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ASSESSMENT OF CLAY MINERAL CONTENTS OF SOILS IN NORTHERN AND EASTERN PIEDMONT PLAINS (AEZ 22) AND CHITTAGONG COASTAL PLAINS (AEZ 23) OF BANGLADESH

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Abstract

Bangladesh comprises of 30 AEZs (Agro Ecological Zones) where mineralogical composition is an important controlling factor of soil fertility. However, such mineralogical information of soils of Bangladesh is very much insufficient and sparse. To address the situation, an initiative was taken to reveal the mineral content of important soils of different AEZs of the country. A part of such initiative, the mineralogy of five soil series from AEZ 22 (Northern and Eastern Piedmont Plains) and twelve soil series from AEZ 23 (Chittagong Coastal Plains) has been included in this manuscript. In AEZ 22, the average content of <2 µm sized clay fraction in soil was 20.4 while the 2-20 µm and 20-53 µm fractions was 32.3 and 34.6%, respectively. On the other hand, in AEZ 23, the average content of those clay fractions in soil was 32.5, 47.8 and 9.3%, respectively**.** Mica was found as the most prevalent among the minerals identified and it varied as 21-45 and 46-66% in AEZs 22 and 23, respectively. Next to mica, kaolinite, chlorite and quartz were present in considerable amount in both the AEZs. Intergraded vermiculite-chlorite minerals were found in some soils of AEZ 22 (Eastern part) while evidence of degradation of chlorite component was observed in AEZ 23. Such mineralogical observation of these AEZs is more or less conforming to the proposed mica-kaolinite-vermiculite* suite.

Keywords: Clay Mineralogy, Agroecological Regions, Northern and Eastern Piedmont Plains, Chittagong Coastal Plains.

Introduction

Agriculture is the backbone of the rural economy of Bangladesh, and it comprises about 11.38% of GDP and provides around 44.33% employment in labor sector (BBS, 2022). The contribution of this part has an inexorable impact on country's employment generation, food security, human resources development and poverty alleviation.

The land resources of Bangladesh have wider variation regarding soil fertility components like mineral compositions. Earlier, there were different type's classification of soils of whole country like 7 tracts, 21 General Soil Types and 537 soil series. Now, the total land area of the country has been grouped into thirty agroecological regions. In such grouping, some criteria i.e., soils, flooding condition, physiography and agro-climatic condition were taken in consideration (FAO-UNDP, 1988). Soil is consider to be one of the major limiting factors of crop cultivation system in Bangladesh where the mineral content of soil is one of the most contributing characters in soil fertility. Plant nutrients those released in course of weathering from various minerals are retained by other minerals through adsorption. That's why mineral contents are the indicators of the extent of weathering and the existence of specific minerals give some clues about soil formation (Schulze, 1989).

Different research activities and technology transfer are now going on the basis of AEZ. In the past, mineralogical study of soil was not carried out giving emphasis on various AEZs of Bangladesh; but it is so essential to know the origin and other properties of soils. Few studies regarding mineralogical composition have been conducted for important soil series on the basis of AEZ of the country. A summary of all revealed database regarding soil clay minerals of Bangladesh have been prepared and subsequently a tentative map of soil clay minerals for the country has been proposed (Moslehuddin et al., 1999). As there was a lack of enough information, an initiative was taken in the Department of Soil Science, Bangladesh Agricultural University (BAU), Mymensingh to study the mineralogical content of soils of all AEZs of Bangladesh.

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Among the AEZs of Bangladesh, AEZ 22 has an identity of intensive crop growing area covering 403758 ha of piedmont plains. On the other hand, AEZ 23 lies in the coastal plains (372007 ha) of Bangladesh. AEZ 22 is an area comprising with narrow strip of land located on base of the AEZ 29 (Northern and Eastern Hills) of the country (BARC, 2018). These areas are occupied with the alluvial fans having gentle slope outward the base of the hilly part. The major general soil types of these areas are Non-calcareous Grey Floodplain Soils and Grey Piedmont Soils. Low to medium fertility level of soil has been noticed there (FAO-UNDP, 1988). Based on physiographical consideration, landscape of AEZ 23 can be described as combination of piedmont, tidal, river and estuarine floodplain.

Moslehuddin et al. (1999) placed the AEZs 22 (eastern part) and 23 under mica-kaolinite-vermiculite*suite in a proposed map showing the major mineralogical composition of the country indicating mica, kaolinite and vermiculite (partly chloritized) were the major minerals. With a view to address the above mentioned problem, this present piece of work was focused to reveal the mineralogical composition of soil by analyzing soils of different soil series from these two AEZs (22 and 23) and to verify the tentative mineralogical suite for these AEZs.

