Mineralogy of Soils from Different Agroecological Regions of Bangladesh : Region 2 - Active tista Floodplain, Region 4 - Karatoya - Bangali Floodplain and Region 7 - Active Brahmaputra - Jamuna Floodplain

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https://doi.org/10.5109/10087

出版情報：九州大学大学院農学研究院紀要. 53 (1), pp.155-161, 2008-02-28. Faculty of Agriculture, Kyushu University
バージョン：
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Table 1. General information of the soils from AEZs 2, 4 and 7

AEZ	Soil series	Location	Land type[1)]	General soil type[2)]	USDA Soil Taxonomy	Vegetation
AEZ 2	Silty Tista Alluvium	Vill.: Nohali char Upazila: Gangachara Dist.: Rangpur	MHL	Noncalcareous Alluvium	Typic Psammaquents	Chili, Garlic, Onion, Vegetable
	Sandy Tista Alluvium	Vill.: Nohali char Upazila: Gangachara Dist.: Rangpur	MLL	Noncalcareous Alluvium	Typic Psammaquents	Aman, Tobacco, Maize
AEZ 7	Chilmari	Vill.: Mollar char Upazila: Gaibandha sadar Dist.: Gaibandha	MHL	Noncalcareous Dark Grey Floodplain Soils	Aeric Haplaquepts	Jute, Aus, Mustard
	Sandy Jamuna Alluvium	Vill.: Daulatpur Upazila: Belkuchi Dist.: Sirajganj	LL	Noncalcareous Alluvium	Typic Fluvaquents	Groundnut, Jute, Sweet potato, Water–melon
	Silty Jamuna Alluvium	Vill.: Daulatput Upazila: Belkuchi Dist.: Sirajganj	LL	Noncalcareous Alluvium	Typic Fluvaquents	Boro–Fallow–Fallow
AEZ 4	Maldaha–1	Vill.: Koizuri Upazila: Shajadpur Dist.: Sirajganj	MLL	Noncalcareous Dark Grey Floodplain Soils	Typic Fluvaquent	Rabi crops–Aus–Fallow
	Shrikhula	Vill.: Daulatput Upazila: Belkuchi Dist.: Sirajganj	HL	Noncalcareous Dark Grey Floodplain Soils	Aeric Fluvaquents	Rabi crops–Aus–Fallow
	Sonatala	Vill.: Khukni Upazila: Shajadpur Dist.: Sirajganj	MHL	Noncalcareous Dark Grey Floodplain Soils	Aeric Haplaquepts	Rabi crops/Boro–T. Aman
	Jamun	Vill.: Nalka Upazila: Raiganj Dist.: Sirajganj	MHL	Noncalcareous Dark Grey Floodplain Soils	Aeric Haplaquepts	Rabi crops–Aus–T. Aman
	Savarbazar	Vill.: Porzana Upazila: Shajadpur Dist.: Sirajganj	LL	Noncalcareous Dark Grey Floodplain Soils	Aeric Haplaquepts	Rabi crops/Boro–Fallow
	Amgaon–1	Vill.: Dattakusa Upazila: Raiganj Dist.: Sirajganj	MLL	Noncalcareous Dark Grey Floodplain Soils	Aeric Haplaquepts	Rabi crops–Aus–Fallow
	Matia	Vill: Porzana Upazila: Shajadpur Dist.: Sirajganj	LL	Noncalcareous Dark Grey Floodplain Soils	Aeric Haplaquepts	Rabi crops/Boro–Fallow
	Laskara	Vill.: Dattakusa Upazila: Raiganj Dist.: Sirajganj	MLL	Noncalcareous Dark Grey Floodplain Soils	Aeric Haplaquepts	Rabi crops/Boro–T. Aman
	Ulipur	Vill.: Dattakusa Upazila: Raiganj Dist.: Sirajganj	MLL	Noncalcareous Dark Grey Floodplain Soils	Aeric Haplaquepts	Rabi crops/Boro–Fallow
	Silmondi	Vill.: Dattakusa Upazila: Raiganj Dist.: Sirajganj	MLL	Noncalcareous Dark Grey Floodplain Soils	Aeric Haplaquepts	Rabi crops/Boro–Fallow
	Maldaha–2	Vill.: Koizuri Upazila: Shajadpur Dist.: Sirajganj	MHL	Noncalcareous Dark Grey Floodplain Soils	Typic Fluvaquent	Rabi crops/Boro–T. Aman
	Amgaon–2	Vill.: Dattakusa Upazila: Raiganj Dist.: Sirajganj	HL	Noncalcareous Dark Grey Floodplain Soils	Aeric Haplaquepts	Rabi crops–Aus–T. Aman
	Daspara	Vill.: Koizuri Upazila: Shajadpur Dist.: Sirajganj	MLL	Noncalcareous Dark Grey Floodplain Soils	Typic Fluvaquent	Rabi crops/Boro–T. Aman
	Kajla	Vill.: Khukni Upazila: Shajadpur Dist.: Sirajganj	LL	Noncalcareous Dark Grey Floodplain Soils	Aeric Haplaquepts	Rabi crops/Boro–Fallow
	Kamarkhanda	Vill.: Gabori Upazila: Belkuchi Dist.: Sirajganj	HL	Noncalcareous Dark Grey Floodplain Soils	Aeric Haplaquepts	Rabi crops–Aus–Fallow

