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Changes in soil properties of four agro-ecological zones of Tangail district in Bangladesh

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Abstract

This study was undertaken to investigate the changes in status of soil properties in four AEZs (AEZ 28, AEZ 9, AEZ 8 and AEZ 7) of Tangail district in Bangladesh over the span of the years. In 2017, the pH value of four AEZ was ranged from strongly acidic to slightly acidic but before 2000 it was strongly acidic to slightly alkaline. The present OM status was medium and before 2000 it was also medium. The present N status was very low, low, low and low, respectively but before 2000 it was low, medium, low and low, respectively. The present P status was low, low, low and very low, respectively in upland and low in wetland but before 2000 it was medium, medium, low and medium in upland and optimum, medium, medium and optimum in wetland, respectively. The present K status was medium, low, low and low in upland and medium, low, low and low in wetland, respectively but before 2000 it was optimum, high, high and optimum in upland and high, very high, very high and optimum in wet land, respectively. Under upland and wetland, the present S status was low, low, very low and low, respectively but before 2000 it was medium in all AEZ. The present Ca status was medium, medium, optimum and optimum, respectively but before 2000 it was optimum, high, high and high, respectively. The present Mg status was high, high, very high and very high, respectively but before 2000 it was medium in all AEZ. The Present Zn status was optimum, medium, low and low, respectively but before 2000 it was medium very high, very high, very high and optimum, respectively. The present B status was low in all AEZ but before 2000 it was optimum, optimum, low and low, respectively. With few exceptions, the nutrient status of the study area was reducing day by day and it was less than optimum level which was not suitable for sustainable crop production.

Key words: AEZ, agriculture, soil properties, soil pH, organic matter

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Introduction

Soil is a dynamic, living, natural body and a key factor in the sustainability of terrestrial ecosystems (Fageria, 2002). It's a finite resource, meaning its loss and degradation is not recoverable within a human life span. As a core component of land resources, agricultural development and ecological sustainability, it is the basis for food, feed, fuel and fiber production and for many critical ecosystem services. It's therefore a highly valuable natural resource, yet it's often overlooked (FAO, 2015). The soils of Bangladesh have been formed from different kinds of parent materials and spread over three major physiographic units: (i) Northern and eastern hills of Tertiary formations, covering 12% of the total area; (ii) Pleistocene terraces of the Madhupur and Barind tracts, covering 8% of the total area; and (iii) Recent floodplains, occupying 80% of the country (Saheed, 1984). The whole of Bangladesh is divided into 30 Agro Ecological Zones (AEZ) on the basis of physiography, soil, depth and duration of seasonal flooding, and climate (FAO-UNDP, 1988). Soil is the main source of plant nutrients. It supplies at least 16 nutrient elements to plants (Rahman *et al.,* 2007). Soil reaction (pH), organic matter (OM) and different macro and micronutrients are the main determinants of soil fertility. OM is the key quality factor for retaining nutrients in soil and pH is the deciding factor for the availability of essential plant nutrients (Tyler and Olsson, 2001). The declining soil fertility followed by declining crop yields is the cause of imbalanced fertilizer application and nutrient mining (Foy and Withers, 1995). Optimum and balanced nutrient levels must be maintained for sustainable crop production. Amount of nutrients in the soils should be known in order to promote soil health, to predict potential crop productivity and to manage the soil environment for sustainable agriculture (Rahman and Ranamukhaarachch**,** 2003). The study was therefore carried out with the following objectives: (i) to know the status of the soil properties in four AEZ and (ii) to observe and compare the changes of soil properties status in four AEZs over the span of years.

Materials and Methods

Tangail district under Dhaka division with an area of 3424.39 km² lies between 24°01′ and 24°47′ North latitudes and between 89°44′ and 90°18′ East longitudes (Banglapedia, 2014). According to SRDI, Tangail is covered by four Agro-Ecological Zones (AEZs), namely Madhupur Tract (AEZ-28), Old Brahmaputra Floodplain (AEZ-9), Young Brahmaputra and Jamuna Floodplain (AEZ-8), Active Brahmaputra-Jamuna Floodplain (AEZ-7) and these AEZs were selected for the study. Total 49 soil samples were collected from different agricultural land. Among these samples twelve soil samples were collected from Madhupur Tract, fifteen soil samples were collected from Old BrahmaputraFloodplain, twelve soil samples were collected from Young Brahmaputra and Jamuna Floodplain and ten soil samples were collected from Active Brahmaputra-Jamuna Floodplain. These soils were categorized based on the land type of High Land (HL), Medium High Land (MHL), Medium Low Land (MLL), Low Land (LL) and Very Low Land (VLL). There was no HL found in Active Brahmaputra-Jamuna Floodplain, and no LL and VLL were found in these four AEZs. Soil samples were collected at the depth of 0-15cm for laboratory analysis. The collected soil samples (500 g) were air dried, grind and sieved for analysis.

