ASSESSMENT OF SALINITY LEVEL AND SOME NUTRIENTS IN DIFFERENT DEPTHS OF SOIL AT KALAPARA UPAZILA OF PATUAKHALI DISTRICT

ABSTRACT

Salinity intrusion is one of the major environmental issues throughout the world. The spatial variability of salt accumulation through the soil profile was studied at Kalapara Upazila, Patuakhali district, Bangladesh. The soil samples were collected from 30 locations covering six villages: Solimpur, Umidpur, Diaramkhola, Hazipur, Monoharpur and Puranmohipur of Kalapara Upazila, Patuakhali district. From each spot, soil samples were collected from two soil depths (0-5cm and 5-10 cm).The study was therefore consisted (30 locations and 2 soil depths) 60 soil samples. The soils were strongly acidic having mean pH value of 4.11, and 4.83 in 0-5, and 5-10 cm soil depth, respectively. In 0-5 cm soil depth, the $EC_{1:5}$ values were 5.80 dS/m. The $EC_{1:5}$ values were drastically reduced to 1.86dS/m in 5-10 cm soil depth. The available P content in 0-5 and 5-10 cm soil depth was 21.3 and 24.1 ppm indicating the less availability of P in the surface soil. Available sulphur content found in 0-5 cm soil depth was 28.5meq/100g soil ppm which reduced by 63% in 5-10 cm soil depth. The Na+ content in surface soil was 23.03 meq/100 g soils where as in subsurface soil it was 16.7 meq/100 g soils that indicated Na affects plants growth in the study area. With the increase of soil depth exchangeable K content was gradually decreased. Based on the electrical conductivity and different nutrients Monoharpur, Puranmohipur, Diaramkhola village were found seriously affected by salinity.

Keywords: Salinity, Nutrients, Soil, Climate, Kalapara upazila, and Patuakhali

INTRODUCTION

Salinity intrusion is a growing problem in the coastal areas around the globe. Bangladesh, as a country with a large coastline, the adverse impacts of saltwater intrusion are significant in Bangladesh. Salinity mainly affects land and water in the coastal areas. Salinity intrusion into the coastal areas of Bangladesh is very threatening to the primary production system, coastal biodiversity and human health [1].The total amount of salinity affected land in Bangladesh was 83.3 million hectares in 1973, which had been increased up to 102 million hectares in 2000 and the amount has risen to 105.6 million hectares in 2009 and continuing to increase, according to the country's Soil Resources Development Institute [2]. In the last 35 years, salinity increased around 26 per cent in the country, spreading into non-coastal areas as well. Soil salinization in coastal zone of Bangladesh as a major risk from climate change. In the coming decades, soil salinity will significantly increase in many areas of Barishal, Chattogram and Khulna districts. It projects a median increase of 26 per cent in salinity by 2050, with increases over 55 per cent in the most affected areas. Soil salinity, water salinity and water-logging are major constraints for higher crop productivity in the south coastal region of Bangladesh. In addition, climate change could result in increased soil surface salinity due to long periods of drought [3]. However; the level of salt accumulation in different depths of soil is not adequately investigated. Through this research attention has been paid to evaluate the spatial variability of salt accumulation through the soil profile. The author [4] predicted a 1 m sea level rise at the end of the century which would affect 17.5% of total land mass of the country. Coastal zone of Bangladesh is comprised of 19 administrative districts stretching into 147 upazilas, delineated based on the tidal fluctuations, cyclone and storm surge risk and salinity intrusion. Among the upazilas, 48 from 12 districts face the coast or lower estuary and known as exposed coast and the rest 99 upazilas that are behind the exposed coast are known as interior coast. The upazilas in the exposed coast have already met or crossed the threshold limit of the three parameters such as tidal movement, salinity and cyclone risk. Salinity intrusion affects fresh water availability into the river systems and therefore, deteriorates usability of drinking and irrigation water. Salinization of soil is a major problem in coastal regions with saline shallow water table. This is influenced by climate, soil type, crop, irrigation water quality and management practice, depth of water table and salinity of the water table.

In this area due to the evapotranspiration losses moisture from the soil rapidly, capillary rise of saline water also increases and formation of salt crust on top soil influencing the soil depth [5]. Especially in the month of March, April the salinity level highly increased in many region of Kalapara upazila, Patuakhali district (Diaramkhola, Solimpur, Umidpur, Hazipur, Monoharpur, Puranmohipur) due to the high evaporation rate. The growth and development of many crops. Plants are greatly hampered in saline soil, especially the shallow rooted crops of south coastal area due to strong saline during the March- April month. The top most surface soils become more saline due to evapotranspiration that affect the plant root zone reduce the plant growth ultimately low or empty yield [6].

Materials and Methods

Study area

This research was performed in Kalapara Upazila, a local administrative region (approximately 483.08 km^2) of Patuakhali district in the coastal area of Bangladesh. Six villages were selected for soil sample collection. The selected villages were Solimpur, Umidpur, Diaramkhola, Hazipur, Mohonpur, Puranmohipur of Kalapara upazila, Patuakhali district. A total of 30 locations across the villages were randomly selected. From each location soil samples were collected from two different soil depths: 0-5cm, and 5-10 cm.