[1)] Land type: HL, highland; MHL, medium highland; MLL, medium lowland; LL, lowland. HL: land which is above the normal flood level; MHL, MLL and LL: land which is normally flooded up to a depth of about 90 cm, 90–180 cm deep and 180–300 cm deep, respectively, during the monsoon season.
[2)] Soil classification based on the Bangladesh system.

Particle–size analysis

The soil samples were treated with hot 7% H_2O_2 to decompose organic matter, dispersed by mechanical stirring and adjusted to the pH 10 using 1 M NaOH. The <2 μm clay fraction was separated by repeated stirring–sedimentation–siphoning. The 2–20 μm fraction was separated by repeated sedimentation and siphoning, and the 20–53, 53–212 and 212–2,000 μm fractions were separated by wet–sieving. Weights of each fraction were determined to calculate the particle–size distribution.

Mineralogical analysis

Specimens for X–ray diffraction (XRD) of the clay fraction were prepared by taking duplicate clay sols containing 50 mg of clay (<2 μm). Of the duplicate sets, one was saturated with K and the other with Mg by washing three times with 1 M KCl and 0.5 M $MgCl_2$, respectively. Excess salt was removed by washing one time with water. An aliquot of 0.4 mL of the clay sol was dropped onto a glass slide (28×48 mm), covering two–thirds of its area, air–dried, and X–rayed (parallel powder mount). XRD patterns were obtained using a Rigaku X–ray diffractometer with CuKα radiation at 40 kV and 20 mA and at a scanning speed of 2° 2θ min^{-1} over a range of 3 to 30° 2θ. In addition to the air–dried specimen, the Mg–saturated clay was X–rayed after solvation with glycerol, and the K–saturated clay was X–rayed after heating at 300 and 550 °C for 2 hr.

For the silt fraction, the specimen was prepared by packing the 2–20 μm silt fraction into a groove of a glass slide (random powder mount) and was X–rayed using the same condition as for the clay specimen.

RESULTS

pH and EC

The soils of AEZ 2 had the pH values below the neutral point (5.0 and 6.5), those of AEZ 7 had the pH values both below and above the neutral point while those of AEZ 4 were mostly acidic to near neutral having the pH values varying from 4.8 to 6.8 except the Daspara soil having the pH value of 7.4. The EC ranged from 0.04 to 0.22 dS m^{-1} in the soils of all 3 AEZs having the lower values in AEZ 4. The values indicate non–saline nature of these soils (Table 2).

Particle–size distribution

Particle–size distribution and textural classes of the soils as determined by the USDA system are shown in Table 2. The clay (<2 μm) content was very low in both soils of AEZ 2 (5 and 7%) and one soil (6%) of AEZ 7 while other two soils of AEZ 7 had 10 and 16% of clay. The clay content in 15 soils of AEZ 4 varied widely from 9 to 27%, and seven soils had the clay content of more than 20%. Variation in the clay content was supposed to be related to the deposition of different types of sediments (parent material) by the rivers from which these soils have been formed.

The 2–20 μm silt fraction varied from 11 to 41% for the AEZ 2 soils, from 21 to 49% for the AEZ 7 soils and from 25 to 74% for the AEZ 4 soils. Almost all soils had this fraction dominating over all other fractions. The 20–53 μm fraction varied widely (4 to 37%) in these soils but was below 20% in most soils.

