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EFFECTS OF SALINITY ON SOIL PROPERTIES OF COASTAL AREAS OF BAGERHAT AND PIROJPUR DISTRICTS

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Abstract

A study was conducted to observe the soil properties under naturally occurring saline soil conditions in Bagerhat and Pirojpur. Soil samples at 0-20 cm depth were collected from Bagerhat sadar and Khachua upazila under Bagerhat district and Projpur sadar and Nazirpur upazila under Projpur district. Observations were made on soil pH, organic matter, cation exchange capacity (CEC), electrical conductivity (EC), exchangeable sodium percentage (ESP), total N, available P, S and exchangeable K, Ca, Na and Mg contents. Result indicates that pH value ranged from 6.70 to 7.40 and 6.60 to 7.79, organic matter 1.75 to 3.61% and 1.57 to 2.90 %, total N 0.11 to 0.18% and 0.08 to 0.97 %, available P 7.40 to 39.18 mg/kg and 2.92 to 23.40 mg/kg and 0.20 to 1.04%, available S 15.53 to 66.82 mg/kg and 3.50 to 35.53 mg/kg in Bagerhat and Pirojpur districts, respectively. In Bagerhat and Pirojpur districts, EC varied from 2.84 to 7.10 ds/m and 1.16 to 4.90 ds/m, CEC 9.77 to 36.35 and 10.34 to 48.70 meq100g^{-1} soils, exchangeable Na 0.62 to 2.80 meq100g^{-1} soil and 0.75 to 2.11 meq100g^{-1} soil, exchangeable K 4.20 to 22.68 meq100g^{-1}soil and 3.64 to 41.04 meq100g^{-1} soil, exchangeable Ca 0.84 to 8.37 meq100g^{-1} and 0.80 to 17.82 meq100g^{-1}, exchangeable Mg 0.13 to 0.60 meq100g^{-1} soil 0.17 to 0.38 meq100g^{-1} soil and ESP 4.36 to 11.72 and 3.12 to 7.34, respectively. In Bagerhat, a positive significant correlation of CEC was found with total N, K, EC, Na, K, Ca and Mg contents. In Pirojpur, a negative significant correlation of CEC was found with OM, S and Na contents. The paired shows that S, EC, CEC, K, Ca and ESP will significant between the two locations. These results would be useful for predicting crop production and varietal response to soil nutrient conditions and developing fertilizer management in the coastal areas of Bangladesh.

Keywords: CEC, EC, OM, Salinity, Soil nutrients

Introduction

A number of environmental issues and problems are hindering the development of coastal livelihood of Bangladesh. Salinity is one of them, which is expected to be aggravated by climate change and sea level rise and eventually which affects crop production. Bangladesh has 147,570 km^2 land area that includes 710 km coastal line

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along the Bay of Bengal equivalent to 47,201 km^2 areas (Alam *et al*., 2017). The cultivable land covers 59% in which 16% area is under rice cultivation (Ahmed, 2011). Salinity has serious negative impacts on agriculture (Hossain, 2009) which otherwise may enhance crop production and national economy. In Bangladesh about 0.883 million hectares of the arable lands, which constitutes about 52.8 percent of the net cultivable area in 64 Upazilas of 13 districts, are affected by varying degrees of soil salinity (Alam *et al*., 2017). A recent study indicates that the salinity affected area has increased from 8,330 km^2 in 1973 to 10,560 km^2 in 2009 (Soil Resource Development Institute (Mahmuduzzaman *et al*., 2014). In shrimp cultivation area soil salinity gradually increased since 1990. This salinization accelerates which may be due to the effect of saline water flooding for long period, slow permeability, presence of highly saline ground water at shallower depth (SRDI, 2018). Tidal flooding occurs during wet season (June-October), direct inundation by saline water and upward on lateral movement of saline ground water during the dry season (November-May) (Alam *et al*., 2017). In addition, cyclone and tidal surge is accelerating this problem (Abedin, 2010). Most of the river water remains saline throughout the year and is not suitable for irrigation (SRDI, 2020). The saline water as irrigation in the coastal areas reduces the growth of most agricultural crops (Murtaza *et al.*, 2006). Liang *et al.*, (2005) also stated soil salinization is one of the most serious types of land degradation as well as and a major obstacle to the optimal utilization of land resources.

Salt affected area are estimated approximately 952 million ha and this area is increasing year after year all over the world including Bangladesh (Wang *et al.,* 2012). Degraded in respect to salinization is around 1.02 million ha which amounts to 6.9% of the geographical area of the country (SRDI, 2020). Soil with an electrical conductivity of saturation extracts above 4 dS m^{-1} is called saline soil (Flowers and Yeo, 1995). Soil salinity (electrical conductivity: EC > 4 dS m^{-1}) is a major abiotic stress which limits plant growth and development, causing yield loss in crop species (Corwin and Yemoto, 2017). Salt-affected soils are identified by excessive levels of water-soluble salts, especially sodium chloride (NaCl) (Tanji, 2002). Salinity causes decline in the crop productivity and yield of the crop which results in severe degradation of bio-environment and ecology (Hoque *et al.*, 2013) which is responsible for low cropping intensity in coastal area (SRDI, 2020).

