1}		% organic matter		% N		P (mg kg^{-1})	
	SS	SSS	SS	SSS	SS	SSS	SS	SSS	SS	SSS
S_1	7.7	7.2	5.0	4.5	1.77	1.62	0.103	0.102	18.80	15.60
S_2	7.9	7.8	3.3	3.0	2.66	2.00	0.137	0.106	14.00	11.40
S_3	7.8	7.7	4.5	4.3	1.78	1.60	0.107	0.102	15.84	11.18
S_4	7.9	7.8	3.8	3.8	2.51	2.17	0.126	0.112	14.24	12.00
S_5	7.9	7.8	3.5	3.4	2.53	2.44	0.128	0.125	20.80	13.00
S_6	7.5	7.3	3.3	3.2	2.68	2.15	0.147	0.110	17.92	15.60
S_7	7.4	7.4	4.8	3.9	2.46	2.28	0.117	0.113	14.20	14.20
S_8	7.5	7.3	4.9	4.7	1.53	1.38	0.101	0.088	15.60	13.78
S_9	7.2	7.1	4.9	4.8	3.19	2.90	0.193	0.189	10.40	7.40
S_{10}	7.4	7.2	4.1	4.0	2.53	2.29	0.126	0.113	8.40	7.36
S_{11}	7.4	7.4	3.5	3.4	1.67	1.60	0.102	0.101	7.72	7.32
S_{12}	7.6	7.5	4.5	2.8	2.02	2.00	0.108	0.106	8.80	7.28
S_{13}	8.0	7.9	4.0	2.8	1.47	1.22	0.099	0.083	22.16	17.80
S_{14}	7.9	7.8	4.0	3.0	2.24	1.82	0.112	0.105	17.60	17.40
S_{15}	8.0	7.8	3.5	3.1	2.71	1.49	0.186	0.101	13.00	11.20
S_{16}	7.8	7.5	4.8	4.4	2.06	1.75	0.109	0.104	14.32	9.12
S_{17}	8.0	7.8	4.7	3.8	1.42	1.09	0.098	0.065	24.80	18.80
S_{18}	7.8	7.7	3.9	3.5	1.55	1.46	0.101	0.100	16.40	12.00
S_{19}	7.8	7.8	4.2	3.2	1.49	1.29	0.099	0.085	18.40	12.68
S_{20}	7.9	7.8	4.2	4.2	1.86	1.66	0.109	0.102	14.00	8.80
Range	7.2 to 8.0	7.1 to 7.9	3.3 to 5.0	2.8 to 4.8	1.47 to 3.19	1.09 to 2.90	0.098 to 0.193	0.065 to 0.189	7.72 to 24.80	7.28 to 18.80
Mean			4.17	3.69	2.10	1.82	0.120	0.105	15.37	12.16
Sd			0.55	0.62	0.51	0.45	0.026	0.022	4.39	3.53
CV%			13.33	19.60	24.24	24.85	22.100	21.708	28.59	29.10

S = Soil sample, SS = Surface soil (0-15 cm), SSS = Sub-surface soil (15-30 cm)

Organic matter

Organic matter content in surface and sub-surface soils of mangrove forest ranged from 1.47 to 3.19% and 1.09 to 2.90% with the mean values of 2.10% and 1.82%, respectively (Table 1). The organic matter status in the cultivated land adjacent to the Sundarbans ranged from 1.15 to 2.53% and 0.58 to 2.38% with the mean values of 1.96 and 1.34% in surface and sub-surface soils, respectively (Table 2) which are less than mangrove forest. It was found that organic matter level of the mangrove forest was higher than that of cultivated land adjacent to the Sundarbans. The possible reason was that the continuous addition of tree leaves to the forest soil and their slow rate of decomposition might have increased the organic matter level.