Materials and Methods

The study was conducted at Department of Soil Science, BAU, Mymensingh, in order to determine the mineralogical properties of representative soil series from AEZ 22 (Eastern part) and AEZ 23. The soil samples from the respective AEZs during the period 2009 to 2013. The prepared slides of clay and silt fraction were analyzed for mineral identification by X-ray diffractrometer in Kyushu University, Japan. The materials used and methods followed in this experiment are described in this chapter.

Soil used

Thirteen soil samples covering the soil series Manu, Pritimpasha, Chakla, Shankochail and Olipur from AEZ 22 and twelve samples covering the soil series Pahartali, Chiringa, Badorkhali, Barabakia, Chakaria and Kutubdia from AEZ 23 were collected. In each of the cases only surface soil (0-15 cm soil depth) was used. Brief information of those soils is presented in Table 1. After drying in shady place, the soil samples were processed using standard procedures and stored in sealed poly bags for chemical analyses.

Table 1. General information of soil samples of AEZs 22 (eastern part) and 23

AEZ	Sample name	Location (upazila[1]) and district)	Land Type[2])	USDA[3]) soil taxonomy	Cropping pattern[4])
	Manu-1	Adorsho Sadar, Cumilla	MHL	Aeric Haplaquepts	B - A - T.A
	Manu-1	Adorsho Sadar, Cumilla	MHL	Aeric Haplaquepts	B - F - T.A
	Pritimpasha-1	Adorsho Sadar, Cumilla	HL	Typic Haplaquepts	V - V - V
	Pritimpasha-2	Burichong, Cumilla	MHL	Typic Haplaquepts	Mu - B - T.A
	Pritimpasha-3	Burichong, Cumilla	MHL	Typic Haplaquepts	B - A - T.A
	Pritimpasha-4	Burichong, Cumilla	MLL	Typic Haplaquepts	B - F - T.A
22	Pritimpasha-5	Adorsho Sadar, Cumilla	HL	Typic Haplaquepts	V - V - T.A
	Pritimpasha-6	Adorsho Sadar, Cumilla	HL	Typic Haplaquepts	V - V - V
	Chakla-1	Adorsho Sadar, Cumilla	MLL	Typic Haplaquepts	B - A- T.A
	Chakla-2	Burichong ,Cumilla	MLL	Typic Haplaquepts	B - F - T.A
	Chakla-3	Burichong, Cumilla	MLL	Typic Haplaquepts	B - F - T.A
	Shankochail	Adorsho Sadar, Cumilla	HL	Typic Fluvaquents	V - V - V
	Olipur	Adorsho Sadar, Cumilla	MHL	Typic Fluvaquents	B - V - T.A

23	Pahartali-1	Chakaria, Cox's Bazar	HL	Typic Haplaquepts	S. C; S
	Pahartali-2	Chakaria, Cox's Bazar	HL	Typic Haplaquepts	S. C; S
	Chiringa-1	Chakaria, Cox's Bazar	HL	Typic Sulfaquents	S.B, T. A/ S.C
	Chiringa-2	Chakaria, Cox's Bazar	HL	Typic Sulfaquents	S.B, T. A/ S.C
	Badarkhali-1	Chakaria, Cox's Bazar	MHL	Typic Sulfaquents	B –T. A; S.B
	Badarkhali-2	Chakaria, Cox's Bazar	MHL	TypicSulfaquents	B –T. A; S.B
	Barabakia-1	Bodorkhali, Cox's Bazar	MHL	Typic Haplaquepts	B –T. A; S.B
	Barabakia-2	Bodorkhali, Cox's Bazar	MHL	Typic Haplaquepts	B –T. A; S.B
	Chakaria-1	Chakaria, Cox's Bazar	LL	Typic Haplaquepts	S. C; S
	Chakaria-2	Chakaria, Cox's Bazar	LL	Typic Haplaquepts	S. C; S
	Kutubdia-1	Chakaria, Cox's Bazar	LL	Typic Haplaquepts	B –T. A; S.B
	Kutubdia-2	Chakaria, Cox's Bazar	LL	Typic Haplaquepts	B –T. A; S.B

[1)] Upazila= Subdistrict; [2)] HL-High Land, above flood level; MHL-Medium High Land, normally flooded up to a depth of 90 cm during the monsoon season, MLL-Medium Low Land, normally flooded from a depth of 90 cm to 180 cm during the monsoon season. [3)] USDA: United States Department of Agriculture[4)] A: Aus; B: Boro rice; B.A: Broadcast Aman rice; F: Fallow; Ma: Maize; Mu: Mustard; S: Shrubs; S.B: Salt bed; S.C: Shrimp culture; T.A: Transplant Aman rice; V: Vegetable

Analysis of particle size distribution of soil

To decompose the organic matter present in the samples, hot 7% H_2O_2 was added to the processed soil samples (Gee and Bauder, 1986). After that mechanical stirring was done to disperse the particles and the pH of that soil suspension was adjusted at 10 by using 1 M NaOH. Repeated stirring, sedimentation and siphoning were done to separate the <2 µm fraction of soil. On the other hand, repeated sedimentation-siphoning was performed to separate the 2-20 µm fractions whereas wet sieving was used for separating the 20-53, 53-212 and 212-2000 µm fractions.