The 53–212 μm sand fraction dominated over other

Table 2. pH and EC, and particle–size distribution and texture of soils

AEZ	Soil series	pH	EC (dS m^{-1})	Particle–size distribution (%)					Soil texture (USDA)
				<2 μm	2–20 μm	20–53 μm	53–212 μm	212–2,000 μm	
AEZ 2	Silty Tista Alluvium	5.0	0.14	5	41	17	36	1	Silt loam
	Sandy Tista Alluvium	6.5	0.12	7	11	25	53	4	Sandy loam
AEZ 7	Chilmari	6.1	0.19	16	37	37	10	0	Silt loam
	Sandy Jamuna Alluvium	7.2	0.13	6	21	19	54	0	Sandy loam
	Silty Jamuna Alluvium	7.4	0.22	10	49	22	18	1	Silt loam
AEZ 4	Maldaha–1	6.6	0.11	23	49	12	16	0	Silt loam
	Shrikhula	6.2	0.07	27	48	15	9	1	Silty clay loam
	Sonatala	5.9	0.09	25	62	8	4	1	Silt loam
	Jamun	5.4	0.05	14	40	18	27	1	Silt loam
	Savarbazar	6.8	0.15	14	57	22	7	0	Silt loam
	Amgaon–1	6.3	0.08	11	56	16	16	1	Silt loam
	Matia	6.6	0.12	21	74	4	1	0	Silt loam
	Laskara	5.4	0.11	26	55	10	7	2	Silt loam
	Ulipur	6.5	0.12	23	54	15	7	1	Silt loam
	Silmondi	5.9	0.10	22	58	16	3	1	Silt loam
	Maldaha–2	5.3	0.10	13	25	21	40	1	Loam
	Amgaon–2	4.8	0.04	9	45	28	18	0	Silt loam
	Daspara	7.4	0.13	13	44	16	27	0	Silt loam
	Kajla		0.14	15	72	8	4	1	Silt loam
	Kamarkhanda	6.1	0.14	19	58	11	11	1	Silt loam

fractions in three soils each from three AEZs. Except six soils, all soils contained this fraction below 20% and the content was even below 10% in as many as eight soils. The amount of coarse sand (212–2,000 μm) fraction was found in a low range between 0 and 4% in all soils of three AEZs. No marked relationship between particle–size distribution and general soil type was observed.

According to the USDA system for textural classes, 2 soils (one each from AEZs 2 and 7) belonged to sandy loam, one to loam (from AEZ 4), one to silty clay loam (from AEZ 4) and all others to silt loam.

Mineralogy of the silt fraction

The approximate mineral composition of the 2–20 μm silt fraction is shown in Table 3. Calculation was made based on the relative peak intensities of the respective minerals in the XRD charts (Moslehuddin and Egashira, 1996). Five minerals of mica (7 to 26%), chlorite (8 to19%), quartz (36 to 61%), K–feldspar (1 to 7%) and plagioclase (8 to 27%) were identified in all soils of all three AEZs. Amphiboles (until 8%) were identified in about 50% of the soils. Quartz was found to be the most predominant mineral in all soils.

The AEZ 2 soils differed from the soils of other two AEZs in having the lower proportion of quartz while the higher proportions of mica and chlorite. The Chilmari soil of AEZ 7 was found to be an exceptional case in having the highest amounts of amphiboles (8% in contrast to other soils containing until 2%) and quartz (61%). The AEZ 4 soils contained a little higher K–feldspar than did the soils of other two AEZs. The land type and general soil type had no influence on the silt mineralogy.

Mineralogy of the clay fraction

The XRD patterns of the <2 μm clay fraction of the Sandy Tista Alluvium soil representing AEZ 2, and those of the Chilmari and Silty Jamuna Alluvium soils representing AEZ 7 are reproduced in Fig. 1a, and those of the Sonatala, Laskara and Kamarkhanda soils representing AEZ 4 are in Fig 1b. Peaks were generally sharp, indicating high crystallinity and/or large crystallite size of the minerals. Mica was identified by the presence of the 1.00 nm reflection appearing in all the treatments. Vermiculite was identified by the decrease in the peak intensity of the 1.42 nm reflection with the corresponding increase in the peak intensity of the 1.00 nm reflection by shifting from Mg–saturation to K–saturation followed by air–drying. The broad bulge around 1.80 nm in the Mg–saturated and glycerol–solvated specimen suggests the presence of smectite. Chlorite was detected by the reflections at 1.42 nm and its rational orders and by remaining of the 1.42 nm reflection in the K–saturated and 550 °C–heated specimen. The peaks or shoulders at 0.716 and 0.357 nm in the Mg–saturated specimen suggested the presence of kaolinite.

