



**PHYSICO-CHEMICAL PROPERTIES OF ACCRETED SOILS OF SAINT MARTIN'S ISLAND, SOUTHEAST BANGLADESH**

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**Abstract:** This research was conducted to observe the constraints of rice cultivation in accreted char land of Saint Martin's Island soils were analyzed and compared with normal reference land of *Batiaghata*, Southwest Bangladesh for same variety of rice (BR-11). The soil pH ranged from 7.63 to 7.74, EC 5.49 dS.m<sup>-1</sup> to 8.24 dS.m<sup>-1</sup>, CEC 37.87 Cmol(+) kg<sup>-1</sup> to 52.13 Cmol(+) kg<sup>-1</sup>, total N 0.086 to 0.11%, available P 1.6 to 2.38 μg.g<sup>-1</sup>, available K 149.73 to 184.93 μg.g<sup>-1</sup>, available S 134.33 to 178.33 μg.g<sup>-1</sup>, available Ca 1333.33-1600 μg.g<sup>-1</sup>, available Mg 800-1066.7 μg.g<sup>-1</sup>, available Na 545.11-1362.77 μg.g<sup>-1</sup>, Cl<sup>-</sup> 591.67-828.33 μg.g<sup>-1</sup>, HCO<sub>3</sub><sup>-</sup> 0.122-0.183%, Organic Carbon 12-15.73 g.kg<sup>-1</sup> and the soil texture was sandy clay loam. The pH of reference *Batiaghata* soil was 7.2, EC 3.13 dS.m<sup>-1</sup>, CEC 27.83 Cmol(+) kg<sup>-1</sup>, total N 0.17%, available P 7.93 μg.g<sup>-1</sup>, available K 125.93 μg.g<sup>-1</sup>, available S 340.1 μg.g<sup>-1</sup>, available Ca 1062.7 μg.g<sup>-1</sup>, available Mg 763.33 μg.g<sup>-1</sup>, available Na 238.25 μg.g<sup>-1</sup>, Cl<sup>-</sup> 110 μg.g<sup>-1</sup>, HCO<sub>3</sub><sup>-</sup> 0.047%, Organic Carbon 60.2 g.kg<sup>-1</sup> and the soil texture was clay loam. Nutrient contents do not differ between the two regions but excess Na<sup>+</sup>, Mg<sup>2+</sup> and percent salts are the main constraints as well as the coarse sand of Saint Martin's Island which enhanced leaching loss of elements and retard high yield in newly accreted region.

**Keywords:** Accreted land, Saint Martin's Island, high yielding soils, chemical attributes

### Introduction

The only coral island, Saint Martin's Island is situated in the south-eastern coastal region of Bangladesh which covers 333 hectares of land (SRDI, 2001) and where people mainly grow rice but the growth and production is not satisfactory (BRRI, 1999). There could be various reasons for such retarded yield. To find out the causes of declining rice production systematic soil analysis for assessing nutrients was required which was compared with the normal reference soils by using same variety of rice. Mainly BR-11 Rice is grown in Saint Martin's Island and the production is about 4.2 t.ha<sup>-1</sup> (H. Saleh, personal communication, 23 October, 2014). On the contrary, the production of the same variety of rice was grown in *Batiaghata* and the production is 5.5 t.ha<sup>-1</sup> (M. Hafiz, personal communication, 30 October, 2014). The yield gap is at about 1.3 t.ha<sup>-1</sup>. It is clear that the same variety of rice production in Saint Martin's Island is lower than that of *Batiaghata* area. Physico-chemical and biological properties of soils play an important role in determining the retention and availability of nutrients in the soils, which depends on the level of organic matter, degree of microbial activity, change in pH, types and amount of clay and status of soil moisture (Zende, 1984). This study was conducted to understand the physical and chemical soil properties

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responsible for low production of rice in Saint Martin's Island soil and also to draw a conclusion of the suitability of rice production and if it is needed to reclaim, suitable measure for achieving high production of rice can be explored.

### Materials and Methods

**Description of the study area:** The sampling sites are situated at Saint Martin's Island of Chittagong division. A reconnaissance survey was conducted in different areas of Saint Martin's Island and the samples were collected from four sampling sites (*Dakshinpara, Golachipa, Uttarpara and Narkeldia*) during 23 October, 2014. Saint Martin's Island is situated in Cox's bazar district at 20°37'38.12" N and 92°19'21.28" E (Chowdhury and Chawdhury, 2012). This island is almost flat and 3.6 meter above mean sea level. *Batiaghata* Upazila is located in between 22°34' and 22°46' north latitudes and in between 89°24' and 89°37' east longitudes (BPC, 2007). The soil of *Batiaghata* was used as the reference soil (Fig. 1).

