Khulna University Studies **Volume 11 (1&2) and 12(1&2) : ??-?? : December 2013**

ENVIRONMENTAL SCIENCE

CHARACTERIZATION OF *SATLA* AND *HARTA* SOIL SERIES OF SOUTH WEST BANGLADESH

Monowara Khatun and Md. Sadiqul Amin*

Soil Science Discipline, Khulna University, Khulna 9208, Bangladesh

KUS: 12/16-240512

Manuscript received: May 24, 2012 Accepted: August 13, 2012

Abstract: *Satla* and *Harta* soil series of Terokhada Upazilla were characterized for morphological, physical and chemical properties. The two soil series varies in texture, pH, mottling and cutans. Percentage of sand, silt and clay of the studied soils varies from 0.78 to 16.71, 34.29 to 68.22 and 19.03 to 53.32, respectively. The bulk density and particle density varies from 0.42 to 1.48 g cm^{-3} and 0.80 to 2.92 g cm^{-3}, respectively. Saturated hydraulic conductivity varies from 0.08 to 5.65 $cmhr^{-1}$. The rubbed fiber content ranged from 1/5 to 3/5 by volume. The value/chroma ratio ranges from 3/4 to 6/6. The Absorbance Index ranged from 25.5% to 60.3% and classified the organic materials as peat. The H values (von Post Scale) varied from H3 to H5. The pH ranges from 5.8 to 8.2. The EC ranges from 0.45 to 5.08 dSm^{-1}. The CEC ranges from 18.5 to 66.6 C $molKg^{-1}$ soil. The %OM varies from 1.76 to 11.60%. The total N varies from 0.08 to 0.55%. The available P, S, B and total Zn varies from 7.5 to 42.6 μgg^{-1} soil, 26.7 to 170 μgg^{-1} soil, 0.14 to 0.71 μgg^{-1} soils and 0.05 to 0.44 μgg^{-1} soil, respectively. The available Ca, Mg and K vary from 2.45 to 12.40 $CmolKg^{-1}$, 2.10 to 20.04 $CmolKg^{-1}$ and 0.13 to 0.46 $CmolKg^{-1}$, respectively. The chemical data shows that OM%, Mg, S, are of very high and %N, P, K, Ca, Zn and B are of low to medium fertility level where as physical properties of the soils are favorable for agricultural development in limited area.

Keywords: Peat soil, *Satla* series, *Harta* series, morphological property, physical property, chemical property

---

Introduction

Peat soil is one of the most important problematic soils of Bangladesh. In Bangladesh peat soil covers an area of about 0.70 million hectares, which is about 4.8% of the total area of the country (USDA, 2003). Peat soils occurred at the low-lying areas of the Gopalganj-Khulna region and also more locally in some haors of the eastern Surma-Kushiyara floodplain, and the adjoining northern and eastern Piedmont plains, Ganges river floodplains, and Ganges tidal floodplains and sporadically in few parts of Bangladesh (Parent, 2003).

According to USDA soil classification, peat soils of Bangladesh include nine types of soil series, having several differentiating characteristics of horizon, i.e. a wide range of chemical and physical properties are Hakaluki series, Harta series, Tarala series, Mohangonj series, Rajoir series, Sarail series, Satgaon series, Satla series and Juri series (Rahman, 2005). But organic layers of Khulna Beels vary from fibric material to sapric material from place to place; often within the profile make it difficult to classify. Limited efforts have been paid for determining nature and decomposition state of the organic materials in field and laboratory in Bangladesh (Ahsan *et al.,* 2005).

DOI: https://doi.org/10.53808/KUS.2013.11and12.1216-L

*Corresponding author: < cnz_bd@yahoo.com>

Terokhada is one of the nine Upazillas of Khulna district occurring under Ganges river floodplains. About 50% land area of Terokhada Upazilla is occupied by a number of peat soil beels where only two soil series were found: Satla and Harta. Satla soil includes seasonally to almost perennially flooded, poorly to very poorly drained, very dark grey to black and very dark grayish brown, organic soils below the topsoil. They have two phases: Poorly drained and very poorly drained. Harta series includes seasonally flooded, strongly gleyed which below a depth of 10-20 inches have a buried organic layer of 35 inches more. Topsoil varies from clay to mucky clay in texture. Those soils usually remain waterlogged for 8-10 months in 6-10 feet deep water. They have two phases: poorly drained and very poorly drained (SRDI staff, 1973 and 1985-1993).