Climate

The experimental area was situated in the sub-tropical climatic zone and characterized by heavy rainfall during the month of April-September (kharif season) and scanty rainfall during the rest period of the year. The Rabi season (Octobar-March) is characterized by comparatively low temperature and plenty of sunshine from November to February [7].

Collection and preparation of soil samples

Soil samples were collected from two soil depths at 0-5cm and 5-10 cm. Thus total 30 soil samples were collected. Geographic positioning system (GPS) reading of the sampling locations. Soil samples were collected from each location by means of an auger on 23-27 March 2018. The collected soil samples were carried to the laboratory, air dried, broken down large macro aggregates, grind and passed through a 2-mm sieve to remove weeds and stubbles from the soil. Chemical analysis of the soil sample was done in the laboratory of the Department of Soil Science, Patuakhali Science and Technology University.

Analysis of different chemical properties of soil

pH, Electrical Conductivity ($EC_{1:5}$), Available sulphur (S), Available phosphorus (P), Exchangeable Sodium (Na^+), Exchangeable Potassium (K^+), Bi –carbonate (HCO_3^-) and Chloride (Cl^-).

Statistical Analysis

Data were compiled and tabulated in proper form for statistical analysis. The recorded data on various soil parameters were statistically analyzed using Microsoft excel computer program.

RESULTS AND DISCUSSION

Soil reaction (pH)

Soil reaction (pH) also roughly influenced by soil depth. Considering soil depth effect, the lowest of 4.11 pH value was found in 0-5 cm soil depth. The pH value gradually increased with the increase of the soil depth. The highest of 4.83 pH value was found in 5-10 cm soil depth. Figure 1 showed that, at 0-5 cm the soil was very strongly acidic, at 5-10cm the soil was strongly acidic. Over the 30samples the pH value in 0-5 and 5-10cm soil depth ranges from 3.50 in Hazipur village to 6.36 in Diaramkhola village indicating that soils were acidic to neutral (Fig.1).Soil pH specifically affects plant nutrient availability by controlling the chemical forms of the different nutrients and influencing the chemical reactions they undergo. The author [8] observed that pH values of satkhira soil was 7.27 to 6.60 across sea side .The optimum pH range for most plants between 5.5 and 7.5; however, many plants have adapted to thrive at pH value outside the range [9].

At 0-5 cm soil depth the lowest mean pH value (3.53) was found in Monoharpur village (range 3.53 to 3.54) and the soil was very strongly acidic. The second lowest mean pH (3.97) was found in Umidpur village. In this village out of six soil samples 3 were very strongly acidic and 2 were strongly acidic. Based on the extent of acidity the villages were ranked as Monoharpur>Umidpur> Hazipur> Solimpur> Puranmohipur> Diaramkhola.

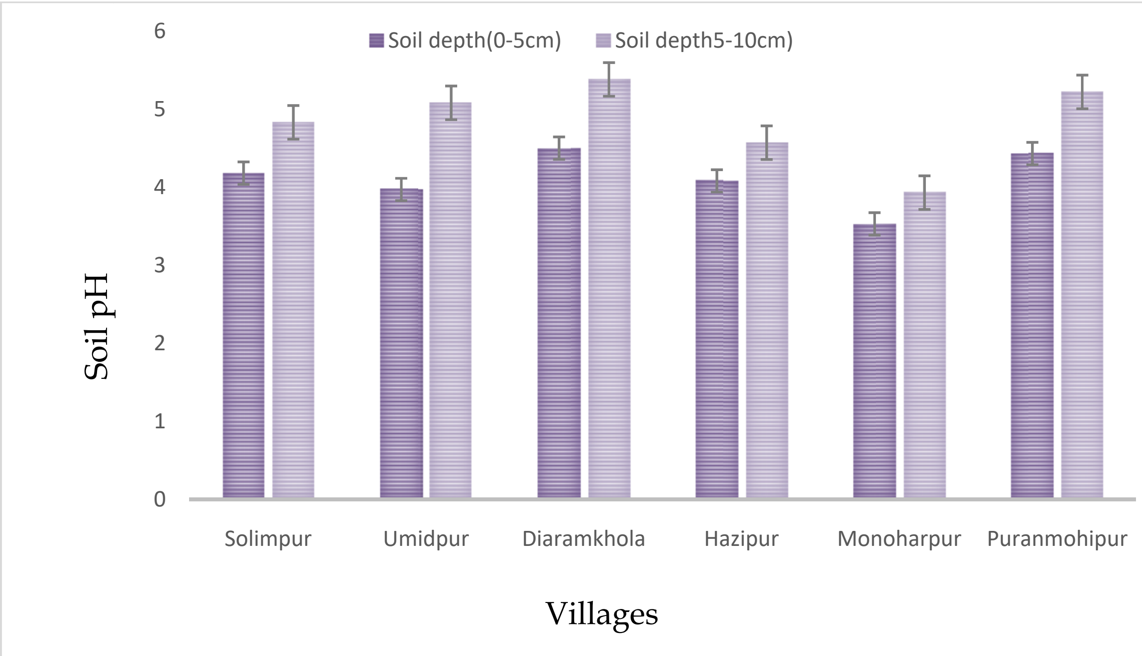

Fig.1. Soil pH in different depths at different villages of Kalapara upazila, Patuakhali, Bangladesh

Electrical conductivity ($EC_{1:5}$)

Electrical conductivity of soil was strongly influenced by soil depth. In the 0-5 cm soil depth, the $EC_{1:5}$ values were 5.80 dS/m.The $EC_{1:5}$ value was drastically reduced to 1.86 dS/m in 5-10 cm soil depth. The critical limit of EC is 4.0 ds/m to be qualified as saline soil while [10] considered on average $EC_{1:5}$ of 0.6dSm^{-1} which may not represent the established critical level.

