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Relationship between Soil Salinity and Physico-chemical Properties of Paddy Field Soils of Jhilwanja Union, Cox's Bazar, Bangladesh

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Abstract

This study attempts to examine the relationship between soil salinity and physico-chemical properties of paddy field soils of Jhilwanja union in Cox's Bazar, Bangladesh. Data were analyzed by the help of Statistical Package for the Social Sciences (SPSS: version-18) and study area map was prepared by Arc GIS 9.3 software. Present investigation reveals that soil textural class ranged from sandy to loam, a mean bulk density 1.58 g/cm^3, and high soil temperature (M = 31.55). Soils were moderately acidic to basic and soil salinity (EC) content comes under low to medium (minimum = 3.10 dS/m, maximum = 7. 24 dS/m) range. The organic matter level exhibited absolutely lower (M = 0.75) than good agricultural soil. Soils of the area represents low in total N (M = 0.08), very low in total P content (M = 0.06), exchangeable Ca (M = 0.0009) were too low and lower content of exchangeable Mg (M = 0.26), but high level of exchangeable K (M = 0.57) content. Simple regression analysis showed that there was a significant effect of soil salinity on soil pH, soil temperature, OM, total N, total P, exchangeable K and Mg. Repairing coastal embankment (rubber dam), cultivating native high yielding variety, using organic fertilizer, implementing Integrated Soil Nutrient Management (ISNM) and adapting Integrated Coastal Zone Management (ICZM) can increase crop production and soil fertility level in study area.

Keywords: soil salinity, physico-chemical properties, paddy field, Jhilwanja union Cox's Bazar, Bangladesh

1. 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 aggravate by climate change and sea level rise and eventually affect food production. Bangladesh has 147,570 km^2 land area that includes 710 km coastal line along the Bay of Bengal (Bangladesh Bureau of Statistics [BBS], 2003). Agriculture is the major sector of national economy. Total coastal zone has 47,201 km^2 areas (Islam, Razzaque, Rahman, & Karim, 2004). The cultivable land covers 59% in which 16% of area is under rice cultivation (Ahmed, 2011). Salinity has serious negative impacts on agriculture (Hossain, 2009). 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 (Karim, Hossain, & Ahmed, 1990). 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 [SRDI], 2010). 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) (Haque, 2006). In addition, cyclone and tidal surge is accelerating this problem (Abedin, 2010). In the coastal areas of Bangladesh, saline water is used for irrigation which reduces the growth of most agricultural crops (Murtaza, Ghafoor, & Qadir, 2006). 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 (Liang, Si, Nikolic, Peng, & Chen, 2005). Approximately 952 million ha are estimated to be salt affected and this area is increasing year after year all over the world (Wang, Wu, Xie, Liu, & Cui, 2012). 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 (Qadir, Oster, Schubert, Noble, & Sahrawat, 2007). Salt-affected soils are identified by excessive levels of water-soluble salts, especially sodium chloride (NaCl) (Tanji, 2002). Salinity is causing decline in soil productivity and crop yield which results in severe degradation of bio-environment and ecology (Hoque, Saika, Sarder, & Biswas, 2013) as well as responsible for low cropping intensity in coastal area (Rahman & Ahsan, 2001).

Rice (*Oryza sativa* L. spp. *indica*) is one of the five main carbohydrate crops responsible for feeding the world's population including Asian countries and more than 3 billion people which comprises 50%-80% of their daily calorie intake from rice (Khush, 2005). Rice has previously been reported as salt susceptible in both seedling (Munns &Tester, 2008), and reproductive stages (Moradi & Ismail, 2007) leading to a reduction of more than 50% in yield when exposed to 6.65 dSm^{-1} ECe (Zeng & Shannon, 2000). Ali (2005) investigated the loss of rice production in a village of Satkhira district (a salinity affected area) where loss of rice production was 69% in the year of 1985 to 2003.

Cox's Bazar district is vulnerable to cyclones, tidal surges, tidal & flash flood, earthquake and other natural calamities (BBS, 2001). From the year 1960 to 1995, seven major cyclones hit whole district. The most devastating cyclone of the last century hit Cox's Bazar in November 1970. In 1991, another deadly cyclone hit there (United Nations Office for Project Services [UNOPS], 2008). The paddy field also become saline because it contact with the sea water and continues to be inundated during high tides and ingress of sea water through river & creeks in Cox's Bazar. As a result salinization process accelerates and reducing soil fertility. Farmers are changing agricultural practices and reducing crop cultivation. The objectives of this study were to determine the level of soil salinity and assessing current soil fertility status of paddy fields and recommend some measures to reduce salinization process to improve soil fertility status in Jhilwanja union of Cox's Bazar district of Bangladesh. Intensive researches on soil salinity have reported the adverse effects of salinity on the physical and chemical properties of soils and on plant growth and yield (Kahlown & Azam, 2003). But there is limited research on the relationship between soil salinity and physico-chemical properties of paddy field soils and prediction their effects. This study attempted to focus to fill that research gap.