In an indirect way, soil salinization can abruptly affect plant growth, due to destruction of the soil configuration and its consequent compacting. This occurs due to a dispersion of the clay particles caused by substitution of the calcium (Ca^{2+}) and magnesium (Mg^{2+}) ions present in the complex by sodium (Na^+), resulting in an increase in soil solidity, which is, in the percentage of exchangeable sodium (PES), that, in the last instance, is the main factor responsible for the deterioration of the physical properties of salt-affected soils. The excessive amounts of salts provided by irrigation waters can have adverse effects on the chemical and physical properties of the soils and on their biological processes (SRDI, 2020). These effects include mineralization of the carbon (C) and nitrogen (N) and the enzymatic activity, which is crucial for the decomposition of organic matter and release of the nutrients necessary for sustainability of the production (Wong *et al.*, 2008). In addition, the agricultural practices can increase or reduce the microbial population, thus altering the activity, source and persistence of the enzymes in the soil. (Gupta *et al*., 2022).

Research has been carried out on naturally occurring saline soils, and the detrimental influence of salinity on the microbial communities of soil and their activities reported in the majority of studies (Sardinha *et al*., 2003). Increase in salinity intrusion and increase in soil salinity will have critically bad impacts on agriculture. The aim of the present study was therefore, to study the soil properties in the south west coastal soils of Bangladesh.

Materials and Methods

Study area

The south western coastal zone is covered by the Sundarban's mangrove forest, covering greater Khulna. Greater Khulna district consists of 9 (nine) Upazilas. Out of them two upazillas namely Bagerhat sadar and Kachua were selected as study area. In Pirojpur district 2 (two) upazillas were selected, namely, Pirojpur sadar and Nazirpur as study areas. From each upazilla (3) three unions were identified for the study. 8 (eight) land sides agriculture field and 4 (four) river sides agriculture field were selected as study sites

Bagerhat District (Khulna division) comprises an area of about 3959.11 square kilometer (sq. km), locates in between 21°49' and 22°59' North latitudes and in between 89°32' and 89°98' East longitudes. It is bounded by Gopalganj and Narail districts on the North, The Bay of Bengal on the South, Gopalganj, Pirojpur and Barguna districts on the East, Khulna district on the West. Kachua is located at 22°39′00″N 89°53′00″E/ 22.6500°N 89.8833°E/22.6500; 89.8833. It has a total area of about 131.62 sq. km.

Pirojpur District comprises with an area of about 1307.6 sq. km, is a district in south-western Bangladesh. It is bounded by Gopalganj and Barisal districts on the north, Barguna district on the south, Jhalokati district on the east, Bagerhat district on the west. Geographically the study area falls in between 22.576475 N 89.9896735 E. Pirojpur (Town) stands on the bank of the Damodor river. Nazirpur Upazila is located in between 22°40' and 22°52' north latitudes and in between 89°52' and 90°03' east longitudes. It has a total area of about 233.63 sq. km.

The study sites are highlighted in Figure 1and 2. The areas lied at 0.9 to 2.1 m above mean sea level. Soil characteristics of the western coastal zone were silty loams or alluvium.

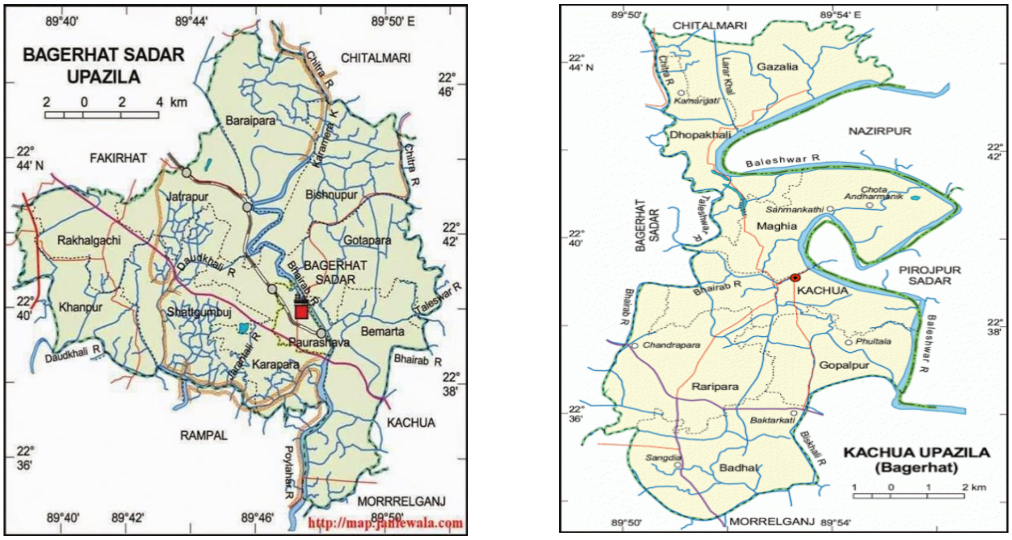

Fig. 1. Study area at Karapara,Gotapara and Bagerhat Sadar in Bagerhat sadar Upazilla and Badhal, Kachua Sadar and Raripara in Kachua Upazilla.