Fig. 2 clearly evidenced that soil salinity developed within a very thin top layer of the soil, below which the salinity level is relatively comfortable for crop growth. Salts generally are transported from a salt led water table to soil surface by capillary rise due to evaporation. When the water table rises close to the soil surface, the net rate of water movement to the surface by capillary action may exceed the downward flow of water. Thus, salts are carried toward the soil surface where the water evaporates and salts accumulate [11]. Over the locations the soils at 0-5 cm soil depth was highly saline.

When soil depth effect is considered between different villages it was found that in 0-5 cm soil depth highest of 8.26 dS/m was recorded in Diaramkhola village which was followed by Monoharpur (7.06 dS/m), Puranmohipur (6.08 dS/m), Hazipur(5.14 dS/m), Solimpur (4.44dS/m) and Umidpur (3.80 dS/m) village (Fig.2). Over the villages the EC value varied from 0.96 in

Umidpur Village to 17.85 in Diaramkhola village which indicates extreme variability in soil salinity. In agreement [7] reported salinity from 0.3 to 70.0 dS/m in Ganges Tidal Flood plain soils. Considering 5-10 cm soil depth highest mean EC (2.67dS/m) was recorded at Hazipur village (Fig. 2).

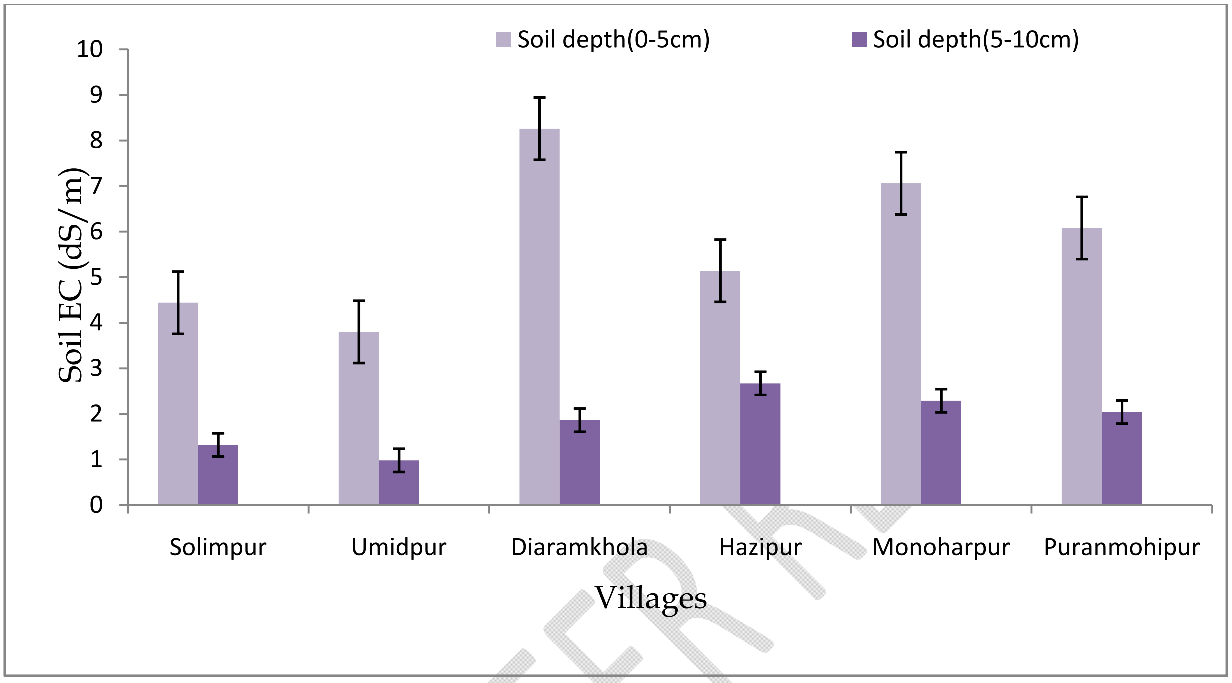

Fig.2. Soil electrical conductivity (dS/m) in different depths at different villages of Kalapara upazila, Patuakhali, Bangladesh

Available phosphorus content in soil

Available phosphorus (P) content was markedly influenced by soil depth. The highest available P content (24.19 ppm) was recorded in 5-10 cm soil depth (Fig.3). The lowest available P content was in 0-5 cm soil depth (21.35ppm). Fig.3 indicates that most of the P content found in all the soil depths was optimum and some of the lower {Solimpur (11.92 ppm), Puranmohipur (10.99 ppm)} which indicates P is deficient for plants growth over the soil column in the study areas.

