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MINERALOGY OF SOILS FROM DIFFERENT AGROECOLOGICAL

REGIONS OF BANGLADESH: REGION 1-OLD HIMALAYAN

PIEDMONT PLAIN

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ABSTRACT

Bangladesh has been divided into 30 Agroecological Regions (AEZs) on the basis of physiography,i nundation land types, soils, and agroclimate. The applied agricultural research has currently been

conducted on this basis. In context of the lack of enough information on mineralogy on the AEZ basis
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an attempt has been taken to study on the mineralogy of important soils from all AEZs of Bangladesh. The present experiment was carried out in order to clarify the mineralogy of soils from Region 1: Old

Himalayan Piedmont Plain. Eleven soil samples consisting of eight soil series were analyzed. The clay content of the surface soils ranged from 9.1 to 18.2% and the texture was loam or silt loam by the USDA soil textural class. The 2-20 sm silt fraction was dominated by quartz, with some mica, chlorite and plagioclase, and with small amounts of K-feldspar. The <2 sm clay fraction was dominated by mica
and chlorite and in most cases by the interstratified mineral of mica and chlorite. These minerals were supposed to be inherited from the parent material of metamorphic rocks. The impact of mineralogy on agriculture or land use has been discussed.

Key words: Mineralogy, Old Himalayan Piedmont Plain, Agroecological Regions, Bangladesh

INTRODUCTION

Bangladesh, an agro-based country having an area
of about 147 thousand km2, comprises a deltaic al-luvial plain formed principally from the Ganges-Tista-Brahmaputra-Meghna river systems. Physiographically the land of Bangladesh is classified into Holocene fl oodplains (80%), Tertiary hills (12%), and Pleistocene terraces (8%). Based on the mode of formation and morphological appearance, soils are grouped into 21 general soil types of the Bangladesh soil classification system that can be correlated with the USDA Soil Taxonomy and FAO-UNESCO Soil Classification System (Saheed, 1984). Bangladesh has been divided into 30 Agroecological Regions (popularly known as AEZs) (Fig. 1) based on physiography, inundation land types, soils, and agroclimate (FAO-UNDP, 1988). Agricultural research, and technology generation and transfer etc. are now going on the AEZ basis.
Mineralogy is an important aspect of soil science that is related to genesis, physico-chemical properties

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nutrient behavior as well as inherent potentiality of soils

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but few systematic works have been done for Bangladesh soils so far (Habibullah et al., 1971; Islam and Lotse, 1986; Egashira, 1988; Egashira and Yasmin, 1990; Moslehuddin and Egashira, 1996). Mineralogical study emphasizing the AEZs of Bangladesh has not been carried out. Recently, Moslehuddin et al. (1999) com-piled and summarized the available mineralogical data and proposed a tentative clay mineralogical map that was constructed on the basis of the AEZs map of Bangladesh. However, mineralogical data are still lacking to make the more comprehensive clay mineralogical map on the whole country basis.
Considering the above, an attempt has been made to study on the mineralogy of soils from all AEZs of Bangladesh. The present paper reports the study on the . This fi rst AEZ of the Old Himalayan Piedmont Plain

AEZ is located in the extreme north of the country, covering most of Panchagarh and Thakurgaon districts and the northwestern part of Dinajpur district having an area of 4,008 km2. The soils of this AEZ have been distributed on the Old Tista alluvial fan extending out from the foot of the Himalayas (Brammer, 1996).

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AGROECOLOGICAL REGIONS

(GENERALIZED)

FIG. 1. Agroecological Regions of Bangladesh. Agroecological Regions: 1. Old Himalayan Piedmont Plain; 2. Active Tista Floodplain; 3. Tista Meander Floodplain; 4. Karatoya-Bangali Floodplain; 5. Lower Atrai Basin; 6. Lower Purnabhaba Flood-plain; 7. Active Brahmaputra-Jamuna Floodplain; 8. Young Brahmaputra and Jamuna Floodplains; 9. Old Brahmaputra Floodplain; 10. Active Ganges Floodplain; 11. High Ganges River Floodplain; 12. Low Ganges River Floodplain; 13. Ganges Tidal Floodplain; 14. Gopalgonj-Khulna Bils; 15. Arial Bil; 16. Middle Meghna River Floodplain; 17. Lower Meghna River Floodplain; 18. Young Meghna Estuarine Floodplain; 19. Old Meghna Estuarine Floodplain; 20. Eastern Surma-Kushiyara Floodplain; 21. Sylhet Basin; 22. Northern and Eastern Piedmont Plains; 23. Chittagong Coastal Plain; 24. St. Martins Coral Island;
25. Level Barind Tract; 26. High Barind Tract; 27. North-Eastern Barind Tract; 28. Madhupur Tract; 29. Northern and Eastern Hills; 30. Akhaura Terrace (FAO-UNDP, 1988).