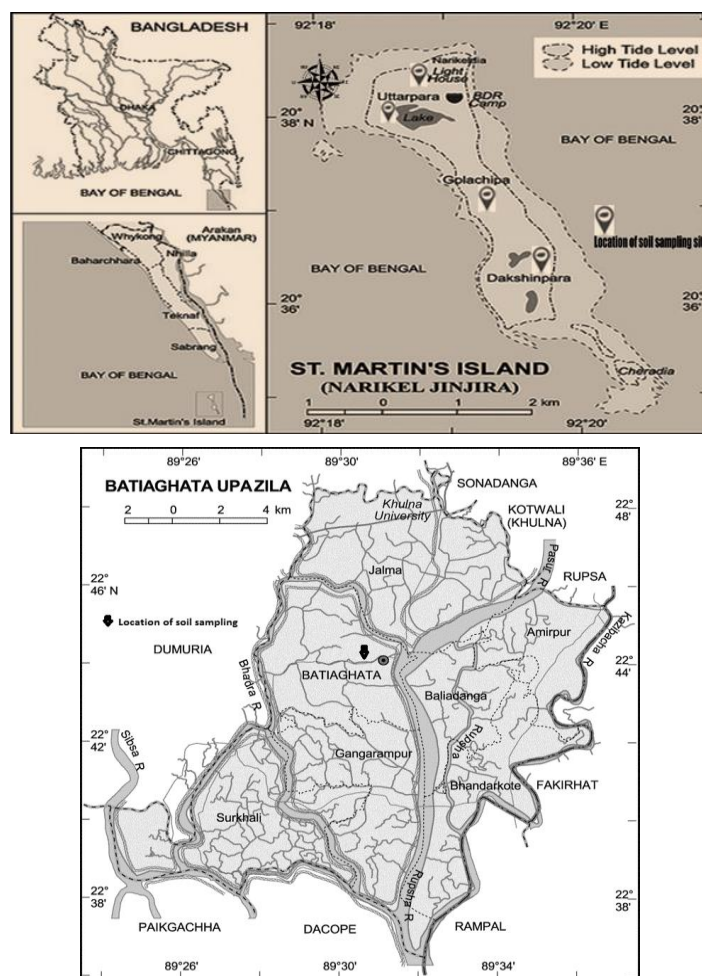


Fig. 1. Sampling sites of the study area

Three replicate soil samples were collected from 0-15 cm depth from three points of each of four places. Samples were collected in the peak processing period of October. The soil samples were prepared by following the procedure as suggested by USDA (1951). Then, the laboratory analysis was conducted.

Soil pH was determined electrochemically with the help of glass electrode pH meter maintaining the ratio of soil to water was 1:2.5 as suggested by Jackson (1973). The electrical conductivity of the soil was measured at a soil: water ratio of 1: 5 by the help of EC meter (USDA, 2004). The CEC of the soils were determined by extracting the soil with 1N KCl (pH 7.0) followed by the replacing the potassium in the exchange complex by 1 N NH<sub>4</sub>OAc. The displaced potassium was determined by a flame analyzer (Jackson, 1973).

Total nitrogen of the soils was determined by colorimetric method (Bremner & Mulvaney, 1982) following H<sub>2</sub>SO<sub>4</sub> acid digestion as suggested by Jackson (1973).

Available phosphorus was extracted from the soil with 0.5 M NaHCO<sub>3</sub> (Olsen Method) at pH 8.5 and Molybdophosphoric blue colour method of analysis was employed for determination (Murphy & Riley, 1962). Available K was determined from NH<sub>4</sub>OAc. (pH- 7.0) extract as described by Jackson (1973). The extract was analyzed for available K by flame photometer (Jackson, 1973). Available Na was determined from NH<sub>4</sub>OAc. (pH- 7.0) extract as described by Jackson (1973). The extract was analyzed using flame photometer (Jackson, 1973). Available sulphur content was determined by turbidimetric method as described by (Jackson, 1973). It was measured by spectrophotometer at 420 nm wavelength. Organic carbon of soil samples was determined by Walkley and Black's wet oxidation method as outlined by Jackson (1973). The CO<sub>3</sub><sup>2-</sup> and HCO<sub>3</sub><sup>-</sup> of the soil samples were determined by extracting the soil with 100 ml distilled water (Soil: water = 1:10) followed by the replacing of the CO<sub>3</sub><sup>2-</sup> and HCO<sub>3</sub><sup>-</sup> in the soil solution. Then the replacing the CO<sub>3</sub><sup>2-</sup> and HCO<sub>3</sub><sup>-</sup> was determined by titrimetric method (Jackson, 1973). The Ca<sup>2+</sup> and Mg<sup>2+</sup> of the soil samples were determined by extracting the soil with 1 N NH<sub>4</sub>OAc (Soil: extractant = 1:10) followed by the replacing the Ca<sup>2+</sup> and Mg<sup>2+</sup> in the soil solution. Then the replacing the Ca<sup>2+</sup> and Mg<sup>2+</sup> were determined by titrimetric method (Lanyon & Heald, 1982). Chloride (Cl<sup>-</sup>) was extracted from the soil with distilled water and determined by Precipitation Titration method (Skoog et al., 1996).

Particle size distribution of the soil samples were determined by Hydrometer method (Gee & Bauder, 1986). Textural Classes were determined by using Marshall's Triangular Coordinate System (Brady & Weil, 2008). LSD and DMRT were carried out by using computer programs and IBM.SPSS.Statistics.V20.32bit.CoMrADO.

## Results and Discussion

The comparison of physico-chemical properties of high yielding BR-11 rice soil of *Batiaghata* union of *Batiaghata* upazilla and the different soils of same rice variety growing Saint Martin's coral island are presented in Table 1.