The improvement of peat soil is a difficult task but not impossible. It is necessary to identify the category of problematic soils. The morphological, physical and chemical characteristics of the soil are very important for determining the suitability and fertility status of the soil for particular crop production. Detailed and systematic investigation on morphological, physical and chemical characteristics of peat soil will help classify the organic soils according to USDA Soil Taxonomy. This classification will help to device better soil and land management practices mainly for crop cultivation. Therefore, the present research was conducted to study the morphological, physical and chemical properties of Satla and Harta soil series.

Materials and methods

Satla soil series from Cola beel and Harta soil series from Bhutier beel were sampled with the help of Thana Nirdeshika map. Topsoil and subsoil were collected from six pedons of the two beels. Representative bulk and core samples were collected at a depth of 0-10 cm, 10-20 cm, and 20-30 cm and peats were also collected from available depths. Two representative master pits for Satla and Harta soil series were dug to study the soil profiles in the Cola beel and Bhutier beel, respectively.

The morphological description of organic soil was performed according to SRDI (1977). The particle size analysis of the soils was done by hydrometer method as described by Bouyoucos (1962). Textural class was determined by Marshalls Triangular co-ordinate system. Bulk density of soil was determined by the method as described by Morel *et al.* (1999). Particle density of soil was determined by the water Pycnometer method as described by Black (1965). Saturated hydraulic conductivity of soil was determined in the laboratory by constant head method as describe by Huizing (1970).

Fiber content (rubbed and unrubbed) was determined by gravimetric method according to (USDA, 1999). Pyrophosphate index (PI) was determined by saturating the peat materials with saturated solution of Sodium Pyrophosphate ($Na_4P_2O_7.10H_2O$) as described by Lynn *et al.* (1974). The absorbance index (PA) was determined by extracting humic substances with 0.025M $Na_4P_2O_7.10H_2O$. The absorbance was read at 550 nm on a spectrophotometer (Schnitzer and Desjardins, 1965). The degree of decomposition of peat materials was assessed by the von Post Pressing Method (von Post, 1937).

The pH was determined with the help of glass electrode pH meter as suggested by Jackson (1962). The ratio of soil to water was 1:2.5 as suggested by Jackson (1962). The electrical conductivity (EC) was measured at a soil: water ratio of 1:2.5 by the help of EC meter (USDA, 2004). The reading was multiplied by 2.5 to get the equivalent EC value for saturated extract (1:1 ratio) the ECe. The cation exchange capacity (CEC) was determined by extracting the soil with 1N KCl (pH 7) followed by the replacing the potassium (K) in the exchange complex by NH_4OAc. The displaced K was determined by a flame analyzer at 589 nm (Jackson, 1967). Organic carbon content was determined by Walkley and Black's wet oxidation method as described by Jackson (1962). Organic matter (OM) was calculated by multiplying the percent value of organic carbon with the conventional Van-Bemmelene's factor of 1.724 (Piper, 1950).

Total nitrogen (N) was determined by Micro-Kjeldahl's method following H_2SO_4 acid digestion as suggested by Jackson (1967). Available phosphorus (P) was determined by Molybdophosphoric blue colour method after extracted with the Bray-1 extractant (0.025N HCl + 0.03 N NH_4F) for soils having pH ≤ 6.5 and extracted with the Olsen extractant (0.5 N $NaHCO_3$ buffered at pH 8.5) for soils having pH ≥ 6.6 (Jackson, 1967). The available K was determined from NH_4OAc (pH 7.0) extract as determined by Jackson (1967). The extract was analyzed for available K by a flame analyzer at 589 nm.

