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# Chemical Properties of General Soil Types of Bangladesh

MD. Lutfe ALAM, Sikder MUHAMMED SAHEED*, Akio SHINAGAWA
and Nobufumi MIYAUCHI
(*Laboratory of Agronomical and Food Chemistry*)
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## Introduction

Bangladesh is known as a tropical and sub-tropical country located on the deltas of two of the greatest rivers of the world, i.e, the Ganges and the Brahmaputra. The country spreads over an area of 144,000 sq km of which more than 79% of land coverd by the recent floodplains comprising piedmont alluvial plains, meander floodplains, basin area, estuarine floodplains, tidal floodplains and sandy beaches. The rest of the land is covered by the northern and eastern hills (13%) of Tertiary formations, and Pleistocene terraces of Madhupur and Barind tracts (8%). All of those are formed by sedimentary geological formations of Tertiary and Quaternary ages (Morgan and McIntire 1959[9], Wadia 1957[12]). The weathering process and soil formation in Banglandesh are profoundly influenced by annual rainfall intensity (1300–5000 mm) and rainfall duration (90% occurs in between Aprial to October), and by the nearly flat topography causing drainage sluggishness, hyperthermic temperature and variations in parent materials and morphology. The reconnaissance soil survey of Bangladesh identified about 521 soil series including young alluvium. They have been tentatively correlated with the USDA soil taxonomy and FAO-UNESCO classification system. For practical purpose, Brammer (1971)[1] grouped these soils into seventeen soil units, designated as General Soil Types. It is a non technical system of classification, based on the mode of formation and broad morphological appearence of soils. The total number of General Soil Types has been raised to 20 by including Calcareous Grey Floodplain Soils and Brown Piedmont Soils and by splitting Grey Terrace Soils into shallow and deep (Saheed, 1984[10]).

Depending on the purposes, chemical, physical and morphological studies of the soils have been done on the basis of their respective interests. Many studies on chemical and physical aspects of Bangladesh soils have been done to characterise the fertility status and fertility reactions in relation to their management practices. But on the mineralogical and pedological aspects quite few works on chemical and physical studies have been done upto now except some reports of CERDI (1983)[3] and SRDI (1965–1977)[11]. Since surface geology is complicated and there is a wide variation in the origin of sedimentation, the soils that are formed over these sedimentary formations must have been different in their nature and degree of weathering.

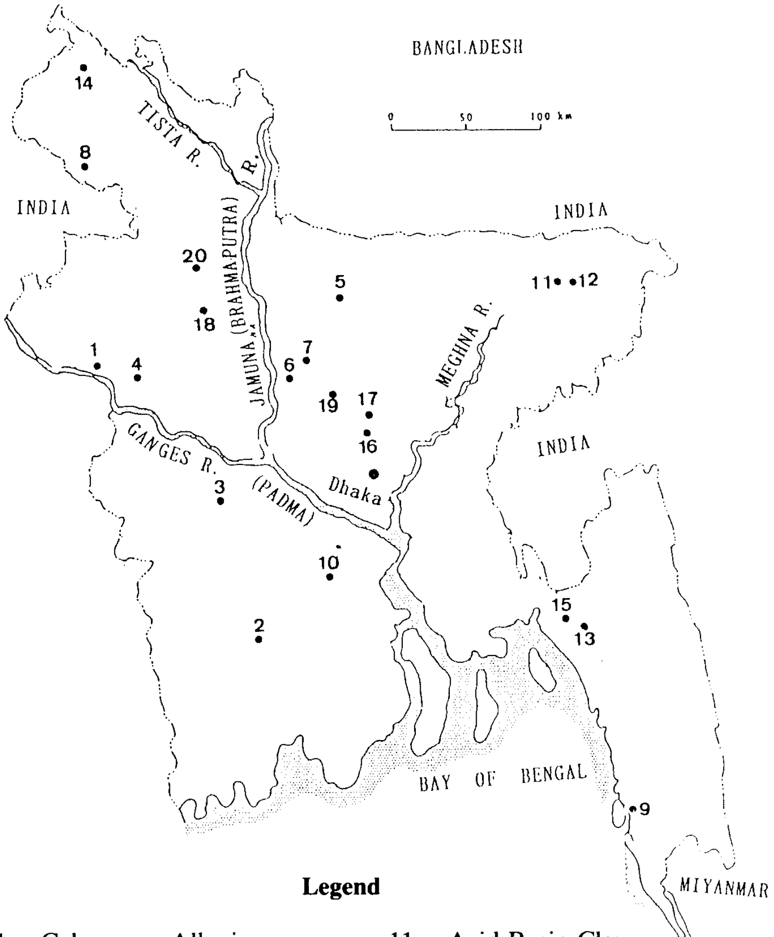
The primary objective of this study is, therefore, to characterise the soils of Bangladesh from the view point of mineralogy and morphology. So, our first work deals with the general physico-chemical characteristics of all General Soil Types in relation to their existing macro and micromorphological descriptons.

* Director, Soil Resources Development Institute, Farmgate, Dhaka, Bangladesh

## Materials and Methods

### 1. Soil descripton

Top and sub soil samples from each General Soil Types (GST) were collected for laboratory analysis. Most of the General Soil Types include several soil series. A typical soil series from each of the GST has been selected for this study. Figure 1. shows the distribution of the sampling sites and general description of soil samples are given in Table 1. Physiographically GST are grouped into floodplain soils, (sample No. 1 to 14), hill soils (sample No. 15) and terrace soils (sample No. 16 to 20). The area and proportion occupied by each General Soil Type according the Agroecological Study Reports (FAO 1988) are presented in Table 2. However, the Agroecological Study Reports failed to recognize the occurance of Brown Piedmont Soils occupying some 44,000 ha on higher piedmont plains. The same study also included made-land as a separate soil




**Legend**

| | |
|---|---|
| 1. Calcareous Alluvium | 11. Acid Basin Clay |
| 2. Calcareous Grey* | 12. Grey Piedmont Soil |
| 3. Calcareous Dark Grey* | 13. Brown Piedmont Soil |
| 4. Calcareous Brown* | 14. Black Terai Soil |
| 5. Noncalcareous Alluvium | 15. Brown Hill Soil |
| 6. Noncalcareous Grey* | 16. Shallow Red Brown** |
| 7. Noncalcareous Dark Grey* | 17. Deep Red Brown** |
| 8. Noncalcareous Brown* | 18. Brown Mottled** |
| 9. Acid Sulphate Soil | 19. Shallow Grey** |
| 10. Peat | 20. Deep Grey** |
| * Floodplain Soil | ** Terrace Soil |

Fig. 1. Location Map of General Soil Types.