Considering 30 soil sample data the range of P content at 0-5, 5-10 cm soil depth was 11.88 ppm (Solimpur) to 37.59 ppm (Hazipur village) and 10.99 ppm in Puranmohipur village to 34.89 ppm in Hazipur village. When soil depth effect in different villages were considered at 0-5 cm soil depth, the highest P content was found in Hazipur village (27.44 ppm). At 5-10 cm soil depth highest P content was found in Monoharpur village (28.67ppm) and the lowest was in Puranmohipur village (20.16ppm). Three types of salts additions could increase the P adsorbtion in the soil solution to compare with the control sample. However, P adsorbtion can be varied according to the type of salts [12].

Probably due to higher pH value in the lower soil depth (5-10 cm) P content was higher because of lower fixation in soil. The author [8] stated that optimum P content in coastal soil was 16-32 ppm for agriculture.

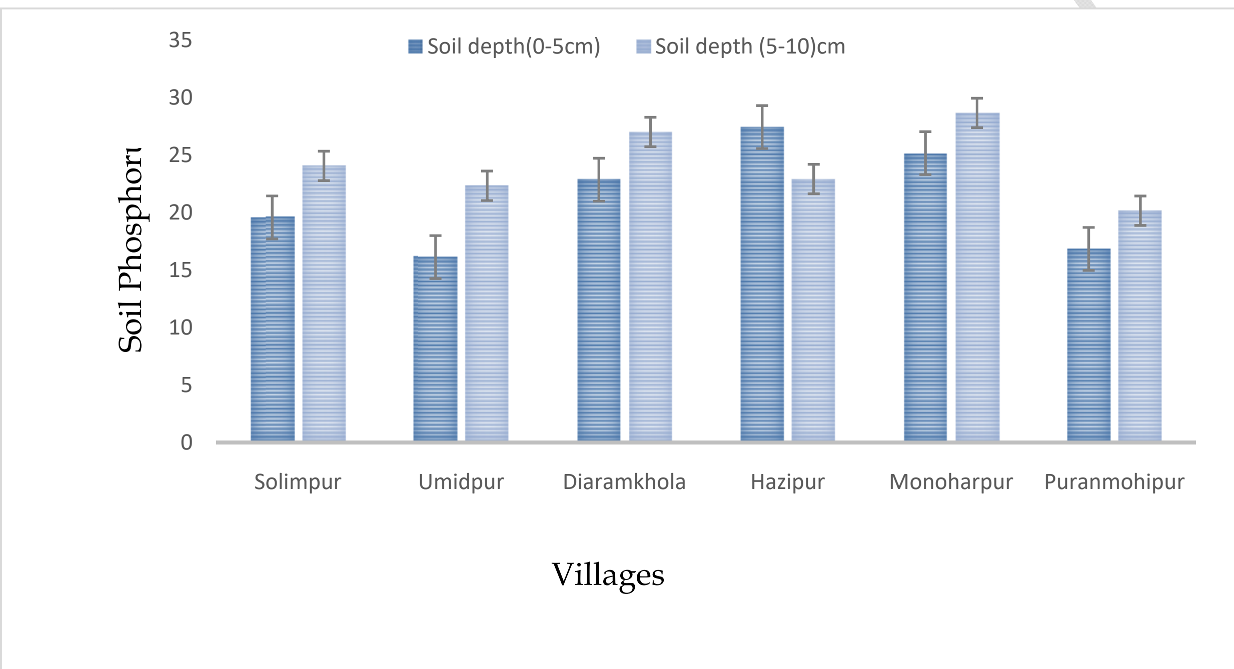

Fig. 3. Soil P in different depths at different villages of Kalapara upazila, Patuakhali, Bangladesh

Available Sulphur content in soil

Available sulphur (S) content was influenced very strongly by soil depths. Under the village 63.37% decrease in 0-5 cm soil depth was observed over 5-10 cm soil depth. The S content found in 0-5cm soil depth was 63.37% lower than that found in 5-10 cm soil depth. The 28.59 ppm available S was recorded in the 0-5 cm soil depth. At 5-10 cm soil depth this value was reduced to 10.47 ppm. Fig.4. shows that at 0-5 cm depth the available S was optimum and with the increase of the soil depth S content was reduced.

Fig.4 shows that at 0-5 cm soil depth, puranmohipur village had the highest 77 .03 ppm available S. Regarding 5-10 cm soil depth the following ranking was observed: Hazipur (17.47ppm)>Monoharpur(13.07ppm)>Diaramkhola(12.87ppm)>Puranmohipur(10.35 ppm)>Umidpur (7.78 ppm)>Solimpur (6.3 ppm. Among the villages available S content ranges from 43.82 to 7.08 ppm. Fig.4. indicates that most of the S content found in all the soil depths was low and some of the very low which indicates S is deficient for plants growth over the soil column in the sample areas. The most uncertain cause of nutrient fluctuation is weathering. Weathering is a source of dissolved inorganic S in soil. Key factors that control chemical weathering processes in the field are lithology, runoff, temperature, physical erosion, morphology, soil, ecosystems, land use as well as tectonic activity [13]. These are the major causes behind the S content variations in soil from surface to subsurface.