Available sulfur (S) content was determined by turbidimetric method as described by Jackson (1973). The S content was measured by Spectrophotometer at 420 nm. The available boron (B) was determined by $CaCl_2$ extraction method using buffer solution and Azomethine Solution on Perkin-Elmer Lambada 11 (2.2) UV/VIS Spectrometer at 420 nm (Jackson, 1973). The available calcium (Ca) and magnesium (Mg) content were determined from NH_4OAc (pH 7) extract by complexometric titration method, involving ethylene diamine tetra-acetic acid (EDTA) as determined by Schwartzenbech *et al.* (1946). The total zinc (Zn) was determined by Atomic Absorption Spectrophotometer (Jackson, 1962), after digestion with HNO_3: $HClO_4$ (2:1) acid mixture.

Results

The morphological characteristics of the two series are described in Table 1and Table 2.

Table 1: Morphological characteristics of a typical profile of *Satla* series

Horizons	Depth	Color, mottling	Texture	Structure	Consistence	Cutans, Pores	Calcareousness	Special Features	Roots	pH	Boundary
Ap	0-11.5cm	5YR 3/1 vdg	C	Om	mfi,ws, wpo	Nil, c1	sc	-	f2	6.2	aw
2	11.5-16.5cm	5YR2/1b	C	Om	mfr,wss,wpo	c2db/vp,c1	sc	Fe staining	f2	6.2	gw
3	16.5-50.8cm	5YR 3/2 drb	-	Om	mfr,wso,wpo	Nil, f3	-	-	-	5.9	cs
4	50.8-85.5cm	5YR 2/2 drb	-	Om	mfr,wso,wpo	Nil, f3	-	-	-	5.3	ci
5	85.5-101cm	5YR 2/1b	-	Om	mfr,wso,wpo	Nil, f3	-	Presence of partially decom-posed logs	-	5.3	cs

[Ap = Disturbed by ploughing or other tillage practices; vdg = Very dark grey, b = Black, drb = Dark reddish brown; C = Clay; Om = Massive; mfi = Firm, mfr = Friable; ws = Sticky, wss = Slightly sticky, wso = Nonsticky; wpo = Nonplastic; c2db/vp = Continuous moderately thick dark reddish brown cutans along ped faces; c1 = Common very fine pores, f3 = Few medium pores; sc = Slightly calcareous; f2= Common fine roots; aw = Abrupt wavy, gw = Gradual wavy, cs = Clear smooth, ci = Clear irregular]

Table 2: Morphological characteristics of a typical profile of *Harta* series.

Horizons	Depth	Color, mottling	Texture	Structure	Consistence	Cutans, Pores	Calcareousness	Roots	pH	Boundary
Ap1	0-11.5cm	5YR 3/1vdg+ f2d 10YR3/3 db	SiC	1c abk/m sbk	mfi,wss, wsp	Nil, f1	mc	vf1 to f1	7.3	as
Ap2	11.5-16.5cm	5Y 4/1dg+c2d 10YR3/3 db	SiCL	Om	mfr,wss,wsp	Nil, f1	mc	vf1 to f1	7.2	as
3	16.5-50.5cm	5Y 5/1g+c2d 10YR4/4 dgb	SiC	Om	mfi,ws,wsp	-	sc	vf2	7.4	cs
4	50.5-86.4cm	5YR 3/1vdg+c2d 10YR3/3 db	C	Om	mfr,wss,wsp	-	sc	-	6.9	cs
5	86.4-101.6cm	5YR 3/1vdg+c2d 10YR3/3 db	SiC	Om	mfr,wss,wsp	-	sc	-	7.1	cs

[Ap = Disturbed by ploughing or other tillage practices; vdg = Very dark grey, dg = dark grey, g = grey, db = dark brown, dgb = dark greyish brown; f2d = common medium distinct mottle; SiC = Silty clay, SiCL = Silty clay loam C = Clay; 1c abk/m sbk = coarse angular blocky breaking into medium subangular blocky, Om = Massive; mfi = Firm, mfr = Friable; ws = Sticky, wss = Slightly sticky, wsp = Slightly plastic wet; f1 = few very fine pores; mc = Moderately calcareous, sc = Slightly calcareous; vf1 = Few very fine, f1 = Few fine, vf2= Common very fine roots; as = Abrupt smooth, cs = Clear smooth]