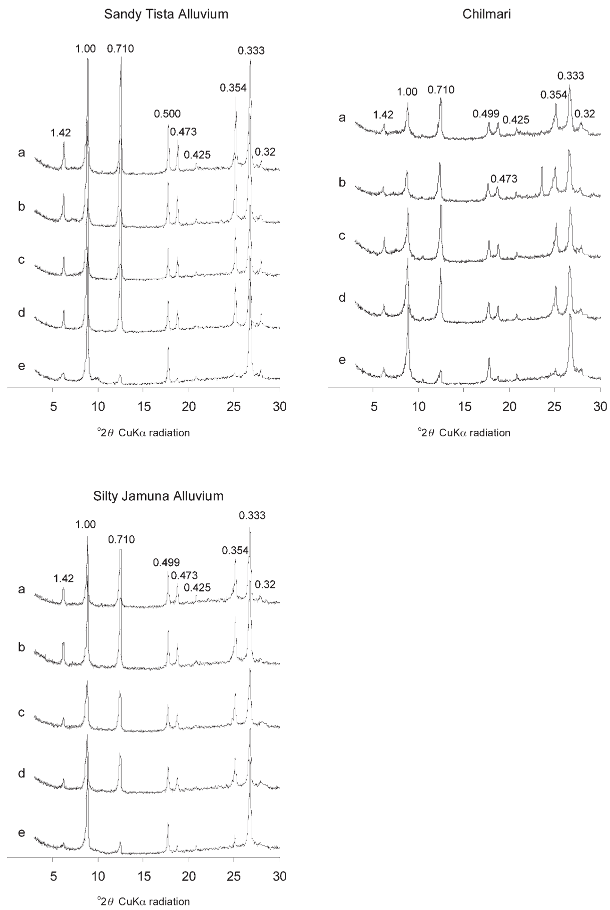
The presence of vermiculite–chlorite intergrade is ascertained by the decrease in the peak intensity of the 1.42 nm reflection by heating in the K–saturated specimen. However, it was not positively detected in any soil. The peak at 1.25 nm in all the treatments suggested the presence of the interstratified mica–chlorite mineral. The reflections of 0.425, 0.418 and 0.32 nm were used for identification of quartz, goethite and feldspars, respectively.

The approximate mineral composition of the <2 μm clay fraction was estimated based on the relative peak intensities of the respective minerals in the XRD charts

Table 3. Approximate mineral contents (%) in the silt fraction (2–20 μm) of soils

AEZ	Soil series	Minerals[1]					
		Mc	Am	Ch	Qr	K–fd	Pl
AEZ 2	Silty Tista Alluvium	26	1	18	38	1	16
	Sandy Tista Alluvium	25	–	19	36	2	18
AEZ 7	Chilmari	7	8	14	61	2	8
	Sandy Jamuna Alluvium	13	–	13	54	2	18
	Silty Jamuna Alluvium	20	1	9	47	1	22
AEZ 4	Maldaha–1	23	1	8	47	4	17
	Shrikhula	9	2	11	55	5	18
	Sonatala	11	–	13	50	6	20
	Jamun	17	–	10	47	3	23
	Savarbazar	9	1	15	52	6	17
	Amgaon–1	16	–	13	48	5	18
	Matia	12	–	12	54	4	18
	Laskara	21	–	11	39	3	26
	Ulipur	22	–	18	48	3	9
	Silmondi	17	–	15	48	5	15
	Maldaha–2	12	1	15	52	2	18
	Amgaon–2	12	–	11	54	5	18
	Daspara	18	1	11	55	2	13
	Kajla	11	–	11	44	7	27
	Kamarkhanda	9	1	10	55	4	21

[1] Abbreviations: Mc, mica; Am, amphiboles; Ch, chlorite; Qr, quartz; K–fd, K–feldspar; Pl, plagioclase.