Table 1. Description of soil samples

| Sample No. | Horizon | Depth (cm) | Genral Soil Type | Series name | USDA Taxonomy | Location | Physiography | Land Use | Drainage | Soil Colour (wet) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1–1 | $A_p$ | 0–14 | Calcareous Alluvium | Silty Ganges Alluvium | Aeric | Srirampur, | Active Ganges | Aus-fallow/ | Poorly | 2.5Y5/2 |
| 1–2 | $C_1$ | 25–50 | | | Fluvaquent | Paba, Rajshahi | Floodplain | Mashkalai | drained | 2.5Y5/4 |
| 2–1 | $A_{p1}$ | 0– 8 | Calcareous Grey | Bajoa | Typic | Katianagla, Batiaghata, Khulna | Ganges tidal | T. Aman-fallow | Poorly | 5Y4/1 |
| 2–2 | $B_{21}$ | 13–25 | Floodplain Soil | | Haplaquept | | floodplain | | drained | 5Y5/1 |
| 3–1 | $A_{p1}$ | 0–12 | Calcareous Dark Grey Floodplain Soil | Ghior | Typic | Nimta, Bhagerpara, Magura | Ganges river | T. Aman-Boro | Poorly | 2.5Y3/2 |
| 3–2 | $B_2$ | 20–55 | | | Haplaquept | | floodplain | | drained | 2.5Y3/2 |
| 4–1 | $A_p$ | 0–15 | Calcareous Brown Flood-plain Soil | Sara | Aquic | Banshpukuria, | Ganges river | Sugercane | Imperfectly | 2.5Y4/2 |
| 4–2 | $B_{w1}$ | 15–35 | | | Eutrochrept | Puthia, Rajshahi | floodplain | | drained | 2.5Y4/4 |
| 5–1 | $A_{pg}$ | 0–16 | Noncalcareous | Silty Brahmaputra | Aeric | Khagdahar, Mymensingh | Active Brahmaputra | Aus-Rabi | Poorly | 5Y5/1 |
| 5–2 | $C_{1g}$ & $C_{2g}$ | 25–50 | Alluvium | Alluvium | Fluvaquent | Sadar, Mymensingh | floodplain | crops | drained | 5Y5/1 –5Y6/3 |
| 6–1 | $A_p$ | 0–15 | Noncalcareous Grey Flood-plain Soil | Dhamrai | Typic | Singaria, | Young Brahmaputra floodplain | T. Aman-Boro | Poorly | 5Y6/1 |
| 6–2 | $B_2$ | 15–40 | | | Haplaquept | Ghatail, Tangail | | | drained | 5Y5/2 |
| 7–1 | $A_p$ | 0–13 | Noncalcareous Dark Grey Flood-plain Soil | Ghatail | Aeric | Atharodana, | Old Brahmaputra floodplain | Deep water | Poorly | 10YR4/1 |
| 7–2 | $B_{2i}$ | 25–37 | | | Haplaquept | Ghatail, Tangail | | T. Aman-Boro | drained | 10YT3/2 |
| 8–1 | $A_p$ | 0–15 | Noncalcareous Brown Flood-plain Soil | Ranisankail | Typic | Karnai, Dinajpur Sadar, Dinajaur | Himalayan piedmont plain | Sugarcane | Moderately | 10YR3/4 |
| 8–2 | $B_{21}$ | 15–35 | | | Dystrochrept | | | | well drained | 10YR4/4 |
| 9–1 | $A_{p1}$ | 0–15 | Acid | Cheringa | Typic | Sarisa Kata, Dulahazara, Cox's Bazar | Matamuhari tidal flood-plain | T. Aman-fallow | Poorly | 5Y5/1 |
| 9–2 | $B_{22}$ | 25–50 | Sulphate Soil | | Sulfaquent | | | | drained | 5Y5/1 |
| 10–1 | $A_p$ | 0–10 | Peat | Satla | Medifabrist | Kaligram, Mokshedpur, Gopalganj | Peat basin | Local Boro- | Very poorly | 10YR3/1 |
| 10–2 | 3 | 25–50 | | | | | | fallow | drained | 5YR2/2 |
| 11–1 | $A_p$ | 0–16 | Acid | Phagu | Typic | Nilgaon, | Surma-Kusiyara floodplain | Boro-fallow | Poorly | 5Y5/1 |
| 11–2 | $B_{21}$ | 25–45 | Basin Clay | | Haplaquept | Sonatola, Sylhet | | | drained | 5Y5/1 |

Table 1. Description samples (cont.)

