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STUDY ON SOME SOILS OF THE HIMALAYAN PIEDMONT PLAIN OF BANGLADESH

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Abstract

Results of four representative pedons of the Old Himalayan piedmont, collected horizon-wise from Thakurgaon district, revealed that the color of the topsoil was dark grayish brown to dark yellowish brown and that of the subsoils was dark yellowish brown to light olive-brown and light brownish grey when moist. The soils have moderately well drained conditions except Baliadangi soils which are imperfectly drained. Prismatic to subangular blocky structure has been developed in subsurface horizons of all the profiles, whereas massive structure was found in the surface horizons. Sand was by far the dominant fraction in the soils. The texture of the soils varied from clay loam to sandy loam. The irregular vertical distribution patterns of sand/silt ratio in the profiles indicate the heterogeneous nature of the parent materials. The pH of the soils ranged from 5.4 to 6.26. The organic matter contents as well as total nitrogen of these soils were, in general, low. The C/N ratios of the soils varied from 4.3 to 10.3. The cation exchange capacity (CEC) in most of the studied soils were low. Calcium and magnesium were the dominant cations in all the soils.

Key words: Himalayan Pidmont plain

Introduction

The Himalayan piedmont plain is the northernmost physiographic unit of Bangladesh. It is located to the north of Barind Tract in the Thakurgaon and Panchagarh districts and comprises of the feet of some coalesced alluvial fan formed by the rivers, washing the adjacent Himalayan slope. Only a part of the Piedmont pains falls within the territorial limit of Bangladesh may be regarded as the alluvial toe slopes of the Himalayas (Ruhe 1960).

The old Himalayan piedmont plain comprises some part of Old Tista alluvial fan at the foot of the Himalayas. Sandy materials were deposited by fast-flowing rivers which constantly changed their courses. When Tista river abandoned the area, probably several thousand years ago, it left behind a complex landscape of broad, low ridges and a criss-crossing network of broad and narrow, abandoned river channels. The Karatoya, Tangan and smaller rivers which crosss the unit are entrenched 5-6 meters below the surrounding landscape (Brammer 1996). The higher parts of the ridges stand above normal flood-

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level in the rainy season, but they periodically become waterlogged during periods of monsoon-season rainfall, especially in the area with black soils in the north. The lower parts of the ridges and the old channels are seasonally shallowly flooded, and they periodically experience flash floods following exceptionally heavy rainfall locally or in the adjoining part of the Himalayas in India.

A very few research work has been done on the soils of the piedmont alluvial soils. Geologically, theses soils are very much important regarding their nature and origin. Brammer (1996) noted that the sandy parent material have mainly weathered to form permeable loamy soils which overlies sand at 90-120 cm. Soil patterns are often complex because of differences in soil texture and drainage within short distances. As an economic resource, land and its production capacity must be carefully assessed and periodically monitored in order to sustain the production of food and other basic human needs (Paul 1993).

The main objective of this paper is to study some soils from the Himalayan piedmont plain of Bangladesh.

Materials and Methods

A total of 15 soil samples were collected on natural horizon basis from four soil profiles for laboratory analysis. Four soil series regarding the Himalayan piedmont plain were selected for the present study. The soils were morphologically described in the field following the method of Soil Survey Manual (Soil Survey Staff, 1993). Information about location and other features of the representative soil series has been presented in Table 1.

Table 1. Location and other features of the soil series.

Characteristics	Soil Series			
	Baliadangi	Ranisankail	Dimla	Domar
Locations	Lalpur, Baliadangi, Thakurgaon	BARI/RARS, experimental field, Thakurgaon.	Dangipara,Haripur, Thakurgaon.	Amjankhun,Haripur, Thakurgaon.
Topography	Level/Partly irregular	Level/Partly irregular	Level/Partly irregular	Level/Partly irregular
Drainage	Imperfectly drained	Moderately well drained	Moderately well drained	Moderately well drained
Permeability	Low- Medium	High	High	High
Vegetation and land use	Boro-Transplanted aman	Mango orchard	Grazed fallow	Horticultural crops
Flooding depth and duration	Flooded by rain water up to a few inches depth or flooded by rain water up to 1-2 feet for 2-3 months in the monsoon season.	Above normal flood level. Rain water drains rather quickly and the soils dry out very early in the dry season.	Above normal flood level. Rain water drains rather quickly and the soils dry out very early in the dry season.	Above normal flood level. Rain water drains rather quickly and the soils dry out very early in the dry season.