Table 1. Chemical properties of Saint Martin's Island, Southeast Bangladesh

| Location                   | pH   | EC<br>(dS.m <sup>-1</sup> ) | CEC<br>(Cmol<br>(+) kg <sup>-1</sup> ) | Total<br>N<br>(%) | Avail-<br>able P<br>(µg.g <sup>-1</sup> ) | Avail-<br>able<br>K <sup>+</sup><br>(µg.g <sup>-1</sup> ) | Avail-<br>able<br>S<br>(µg.g <sup>-1</sup> ) | Avail-<br>able<br>Ca <sup>2+</sup><br>(µg.g <sup>-1</sup> ) | Availa-<br>ble<br>Mg <sup>2+</sup><br>(µg.g <sup>-1</sup> ) | Avail-<br>able<br>Na <sup>+</sup><br>(µg.g <sup>-1</sup> ) | Cl <sup>-</sup><br>(<br>µg.g <sup>-1</sup> ) | HC<br>O <sub>3</sub> <sup>-</sup><br>(%) | SOC<br>(g.kg <sup>-1</sup> ) |
|----------------------------|------|-----------------------------|--|-------------------|---|---|--|---|---|--|--|--|------------------------------|
| <i>Dakshinpara</i>         | 7.74 | 7.82                        | 37.87                                  | 0.09              | 1.60                                      | 154.33  | 134.33                                       | 1433  | 933   | 1363   | 828  | 0.12                                     | 12.00                        |
| <i>Golachipa</i>           | 7.67 | 8.24                        | 52.13                                  | 0.09              | 2.37                                      | 158.97  | 178.33                                       | 1400  | 1067  | 636  | 828  | 0.18                                     | 15.73                        |
| <i>Uttarpara</i>           | 7.63 | 5.70                        | 37.87                                  | 0.11              | 2.06                                      | 149.73  | 137.00                                       | 1333  | 900   | 545  | 828  | 0.12                                     | 14.77                        |
| <i>Narkeldia</i>           | 7.70 | 5.49                        | 47.71                                  | 0.10              | 2.38                                      | 184.93  | 153.37                                       | 1600  | 800   | 818  | 592  | 0.18                                     | 15.50                        |
| <i>Batiaghata<br/>(RS)</i> | 7.20 | 3.13                        | 27.83                                  | 0.17              | 7.93                                      | 125.93  | 340.10                                       | 1063  | 763   | 238  | 110  | 0.05                                     | 60.20                        |

RS= Reference Soil

The pH of different rice fields (*Dakshinpara*, *Golachipa*, *Uttarpara* and *Narkeldia*) of accreted Saint Martin's Island and the reference rice field of *Batiaghata* were 7.74, 7.67, 7.63, 7.7 and 7.2 respectively (Table 1). The pH of Saint Martin's Island was more than that of reference soil and not highly varied for all points of the island. pH significantly ( $p \leq 0.05$ ) varied with *Dakshinpara* and *Narkeldia* of Saint Martin's Island soil but exception for *Golachipa* and *Uttarpara* in respect of reference soil of *Batiaghata* (Table 1). Due to the increasing trend of Na<sup>+</sup>, K<sup>+</sup>, Ca<sup>2+</sup> and Mg<sup>2+</sup> in Saint Martin's Island soil than that of reference soil of *Batiaghata*, the pH increased in Saint Martin's Island soil (Shuai et al., 2015). The variation of pH from reference soil of *Batiaghata* to Saint Martin's Island soil may be for different parent materials. The annual precipitation is high in *Batiaghata* than Saint Martin's is land when enhanced leaching of Ca<sup>2+</sup> and Mg<sup>2+</sup> and decrease soil pH. On the contrary more Phosphorus in *Batiaghata* soil may decrease soil pH and balanced with Saint Martin's Island.

The Electrical Conductivity (EC) of different rice fields (*Dakshinpara*, *Golachipa*, *Uttarpara* and *Narkeldia*) of accreted Saint Martin's Island and the referenced rice field of *Batiaghata* were 7.82 dS.m<sup>-1</sup>, 8.24 dS.m<sup>-1</sup>, 5.7 dS.m<sup>-1</sup>, 5.49 dS.m<sup>-1</sup> and 3.13 dS.m<sup>-1</sup>(Table 1). The Electrical Conductivity of Saint Martin's Island was more than that of reference soil (Table 1). Electrical Conductivity was significantly ( $p \leq 0.05$ ) varied with *Golachipa* of Saint Martin's Island soil but exception for *Dakshinpara*, *Uttarpara* and *Narkeldia* in respect of reference soil of *Batiaghata* (Table 1). Saline soils are those which have an electrical conductivity of the saturation soil extract of more than 4 dS.m<sup>-1</sup> at 25 °C (Richards, 1954). The EC of Saint Martin's Island soil ranged from 5.49 dS.m<sup>-1</sup> to 8.24 dS.m<sup>-1</sup>. So, the Saint Martin's Island soil is Saline. The EC of reference soil (*Batiaghata*) was 3.13 dS.m<sup>-1</sup>, which is slightly saline soil. Salt 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 (Adviento-Borbe et al., 2006). Excess salts hinder plant growth by affecting the soil-water balance. Rising of salinity level will decrease agricultural production by unavailability of fresh water and soil

degradation. Salinity also decreases the terminative energy and germination rate of some plants (Ali, 2009).