2. Study Area

Cox's Bazar is a coastal district and natural combination of hill and sea. Cox's Bazar Sadar has 10 Unions, 140 villages and 40 Mahallas, Jhilwanja union is one of them (District Statistics, 2011; BBS, 2013). Jhilwanja union lies between 21º28′ and 21º30′ N latitudes and between 91º58′ and 92º02′ E longitudes (Map 1). *Population*; total population of Jhilwanja union is 79,203 and population density 2,579/km^2. *Topography;* Total area of Jhilwanja union is 2913ha and hilly forest area cover 1515.38 ha (25%), high land 10%, medium high land 50% and medium low land 15% of total area of this union. *Soil characteristics*: soil pH ranges 4.5-5.7, soil texture is silt, soil salinity ranges 0-12 dS/m, soil pattern is complex due to local differences in sand, silt and clay contents of the underlying sedimentary rock, moderately fertile soil with low organic matter content, moisture holding capacity is poor and moderately suitable for agricultural crops due to hilly forest land. *Agricultural activities;* about 30% people are directly or indirectly depends on agriculture and they cultivate paddy, potato, pulse, onion, garlic, ginger, betel leaf, betel nut, wheat, sugarcane, ground nut, tobacco, rubber and vegetables, (Municipal Manuel, 2013 ; BBS, 2001).

3. Methods

3.1 Soil Sample Collection

Spot method and random sampling techniques were used for sample collection from different paddy fields. Soil samples were collected from 0-15 cm depth. A total number of 11 samples were collected to determine surface soil salinity and fertility status. Samples were collected and analyzed from November 2015 to April 2015. 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 labelled. 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 (Hesse, 1971; Petersen, 2002). The labeled samples were analyzed in the environmental lab of the Department of Geography and Environmental Studies and Department of Soil Science, University of Chittagong, Bangladesh.

Table 1. Sampling location of the study area

Site No.	Sample no.	Sampling Station	GPS value
Site 1	S1	Kolatoli Hill (Valley area)	21°24′50.9″-91°59′13.2″
Site 2	S2	South Kolatoli Hill (Valley area)	21°24′22.2″-91°59′30.7″
Site 3	S3	Chondrica (Valley area)	21°24′50.8″-91°59′18.5″
Site 4	S4	Police Line (Valley area)	21°25′09.3″-91°59′31.3″
Site 5	S5	College Area (Plain area)	21°25′23.4″-92°01′2.5″
Site 6	S6	Janar Gona (Plain area)	21°25′40.4″-92°01′71″
Site 7	S7	Chandro Pahar (Plain area)	21°25′42.5″-92°01′9.9″
Site 8	S8	South Rubber Dam (Plain area)	21°26′2.6″-92°01′10.7″
Site 9	S9	North Rubber Dam (Plain area)	21°26′7.7″-92°01′12.8″
Site 10	S10	Khurulia (Plain area)	21°25′52.3″-92°01′44.6″
Site 11	S11	Link Road (Plain area)	21°25′6.6″-92°01′38.8″

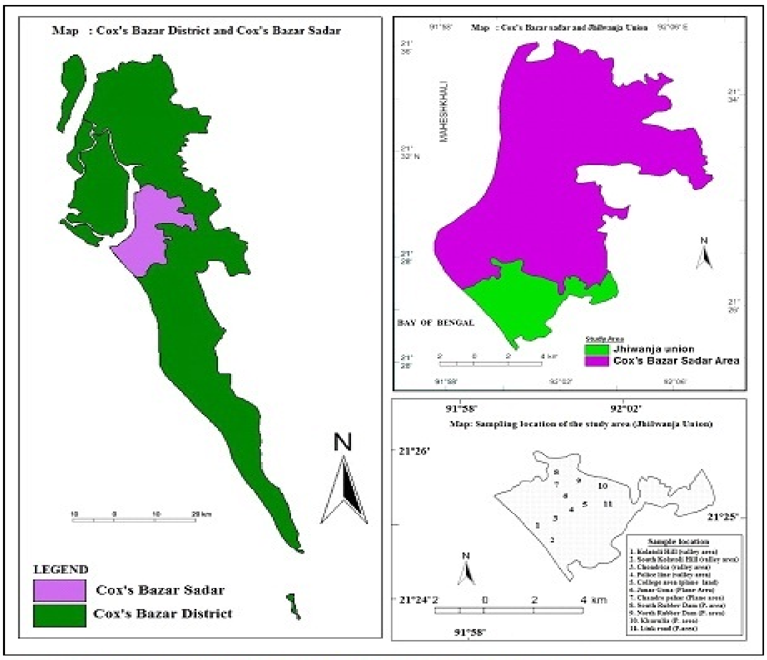

Figure 1. Location of the study area (Cox's Bazar District, Cox's Bazar Sadar and Jhilwanja Union)

Source: Base map was collected from Cox's Bazar Municipility (2013) and LGED (2003).