Moslehuddin et al.(1999) put soils of this AEZ in the mica-chlorite* suite indicating that mica and chlorite were major minerals where chlorite component was somewhat degraded. The present study was planned to verify the proposed mineralogical suite for this AEZ by covering more comprehensive soil samples of the Old Himalayan Piedmont Plain.

MATERIALS AND METHODS

Soils used

The experiment was carried out in the laboratory of Soil Science Department, Bangladesh Agricul-

tural University, Mymensingh, and partly in the central
laboratory of Soil Resource Development Institute,
Dhaka, Bangladesh. Eleven soils representing eight
different soil series of the Old Himalayan Piedmont
Plain were selected for the mineralogical analysis: two
each from the Gangachara, Atwari and Baliadangi se-
ries, and one each from the Ranisankail, Jamun, Jagdal,
Pirgachha and Ruhea series. The soils used in the
present study were previously collected by Soil Science
Division of Bangladesh Institute of Nuclear Agriculture
from a depth of 0-15 cm. Description of the soils has
been given in Table 1.

Determination of pH and exchangeable cations
The pH was determined by a glass-electrode pH
meter in the soil suspension having a soil: water ratio
of 1: 2.5, after 30-min shaking. Exchangeable cations
were extracted from soil by 1 M NH4CH3C00 (pH 7.0)
through shaking and centrifugation followed by filtra-
tion. The concentrations of Ca, K and Na in the filtrate
were determined by a ‚†‚Œame photometer.

Particle-size analysis
The soil samples were treated with hot 7% H2O2 to
decompose organic matter, stirred with a mechanical
stirrer, adjusted to the pH 10 using 1 M NaOH. The
<2 gm clay fraction was separated by repeated stirring-
sedimentation-siphoning. The 2-20 gm fraction was
separated by repeated sedimentation and siphoning, and
the 20-53, 53-200 and 200-2,000 gm 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 gm). Of the duplicate sets,
one was saturated with K and the other with Mg by
washing three times with 1 M KC1 and 0.5 M MgC12,
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 Shimadzu X-ray diffractometer XED-600 with Ni-
fi ltered CuKa radiation at 40 kV and 30 mA and at a
scanning speed of 2•‹ 20 min-1 over a range of 3 to 35•‹
20. 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 at 550•Ž for 2 hr.
For the silt fraction, the specimen was prepared by
packing the 2-20 gm silt fraction into a groove of a
metallic slide (random powder mount) and X-rayed over
a range of 3 to 35•‹ 20. The conditions of XRD were the
same as for the clay fraction.

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TABLE 1. Description of the soils

1) Land type: HL, highland; MHL, medium highland. HL: land which is above the normal flood level; MHL: land which is normally flooded up to a depth of about 90 cm during the monsoon season.
2) Soil classification based on the Bangladesh system
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RESULTS

pH and exchangeable cations
The pH and the contents of exchangeable cations of soils are shown in Table 2. The soils of the Old

Himalayan Piedmont Plain were found to be slightly acidic in nature having pH values ranging between 5.4 and 6.4. The exchangeable Ca content was compar-atively low in these soils ranging from 0.21 to 0.77 cmolc kg-1. All soils showed exchangeable Ca content below the critical level of 2.0 cmolc kg-1 as specified by BARC (1997). The exchangeable K content was in between 0.07 and 0.27 cmolc kg-1, and two soils had values below the critical limit of 0.12 cmol, kg-1 while the most others were in a low range. The exchangeable Na content was relatively high with a range of 0.24 to

TABLE 2. pH and exchangeable cations of soils

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TABLE 3. Particle-size distribution and texture of soils

1 Abbrevialtions: L
, loam; SiL, silt loam.

0.62 cmol, kg' that might coincide with the marine deposition of the Himalayan sediments.