Measurement of pH and EC

After 30 minutes shaking of soil:water suspension with a ratio of 1:2.5 pH was determined using a glass-electrode pH meter and the electrical conductivity (EC) of soil suspension was measured by an EC meter maintaining a soil:water ratio of 1:5 (McLean, 1982).

Measurement of exchangeable K and Ca

Ammonium acetate (8 mL) was added as extracting solution to 2.5 g of soil sample in a 15 mL centrifugal tube for extracting exchangeable K and Ca. The decanted supernatant was filtered after 10 minutes of shaking followed by centrifuging the suspension for 5 minutes at 1500 rpm. After repetition of the process for two more times, a flame photometer was used to determine the concentration of K and Ca (Knudsen et al., 1982).

Analysis for mineralogical content

To prepare the specimens for XRD (X-ray diffraction) study, duplicate clay sols having 50 mg of clay (<2 µm) were taken. A centrifugal tube(10 mL) was used for washing the sols with 8 mL solution mixture of equal amount of 1M CH3COONa (pH 5) and 1M NaCl through centrifugation-decantation process for twice. Such process was done to reduce the pH value of preserved clay sols. One of the duplicate sets was saturated with K by washing three times with 8 mL of 1M KCl and the other set was saturated with Mg using 0.5 M $MgCl_2$ following the same process. In each of the sets, the sol was washed with 8 mL of water to remove the excess salt.

After suspending the clay in the tube with 1 mL of water, a 0.4 mL aliquot of the sol was dropped onto a glass slide having size 7.6 cm × 2.6 cm. The drop was spread on the slide leaving one-thirds of its area free for easy handling. Following air-drying the slides was X-rayed with the help of an X-ray diffractometer (Rigaku, RINT 2100V) using Cu K**α** radiation at

40 kV and 20 mA. The process had a scanning speed of 2°2θ min^{-1} over a range of 3 to 30° 2θ. Besides the air-dried specimen, another two specimens (clay saturated with Mg and K) were X-rayed after solvation with glycerol. The latter two specimens were heated at 300°C and 550°C for 2 hrs, respectively, before X-rayed. The relative peak intensities of the respective minerals in the XRD charts were used to determine the approximate mineral composition of the <2 µm fraction (Moslehuddin and Egashira, 1996). To find out the presence of mineral components of the soil samples under study various relevant measurements and ratios of the peaks were used (Akter et al, 2015).

Results

Particle-size distribution

The soil samples were analyzed for particle-size distribution as well as textural classes following the USDA system (Table 2 and 3). In AEZ 22, the highest and lowest clay content was found as 40.9% (in Chakla-3) and 8.6% (in Chakla-1), respectively, with an average of 20.44% whereas in AEZ 23 the highest, lowest and average clay content were 65% (Chakaria-2), 13% (in Pahartali-1) and 32.50%, respectively. The average percentage of 2-20 µm fractions in AEZ 22 ranged from 18.6-58.5% where average value was 32.26% and in AEZ 23 it was 24-70% with an average of 47.75%.

Table 2. Particle-size distribution and textural classes of soil samples in AEZ 22 (eastern part)

Soil series	**Particle-size distribution** (%)					
	<2 µm	**2-20 µm**	**20-53 µm**	**53-212 µm**	**212-2000 µm**	**USDA soil textural classes**
Manu-1	23.9	31.0	31.3	11.6	2.2	Silt loam
Manu-2	18.6	31.6	31.1	16.5	2.2	Silt loam
Pritimpasha-1	10.3	18.6	38.5	30.5	2.1	Silt loam
Pritimpasha-2	11.8	58.5	28.2	1.4	0.1	Silt loam
Pritimpasha-3	11.8	27.1	34.5	24.3	2.3	Silt loam
Pritimpasha-4	19.9	37.1	42.0	0.9	0.1	Silt loam
Pritimpasha-5	16.0	22.5	54.5	5.3	1.7	Silt loam
Pritimpasha-6	11.4	21.1	42.8	22.3	2.3	Silt loam
Chakla-1	8.6	57.6	30.5	2.9	0.4	Silt
Chakla-2	56.6	28.6	9.0	5.5	0.3	Clay
Chakla-3	40.9	22.4	34.9	1.5	0.3	Silty clay loam
Shankochail	9.4	25.8	46.1	9.5	9.1	Silt loam
Olipur	26.5	37.5	26.8	8.5	0.8	Silt loam
Average	**20.4**	**32.3**	**34.6**	**10.8**	**1.8**	

USDA: United States Department of Agriculture

Table 3. Particle-size distribution and textural classes of soil samples in AEZ 23