The soil samples were processed and analyzed in the laboratory. The particle size analysis of soils was carried out by hydrometer method (Day 1965). Hygroscopic moisture content of soils was determined by drying the air-dried soils at 105-110^{0}C for 14 hours. The pH (H_2O) of soils was determined at a soil-water ratio (1:2.5) using a pH meter. The organic carbon content of soils was determined volumetrically (Jackson 1967) and that of total nitrogen by Kjeldahl's method (Jackson 1967). Cation exchange capacity of soils was determined with 1N NH_4OAc (pH 7.0) extract as described by (Jackson 1967). Exchangeable Ca^{++} and Mg^{++} were determined by atomic absorption Spectrophotometer, while Na^+ and K^+ were analyzed by flame photometer.

Results and Discussion

Morphological Properties: The matrix color of the soils was found to be a mixture of dark grayish brown, light olive brown, dark brown and dark yellowish brown. All the soils are imperfectly drained to moderately well in drainage conditions and rain water drains rather quickly and the soils dry out very early in the dry season except Baliadangi series which is flooded by rain water up to 1-2 feet for 2-3 months in the monsoon season. This grey color of the soils is related to the gradual removal of a portion of iron from the soil profile by leaching. The formation of various colored mottles is generally associated with seasonal fluctuation of ground water table (FAO-UNDP 1988). Due to alternative wetting and drying conditions abundant quantities of mottles have been formed in all the soil profiles. The occurrence of grey horizons in the studied pedons regarding mottling is the features of hydromorphic soils. The consistence of the surface soils of Dimla and Domar was found to be non sticky, non plastic when wet, while it was slightly sticky and slightly plastic when wet in Baliadangi series and in Ranisankail series it was slightly sticky and non plastic when wet. The structure of the soils is massive in all the surface horizons of the studied soils. Structure is not developed in the surface as this layer has been ploughed for many years. The Domar and Dimla series showed very weak coarse and medium subangular blocky structure. Ranisankail series showed weak course sub-angular blocky structure. In Baliadani series, moderate coarse prismatic structural aggregates breaking into weak coarse subangular blocky structure were found. In Dimla series, clear smooth and abrupt wavy boundary were observed. In Baliadangi, Ranisankail and Domar soil series, abrupt smooth and clear smooth boundary were found.

Physical properties: The texture ranged from sandy loam except the Baliadangi series in which the texture was sandy clay loam to loam (Table 2). The variation in clay, silt and sand content in most profiles suggests that texture is mainly due to sedimentary variations rather than a result of soil forming processes. Sandy loam to Sandy clay loam and Loam are the predominant texture of the soil area. The mean sand, silt and clay contents in the studied soils are 67, 16 and 17 percent respectively. The sand content is much higher in these soils (average 67%). This is the common feature in the

Himalayan piedmont soils of Bangladesh (SRDI 1968). The vertical distribution of sand and silt fraction in the profiles is irregular. Sand is by far the dominant size fraction and therefore, plays a significant role in moulding the congenial physical condition of theses soils. The vertical distributions of sand in the studied profiles are irregular. This irregularity in sand distribution pattern was thought to be related to the depositional processes of the soil parent materials. The high percentage of sand fraction in the soils under the present investigation corroborates the observation of Brammer (1964) that the texture of the soils across Bangladesh becomes gradually finer as one move from north to south.

Higher moisture percentage was recorded in Baliadangi (1.24 % to 2.80%) series, in contrast Domar series contained lower moistures (Table 2). Such a variation in moisture contents retained by air dry soils was possibly due to the differences in their clay and organic matter contents.

Table 2. Particle size distribution of the soils.