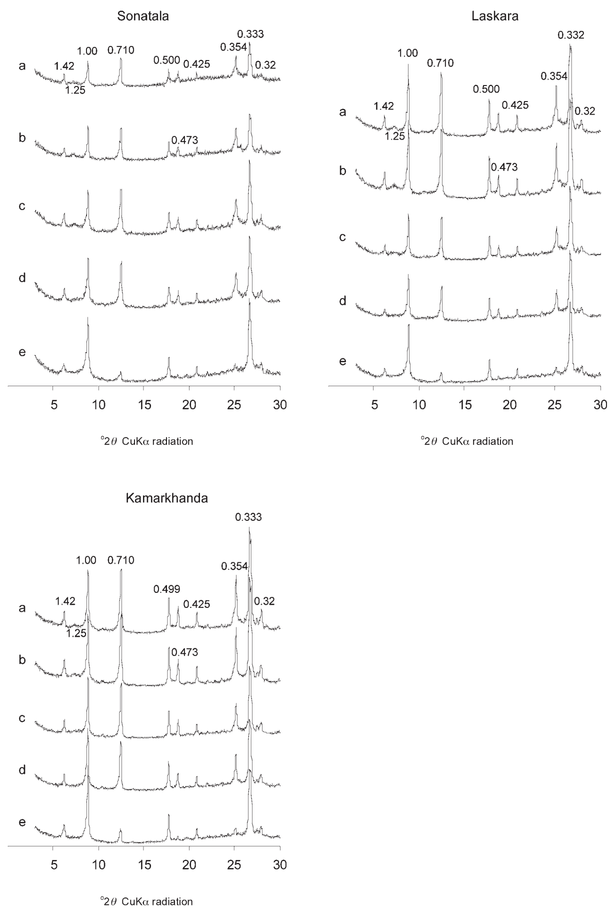


Fig. 1a. X–ray diffraction patterns of the <2 μm clay fraction separated from the Sandy Tista Alluvium soil in AEZ 2, and the Chilmari and Silty Jamuna Alluvium soils in AEZ 7. Spacing is in nm. Treatments: a, Mg–saturation and glycerol–solvation; b, Mg–saturation and air–drying; c, K–saturation and air–drying; d, K–saturation and heating at 300 °C; e, K–saturation and heating at 550 °C.

Fig. 1b. X–ray diffraction patterns of the <2 μm clay fraction separated from the Sonatala, Laskara and Kamarkhanda soils in AEZ 4. Spacing is in nm. Treatments: a, Mg–saturation and glycerol–solvation; b, Mg–saturation and air–drying; c, K–saturation and air–drying; d, K–saturation and heating at 300 °C; e, K–saturation and heating at 550 °C.

Table 4. Approximate mineral contents (%) in the clay fraction (<2 μm) of soils

AEZ	Soil series	Minerals[1)								
		Mc	St	Vt	Ch	Kt	Mc/Ch	Qr	Gt	Fd
AEZ 2	Silty Tista Alluvium	58	1	1	22	4	2	7	–	5
	Sandy Tista Alluvium	63	–	–	18	2	3	8	–	6
AEZ 7	Chilmari	44	–	–	17	8	4	15	1	11
	Sandy Jamuna Alluvium	50	–	10	21	3	–	12	1	3
	Silty Jamuna Alluvium	45	–	7	26	3	–	12	1	6
AEZ 4	Maldaha–1	43	–	3	20	7	–	17	1	9
	Shrikhula	43	–	4	23	4	1	18	–	7
	Sonatala	35	–	1	19	3	11	21	–	10
	Jamun	41	–	1	22	4	6	19	–	7
	Savarbazar	41	–	–	22	4	2	22	–	9
	Amgaon–1	44	–	–	20	5	10	16	–	5
	Matia	48	–	3	17	4	3	19	–	6
	Laskara	42	–	3	17	3	4	23	–	8
	Ulipur	44	–	–	20	4	8	16	–	8
	Silmondi	40	–	1	22	5	5	21	–	6
	Maldaha–2	41	–	–	23	8	4	17	–	7
	Amgaon–2	49	–	–	19	6	7	13	–	6
	Daspara	51	–	–	20	5	4	15	–	5
	Kajla	45	–	–	19	5	6	19	–	6
	Kamarkhanda	40	–	–	17	3	5	23	–	12

[1) Abbreviations: Mc, mica; St, Smectite; Vt, vermiculite; Ch, chlorite; Kt, kaolinite; Mc/Ch, interstratified mica–chlorite; Qr, quartz; Gt, goethite; Fd, feldspars.

following Moslehuddin and Egashira (1996), and is shown in Table 4. The results indicated that mica (58 to 63% in the AEZ 2 soils, 44 to 50% in the AEZ 7 soils and 35 to 51% in the AEZ 4 soils) was the most predominant mineral in all soils of three AEZs. Next to mica, chlorite was present in all soils in good amounts: 18 to 22% for AEZ 2, 17 to 26% for AEZ 7 and 17 to 23% for AEZ 4. Small amounts of kaolinite (2 to 8%) were found in all soils. Some vermiculite (1%) was identified in one soil of AEZ 2, 2 soils of AEZ 7 (7 to 10%) and 7 soils of AEZ 4 (1 to 4%). Smectite (1%) was identified only in the Silty Tista Alluvium soil of AEZ 2. The interstratified mica–chlorite mineral (1 to 11%) was identified in all soils except 2 soils of AEZ 7 and one soil of AEZ 4.