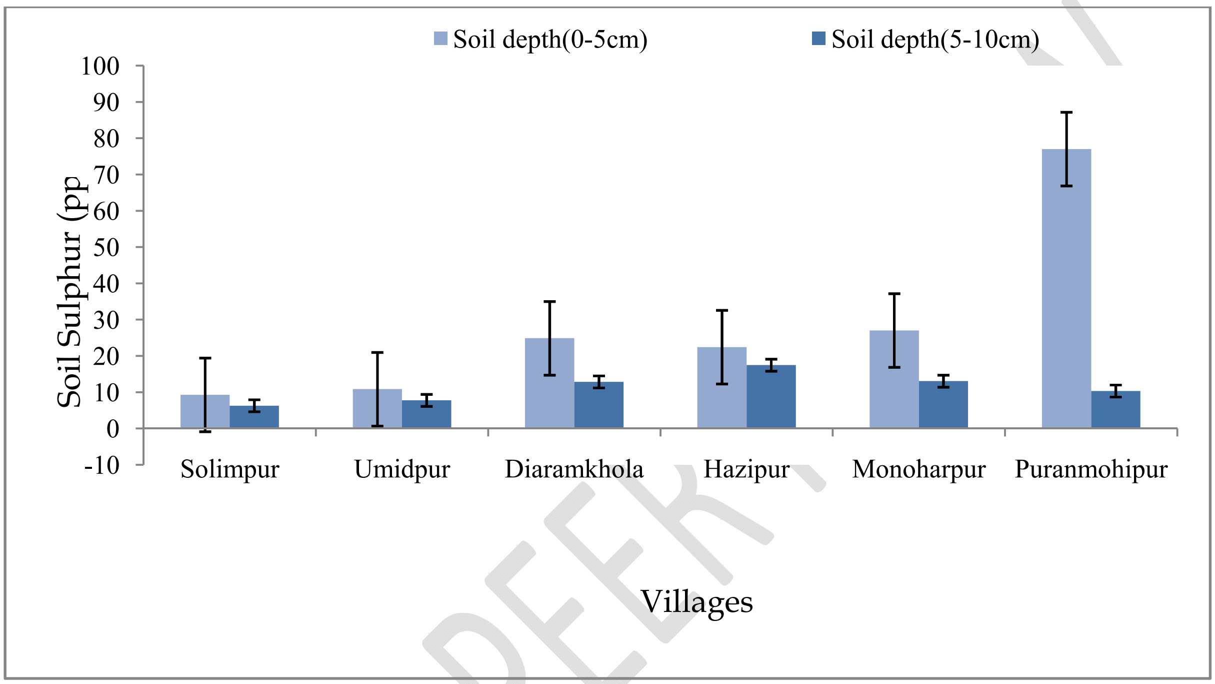

Fig.4. Soil S in different depths at different villages of Kalapara upazila, Patuakhali, Bangladesh

Exchangeable Na content of soil

Variation was observed among the soil depths in relation to exchangeable Na content of soil. Over 0-5 cm soil depth 27.18 % decreased Na content was found in 5-10 cm soil depth. Among the 30 sample data exchangeable Na content in 0-5, and 5-10 cm soil depth ranged from 8.26 to 39.21 and 8.94 to 28.21(meq/100g soil**),** respectively. When mean of 30 samples was considered highest of 39.21 (meq/100g soil**)** was recorded at 0-5 cm soil depth. The lowest value of 8.94 (meq/100g soil**)** was in 5-10 cm soil depth and highest of 28.21 (meq/100g soil**)** was recorded at 5-10 cm soil depth. The lowest value of 8.26 ppm was in 0-5 cm soil depth. Fig.5. indicated that with the increases of soil depth the Na content was reduced gradually.

Considering soil depth effect in different villages it was found that the Diaramkhola village had highest Na content 27.65(meq/100g soil**)** in 0-5 cm soil depth. In 5 to 10 cm soil depth the highest Na content was in Diaramkhola village (mean 20.38ppm). The ranking of the villages in relation to Na content was as follows:Diaramkhola (24.01meq/100gsoil)>Monoharpur

(20.46meq/100gsoil)>Hazipur (19.68 meq/100gsoil) >Puranmohipur(19.60meq/100gsoil)>Umidpur(18.05meq/100gsoil)>Solimpur(17.59meq/100gsoil)Na^+ at high amounts are toxic to plants, especially if they increase in the cytosol. Despite this relevance, not much is known about cytosolic processes that are impaired by excessive concentrations of salt ions. For instance, toxicity effects of chloride in the cytosolremain to be elucidated [14].Therefore, soils with high levels of exchangeable sodium (Na+) may impact plant growth by dispersion of soil particles, nutrient deficiencies or imbalances, and specific toxicity to sodium sensitive plants [15].

The use of irrigating water containing Na+ for crop production creates long-term changes on the soil properties that eventually lead to the serious modification in the soil Fertility. [16] reported that the use of irrigation water with a high Na+ Concentration causes high accumulation of exchangeable Na+ around soil particles. Excess sodium on adsorption site is hazardous to plant health which affects the growth and Yield of crops. [17] also stated that almost every aspect of the plant's Physiology and morphology is affected by soil salinity.