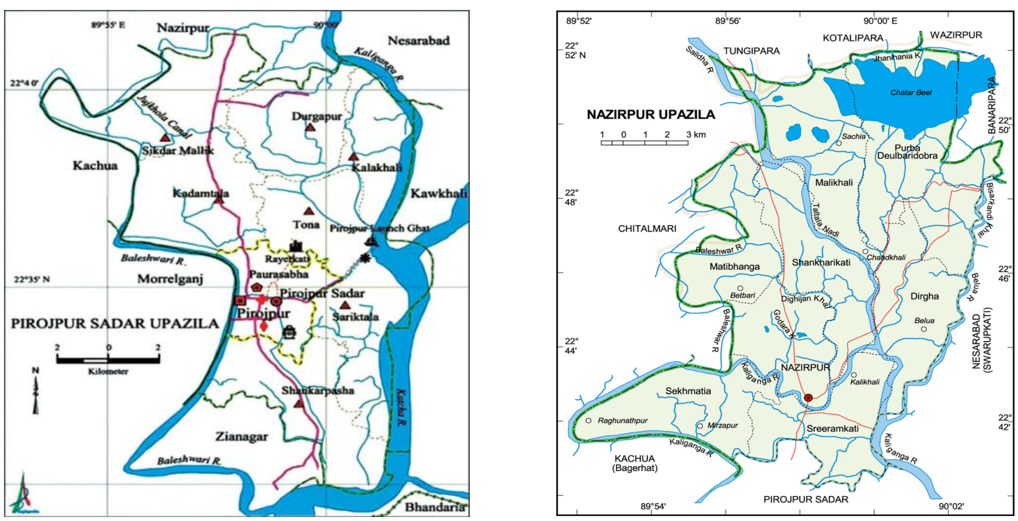

Fig. 2. Study area at Shankorpasa, Pourosova and Sariktola dumuritola in Pirojpur sadar upazilla and Sheikhmatia, Siramkathi and Mativanga in Nazirpur upazilla.

Soil sample collection

Systematic random sampling techniques were used for sample collection from different paddy fields. Soil samples were collected from 0-20 cm depth. A total number of 12 samples (with 3 replications for each sample) were collected to determine soil salinity and fertility status. Samples were collected from 15-16 March, 2020. Global

Positioning System (GPS) was used to record the absolute positions of collected samples (Table 1). For soil samples, a transparent polythene bags were used to preserve the samples and each bag was labeled. About 1kg of soil was collected from each place to prepare a representative sample. Samples were placed in sealed polythene bags that were labeled to avoid any damage. The level contained the name of the places, date of collection and code number of soil sample. Samples were dried in laboratory at room temperature (25 ºC) for 20 days and then ground. The ground samples were then sieved through a 20-mesh sieve (< 2 mm diameter) to make the samples suitable for chemical analyses (Petersen, 2002). The labeled samples were analyzed in the central lab of the Soil Resource Development Institute, Dhaka, Bangladesh.

Table 1. Sampling locations in the study area

Site No.	Sample no.	Sampling Station	Latitude	Longitude
Site 1	S_1	Karapara, Bagerhat Sadar, (Agriculture field)	22º39´49˝N	89º46´16˝E
Site 2	S_2	Gotapara, Bagerhat (Agriculture field)	22º39´59.748˝N	89º50´47.682˝E
Site 3	S_3	Bemorta, Bagerhat Sadar (River bank agriculture field)	22º63´16˝N	89º82´24˝E
Site 4	S_4	Badhal, Kachua (Agriculture field)	22º38´33.37962˝N	89º51´30.02828˝E
Site 5	S_5	Sadar, Kachua (Agriculture field)	22º38´10.96476˝N	89º51´37.08216˝E
Site 6	S_6	Raripara, Kachua (River bank agriculture field)	22º36´0.57107˝N	89º50´6.97538˝E
Site 7	S_7	Shankorpasa, Pirojpur (Agriculture field)	22º32´3.42144˝N	89º57´20.34396˝E
Site 8	S_8	Pourosova , Pirojpur Sadar (Agriculture field)	22º35´2.77814˝N	90º1´31.74766˝E
Site 9	S_9	Sariktola dumuritola, Pirojpur (River bank agriculture field)	22º34´50.73542˝N	90º1´32.00696˝E
Site 10	S_{10}	Siramkathi, Nazirpur (Agriculture field)	22º42´13.824˝ N	89º57´56.124˝ E
Site 11	S_{11}	Sheikhmatia, Nazirpur (Agriculture field)	22º43´29.028˝ N	89º 54´42.66˝ E
Site 12	S_{12}	Mativanga, Nazirpur (River bank agriculture field)	22º42´13.86˝ N	89º 57´56.16˝ E

