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Monitoring of Water Chemistry in Salt Marsh Area along Karnafully River Coast, Chittagong, Bangladesh

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Abstract:

The importance of salt marsh environment and their floral communities lies in their ability to act as a buffer between land and aquatic systems. Run off from rural and urban areas, ship breaking & fertilizer industry, eastern refinery and heavy industry all contribute pollutants to the Karnafully river estuary, Bangladesh. Dissolve oxygen in the study area varied from 0.51 mg/L to 2.73 mg/L. Biological Oxygen Demand of the pore water for 24 hours of salt marsh bed ranged from 20.67 to 69.67 mg/L. Pore water Salinity in the salt marsh bed ranged from 1.87 to 6.93 ppt in the study area. Nitrite Nitrogen (NO_2-N) in the pore water of salt marsh bed ranged from 5.51 to 14.44 µg/L. Phosphate-Phosphorus (PO_4-P) in the pore water of salt marsh bed ranged from 46.26 to 63.25 µg/L. Silicate-Silicon (SiO_3-Si) in the pore water of salt marsh bed ranged from 284.20 to 1901.68µg/L. Carbonate (CO_3^{--}) in the pore water of salt marsh bed ranged from 0.000203 to 0.000765 gm/L. P^H of the pore water of salt marsh bed ranged from 6.20 to 7.27. Water temperature varied from 25.1°C to 31.5°C in the present study area. Highest value was recorded in July and lowest value was recorded in March.

Key words- **Salt marsh, Estuary, Aquatic, Fertilizer, etc.**

INTRODUCTION

Karnafully is the most important tidal river of Chittagong district and Karnafully River estuary is the most tidal part of this river system that falls into the Bay of Bengal. The Karnafully River estuary is the typical estuary where both tidal oscillation and fresh water discharges are dominantly acting together in creating high mixing mechanism of the neretic and fluvial water for estuarine system (Mahmood et al., 1979). This estuary is important for many aspects including navigation, transportation, fishing activities, docking yards, and the industrial utility of river water.

Thousands of the industries and factories are situated on the bank of the Karnafully River or very close to the river system and they don't have any waste treatment facilities. They discharge the untreated waste into the nearest water bodies, which finally reach into Karnafully River through different canal system. Annually about 1216 ships and 45-60 oil tankers are handled at the Chittagong port (Ashraful, 2003). As a result, various refuse and disposable materials are being discharged and spills from the ships, oil tankers and fishing boats get mixed with the water and sediments.

Heavy metals are an important class of pollutant in the aquatic environment. Some heavy metals such as Mercury, Lead, Cadmium, Copper and Zinc have been shown in some previous investigations to occur at a significant level in the salt marsh plants. The accumulation of these heavy metals might affect the coastal ecosystems as well as salt marsh biota. In view of the economic importance of the coastal regions and the adverse effects of metal pollution on living resources.

The possible exchanges of water that can occur between a regular inundated tidal marsh and its surroundings. Inputs of water into a tidal marsh include infiltration of flooding tidal water (saline or brackish) and precipitation. Infiltration is important in controlling subsurface hydrology and interstitial water chemistry because it regulates the amount of tidal water from (marine or river sources) or precipitation entering the marsh sediment. In addition depending on topography and hydrology of the adjacent uplands surrounding a marsh, there may be exchanges between interstitial water in the marsh sediments and ground water draining from a regional aquifer (Harvey and Odum, 1990). Recharge or/and discharge may also occur between a deeper fresh water aquifer and the tidal marsh, the two main fluxes of water from marsh sediment include surface flow to tidal channels or coastal waters and evatranspiration.