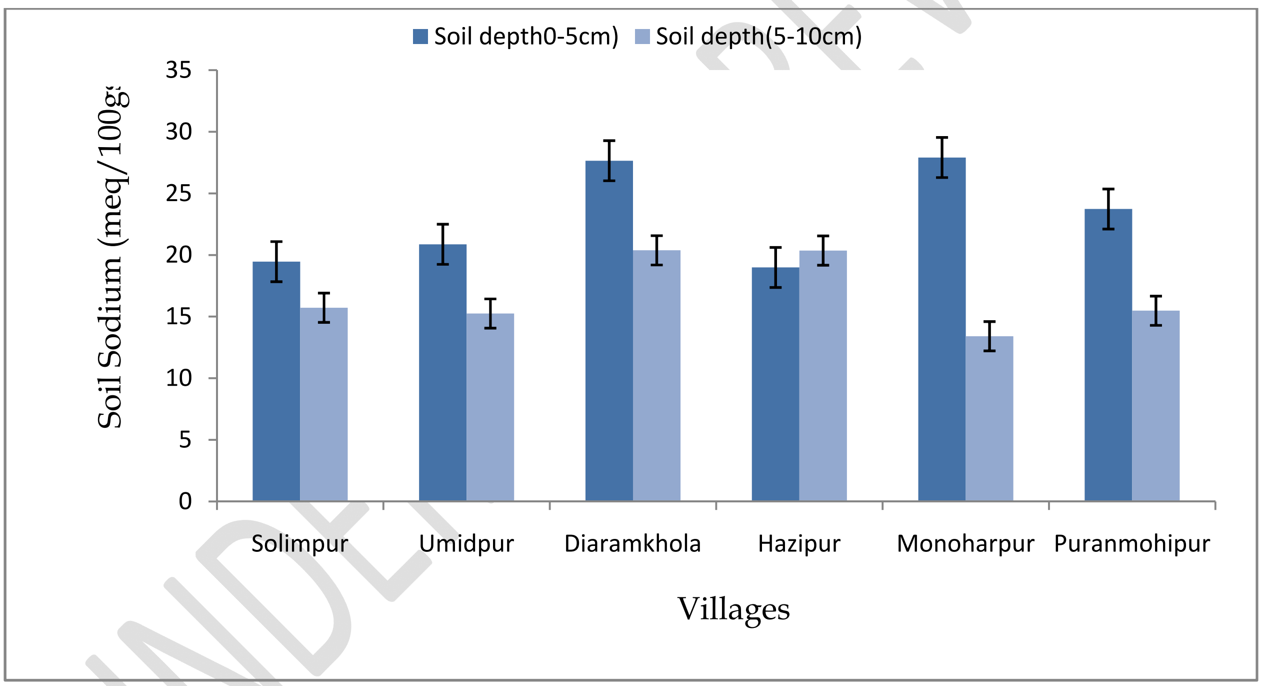

Fig.5. Soil Sodium (Na) in different depths at different villages of Kalapara upazila, Patuakhali, Bangladesh

Exchangeable K content in soil

Potassium content was strongly influenced by both soil depth and villages. The ammonium acetate extractable K found in 0-5 and 5-10 cm soil depth was 0.28, and 0.23meq/100g soil, respectively (Fig.6.). The highest K was found in 0-5 cm soil depth. The results clearly evidenced that with the increasing of soil depth exchangeable K content was gradually decreased. It was probably occurred due to leaching loss of K from surface soil and accumulation in the sub-surface layer of the soil.

The K content found in 0-5cm soil depth was 17.85% lower than that found in5-10 cm soil depth. When soil depth effect was considered on village basis it was found that at 0-5cm and 5-10cm soil depth in K content range Monoharpur(0.29), Diaramkhola(0.27), Puranmohipur(0.26), Hazipur(0.25) and (0.24)Umidpur,Solimpur (0.22) village. When K content was compared between different villages it was found that the Monoharpur village had highest K content (meq/100gsoil0.36). The second highest K content was found in diaramkhola (0.30) village and lower Umidpur (0.12).When the exchangeable K content data were interpreted; it was found that all the depth mean data were very high with some variation. Sedimentation, river bank infiltration, flooding, weathering, soil retention, nutrient release by organic or inorganic fertilizer use, rhizospheric nutrient deposition etc. influences K content in crop fields from sea to in-stream [18].