3.2 Soil Analysis

The particle size distribution was determined by hydrometer method of Day (1965). Percentages of sand (> 50 μm), silt (2 to 50 μm) and clay (< 2 μm) were determined and used to identify the textural class from the textural triangle. This standard soil textural triangle was devised by the United States Department of Agriculture (USDA) (Soil Survey Staff, 1951). Bulk density was determined by Saxton, Rawls, Romberger, and Papendick (1986) adapted by the Canadian soil texture triangle by Pedosphere.ca. Temperature (^oC) was determined by the thermometer. 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 by using a conductivity meter (Rhoades, 1982), and Organic carbon was determined by wet-oxidation method of Walkley and Black (1934) as modified by Allison (1965) was used to determine organic carbon. The organic matter was obtained by multiplying the content of organic carbon by Van Bemmelen, factor of 1.73 (Page, Miller, & Keeney, 1982). Total nitrogen was determined by micro-Kjeldahl digestion by using $CuSO_4$-Na, SO_4 catalyst mixture was used to determine total nitrogen. The ammonia (NH_3) from the digestion was distilled with 40% NaOH into 5% Boric acid and determined by titrating with 0.001N H_2SO_4 (Jackson, 1973). Total P of the soil samples were determined after digestion with nitric acid-perchloric acid (Olsen & Sommers, 1982; Chintala et al., 2014a). P in the extract was measured colourimetrically by the phospho-vanadomolybdate method (Kitson & Mellon, 1944; Hanson, 1950). Content of exchangeable Potassium (K), Calcium (Ca) and Magnesium (Mg) of the soil samples were determined after digestion with nitric acid-perchloric acid (Olsen & Sommers, 1982; Chintala et al., 2014b); and measured by Atomic Absorption Spectrophotometer. Data were analyzed with SPSS 18.0 and Microsoft Office Excel and final map was prepared by Arc GIS 9.3 software.

4. Results and Discussion

4.1 Determination of Physico-chemical Properties of Soil

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, Jiang, Ying, Zhang, and Han (2011). Saline soils vary widely in their physical and chemical properties as well as hydrology (Ikehashi & Ponnamperuma, 1978). Following table summarize the selected physico-chemical properties [% Sand,% Silt,% Clay, Bulk Density (g/cm^3), Soil Temperature (^{o}C), pH, EC (dS m^{-1}), Organic Matter (%), Total N (%), Total P (%), Exchangeable K (%), Exchangeable Ca (%), Exchangeable Mg (%)] of soils from paddy fields of Jhilwanja union of Cox's Bazar, Bangladesh.

Table 2. Descriptive statistics of physico-chemical properties of soil from paddy fields

Physico-chemical properties	N	Minimum	Maximum	*M*	*SD*
Sand (%)	11	33.00	93.00	56.99	18.98
Silt (%)	11	2.00	60.00	35.68	18.03
Clay (%)	11	5.00	10.00	7.33	1.75
Bulk Density (g/cm^3)	11	1.51	1.66	1.58	0.05
Soil Temperature (^{o}C)	11	26.00	35.00	31.55	2.50
Soil pH	11	5.10	8.10	6.84	1.18
EC (dS/m)	11	3.10	7.24	5.28	1.42
O.M (%)	11	0.22	1.32	0.75	0.31
Total N (%)	11	0.03	0.12	0.08	0.03
Total P (%)	11	0.01	0.10	0.06	0.03
Exchangeable K (%)	11	0.20	1.04	0.57	0.25
Exchangeable Ca (%)	11	.0000	0.0037	0.0009	0.0013
Exchangeable Mg (%)	11	0.05	0.61	0.26	0.21

Note. The soil analysis is a mean of three replications.

4.1.1 Soil Texture

The relative percentage of soil separates (Sand, Silt and Clay) of a given soil is referred to as soil texture. The common textural classes, as recognize by USDA (U.S. Department of Agriculture) are given in equilateral triangles are international equilateral triangles model, (Shukla & Chandel, 2000). Present investigation shows that, sand content of the soil ranged from 33.00 to 93.00% with a mean value of 56.99% (Table 2). Silt content varied from 2.00 to 60.00% with an average value of 35.68% and Clay content was found from 5.00 to 10.00% with a mean of 7.33% (Table 2). Sand particles were found highest in S1 (93.00%) sample and lowest was in S9 (33.00) sample. Maximum value of silt% was found in S9 sample (60.00%) and lowest was investigated in S1 (2.00%). Clay content was highest in S3, S8 & S11 (10.00%) and lowest value was found in S1 & S5 (5.00%). Textural class of the soils ranged from Sandy to Loam. Sandy soil was found 9.09% (in S1, valley area soil), Sandy loam 45.45% [S2, S4, S5, S6 & S7 (valley area & plain area)], Silt Loam 27.27% [S3, S9, & S10 (valley area and plain area)] and Loam was 18.18% [S8 & S11 (plain area)] in study area. Islam, Anusontpornperm, Kheoruenromne, and Thanachit (2014) found most soils had loamy sand to sandy loam texture. Velayutham et al. (1999) found partially similar findings in respect to soil particles percentage in coastal agricultural soils.