Percentage of sand varied from 0.78 (at 0-10 cm depth in pedon 4) to 16.71 (at 0-10 cm depth in pedon 3) (Table 3). Percentage of silt varied from 19.03 (at 10-20 cm depth in pedon 3) to 53.32 (at 10-20 cm depth in pedon 4) (Table 3). Percentage of clay varied from 34.29 (at 20-30 cm depth in pedon 5) to 68.22 (at 10-20 cm depth in pedon 3) (Table 3). The bulk density varied from 0.42 to 1.48 g cm^{-3}. The highest bulk density was observed in Harta soil series and the lowest was in Satla soil series (Table 3). The particle density varied from 0.80 (at 20-30 cm depth in pedon 2) to 2.62 (at 10-20 cm depth in pedon 4) (Table 3). Hydraulic conductivity varied from 0.08 in Harta soil series to 5.65 cm hr^{-1} in Satla soil series.

Table 3: Some important physical properties of the analyzed soil samples

Profile no.	Sample no.	Sampling depth (cm)	Series	Textural class	% sand	% silt	% clay	Db gcm^{-1}	Dp gcm^{-1}	Ks $cmhr^{-1}$
1	1	0-10	Satla	Silty clay	2.12	41.06	56.92	1.29	2.24	1.15
	2	10-20		Clay	2.10	36.36	61.54	1.02	2.13	0.30
	3	20-30		Clay	2.05	34.61	63.34	0.98	2.08	0.25
2	5	0-10		Clay	2.13	33.87	64.00	0.94	2.17	0.14
	6	10-20		Clay	9.81	24.15	66.04	0.80	1.87	0.21
	7	20-30		peat				0.44	0.90	4.54
3	8	0-10		Clay	16.71	19.03	64.26	0.95	2.05	0.32
	9	10-20		Clay	10.76	21.02	68.2	0.90	2.13	0.86

							2			
	10	20-30			peat			0.42	0.80	5.65
4	11	0-10	Harta	Silty clay	0.78	50.84	48.38	1.33	2.30	2.54
	12	10-20		Silty clay	1.33	53.22	45.45	1.30	2.62	1.45
	13	20-30		Silty clay	2.87	48.48	48.67	1.24	2.25	0.95
5	15	0-10		Silty clay	2.49	52.60	44.91	1.46	2.24	0.24
	16	10-20		Silty clay	2.11	49.88	48.01	1.42	2.10	0.22
	17	20-30		Silty clay loam	13.36	52.35	34.29	1.38	2.09	0.18
6	19	0-10		Clay	12.97	35.27	51.76	1.48	2.36	0.14
	20	10-20		Clay	13.06	34.03	52.91	1.45	2.40	0.08
	21	20-30		Clay	13.41	32.39	54.20	1.33	2.52	0.08

[Db = Bulk density; Dp = Particle density; %f = % porosity; Ks = Saturated hydraulic conductivity]

The rubbed fiber content ranged from 1/5 to 3/5 by volume and the Pyrophosphate index ranged from 3/4 to 6/6 on 10YR page of Munsell Color Chart (Table 4). The Absorbances of extracted humic substances were ranged between 25.5% and 60.3% (Table 4). According to the von Post Scale (H) for assessing degree of peat decomposition the H values of the studied peat soil materials were varied from H3 to H5 (Table 4).

Table 4: Some important physical properties of the analyzed peat materials.