Nitrogen

The total amount of nitrogen in surface and sub-surface soils of the forest ranged from 0.098 to 0.193% and 0.065 to 0.189% having mean values of 0.120% and 0.105%, respectively (Table 1). But the amount of total nitrogen in surface and sub-surface soils of the cultivated land adjacent to the Sundarbans ranged from 0.087 to 0.131% and 0.050 to 0.114% having mean values of 0.112 and 0.084, respectively. Total N level in surface soil was found to be higher than that of sub-surface soils in both mangrove forest and cultivated land. The results of the present study were in good agreement with that of Fouda and Al-Muharranmi (1996). Due to the presence of higher amount of organic matter in surface soil, the level of nitrogen in the soil was higher.

Phosphorus

Available phosphorus content in surface and sub-surface soils of the mangrove forest varied from 7.72 to 24.80 mg kg^{-1} and 7.28 to 17.40 mg kg^{-1} with the mean values of 15.37 and 12.16 mg kg^{-1}, respectively (Table 1). But the amount of available phosphorus in surface and sub-surface soils of the cultivated land ranged from 11.32 to 24.00 and 8.56 to 16.36 mg kg^{-1} and the mean values were 19.02 and 13.40 mg kg^{-1}, respectively (Table 2). The average content of available phosphorus in surface soil was higher than that of sub-surface soils both inside and outside the embankment. The results indicated that the amount of phosphorus was higher in the cultivated land adjacent to the Sundarbans than that of the mangrove forest.

Table 2. pH, EC, organic matter, N, P, K and S status of surface and sub-surface soils of cultivated land inside the embankment of Koyra Upazila adjacent to the Sundarbans

Sample No.	pH		EC dsm^{-1}		% organic matter		% N		P (mg kg^{-1})	
	SS	SSS	SS	SSS	SS	SSS	SS	SSS	SS	SSS
SC_1	5.3	4.0	3.9	3.0	2.53	2.38	0.131	0.114	16.4	14.8
SC_2	7.1	7.0	1.8	1.1	1.87	0.98	0.109	0.068	23.6	14.3
SC_3	7.2	6.0	3.1	2.3	1.95	0.58	0.110	0.050	16.4	12.4
SC_4	5.3	4.14	4.2	3.9	2.48	1.18	0.127	0.091	11.32	8.56
SC_5	7.3	4.6	3.0	2.6	1.15	1.13	0.087	0.075	24.0	16.36
SC_6	6.9	4.3	2.8	1.9	1.82	1.80	0.108	0.107	22.4	14.0
Range	5.3 to 7.3	4.0 to 7.0	1.8 to 4.2	1.1 to 3.9	1.15 to 2.53	0.58 to 2.38	0.087 to 0.131	0.050 to 0.114	11.32 to 24.0	8.56 to 16.36
Mean			3.13	2.46	1.96	1.34	0.112	0.084	19.02	13.40
Sd			0.77	0.87	0.46	0.58	0.014	0.022	4.65	2.46
CV%			24.83	35.39	23.47	43.77	12.835	26.430	24.49	18.35

SC = Cultivated Soil, SS =Surface Soil, SSS =Sub Surface Soil

Potassium

Exchangeable potassium content of surface and sub-surface soils of the mangrove forest ranged from 0.803 to 1.57 and 1.10 to 1.855 cmol kg^{-1} with the average values of 1.22 and 1.43 cmol kg^{-1}, respectively (Table 3). The results indicated that the amount of potassium in sub-surface soil was greater than that of surface soil in both the mangrove forest and the cultivated land of Koyra Upazila adjacent to the Sundarbans. It could possibly happen for the luxury consumption of potassium by plants, sorptions and diffusion of free potassium ions from the surface soils (Brady, 1990).