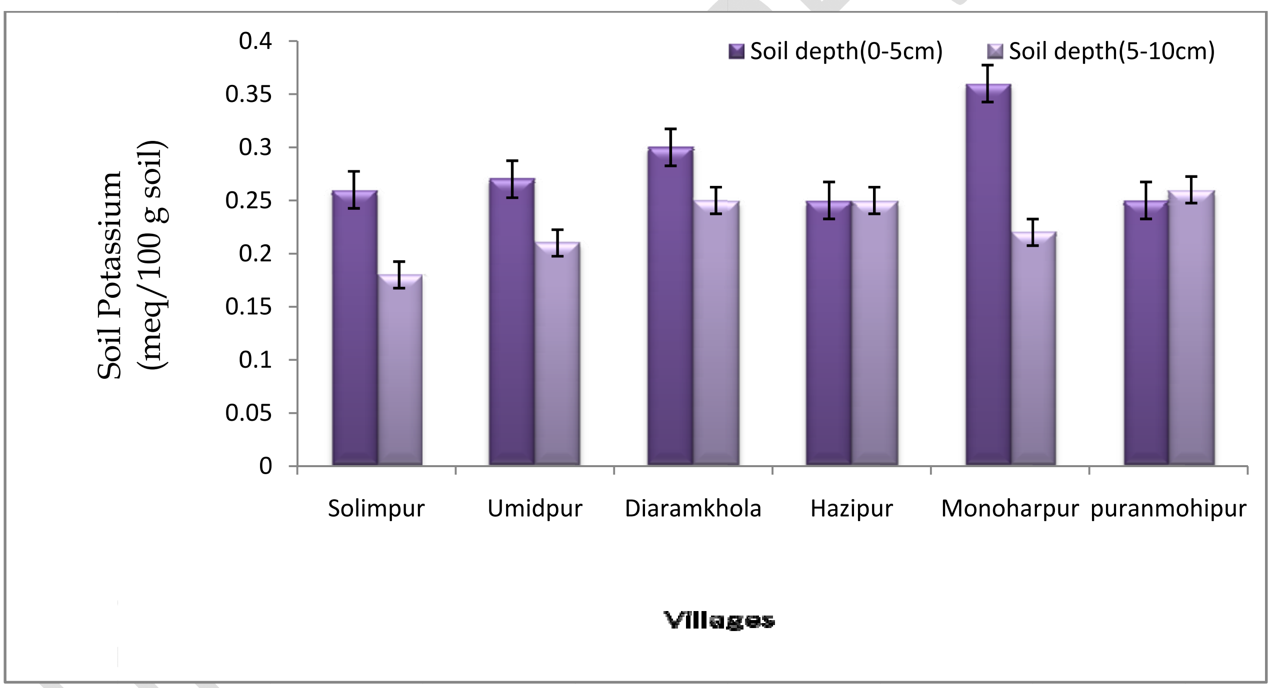

Fig.6. Soil Potassium (K) in different depths at different villages of Kalapara upazila, Patuakhali, Bangladesh

Bi-carbonate content in soil

Considering soil depth effect, the lowest of HCO_3^- concentration 0.43mg/100gsoil was found in 5-10cm soil depth. The HCO_3^- concentration gradually decreased with the increase of the soil depth. The highest of 0.46mg/100g soil was found HCO_3^- concentrationin 0-5 cm soil depth .Over the 30 samples the HCO_3^- concentration in 0-5 and 5-10 cm soil depth lowest 0.2mg/100g soil in Solimpur village and highest 0.90mg/100gsoil in Diaramkhola, Umidpur ,Monoharpur village (Fig.7.) . The anions HCO_3^- in the irrigation water tend to precipitate calcium and magnesium ions in the soil resulting in an increase in the proportion of the sodium ion. It has been stated that, on limestone soils, HCO_3^- can passively enter into plant roots and recorded HCO_3^- concentration varied 60.5 to 95.2 in the top soil [19]. The HCO_3^- concentration found in 0-5cm soil depth was 6.5% higher than that found in 5-10 cm soil depth.

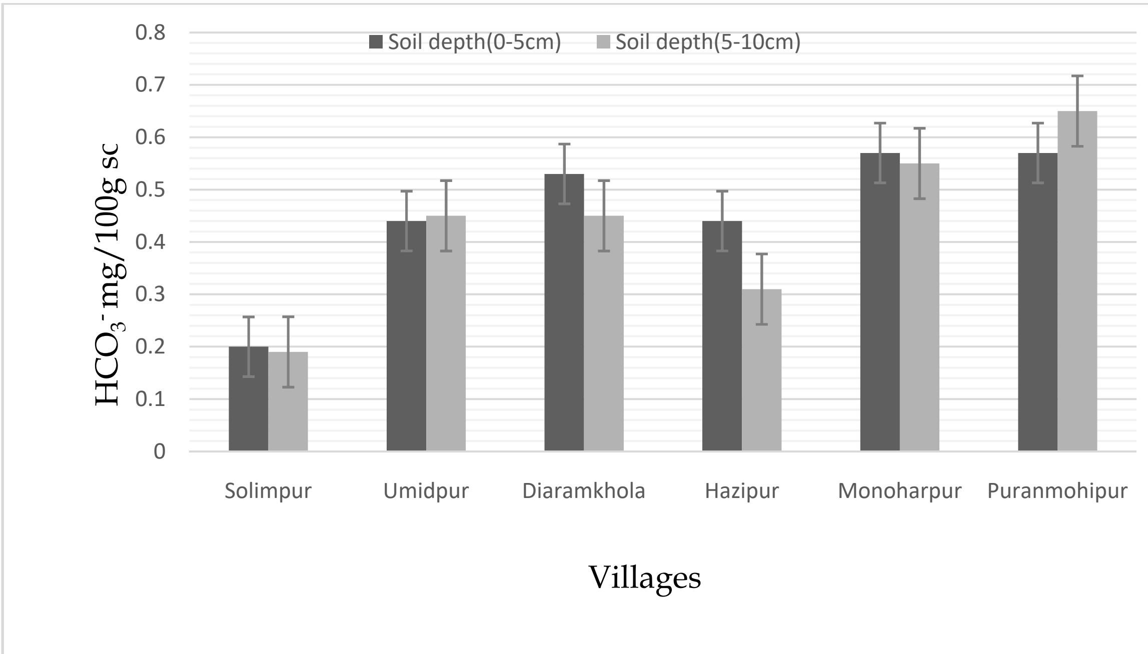

Fig.7. Soil Bi-carbonate in different depths at different villages of Kalapara upazila, Patuakhali, Bangladesh