Soil series	**Particle-size distribution** (%)					
	<2 μm	**2-20 μm**	**20-53 μm**	**53-212 μm**	**212-2000 μm**	**USDA soil textural classes**
Pahartali-1	13.0	67.0	13.0	4.0	3.0	Silt loam
Pahartali-2	27.0	39.0	12.0	16.0	6.0	Silt loam
Chiringa-1	18.0	70.0	3.0	5.0	4.0	Silt loam
Chiringa-2	20.0	24.0	25.0	30.0	1.0	Loam
Badarkhali-1	37.0	52.0	8.0	2.0	1.0	Silty clay loam
Badarkhali-2	43.0	40.0	7.0	4.0	6.0	Silty clay
Barabakia-1	32.0	48.0	12.0	7.0	1.0	Silty clay loam
Barabakia-2	43.0	40.0	6.0	6.0	5.0	Silty clay
Chakaria-1	38.0	50.0	7.0	3.0	2.0	Silty clay loam
Chakaria-2	65.0	29.0	2.0	3.0	1.0	Clay
Kutubdia-1	31.0	54.0	10.0	4.0	1.0	Silty clay loam
Kutubdia-2	23.0	60.0	6.0	6.0	5.0	Silt loam
Average	**32.5**	**47.8**	**9.3**	**7.5**	**3.0**	

USDA: United States Department of Agriculture

The lowest and highest content of 20-53 μm fractions varied from 9.0 (Chakla-2) to 54.5% (Pritimpasha-5) in AEZ 22, and 3% (Chiringa-1) to 25% (Chiringa-2) in AEZ 23. The lowest content (0.9%) of 53-212 μm fraction was found in Pritimpasha-4 where the highest value (30.5%) was in Pritimpasha-1 in AEZ 22 while in AEZ 23 it ranged from 2.0% (in Badarkhali-1) to 30.0% (in Chiringa-2). In case of coarse sand (212-2000 μm) the content was very negligible to small amounts ranging from 0.1-9.1% in AEZ 22 whereas it was 1.0 to 6.0% in AEZ 23.Based on USDA system in AEZ 22, ten samples was grouped as silt loam and the remaining three samples as silt, silty clay loam and clay, respectively. On the other hand, the grouping in AEZ 23 was 1 loam, 4 silt loam, 4 sandy clay loam, 2 silty clay and 1 clay.

Soil pH and EC

Soil pH of the studied samples was varied from 4.38 (Pritimpasha-4) to 5.12 (Pritimpasha-6) and 6.3 (Badarkhali-1 and Chakaria-2) to 6.8 (Barabakia-1) in AEZ 22 and 23, respectively (Table 4 and 5). The average pH was 4.78 (in AEZ 22) and 6.46 (in AEZ 23).

In AEZ 22, soil EC values varied from 0.020 to 0.096 dS m^{-1} where the lowest and highest values of EC recorded in Chakla-1 and Pritimpasha-1 soil series, respectively (Table 4). On the other hand, the lowest and highest EC was found in Pahartali-2 (3.1 dS m^{-1}) and Kutubdia-1 (16.5 dS m^{-1}), respectively, in AEZ 23 (Table 5).

Exchangeable potassium and calcium

In the soil samples studied, the highest exchangeable potassium (0.19 $cmol_c kg^{-1}$) was recorded in Manu series while the lowest (0.09 $cmol_c kg^{-1}$) was in Olipur soil series. The exchangeable calcium in AEZ 22 varied from 0.20$cmol_c kg^{-1}$ (in Pritimpasha-1 series) to 0.39 $cmol_c kg^{-1}$(in Manu-1 series) (Table 4). Again, in AEZ 23 exchangeable potassium and calcium differed from 0.21 to 1.75 and 1.3 to 7.6 $cmol_c kg^{-1}$, respectively. Both potassium and calcium contents were the highest in Kutubdia-1 soil series in AEZ 23 (Table 5).

Table 4. pH, EC, exchangeable K and Ca of soil samples in AEZ 22 (eastern part)

Sample name	pH	EC ($dS\ m^{-1}$)	Exchangeable K ($cmol_c\ kg^{-1}$)	Exchangeable Ca ($cmol_c\ kg^{-1}$)
Manu -1	5.10	0.067	0.19	0.39
Manu-2	4.76	0.047	0.11	0.37
Pritimpasha-1	5.00	0.096	0.16	0.20
Pritimpasha -2	4.76	0.069	0.13	0.29
Pritimpasha-3	4.55	0.048	0.12	0.22
Pritimpasha-4	4.38	0.086	0.10	0.27
Pritimpasha-5	5.08	0.089	0.11	0.28
Pritimpasha-6	5.12	0.067	0.10	0.32
Chakla-1	5.10	0.020	0.10	0.24
Chakla-2	4.62	0.082	0.11	0.33
Chakla-3	4.50	0.050	0.15	0.31
Shankochail	4.68	0.026	0.11	0.36
Olipur	4.54	0.036	0.09	0.31
Average	**4.78**	**0.06**	**0.12**	**0.30**