The Cation Exchange Capacity (CEC) of accreted Saint Martin's Island rice fields (*Dakshinpara*, *Golachipa*, *Uttarpara* and *Narkeldia*) and the referenced soil of *Batiaghata* were 37.87 Cmol(+) kg<sup>-1</sup>, 52.13 Cmol(+) kg<sup>-1</sup>, 37.87 Cmol(+) kg<sup>-1</sup>, 47.71 Cmol(+) kg<sup>-1</sup> and 27.83 Cmol(+) kg<sup>-1</sup> (Table 1). The Cation Exchange Capacity of Saint Martin's Island was more than that of reference soil (Table 1). Cation Exchange Capacity was significantly ( $p \leq 0.05$ ) varied with *Golachipa* and *Narkeldia* of Saint Martin's Island soil but exception for *Dakshinpara* and *Uttarpara* in respect of reference soil of *Batiaghata* (Table 1). Cation Exchange Capacity showed variable behavior among different locations of Saint Martin's rice field. As the salinity level of Saint Martin Island soil (>4 dS.m<sup>-1</sup>) is higher than that of *Batiaghata* (<4 dS.m<sup>-1</sup>). For excess salt the cations (Na<sup>+</sup>, Mg<sup>2+</sup> etc.) are higher in saline soil (Table 1). As the cations are more in Saint Martin's Island soil than that of reference soil (*Batiaghata*), the capacity to exchange the cations was also high in Saint Martin's Island soil. As the clay and organic matter content in Saint Martin's Island soil was low (Table 1 and 2), the nutrients cannot form chelates and most are remain in exchangeable position (Clemens et al., 1990).

Total Nitrogen (N) of different rice fields (*Dakshinpara*, *Golachipa*, *Uttarpara* and *Narkeldia*) of accreted Saint Martin's Island and the referenced rice field of *Batiaghata* was 0.086%, 0.09%, 0.11%, 0.10% and 0.17% (Table 1). The highest total Nitrogen content was found in *Batiaghata* (reference soil) and lowest in *Dakshinpara* rice field soil *i.e.* Saint Martin's Island soil (Table 1). Total Nitrogen of Saint Martin's Island was lower than that of reference soil and (Table 1). Total Nitrogen was significantly ( $p \leq 0.05$ ) varied with all of the four soil of Saint Martin's Island in respect of reference soil of *Batiaghata* (Table 1). Though total Nitrogen showed variable behavior in amount among different locations of Saint Martin's rice field but the variation among them was not significant. Water moves more quickly through large pore spaces in a sandy soil than it does through small pores in a clayey soil and water holding capacity is much lower in sandy soils, making them especially vulnerable. Low organic matter content in Saint Martin's Island (Table 1) may also be the cause of low total Nitrogen in Saint Martin's Island soil. Salt content (electrical conductivity) affect the rate of Nitrogen mineralization from organic matter decomposition, Nitrogen cycling, Nitrogen losses through leaching, runoff or de-nitrification. The volatilization of Nitrogen may also be the cause of little total Nitrogen in Saint Martin's Island soil. As the percentage of Nitrogen is much more in reference soil than the Saint Martin's Island soil, plant easily can uptake the most important Nitrogen nutrient from soil solution than the plant of Saint Martin's Island soil.

The available (Water soluble + Exchangeable) Phosphorous (P) of accreted Saint Martin's Island rice fields (*Dakshinpara*, *Golachipa*, *Uttarpara* and *Narkeldia*) and the referenced rice field of *Batiaghata* were 1.6 µg.g<sup>-1</sup>, 2.37 µg.g<sup>-1</sup>, 2.06 µg.g<sup>-1</sup>, 2.38 µg.g<sup>-1</sup> and 7.93 µg.g<sup>-1</sup> (Table 1). The available Phosphorous of Saint Martin's Island was lower than that of reference soil (Table 1). Available Phosphorous was significantly ( $p \leq 0.05$ ) varied with all of the four soil of Saint Martin's Island in respect of reference soil of *Batiaghata* (Table 1) that also represent the variable behavior among different locations of Saint Martin's rice field but the variation among them was not significant. Phosphorus availability is pH dependent. As,

the pH was low in reference soil of *Batiaghata*, the availability of phosphorous was more here. Phosphorus is strongly bound in soils and tends to be a sink for added phosphorus (Pavinato et al., 2009). As the Phosphorous was more in *Batiaghata* soil, the plant can uptake more easily from soil solution than the plant of Saint Martin's Island soil.

The available (Water soluble + Exchangeable) Potassium of different rice fields (*Dakshinpara*, *Golachipa*, *Uttarpara* and *Narkeldia*) of accreted Saint Martin's Island and the referenced rice field of *Batiaghata* were 154.33  $\mu\text{g.g}^{-1}$ , 158.97  $\mu\text{g.g}^{-1}$ , 149.73  $\mu\text{g.g}^{-1}$ , 184.93  $\mu\text{g.g}^{-1}$  and 125.93  $\mu\text{g.g}^{-1}$  (Table 1). Available Potassium was significantly ( $p \leq 0.05$ ) varied with *Narkeldia* of Saint Martin's Island soil but exception for *Dakshinpara*, *Golachipa* and *Uttarpara* in respect of reference soil of *Batiaghata* (Table 1). The available Potassium of Saint Martin's Island was more than that of reference soil and not highly varied for all points of the Island (Table 1). As the salinity level is very high in Saint Martin's Island soil, the Potassium may be retained by different salts like KCl,  $\text{K}_2\text{SO}_4$ ,  $\text{KNO}_3$  etc. Higher soil moisture usually means greater availability of  $\text{K}^+$  (Rehm & Schmitt, 2002). As the ground water table is high in Saint Martin's Island, may be the cause of more potassium availability. Air is necessary for root respiration and  $\text{K}^+$  uptake (Rehm & Schmitt, 2002). As the soil of Saint Martin's Island is sandy type, the pore space is more in the soil and that may be another cause of more potassium availability. In spite of being more potassium in Saint Martin's Island soil the poor yielding or small growth of crop plants may be due to the high leaching loss of Potassium after irrigation.