| Sample No. | Horizon | Depth (cm) | Genral Soil Type | Series name | USDA Taxonomy | Location | Physiography | Land Use | Drainage | Soil Colour (wet) |
|---|---|---|---|---|---|---|---|---|---|---|
| 12–1 | $A_{p1}$ | 0–16 | Grey | Bijipur | Typic | Boroghol, | Eastern piedmont plain | Aus-T. Aman- | Imperfectly | 5Y5/1 |
| 12–2 | $B_2$ | 25–40 | Piedmont Soil | | Haplaquept | Akhali, Sylhet | | fallow | drained | 5Y5/1 |
| 13–1 | $A_1$ | 0–16 | Brown | Swalak | Typic | Baramasia tea garden, Fatikchari, Chittagong | Low Hill | Tea | Moderately | 10YR5/4 |
| 13–2 | $B_1$ | 16–34 | Piedmont Soil | | Dystrochrept | | Area | | well drained | 10YR5/4 |
| 14–1 | $A_p$ | 0–13 | Black | Atwari | Typic | Surbhita, Panchagar Sadar, Phanchagar | Himalayan | T. Aman-fallow | Poorly | 10YR3/2 |
| 14–2 | $B_3$ | 30–88 | Terai Soil | | Haplumbrept | | piedmont plain | | drained | 2.5Y3/2 |
| 15–1 | $A_1$ | 0–16 | Brown | Barkal | Udic | Jungle Bhatiyari, Shitakund, Chittagong | Hills | Thickets | Somewhat excessively drained | 10YR3/3 |
| 15–2 | $B_1$ | 16–34 | Hill Soil | | Ustochrept | | | and bushes | | 10YR5/4 |
| 16–1 | $A_1$ & $B_1$ | 0–10 | Shallow Red Brown Terrace Soil | Gerua | Typic | Rajendrapur Chourasta, Gazipur | Madhupur | Mixed | Moderately | 10YR6/4 |
| 16–2 | $B_2$ | 10–30 | | | Dystrochrept | | tract | Sal forest | well drained | 7.5YR5/6–8 |
| 17–1 | $A_p$ | 0– 8 | Deep Red Brown Terrace Soil | Tejgaon | Typic | Shirirchala, | Madhupur | Fellow/ | Well | 10YR5/6 |
| 17–2 | $B_1$ | 8–24 | | | Paleudult | Gazipur | tract | Aus-mustard | drained | 5YR4/4 |
| 18–1 | $A_{p1}$ | 0–11 | Brown Mottled | Noadda | Aquic Dystrc- | Kanaiganti, | Barind | T. Aman-fallow | Imperfectly | 5Y5/1–6/1 |
| 18–2 | $B_{21}$ | 17–44 | Terrace Soil | | Chrepr/Hapludalf | Serpur, Bogra | tract | | drained | 10YR5/6 |
| 19–1 | $A_{p1}$ | 0– 8 | Shallow Grey | Chhiata | Typic | Rajendrapur, | Madhupur | T. Aman-fallow | Imperfectly | 10YR2/1 |
| 19–2 | $A_{p3}$ | 16–40 | Terrace Soil | | Albaquept | Gazipur | tract | | drained | 10YR5/2 |
| 20–1 | $A_{p1}$ | 0–10 | Deep Grey | Amnura | Aeric | Bayradishi, Bogra Sadar, Bogra | Braind | T. Aman-Boro | Poorly | 5Y6/1 |
| 20–2 | $B_{21}$ | 15–30 | Terrace Soil | | Albaquept | | tract | | drained | 10YR5/6 |

Table 2. Area and Proportions Occupied by General Soil Types (FAO, 1988)[6)]

| General Soil Type | Area ha | Proportion % |
|---|---|---|
| Floodplain Soils | | |
| Calcareous Alluvium | 591 796 | 4.1 |
| Calcareous Grey Floodplains Soils | 170 767 | 1.2 |
| Galcareous Dark Grey Floodplain Soils | 1 434 678 | 9.9 |
| Calcareous Brown Floodplain Soils | 478 518 | 3.3 |
| Noncalcareous Alluvium | 562 242 | 3.9 |
| Noncalcareous Grey Floodplain Soils | 3 387 153 | 23.4 |
| Noncalcareous Dark Grey Floodplain Soils | 1 599 645 | 11.0 |
| Noncalcareous Brown Eloodplain Soils | 383 312 | 2.6 |
| Acid Sulphate Soils | 226 647 | 1.6 |
| Peat | 130 005 | 0.9 |
| Acid Basin Clays | 348 994 | 2.4 |
| Grey Piedmont Soils | 215 279 | 1.5 |
| Made-land | 106 278 | 0.7 |
| Area of Floodplain Soils | 9 718 722 | 67.1 |
| Proportion of total soil area | | (79.0) |
| Brown Hill Soils | 1 561 472 | 10.8 |
| Area of Hill Soils | 1 561 472 | 10.8 |
| Proportion of total soil area | | (12.7) |
| Terrace Soils | | |
| Shallow Red-Brown terrace Soils | 72 549 | 0.5 |
| Deep Red-Brown Terrace Soils | 189 380 | 1.3 |
| Brown Mottled Terrace Soils | 34 235 | 0.3 |
| Shallow Grey Terrace Soils | 265 427 | 1.8 |
| Deep Grey Terrace Soils | 352 152 | 2.4 |
| Grey Valley Soils | 114 287 | 0.8 |
| Area of Terrace Soils | 1 028 030 | 7.1 |
| Proportion of total soil area | | (8.3) |
| Total Soil Area | 12 308 224 | 85.0 |
| Miscellaneous Land Types | | |
| Rivers, bills, etc. | 973 430 | 6.7 |
| Urban | 81 945 | 0.6 |
| Homesteads and included tanks | 1 122 670 | 7.7 |
| Area of Miscellaneous Land Types | 2 178 045 | 15.0 |
| Total | 14 486 269 | 100.0 |

unit, which infact is developed in all kinds of parent materials occuring in areas of different physiographic units under homesteads. The present study includes the Brown Pieddmont Soils and ignores the made-land to avoid complicacy. The floodplain soils have been formed in river floodplain and piedmont alluvial plains ranging from very recent to several thousand years back. The seasonal flooding is mainly brought about by accumulated rain water or by the raised ground water level. Depth of flooding varies both, regionally and locally. Shallow flooding occurs in north, east, south and west of the country and becoming deeper towards the centre. Basins and adjaecent ridges remian wet for part or all of the dry season. Piedmont alluvial plains are built up by transported materials from Himalayas and other lesser hill ranges. Meander floodplains are developed by the sedimentation of major rivers such as the Ganges, the Brahmaputra, Jamuna, Tista, Surma-Kusiyara and Meghna. Some tidal floodplans in northern area are flooded by fresh water where the land scape are leveled and criss-crossed by numerous tidal creeks. But in south, flooding is caused by brakish water. Hill soils have developed over consolidated and unconsolidated shales, siltstones and sandstones, which are of Oligo-Miocene to Plio-Pleistocene age (Wadia, 1957[12]). Mainly they are excessive to well drained with relatively thin soil profile ranging from about a meter to a few centimeters. Terrace soils have formed over uplifted blocks of Madhupur clays which mainly stand a few meters above the flood levels on adjoining floodplains. It is probably a Pleistocene marine formation (FAO, 1971)[4]. Soil differences are due to difference in drainage and in depth and degree of weathering of parent Madhupur clay.