Soil Series	Horizons	Depth(cm)	% Sand	% Silt	% Clay	Sand/ Silt ratio	Silt/ Clay ratio	% H.M.
Baliadangi	Ap	0-10	47.61	30.85	21.54	1.54	1.43	1.83
	Ap2	10-45	47.83	29.3	22.87	1.63	1.28	2.24
	B2	45-60	57.52	15.13	27.35	3.8	0.55	2.8
	B3	60-80	56.64	19.21	24.15	2.95	0.8	2.11
	C	80-100+	58.28	20.35	21.37	2.86	0.95	1.24
Ranisankail	Ap	0-10	73.7	12.03	14.27	6.13	0.84	0.81
	B2	10-40	70.63	13.76	15.61	5.13	0.88	1.73
	B3	40-60	78.67	4.21	17.12	18.69	0.25	1.9
	C	60+	78.63	12.07	9.3	6.51	1.3	0.98
Domar	Ap	0-15	70.84	16.97	12.19	4.17	1.39	0.62
	B2	15-45	74.63	8.55	16.82	8.73	0.51	1.2
	C	45-70	70.24	20.35	9.41	3.45	2.16	0.4
Dimla	Ap	0-10	67.67	15.36	16.97	4.4	0.91	0.85
	B2	10-40	72.9	7.64	19.46	9.54	0.39	1.83
	C	40-70	80.4	7.64	11.97	10.53	0.64	1.32

*HM=Hygroscopic moisture.

Chemical properties : The cation exchange capacity of the soils under the present investigation ranged from 7.24 to 13.25 cmol (+) /kg with a mean value of 9.86 cmol (+) /kg (Table 3). These results were found to indicate that the fine textured soils contain the higher CEC than the medium textured soils due to their higher clay content. Increase in CEC values with increase in clay contents in soils has been reported by many authors (Gupta and Misra 1970) and (Pathak and Patal 1980). The highest mean value of CEC among the profiles was found in the Baliadangi soils and the lowest in the Dimla soil. The variation of CEC values of the pedons studied reflects the important influence of both the clay and organic matter content of these soils. The index of weathering (W = CEC / clay ratio) of these soils is found to vary from 0.42 to 0.88 with a mean of 0.60 (Table 3). These results indicate that the CEC / clay ratio of the present soils was quite uniform and the average CEC of the clay fraction in these soils was only 9.86 cmol (+) /kg. The soils showed a large CEC relative to total exchangeable cations which is a unsolved problem as noted by Brammer and Hesse (1970) also.

The amounts of exchangeable Ca^{++} ranged from 1.9 to 4.2 cmol (+) /kg with a mean of 2.75 cmol cmol (+) /kg. Exchangeable Ca^{++} is by far the most dominant metal ion in all the soils. Exchangeable Ca^{++} occupied about 35 percent of the total exchange position in the soils. The predominance of Ca^{++} was reported by George *et. al.,* (1958) in some humic gley soils of Ohio. Similar observation was also made by SRDI (1968).

The highest exchangeable Ca^{++} was found in the soils of Baliadangi series while the lowest value was found in Domar series. The exchangeable Mg^{++} contents in the exchange position in all the soil profiles ranged from 0.98 to 2.7 cmol (+) /kg with a mean of 1.73 cmol (+) /kg. The vertical distribution of exchangeable Mg^{++} in the profiles showed irregular trend in all the soil profiles. All the soils had low exchangeable Ca^{++}/Mg^{++} ratio (Table 3). Hussain and Chowdhury (1980) reported an exchangeable Ca^{++}/Mg^{++} ratio of around 2 in some poorly drained floodplain soils from Bangladesh.

The amount of exchangeable Na^{+} in all the soil profiles ranged from 0.20 to 0.89 cmol (+) /kg with a mean of 0.38 cmol (+) /kg (Table 3). Of all the soil profiles, Domar series contained the highest amount of exchangeable Na^{+}, while Ranisankail series contained the lowest amount. The distribution pattern of exchangeable Na^{+} in all the profiles was more or less irregular in pattern. The exchangeable K^{+} in the studied soils series ranged from 0.04 to 0.34 cmol (+) /kg, with a mean value of 0.141 cmol (+) /kg (Table 3). The vertical distribution of exchangeable K^{+} in the profiles showed no significant pattern.

Table 3. Cation exchange capacity and exchangeable cations of the soil samples.