Sulphur

The sulphur content in surface and sub-surface soils of mangrove forest was found to vary in between 152.43 to 335.35 mg kg^{-1} and 101.62 to 223.57 mg kg^{-1} with their mean values of 225.51 and 162.05 mg kg^{-1}, respectively (Table 3).The amount of sulphur in surface and sub-surface soil of the cultivated land adjacent to the Sundarbans ranged from 264.22 to 660.55 mg kg^{-1} and 140.64 to 528.44 mg kg^{-1}

greater in the mangrove forest than cultivated land. The amount of Ca in forest soil was higher possibly due to continuos flooding by saline sea water. Sea water contained higher amount of calcium. The range of soil calcium was in good agreement with that of Chaffey *et al.* (1985).

Magnesium

The amount of magnesium in surface and sub-surface soils of mangrove forest of the Sundarbans ranged from 6.1 to 10.2 cmol kg^{-1} and 6.9 to 11.0 cmol kg^{-1} with their average values of 8.03 cmol kg^{-1} and 9.13 cmol kg^{-1}, respectively (Table 3). In case of cultivated land adjacent to the Sundarbans the Mg content in surface and sub-surface soils ranged from 3.7 to 8.0 cmol kg^{-1} and 6.3 to 9.4 cmol kg^{-1} with their average respective values of 6.60 cmol kg^{-1} and 7.86 cmol kg^{-1}, respectively(Table 4). The amount of Mg in sub-surface soil in both mangrove forest and the cultivated land adjacent to the Sundarbans was higher than that of surface soil. But the amount of Mg was higher in mangrove forest than cultivated soil.

Table 4. K, S, Ca, Mg and B status of surface and sub-surface soils of cultivated land adjacent to the Sundarbans inside the embankment

Sample No.	K (cmol kg^{-1})		S (mg kg^{-1})		Ca (cmol kg^{-1})		Mg (cmol kg^{-1})		B (mg kg^{-1})	
	SS	SSS	SS	SSS	SS	SSS	SS	SSS	SS	SSS
SC_1	0.99	1.35	660.55	528.44	3.9	7.3	8.0	9.4	0.5	0.5
SC_2	0.70	1.12	315.03	171.13	4.9	5.5	7.9	8.0	1.0	0.5
SC_3	1.09	1.25	294.70	140.64	2.2	3.8	3.7	6.3	1.0	0.9
SC_4	1.16	1.43	548.76	355.68	3.7	5.2	7.2	8.1	1.1	1.1
SC_5	1.04	1.40	325.19	264.22	4.34	6.7	6.8	7.2	1.1	0.5
SC_6	0.79	0.79	264.22	254.05	3.3	5.1	6.0	8.2	0.6	0.6
Range	0.70 to 1.16	0.79 to 1.43	264.22 to 660.55	140.64 to 528.44	2.2 to 4.9	3.8 to 7.3	3.7 to 8.0	6.3 to 9.4	0.5 to 1.1	0.5 to 1.1
Mean	0.96	1.22	401.40	285.69	3.72	5.60	6.60	7.86	0.88	0.68
Sd	0.163	0.21	148.51	128.74	0.84	1.13	1.46	0.95	0.24	0.23
CV%	17.01	17.94	36.99	45.06	22.72	20.30	22.14	12.09	27.27	34.23

SC = Cultivated Soil, SS =Surface Soil, SSS =Sub Surface Soil

Boron

Boron content in surface and sub-surface soil in the mangrove forest ranged from 0.2 to 1.3 mg kg^{-1} and 0.2 to 1.25 mg kg^{-1} with their average values 0.75 mg kg^{-1} and 0.572 mg kg^{-1}, respectively (Table 3). But B content in surface and sub-surface soils of the cultivated land ranged from 0.5 to 1.1 mg kg^{-1} and 0.5 to 1.1 mg kg^{-1} with the average values of 0.88 mg kg^{-1} and 0.68 mg kg^{-1}, respectively (Table 4). B content in surface soil was greater than that of respective sub-surface soils.