Particle-size distribution

Particle-size distribution of soils has been presented in Table 3. The soils were medium-textured belonging to loam and silt loam textural classes. The <2 gm clay fraction ranged from 9.1% in the Gangachara-I soil to 18.2% in the Atwari-II soil. Most soils were in a range between 15 and 18% in the clay content, and no marked relationship between the clay content and general soil type was observed. Moslehuddin and Egashira (1996) found 15.1% clay in the Baliadangi soil of the same AEZ, which is comparable to the values obtained in the present study. Usually, soils situated on the medium highland had the higher clay content than those on the highland. This is due to no sedimentation in the highland as they are situated on the above-flood-level topography, while soils on the medium highland have a chance to receive finer sediments with run-off water from

the surrounding highlands.
Soils on the Old Himalayan Piedmont Plain were dominated by the silt to fine-sand fractions in size of 2 to 200 sm. The total contents were around 70% with a

relatively narrow range of 68.7 to 77.1%; among the eleven soils examined, five soils were highest in the 2-20 gm fraction, one soil in the 20-53 sm fraction, and the remaining five soils in the 53-200 sm fraction. The content of the 200-2,000 gm coarse-sand fraction was in a range of 7.8 to 17.0%. Therefore, the soil of the Old Himalayan Piedmont Plain was considered as dominated with coarser particles, having the lower nutrient and water holding capacities.

Mineralogy of the silt fraction
The mineralogical composition of the 2-20 gm silt fraction is shown in Table 4. The calculation of the

mineralogical composition was followed to the method described by Moslehuddin and Egashira (1996), based on the peak intensities of minerals in the XRD charts. Quartz was the most dominant mineral in the silt fraction having the content ranging from 41 to 68%.

TABLE 4. Approximate mineral contents (%) in the silt fraction (2-
20 gm) of soils

"Abbreviations: Abbreviations: Mc, mica; Ch, chlorite; Mc/Ch, the interstratified mineral of mica and chlorite; Qr, quartz; K-fd, K-feldspar; Pl, plagio-clase.

Next to quartz, mica was found as the dominant mineral in all soils (10 to 24%) . Considerable amounts of chlorite

(4 to 21%), plagioclase (8 to 18%) and K-feldspar (3 to 11%) were also present in all soils. The interstratified mineral of mica and chlorite was identified only in the Pirgachha and Baliadangi-II soils. Egashira and Yasmin (1990) and Moslehuddin and Egashira (1996) reported the similar mineralogical composition of the silt fraction of soils from the Gangachara series of the nearby Tista Floodplain and the Baliadangi series of the same AEZ, respectively. They also detected small amounts of amphiboles that were not identified in the present study. Land type and general soil type had no influence on the silt mineralogy.

Mineralogy of the clay fraction
In Fig. 2, XRD patterns of the <2 gm clay fraction of the Ranisankail (a), Gangachara-I (b) and Baliadangi-II (c) soils are reproduced as representatives of soils in the Old Himalayan Piedmont Plain. They were almost similar to one another, indicating the similarity in the clay mineralogy. The peaks were usually sharp, indi-

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(a) Raaisankail

(c) Baliadangi-II

(b) Gangachara-I

FIG. 2. X-ray diffraction patterns of the <2ƒÊm clay fraction of
(a) Ranisankail,(b) Gangachara-I, and (c) Baliadangi-II soils.
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•Ž; e, K-saturation
and heating at 550•Ž.

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TABLE 5. Approximate mineral contents (%) in the clay fraction (<2um) of soils

1) Abbreviations: Mc, mica; St, smectite; Vt, vermiculite; Ch, chlorite; Kt, kaolinite; Vt-Ch, vermiculite-chlorite intergrade; Mc/Ch, the inter-stratified mineral of mica and chlorite; Gb, gibbsite; Qr, quartz; Fd, feldspars.
2) tr.: trace.

