A PRELIMINARY EVALUATION OF THE CLAY MINERALOGY OF THE SUNDARBAN SOILS

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Preliminary investigations were carried out for the determination of clay mineralogy of the Sundarban soils. A total of 50 pedons were examined over a north-west to south-east transect running through the Sundarbans. Finally, four pedons were selected for laboratory investigation.

Based on the observations made from the field investigations, as well as from the results of the physicochemical analyses, it appeared that pedologically the soils were very young and possessed no diagnostic horizon.

The dominant minerals in the clay fraction are weathered mica and smectite with traces of kaolinite, chlorite and interstratified minerals. The clay minerals were identified mainly by the X-ray diffraction technique supported by other techniques. It was observed that, so far as the clay mineralogical composition was concerned, the Sundarban soils had a homogeneity both in vertical and in horizontal directions. Slight variation in the clay mineralogical composition and content occurring among the pedons are the inherited properties of the soil materials.

INTRODUCTION

The Sundarban forests lie on the south-west part of Bangladesh and occupy a major part of the deltaic regions having a land area of 4,75,000 hectares. The forest is comprised of a wide variety of tall mangrove species and short undergrowths. Th area, being dissected by numerous interconnecting rivers and creeks, is difficult to approach by land communications ; consequently the Sundarbans have been less disturbed enthropically. These forests thus provide an excellent opportunity to study the whole area from various angles. In order to achieve the desired goal an integrated approach by the different disciplines like hydrology, ecology, silviculture, sedimentology and pedology, seems to be appropriate. Such a concerted approach may take a long time to be initiated by the concerned departments. In the meantime a preliminary investigation related to the soil and the clay minerals has been considered necessary.

GENERAL BACKGROUND

Location and extent : The Sundarbans occupying part of the Khulna and Patuakhali districts lie between the latitudes 21°30′ and 22°20′ North and between the longitudes 88°45′ and 90°30 East (Fig. 1).

Hydrology : Tidal inundation regulates the hydrology of the area. Based on the frequency of tidal inundation, specially during the May-October period, the Sundarbans can be divided into four hydrological zones, (i) areas inundated by all tides : poorly oxygenated new accretions occurring on the mouths of big rivers and along the sea coast, (ii) areas inundated by normal high tides : this zone includes greater part of the Sundarbans, (iii) areas inundated by spring high tides : this zone includes northern part of the Sundarbans and (iv) areas inundated by the monsoon high tides : this zone consists of the high levees located at the north-east part of the Sundarbans.

Soil : The soils of the Sundarbans are unreclaimed, partly ripened or unripened grey muds. These are neutral to mildly alkaline in reaction under the field conditions but in some localities the pH value of dried up subsoil samples go down to 6.5. The eastern part of the alluvium on the river banks is slightly calcareous. A buried layer is encountered at variable depths locally. The soils are slightly saline in the east/north-east and moderately saline in the west/south-west parts.

Pons (1970) suggested a simple method for differentiating the soils which develop toxic acidity level on drainage improvement and the ones that do not. It appears that the pedons included is this study do not satisfy the conditions set by the above author for the formation of acid sulphate or of pseudo acid sulphate soils.

Soil salinity : The soil salinity at the northern fringe of the Sundarbans has been recorded since 1977 at Bogi, Chandpai and at Burigoalini. The trend of mean monthly salinity levels as monitored in this study is shown in Fig. 2. It is observed from the salinity trend that soil salinity increases from Bogi (north-east) toward Burigoalini (north-west) but remains less than 6 mmhos/cm even in the driest months (April–May). It also appears from the above figure that a seasonal gradient of salinity fluctuation exists both in soil and in water of the Passur river. The salinity gradient in water reaches its peak in April–May but drops down abruptly in June due to high rainfall within the country and in the catchment areas. The high rainfall and the consequent low salinity of the inundating river water during the monsoon probably help to maintain a sustained low salinity level of the Sundarban soil.