The available (Water soluble + Exchangeable) Sulfur of accreted Saint Martin's Island rice fields (*Dakshinpara*, *Golachipa*, *Uttarpara* and *Narkeldia*) and the referenced rice field of *Batiaghata* were 134.33  $\mu\text{g.g}^{-1}$ , 178.33  $\mu\text{g.g}^{-1}$ , 137  $\mu\text{g.g}^{-1}$ , 153.37  $\mu\text{g.g}^{-1}$  and 340.1  $\mu\text{g.g}^{-1}$  (Table 1). The available Sulfur of Saint Martin's Island was lower than that of reference soil and not highly varied for all points of the island (Table 1). From statistical point of view, the available Sulfur was significantly ( $p \leq 0.05$ ) varied with all of the four soils of Saint Martin's Island in respect of reference soil of *Batiaghata* (Table 1). The available Sulfur showed variable behavior among different locations of Saint Martin's rice field but the variation among them was not significant. The iron minerals adsorbed rather small amounts of the sulfate (Ensminger, 1953). As the Saint Martin's Island soil is saline soil, so the iron minerals may be present here that may cause the low availability of Sulfur. Increasing amounts of superphosphate applied to a sandy clay loam resulted in decreasing amounts of soluble sulfate (Ensminger, 1953). Phosphorous content was low in Saint Martin's Island soil. So, the farmers use more superphosphate to grow their expected crops that may cause the low level of Sulfur availability in soil. Due to the low availability of Sulfur content in Saint Martin's Island soil, the yield of crop may be decreased than the reference soil.

The available (Water soluble + Exchangeable) Calcium of different rice fields (*Dakshinpara*, *Golachipa*, *Uttarpara* and *Narkeldia*) of accreted Saint Martin's Island and the referenced rice field of *Batiaghata* were 1433  $\mu\text{g.g}^{-1}$ , 1400  $\mu\text{g.g}^{-1}$ , 1333  $\mu\text{g.g}^{-1}$ , 1600  $\mu\text{g.g}^{-1}$  and 1063  $\mu\text{g.g}^{-1}$  (Table 1). The available Calcium of Saint Martin's Island was more than that of reference soil and not highly varied for all points of the island (Table 1). Available Calcium was significantly ( $p \leq 0.05$ ) varied with all of the rice fields of Saint Martin's Island soil in respect of reference soil of *Batiaghata* (Table 1). The available Calcium among different locations of Saint Martin's rice field is varied. Due to the Coral island and its salinity, Saint

Martin's Island contains much Calcium as salt like  $\text{CaCO}_3$ ,  $\text{CaCl}_2$  etc. Calcium is not considered a leachable nutrient. Many soils will contain high levels of insoluble Calcium such as Calcium carbonate, but crops grown in these soils will often show a calcium deficiency (TETRA chemicals, n.d.). High levels of other cations such as Magnesium, Ammonium, Iron, Aluminum and especially Potassium, will reduce the calcium uptake in some crops (TETRA chemicals, n.d.). For these reasons the Saint Martin's rice plants cannot uptake the sufficient  $\text{Mg}^{2+}$  and as a result less yielding may be occurred.

The available (Water soluble + Exchangeable) Magnesium of accreted Saint Martin's Island rice fields (*Dakshinpara*, *Golachipa*, *Uttarpara* and *Narkeldia*) and the referenced rice field of *Batiaghata* were  $933 \mu\text{g.g}^{-1}$ ,  $1067 \mu\text{g.g}^{-1}$ ,  $900 \mu\text{g.g}^{-1}$ ,  $800 \mu\text{g.g}^{-1}$  and  $763 \mu\text{g.g}^{-1}$  (Table 1). The highest available Magnesium content was found in *Golachipa* i.e. Saint Martin's Island and lowest was in reference soil of *Batiaghata* soil (Table 1). The available Magnesium of Saint Martin's Island was more than that of reference soil and not highly varied for all points of the island (Table 1). Available Magnesium was significantly ( $p \leq 0.05$ ) varied with *Golachipa* rice fields of Saint Martin's Island soil but exception for *Dakshinpara*, *Uttarpara* and *Narkeldia* soil in respect of reference soil of *Batiaghata* (Table 1). The available Magnesium showed variable behavior among different locations of Saint Martin's rice field. The interaction of Potassium on reducing Magnesium concentration in plant tops is well documented (Wilkinson, 1983). Magnesium activity in alkaline soils is influenced by the proportions of competing ions, whether they are  $\text{Ca}^{2+}$ ,  $\text{Na}^+$  or  $\text{K}^+$ . Magnesium uptake in calcareous alkaline soils can be reduced by Calcium, and sometimes by Potassium (Mayland et al., 1989). The texture of Saint Martin's Island soil was Sandy loam (Table 3) which contained more sand particles that accelerate the leaching loss of nutrients. The leaching loss of  $\text{Mg}^{2+}$  ions after irrigation also may be the cause of low yielding of crop in Saint Martin's Island.