### 2. Analytical methods

Air dried fine earth samples were prepared for the mechanical and chemical analyses. Each sample after treating with $H_2O_2$ were fractionated into clay (<0.002 mm), silt (0.002–0.02 mm), fine sand (0.02–0.2 mm) and coarse sand (0.2–2 mm) by repeating sonification-sedimentation-siphoning. The soil texure was then determined by following the classification of International Society of Soil Science.

The pH of the samples were measured in 1:2.5 soil/water and 1 N KCl suspensions. Acidity was determined by titration with 0.01 N NaOH after extraction with 1 N KCl. Organic carbon was determined by the wet combustion method using 0.4 N $K_2Cr_2O_7$ in 1:1 $H_2SO_4$ as oxidizer. Soils were digested in conc. $H_2SO_4$ in a microkjeldahl flask and then distillated with 40% NaOH for determining total nitrogen (Jackson, 1962)[8]. Exchangeable bases were extracted with 1 N $NH_4OAC$ (pH 7.0) and 1 N $NH_4Cl$ by centrifugation. For checking exchangeable bases of calcareous and noncalcareous soils, the samples were again extracted by $BaCl_2$-triethanolamine as described by Jackson, 1962[8]. The concentrations of Ca, Mg, Na and K were determined by the atomic absorption spectrometry. After replacement of all cations of each samples with 1 N $NH_4OAC$ and $NH_4Cl$ as previous and washing with 80% ethanol upto chloride disappearance, $NH_4^+$ from exchange site was then replaced by 10% KCl by successive centrifugation. $NH_4$-N content was estimated by distillation method for the CEC determination. Phosphate absorption percentage was measured by extracting the soil samples with $H_3PO_4$ and the phosphate remained in the filtrate was analyzed by the molybdivanado phosphoric acid colorimetric method and for determining available phosphrous Truog's pH 3 buffer (Ammonium sulphate-sulphuric acid) solution was used.

## Results and Discussion

The general physical and chemical properties of General Soil Types of Bangladesh are presented in Table 3 and Table 4. Table 3 shows the particle size distribution and soil texture. The clay content ranged as low as 3.6% to as much high as 78.5%. Generally speaking, Floodplain Soils have higher clay content than Hill and Terrace Soils. Among the Calcareous and Noncalcareous Floodplain Soils, higher clay contents were observed in Grey and Dark Grey

Table 3. Particle size distribution and soil texture of Bangladesh soils

| Sample No. | Coarse sand (2–0.2 mm) % | Fine sand (0.2–0.02 mm) % | Sand Total % | Silt (0.02–0.002 mm) % | Clay (<0.002 mm) % | Soil texture |
|---|---|---|---|---|---|---|
| 1–1 | 0.0 | 57.7 | 57.7 | 33.8 | 8.5 | L |
| 1–2 | 0.0 | 79.9 | 79.9 | 16.3 | 3.8 | FSL |
| 2–1 | 0.0 | 15.0 | 15.0 | 62.6 | 22.4 | SCL |
| 2–2 | 0.0 | 6.1 | 6.1 | 57.5 | 36.4 | SiC |
| 3–1 | 0.0 | 8.8 | 8.8 | 38.3 | 52.9 | HC |
| 3–2 | 0.0 | 11.0 | 11.0 | 37.8 | 51.2 | HC |
| 4–1 | 0.0 | 68.2 | 68.2 | 23.5 | 8.3 | FSL |
| 4–2 | 2.1 | 56.7 | 58.8 | 35.2 | 6.0 | L |
| 5–1 | 0.0 | 54.1 | 54.1 | 38.7 | 7.2 | L |
| 5–2 | 0.0 | 57.7 | 57.7 | 35.0 | 7.3 | L |
| 6–1 | 0.0 | 39.2 | 39.2 | 36.6 | 24.2 | CL |
| 6–2 | 0.0 | 20.3 | 20.3 | 57.4 | 22.3 | SiCL |
| 7–1 | 0.0 | 28.7 | 28.7 | 33.2 | 38.1 | LC |
| 7–2 | 1.3 | 26.2 | 27.5 | 34.2 | 38.3 | LC |
| 8–1 | 33.1 | 48.9 | 82.0 | 11.2 | 6.8 | FSL |
| 8–2 | 31.3 | 51.6 | 82.9 | 8.6 | 8.5 | FSL |
| 9–1 | 0.0 | 28.1 | 28.1 | 37.8 | 34.1 | LC |
| 9–2 | 0.0 | 28.6 | 28.6 | 46.6 | 24.8 | SiCL |
| 10–1 | 0.0 | 3.1 | 3.1 | 26.8 | 70.1 | HC |
| 10–2 | 0.0 | 21.2 | 21.2 | 59.6 | 19.2 | SiCL |
| 11–1 | 12.3 | 74.5 | 86.8 | 9.9 | 3.3 | LFS |
| 11–2 | 26.2 | 57.2 | 83.4 | 10.2 | 6.4 | FSL |
| 12–1 | 0.0 | 3.8 | 3.8 | 17.7 | 78.5 | HC |
| 12–2 | 0.0 | 3.1 | 3.1 | 21.0 | 75.9 | HC |
| 13–1 | 3.3 | 70.2 | 73.5 | 15.8 | 10.7 | FSL |
| 13–2 | 2.7 | 70.3 | 73.0 | 15.0 | 12.0 | FSL |
| 14–1 | 29.0 | 49.3 | 78.3 | 12.9 | 8.8 | FSL |
| 14–2 | 26.6 | 59.3 | 85.9 | 10.5 | 3.6 | LFS |
| 15–1 | 8.7 | 53.3 | 62.0 | 20.3 | 17.7 | SCL |
| 15–2 | 4.5 | 55.3 | 59.8 | 20.2 | 20.0 | SCL |
| 16–1 | 3.3 | 53.0 | 56.3 | 25.4 | 18.3 | CL |
| 16–2 | 5.0 | 48.9 | 53.9 | 24.3 | 21.8 | CL |
| 17–1 | 15.0 | 48.0 | 63.0 | 21.0 | 16.0 | CL |
| 17–2 | 9.0 | 40.2 | 49.2 | 28.5 | 22.3 | CL |
| 18–1 | 9.2 | 60.8 | 70.0 | 22.9 | 7.1 | FSL |
| 18–2 | 5.6 | 47.4 | 53.0 | 25.8 | 21.2 | CL |
| 19–1 | 0.0 | 52.3 | 52.3 | 35.8 | 11.9 | L |
| 19–2 | 1.8 | 35.8 | 37.6 | 35.1 | 27.3 | LiC |
| 20–1 | 4.0 | 58.1 | 62.1 | 27.6 | 10.3 | L |
| 20–2 | 4.2 | 56.9 | 61.1 | 25.3 | 13.6 | L |