Pedon no.	Sample no.	Sampling depth (cm)	Series	Rubbed fiber content (By volume)	*Pyrophosphate Index*	*Absorbance Index*	Degree of decomposition
1	4	40+	Satla	2/5	4/6	40.5	H4
2	7	20-30		1/5	6/6	60.3	H5
3	10	20-30		2/5	6/6	25.5	H4
4	14	170+	Harta	3/5	3/4	41.4	H3
5	18	80+		3/5	3/6	29.2	H4
6	22	70+		2/5	4/6	35.4	H4

The pH of the soils ranged from 5.8 to 8.2 with an average of 7.2 (Table 5a). The pH of the Satla soil series varied from 5.8 to 7.2 and 7.8 to 8.2 for Harta soil series. The average pH varied from 5.9 to 8.1within 6 pedons. The EC value ranged from 0.45 (at 10-30 cm depth in pedon 1) to 5.08 dSm^{-1} (at 20-30 cm depth in pedon 2) with an average of 1.26 dSm^{-1} (Table 5a). The average EC value varied from 0.56 to 3.32 dSm^{-1}. The CEC values ranged from 18.5 (at 20-30 cm depth in pedon 6) to 66.6 C $molKg^{-1}$ (at 0-10 cm depth in pedon 2) soil with an average of 38.9 C $molKg^{-1}$ (Table 5a). The %OM of the samples was found to vary from 1.76% to 11.60% with an average of 4.97% (Table 5a). The highest %OM was found in Satla soil series.

Table 5a: Some important chemical properties of soil samples.

Pedon no.	Series	Sample no.	Sampling depth (cm)	pH	EC dSm^{-1}	CEC C $molKg^{-1}$	%OM	Total N (%)
1	Satla	1	0-10	7.2	0.78	45.5	3.45	0.16
		2	10-20	7.2	0.78	48.4	4.34	0.21
		3	20-30	7.2	0.45	32.0	4.50	0.21
			Mean	**7.2**	**0.67**	**41.97**	**4.10**	**0.19**
2		5	0-10	6.2	1.78	66.6	5.87	0.26
		6	10-20	6.2	3.09	38.2	9.92	0.47
		7	20-30	5.9	5.08	32.2	11.60	0.55
			Mean	**6.1**	**3.32**	**45.7**	**9.13**	**0.43**
3		8	0-10	6.0	1.45	65.2	5.89	0.27
		9	10-20	5.9	1.45	58.6	10.10	0.48
		10	20-30	5.8	-	-	11.02	0.52
			Mean	**5.9**	**1.45**	**61.9**	**9.0**	**0.42**
4	Harta	11	0-10	7.8	0.78	35.6	1.78	0.19
		12	10-20	8.1	0.45	26.8	2.85	0.14
		13	20-30	8.1	0.45	23.3	3.78	0.09
			Mean	**8.0**	**0.56**	**28.6**	**2.80**	**0.14**
5		15	0-10	7.8	0.78	39.8	1.95	0.09
		16	10-20	8.2	0.45	27.9	2.86	0.14
		17	20-30	8.2	0.45	23.3	1.76	0.08
			Mean	**8.1**	**0.56**	**28.9**	**2.19**	**0.10**
6		19	0-10	7.8	1.11	34.6	1.99	0.10
		20	10-20	8.1	0.78	26.5	2.68	0.13
		21	20-30	8.2	1.11	18.5	3.31	0.16
			Mean	**8.0**	**1.0**	**26.5**	**2.69**	**0.13**
		Grand mean		**7.2**	**1.26**	**38.9**	**4.97**	**0.24**

[EC = Electrical conductivity; CEC = Cation Exchange Capacity; OM = Organic matter; N = Nitrogen]

The total N of the samples was found to vary from 0.08% to 0.55% with an average of 0.24% (Table 5a). The available P content of the studied soils varied from 7.5 to 42.6 μgg^{-1} soil with an average of 17.06 μgg^{-1} soil (Table 5b). The available K content of the studied soils varied from 0.13 to 0.46 C $molKg^{-1}$ with an average of 0.32 C $molKg^{-1}$ (Table 5b). The available S content of the soils varied from 26.7 to 170 μgg^{-1} with an average of 78.25 μgg^{-1} soil (Table 5b). The available B content of the studied soils varied from 0.14 to 0.71 μgg^{-1} soil with an average of 0.46 μgg^{-1} soil (Table 5b). The available Ca content of the studied soils varied from 2.10 to 20.04 C $molKg^{-1}$ with an average of 9.64 C $molKg^{-1}$ (Table 5b). The available Mg content varied from 2.45 (at depth of 0-10 cm in pedon 4) to 12.40 (at depth of 20-30 cm in pedon 1) C $molKg^{-1}$ with an average of 6.09 C $molKg^{-1}$ (Table 5b). The total Zn content of the studied soils varied from 0.05 to 0.44 μgg^{-1} soil with an average of 0.16 μgg^{-1} soil (Table 5b).