Soil Series	Horizon	Depth (cm)	CEC* (cmol/ kg)	Exchangeable cations (cmol +/kg)				Ca^{2+}/ Mg^{2+}	Na^+/K^+	TEB** (cmol +/kg)	BSP	CEC/ Clay
				Ca^{2+}	Mg^{2+}	Na^+	K^+					
Baliadangi	Ap	0-10	11.25	2.4	1.48	0.2	0.16	1.62	1.25	4.24	37.69	0.52
	Ap2	10-45	11.24	3.6	1.25	0.75	0.04	2.88	18.75	5.64	50.18	0.49
	B2	45-60	13.25	3.6	1.78	0.22	0.16	2.02	1.38	5.76	43.47	0.48
	B3	60-80	12.79	4.2	2.73	0.35	0.34	1.54	1.03	7.62	59.58	0.53
	C	80-100+	10.33	2.8	2.73	0.67	0.21	1.03	3.19	6.41	62.05	0.48
Ranisankail	Ap	0-10	9.02	2.9	1.89	0.24	0.14	1.53	1.71	5.17	57.32	0.63
	B2	10-40	10.04	2.6	1.79	0.21	0.09	1.45	2.33	4.69	46.71	0.64
	B3	40-60	11.63	2.1	1.87	0.15	0.1	1.12	1.5	4.22	36.29	0.68
	C	60+	8.16	2.1	1.03	0.89	0.11	2.04	8.09	4.13	50.61	0.88
Domar	Ap	0-15	8.01	2.2	1.88	0.37	0.16	1.17	2.31	4.61	57.55	0.66
	B2	15-45	11.33	2.8	1.99	0.45	0.11	1.41	4.09	5.35	47.22	0.67
	C	45-70	8.1	2.2	1.86	0.37	0.16	1.18	2.31	4.59	56.67	0.86
Dimla	Ap	0-10	7.43	1.9	0.98	0.24	0.14	1.94	1.71	3.26	43.88	0.44
	B2	10-40	8.14	2.9	1.67	0.28	0.07	1.74	4	4.92	60.44	0.42
	C	40-70	7.24	2.9	0.98	0.38	0.16	2.96	2.38	4.42	61.05	0.61

*CEC = Cation Exchange Capacity; ** TEB = Total Exchangeable Bases.

The pH value of the Himalayan Piedmont soils under the present study ranged within wide limits. It ranged from 5.4 to 6.26 with a mean of 5.9 (Table 4). All the pedons, therefore, are moderately acid to neutral. (Table 4). The percentage of organic matter ranged from 0.62% to 1.95% with a mean value of 1.3 percent (Table 4). From the results it may be concluded that the studied soils contain low amount of organic matter. This finding has relevance with the findings of Ali *et al*. (1997), who reported that most agricultural soils of Bangladesh have low organic matter content. The Baliadangi soil contained relatively higher amount of organic matter throughout the profile (1.95 to 1.38%). All the soil profiles contained higher amount of organic matter in the surface than in the subsoil (Table 4). The total nitrogen content of the soil samples ranged from 0.056 to 0.143 percent with a mean of 0.098 percent (Table 4). The highest mean value of nitrogen content among the profiles was found in the Baliadangi soil whereas the lowest amount was found in the Ranisankail soil. The C/N ratio in the soils ranged from 4 to 10 with a mean ratio of 7.5 (Table 4). The C/N ratio within the soil profiles showed irregular patterns. The highest mean C/N ratio was found in the Ranisankail soil whereas the lowest value was found in Domar soils. The C/N ratios had no sequence in the studied soils with depth (Table 4). The reason for this feature possibly was their textural conditions.

Table 4. Chemical Properties of the soils.

Soil Series	Horizon	Depth (cm)	Organic Carbon%	Organic matter%	Total N %	C/N* Ratio	pH (H_2O)
Baliadangi	Ap	0-10	0.67	1.95	0.12	9.29	5.4
	Ap2	Oct-45	0.74	1.77	0.12	8.87	5.8
	B2	45-60	0.68	1.6	0.1	9.61	5.83
	B3	60-80	0.54	1.62	0.08	8.1	6
	C	80-100+	0.61	1.38	0.09	3.69	6.26
Ranisankail	Ap	0-10	0.79	1.35	0.13	7.8	5.4
	B2	Oct-40	0.75	1.31	0.11	6.7	5.7
	B3	40-60	0.54	1.22	0.08	7.9	5.8
	C	60+	0.43	0.98	0.06	6.2	6.2
Domar	Ap	0-15	1.21	2.07	0.1	10.3	5.8
	B2	15-45	1.2	2.07	0.1	9.5	6.1
	C	45-70	0.36	0.62	0.09	4.3	6.2
Dimla	Ap	0-10	0.78	1.12	0.14	5.7	5.9
	B2	0-40	0.73	1.02	0.09	7.7	6
	C	40-70	0.49	0.84	0.07	5.2	6.22

C/N*= Carbon/Nitrogen.

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