Soil analysis

Soil pH was determined by glass electrode pH meter as described by Jackson, (1962) with soil water ratios of 1:2.5. Soil electrical conductivity (EC) was measured with the EM-38 instrument, a conductivity meter (Rhoades, 1982) and with four-electrode techniques in field plots having salinity adjusted to different levels but uniform with depth and organic carbon was determined by wet-oxidation method Walkley and Black, (1934) as modified by Allison, (1965). The organic matter was obtained by multiplying the content of organic carbon by Van Bemmelen, factor of 1.73 Page *et al.* (1982). Total N was determined by micro-Kjeldahl digestion by using $CuSO_4$-$NaSO_4$ catalyst mixture was used to determine total N. The ammonia (NH_3) from the digestion was distilled with 40% NaOH into 5% Boric acid and determined by titrating with 0.01 N H_2SO_4 (Jackson, 1973). Available P in the soil sample was measured colorimetrically by the phospho-vanadomolybdate method (Hanson, 1950). Consentration of exchangeable K, Ca and Mg of the soil samples were determined after the soil by mixing 10 milliliters of 1 normal, pH-7, ammonium acetate with a 1 gram scoop of air-dried soil sample and shaking for 5 minutes, the filtered extract is analyzed with an inductively coupled plasma atomic emission spectrometer (ICP-AES) (Chintala *et al*., 2014). For both soil sample; Na was determined by flame emission spectrophotometer and S was determined by turbid metric method with the help of a spectrophotometer. CEC was reported as milliequivalents per 100 grams of soil (meq/100g) Reganold and Harsh, (1985). The ESP is an already familiar ion-exchange parameter: the exchangeable sodium equivalent fraction multiplied by 100. A common alternative parameter is the exchangeable sodium ratio (ESR) also found. (Bleam, 2017). Data were analyzed with SPSS 26.0 and correlation among soil properties were performed with Microsoft Office Excel spreadsheet.

Results and Discussion

Determination of chemical properties of soil

The pH, OM and the concentration of total N, available P and S in soil different soil samples of Bagerhat district varied significantly (Table 2). In Bagerhat, the highest pH value was (7.40) found in S_6 sample and the lowest (6.70) was found S_1 sample which is statistically similar with S_2, S_3, S_4 and S_5 samples. In Pirojpur, the pH value ranged from 6.60 to 7.79 with a mean of 7.16. The highest pH value (7.97) found in S_{10} sample and the lowest (6.70) was found in soil sample S_7. The concentrations of soil nutrients (e.g., organic C, N, P, and K) are good indicators of soil quality and productivity because of their favorable effects on the physical, chemical, and biological properties of soil (Cao *et al*., 2011). Saline soils vary widely in their physical and chemical properties as well as hydrology (Ikehashi and Ponnamperuma, 1978). The pH of the present study corroborates with some other studies (Uddin *et al*., 2014).

In Bagerhat, the OM concentration of soil samples ranged from 1.75 to 3.61% with a mean of 2.47%. The highest OM was found in S_{11} and lowest was recorded in S_7 soil sample. In Pirojpur, the OM range of soil sample was from 1.57 to 2.90 % with a mean of 2.12%. The highest OM found in S_7 sample and the lowest was recorded in S_{11} soil sample.

Although the results represent OM content at considerable status in some of the study areas but it was not the case for every sample location. Hossain (2001) reported that the low OM content of soils in Bangladesh is one of the most serious threats to the sustainability of agriculture and application of OM improves crop growth and yield. The low OM content in Bangladesh soils may be due to the rapid decomposition of OM because of tropical monsoon climate, rapid removal of mineralized products through leaching and crop removal, high cropping intensity and low return of crop residues to the soil (Karim and Iqbal, 2001).

The total N in the studied soils ranged from 0.11 to 0.18% in Bagerhat district and the maximum content of total N was found in S_3, S_4, S_5 and S_6 whereas the minimum was found in S_1 which is statistically similar to S_2. The highest total N (0.97 %) was found in S_8 whereas the lowest (0.08) was found in S_7 in Pirojpur. Soil N content was low in the study area (M = 0.08, Table 2) (Chowdhury *et al*., 2011). Nitrogen status in the studied soils was less fertile and farmers need to use different organic and inorganic fertilizers in paddy fields. The result of the present study showed similarities with several researches, as of Islam *et al*., (2014) and Maliwal, and Somani, (2010) found most soils had very low amounts of total N. Like other tropical and subtropical soils, Bangladesh soils have long been categorized as poor in soil N fertility because of low N supplying capacity (Islam, 1983). Patcharapreecha *et al.,* (1989) reported that total N contents in saline soils (0.005-0.043%) were very low in all the soils they studied. Several studies have shown that salinity reduces N uptake (Al-Rawahy *et.al.*, 1992) by crops and do not support plant growth due to a higher osmotic pressure in the plant soil system (Bhumbla, 1977) despite adequate nutrient levels being available in the soil. Nitrogen availability in wet soils prevailing in the saline areas is sensitive to various environmental factors, including air temperature, water tables, flooding periods and soil properties (Ehrenfeld and Yu, 2012).