4.1.2 Bulk Density (g/cm^3)

Dry weight of unit volume of soil inclusive of pore spaces is called bulk density. Average density of soil in bulk is 1.5 g/cm^3. Organic soils have low bulk density as compared to mineral soils (Shukla & Chandel, 2000). Bulk density of the studied soils ranged from 1.51 (S3) to 1.66 g/cm^3 (S1) with a mean value of 1.58 g/cm^3 (Table 2). A normal range of bulk densities for clay is 1.0 to 1.6 g/cm^3 and a normal range for sand is 1.2 to 1.8 g/cm^3 with potential root restriction occurring at ≥ 1.4 g/cm^3 for clay and ≥ 1.6 g/cm^3 for sand Aubertin and Kardos (1965). Islam et al. (2014) found most soils had high bulk density in coastal agricultural soil and influences by soil physical (texture, porosity) and chemical (organic matter, constituent minerals) properties Chaudhari, Ahire, Ahire, Chakravarty, and Maity (2013). In sandy textured soil contains higher bulk density (1.66 g/cm^3) than sandy loam (1.59 to 1.63 g/cm^3), silt loam (1.51 to 1.59 g/cm^3) and loam (1.53 g/cm^3) textured soil. These results were in confirmatory with the results reported by Chaudhari et al. (2013).

4.1.3 Soil Temperature (°C)

Soil temperature ranged from 26-35 °C (*M* = 31.55) and this temperature can adversely effects on rice production in studied area because of extreme temperatures (whether low or high) causes injury to the rice plant. High temperatures are a constraint to rice production and cause a significant yield reduction. When temperatures exceed the optimal for biological processes, crops often respond negatively with a steep decline in net growth and yield (Basak, Ali, Islam, & Alam, 2009). Hence, the critically low and high temperatures, normally below 20 °C and above 30 °C, vary from one growth stage to another stage Krishnan, Ramakrishnan, Reddy, and Reddy (2011).

4.1.4 Soil pH

The activity of microorganisms, plant growth, biochemical breakdown, solubility and absorption of colloids etc. are known through soil pH (Brady & Weil, 2004). Soil pH is the most important factor in the nutrient available of soils. In most cases, a pH range of 6.0-7.5 is optimum for the adequate availability of nutrients in the soil (Bangladesh Agricultural Research Council [BARC], 2005). Soil pH of the paddy field was moderately acidic to basic (Table 3) here. Maximum pH content was found 8.10 and minimum 5.10, (*M* = 6.84) (Table 2). Lowest pH value was found in S1 and highest value was found in S11 sample. It was noticeable that soil pH was so acidic in valley area (S1) but it gradually increased (basic) towards plain agricultural fields (in S6, S8, S9 & S10). The classification of soils from study area on the basis of pH is summarized in Table 3.

Table 3. Classification of soil pH of the sample according to standard of Boyed et al. (2004)

pH range	Type	No. of Soil Samples, percentage (%) and locations
Less than 4.0	Strongly acidic	Nill
4.1 to 5.0	Acidic	Nill
5.1 to 6.8	Moderately acidic	5, 45.45%, S1, S2, S3, S4 & S7
6.9 to 7.0	Neutral	1, 9.09%, S5
7.2 to 7.9	Moderate basic	2, 18.18%, S6 & S10
8.0 to 8.9	Basic	3, 27.27%, S8, S9 & S11
More than 9.0	Strongly basic	Nill

It is observed from the Table 3 that out of 11 soil samples 5 (45.45%) sample shows moderately acidic soil which is located in valley area and topographically higher areas, while 1 (0.09%) sample shows neutral in nature. Moderate basic (2 soil samples; S6 & S10; 18.18%) and basic (27.27%; 3 soil samples; S8, S9 & S11) soil was found in study area. There were no strongly acidic, acidic or strongly basic soils were found in this study area. Results were almost similar with Uddin and Islam (1998) found most soil pH ranges 2 to 8.5 of the Coastal soils of Bangladesh.

4.1.5 Soil Electrical Conductivity (EC)

Soil electrical conductivity (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 nitrogen oxides, methane, and carbon dioxide (Smith & Doran, 1996). Samphors, Thirapong, Tomomi, and Jiro (2015) revealed that the changes in soil EC were significantly sensitive to the ripening stages of rice planted on different levels of soil salinity. Following table (Table 4) shows the content of soil electrical conductivity (EC) of paddy fields in the study area.