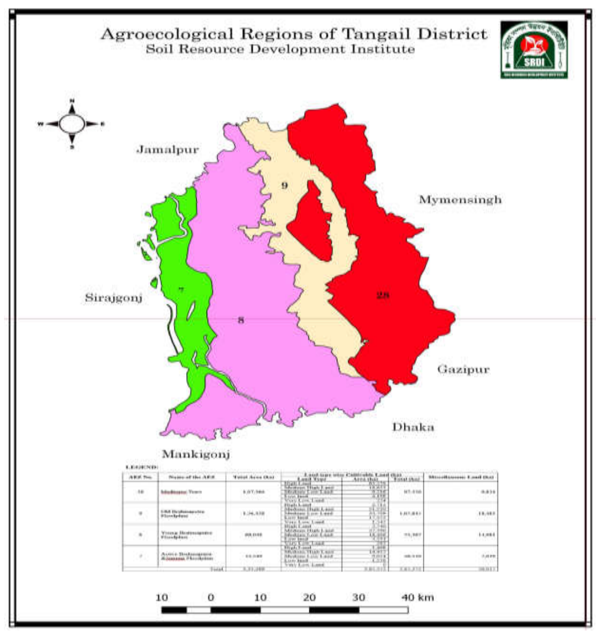

Figure 1. Map of the Study area (Source: SRDI, 2017)

In this study, the pH was determined by electrometric method (Davis and Freitas, 1970). The organic matter of the soil sample was measured titrimetrically according to Walkley and Black's wet oxidation method (Walkley and Black, 1934). Total N content of soil was determined by Micro Kjeldahl method. Available phosphorus was extracted from the soil by shaking with 0.03M NH4F – 0.025 M HCl solution at pH < 7.0following the method of Bray and Kurtz method (Bray and Kurtz, 1945). The available calcium

(Ca) and magnesium (Mg) contents were extracted by ammonium acetate extraction method and determined by Ethylene-di-amine tetra acetic acid titration, Zinc of the soil sample was determined by '0.1N HCl (hydrochloric acid) extraction' method (Huqand Alam, 2005). The available sulphur in soil was determined by calcium chloride extraction method. Available potassium in soil was determined by ammonium acetate extraction method (Satter and Rahman, 1987). Boron was determined by hot water extraction method using a dilute calcium chloride solution (Berger and Truog, 1939). The Microsoft Office Excel software was used to present and interpret the collected data.

Results and Discussion

Soil pH: In AEZ-28, pH status ranged from strongly acidic to slightly acidic (4.98-5.72). In 2017 the mean pH status of HL, MHL, MLL and the average was strongly acidic (5.20, 5.52, 5.27 and 5.33 respectively), on the contrary, before 2000 it was also strongly acidic (4.80, 5.27, 5.22 and 5.09 respectively) (Figure 2a). In AEZ-9, pH status ranged from strongly acidic to slightly acidic (5.05-6.38). In 2017 the mean pH status of HL, MHL, MLL and the average was slightly acidic (5.55, 5.58, 5.65 and 5.59 respectively), on the contrary, before 2000 it was strongly acidic to slightly acidic (6.20, 5.23, 4.79 and 5.40 respectively) (Figure 2b). In AEZ-8, pH status ranged from strongly acidic to slightly alkaline (5.5-7.90). In 2017 the mean pH status of HL, MHL, MLL and the average was strongly acidic to neutral (5.50, 6.64, 7.04 and 5.39 respectively), on the contrary, before 2000 it was slightly acidic to slightly alkaline (7.50, 6.82, 6.45 and 6.92 respectively) (Figure 2c). In AEZ-7, pH status ranged from slightly acidic to slightly alkaline (5.70-7.65). In 2017 the mean pH status of MHL, MLL and the average was slightly acidic to neutral (6.35, 6.68 and 6.51 respectively), on the other hand, before 2000 it was slightly alkaline (7.73, 7.60 and 7.66 respectively) (Figure 2d). From the study it can be said that soil acidity was increasing day by day that is threat for soil fertility and agricultural crop production. Soil pH ranges from 6.6-7.3 can be categorized as neutral soil and suitable for maximum agricultural crop production (BARC, 2012).

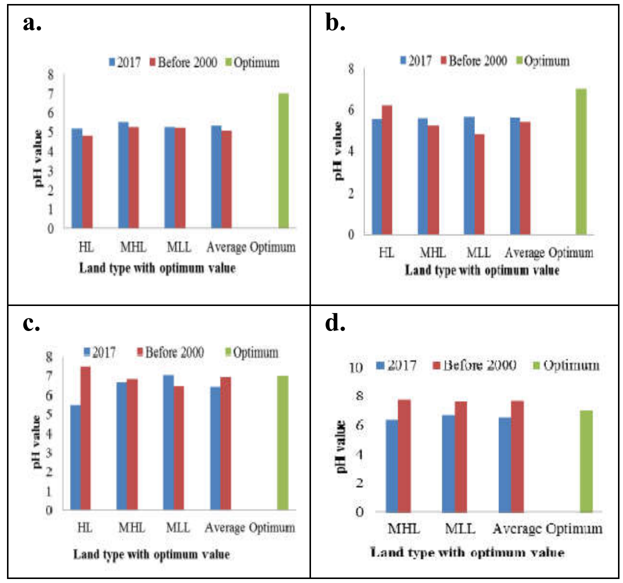

Figure 2. pH status of different zones; a. AEZ-28, b. AEZ-9, c. AEZ-8 and d. AEZ-7.