Available P content of soils varied from 39.18 mg/kg (S_1 sample) to 7.40 mg/kg (S_4 sample). In Bagerhat, the concentration of available P was highest in S_1 (39.18 mg/kg) and that of the lowest in S_4 (7.40 mg/kg). However, the mean of total concentration of P of the samples was 19.01 mg/kg. In case of Pirojpur, the concentration of available P was highest in S_8 sample (23.4 mg/kg) and that of the lowest in S_9 sample (2.92 mg/kg) whereas, the mean of total concentration of P was 13.85 mg/kg. available P in soils are classified in four groups such as low (< 12), medium (12.1-24.00), high (24.0-30.00) and very high (> 30.0) (Chowdhury *et al.,* 2011). The critical limit for P in Bangladesh soils is considered to be 10.0 mg/kg for neutral and calcareous soils and 7.0 mg /kg for acid soils (FRG, 2018). Thus, the concentration of % of total P were very low (Tables 3 and 6) in study area according to BARC (2018) and Chowdhury *et al*., (2011) who reported that 41% of the soils of Bangladesh contained P below the critical level and 35% of the soils contained P in between the critical level the optimum level. The P content in soils depends largely on the application of fertilizers for agricultural practices and it present in soil as solid phase with varying degree of solubility. When water soluble P is added to the soil, it is converted very quickly to insoluble solid phase by reacting with soil constituents. These may include calcium (Olsen, 1953), Fe and Al oxides (Dean and Rubin, 1947) and partly OM. The added P is more likely to be absorbed on hydrated Fe and Al oxides or on the edge of the clay minerals in neutral to acidic range of soils (Russell, 1988). These reactions affect the availability of P and as a result of these reactions, a very small amount of total P is present in soil solution at any time reflected by soil testing. However, a low to medium range of available P in soils of the under-study area may be mostly affected by previous fertilization, pH, OM content, texture, various soil management and agronomic practices (Verma *et. al*., 2005).

In Bagerhat, S content ranged from 15.5 to 66.82 mg/kg with an average content of 38.71 mg/kg, whereas the highest S (66.82 mg/kg) was recorded in S_2 sample (Table-2) and the lowest (15.53 mg/kg) in S_1 sample. In Pirojpur, the total S content ranged from 3.5 to 35.5 % with an average content of 16.83 mg/kg, whereas the highest amount (35.5 %) was found in S_{10} sample and lowest amount (3.50 mg/kg) in S_9 sample. Except coastal saline areas, most soils in Bangladesh react to K and S. The critical limits of S are 0.12 meq/100 g soil and 10 mg/kg soil. Considering these critical limits, coastal soils usually have higher concentrations of S than its corresponding critical limits (Huq and Shoaib, 2013).

Table 2. Soil nutrient content (%) in different soil samples from Bagerhat district

Sample no.	pH	Organic matter (%)	Total N (%)	Available P	S
				(mg/kg)	
S_1	6.70b	1.75f	0.11b	39.18a	15.53f
S_2	6.90b	1.95e	0.13b	11.60e	66.82a
S_3	6.80b	2.15d	0.18a	22.68b	45.92c
S_4	6.93b	2.89b	0.18a	7.40f	37.23d
S_5	6.87b	3.61a	0.18a	12.47d	16.83e
S_6	7.40a	2.52c	0.18a	20.73c	49.92b
Mean	6.94	2.47	0.16	19.01	38.71
CV (%)	2.01	3.05	10.59	0.14	0.95

Note: S_1 =Karapara, Bagerhat Sador (agriculture field) S_2=Gotapara, Bagerhat (Agriculture field), S_3= Bemorta, Bagerhat Sadar (River bank Agriculture field). S_4= Badhal, Kachua (Agriculture field), S_5= Sador, Kachua (Agriculture field) and S_6= Raripara, Kachua (River bank Agriculture field)

Table 3. Soil nutrient content (%) in different soils samples from Pirojpur district

Sample no.	pH	Organic Matter (%)	Total N (%)	Available P	S
				(mg/kg)	
S_7	6.60e	2.90a	0.19b	8.60e	25.15b
S_8	6.80d	1.96d	0.97a	23.40a	19.60c
S_9	6.70de	2.37b	0.12c	2.92f	3.50f
S_{10}	7.97a	2.05c	0.12c	20.02b	35.53a
S_{11}	7.80b	1.57f	0.08d	11.37d	6.57e
S_{12}	7.12c	1.84e	0.09cd	16.80c	10.50d
Mean	7.16	2.12	0.21	13.85	16.81
CV (%)	1.19	0.45	0.033	0.75	1.92

Note: S_7= Shankorpasa, Pirojpur (Agriculture field), S_8= Pourosova, Pirojpur Sadar (Agriculture field), S_9= Sariktoladumuritola, Pirojpur (River bank agriculture field), S_{10}=Siramkathi, Nazirpur (Agriculture field), S_{11}= Sheikhmatia, Nazirpur& S_{12}= Mativanga, Nazirpur (River bank agriculture field)