Table 5. pH, EC, exchangeable K and Ca of soil samples in AEZ 23

Sample name	pH	EC ($dS\ m^{-1}$)	Exchangeable K ($cmol_c\ kg^{-1}$)	Exchangeable Ca ($cmol_c\ kg^{-1}$)
Pahartali-1	6.7	7.1	1.38	2.8
Pahartali-2	6.4	3.1	0.85	1.8
Chiringa-1	6.5	11.7	1.43	5.5
Chiringa-2	6.4	7.8	0.85	2.9
Badarkhali-1	6.3	5.7	0.21	2.7
Badarkhali-2	6.4	7.5	1.33	1.3
Barabakia-1	6.8	15.1	1.59	3.0
Barabakia-2	6.4	4.0	0.74	2.2
Chakaria-1	6.4	3.9	0.80	3.5
Chakaria-2	6.3	10.9	1.65	4.2
Kutubdia-1	6.4	16.5	1.75	7.6
Kutubdia-2	6.5	9.0	1.59	2.1
Average	**6.5**	**8.5**	**1.18**	**3.30**

Mineral contents of clay fraction

The patterns observed from XRD for the <2 µm fraction of the major soil series in AEZs 22 (eastern part) and 23 are shown in Figure 1 and 2, respectively. In AEZ 22, the peaks are sharp for most of the samples which indicates the good crystallinity and/or large crystallite size of the minerals and sometimes broad, indicating low crystallinity and/or small crystallite size of the minerals indicating presence of mixed layer minerals. On the other hand the peaks of most samples are broad which indicates low crystallinity and/or small crystallite size of the minerals in AEZ 23. The approximate mineral composition of the <2 µm fraction is presented in Table 6 and 7. In the soils under study from AEZ 22, ten different minerals were identified in the <2 µm clay fraction which are mica, smectite, chlorite, vermiculite, vermiculite-chlorite intergrade, kaolinite, feldspars, lepidocrocite, goethite and quartz. Again in AEZ 23, five silicate minerals (vermiculite, mica, chlorite, smectite and kaolinite) and two most complex silicate minerals (quartz and feldspar) were identified in variable amounts; no interstratified minerals was noticed in the soils of this AEZ.

Mica was found as the most dominant one in both the AEZs, and it varied from 21 (Olipur soil) to 45% (Pritimpasha-2 soil) and 46 (Chiringa-1 soil) to 66% (Chiringa-2 soil) in AEZ 22 and 23, respectively. In AEZ 22 next to mica, kaolinite and chlorite were observed in larger amount than other minerals which ranged from 11 to 24% and 11 to26%, respectively. Pritimpasha-1 soil possesses the highest amount of both kaolinite and chlorite where kaolinite was found as the lowest amount in Pritimpasha-2 soil. Again, the lowest amount of chlorite was possessed by both Pritimpasha-6 and Shankochail soils.