Khatun M and Amin M.S. 2013. Characterization of *satla* and *hatla* soil series of southwest Bangladesh. *Khulna University Studies* Volume 11 (1&2) and 12(1&2) : ??-??

Table 5b: Some important chemical properties of the analyzed soil samples

Pedon no.	Series	Sampling depth (cm)	Available						Total Zn μgg^{-1} soil
			K $CmolKg^{-1}$	P μgg^{-1} soil	S μgg^{-1} soil	B μgg^{-1} soil	Ca $CmolKg^{-1}$	Mg $CmolKg^{-1}$	
1	Satla	0-10	0.35	10.5	70.5	0.33	7.4	4.11	0.16
		10-20	0.41	12.6	73.4	0.14	10.10	7.80	0.17
		20-30	0.40	22.6	80.4	0.29	14.20	12.40	0.07
		Mean	0.39	15.2	74.77	0.25	10.6	8.1	0.13
2		0-10	0.33	7.50	150	0.54	8.60	4.12	0.23
		10-20	0.36	11.2	41.42	0.28	16.05	7.40	0.44
		20-30	0.30	14.5	170	0.51	16.10	2.47	0.16
		Mean	0.33	11.1	120.5	0.44	13.58	4.66	0.28
3		0-10	0.46	10.2	140	0.55	13.50	5.10	0.33
		10-20	0.45	13.9	145	0.68	18.40	7.45	0.25
		20-30	-	-	-	-	20.04	8.30	-
		Mean	0.46	12.05	142.6	0.62	17.31	6.95	0.29
4	Harta	0-10	0.22	16.8	60.8	0.32	5.25	2.45	0.11
		10-20	0.21	22.6	57.0	0.71	6.08	7.60	0.05
		20-30	0.17	12.2	54.9	0.58	3.10	5.85	0.11
		Mean	0.20	17.2	57.57	0.54	4.81	5.3	0.09
5		0-10	0.33	42.6	40.4	0.71	4.50	3.34	0.15
		10-20	0.32	14.2	41.5	0.56	7.88	8.92	0.05
		20-30	0.29	30.2	48.0	0.42	8.20	4.80	0.06
		Mean	0.31	28.97	43.3	0.56	6.86	5.65	0.09
6		0-10	0.28	19.5	30.7	0.32	4.40	2.60	0.17
		10-20	0.20	16.2	35.2	0.41	7.60	8.47	0.05
		20-30	0.13	17.8	26.7	0.37	2.10	6.58	0.07
		Mean	0.20	17.83	30.87	0.37	4.7	5.85	0.10
		Grand mean	0.32	17.06	78.25	0.46	9.64	6.09	0.16

Discussion

Morphology: Arrangement of organic and mineral horizons indicated peat accumulation followed by sedimentation. Ahsan *et al.* (2005) reported repeated peat accumulation and sedimentation. In Satla soil series more than 50.8 cm thick peat layers were found below 11.43-40.64 cm mineral layers and in Harta soil series more than 101.6 cm thick peat layers were found below 68.58-149.86 cm mineral layers. The brownish color of some peat material indicated partial or arrested decomposition. Accumulation of logs, stem and other plant parts indicated past mangrove vegetation. Similar results reported by Ahsan *et al.* (2005).