Urban salt marshes often receive large pollutant loads, including discharges of heavy metals from industry and transportation activities. Where marsh sediment contains high concentrations of heavy metals, plant roots may absorb metals and translocate them to above-ground biomass. It has been thought that the roots of salt marsh plants, located close to the surface of the marsh, act to quickly absorb and incorporate metals into the anaerobic sediment (Orson *et al*., 1992). The uptake of metals by plants is affected by a number of environmental characteristics of the sediments, most notably the P^H and redox potential. Numerous studies have documented that higher redox potential (more oxic conditions) and lower P^H are associated with greater bioavailability of sediment bound metals (De Laune & Smith, 1985; Gambrell, 1994). Tidal wetland soils tend to be reduced, and the metals tend to be immobilized in the form of insoluble metal sulfides (Simpson & Good, 1985). However, these metals do not remain inert (Lacerda *et al*., 1997), and the plants themselves modify the redox of the soils in their immediate vicinity.

Many wetland plant species are capable of transporting oxygen down to the roots via aerenchyma tissue, and releasing oxygen from roots, thus generating an oxidizing soil environment in the rhizosphere (Giblin *et al*., 1986) and oxidizing sulfide (Lee *et al*., 1999). Oxygenation of the rhizosphere alters the sediment chemistry such that a concentration gradient is created which forces metals in the direction of the root (Lacerda *et al*., 1997; Sundby *et al*., 1998). When plants absorb and translocate metals to above-ground tissue, they can act as a conduit for the movement of toxic metals from sediments into the food webs of marshes and near shore waters (Kraus *et al*., 1986; Kraus, 1988; Sanders & Osman, 1985). Some portion of the metals in leaves can persist in the detritus which forms the base of important estuarine food webs (Rahn, 1973). Accumulation and distribution of heavy metals may vary between species. *Porteresia coarctata* is known to absorb and translocate metals from contaminated sediment to aerial plant tissue where metals are accumulated in leaves and stems (Banus *et al*., 1975; Giblin *et al*., 1980).

Otero and Macis (2002) worked on spatial and seasonal variation in heavy metals in interstitial water of salt marsh. They found that the pH and concentrations of heavy metals differed with season, but not all environments showed the same variations. However, the result also supported that higher temperatures lead to an increase in the activity of sulfate-reducing bacteria, which in turn leads to an increase in alkalinity and concentration of sulfides in the water.

Khan and Talukder (1995), reported that the concentration of some trace metals were high around the Karnafully river mouth than the Kutubdia channel, Bay of Bengal (Bangladesh coast). Which might be due to influence of untreated effluents discharged by various small and large industries located in the bank of the Karnafully River.

Satyanarayan *et al*. (1990), determined the concentrations of Ni, Zn, Cu, Cd, Mn, Pb and Fe in 93 water samples collected at different water depth from the western Bay of Bengal. Surface distribution revealed that relatively high concentration of the trace metals and nutrients were associated with low. Salinity in inshore and vice versa in the offshore water.

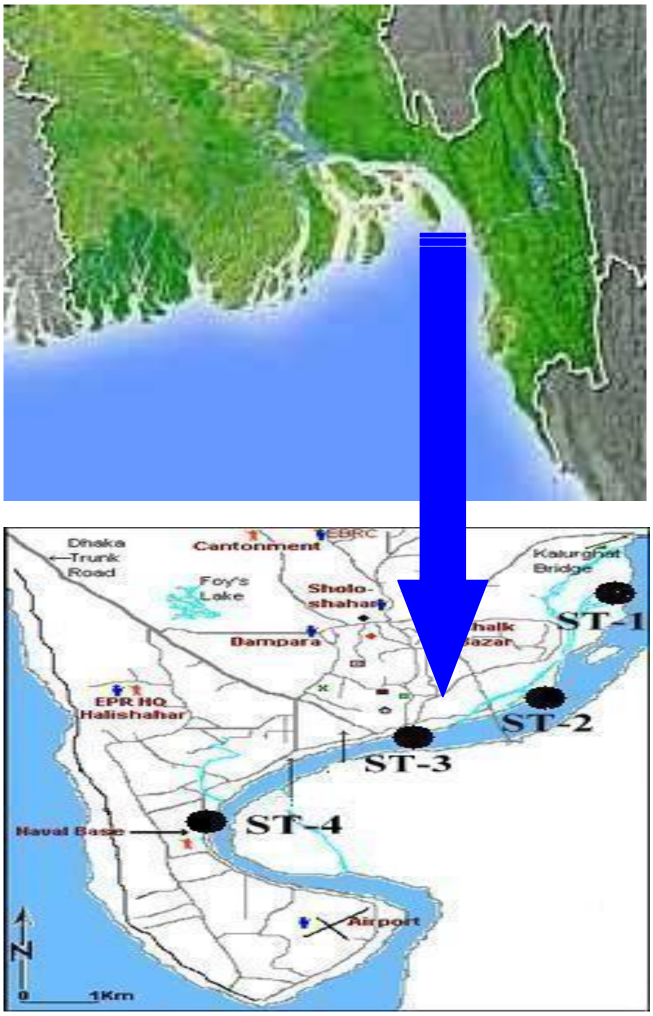
Khan and Rahman (1994), studied on the accumulation of trace metals (Fe, Cu, Zn, Hg and Pb) in water and fishes of the Karnafully river and reported that the concentrations of trace metals were always higher in fishes in comparison with the water sample. The metal concentrations of water samples were within the certified values of EQS for Bangladesh except mercury (Hg).