The EC, CEC, exchangeable Na, K, Ca, Mg and ESP value of different soil sample varied significantly (Table 4). Results of the present study Result showed that in Bagerhat, the highest EC value recorded in S_3 and S_5 samples (7.10 ds/m) and the lowest was recorded S_4 samples (2.84 ds/m) which is statistically similar with S_1 samples with a mean EC value of 4.68 ds/m. In Pirojpur, the highest EC value was recorded in S_{12} sample (4.90 ds/m) and the lowest was recorded in S_8 sample (1.61 ds/m) with a mean value of EC 3.19 ds/m. The higher EC values means transpiration of salts in this area with negligible surface runoff. Instead evaporation of surface and groundwater at shallow depth leave behind the salts which appear as encrustation on soils. On the other hand, lower values of EC were recorded for upstream and topographically higher areas can be attributed to the rolling topography, relatively higher gradient, seasonal irrigation and alternating cropping patterns. About 33% of studied soil samples were saline according to the acceptable range as indicated by Allotey *et.al.*, (2009) and Indonesian Agency for Agricultural Research and Development, Indonesia and NSW Department of Primary Industries, Australia (2008). Almost similar findings were reported by Uddin and Islam (1998) in different coastal agricultural saline soils. Soil EC is a measure of the amount of salts in soil (salinity of soil). It is an important indicator of soil health and it affects crop yields, crop suitability, plant nutrient availability, and activity of soil microorganisms which influence key soil processes including the emission of greenhouse gases such as N oxides, methane, and carbon dioxide (Smith and Doran, 1996).

The mean value of CEC was 20.7 meq100g^{-1}and the highest CEC was recorded in S_3 sample (36.4 meq100g^{-1}) and the lowest was recorded in S_2 sample (9.77 meq100g^{-1}) in Bagerhat. In case of Pirojpur, the mean value of CEC was 37.99 meq100g^{-1} and the highest was recorded in S_{11} sample (48.7 meq100g^{-1}) and the lowest was recorded in S_7 sample (10.34 meq100g^{-1}). CEC is a fundamental soil property used to predict plant nutrient availability and retention in the soil. It is the potential of available nutrient supply, not a direct measurement of available nutrients (Barker, *et al.*, 2017).

In Bagerhat, the total amount of exchangeable Na was found highest in S_{11} sample (2.8 meq100g^{-1}) and that of the lowest in S_7 sample (0.62 meq100g^{-1}) with an average of 1.42 meq100g^{-1}. The total amount of exchangeable sodium was found highest in S_{10} sample (2.11 meq100g^{-1}) and that of the lowest was recorded in S_7 sample (0.75 meq100g^{-1}) in Pirojpur. Incase of Bagerhat, the highest amount of exchangeable K was observed in S_3 sample (22.68 meq100g^{-1}) and the lowest in S_1 sample (4.20 meq100g^{-1}) with an average of 12.7 meq100g^{-1}. In Pirojpur, the highest amount of exchangeable K was observed in S_{10} sample (41.04 meq100g^{-1}) and the lowest was recorded in S_7 sample (3.64 meq100g^{-1}) with an average of 12.7 meq100g^{-1}. Adequate level of exchangeable K in the study area may be attributed to the prevalence of K-rich clay minerals like Illite and Kaolinite. Besides farmers use of different types of organic and inorganic fertilizers that include K containing fertilizers (BARC, 2018; Islam *et.al.*,1985), the decomposition of the minerals containing K are mentionable worthy reasons of increasing K in saline soils (Sharpley,1989). However, K can be found rich in saline soils (Maliwal and Somani, 2010).

Calcium (Ca) is the predominant positively charged ion (Ca^{++}) held on soil clay and OM particles. Soils normally have large amounts of exchangeable Ca (300-5000 ppm). Exchangeable Ca of soils collected from Bagerhat area ranged from 0.84 to 8.37 meq100g^{-1} soil with an average content of 4.45 meq100g^{-1} soil. In Pirojpur, exchangeable Ca ranged from 0.80 to 17.82 meq100g^{-1} soil with an average content of 8.33 meq100g^{-1} soil. Other reports also show low soil Ca content in the different soil samples in the saline areas (BARC 2018; Chowdhury *et al*., 2011). This lower Ca content may be attributed to changes in osmotic and ion-specific effects that can produce imbalances in plant nutrients, including deficiencies of several nutrients or excessive levels of Na^+ (Kaya *et.al*., 2001).

Table 4. Chemical properties of different soil samples from Bagerhat district

Sample no.			Exchangeable cations (meq^{-1}100 g soil)				
	EC	CEC	Na	K	Ca	Mg	ESP
S_1	2.96e	9.77c	0.62e	4.20f	1.11d	0.24c	6.41d
S_2	3.20c	11.47c	1.33c	7.38d	0.93e	0.23c	11.72a
S_3	7.10a	36.35a	2.80a	22.68a	7.97b	0.50b	7.71c
S_4	2.84e	9.80c	0.80de	6.83e	0.84f	0.13c	8.22b
S_5	7.10a	27.58b	1.20cd	15.81c	8.37a	0.60a	4.36e
S_6	4.90b	29.14b	1.80b	19.39b	7.48c	0.47b	6.18d
Mean	4.68	20.68	1.42	12.71	4.45	0.36	7.43
CV (%)	0.82	6.73	6.63	0.55	1.49	7.23	7.16

Note: S_1 =Karapara, Bagerhat Sador (agriculture field) S_2=Gotapara, Bagerhat (Agriculture field), S_3= Bemorta, Bagerhat Sadar (River bank agriculture field). S_4= Badhal, Kachua (Agriculture field), S_5= Sador, Kachua (Agriculture field) and S_6= Raripara, Kachua (River bank agriculture field). EC=Electrical conductivity. CEC=Cation Exchange Capacity, ESP= Exchangeable sodium percentage.