Physical properties: The textural class of Satla soil series was dominantly clay and Silty clay for Harta soil series. The highest percentage of sand, silt and clay was found in pedon 3 and the lowest in pedon 4 for sand and silt and clay in pedon 5. The bulk density decreased with depth in all pedons due to increase in OM content. The particle density decreased with increasing depth in pedon 1, 2 and 5 and increased with increasing depth in pedon 6. The particle density varied irregularly with depth in pedon 3 and 4. The saturated hydraulic conductivity increased with increasing depth in pedon 2 and 3 and decreased with increasing depth in pedon 1, 4, 5 and 6. Ahsan *et al.* (2005) reported that bulk density, particle density and hydraulic conductivity varied irregularly with depth.

According to USDA, 2003 the fiber content meet the criterion of fiber content for fibric soil material and the PI defined the organic soil materials as sapric. According to Schnitzer and Desjardins (1965) the PA <40 indicates peat and PA >60 implies muck. Absorbance Index indicated that organic soil materials could be classified as peat. The value for H1 to H4 indicates fibric and H5 to H6 indicates sapric materials.

Chemical properties: The pH of the studied soils indicated that Satla soil series was ranged from slightly acidic to neutral and Harta soil series was slightly alkaline in reaction. Similar result was reported for some organic soils by SRDI staff (1985-1993). This is a common feature of the seasonally flooded soils in Bangladesh (Brammer, 1971). The EC varied from non saline to slightly saline. SRDI staff (1973) reported similar results. The CEC values seem to be very high. Similar result was reported by SRDI staff (1973 and 1985-1993). The results indicated that the studied soils were rich in clay minerals having high surface charge. The high clay and silt contents as well as high CEC of the soils are indicative of the fact that when stabilized they can be good productive soils.

The %OM of the soils indicated medium to very high. The %OM of the studied soils was lower than that was reported by SRDI staff (1985-1993) which might be due to organic matter decomposition with time. The %OM was relatively lower in the surface horizons and it gradually increased with depth in all horizons. The total N content of the samples indicated low nutrient level. The total N of the studied soils was lower than that was reported by SRDI staff (1973). The available P content of the studied soils indicated very low to optimum level of P. Similar result was reported by Almamun (2009). The higher available P content was due to lower pH and higher organic matter content of the soils. The available K of the studied soils indicated very low to optimum level of K. Similar result was reported by SRDI staff (1985-1993). The higher level of K might be due to the intensity of potassium fixation, progressively increased with time and directly related with the amount of clay in the soil. Raising soil pH from 5.5 to 7.0 will favour the collapse of silicate layers of expanded clays, and trap K^+ already present in the interlayer. The available S content of the soils indicated optimum to very high amount of S. Similar result was reported by SRDI staff (1985-1993).

The S content increased with increasing depth in pedon 3 and 5 and decreased with increasing depth in pedon 4 and 6. The S content varied irregularly with increasing depth in pedon 1 and 2. The available B content of the studied soils indicated very low to optimum level of B. Similar result was reported by SRDI staff (1985-1993). High content of B might be due to high organic matter and high clay percentage. The available Ca content of the studied soils indicated medium to very high amount of Ca. Similar result was reported by SRDI staff (1985-1993). The available Mg content of the studied soils indicated optimum to very high amount of Mg. Similar result was reported by SRDI staff (1985-1993). The total Zn content of the studied soils indicated very low level of zinc. The Zn contents of the studied soils are below the critical limit. The low Zn content might be due to high organic matter (>2.6%). (Dobermann and Fairhurst, 2000). Decreasing pH in submerged, calcareous soils would usually increase zinc solubility.

Conclusion

Distribution of organic and mineral horizons in different profiles was not in same pattern and irregular. The two profiles vary mostly in texture, pH, mottling and cutans. Samples of Satla series are relatively higher in %clay, moisture content and total porosity. Samples of Harta series are relatively higher in %sand, %silt, bulk density, particle density and saturated hydraulic conductivity. The physical properties of the peat materials classified the soil as peat. The chemical data shows that OM%, Mg, S, are very high in amount and %N, P, K, Ca, Zn and B are low or medium in amount where as physical properties of the soils are favorable for agricultural development in limited area. The management of the two soil series is difficult. There are some possibilities to improve the soils by allowing sediments settling down on these peat basins from the adjoining tidal rivers. This process of sedimentation should be continued for several years to make the land high and potential for agriculture.