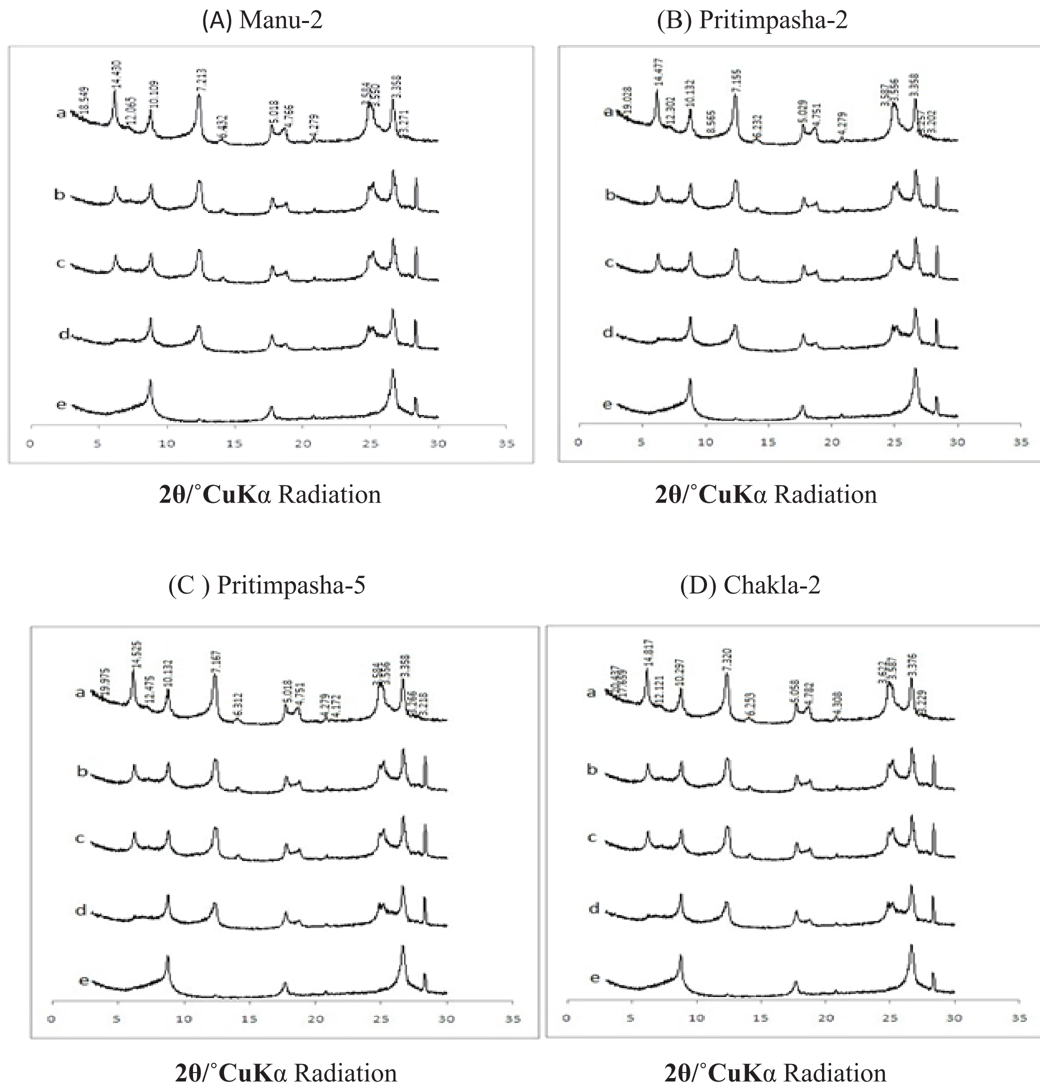

Figure 1 X-ray diffraction patterns of the <2µm clay fraction of (A) Manu-2, (B) Pritimpasha-2, (C) Pritimpasha-5, (D) Chakla-2 soil. Spacing in Å. Treatment: a) Mg-saturation and glycerol-solvation; b) Mg-saturation and air-drying; c) K-saturation and air-drying; d) K-saturation and heating at 300ºC; e) K-saturation and heating at 550ºC