Table 4. Chemical properties of the soils (oven dry basis)

| Sample No. | pH | | Acidity | | T-C % | T-N % | C/N | CEC meq/100 g | Extractable base meq/100 g | | | | Base saturation degree | Carbonate as $CaCO_3$ % | P-absorption % | Available P mg/100 g |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $H_2O$ | N-KCl | $Y_1$ N-KCl | $Y_1$ CaOAc | | | | | Ca | Mg | K | Na | | | | |
| 1–1 | 8.29 | 7.47 | 0.12 | 1.86 | 0.42 | 0.041 | 10.24 | 12.10 | 21.50 | 5.57 | 0.59 | 0.29 | 231.0 | 2.38 | 4.64 | 5.12 |
| | | | | | | | | | (14.30) | (2.86) | (0.35) | (0.09) | | | | |
| 1–2 | 8.36 | 7.62 | 0.12 | 2.18 | 0.38 | 0.037 | 10.27 | 19.95 | 17.20 | 3.22 | 0.36 | 0.19 | 105.1 | 3.60 | 2.84 | 3.19 |
| | | | | | | | | | (9.80) | (1.57) | (0.24) | (0.03) | | | | |
| 2–1 | 7.52 | 6.95 | 0.15 | 3.24 | 2.29 | 0.114 | 20.09 | 36.35 | 29.70 | 17.40 | 0.83 | 12.60 | 166.5 | 1.50 | 8.51 | 26.82 |
| | | | | | | | | | (16.10) | (8.30) | (0.48) | (6.24) | | | | |
| 2–2 | 7.74 | 6.51 | 0.15 | 4.08 | 0.95 | 0.065 | 14.62 | 36.25 | 26.30 | 14.60 | 0.68 | 6.80 | 133.5 | 3.00 | 9.28 | 127.91 |
| | | | | | | | | | (14.10) | (6.18) | (0.42) | (2.90) | | | | |
| 3–1 | 7.19 | 5.49 | 0.56 | 7.28 | 1.08 | 0.079 | 13.67 | 58.10 | 50.60 | 14.80 | 0.73 | 0.43 | 114.6 | 7.08 | 17.53 | 9.54 |
| | | | | | | | | | (25.60) | (6.12) | (0.36) | (0.23) | | | | |
| 3–2 | 7.92 | 5.99 | 0.60 | 3.14 | 0.52 | 0.033 | 15.76 | 59.75 | 54.60 | 14.80 | 0.61 | 0.69 | 118.2 | 7.50 | 13.14 | 13.78 |
| | | | | | | | | | (27.80) | (6.23) | (0.34) | (0.35) | | | | |
| 4–1 | 8.18 | 7.36 | 0.12 | 1.91 | 0.69 | 0.081 | 8.52 | 19.15 | 15.00 | 2.30 | 0.27 | 0.19 | 92.7 | 10.30 | 2.09 | 59.37 |
| | | | | | | | | | (10.40) | (0.81) | (0.23) | (0.04) | | | | |
| 4–2 | 8.29 | 7.32 | 0.12 | 1.90 | 0.31 | 0.036 | 8.61 | 16.45 | 21.90 | 4.00 | 0.23 | 0.19 | 160.0 | 9.60 | 3.41 | 1.28 |
| | | | | | | | | | (13.30) | (1.54) | (0.18) | (0.04) | | | | |
| 5–1 | 7.83 | 6.81 | 0.12 | 21.85 | 0.48 | 0.047 | 10.21 | 10.72 | 13.90 | 4.35 | 0.29 | 0.17 | 174.5 | — | 7.99 | 35.11 |
| | | | | | | | | | (11.00) | (1.03) | (0.27) | (0.07) | | | | |
| 5–2 | 7.62 | 6.92 | 0.17 | 0.67 | 0.50 | 0.046 | 10.87 | 11.80 | 14.00 | 4.22 | 0.32 | 0.26 | 159.3 | — | 7.47 | 29.98 |
| | | | | | | | | | (7.38) | (2.00) | (0.23) | (0.10) | | | | |
| 6–1 | 6.20 | 4.69 | 0.82 | 11.96 | 1.20 | 0.099 | 12.12 | 25.00 | 13.60 | 4.91 | 0.20 | 0.46 | 76.7 | — | 13.40 | 69.71 |
| | | | | | | | | | (8.41) | (2.20) | (0.09) | (0.16) | | | | |
| 6–2 | 8.06 | 6.13 | 0.50 | 3.84 | 0.52 | 0.053 | 9.81 | 20.12 | 14.40 | 5.93 | 0.21 | 0.60 | 105.1 | — | 9.54 | 109.34 |
| | | | | | | | | | (8.53) | (2.50) | (0.12) | (0.26) | | | | |

( ): Values in parenthesises are BaCl-triethanolamine extractable bases.