Table 4. Classification of soil EC of the sample according to standard of SRDI, (2003); BARC, (2005) and Chowdhury et al. (2011)

Type	EC range (dS/m)	No. of Soil Samples, percentage (%) and locations
Low	2.0-4.0	3, 27.27%, S1, S2 & S3
Medium	4.1-8.0	8, 72.73%, S4, S5, S6, S7, S8, S9, S10 & S11
High	8.1-16.0	Nill
Very high	> 16	Nill

The EC values ranged from 3.10 to 7.24 dS/m in the study area. The lowest value was found in valley areas soil (S1), and highest was in S11 (7.24 dS/m). In this area (S11), transpiration of salts with surface runoff is negligible. Instead evaporation of surface and groundwater at shallow depth leave behind the salts which appear as encrustation on soils. The higher values (> 4 dS/m) of EC have been obtained from both valley areas and plain areas (72.73%, S4 and S5, S6, S7, S8, S9, S10 & S11) reflecting low flushing rate and sluggish groundwater movement. The salt accumulation in the area is associated with the areas of high (shallow) water table. 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 pattern (27.27%, S1, S2 & S3). About 72.73% (Table 4) soil samples were saline according to the acceptable range of Allotey, Asiamah, Dedzoe, and Nyamekye (2009); Richards (1954) 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), and Patcharapreecha, Topark-Ngarm, Goto, and Kimura (1989) in different coastal agricultural saline soils.

4.1.6 Relation between Soil Texture and Soil Salinity (EC) in Paddy Fields of the Study Area

Following Figure 2 shows relation between soil texture and different soil salinity (EC) in different paddy fields.

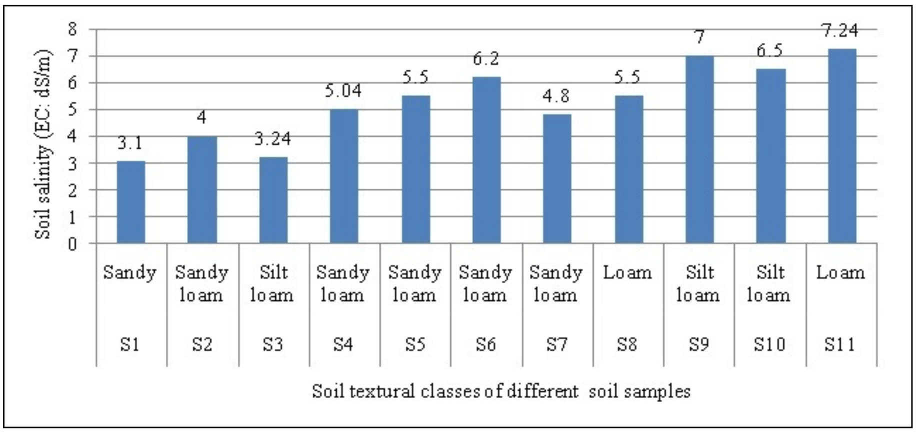

Figure 2. Soil texture with different soil salinity level in study area

Above Figure 2 shows the relationship between soil textural classes and soil salinity in different study area samples. The highest soil salinity was found 7.24 dS/m in site 11 (S11) which was loam textured soil, whereas the lowest value was found 3.10 dS/m in site 1 (S1) which was sandy texture soil (Figure 1). Rather than this value another lower salinity was found in site 3 (S3) which represents silt loam texture soil, although comparatively higher values of soil salinity were found in silty loam textured soil of site 9 & 10. Although S3 shows lower salinity with silty loam it may cause due to low soil pH (Table 1 & 3). Medium soil salinity was found in sandy loam textured soils of S2, S4, S5, S6 & S7. It can be assumed that soil texture has profound effects on changing soil salinity of this study area. This finding is conformity with Indonesian Agency for

Agricultural Research and Development, Indonesia and NSW Department of Primary Industries, Australia (2008).

4.1.7 Soil Organic Matter (OM) Content (%)

Soil organic matter plays an important role on physical, chemical and biological properties of a soil. Organic matter is known as 'storehouse of plant nutrients' and 'life force of a soil'. A good soil should have at least 2.5% organic matter, but in Bangladesh most of the soil has less than 1.5%, and some soil possess even less than 1% organic matter (BARC, 2005; SRDI, 1985). According to Malaysian Agriculture Research and Development Institute [MARDI] (2000) optimum soil OM content for paddy is 3-5%. Soil OM content in the study areas were low and ranged from 0.22 to 1.32% (M = 0.75) in study area (Table 2), which is absolutely lower than good agricultural soil OM content according to BARC, 2005 and SRDI, 1985. Lowest value of soil OM content was found in S8 (0.22%), and highest value was found in S3 (1.32%). This possibly caused by the effects of soil salinity (EC) in paddy field. Islam et al. (2014) found most soils had very low amounts of organic matter. A high concentration of Na^+ caused a highly significant depletion of OM in soils, creating extremely hazardous conditions in crop production, especially in low-lying areas. Uddin and Islam (1998) investigated the Coastal soils of Bangladesh and most soil Organic matter (%) ranges < 2 to > 20. Patcharapreecha et al. (1989) investigated saline soils that contain 0.07-0.74% soil OM. Haque (2006) found the pretty low (1.0-1.5%) soil OM content in coastal saline soils.