Other than layer silicates, good amounts of quartz (7 to 23%) and small amounts of feldspars (3 to 12%) were present in the soils of three AEZs, and goethite (1%) was present in all soils of AEZ 7 and one soil of AEZ 4. Clay mineralogical composition was hardly affected by the land type and general soil type.

DISCUSSION

The soils of three AEZs were acidic to near neutral or neutral in reaction. The soils were mostly of medium–texture (mainly silt loam) with exception of two coarse–textured (sandy loam) and one fine–textured (silty clay loam) soils. They had variable amounts of clay: very low for AEZ 2, very low to low for AEZ 7 and low to medium for AEZ 4 soils. The variation was mainly related to the differential nature of sediments deposited by the rivers in different times.

The 2–20 μm silt fraction was dominated by quartz, mica, chlorite and plagioclase with some K–feldspar in all soils and amphiboles in some soils. In the $<2\ \mu$m clay fraction, mica was a predominant mineral in all soils. Next to mica, chlorite was found as a dominant mineral in all soils. Kaolinite was present in all soils but in small amounts. Vermiculite was found in good amounts in two soils of AEZ 7 and in small amounts in some soils of other two AEZs. The interstratified mica–chlorite mineral was found in almost all soils but mainly in small amounts.

The results obtained in the present study for AEZ 2 of the Active Tista Floodplain were broadly similar to those obtained by Egashira and Yasmin (1990) and Samsuzzoha *et al*. (2003) for the adjacent AEZ 3 of the Tista Meander Floodplain and by Moslehuddin and Egashira (1996) and Islam *et al*. (2003) for the adjacent AEZ 1 of the Old Himalayan Piedmont Plain. They found that mica and chlorite and sometimes the interstratified mica–chlorite mineral and vermiculite–chlorite intergrade were the major minerals. The major difference of the present study from those studies was the smaller amount of the interstratified mica–chlorite mineral and absence of vermiculite–chlorite intergrade. Thus the present study broadly supports the mineralogical suite of AEZ 2 as proposed by Moslehuddin *et al*. (1999).

Moslehuddin *et al*. (1999) put the soils of AEZs 4 and 7 along with the soils of AEZ 8 in the mica–vermiculite*–kaolinite suite where mica, vermiculite and kaolinite are major minerals and parts of vermiculite are being chloritized. They supposed the mineralogical suite as such from the study on one soil of AEZ 7, one soil from AEZ 8 reported by Alam *et al*. (1993) and no soil from AEZ 4. The present study gave the different result. In case of AEZ 4, the results were pretty similar to those obtained for the two soils of AEZ 2. So, the soils of AEZ 4 should be placed in the mica–chlorite* suite as proposed for AEZs 1, 2, 3, 5 and 6 by Moslehuddin *et al*. (1999). Again, the soils of AEZ 7 showed mica and chlorite as main minerals while two of them had 7 to 10% of vermiculite, but kaolinite was not a dominant mineral here. Thus, the result obtained in the present study was different from the only report for AEZ 7 by Alam *et al*. (1993) who found that mica, vermiculite and kaolinite were the major minerals. Thus AEZ 7 too could be placed in the mica–chlorite suite. However, more study is required with more soils to verify it.

CONCLUSIONS

The soils of AEZ 2 of the Active Tista Floodplain, AEZ 7 of the Active Brahmaputra–Jamuna Floodplain and AEZ 4 of the Karatoya–Bangali Floodplain are acidic to neutral in reaction, and have the very low to medium clay content. The clay fraction was dominated mostly by mica and chlorite. Therefore, the results of the present study broadly support the mineralogical suite of mica–chlorite for those AEZs but do not support the mineralogical suite of mica–vermiculite–kaolinite for AEZ 4 and 7 as proposed by Moslehuddin *et al*. (1999). It is concluded that soils of AEZs 4 and 7 be placed in the mica–chlorite* suite as well.

ACKNOWLEDGEMENTS

We are grateful to the staffs of Soil Resource Development Institute (SRDI), Rangpur and Pabna, Bangladesh for helping in collection of the soil samples for this study.

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