Table 4. Chemical properties of the soils (oven dry basis) (cont.)

| Sample No. | pH | | Acidity | | T-C % | T-N % | C/N | CEC meq/100 g | Extractable base meq/100 g | | | | Base saturation degree | Carbonate as $CaCO_3$ % | P-absorption % | Available P mg/100 g |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $H_2O$ | N-KCl | $Y_1$ N-KCl | $Y_1$ CaOAc | | | | | Ca | Mg | K | Na | | | | |
| 7-1 | 5.24 | 4.40 | 1.15 | 19.84 | 2.45 | 0.212 | 11.56 | 32.35 | 14.00 | 5.21 | 0.35 | 0.43 | 61.8 | — | 13.40 | 7.18 |
| | | | | | | | | | ( 9.00) | ( 2.30) | (0.16) | ( 0.13) | | | | |
| 7-2 | 7.36 | 5.40 | 0.45 | 5.88 | 0.95 | 0.064 | 14.84 | 24.80 | 29.41 | 11.30 | 0.33 | 0.46 | 167.3 | 3.18 | 14.69 | 12.54 |
| | | | | | | | | | (16.50) | ( 5.24) | (0.19) | ( 0.22) | | | | |
| 8-1 | 5.58 | 4.55 | 0.87 | 11.15 | 0.53 | 0.067 | 7.91 | 10.75 | 2.75 | 1.11 | 0.98 | 0.17 | 46.6 | — | 2.62 | 106.31 |
| | | | | | | | | | ( 1.50) | ( 0.41) | (0.36) | ( 0.04) | | | | |
| 8-2 | 5.81 | 4.32 | 1.25 | 12.07 | 0.39 | 0.035 | 11.14 | 10.75 | 2.50 | 0.94 | 0.47 | 0.11 | 32.4 | — | 3.93 | 71.02 |
| | | | | | | | | | ( 1.26) | ( 0.28) | (0.25) | ( 0.03) | | | | |

( ): Values in parenthesises are $BaCl_2$-triethnolamine extractable bases.

| Sample No. | pH $H_2O$ | pH N-KCl | Acidity $Y_1$ N-KCl | Acidity $Y_1$ CaOAc | T-C % | T-N % | C/N | CEC meq/100 g | Ca | Mg | K | Na | Base saturation degree | Carbonate as $CaCO_3$ % | P-absorption % | Available P mg/100 g |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9-1 | 3.98 | 3.68 | 22.83 | 30.59 | 1.12 | 0.093 | 12.04 | 17.75 | 1.98 | 11.30 | 1.12 | 41.80 | 316.6 | — | 10.82 | 9.99 |
| 9-2 | 3.93 | 3.45 | 22.95 | 51.97 | 2.99 | 0.124 | 24.11 | 22.20 | 1.21 | 6.38 | 1.07 | 30.10 | 174.6 | — | 8.25 | 6.73 |
| 10-1 | 5.92 | 4.75 | 2.26 | 28.42 | 4.45 | 0.389 | 11.44 | 41.75 | 25.00 | 6.09 | 0.34 | 0.36 | 76.1 | — | 23.71 | 3.40 |
| 10-2 | 5.18 | 4.80 | 3.34 | 104.2 | 41.44 | 1.652 | 25.08 | 85.50 | 34.20 | 9.54 | 0.30 | 1.18 | 52.9 | — | 18.56 | tr. |
| 11-1 | 5.25 | 4.13 | 22.47 | 47.19 | 0.71 | 0.049 | 14.49 | 4.75 | 0.14 | 0.07 | 0.09 | 0.12 | 8.8 | — | 1.55 | 3.75 |
| 11-2 | 5.46 | 4.12 | 4.97 | 9.57 | 1.83 | 0.114 | 16.05 | 4.65 | 0.18 | 0.11 | 0.11 | 0.09 | 10.5 | — | 1.29 | 2.26 |
| 12-1 | 5.27 | 3.55 | 2.29 | 9.63 | 2.18 | 0.201 | 10.85 | 29.20 | 8.23 | 3.23 | 0.24 | 0.16 | 40.6 | — | 21.65 | 1.59 |
| 12-2 | 5.46 | 3.59 | 23.08 | 38.66 | 1.60 | 0.122 | 13.11 | 27.00 | 7.50 | 7.83 | 0.28 | 0.21 | 58.6 | — | 15.20 | 3.22 |
| 13-1 | 5.12 | 3.94 | 10.92 | 20.73 | 0.77 | 0.075 | 10.27 | 7.35 | 1.53 | 0.59 | 0.36 | 0.11 | 35.2 | — | 2.61 | 1.36 |
| 13-2 | 5.28 | 3.92 | 12.40 | 20.40 | 0.64 | 0.064 | 10.00 | 10.05 | 1.71 | 0.48 | 0.14 | 0.10 | 24.2 | — | 8.66 | tr. |
| 14-1 | 4.94 | 4.41 | 3.97 | 20.70 | 1.91 | 0.075 | 25.47 | 10.50 | 0.17 | 0.05 | 0.11 | 0.09 | 4.0 | — | 14.96 | 2.58 |
| 14-2 | 6.15 | 5.01 | 0.74 | 20.08 | 0.92 | 0.041 | 22.44 | 8.40 | 0.29 | 0.04 | 0.09 | 0.08 | 6.0 | — | 21.78 | tr. |

Table 4. Chemical properties of the soils (oven dry basis) (cont.)