Chloride (Cl^-) in soil

Considering soil depth effect, the lowest of Cl^- concentration 0.14mg/100gsoilwas found in 5 -10 m soil depth. The Cl^- concentration found in 0-5cm soil depth was 17.64% higher than that found in 5-10 cm soil depth.The Cl^- concentration gradually decreased with the increase of the soil depth. The highest of 0.14 mg/100gsoilwas found Cl^- in 0-5 cm soil depth .Over the 30 samples the Cl^- in 0-5 and 5-10 cm soil depth lowest 0.04mg/100g soil in Solimpur village and highest 0.44mg/100 g soil in Hazipur village.

Increasing plant growth and fruit production by adding potassium chloride to the nutrient solutions observed in this experiment is in agreement with the results of [20], who reported a better quality of tomatoes when treated with potassium chloride instead of potassium nitrate. The chloride ion is found together with sodium in saline soils. The chloride ion is known as a toxic element for plants, although its toxicity is associated with the osmotic effect in saline soils. In other cases chloride is not toxic even when it is in higher concentrations compared to the other micronutrients. This fact is confirmed by the present study. Cl^- at high amounts are toxic to plants, especially if they increase in the cytosol. Despite this relevance, not much is known about cytosolic processes that are impaired by excessive concentrations of salt ions. For instance, toxicity effects of chloride in the cytosol remain to be elucidated [14]. Fig.8. clearly evidenced that, Puranmohipur(0.22) village in o-5 cm soil depth is lower toxic for plants and Slimpur(0.14),Monoharpur(0.14), Diaramkhola(0.14) higher toxic for plants. On the other hand, 5-10cm soil depth; puranmohipur (0.19) village is higher and Monoharpur (0.07) is lower toxic for plants. Based on the extent of toxicity the villages were ranked as Monoharpur> Puranmohipur> Hazipur>Umidpur> Solimpur > Diaramkhola.

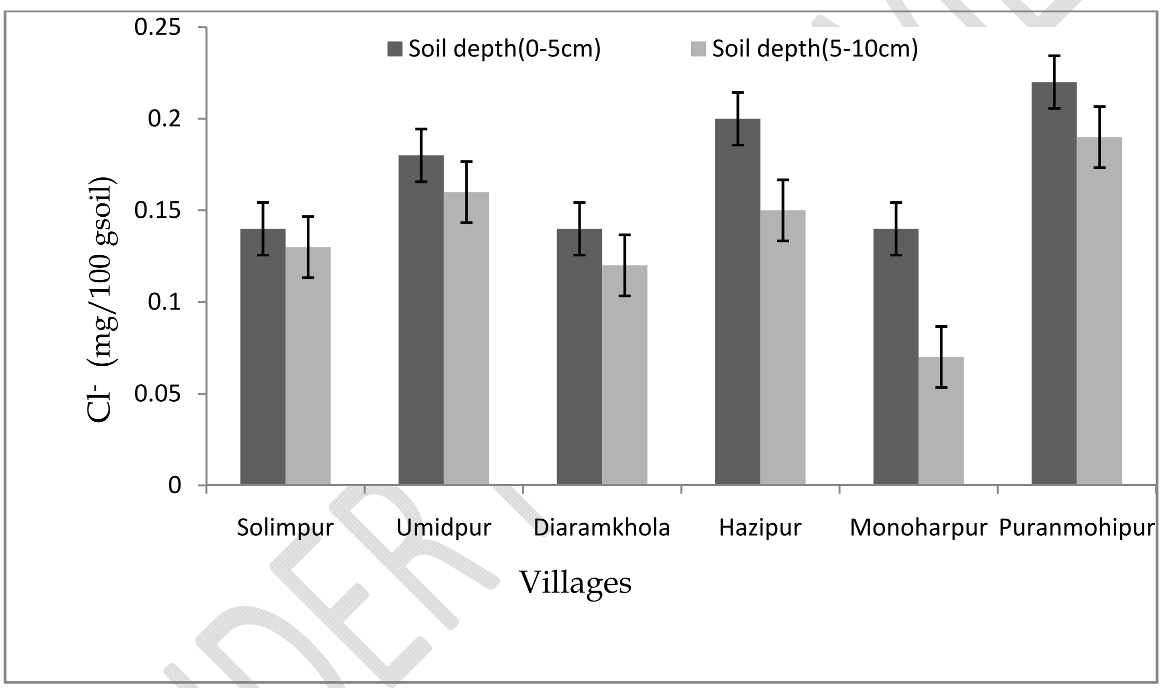

Fig.8. Soil Chloride in different depths at different villages of Kalapara upazila, Patuakhali, Bangladesh

Conclusion

The findings of this study that severe salt accumulation in the surface soil seriously hampers crop production. Salts generally developed within a thin surface soil. So deep rooted crops are may be suitable for growing in the coastal saline soils with this contribute in agricultural management and ecological restoration in Kalapara Upazila of Patuakhali districts of Bangladesh.

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