In case of Bagerhat, the highest amount of exchangeable Mg was found in S_5 sample (0.60 meq100g^{-1} soil) and the lowest in S_4 sample (0.13 meq100g^{-1} soil) (Table 4).

In case of Pirojpur the highest amount of exchangeable Mg was found in S_8 sample (0.38 meq^{-1}100 g soil) and the lowest in S_{11} sample (0.17 meq^{-1}100 g soil). Mg content was very low in soil samples of Pirojpur district (Table 5). Similarly Mg content was low in soil sample of Bagerhat district (Table 5). Similar results were also recorded in the study of Chowdhury *et. al.,* (2011). Differences in osmotic and ion-specific effects as found in saline soils resulted in the imbalances in plant nutrients that caused nutrient deficiencies in soil (Kaya *et al.,* 2001). Mg is located both in clay minerals and associated with cation exchange sites on clay surfaces. The primary and secondary minerals are important sources of Mg for plant nutrition, especially in unfertilized soil. But plant-available Mg concentrations cannot be accurately predicted based only on the parent material composition due to differences in mineral weathering rates and leaching (Chowdhury *et. al*., 2011).

The highest ESP value was observed in S_2 sample (11.72) and the lowest in S_5 sample (4.36) in Bagerhat. The highest ESP value was observed in S_1 sample (7.34) which was statistically similar with S_4 sample and the lowest in S_3 sample (3.12) in Pirojpur. When the values of ESP in soils are greater than 15, the soils are said sodic soils and considered as problem soils (Osman, 2013). All collected soil samples were in the category of non-sodic as ESP was found to be less than the critical sodicity values. Highly significant positive relationship of CEC with clay content and CEC has already been observed by several authors (Wang *et al.*, 2005). The positive relationship between clay content and exchangeable Ca and Mg may be the resultant effects of negatively charged sites of clays which adsorb positively charged ions (Mckenzie *et. al.*, 2004).

Table 5. Chemical properties of different soil samples from Pirojpur district

Sample no.			Exchangeable cations (meq^{-1}100 g soil)				
	EC	CEC	Na	K	Ca	Mg	ESP
S_7	2.18d	10.34e	0.75e	3.64e	0.80f	0.35b	7.34a
S_8	1.61f	47.77ab	1.62c	33.03d	10.34c	0.38a	3.39bc
S_9	2.12e	46.40bc	1.45d	23.18d	17.82a	0.35b	3.12c
S_{10}	4.29b	29.47d	2.11a	23.98d	3.06e	0.32c	7.16a
S_{11}	4.06c	48.70a	1.83b	41.04a	5.66d	0.17e	3.77bc
S_{12}	4.90a	45.29c	1.92b	30.84c	12.31b	0.22d	4.25b
Mean	3.19	37.99	1.61	25.95	8.33	0.29	4.83
CV (%)	0.66	2.58	3.017	2.72	2.82	4.99	10.33

Note: S_7= Shankorpasa, Pirojpur (Agriculture field), S_8= Pourosova, PirojpurSadar (Agriculture field), S_9= Sariktoladumuritola, Pirojpur (River bank agricure field), S_{10}=Siramkathi, Nagirpur (Agriculture field), S_{11}= Sheikhmatia, Nazirpur& S_{12}= Mativanga, Nazirpur (River bank agriculture field. EC=Electrical conductivity. CEC=Cation Exchange Capacity, ESP= Exchangeable sodium percentage.

Correlation

The correlations among the studied parameters were done to observe the relationship. In Bagerhat, in case of EC the positive significant relation was found with total N, total K, CEC, exchangeable Na, exchangeable K, exchangeable Ca and exchangeable Mg whereas the negative non-significant relation was found with total P and ESP (Tabel-6). In CEC the positive significant relation was found with total N, total K and EC exchangeable Na, exchangeable K, exchangeable Ca and exchangeable Mg whereas the negative non-significant relation was found with total P and ESP (Tabel-6).

In Pirojpur, in case of EC, the positive significant relation was found with total pH and CEC whereas the significant negative relation was found with OM, N, K, S and Ca. In CEC, the negative significant relation was found with total OM, total S and exchangeable Na whereas the significant positive relation was found with exchangeable Ca (Tabel-8). These results were in conformity with the results reported by several researchers (Pan *et.al.*,2013; Eltaib, 2003).