| Sample No. | pH | | Acidity | | T-C % | T-N % | C/N | CEC meq/100 g | Extractable base meq/100 g | | | | Base saturation degree | Carbonate as $CaCO_3$ % | P-absorption % | Available P mg/100 g |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $H_2O$ | N-KCl | $Y_1$ N-KCl | $Y_1$ CaOAc | | | | | Ca | Mg | K | Na | | | | |
| 15–1 | 5.82 | 3.96 | 5.27 | 16.16 | 0.69 | 0.082 | 8.41 | 15.40 | 4.85 | 3.15 | 0.18 | 0.12 | 53.9 | — | 8.92 | tr. |
| 15–2 | 5.82 | 3.81 | 10.88 | 18.25 | 0.42 | 0.062 | 6.77 | 15.15 | 3.77 | 2.54 | 0.14 | 0.18 | 43.8 | — | 9.45 | tr. |
| 16–1 | 5.36 | 3.87 | 28.16 | 32.76 | 0.45 | 0.039 | 11.54 | 13.75 | 0.35 | 0.93 | 0.24 | 0.09 | 11.7 | — | 12.60 | tr. |
| 16–2 | 5.34 | 3.95 | 15.08 | 25.21 | 0.70 | 0.064 | 10.87 | 11.80 | 0.51 | 0.98 | 0.26 | 0.10 | 15.7 | — | 9.92 | tr. |
| 17–1 | 5.24 | 4.15 | 3.51 | 15.68 | 0.79 | 0.077 | 10.26 | 9.75 | 0.92 | 0.28 | 0.22 | 0.08 | 15.4 | — | 7.09 | 9.56 |
| 17–2 | 5.76 | 4.11 | 5.47 | 17.54 | 0.62 | 0.070 | 8.86 | 12.75 | 1.86 | 0.61 | 0.21 | 0.10 | 21.8 | — | 13.08 | tr. |
| 18–1 | 4.92 | 4.02 | 2.65 | 11.10 | 0.80 | 0.091 | 8.79 | 5.75 | 0.78 | 0.16 | 0.14 | 0.13 | 21.0 | — | 4.19 | 3.21 |
| 18–2 | 6.00 | 4.96 | 0.39 | 7.64 | 0.37 | 0.042 | 8.81 | 8.75 | 2.40 | 0.94 | 0.13 | 0.11 | 40.9 | — | 8.13 | tr. |
| 19–1 | 5.10 | 4.05 | 5.10 | 14.70 | 0.89 | 0.084 | 10.60 | 6.10 | 1.03 | 0.24 | 0.15 | 0.11 | 25.1 | — | 5.77 | 2.54 |
| 19–2 | 6.18 | 4.16 | 6.75 | 14.62 | 0.35 | 0.040 | 8.75 | 12.35 | 2.14 | 1.14 | 0.11 | 0.14 | 28.6 | — | 9.97 | tr. |
| 20–1 | 5.60 | 4.15 | 1.68 | 12.34 | 1.05 | 0.110 | 9.55 | 7.20 | 3.24 | 0.64 | 0.11 | 0.13 | 57.2 | — | 4.99 | 4.44 |
| 20–2 | 7.36 | 5.92 | 0.38 | 4.55 | 0.25 | 0.029 | 8.62 | 7.10 | 1.62 | 1.13 | 0.09 | 0.13 | 41.8 | 0.75 | 4.72 | tr. |

Floodplain Soils (22.3 to 52.9%) than those from Alluvium and Brown Floodplain Soils (3.8 to 8.5%). The clay contents in top and sub soil samples were more or less the same. Among the other Floodplain Soils, Piedmont Soils and Black Terai Soil showed very low clay contents ranging from 3.3. to 12.0% and Acid Basin Clay showed very high clay content (78.5% in top and 75.9% in sub soil). High clay content was observed also in the top of Peat Soil (70.1%) but sub soil had only 19.2% clay. Hill and Terrace Soils had moderate amounts of clay ranging from 7.1 to 18.3% in top soils and sub soils ranging from 13.6 to 27.3%, showing the higher clay content in sub soil than top soil in general. The same trend was also found in Piedmontplains Soils. Sand particles larger than 0.2 mm are absent in most of the Floodplain Soils except samples No. 7, 12, 13 and 14; among those samples No. 12 and 14 had considerable amounts of coarse sand. Hill and all Terrace Soils also had coarse sand but their amounts were small ranging between 1.8 to 15.0%. The texture among the all soil groups showed a wide variation ranging from heavy clay to fine sandy loam (Table 3).