Sodium

Sodium content in the surface and sub-surface soils of the mangrove forest ranged from 9.31 to 13.48 cmol kg^{-1} and 8.48 to 12.60 cmol kg^{-1} with their mean values of 11.67 and 10.35 cmol kg^{-1}, respectively (Table 5). In case of cultivated land the amount of Na ranged from 5.7to 10.91 cmol kg^{-1} and 4.34 to 10.6 cmol kg^{-1} with their respective mean values of 8.83 and 6.14 cmol kg^{-1}, respectively(Table 6). The results indicated that Na content in surface soil was greater than that of sub-surface soils. Similar findings were also presented by Zakir and Gayatri (1994). The amount of sodium in the mangrove forest of the Sundarbans was greater than that of cultivated land adjacent to the Sundarbans. It might be due to routine flooding of the forest soil by saline water.

Zinc

The surface and sub-surface soils of the mangrove forest contained available zinc within the range from 2.47 to 6.43 mg kg^{-1} and 1.97 to 4.97 mg kg^{-1} and the calculated mean values were 3.96 and 3.32 mg kg^{-1}, respectively (Table 5).

Table 5. Na, Zn, Cu, Fe, and Mg status of surface and sub-surface soils of the mangrove forest outside the embankment of the Sundarbans of Koyra Upazila

Sample No.	Na (cmol kg^{-1})		Zn (mg kg^{-1})		Cu (mg kg^{-1})		Fe (mg kg^{-1})		Mn (mg kg^{-1})	
	SS	SSS	SS	SSS	SS	SSS	SS	SSS	SS	SSS
S_1	13.04	10.87	4.15	3.8	11.72	8.47	180.25	159.25	11.10	9.87
S_2	9.35	7.60	6.34	4.60	12.15	8.87	207.50	160.31	14.20	11.04
S_3	12.60	11.52	3.10	3.07	13.02	12.62	177.70	167.90	19.10	16.93
S_4	12.54	11.72	3.90	2.35	10.77	9.77	293.30	254.25	20.48	19.77
S_5	10.00	8.48	3.35	2.82	11.32	10.7	206.00	197.75	19.15	18.08
S_6	11.09	10.25	5.56	3.75	12.65	9.18	180.77	159.20	20.85	16.55
S_7	12.82	12.60	4.05	3.35	9.22	9.17	264.50	249.50	17.10	15.42
S_8	12.04	9.13	5.02	4.97	15.87	14.55	143.61	140.78	18.08	14.97
S_9	12.04	12.82	6.43	4.15	10.45	10.3	125.81	121.60	15.89	12.65
S_{10}	13.48	11.73	3.52	3.35	8.60	7.60	186.80	157.70	10.70	7.37
S_{11}	12.39	11.52	3.03	2.31	9.22	7.85	124.93	121.80	21.91	10.41
S_{12}	12.17	9.13	3.30	3.00	9.20	9.17	141.75	132.00	17.47	17.20
S_{13}	10.65	8.91	4.95	4.97	8.10	7.10	377.00	298.40	23.41	20.10
S_{14}	10.87	8.91	3.02	3.00	11.35	10.35	156.70	150.75	13.60	12.51
S_{15}	9.31	9.13	3.00	3.8	9.42	8.15	124.50	123.50	19.87	14.60
S_{16}	12.93	12.17	3.09	2.82	8.40	7.82	221.50	221.50	18.70	18.66
S_{17}	12.17	10.22	2.47	1.97	9.20	7.80	190.80	180.75	14.02	14.01
S_{18}	11.09	10.21	3.67	3.00	11.35	10.32	125.50	123.90	15.50	13.50
S_{19}	10.87	9.35	4.49	3.125	9.37	7.42	189.80	178.80	25.75	14.96
S_{20}	11.09	10.87	2.85	2.32	11.72	9.17	129.50	126.70	15.41	15.37
Range	9.31 to 13.48	8.48 to 12.60	2.47 to 6.43	1.97 to 4.97	8.10 to 15.87	7.10 to15.55	124.50 to 377.00	121.80 to 298.40	10.70 to 25.75	9.87 to 20.10
Mean	11.67	10.35	3.96	3.32	10.65	9.31	187.40	171.31	17.56	14.69
Sd	1.21	1.45	1.13	0.83	1.87	1.78	62.850	48.71	3.76	3.29
CV%	10.40	14.03	28.48	25.25	17.57	19.19	33.530	28.43	21.44	22.43