In addition to the heavy metals remaining in detritus, which are available for food chain transfer, some metals may be exported to the environment by release through living leaves. Release rates may vary according to the physiological and morphological properties of the plant. *Porteresia coarctata* possesses salt glands on its leaf surfaces (Anderson, 1974; Hansen *et al*., 1976) which excrete salt and are important in maintaining ionic balance in the saline environment (Adam, 1990). These glands have also been found to excrete heavy metals such as mercury, lead and chromium (Kraus *et al*., 1986). As heavy metals on the leaf surface may be dissolved in water at flood tides or during rainfall, release by leaf tissue increases the availability of metals in the food web.

MATERIALS AND METHOD

The investigated area

The study area was selected for the present investigation is situated in the Karnafully river mouth ranging from Kalurghat breeze to Potenga Sea beach. The Karnafully is one of the most important river systems in the south-east coast of Bangladesh. In the present work, I have selected the region because this area is one of the best research sites to estimate the impact of heavy metal on plants, fishes, and shell fishes as well as on human health on the estuarine and coastal belt.



Map 1 Geographical location of the study area

The research area is divided into four stations - **Station 1:** mouth of the Rajukhali Khal(22^0 $19.67^/$ N and 91^0 $51.13^/$ E), **Station 2:** Chaktai Khal (22^0 $19.55^/$ N and 91^0 $50.49^/$ E), **Station 3:** Monwarkhali Khal (22^0 $19.48^/$ N and 91^0 $49.98^/$ E) and **Station 4:** Chittagong port area (22^0 $18.48^/$ N and 91^0 $48.63^/$ E). Most of the industries and factories of Chittagong are situated in this area of the Karnafully river or very close to the river system. These industries have no any waste treatment facilities and they discharge their untreated wastes directly into the Karnafully

River through different drainage system. Many wastes are disposed off from the Oil spills, effluent and thus pollute the water of the Karnafully River. So the Karnafully river estuary is apprehended to be polluted part of the river system. So it is necessary to investigate enormously the chronic effect of these wastes to the plants, organisms of the Karnafully River. But it is unfortunate that in Bangladesh a few works have been performed in relation to pollution aspects to assess the environmental impacts of the industrial effluents, agrochemicals, pesticides, herbicides, untreated municipal wastes and heavy metals of the Karnafully river estuary.

According to FAO (1992) the industrial and agricultural sources of detected heavy metals which influence the Karnafully river water are represented in the following table.

No.	User	Heavy metals
1	Fertilizer	Pb, Cd, Cr, Ni, Zn, Cu
2	Refineries	Ni, Pb, Fe, Mn, Zn
3	Paints and pigments	Cd, Pb, Zn, Mn, Cr, Cu, Fe
4	Textiles	Ni, Pb, Fe, Mn, Zn
5	Pesticides, Herbicides, Insecticides	Pb, Cu, Zn, Mn
6	Power generation plant	Cd, Pb, Zn, Mn, Ni
7	Alloy and solders	Cd, Mn, Pb, Zn, Ni, Cu
8	Glass	Mn
9	Fuel	Ni, Cu, Fe, Cd, Pb, Mn

Table 1 Source of heavy metals

Considering the above pollutant sources in the estuarine of the Karnafully River and the Bay of Bengal, the stations were selected for the present investigation. The interface between sea and river, estuaries are very important even their area is only a small proportion of the total world's surface. But the promotion to their topography making for easier navigation for large ships and large- scale pollution, as a result of industrialization and population increases. In this point of view, Karnafully river estuary is one of the most polluted parts in Chittagong.