eating good 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.
Chlorite was detected by the reflections of 1.42 nm and
its higher orders and by the remaining of the 1.42 nm
reflection in the K-saturated and 550•Ž-heated specimen.
The presence of kaolinite was indicated by the shoulder
around 0.357 nm in the Mg-saturated specimen. Ver-
miculite was identified by the decrease in the peak in-
tensity of the 1.42 nm reflection with the corresponding
increase in the intensity of the 1.00 nm reflection from
Mg-saturation to K-saturation. The interstratified min-
eral of mica and chlorite was identified by the broad
reflection around 1.2 nm appearing in all the treat-
ments. The presence of vermiculite-chlorite intergrade
was ascertained by decrease in the peak intensity of the
1.42 nm reflection by heating in the K-saturated spec-
imen. The reflections of 0.484, 0.425, and 0.32 nm were
used for identification of gibbsite, quartz, and feldspars,
respectively.
Approximate mineral composition of the clay fraction
was estimated based on the relative peak intensities of
the respective minerals in the XRD charts following
Moslehuddin and Egashira (1996), and was presented in
Table 5. Mica was found to be the most dominant
mineral in all soils (22 to 45%) followed by chlorite (14
to 27%). The interstratified mineral of mica and chlorite
was present in all soils but was found as a dominant
mineral in seven soils (13 to 21%). The chlorite com-
ponent was found as the somewhat degraded phase in
XRD charts. Moslehuddin and Egashira (1996) made
the exactly similar observation for the soil from the
Baliadangi series and almost the similar result was found
in the soil of the Ranisankail series by Alam et al.
(1993). The result of the present study confirms the clay
mineralogical suite of mica-chlorite* in AEZ of the Old
Himalayan Piedmont Plain as proposed by Moslehuddin
et al. (1999).
Kaolinite was detected in small amounts in all soils

(2 to 7%) . Vermiculite-chlorite intergarde was identified
in all soils except for the Gangachara-I soil while

vermiculite was present in the Gangachara-I and Atwari-II soils. As minerals other than layer silicates, quartz (5 to 22%) and feldspars (2 to 16%) were present in all soils and small amounts of gibbsite in all (1 to 5%) but the Jagdal and Ruhea soils. The presence of gibbsite may be estimated as the degradation product of Al-dominated interlayered material of chlorite. Clay mineralogical composition was not affected by land type or general soil type.

DISCUSSION

The soils of the Old Himalayan Piedmont Plain were found to be medium-textured having the clay content less than 18% in all the soils under study. The silt fraction composed mainly of quartz, with some mica, chlorite and plagioclase, and small amounts of K-feldspar. In the clay fraction mica, chlorite and the interstratified mica/chlorite mineral were found to be the

most dominant minerals. Moslehuddin and Egashira (1996) found large amounts of mica, chlorite and the interstratified mineral of mica and chlorite in the coarse

clay, fine clay as well as in the silt fractions of the Baliadangi soil of the Old Himalayan Piedmont Plain and opined that these minerals have been derived from the parent material possibly from metamorphic rocks. The degraded nature of chlorite indicates that chlorite-vermiculite intergrade was possibly altered from chlorite as a weathering product and that in the course of weathering it would be changed finally to vermiculite. The Old Himalayan Piedmont Plain is an agricul-turally important region of Bangladesh. Crop production of Bangladesh has many limiting factors of which soil is often a dominant one. The type and amount of clay minerals strongly control the soil-related problems. The Old Himalayan Piedmont Plain is already known as having deficiency of different nutritional elements. Un-common to other regions, deficiency of Ca is observed in the present study, and that of Mg has been reported by Portch and Islam (1984) in soils of this region. The present study clearly reveals the problematic condition of

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soils of the Old Himalayan Piedmont Plain: low clay content with high coarser fractions, and the clay fraction rich in the mica and chlorite type of minerals having less contribution to the inherent potentiality. Considering the type and amount of clay, it is clear that the water
and nutrient holding capacities of these soils are very
low and that soils are vulnerable to leaching of added nutrients at the time of irrigation and high rainfall. Little variation among the soil series has been observed. In Bangladesh, research, and technology genera-tion and transfer are being done on the AEZ basis.
The findings of the present study are useful for this

purpose as well, especially in terms of nutrient man-agement, selection of crops and so on. The land of the Old Himalayan Piedmont Plain is better suitable for upland crops than for irrigated rice crops, and well

plant-nutrient management practice is needed even for
cultivation of upland crops due to the low inherent

potentiality of soils including the poor "exchangeable-base" status.

CONCLUSIONS

The soils of the Old Himalayan Piedmont Plain have the low clay content. The layer-silicate minerals of the soils were identified to be dominant with mica and

chlorite and their interstratified mineral, although their relative proportions varied with the soils. Therefore, the result of the present study confirms the mica-chlorite* suite of the Old Himalayan Piedmont Plain as proposed by Moslehuddin et al.(1999). The soils are considered

good for cultivation of upland crops.

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