Organic Matter (OM): Under AEZ-28, organic matter status ranged from very low to medium (0.82-2.68 percent). In 2017 the mean organic matter status of HL, MHL, MLL and the average was low to medium (1.28, 1.53, 2.42 and 1.74 percent) respectively, on the contrary, before 2000 it was medium (1.89, 1.71, 2.30 and 1.96 percent) respectively (Figure 3a). In AEZ-9, organic matter status ranged from low to medium (1.44-2.82 percent). In 2017 the mean organic matter status of HL, MHL, MLL and the average was medium (1.95, 2.0, 2.12 and 2.02 percent) respectively, on the other hand, before 2000 it was low to medium (1.0, 2.32, 1.91 and 1.74 percent) respectively (Figure 3b). In AEZ-8, organic matter status ranged from very low to medium (1.23-2.94 percent). In 2017 the mean organic matter status of HL, MHL, MLL and the average was medium (2.13, 1.99, 1.81 and 1.97 percent) respectively, on the contrary, before 2000 it was medium (2.13, 1.99, 1.81 and 1.97 percent) respectively, on the contrary, before 2000 it was medium (1.96, 1.86, 2.18 and 2.0 percent) respectively

(Figure 3c). Under AEZ-7, organic matter status ranged from very low to medium (0.76-2.33 percent). In 2017 the mean organic matter status of MHL, MLL and the average was low to medium (2.0, 1.44 and 1.57 percent) respectively, on the other hand, before 2000 it was also low to medium (1.40, 1.75 and 1.57 percent) respectively (Figure 3d). Almost 5 percent organic matter should have present in a soil composition. About 3.4 percent organic matter is suitable for almost all agricultural crop production (BARC, 2012) but in all the land type of four AEZ, organic matter status ranged from very low to medium (0.76-2.94 percent) which is lower than optimum level and that was alarming for crop production.

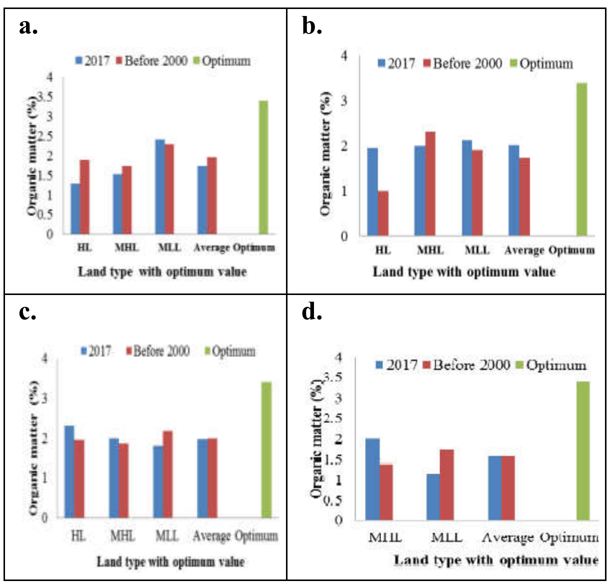

Figure 3. OM status of different zones; a. AEZ-28, b. AEZ-9, c. AEZ-8 and d. AEZ-7.

Total Nitrogen (N): Under AEZ-28, N status ranged from very low to low (0.04-0.13 percent). In 2017 the mean N status of HL, MHL, MLL and the average was very low, very low, low and very low (0.07, 0.07, 0.10 and 0.08 percent) respectively, on the contrary, before 2000 it was very low, very low, low and low (0.08, 0.09, 0.11 and 0.093 percent) respectively (Fig.4 a.). In AEZ-9, N status ranged from very low to low (0.07-0.11 percent). In 2017 the mean N status of HL, MHL, MLL and the average was low (0.10, 0.10, 0.11 and 0.11 percent) respectively, on the contrary, before 2000 it was low, medium, low and medium (0.13, 0.21, 0.14 and 0.183 percent) respectively (Figure 4b). Under AEZ-8, N status ranged from very low to low (0.06-0.14 percent). In 2017 the mean N status of HL, MHL, MLL and the average was low, low, very low and low (0.12, 0.10, 0.09 and 0.10 percent) respectively, on the contrary, before 2000 it was only low (0.14, 0.17, 0.16 and 0.15 percent respectively) in all the land types (Figure 4c). In AEZ-7, N status ranged from very low to low (0.12-0.02 percent). In 2017 the mean N status of MHL, MLL and the average was low, very low and very low (0.10, 0.06 and 0.08 percent) respectively, on the contrary, before 2000 it was also low (0.13, 0.17 and 0.16 percent respectively) in all the land types (Figure 4d).The above result was showed that, N status of the soil in the study area was decreased over the span of the years. Optimum value of nitrogen is 0.27 percent for agricultural land (BARC, 2012).

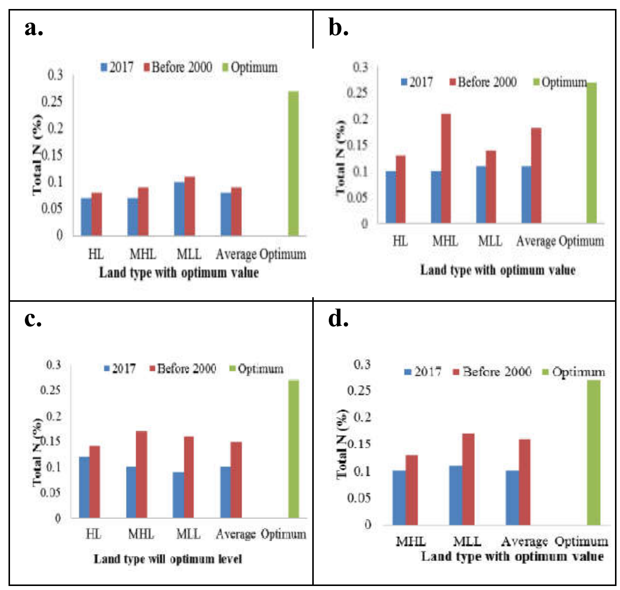

Figure 4. Total Nitrogen status of different zones; a. AEZ-28, b. AEZ-9, c. AEZ-8 and d. AEZ-7