Sampling design

Six samples were taken in six months with three replicate samples by zoning the intertidal salt marsh bed. The research area is divided into four stations- Station 1: mouth of the Rajukhali Khal(22^0 19.67$^/$ N and 91^0 51.13$^/$ E), Station 2: Chaktai Khal (22^0 19.55$^/$ N and 91^0 50.49$^/$ E), Station 3: Monwarkhali Khal (22^0 19.48$^/$ N and 91^0 49.98$^/$ E) and Station 4: Chittagong port area (22^0 18.48$^/$ N and 91^0 48.63$^/$ E).

Sample collection

Temporal variations in the bioavailability of heavy metals in the marine environment are affected over time of total ambient metal load. Heavy metal bio-monitoring needs to conform to certain required characteristics, not least being metal accumulators. The pattern for collection data is shown in Figure 1 Sampling was conducted from a rented boat with local diver to assist collecting of water, suspended solid, sediment and plant samples.

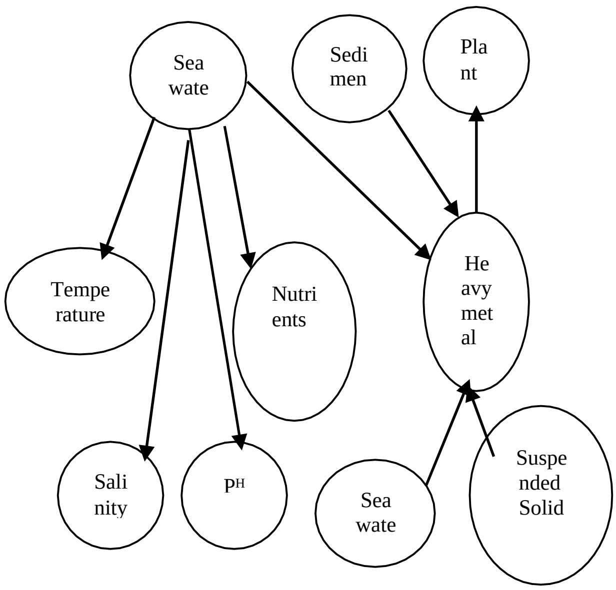


Figure 1 Diagram for sample collection

Pore seawater

Pore water samples for dissolved metal analysis were collected separately and stored in a 1-litre polyethylene bottle with 5 ml HNO_3. The collected pore water samples were preserved fixed and analyzed as recommended in the standard procedures considering analysis of different parameters. DO samples were fixed immediately with 1ml $MnSO_4$ and 1ml KI per 100ml of sample in DO bottle.

The preserved samples were analyzed in the chemical laboratory of institute of Marine Sciences and Fisheries, University of Chittagong, on the following day after arriving. All the frozen samples in the Icebox were analyzed in the laboratory after attaining room temperature.

In situ data collection

In situ air and water temperature were recorded by using a centigrade thermometer named in °C .the hydrogen ion concentration, Soil p^H was determined by using digital p^H meter. Water salinity was determined by using a hand held refract meter (ATAGO, S/Mill, Salinity 2-100‰. Japan).

Laboratory Analysis of Pore Water

Determination of DO

Do of the pore water samples were measured using methods according to Winkler (1988) for water analysis.

Nitrite-Nitrogen (NO_2 –N)

Nitrite-Nitrogen (NO_2 –N) of the pore water samples were measured using methods according to APHA (1976) for water analysis.

Phosphate-Phosphorus (PO_4 –P)

Phosphate-Phosphorus (PO_4 –P) of the pore water samples were measured using methods according to APHA (1976) for water analysis.