4.1.8 Soil Nutrient Content (%) in Different Paddy Field Soils of the Study Area

Proper nutrition is essential for satisfactory crop growth and production. An understanding of general nutrient status can be obtained for a field if soil tests are done. The essential nutrient elements are N, P, K, Ca, Mg, and S. Among these nutrient elements, N ranks first in plant requirement and phosphorus (P) ranks second followed by potassium (K). N, P, and K are referred to essential nutrients because nearly all plants use them for growth and development Samuel and Ebenezer (2014). Soil nutrient contents (N, P, K, Ca & Mg) in different paddy field soils of Jhilwanja Union, Cox's Bazar, Bangladesh is given below (Table 5).

Table 5. Soil nutrient content (%) in different paddy field soils of Jhilwanja Union, Cox's Bazar, Bangladesh

Sample no.	Total N	Total P	Exchangeable K	Exchangeable Ca	Exchangeable Mg
S1	0.12 a	0.01 e	0.20 d	0.0031 ab	0.07 ef
S2	0.10 b	0.02 e	0.26 cd	0.0001 bc	0.08 ef
S3	0.12 a	0.05 d	0.29 cd	0.0000 c	0.05 f
S4	0.09 b	0.06 cd	0.54 bc	0.0002 bc	0.11 de
S5	0.07 c	0.06 cd	0.54 bc	0.0002 bc	0.14 d
S6	0.07 c	0.10 a	0.72 b	0.0007 bc	0.34 c
S7	0.12 a	0.08 b	0.70 b	0.0002 bc	0.11 de
S8	0.03 d	0.08 b	1.04 a	0.0037 a	0.61 a
S9	0.06 c	0.08 b	0.55 bc	0.0009 abc	0.51 b
S10	0.04 d	0.09 ab	0.77 ab	0.0002 bc	0.31 c
S11	0.04 d	0.07 bc	0.64 b	0.0010 abc	0.54 b

Note. Figures in the same column denoted by the same letter (s) did not differ significantly according to DMRT at $p < 0.05$.

1) Total Nitrogen (N) Content (%)

Nitrogen is the most limiting factor in crop production. The pale green color of N-deficient plants is the most common deficiency symptom exhibited by growing plants (Thompson & Troeh, 1978). Optimum limit of percentage of total nitrogen (N) is four categories such as low (< 0.180%), medium (0.180-0.360%), high (0.361-0.450%) and very high (> 0.45%) (SRDI, 2003; BARC, 2005; Chowdhury, Khairun, Salequzzaman, & Rahman, 2011). Total nitrogen (%) content ranged from 0.03 to 0.12% in the study area (Tables 2 and 5). Highest value was found in S1, S3 & S7 and lowest was found in S8. Soil N content was low in the study area (M = 0.08, Table 2) according to SRDI, 2003; BARC, 2005 and Chowdhury et al. 2011. Table 5 shows statistically similar results in site 2 & site 4. Similar results were also appeared in S5, S6 & S9 and with also in S8, S10 & S11 respectively. Results also revealed that, comparatively higher N content were found in valley areas soils than plain areas soils except S7. It may caused by the effects of soil salinity (Sumner, 2000). Nitrogen status demarked that considering agricultural field's areas were less fertile and farmers need to use different organic and inorganic fertilizers in paddy fields. Result shows similarities with several researchers, as (Rahman, Hassan, Alam, Akid, & Riyad, 2014; Maliwal & Somani, 2010). Islam et al. (2014) 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 fertility because of low N supplying capacity (Islam, 1983). Patcharapreecha et al. (1989) investigated saline soils contains total nitrogen (0.005-0.043%) contents were very low in all the soils. Several studies have shown that salinity reduces N uptake (Al-Rawahy, Stroehlein, & Pessarakli, 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 wetlands is sensitive to various environmental factors, including air temperature, water tables, flooding periods and soil properties (Bai, Gao, Xiao, Wang, & Huang, 2012; Chen, Borken, Stange, & Matzner, 2012; Ehrenfeld & Yu, 2012).