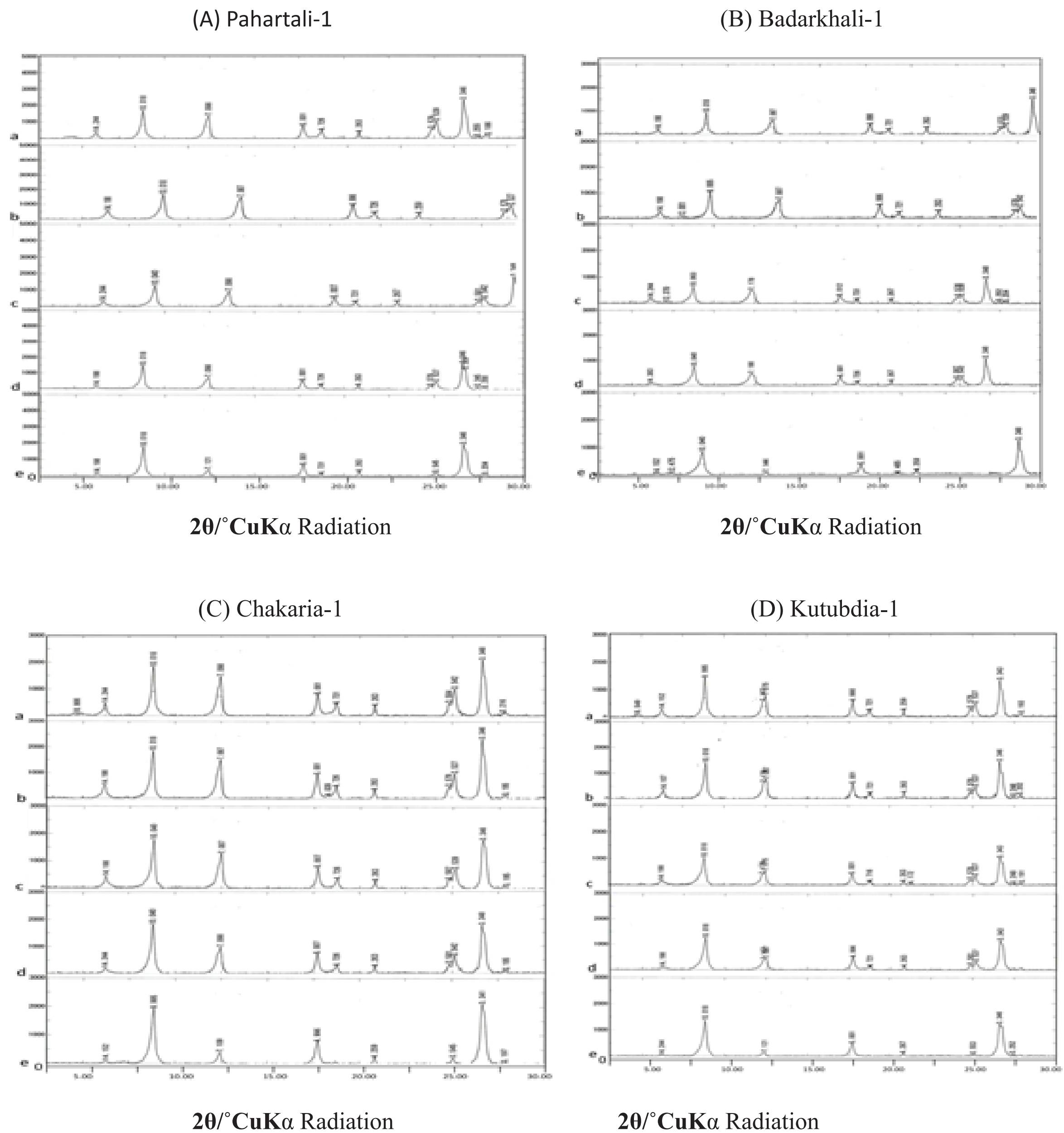

Figure 2 X-ray diffraction patterns of the <2µm clay fraction of (A) Pahartali-1, (B) Badarkhali-1, (C) Chakaria-1, (D) Kutubdia-1 soil. Spacing in Å. Treatment: a) Mg-saturation and glycerol-solvation; b) Mg-saturation and air-drying; c) K-saturation and air-drying; d) K-saturation and heating at 300ºC; e) K-saturation and heating at 550ºC.

Table 6. Approximate mineral contents (%) of the clay fraction (<2µm) of soils in AEZ 22 (eastern part)

	Minerals									
Series	Mc	St	Vt	Ch	Kt	Vt-Ch	Qr	Gt	Lp	Fd
Manu-1	30	-	-	14	17	16	12	-	6	5
Manu-2	39	-	4	14	19	5	18	-	-	1
Pritimpasha-1	33	-	-	26	24	-	10	1	-	6
Pritimpasha-2	45	-	3	21	11	-	11	-	-	6
Pritimpasha-3	37	2	-	16	18	4	18	-	-	5
Pritimpasha-4	34	4	-	21	23	6	9	-	-	3
Pritimpasha-5	32	1	13	16	18	1	13	-	3	3
Pritimpasha-6	42	-	4	11	14	6	19	-	-	4
Chakla-1	35	-	-	15	14	-	26	-	-	10
Chakla-2	36	-	-	13	19	12	18	-	-	2
Chakla-3	34	7	-	21	21	-	12	-	-	5
Shankochail	43	-	-	11	16	2	19	1	-	8
Olipur	21	20	-	19	21	-	7	-	10	2

Abbreviations: Mc: Mica; St: Smectite; Ch: Chlorite; Kt: Kaolinite; Vt: Vermiculite; Vt-Ch: Vermiculite-Chlorite intergrade; Qr: Quartz; Gt: Goethite; Lp: Lepidocrocite; Fd: Feldspar.

Table 7. Approximate mineral contents (%) of the clay fraction (<2µm) of soils in AEZ 23

	Minerals						
Series	Mc	St	Vt	Ch	Kt	Qr	Fd
Pahartali-1	52	0	3	13	13	18	0
Pahartali-2	57	0	0	10	10	16	7
Chiringa-1	46	0	2	19	16	17	0
Chiringa-2	66	1	2	11	11	11	0
Badarkhali-1	51	0	0	13	13	24	0
Badarkhali-2	53	0	4	12	10	16	4
Barabakia-1	52	0	1	13	13	17	3
Barabakia-2	58	0	3	8	8	18	7
Chakaria-1	51	1	2	18	12	16	0
Chakaria-2	55	0	1	9	9	20	4
Kutubdia-1	47	0	0	14	9	16	13
Kutubdia-2	49	0	3	18	12	18	2

Abbreviations: Mc: Mica; St: Smectite; Ch: Chlorite; Kt: Kaolinite; Vt: Vermiculite; Qr: Quartz; Fd: Feldspar.