Available Phosphorus (P): In AEZ-28, available P status ranged from very low to low (2.04-9.47µg/g soil). In 2017,under upland condition the mean P status of HL, MHL, MLL and the average was low, low, very low and low (5.97, 6.52, 3.80 and 5.83 µg/g soil) respectively, on the contrary, before 2000 it was medium (13.2, 12.53, 12.28 and 12.61 µg/g soil) respectively in all land types. Under wetland condition, in 2017 the mean P status of HL, MHL, MLL and the average was low, on the contrary, before 2000 it was optimum low in all land types (Figure 5a). In AEZ-9, available P status ranged from very low to low (2.18-23.52 µg/g soil). In 2017, under upland condition the mean P status of HL, MHL, MLL and the average was low (10.20, 9.90, 9.05and 9.44 µg/g soil)respectively, in all land types, on the contrary,before 2000 it was medium, medium, low and medium (22.0, 15.11, 14.72 and 17.27 µg/g soil) respectively. Under wetland condition, in 2017 the mean P status of HL, MHL, MLL and theaverage was low in all land types; on the contrary, before 2000 it was optimum, medium, medium and medium respectively (Figure 5b). In AEZ-8, available P status ranged from very low to high (2.09-24.25 µg/g soil). In 2017,under upland condition the mean P status of HL, MHL, MLL and the average was low, low, very low and low (11.19, 9.08, 3.72 and 7.99 µg/g soil respectively), on the contrary, before 2000 it was low, optimum, low and low (14.0, 17.42, 11.91 and 14.44 µg/g soil) respectively. Under wetland condition, in 2017 the mean P status of HL, MHL, MLL and the average was low, low, very low and low respectively; on the contrary, before 2000 it was medium, medium, low and medium respectively (Figure 5c). In AEZ-7, available P status ranged from very low to low (2.63-8.73 µg/g soil).In 2017, under upland condition and wetland condition the mean P status of MHL, MLL and the average was low, low and very low (11.33, 3.08 and 7.20 µg/g soil) respectively, on the contrary, before 2000 under upland condition it was medium (19.30, 18.66 and 18.98 µg/g soil) respectively and under wetland condition it was optimum in all land types (Figure 5d). For upland condition, optimum value of available phosphorus is 15.76 (µg/g soil) and for wetland condition optimum value is 11.26 (µg/g soil) (BARC, 2012). From this study it can be said that available phosphorus status of four AEZ were decreasing day by day which is threat for agricultural crop production.

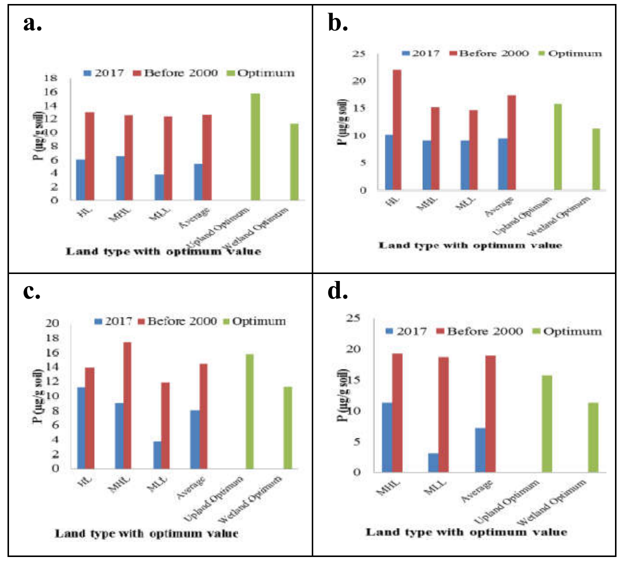

Figure 5. Available Phosphorus status of different zones; a. AEZ-28, b. AEZ-9, c. AEZ-8 and d. AEZ-7.