2) Total Phosphorus (P) Content (%)

Phosphorus (P) is essential for plant growth and it stimulates growth of young plants, giving them a good and vigorous start. Soil phosphorus is most available for plant use at pH values of 6 to 7 (http://msucares.com/crops/soils/phosphorus.html). Optimum limit of percentage of total P is four categories such as low (< 12), medium (12.1-24.00), high (24.0-30.00) and very high (> 30.0) (SRDI, 2003; BARC, 2005; Chowdhury et al., 2011). Total P content of soils varied from 0.01% (S1) to 0.10% (S6). Thus, the minimum value was obtained in valley area and the maximum value was obtained in plain area. Results also revealed that S7, S8, S9, S10 & S11 shows statistically similar and result indicated plain area contain higher P content than valley area soils, as site of S1, S2, S3 & S4. Thus, Content of % of total phosphorus were very low (Tables 2 and 5) in study area according to SRDI, 2003; BARC, 2005 and Chowdhury et al. 2011 reported that 41% of the soils of Bangladesh contained P below the critical level and 35% of the soils contained P above the critical level but below the optimum level. The phosphorus 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 Cate (Olsen, 1953), Fe and Al oxides (Dean & Rubin, 1947) and partly organic matter. 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 soils available P under study area may be mostly affected by past fertilization, pH, organic matter content, texture and various soil management and agronomic practices Verma, Patel, Toor, and Sharma (2005).

3) Exchangeable Potassium (K) Content (%)

Potassium (K) is another important nutrient, it not only important for the increase of soil fertility status but also directly involved with plant growth. Potassium is important for early growth stimulation, increasing protein production, improves the efficiency of water and improves resistance to diseases and insects. Results shows that (Tables 2 and 5) minimum K content was found in S1 (0.20%) and maximum (1.04%) in S8 with a mean of 0.57% shows K status of study area is high (Tables 2 and 5). Potassium level (0.20% to 1.04%) represents the considering agricultural fields were fertile and Rahman et al. (2014) found K (0.3-1.0%) which was almost similar with this investivagation. Statistically similar results were found in S8 & S10; S4, S5, S6, S7, S9 & S11 and S1, S2, S3, S4, S5, S10 & S11. Results also reveals that, there were lower K content in valley soils compared with plain areas soils (Table 5). Adequate level of available K in the study area may be attributed to the prevalence of K-rich clay minerals like illite and kaolinite. Farmers used different types of organic and inorganic fertilizers, especially potash fertilizer Islam, Altamash, Sarker, and Hossain (1985), and the decomposition of the minerals containing potassium, the content of total K was largely determined by the soil type and the mineral composition of the soils (Sharpley, 1989). However, potassium is rarely a limiting factor in saline soils Maliwal and Somani (2010).

4) Exchangeable Calcium (Ca) Content (%)

Calcium (Ca) is the predominant positively charged ion (Ca^{++}) held on soil clay and organic matter particles because it is held more strongly than magnesium (Mg^{++}), potassium (K^{+}), and other exchangeable cations. Soils normally have large amounts of exchangeable calcium (300-5000 ppm). Ideal limit of percentage of total calcium (Ca) is four categories such as low (< 3.0), medium (3.1-6.0), high (6.1-7.5) and very high (> 7.5) (SRDI, 2003; BARC, 2005; Chowdhury et al., 2011). Soil Ca content was too low in the paddy fields of the study area (Table 2) according SRDI, 2003; BARC, 2005 and Chowdhury et al. 2011. Result reveals that Ca varied from 0% (S8) to 0.0037% (S3) with mean value of 0.0009%, respectively (Tables 2 and 5). Statistically similar results were found among all sites of study area samples (Table 5) except S3 & S8. This lower Ca content may be due 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, Kirnak, & Higgs, 2001).

5) Exchangeable Magnesium (Mg) Content (%)

Magnesium (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. Perfect limit of percentage of exchangeable Mg is four categories such as low (< 0.75), medium (0.751-1.5), high (1.51-1.87) and very high (> 1.875) (SRDI, 2003; BARC, 2005; Chowdhury et al., 2011). Mg content ranged from 0.05% (S3) to 0.61% (S8) with a mean of (M = 0.26) in study area sample. Mg content was low content in everywhere of the studied samples (Table 5) according SRDI, 2003; BARC, 2005; Chowdhury et al., 2011. Osmotic and ion-specific effects produced the imbalances in plant nutrients causing deficiencies of nutrients in soil (Kaya et al., 2001).

4.2 Correlations and Regression between Soil Salinity (EC) and Physico-chemical Properties of Soil

Correlations and regression between soil salinity (EC) and physico-chemical properties of field soils of Jhilwanja Union, Cox's Bazar, Bangladesh is given in Table 6.

Table 6. Correlations between soil salinity (EC) and physico-chemical properties of soil

Physico-chemical properties	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1 Soil pH	---									
2 Soil Temperature (^oC)	.783**	---								
3 **EC (dS/m)**	**.917****	**.808****	---							
4 Bulk Density (g/cm^3)	-.427	-.158	**-.326**	---						
5 O. M (%)	-.775**	-.896*	**-.712***	.251	---					
6 Total N (%)	-.875**	-.809**	**-.830****	.500	.853**	---				
7 Total P (%)	.848**	.624*	**.762****	-.298	-.480	-.601	---			
8 Exchangeable K (%)	.808**	.828**	**.653***	-.291	-.738**	-.738**	.833**	---		
9 Exchangeable Ca (%)	.115	.289	**-.101**	.041	-.579	-.244	-.159	.250	---	
10 Exchangeable Mg (%)	.884**	.800**	**.785****	-.510	-.879**	-.870**	.597	.714*	.435	---

Note. *p = .05, **p = .01.