References

Ahsan, M.M.; Rabbi, S.M.F.; Islam, M.S.; Amin, M.S. and Hossain, M.Z. 2005. Characterization of morphological and physical properties of peat soils in Bangladesh. SRDI, Bangladesh Agricultural Research Council, Govt. of the People's Republic of Bangladesh.

Almamun, M.N.H. 2009. Management of organic peat soils in Bangladesh. SRDI, Bangladesh. pp. 2-4, 7.

Black, C.A. 1965. Methods of soil analysis. ASA, Monograph 9. Madison, WI. USA.

Bouyoucos, G.J. 1962. Hydrometer method improved for making particle size analysis of soils. *Agronomy Journal,* 54:464-465.

Brammer, H. 1971. Bangladesh: Soil resources. AGL: SF/PAK-6, Technical report no. 3, FAO, Rome.

Dobermann, A. and Fairhurs, T. 2000. Rice nutrient disorders and nutrient management. Handbook series. Potash and Phosphate Institute (PPI), Phosphate Institute of Canada (PPIC) and International Rice Research Institute (IRRI). pp.193.

Huizing, E.H. 1970. A Compact Constant-Head Parameter for Measuring Saturated Hydraulic Conductivity. *Soil Science Society America Journal,* 53(5): 1356-1361.

Jackson, M.L. 1962. *Soil Chemical Analysis*. Prentice Hall of India Pvt. Ltd. New Delhi.

Jackson, M.L. 1967. *Soil Chemical Analysis*. Prentice Hall of India Pvt. Ltd. New Delhi.

Jackson, M.L. 1973. *Soil Chemical Analysis.* Prentice Hall of India Pvt. Ltd. New Delhi. pp. 495-498.

Lynn, W.C.; McKinzie, W.E., and Grossman, R.B. 1974. Field laboratory test for the characterization of histosols. In: Aandahl *et al.* (eds.) Histosols: their characterization, use and classification. *Soil Science Society America Special Publication,* 6, Madison, WI.

Morel, J.; Habib, L.; Plantureux, S. and Guckert, A. 1999. Organic soils and peat materials for sustainable agriculture. *Plant and Soil.* 136: 111-119.

Parent, L.E. 2003. Organic soil and Peat Materials for Sustainable Agriculture. CRS Press, U. K.

Piper, C.S. 1950. *Soil and Plant Analysis.* The University of Adelaide Press, Adelaide, Australia.

Rahman, M.R. 2005. Soils of Bangladesh. Darpan publication, Banglabazer, Dhaka.

Schnitzer, M and Desjardins, J.G. 1965. Carboxyl and phenolic groups at some organic soils and their relation to degree of humification. *Canadian Journal of Soil Science,* 45:257-264.

Schwartzenbech, G.; Biedermann, W. and Bangerter, F. 1946. Analytical chemistry. *Helvetica Chimica Acta,* 44:811.

SRDI staff. 1973. Reconnaissance soil survey report of Sadar and Bagerhat subdivisions. Khulna district, Soil Survey Department, Ministry of Agriculture, Govt. of the People's Republic of Bangladesh. pp. 111-113, 190.

SRDI (Soil Resources Development Institute). 1977. Reconnaissance soil survey: Sadar and Bagerhat subdivisions, Khulna District.

SRDI staff. 1985-1993. Thana Nirdeshika of Dumuria, Mollahat and Terokhada, SRDI, Ministry of Agriculture, Govt. of the People's Republic of Bangladesh. pp. 40-41, 47.

USDA (United States Department of Agriculture). 1999. Soil Taxonomy. USDA

USDA (United States Department of Agriculture). 2003. Keys to Soil Taxonomy. USDA

USDA (United States Department of Agriculture). 2004. Soil survey laboratory manual, soil survey investigation report no. 42, version 4.0, USDA-NRCS, Nebraska, USDA

von Post, L. 1937. The geographical survey of Irish bogs. *Irish Naturalists' Journal*, 6:210-277.