MATERIALS AND METHODS

A total of 50 pedons were examined over a transect running across the Sundarbans

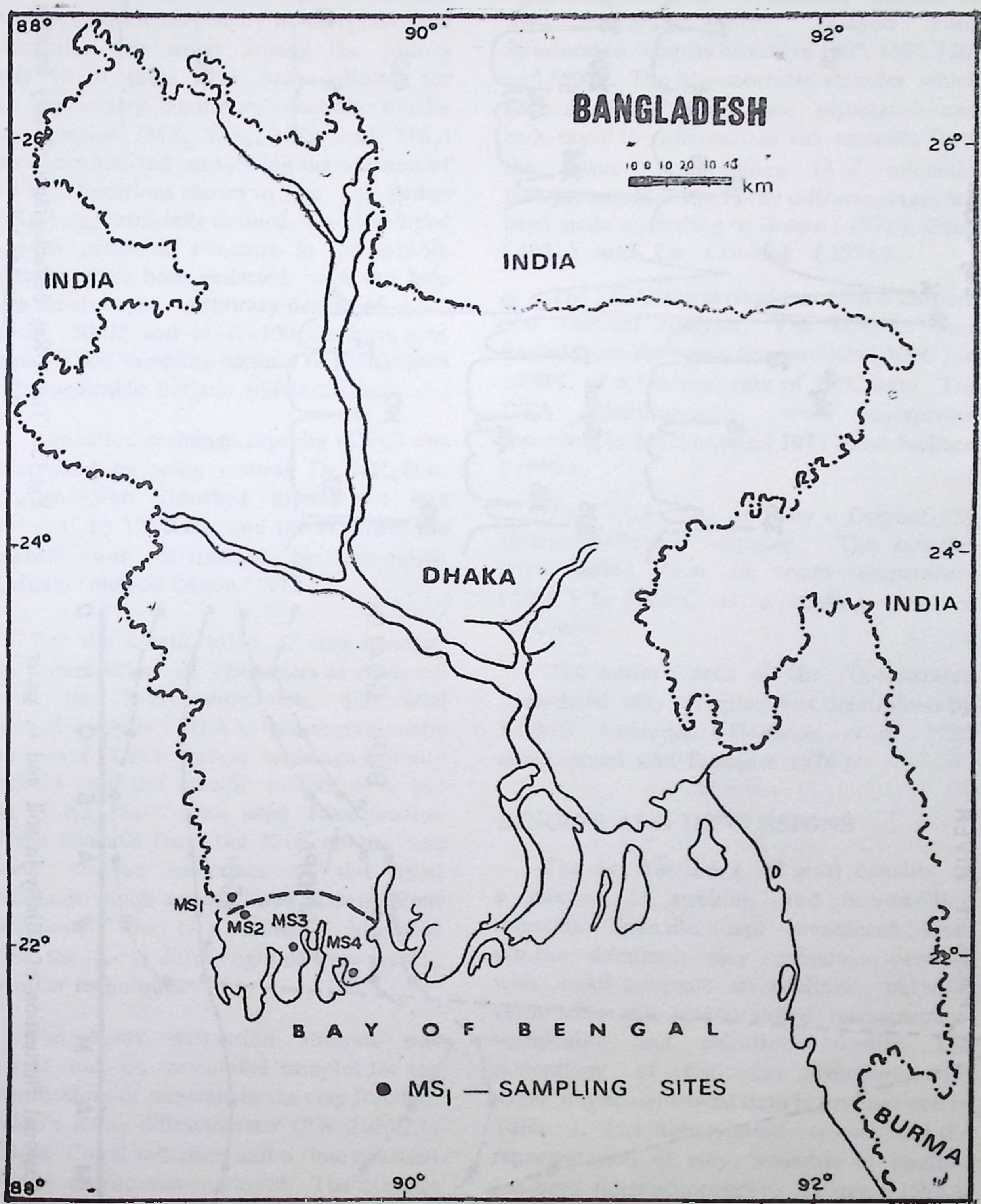

Fig. 1. Location of the Sundarbans

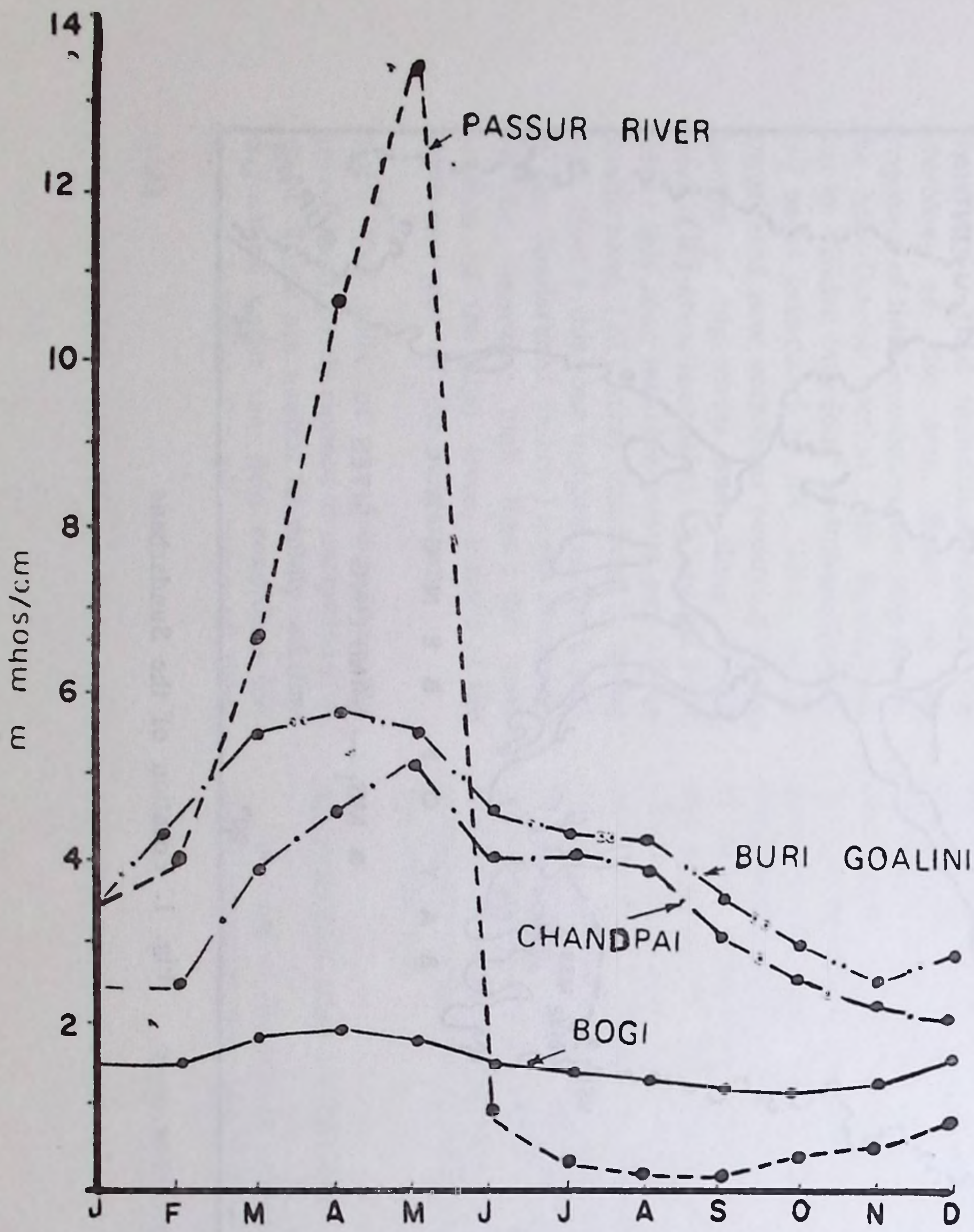

Fig. 2. Seasonal fluctuation of salinity in soil and in water

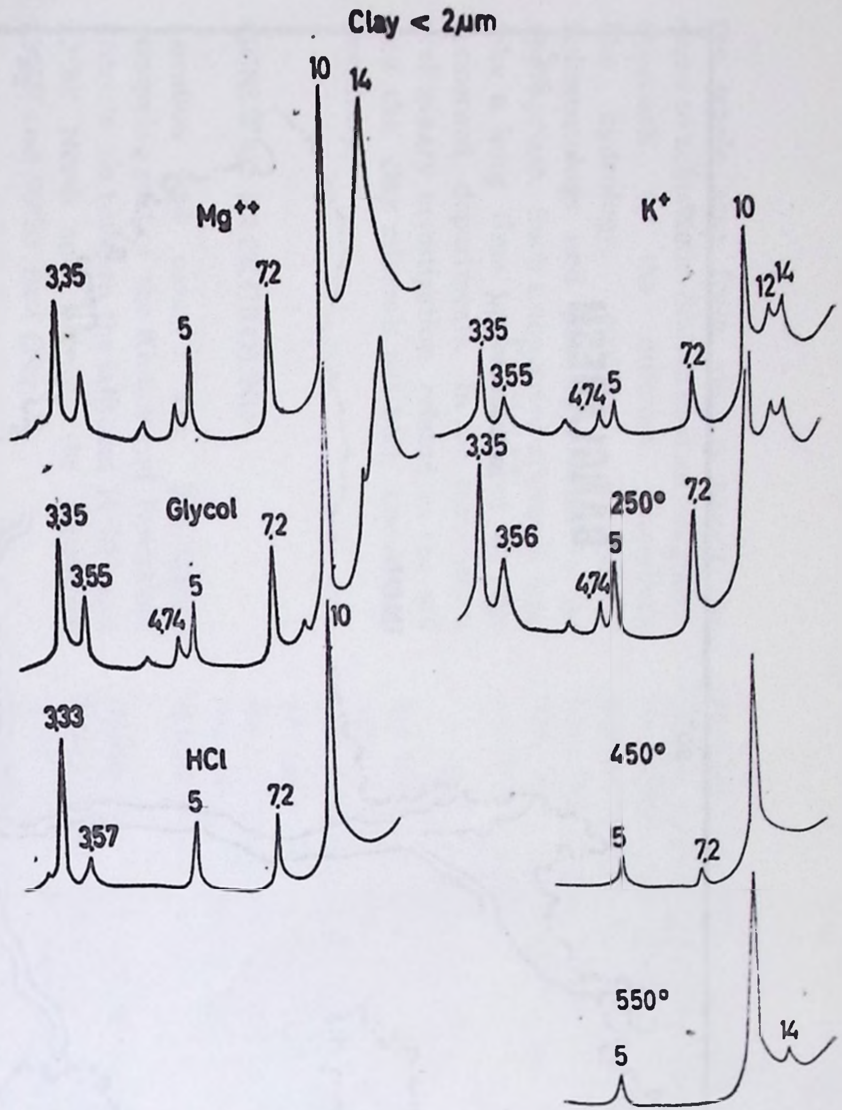

Fig. 3. The X-Ray defractograms of clay fraction (0-2m, pedon MS).

from the north-west toward the south-east. Because of the homogeneity in morphological properties that exists among the pedons only 10 of them have been collected for the preliminary laboratory analysis. Finally four pedons (MS_1, MS_2, MS_3, and MS_4) have been selected considering the vastness of the area (locations shown in Fig. 1). Pedon MS_I, being artificially drained, has developed a weak prismatic structure in the subsoil. Samples have been collected with the help of a dutch auger. Arbitrary depths of 0–25, 25–50, 50–75 and of 75–100 cm have been used for soil sampling because of the absence of recognizable horizon differentiation.