Potassium (K)**:** In AEZ-28, K status ranged from low to optimum (0.10-0.30 meq/100g soil). In 2017, under upland condition the mean K status of HL, MHL, MLL and the average was medium, medium, low and medium (0.21, 0.19, 0.17 and 0.19 meq/100g soil) respectively, on the contrary, before 2000 it was high, optimum, optimum and optimum (0.41, 0.32, 0.33 and 0.35 meq/100g soil) respectively. Under wetland condition, the mean K status of HL, MHL, MLL and the average was medium in all land types; on the contrary, before 2000 it was very high, high, high and high respectively (Figure 6a). In AEZ-9, K status ranged from very low to high (0.08-0.40 meq/100g soil). In 2017, under upland condition the mean K status of HL, MHL, MLL and the average was low, medium, low and low (0.16, 0.19, 0.14 and 0.16 meq/100g soil) respectively, on the contrary, before 2000 it was optimum to high (0.21, 0.34, 0.42 and 0.32 meq/100g soil) respectively. Under wetland condition, the mean K status of HL, MHL, MLL and the average was medium, medium, low and medium; on the contrary, before 2000 it was medium, high, very high and very high (Figure 6b). In AEZ-8, K status ranged from low to optimum (0.11-0.24 meq/100g soil). In 2017, under upland condition and wetland condition the mean K status of HL, MHL, MLL and the average was low (0.11, 0.15, 0.14 and 0.13 meq/100g soil) respectively, in all land types, on the other hand, before 2000, under upland condition it was very high, medium, medium and high (0.77, 0.24, 0.27 and 0.42 meq/100g soil) respectively and under wetland condition it was very high, optimum, optimum and very high respectively (Figure 6c).In AEZ-7, K status ranged from very low to high (0.08-0.40 meq/100g soil). In 2017, under uplandcondition and wetland condition the mean K status of MHL, MLL and the average was low (0.12, 0.14 and 0.13meq/100g soil) respectively, on the contrary, before 2000, under upland condition it was optimum (0.32, 0.29 and 0.30meq/100g soil) respectively in all land types and under wetland condition it was high,optimum and optimum respectively (Figure 6d). For upland condition, optimum value of potassium is 0.271 (meq/100g soil) and for wetland condition optimum value is 0.226 (meq/100g soil)) (BARC, 2012).

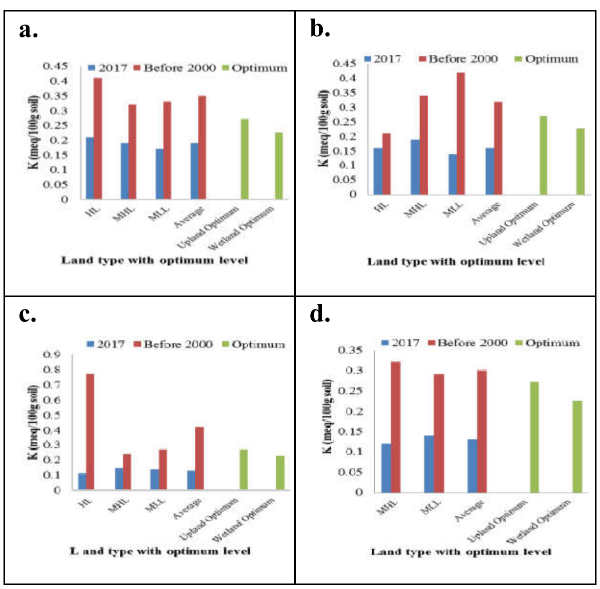

Figure 6. Potassium status of different zones; a. AEZ-28, b. AEZ-9, c. AEZ-8 and d. AEZ-7.

This study showed that K status of the soil in four AEZ was decreased rapidly over the span of the years.

Sulfur (S): In AEZ-28, S status ranged from very low to medium (4.68-22.23 µg/g soil). In 2017, under upland condition and wetland condition the mean S status of HL, MHL, MLL and the average was low, very low, low and low (11.37, 6.06, 14.60 and 10.67 µg/g soil) respectively, on the contrary, before 2000, under upland condition it wasmedium, medium, optimum and medium (17.06, 17.42, 24.75 and 19.74 µg/g soil) respectively and under wetland condition it was low, low, medium and medium respectively (Figure 7a). In AEZ-9, S status ranged from very low to medium (4.18-20.02 µg/g soil). In 2017, under upland condition the mean S status of HL, MHL, MLL and the average was low, very low, low and low (13.74, 7.08, 8.20 and 9.67 µg/g soil) respectively, on the contrary, before 2000 it was low medium, optimum and medium (12.0, 16.80, 29.09 and 19.29 µg/g soil) respectively. Under wetland condition, the mean S status of HL, MHL, MLL and the average was low, very low, very low and low; on the contrary, before 2000 it was low, lowoptimum and medium respectively (Figure 7b). Under AEZ-8, S status ranged from very low to low (3.70-9.74 µg/g soil). In 2017, under upland condition the mean S status of HL, MHL, MLL and the average was very low, very low, low and very low (4.62, 6.20, 8.96 and 6.59 µg/g soil) respectively, on the contrary, before 2000 it was medium, medium, optimum and medium (22.0, 15.28, 23.45 and 20.24 µg/g soil) respectively. Under wetland condition, the mean S status of HL, MHL, MLL and the average was very low in all land types; on the contrary, before 2000 it was medium, low, medium and medium respectively (Figure 7c). In AEZ-7, S statusranged from low to medium (7.66-5.75 µg/g soil). In 2017, under upland condition and wetland condition the mean S status of MHL, MLL and the average was low (10.0, 11.28 and 10.64µg/g soil) respectively, on the contrary, before 2000 it was medium (21.53, 20.41 and 20.97 µg/g soil) respectively in all land types (Figure 7d). For upland condition, optimum value of S is 22.51 (µg/gsoil) and for wetland condition optimum value is 27.1 (µg/gsoil) for an agricultural land (BARC, 2012). Above study showed that S status of thesoil in four AEZ except HL of AEZ-9 were reduced over the span of the year.