S = Soil sample, SS = Surface soil, SSS = Sub-surface soil

In the cultivated land the zinc content in surface and sub-surface soils varied from 4.18 to 7.81 mg kg^{-1} and 3.71 to 7.4 mg kg^{-1} with their mean values of 5.4 and 4.80 mg kg^{-1}, respectively (Table 6). The result showed that the available Zn was higher in surface soils than that of sub-surface soils both in mangrove forest and in cultivated soils adjacent to the Sundarbans. The decreasing trend of Zn with increasing soil depth was in good agreement with that of Razzaque (1995). The results also indicated that the zinc content in cultivated soils was higher than that of mangrove forest of the Sundarbans.

Copper

The concentration of available copper in surface and sub-surface soils of the mangrove forest ranged from 8.10 to 15.87 mg kg^{-1} and 7.10 to 15.55 mg kg^{-1} and the calculated mean values were 10.65 and 9.31 mg kg^{-1}, respectively (Table 5). The amount of copper in surface and sub-surface soils of the cultivated soil ranged from 6.3 to 10.56 mg kg^{-1} and 4.08 to 8.47 mg kg^{-1} and the calculated mean values were 10.49 mg kg^{-1} and 6.25 mg kg^{-1}, respectively (Table 6). The results reflected that available copper was higher in surface soil than that of sub-surface soil both in mangrove forest and the cultivated land. The results further indicated that the amount of copper in surface of both the soils was about similar, but sub-surface soils of cultivated land contained higher amount than mangrove forest of the Sundarbans.

Iron

The results indicated that iron (Fe) content of surface soils were higher than that of sub-surface soils both inside and outside the embankment (Table 5 and 6). The results further indicated that the mean amount of Fe was greater in cultivated soil (269.45 mg kg^{-1}) than that of mangrove forest (187.40 mg kg^{-1}) of the Sundarbans.

Table 6. Na, Zn, Cu, Fe, and Mg status of surface and sub-surface soils of cultivated land adjacentto the Sundarbans (inside the embankment)

Sample No.	Na (cmol kg^{-1})		Zn (mg kg^{-1})		Cu (mg kg^{-1})		Fe (mg kg^{-1})		Mn (mg kg^{-1})	
	SS	SSS	SS	SSS	SS	SSS	SS	SSS	SS	SSS
SC_1	5.80	4.75	4.56	4.18	6.71	5.81	332.9	320.8	11.58	9.85
SC_2	10.91	10.60	6.30	5.92	6.30	4.08	230.8	229.2	10.63	6.41
SC_3	10.60	7.39	4.18	3.72	13.06	8.02	189.9	178.0	12.60	9.88
SC_4	5.70	4.8	7.81	7.4	16.43	6.09	378.4	365.7	10.57	5.38
SC_5	10.50	5.00	4.28	3.87	10.56	8.47	286.0	277.7	10.87	5.37
SC_6	9.52	4.34	5.27	3.71	9.92	5.03	198.7	189.6	9.95	7.90
Range	5.7 to 10.91	4.34 to 10.60	4.18 to 7.81	3.71 to 7.4	6.3 to 10.56	4.08 to 8.47	189.9 to 378.4	178.0 to 365.7	9.95 to 12.60	5.38 to 9.88
Mean	8.83	6.14	5.40	4.80	10.49	6.25	269.45	251.83	11.03	7.46
Sd	2.22	2.22	1.29	1.39	3.51	1.55	69.51	68.48	0.84	1.89
CV%	25.17	36.20	24.0	28.99	33.47	24.85	25.80	27.19	7.70	25.39

SC = Cultivated Soil, SS =Surface Soil, SSS =Sub Surface Soil

Manganese

The results indicated that the mean amount of Mn was higher in surface soil (17.56 mg kg^{-1} and 11.03 mg kg^{-1}) than that of sub-surface soils (14.69 mg kg^{-1} and 7.46 mg kg^{-1}) both in mangrove forest and cultivated soils adjacent to the Sundarbans, respectively (Table 5 and 6). The results also showed that the amount of Mn was higher in the mangrove forest of the Sundarbans than that of cultivated soil adjacent to the Sundarbans.