Silicate-Silicon (SiO_3-Si)

Silicate-Silicon (SiO_3-Si) of the pore water samples were measured using methods according to APHA (1976) for water analysis.

Determination of $BOD_{1\ day}$

Biological oxygen demand for four hours was measured using methods according to APHA.

Determination of $_P$H

Bench top digital p^H meter was used to determine the p^H of water.

Statistical analysis

Correlation co-efficient analysis was applied for the relationship between heavy metals of salt marsh plants, soil parameters and pore water parameters. One way ANOVA classification was applied to assess the significance difference between the stations and also the months. Statistical significance was tested at 95% confidence level.

RESULTS AND DISCUSSION

Pore Water Quality of the Study Site

Dissolved Oxygen (DO)

Dissolve oxygen in the study area varied from 0.51 mg/L to 2.73 mg/L with mean values of 1.30±0.00, 1.30±0.10, 1.53±0.06, 2.13±0.06, 2.57±0.12, 2.73±0.12 mg/L during March to August respectively in Station 1, in Station 2: 0.81±0.01, 1.03±0.06, 1.23±0.06, 1.77±0.06, 2.13±0.0.6, 2.07±0.06 mg/L during March to August respectively, in Station 3: 0.51±0.01, 1.03±0.06, 1.03±0.06, 1.47±0.06, 1.90±0.10, 1.83±0.06 mg/L during March to August respectively and in Station 4: 0.79±0.04, 0.92±0.03, 1.17±0.06, 1.83±0.06, 2.17±0.0.6, 2.27±0.06 mg/L during March to August respectively Lowest value was observed in March at Station 3; highest value was observed in September Station 1.

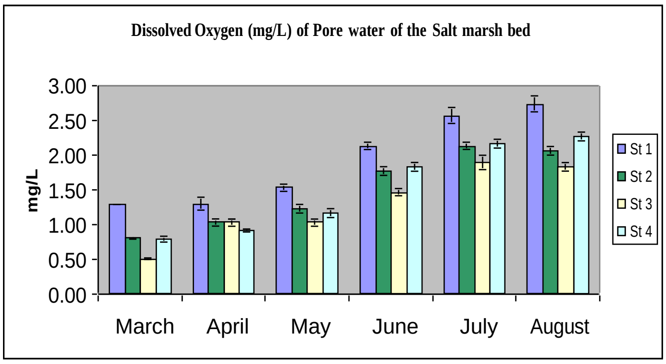


Figure 2 Dissolved Oxygen of pore water of the salt marsh bed in different months

***Biological Oxygen Demand (B.O.D)** 1 day*

Biological Oxygen Demand of the pore water for 24 hours of salt marsh bed ranged from 20.67 to 69.67 mg/L. The mean values of B.O.D are 50.00±0.00, 49.33±1.53, 44.33±1.15, 27.33±1.15, 24.00±3.46, 20.67±1.15 mg/L in Station 1, 56.00±0.00, 51.33±1.15, 50.67±0.58, 40.67±1.15, 27.33±1.15, 28.67±1.15mg/L in Station 2, 69.67±0.58, 51.67±0.58, 51.67±0.58, 45.33±0.58, 37.67±2.52, 39.33±1.15mg/L in Station 3 and 56.33±0.58, 53.67±0.58, 51.33±0.58, 39.33±1.15, 23.33±0.58, 22.33±0.58 mg/L in Station4 during March to August respectively. Lowest value was observed in August at Station 1; highest value was observed in March at Station 3.