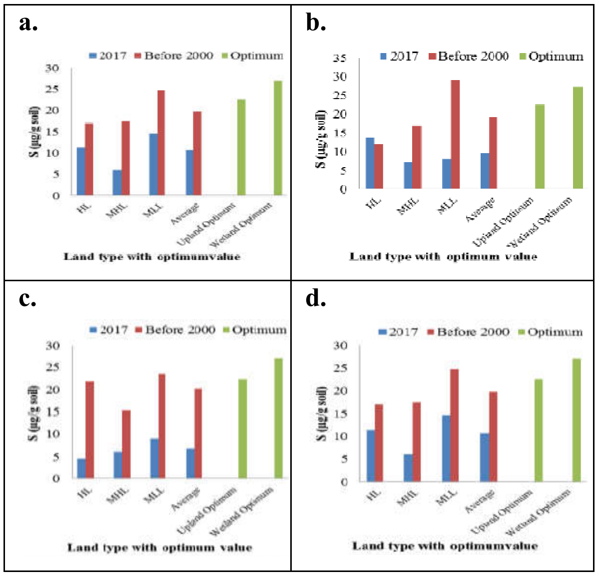

Figure 7. Sulfur status of different zones; a. AEZ-28, b. AEZ-9, c. AEZ-8 and d. AEZ-7.

Calcium (Ca): Under AEZ-28, Castatus ranged from low to high (2.05-6.54 meq/100g soil). In 2017, the mean Ca status of HL, MHL, MLL and the average was medium, low, medium and medium (4.44, 2.63, 3.40 and 3.39 meq/100g soil) respectively, on the contrary, before 2000 it was medium, optimum, optimum and optimum (3.58, 4.92, 5.52 and 4.67 meq/100g soil) respectively (Figure 8a). In AEZ-9, Castatus ranged from low to high (2.30-6.45 meq/100g soil). In 2017, the mean Ca status of HL, MHL, MLL and the average was low, optimum, optimum and medium (2.66, 5.44, 4.82 and 4.28 meq/100g soil) respectively, on the contrary, before 2000 it was medium, high, high and high (4.91, 6.98, 6.63 and 6.17 meq/100g soil) respectively (Figure 8b).Under AEZ-8, Castatus ranged from low to very high (2.50-10.49meq/100g soil). In 2017 the mean Ca status of HL, MHL, MLL and the average was low, high, high and optimum (2.50, 7.31, 6.85 and 5.55meq/100g soil) respectively, on the contrary, before 2000 it was medium, high, very high and high (3.7, 7.37, 8.26 and 6.44 meq/100g soil) respectively (Figure 8c).Under AEZ-7, Castatus ranged from medium to very high (2.50-7.67 meq/100g soil). In 2017 the mean Ca status of MHL, MLL and the average was high, optimum and optimum (6.05, 4.7 and 5.37 meq/100g soil) respectively, on the on the other hand, before 2000 it was high, very high and high (6.78, 7.08 and 6.93 meq/100g soil) respectively (Figure 8d).

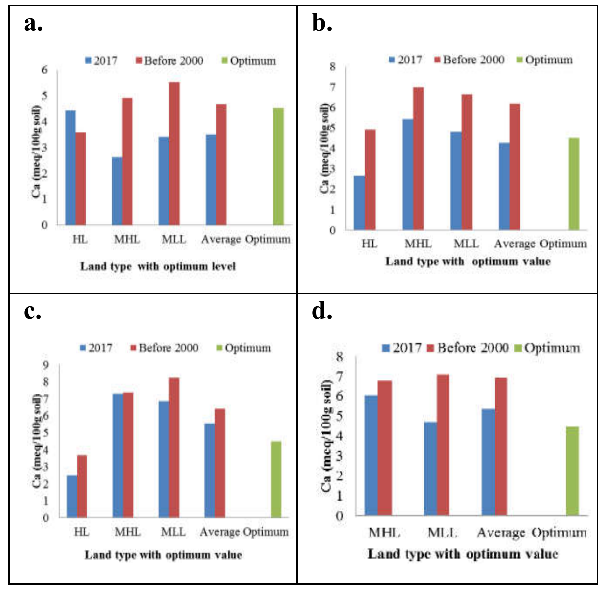

Figure 8. Calcium status of different zones; a. AEZ-28, b. AEZ-9, c. AEZ-8 and d. AEZ-7.

The above result was showed that, Ca status of the soil was decreased slowly over the span of the years. Optimum value of Ca is 4.51 (meq/100g soil) for agricultural crop production (BARC, 2012).

Magnesium (Mg): Under AEZ-28, Mg status ranged from low to very high (0.72-2.26 meq/100g soil). In 2017 the mean Mg status of HL, MHL, MLL and the average was high, high, optimum and high (1.59, 1.60, 1.37 and 1.52 meq/100g soil) respectively, on the contrary, before 2000 it was high, high, very high and very high (1.77, 1.67, 2.21 and 1.88 meq/100g soil) respectively (Figure 9a). In AEZ-9, Mg status ranged from medium to very high (1.02-2.37 meq/100g soil). In 2017 the mean Mg status of HL, MHL, MLL and the average was medium, very high, very high and high (1.02, 2.0, 2.02 and 1.68 meq/100g soil) respectively, on the contrary, before 2000 it was only very high (3.5, 4.52, 4.65 and 4.22 meq/100g soil respectively) in the all land types (Figure 9b). In AEZ-8, Mg status ranged from medium to very high (0.94-2.45 meq/100g soil). In 2017 the mean Mg status of HL, MHL, MLL and the average was medium, very high, very high and very high (9.05, 2.23, 2.17 and 1.78 meq/100g soil) respectively, on the contrary, before 2000 it was only very high (2.50, 4.45, 4.54 and 3.83 meq/100g soil respectively) in the all land types (Figure 9c).In AEZ-7, Mg status ranged from optimum to very high (1.31-2.42 meq/100g soil). In 2017 the mean Mg status of MHL, MLL and the average was very high, high and very high (2.28, 1.85 and 2.06 meq/100g soil) respectively, on the other hand, before 2000 it was only very high (2.90, 2.95 and 2.92 meq/100g soil respectively) in the all land types (Figure 9d).From this study it can be said that, Mg status of soil in the study area was sufficient for crop production but decreased over the span of the years. Optimum value of Mg is 1.12 (meq/100g soil) for agricultural crop production (BARC, 2012).