The available (Water soluble + Exchangeable) Sodium of different rice fields (*Dakshinpara*, *Golachipa*, *Uttarpara* and *Narkeldia*) of accreted Saint Martin's Island and the referenced rice field of *Batiaghata* were  $1363 \mu\text{g.g}^{-1}$ ,  $636 \mu\text{g.g}^{-1}$ ,  $545 \mu\text{g.g}^{-1}$ ,  $818 \mu\text{g.g}^{-1}$  and  $238 \mu\text{g.g}^{-1}$  (Table 1). The available Sodium of Saint Martin's Island was more than that of reference soil (Table 1). Available Sodium was significantly ( $p \leq 0.05$ ) varied with *Dakshinpara* of Saint Martin's Island soil but exception for *Golachipa*, *Uttarpara* and *Narkeldia* in respect of reference soil of *Batiaghata*. The available Sodium content of *Golachipa* and *Uttarpara* was strongly non-significantly varied in respect of reference soil of *Batiaghata* (Table 1). The available Sodium varied in the four places of Saint Martin's Island. Due to the Coral island and its salinity, Saint Martin's Island contains much Sodium as salt like  $\text{NaCl}$ ,  $\text{Na}_2\text{SO}_4$ ,  $\text{Na}_2\text{CO}_3$  etc. The more Sodium generally denotes the high salinity of the soil. As the Sodium content was higher in Saint Martin's Island soil than that of reference soil of *Batiaghata* refer that the more salinity in Saint Martin's Island soil. The primary physical processes associated with high sodium concentrations are soil dispersion and clay platelet and aggregate swelling. The forces that bind clay particles together are disrupted when too many large sodium ions come between them. When this separation occurs, the clay particles expand, causing swelling and soil dispersion (Abu-Sharar et al., 1987). This may hamper the yield of production.

The Chloride content of accreted Saint Martin's Island rice fields (*Dakshinpara*, *Golachipa*, *Uttarpara* and *Narkeldia*) and the referenced rice field of *Batiaghata* were 828  $\mu\text{g.g}^{-1}$ , 828  $\mu\text{g.g}^{-1}$ , 828  $\mu\text{g.g}^{-1}$ , 592  $\mu\text{g.g}^{-1}$  and 110  $\mu\text{g.g}^{-1}$  (Table 1). The Chloride content of Saint Martin's Island was more than that of reference soil and not highly varied for all points of the island (Table 1). Chloride content was significantly ( $p \leq 0.05$ ) varied with all the rice fields of Saint Martin's Island soil in respect of reference soil of *Batiaghata* (Table 1). The Chloride content in Saint Martin's Island was almost same. The soil solution of saline soils is composed of a range of dissolved salts, such as NaCl,  $\text{Na}_2\text{SO}_4$ ,  $\text{MgSO}_4$ ,  $\text{CaSO}_4$ ,  $\text{MgCl}_2$ , KCl, and  $\text{Na}_2\text{CO}_3$ , each of which contribute to salinity stress, but NaCl is the most prevalent salt and has been the focus of much of the work on salinity to date (Rengasamy, 2002; Munns & Tester, 2008). The reductions in growth from high salinity are the consequences of both osmotic stress inducing a water deficit and the effects of excess  $\text{Na}^+$  and  $\text{Cl}^-$  ions on critical biochemical processes (Munns & Tester, 2008). High salinity constrains the crop grown and restricts the yield production.

The Bicarbonate content of different rice fields (*Dakshinpara*, *Golachipa*, *Uttarpara* and *Narkeldia*) of accreted Saint Martin's Island and the referenced rice field of *Batiaghata* were 0.122%, 0.183%, 0.122%, 0.183% and 0.0467% (Table 1). The highest Bicarbonate content was found in *Golachipa* and *Narkeldia* i.e. Saint Martin's Island. The Bicarbonate content of Saint Martin's Island was more than that of reference soil and (Table 1). Bicarbonate content was significantly ( $p \leq 0.05$ ) varied with all of the rice field of Saint Martin's Island soil in respect of reference soil of *Batiaghata* (Table 1). The Bicarbonate content was highest with same in *Golachipa* and *Narkeldia* and medium in *Dakshinpara* and *Uttarpara* were significantly varied. At high moisture, soil pores remain filled with water and the partial pressure of  $\text{CO}_2$  in the soil air increased. Since the soil pH is strongly buffered by the high Cation Exchange Capacity of the soils, soil pH remained constant and  $\text{HCO}_3^-$  increased (Paul & William, 1986). The all carbonate of Saint Martin's Island soil is turned into Bicarbonate. The Carbonate content was determined zero.

The Soil Organic Carbon of accreted Saint Martin's Island rice fields (*Dakshinpara*, *Golachipa*, *Uttarpara* and *Narkeldia*) and the referenced rice field of *Batiaghata* were 12  $\text{g.kg}^{-1}$ , 15.73  $\text{g.kg}^{-1}$ , 14.77  $\text{g.kg}^{-1}$ , 15.5  $\text{g.kg}^{-1}$  and 60.2  $\text{g.kg}^{-1}$  (Table 1). The Soil Organic Carbon of Saint Martin's Island was lower than that of reference soil and not highly varied for all points of the island (Table 1). Soil Organic Carbon was significantly ( $p \leq 0.05$ ) varied with all of the four soil of Saint Martin's Island in respect of reference soil of *Batiaghata* (Table 1). The organic Carbon content showed variable behavior among different locations of Saint Martin's rice field but the variation among them was not significant. The soil Organic Carbon ultimately refers the Soil Organic matter. The Saint Martin's Island Soil was Sandy loam in texture and the *Batiaghata* soil was Clay loam or Silty Clay loam in texture (Table 2). Fine textured, clay soils hold much more organic matter than sandy soils for two reasons. Firstly clay particles form bonds that hold organic compounds. Secondly, decomposition occurs more quickly in well aerated sandy soils. A sandy loam will rarely hold more than 2% organic matter. Higher temperatures speed up the decomposition of organic material and in areas of high rainfall or irrigation there is more plant growth and therefore more roots and