The cation exchange capacity (CEC) was determined by using neutral IN NH_4OAc solution. The absorbed ammonium was replaced by 1N KCl and the N_2 from the leachate was determined by semi-micro Kjeldahl method (Anon. 1972).

For the identification of clay minerals the combination of characters as observed from the X-ray diffraction, differential thermal analysis (DTA), thermogravimetric analysis (TGA), cation exchange capacity (CEC) and the specific surface area per gm of clay have been used. Identification of the minerals from the X-ray spectra was based on the behaviour of the basal reflections which are exhibited after different treatments. The clay minerals identified from the X-ray diffractograms were verified by other techniques.

The X-ray diffraction analysis was carried out on orientated samples for the identification of minerals in the clay fraction. Phillip's X-ray diffractometer (PW–1050/25) with a Co K radiation and a time constant of one second was employed. The samples containing smectite, vermiculite, chlorite or their intergrades were X-rayed using K-saturated samples heated to 150°, 250°, 350° and 550°C. The Mg–saturated samples which gave a 14 A° peak were glycolated and re-X-rayed to differentiate the smectite from the other non-swelling 14 Å minerals. Interpretation of the X-ray diffractograms has been made according to Brown (1972), Grim (1971) and De Coninck (1978).

The DTA was carried out with a Dupont 900 thermal analyser. The samples were heated from the room temperature (20°C) to 1000°C at a heating rate of 20°C/min. The DTA thermographs were interpreted according to Mackenzine (1972) and Jackson (1969).

The TGA was done by a Dupont 950 thermogravimetric analyser. The samples were heated from the room temperature (20°C) to 1000°C at a heating rate of 15°C/min.