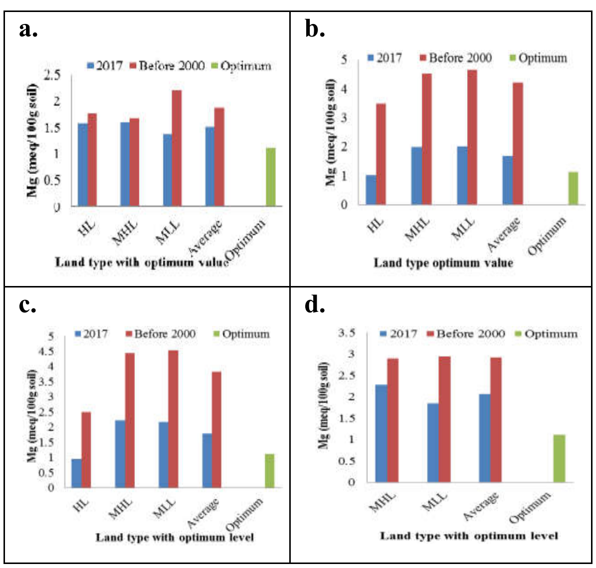

Figure 9. Magnesium status of different zones; a. AEZ-28, b. AEZ-9, c. AEZ-8 and d. AEZ-7.

***Zinc (Zn)*:** Under AEZ-28, Zn status ranged from low to very high (0.52-2.86 µg/g soil). In 2017 the mean Zn status of HL, MHL, MLL and the average was medium, high, medium and optimum (0.91, 1.98, 1.34 and 1.41 µg/g soil) respectively, on the contrary, before 2000 it was high, high, very high and very high (2.13, 1.82, 2.92 and 2.29 µg/g soil) respectively (Figure 10a). In AEZ-9, Zn status ranged from very low to very high (0.39-3.06 µg/g soil). In 2017 the mean Zn status of HL, MHL, MLL and the average was low, medium, medium and medium (0.67, 1.28, 1.0 and 0.98 µg/g soil) respectively, on the contrary, before 2000 it was very high, optimum, optimum and very high (4.20, 1.37, 1.38 and 2.31 µg/g soil) respectively (Figure 10b). In AEZ-8, Zn status ranged from very low to very high (0.41-3.37 µg/g soil). In 2017 the mean Zn status of HL, MHL, MLL and the average was low, medium, low and low (0.84, 0.97, 0.68 and 0.83 µg/g soil) respectively, on the contrary, before 2000 it was only very high (5.6, 2.42, 2.57 and 3.53 µg/g soil) respectively in all land types (Figure10c). Under AEZ-7, Zn status ranged from medium to optimum (0.24-1.44 µg/g soil).

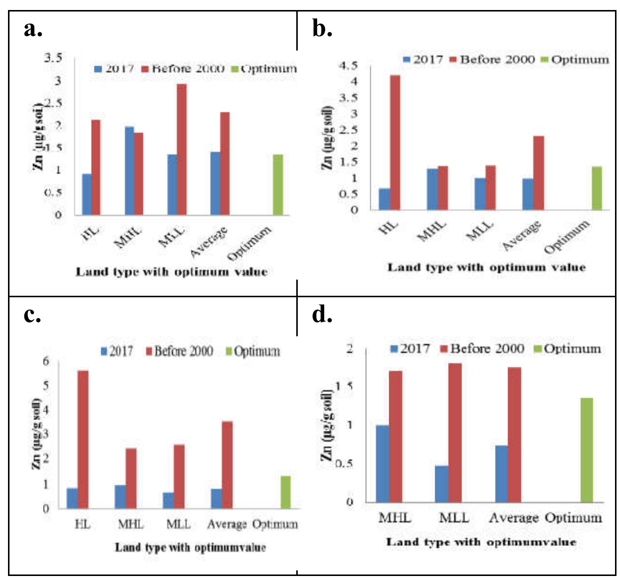

Figure10. Zinc status of different zones; a. AEZ-28, b. AEZ-9, c. AEZ-8 and d. AEZ-7.

In 2017 the mean Zn status of MHL, MLL and the average was medium, low and low (1.0, 0.48 and 0.74 µg/g soil) respectively, on the contrary, before 2000 it was optimum, high and optimum (1.7, 1.81 and 1.75 µg/g soil) respectively (Figure 10d). Uddin *et al*., (2016) conducted study on Zn estimation in soils where the contents were higher in industrial waste mixed soils than municipal soils and control soils. From this study it can be said that Zn status of soil in four AEZ was changing that means Zn status was reduced day by day which is alarming for future. Optimum value of Zn is 1.12 (µg/g soil) for agricultural crop production (BARC, 2012).