residues entering the soil (Lewandowski, 2002). Due to high temperature and rainfall in *Batiaghata* soil the organic matter content is high. Poorly drained areas have higher organic matter levels as the reduced oxygen levels slow down decomposition. But, due to the sandy structure, the Saint Martin's Island soil is relatively high drained. As the organic constituents and decomposition is slow in Saint Martin's Island soil, the release of nutrient is also slow. So, the plants of Saint Martin's Island soil get low nutrients and may be the cause of less yield production.

The particle size analysis had been performed and determined the soil texture of the reference soil of *Batiaghata* and the newly accreted soil of Saint Martin's Island. The Percentage of different soil particles and their textures are presented in Table 2.

Table 2. Particle size of soil from Saint Martin's Island, Southeast Bangladesh

| Locations              | Sand (%) | Silt (%) | Clay (%) | Textural class  |
|------------------------|----------|----------|----------|-----------------|
| <i>Dakshinpara</i>     | 68.9     | 12.40    | 18.70    | Sandy loam      |
| <i>Golachipa</i>       | 65.15    | 13.80    | 24.05    | Sandy clay loam |
| <i>Uttarpara</i>       | 62.05    | 15.00    | 22.95    | Sandy clay loam |
| <i>Narkeldia</i>       | 65.24    | 15.05    | 19.71    | Sandy loam      |
| <i>Batiaghata</i> (RS) | 25.34    | 45.05    | 29.61    | Clay loam       |

RS = Reference soil

The sand particle in Saint Martin's Island soil is high and ranged from 62.05 to 68.9% and the silt and clay percentage were very low in amount. The texture was sandy loam or sandy clay loam. In case of the reference soil of *Batiaghata*, the sand particle was 25.34% and silt and clay percentage were high. The texture was clay loam. Soil texture influences many soil physical properties, such as water-holding capacity and water infiltration rates. Coarse-textured sandy soils generally have high infiltration rates but poor water-holding capacity, whereas a fine-textured clay soil generally has a low infiltration rate but a good water-holding capacity. Soil texture also influences the soil's inherent fertility. More nutrients can be adsorbed by a gram of clay particles than by a gram of sand or silt particles, because the clay particles provide a much greater surface area for adsorption. Soil texture helps to determine how much water will be able to pass through the soil, how much water the soil can store, and the ability of sodium to bind the soil (Nikos et al., 2003). Due to Sandy structure, the leaching of nutrients also accelerated and plant suffer from nutrient deficiency. This may be the cause of reduced crop growth and poor yield production.

### Conclusion

The content of available N, P, K, S and organic matter were low in some extent in Saint Martin's Island but the available Ca, Mg, Na, Cl<sup>-</sup> and Electrical Conductivity were higher than that of high yielding *Batiaghata* rice field soil. Due to low water solubility of Calcium and Magnesium and dispersion effect of excess Sodium the soil quality may be decreased. Therefore, the main constraints of the Saint Martin's Island were excess salinity and coarse

soil particles (sandy loam). The nutrients which come in available form for plant (rice) are leached out through sand particles and the water holding capacity is also low which affect the yield of rice. If these constraints are removed from the soil of Saint Martin's Island, then the soil may be more productive. More salt tolerated variety and decreasing the amount of salinity by using chemicals may be effective in more yield production. For cultivation, the top soil is eroded day by day. So, my recommendation is to tillage in Saint Martin's Island soil with conservation practices with the use of organic fertilizer that can help in binding the soil particles as well as increase the water holding capacity to reduce the leaching loss of nutrients. But, if possible no cultivation is recommended to save the important coral island and important tourism site of Bangladesh.