Table 6. Correlation in different field and riverbank field soil of Bagerhat district

	pH	OM (%)	N	P	K	S	EC	CEC	Na	K	Ca	Mg	ESP
pH	1												
OM (%)	.206	1											
N	.293	.613**	1										
P	-.237	-.608**	-.510*	1									
K	.174	.449	.459	.032	1								
S	.375	-.367	.072	-.412	-.189	1							
EC	.030	.464	.543*	-.078	.933**	-.159	1						
CEC	.219	.274	.625**	.002	.890**	.057	.916**	1					
Na	.174	.449	.459	.032	1.000**	-.189	.933**	.890**	1				
K	.360	.269	.657**	-.083	.832**	.178	.867**	.982**	.832**	1			
Ca	.301	.468	.616**	-.031	.960**	-.112	.939**	.956**	.960**	.932**	1		
Mg	.170	-.112	.436	-.024	.563*	.442	.671**	.824**	.563*	.852**	.660**	1	
ESP	.007	-.442	-.336	-.242	-.503*	.646**	-.419	-.369	-.503*	-.290	-.497*	.181	1

Note: OM=Organic Matter, EC=Electrical conductivity. CEC=Cation Exchange Capacity, ESP= Exchangeable sodium percentage.

Table 7. Correlation of different soils sample of Pirojpur District, Bangladesh

	pH	OM (%)	N	P	K	S	EC	CEC	Na	K	Ca	Mg	ESP
pH	1												
OM (%)	-.649**	1											
N	-.359	-.059	1										
P	.345	-.466	.582*	1									
K	-.573*	.669**	.541*	.055	1								
S	.255	.308	.166	.537*	.426	1							
EC	.733**	-.572*	-.622**	.220	-.773**	.027	1						
CEC	.167	-.793**	.214	.152	-.363	-.671**	.151	1					
Na	-.567*	.667**	.539*	.040	.997**	.411	-.783**	-.355	1				
K	.507*	-.969**	.167	.369	-.576*	-.451	.382	.898**	-.570*	1			
Ca	-.373	-.207	.105	-.244	.074	-.719**	-.160	.726**	.081	.360	1		
Mg	.760**	-.850**	-.086	.533*	-.451	.004	.689**	.616**	-.454	.764**	.192	1	
ESP	.208	.512*	-.286	.094	.214	.815**	.161	-.896**	.203	-.682**	-.801**	-.231	1

Note: OM=Organic Matter, EC=Electrical conductivity. CEC=Cation Exchange Capacity, ESP= Exchangeable sodium percentage.

Paired t-test

In pair sample t test of studied parameters of both Bagerhat and Pirojpur soils, S, EC, CEC, exchangeable K, exchangeable Ca and ESP were found significant while other parameters did not vary significantly (Table-8).

Table 8. Soil nutrient content (%) in different field and riverbank field soils from Bagerhat and Pirojpur districts

		Mean	T value	Significance
pH	Bagerhat	6.93	-1.735	NS
	Pirojpur	7.16		
OM (%)	Bagerhat	2.47	1.503	NS
	Pirojpur	2.11		
N (%)	Bagerhat	.16	-1.242	NS
	Pirojpur	.26		
P	Bagerhat	19.00	1.354	NS
	Pirojpur	13.85		
K	Bagerhat	.36	1.143	NS
	Pirojpur	.29		
S	Bagerhat	38.70	4.103	**
	Pirojpur	16.80		
EC	Bagerhat	4.68	2.955	**
	Pirojpur	3.19		
CEC	Bagerhat	20.68	-6.501	**
	Pirojpur	37.99		
Na	Bagerhat	.36	1.121	NS
	Pirojpur	.29		
K	Bagerhat	12.71	-5.161	**
	Pirojpur	25.95		
Ca	Bagerhat	4.45	-3.423	. **
	Pirojpur	8.33		
Mg	Bagerhat	1.42	-.939	NS
	Pirojpur	1.61		
ESP	Bagerhat	7.43	3.082	**
	Pirojpur	4.83		

Conclusion

Coastal field soils and Riverbank agriculture field soils of Bagerhat district in Bangladesh can be characterized as nearly neutral to basic in soil reaction (pH ranged 6.70 to 7.40%) and soil salinity fell in low to medium (EC ranged 2.84 from 7.10). Soils of Shankorpasa, Pirojpur (Agriculture field), Pourosova, Pirojpur Sadar (Agriculture field) and Sariktoladumuritola, Pirojpur (River bank agriculture field), can be characterized as slightly acidic to basic (pH ranged 6.60 to 7.8), EC low to normal range (EC ranged from 1.16 to 4.90) in soil reaction. The OM level of both districts exhibited lower to medium than good agricultural soil (OM ranged 1.75 to 3.61% and 1.57 to 2.90 %).The soils of Bagerhat district showed low concentrations of total N, available P, exchangeable Ca, low exchangeable Mg and high level of exchangeable K. In Piropur district total N, K, S concentrations were low and exchangeable K and Ca was medium to high. In Bagerhat, CEC had positive significant relation with total N, total K, EC, exchangeable Na, K, Ca and Mg. In Pirojpur, CEC had the significant positive relation with pH, OM, total N, K, exchangeable Na and exchangeable Ca. Further investigation can be performed to justify these significant correlations between chemical characteristics of soil.

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Conflicts of Interest

The authors declare no conflicts of interest regarding publication of this manuscript.

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