Boron (B): Under AEZ-28, B status ranged from low to medium (0.19-0.35 µg/g soil). In 2017 the mean B status of HL, MHL, MLL and the average was low (0.25, 0.25, 0.27 and 0.26 µg/g soil) respectively, on the contrary, before 2000 it was optimum (0.59, 0.59, 0.55 and 0.57 µg/g soil) respectively, in all land types (Fig.11 a.).In AEZ-9, B status ranged from low to medium (0.18-0.42µg/g soil). In 2017 the mean B status of HL, MHL, MLL and the average was medium, low, low and low (0.35, 0.28, 0.24 and 0.29 µg/g soil) respectively, on the contrary, before 2000 it was optimum, optimum, high and optimum (0.53, 0.47, 0.61 and 0.50µg/g soil) respectively (Fig.11 b.). In AEZ-8, B status ranged from low to medium (0.21-0.34 µg/g soil). In 2017 the mean B status of HL, MHL, MLL and the average was low (0.25, 0.28, 0.26 and 0.26 µg/g soil) respectively, in all land types, on the other hand, before 2000 it was optimum, low, low and low (0.49, 0.28, 0.29 and 0.27 µg/g soil) respectively (Fig. 11 c.).In AEZ-7, B status ranged from very low to medium (0.11-0.32 µg/g soil). In 2017 the mean B status of MHL, MLL and the average was low (0.20, 0.22, and 0.21µg/g soil) respectively on the other hand, before 2000 it was low (0.22, 0.23, and 0.22µg/g soil) respectively, in all land types (Fig.11 d.). Islam *et al.* (2017) reported that Cr and Pb concentration are not detected in soil used in brick kilns area. The above result was showed that, B status of the soil in the study area was reduced over the span of the years. Optimum value of B is 0.45 µg/g soil for agricultural land (BARC, 2012).

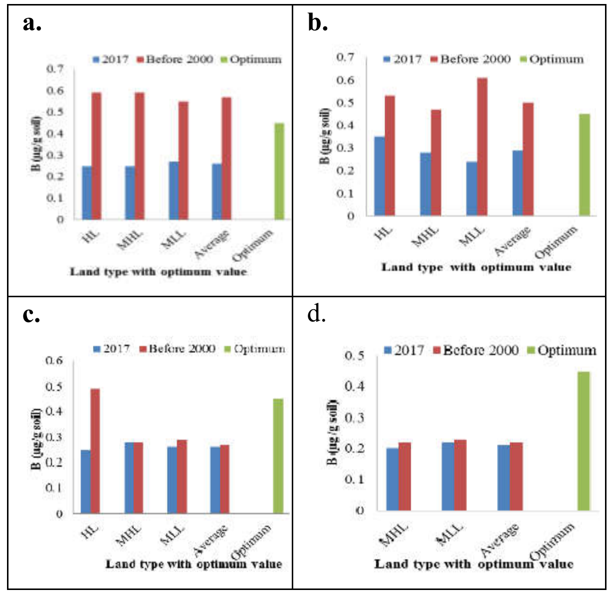

Figure11. Boron status of different zones; a. AEZ-28, b. AEZ-9, c. AEZ-8 and d. AEZ-7.

Conclusion and Recommendations

This study showed that the pH of four AEZ was ranged from strongly acidic to slightly acidic but before 2000 it was strongly acidic to slightly alkaline. The study revealed that soil acidity of four AEZ was increasing day by day. Present OM status of four AEZ was medium and before 2000 it was also medium but these values was lower than optimum value. Present N status of four AEZ was very low, low, low and low respectively, before 2000 it was low, medium, low and low respectively. Present P status was low, low, low and very low in upland and low in wetland respectively, before 2000 it was medium, medium, low and medium under upland and in wetland optimum, medium, medium and optimum respectively. Present K status was medium, low, low and low in upland and under wetland it was medium, low, low and low respectively, before 2000 it was optimum, high, high and optimum in upland and high, very high, very high and optimum in wet land respectively. In 2017, under upland and wetland condition, S status of four AEZ was low, low, very low and low respectively, before 2000 it was medium respectively. Optimum value of S for upland is 22.51. Present Ca status was medium, medium, optimum and optimum respectively, before 2000 it was optimum, high, high and high respectively. Present Mg status was high, high, very high and very high respectively, before 2000 it was medium in all AEZs. Present Zn status was optimum, medium, low and low respectively, before 2000 it was medium, very high, very high, very high and optimum respectively. Present B status was low respectively, before 2000 it was optimum, optimum, low and low respectively. From the evaluation of the results, it can be stated that most of the soil nutrients status of the study areas were reducing day by day and also below the optimum level that is threat for agricultural crop production. This might be due to imbalanced used of fertilizer, intensive crop cultivation, temperature rising due to climate change etc. Soil organic matter status should be enriched by incorporating well decomposed cow dung, compost, vermi-compost,farmyard manure (FYM) and green manure to the soil of the study area. To ensure sustainable agriculture and friendly environment, a set of best management practices (soil testing, location specific and cropping pattern based fertilizer recommendations and maintenance of optimum OM status as priority) should be recognized and promoted to the farmers.

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