## References

- Abu-Sharar, T. M., Bingham, F. T., & Rhoades, J. D. (1987). Stability of soil aggregates as affected by electrolyte concentration and composition. *Soil Science Society of America Journal*, 51, 309-314
- Adviento-Borbe, M. A. A., Doran, J. W., Drijber, R. A., & Dobermann. A. (2006). Soil electrical conductivity and water content affect nitrous oxide and carbon dioxide emissions in intensively managed soils. *Journal of Environmental Quality*, 35, 1999-2010
- Ali, A. M. S. (2009). Rice to shrimp: Land use/ land cover changes and soil degradation in Southwestern Bangladesh, Land Use Policy
- BPC (Bangladesh Population Census). (2007). Bangladesh Bureau of Statistics; *Cultural survey report of Batiaghata Upazila*, 2001
- Brady, N. C. & Weil, R. R. (2008). *The nature and properties of soils* (14<sup>th</sup>ed.). Prentice Hall, Upper Saddle River, NJ, USA
- Bremner, J. M. & Mulvaney, C. S. (1982). Nitrogen-total. In: Page *et al.* (eds.) *Methods of Soil Analysis, Part II*. (2<sup>nd</sup>ed.). *Agronomy. American Society of Agronomy, Inc., Madison, Wisconsin, USA*, 09, 595-624
- BRRI (Bangladesh Rice Research Institute). (1999). *Adhunik Dhaner Chash* (in Bengali). 54 PP
- Chowdhury. & Chawdhury, S. Q. (2012). *St Martin's Island*. A Banglapedia: *National Encyclopedia of Bangladesh* (2<sup>nd</sup>ed.). Asiatic Society of Bangladesh, Dhaka
- Clemens, D. F., Whitehurst, B. M., & Whitehurst, G. B. (1990). Chelates in agriculture. *Fertilizer Research*. 25, 127-131. doi: 10.1007/BF01095092
- Ensminger, L. E. (1953). Some Factors Affecting the Adsorption of Sulfate by Alabama Soils. *Journal of Soil Science Society of America*, 18(3), 259-264
- Gee, G. W. & Bauder, J. W. (1986). Particle size analysis. In: *Klute, A. (ed), Methods of Soil Analysis, Part-1* (2<sup>nd</sup> ed.). *Agronomy Monograph*, Madison
- Jackson, M. L. (1973). *Soil Chemical Analysis* (2<sup>nd</sup>ed.). *Prentice-Hall Inc.*, Englewood Cliffs, New Jersey, USA
- Lanyon, L. E. & Heald, W. R. (1982). Magnesium, Calcium, Strontium and Barium. In: Page *et al.* (ed.) *Methods of soil analysis, Part II* (2<sup>nd</sup>ed.). *Agronomy. American Society of Agronomy, Inc., Madison, Wisconsin, USA*, 09, 252-255

- Lewandowski, A. (2002). Organic matter management: *Soil management and health*. University of Minnesota Extension. Retrieved from <<http://www.extension.umn.edu/agriculture/soils/soil-properties/soil-management-series/organic-matter-management>>
- Mayland, H. F., Wilkinson, S. R., Watkinsville, G. A. & Anim, J. (1989). Soil factors affecting magnesium availability in plant-animal systems. U.S. *Department of Agriculture, Kimberly, ID 83341*, 67, 3439 pp
- Munns, R. & Tester M. (2003). Mechanisms of salinity tolerance. *Annual Review of Plant Biology*, 59, 651–681
- Murphy, J. & Riley, J. P. (1962). A modified single solution method for the determination of phosphate in natural water. *Analytica Chimica Actalytica*, 27, 31-36
- Nikos, J., Warrence., Krista, E., Pearson. & Bauder, J. W. (2003). Basics of Salinity and Sodicity Effects on Soil Physical Properties
- Paul, R.& William, P. (1986). Iron Nutrition and Interactions in Plants. *Journal of Plant Nutrition*, 9 (3-7), 215-228
- Pavinato, P. S., Merlin, A., &Rosolem, C. A. (2009). Phosphorus fractions in Brazilian Cerrado soils as affected by tillage. *Soil and Tillage Research*, 105, 149-155
- Rehm, G. & Schmitt, M. (2002). *Potassium for crop production*. Extension soil scientist University of Minnesota
- Rengasamy, P. (2002). Transient salinity and subsoil constraints to dry land farming in Australian sodic soils: an overview, *Australian Journal of Experimental Agriculture*, 42, 351–361
- Richards, L. A. (1954). *Diagnostic and improvement of saline and alkaline soil*. *Agriculture hand book*, USDA, 160 pp
- Shuai, S. H. A. O., Mingming, Q. I., Shuang, T. A. O., Jixiang, L. I. N., Yingnan, W. A. N. G. & Xiufeng, Y. A. N. (2015). Physiological and Biochemical Responses of Jerusalem Artichoke Seedlings to Mixed Salt-Alkali Stress Conditions. *Not Bot Horti Agrobo*, 43(2), 473-478
- Skoog, D. A., West, D. M. & Holler, F. J. (1996). *Fundamentals of Analytical Chemistry* (7<sup>th</sup>ed.). Thomson Learning, Inc., USA
- SRDI (Soil Resource Development Institute). (2001). *Vumi O Mrittika Sompod Babobar Nirdedhika*. Teknaf Upazilla, Cox's Bazar district. SRDI, Dhaka, pp. 51-60
- TETRA chemicals. (n.d.). *The Importance of Calcium*. Retrieved from <[http://www.tetrachemicals.com/Products/Agriculture/The\\_Importance\\_of\\_Calcium.aqf](http://www.tetrachemicals.com/Products/Agriculture/The_Importance_of_Calcium.aqf)>
- USDA (United States Department of Agriculture). (2004). *Soil survey laboratory manual*, soil survey investigation report no. 42, version 4.0, USDA-NRCS, Nebraska, USA
- USDA (United States Department of Agriculture). (1951). Methods of making mechanical analyses of soils. *Soil Sci.* 68, 15-24
- Wilkinson, S. R. (1983). Effect of soil application of magnesium and other minerals on plant magnesium content. pp. 61-80. In: Fontenot, J. P., Duncce, G. E., Webb, K. E. Jr. & Vivien, G. A. (Ed.), *Role of Magnesium in Animal Nutrition*. Virginia Polytechnic Inst. and State Univ., Blacksburg
- Zende, G. K. (1988). Fertility management for higher sugar production. *Maharashtra sugar* 9(4), 9-25