The surface area of the Na-saturated oven-dried clay samples was determined by EGME technique (Heilman *et al* 1965 and Cihacek and Bremner 1979).

RESULTS AND DISCUSSIONS

The clay fraction (<2 mm) consists of a mixture of swelling and non-swelling minerals. Smectite and weathered mica are the dominant clay minerals present with small amounts of koalinite, chlorite, vermiculite and interstratified micasmectite-vermiculite and chlorite-vermiculite. The mineralogy of the clay fraction with some physico-chemical data is summarized in Table 1. The abbreviation system and the representation of clay minerals in mixture has been done according to Thorez (1975).

Table 1. Clay mineralogy of the sub-soils of a few pedons of the Sundarbans

Pedons	Depth (cm)	Unit meq/ 100 gm clay	Surface area (m^2 /gm clay)	Clay minerals
MS_1	25–50	33.6	185	I, Sm (K, Chl, V) I–V–Sm, Chl, V)
MS_2	25–50	32.0	197	ditto
MS_3	25–50	–	191	ditto
MS_4	25–50	32.5	201	ditto

Sm=Smectite, I=Weathered mica, K=Kaolinite, V=Vermiculite, Chl=Chlorite
Chl—V and I–V–Sm=Interstratified minerals

Figure 3 represents the X-ray differactograms of the clay fraction of pedons MS_1. The spectra indicate that on glycolation of the Mg-saturated sample part of the 14 Å peak shifts to 18 Å. This behaviour of the 14 Å peak confirms the presence of smectite. The non-swelling 14 Å peak stands for either chlorite and/or vermiculite. The presence of a 14 Å peak resistant to 550o C heat treatment confirms the presence of chlorite. On heating the K–saturated samples at a temperature between 150°C and 250°C the intensity of the 14 Å peak decreases with a relative increase of the 10 Å peak. This indicates the presence of vermiculite. The presence of 12.5Å peak after heating to 550°C and its tailing toward 10Å stands for the interstratified minerals (Chlorite–Vermiculite/Chlorite-Smectite). The presence of kaolinite was confirmed by HCl treatment (Brindley 1972 and De Coninck 1978). Weathered mica is irrevocably present as the 10Å, 5Å and 3.33Å peaks in the X-ray spectra persisted through all the heat treatments (Brown 1972, Grim 1971).

It appears from this study that all the pedons possess similar clay mineralogical composition. There is no vertical differentiation of clay minerals within the pedons, except in cases of some minor local variations.

The prevailing pedo-environmental conditions (very poor drainage, high base status of the alluvium and of the inundating water) of the Sundarbans are favourable for the neosynthesis of smectite (Jackson 1968, Tavernier and Eswaran 1972). But in consideration of the active alluvial nature of the sediments and the homogeneity in the vertical distribution of clay minerals within the pedons the smectite present in these soils is considered as the inherited one rather than the product of pedogenesis *in situ*. The presence of kaolinite in the clay fraction also conforms to this assumption. The interstratified minerals which are observed from the X-ray diffractograms constitute both the swelling and the non-swelling ones. This is apparent from the fact that some of the 2/1 and 2/1/1 phyllosilicates (mica, vermiculite, smectite and chlorite)

Table 2. Mineralogy of clay fraction of pedon MS

Depth (cm)	I	Sm	K	V	Chl	I–V–Sm	Chl–V
25–50	+++	+++	+	tr	tr	+	+
50–100	+++	+++	+	tr	tr	+	+

+++ = *High amount* (30–40%)
+ = *Low amount* (> 10%)
tr = *Trace* (<5%)

present in these soils possess transition structures. These transition forms are due to the processes of transformation. Part of the K+ions of mica or of the brucite sheet of chlorite may have been replaced by hydrated ions. Intergrade minerals having swelling layers form the smectitic intergrades and those with non-swelling layers form the vermiculitic intergrades.

The semi-quantitative mineralogical composition of the clay fraction of pedon MS_1 is summarized in Table 2.

The presence, as well as the variation in the composition of clay minerals within the pedons, cannot be correlated with the pedogenesis in the studied area. This is because pedogenetic influences significant for the alteration of clay minerals are, in fact, lacking in the Sundarban soils. Hence, the clay minerals present in these soils are assumed to have been inherited from the alluvial soil materials on which they had formed.

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