Quartz and feldspar were also found in all the soils ranging from 9 (in Pritimpasha-4 soil) to 26% (in Chakla-1 soil) and 1 (in Manu-2 soil) to 10% (in Chakla-1 soil), respectively. Vermiculite-Chlorite intergraded minerals were found in some soils having a range from 1 (in Pritimpasha-5 soil) to 16% (in Manu-1 soil. Little amount (1 -20 and 3-13%, respectively) of smectite and vermiculite were found in few soil samples. A little amount of lepidocrocite was identified in Manu-1 (6%), Pritimpasha-5 (3%) and Olipur (10%) soils. Negligible amount (1% in each) of goethite was recorded in Pritimpasha-1 and Shankochail soils. On the other hand in AEZ 23, chlorite, kaolinite and quartz present in all soils in good amounts: 18-19%, 8-16% and 11-24%, respectively. Also small amount of vermiculite (1-4%) were found in 9 samples, feldspar (2-13%) in 7 samples and little amount of smectite (1%) was identified in two soils samples.

Discussion

Results of particle-size distribution revealed that the soils from AEZ 22 (eastern part) were fine to medium textured which categorized as clay to silt loam textural classes. Strongly acidic to slightly acidic soil reactions were as found in the study which is in agreement with BARC (2018) and SRDI (1999, 2000). Again, the EC value for soils from AEZ 22 of the present study indicated non-saline nature of these soils which is well fitted with BARC (2018). In AEZ 23, the pH of all the soil samples under study lied below neutral point which has accordance with BARC (2018). The EC values found for soils from AEZ 23 in the present study indicate saline nature of these soils and it is well agreed with BARC (2018). High salinity of the soils of Chittagong Coastal Plains (AEZ 23) is major problem during October to May. It is due to low precipitation in those months.

The exchangeable K content in most soils was in low category in AEZ 22. Exchangeable calcium of those soil samples varied from 0.20 to 0.39 $cmol_c kg^{-1}$. BARC (2018) also grouped the exchangeable potassium and calcium of this AEZ as low to medium and medium to optimum category, respectively. On the other hand, these results of present study also well agreed with SRDI (1999, 2000) for similar soil series. The exchangeable K content was very high (0.74-1.75 $cmol_c\ kg^{-1}$) in all soils except one soil which had medium (0.21) level of exchangeable K. Good amounts of mica in both silt and clay fraction of these soils might be the main contributor of high exchangeable K content. In most cases the K content in soils of AEZ 23 belongs to low to optimum (BARC, 2018). Exchangeable Ca content was in great variation (very low to very high level) in soils of this AEZ. Fertilizer Recommendation Guide, 2018 of BARC described medium to optimum content of exchangeable calcium in AEZ 23.

The mineralogical composition is the central theme of the present study. The result indicated that the most predominant mineral was mica in all the soil samples followed by kaolinite and chlorite in both the AEZs. In AEZ 22, the chlorite component was somewhat degraded, and the degraded nature of chlorite is an indication ofaltering vermiculite-chlorite intergrade from chlorite due to long term or severe weathering (Egashira and Yasmin, 1990) which would be altered finally to vermiculite in the course of weathering. Vermiculite was found only in four samples (3-13%). Small amount of chlorite–vermiculite intergraded minerals were found in eight soil samples. Low amount of smectite was also observed. Absence or presence of the vermiculite-chlorite intergraded along with vermiculite and smectite indicated different stages of weathering of the concerned soils.

During the preparation of a tentative mineralogical map of Bangladesh, Moslehuddin et al. (1999) placed the soils of these AEZs in mica-kaolinite-vermiculite* suite. This means mica and kaolinite were the major minerals with some vermiculite that was partly chloritized. In this study, mica and kaolinite were the dominant minerals along with chlorite, in addition to some vermiculite and/or chlorite-vermiculite intergraded minerals in AEZ 22. Again in AEZ 23, mica, kaolinite and chlorite was found as major minerals with some vermiculite. However, from the XRD charts it is evident that the chlorite component is somewhat degraded with high temperature. Thus the results obtained in the present study concerning soils of AEZs 22 and 23 partly support the proposed mica-kaolinite-vermiculite* suite by Moslehuddin et al. (1999). However, these two AEZs are occupying a considerable large area of Bangladesh while the areas covered by the current study were limited to only a part of these AEZs. Therefore, further intensive evaluation is needed using soils from other concern areas of these AEZs for making a concrete decision on it.

Conclusion

Non-saline andfine to medium textured soils having strongly acidic to slightly acidic reactions were found in Northern and Eastern Piedmont Plains while in Chittagong Coastal Plain soils were medium textured, mostly slightly acidicin reaction and saline in nature. Among the dominating minerals mica, kaolinite, chlorite and quartz are the major minerals in clay fraction in both the AEZs. Intergraded vermiculite-chlorite minerals were also found in some soils of AEZ 22 while in case of AEZ 23 there is evidence from the XRD charts that the chlorite component is somewhat degraded with high temperature. In such context, it can be concluded that the results of the present study is almost similar to the tentative mica-kaolinite-vermiculite*-suite for AEZs 22 (eastern part) and 23 proposed by Moslehuddin et al. (1999). For more authentication of this issue, further study is necessary but the outcomes of the present research are very useful to resolve the water and nutrient management and also for selecting crops for that particular area.

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