Table 6 shows that soil salinity (EC) is significantly positively correlated with soil pH (r = .917), soil temperature (r = .808), total P content (r = .762), exchangeable K (r = .653) and exchangeable Mg (r = .785). Moreover, soil salinity (EC) is negatively correlated with soil OM (r = -.712) and total N (r = -.830). Neither bulk density nor exchangeable Ca content was significantly associated with soil salinity (EC). These results were in confirmatory with the results reported by several researchers (e.g. Rhoades, Chanduvi, & Lesch, 1999; Pan, Zhao, Zhao, Han, & Wang, 2013; Eltaib, 2003).

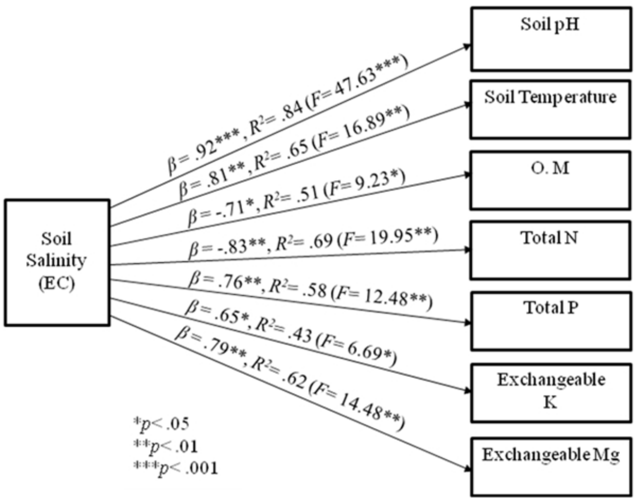

Figure 3. Effects of soil salinity (EC) on soil pH, soil temperature, O.M, total N, total P, exchangeable K, and exchangeable Mg

We performed simple regression analysis to investigate the contribution of soil salinity (EC) on soil pH, soil temperature, O.M, total N, total P, exchangeable K, and exchangeable Mg. Results of analyses are displayed in Figure 3. There, one can see that soil salinity (EC) had a significant contribution to soil pH ($\beta = .92$, $t = 6.90$, $p < .001$), which reveals that 1 unit increase in soil salinity (EC) increases .92 unit in soil pH. Moreover, R^2 value indicates that soil salinity can explain approximately 84% variability in soil pH. Figure 2 also indicates that soil salinity (EC) was a significant predictor variable of soil temperature ($\beta = .81$, $t = 4.12$, $p < .01$) as well as O.M ($\beta = -.71$, $t = -3.04$, $p < .05$), which reveals that 1 unit increase in soil salinity (EC) increases .81 unit in soil temperature and .71 unit decrease in O.M. Furthermore, approximately 65% variability in soil temperature and approximately 51% variability in O.M could be explained by soil salinity. Total N, total P, exchangeable K and exchangeable Mg also depend on soil salinity. Because soil salinity significantly contribute to total N ($\beta = -.83$, $t = -4.47$, $p < .01$), total P ($\beta = .76$, $t = 3.53$, $p < .01$), exchangeable K ($\beta = .65$, $t = 2.59$, $p < .05$) and exchangeable Mg. ($\beta = .79$, $t = 3.81$, $p < .01$) which reveals that 1 unit increase in soil salinity (EC) decreases .83 unit in total N, .76, .65 and .79 unit increase in total P, exchangeable K and exchangeable Mg respectively. In addition, there was variance of 58%, 43%, and 62% in total P, total N, exchangeable K and exchangeable Mg respectively due to variations in soil salinity (EC).

5. Conclusion

Coastal paddy field soils of Jhilwanja Union of Cox's Bazar district of Bangladesh is characterized under moderately acidic to basic in soil reaction, soil salinity (EC) content comes under low to medium range. The organic matter level exhibited absolutely lower than good agricultural soil. The soils of this area showed low concentrations of total N, in total P content, exchangeable Ca, low content of exchangeable Mg and high level of exchangeable K. In this investigation there was small sample size so, the findings should need to consider cautiously. If potential investigators take more samples for such types of research it will be a better option for generalizing the research findings. Due to laboratory limitation we used electrical conductivity to determine the intensity of soil salinity. However, exchangeable Na^+ and Cl^- can also be suggested for accurate salinity assessment. Many environmental factors worked on soil properties, if future investigators take soil samples from study site and set an experiment in a greenhouse and observe different effects on rice performance it will be a better effort for controlling these factors. So, soils require attention regarding integrated nutrient management approaches and regular monitoring of soil health for better crop productivity and sustainable agriculture associated with applying integrated coastal zone management to ensure the food security for future generation.

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