REFERENCES

Allen, E.S., Grimshaw, H.W., Parkinson, J.A. and Quarmby, C. 1974. Chemical analysis of Ecological materials, Blackwell Scientific Publications, Oxford. pp.30-34.

Anderson, J.M. and Ingram, J.S.I 1996. Tropical Soil Biology and Fertility a Handbook of Methods 2nd edi. CAB International. Wallingford, U.K. pp.57-58.

Brady, N.C. 1990. The Nature and Properties of Soils. 10th edn. Macnillan Publishing Company, New York. pp. 315-337.

Chaffey, D.R., Miller F.R. and Sandon J.H. 1985. A forest inventory of the Sundarbans. Bangladesh Main report. Overseas Development Administration. England. 196p.

Chihyu, C., Shuicheng, L., Hau Tsueng, J., Ming Tan, H., YuanHsun, H., Chiu, CY., Lee, SC., Juang, HT., Hur, MT. and Hwang, YH. 1996. Nitrogen nutritional status and fate of applied N in mangrove in mangrove soils. *Botanical Bulletin of Acadamia. Sinica.* 37(3): 191-196.

Fouda, M.M. and Al-Muharrami, M.A. 1996. Significance of mangroves in the arid environment of the Sultanate of Oman. *Sultan Quboos Univ. J. Sci. Res. Agric. Science,* 1:41-49.

Ghosh, A.B., Bajaj, J.C., Hasan, R. and Singh, D. 1983. Soil and Water Testing Methods. *A Laboratory Manual,* Division of Soil Science and Agricultural Chemistry, IARI, New Delhi – 110012. pp.1-45.

Gunasekaran, S., Jayapaul, A., Raju, P.M. and Azariah, J. 1992. Distribution of mangrove plants in relation to the chemical characteristics of the Soil, Muthupet, Tamil. *Asian Environ.* 14 (3) : 54-69.

Jackson, M.L. 1973. Soil Chemical Analysis. Prentice Hall of India Private Limited, New Delhi. pp.10-144.

McLaren, R.G., Swift, R.S. and Quin, B.F. 1984. EDTA extractable copper, zinc, iron and manganese in soils of the Canterbury Plains. *New Zealand J. Agril. Res.* 27 : 207-217.

Olsen, S.R., Cole, C.V., Watanable, F.S. and Dean, L.A. 1954. *Estimation of available phosphorus in soils by extraction with sodium bicarbonate.* U.S. Dept. Agr. Cire. 939p.

Page, A.L., Miller, R.H. and Keeney, D.R. (ed.) 1982. *Methods of Soil Analysis, Part 2, Chemical and Microbiological Properties,* American Society of Agronomy, Inc. Soil Sci. Soc. of America. Inc. Madison, Wisconsin, U.S.A. pp.252-255.

Razzaque, M.A. 1995. Assessment of ionic toxicity in water source and their longterm effect on soil properties. M.S. (Ag.) Thesis, Dept. of Agril. Chem., BAU, Mymensingh.

Walkley, A. and Black, C.A. 1934. An examination of the Degtjareff method for determining soil organic matter and proposed modification of the chromic acid titration method. *Soil Sci.* 37: 29-38.

Zakir, A. and Gayatri A. 1994. Mangrove of the Sundarbans volume two Bangladesh. IUCN-the world conservation union DYNA Print Ltd. Bangkok, Thailand. pp.27-40.