From Table 4, it is revealed that most of the soils except all Calcareous and Acid Sulphate Soil fall in the pH ($H_2O$) range between 5.12 and 5.82 in top and 5.18 and 6.18 in sub soil. Acid Sulphate Soil had an extreamly low pH of 3.98 in top and 3.93 in the sub soil. Calcareous Soils had higher pH ranges from 7.19 to 8.36. Some Noncalcareous especially, Alluvium and Grey Floodplain Soils had the soil pH nearly 7.0. In general, pH of the sub soils were found a bit higher than the top soils. The values of pH (KCl) in each soil was generally lower than pH ($H_2O$), showing similar tendency in lowering the pH by KCl and in the Acid Basin Clay the pH was reduced by nearly 2.0 units. In the great majority of the soils, the total carbon contents were below 1%, with a few going up to 2.99% with the exception of the Peat Soil which had 41.44% in the sub soil and 4.45% in the top soil. C/N ratio in Hill and Terrace Soils (8.41 to 11.54) was lower as compared to Floodplain Soils (7.91 to 25.47). There is a wide variation in CEC value among the samples within the Calcareous Soils, the Calcareous Grey and Calcareous Dark Grey had exceedingly higher CEC value than Alluvium and Brown Floodplain Soils. The values ranging from 4.65 to 36.35 meq/100 gm. Similar result was also observed in Noncalcareous Floodplain Soils where the CEC ranged between 10.72 and 32.35 meq/100 gm. The higher value in Grey and Dark Grey Soils were due to their high clay content. Exceptionally higher CEC value was observed in sub soil of Peat Soil (85.5 meq/100 gm) due to the higher mucky organic matter content in its sub soil. The CEC in the other Floodplain Soils ranged from 10.0 to 25.47 meq/100 gm. Black Terai Soil, Acid Sulphate Soil and Acid Basin Caly had higher CEC values observed. Hill and Terrace Soils had low CEC value ranging between 5.75 and 15.40 meq/100 gm. Extractable bases especially Ca and Mg content were higher in the soil which had pH above 7.0. Their values were lower when $BaCl_2$-triethanolamine used as extractant. Extractable Ca content was low in Hill and Terrace Soils ranging from 0.35 to 4.85 meq/100 gm. The Floodplain Soils other than Calcareous and Noncalcareous Floodplains had lower observed Ca content of 0.14 to 8.23 meq/100 gm except the Peat Soil (34.2 meq/100 gm in sub and 25.0 meq/100 gm in top) which contained high CEC and high organic matter. The extractable Ca content in Calcareous Soils ranged between 15.0 and 54.6 meq/100 gm. In Noncalcareous Soils it ranged from 2.5 to 29.41 meq/100 gm with $NH_4OAC$ extraction. But with $BaCl_2$-triethanolamine it ranged from 9.98 to 27.18 meq/100 gm for Calcareous Soils and 1.5 to 16.5 meq/100 gm for Noncalcareous Soils. Extractable Mg content was also higher in Calcareous Grey and Dark Grey Floodplain Soils than in Alluvium and Calcureous Brown Floodplain Soils. The range was 2.3 to 17.4 meq/100 gm in $NH_4OAC$ extraction and 0.18 to 8.3 meq/100 gm in $BaCl_2$-triethanolamine extraction. The Mg values in Noncalcareous Soils did not differ very much, except for the Brown Floodplain Soil that showed a low Mg content of 0.94 meq/100 gm. In the others, Mg content ranged from 4.22 to 5.93 meq/100 gm. The observed K and Na contents were more or less same in all the soils, except Na content in Calcareous Grey Floodplain Soil (12.6 meq/100 gm in top and 6.8 meq/100 gm in subsoil) and that in the Acid Sulphate Soil (41.8 meq/100 gm in top and 30.1 meq/100 gm in sub soil). The values for K in all samples were 0.09 to 1.12 meq/100 gm, and for Na in other soils were 0.09 to 1.18 meq/100 gm. Therefore, a high base saturation degrees were observed in all Calcareous and Noncalcareous Soils with a few exceptions like Noncalcareous Brown Floodplain Soil (both top and sub soil) and top of the Noncalcareous Grey Floodplain, Nonclacareous Dark Grey Floodplain and Calcareous Brown Floodplain Soils. The base saturation degree in other Floodplain Soils, Hill Soil and Terrace soils were lower than 100% except in Acid Sulphate Soil where it was observed more than 300% at top and 174% at sub soil. The base saturation degree in Hill and Terrace Soils were ranged only between 11.7 and 57.2%. Phosphate adsorption percentage was not much more higher in all soils. The available phosphorus content was very lowly ranged from a trace amount to upto 15 ppm, except by the Noncalcareous and Calcareous Grey and Brown Floodplain Soil which contained considerable amounts of available phosphorus ranging from 59.0 to 128.0 ppm.

The high clay contents in Grey and Dark Grey Floodplain Soils in both Calcareous and Noncalcareous Soils are may be due to their formation in slope basin to level basin floodplain areas. Whereas the Alluvium and Brown Floodplain Soils were formed in the tidal ridges containing a low amount of clay. On the other hand, very high content of clay in Peat and Acid Basin Clay may be due to alluvial clay deposition in level basin area (explained in Table 1) (FAO, 1971)[4]. In Terrace Soils, high clay content observed in the sub soil rather than in the top soils reveals the translocation of clay from top to sub soil (Brinkham, 1977)[2]. The high pH in Calcareous Soils could be due to Ganges alluvial deposition derived from the Peninsula Indian Shield and from Calcareous Terrace Soils (Huizing, 1971)[7]. The other Floodplain Soils of Himalayan origin, brought down by Brahmaputra, Tista and other rivers are rich in weatherable mineral (Huizing, 1970)[7]. Low carbon contents in the most soils may be due to accelerated decomposition of organic matter in tropical environment, less amendment of organic matter addition etc.. However, the high organic matter content in Noncalcareous Dark Grey Floodplain Soils, Calcareous Dark Grey Floodplain Soil and Acid Basin Clay might be due to accumulation in submurged condition under reduced state of decompositon, whereas in Peat it might be due to accumulation of slowly decomposing vegitation under natural state. By examining the Tables 3 and 4, it appears to be celar that observed CEC is highly related with clay content in general. The observed CEC variation among some soils of approximately same clay level can be caused by clay mineralogical defferences. Terrace Soils have considerablely lower values of CEC in comparision to their clay content revealing the presence of low amount of 2 : 1 type clay mineral. The presence of free lime in both top and sub soils in Calcareous and sub soils of Noncalcareous Soils increased the extractable Ca and Mg contents leading to the higher base saturation degree observed in the soils. The high Na content in Calcareous Grey Floodplain and Acid Sulphate Soils may be due to tidal effect.

## Summary

Fourty soil samples including top and sub soils of all the twenty General Soil Types of

Bangladesh were analyzed. The results obtained were summerized as follows:

1. There was a wide variation in texture from heavy clay to fine sandy loam. In general, most of the soils were loamy in texture. Clay content ranged from 3.6% to 78.5%. Hill and Terrace Soils had moderate amount of clay; and Acid Basin Clay, top of the Peat and Dark Grey Floodplain Soils had excessively high clay.
2. Acidic pH is existed in most of the soils ranging in between 5.12 and 5.82. Extreamely low pH was observed in Acid Sulphate Soil and high pH was observed in Calcareous Floodplain groups.
3. Total carbon content in most of the soils was below 1% with a few going upto 2.99%. Exceptionally high mucky organic matter was found in Peat Soil as a natural deposition. C/N ratio was broad in general.
4. CEC was mainly dependent on clay content and may be also on the nature of clay and organic matter.
5. Base saturation degree was observed higher (>100%) in most of the Calcareous and Noncalcareous Floodplain Soils and also in Acid Sulphate Soil. The others had very low base saturation degree.
6. Phosphate adsorption percentage was rather low in all soils.
7. The available phosphorus content was very low in general, though there were some having considerable amounts, especially Noncalcareous and Calcareous Brown Floodplain and Noncalcareous and Calcareous Grey Floodplain Soils.

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