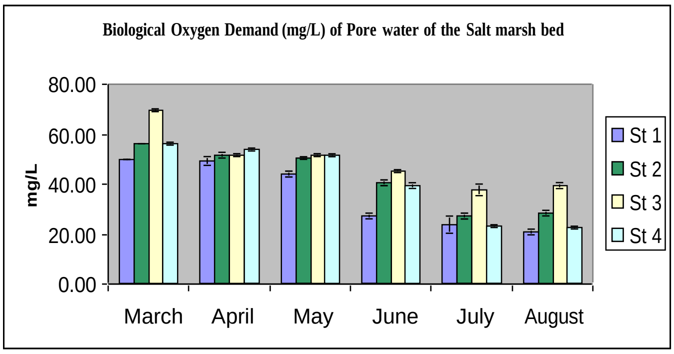


Figure 3 BOD of pore water of the salt marsh bed in different months

Salinity

Pore water Salinity in the salt marsh bed ranged from 1.87 to 6.93 ppt in the study area. The mean values of the pore water salinity are 4.83±0.06, 4.63±0.12, 4.67±0.06, 2.87±0.06, 1.87±0.06, 2.43±0.06 ppt in Station 1, 5.23±0.06, 5.43±0.12, 5.10±0.10, 3.87±0.06, 3.07±0.06, 3.57±0.06 ppt in Station 2, 5.53±0.15, 5.57±0.06, 5.23±0.06, 4.17±0.06, 3.57±0.06, 3.77±0.06 ppt in Station 3 and 6.73±0.12, 6.93±0.06, 6.23±0.06, 4.73±0.12, 4.30±0.10, 4.83±0.12 ppt in Station 4 during March to August respectively. Highest salinity was recorded in April at Station 4 and lowest in July at Station 1.

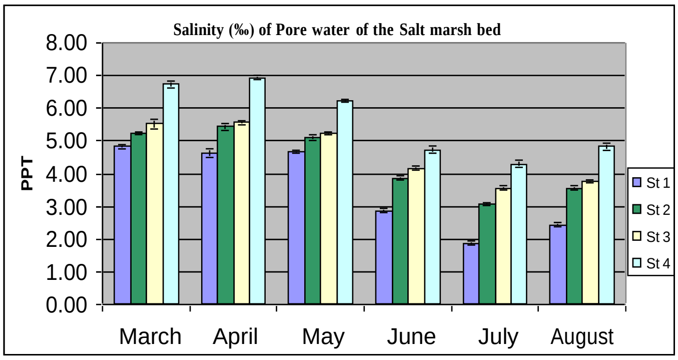


Figure 4 Salinity of pore water of the salt marsh bed in different months

Nitrite Nitrogen (NO_2-N)

Nitrite Nitrogen (NO_2-N) in the pore water of salt marsh bed ranged from 5.51 to 14.44 µg/L. The mean values of Nitrite- Nitrogen (NO_2-N) are 9.83±0.20, 9.68±0.02, 11.28±0.19, 10.34±0.09, 9.95±0.07, 11.36±0.15µg/L in Station 1, 13.21±0.11, 13.19±0.04, 14.33±0.14, 13.53±0.12, 14.23±0.06, 14.44±0.07µg/L in Station 2, 7.82±0.04, 8.14±0.05, 8.17±0.08, 7.55±0.09, 6.28±0.03, 8.15±0.05 µg/L in Station 3 and 6.23±0.13, 6.14±0.15, 7.55±0.21, 5.51±0.06, 5.65±0.13, 6.21±0.04µg/L in Station during March to August respectively. Lowest value was observed in June Station 4; highest value was observed in August Station 2.

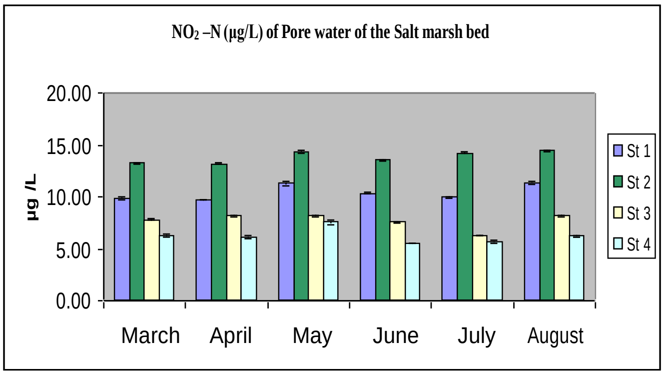


Figure 5 Nitrite Nitrogen of pore water of the salt marsh bed in different months

Phosphate-Phosphorus (PO_4-P)

Phosphate-Phosphorus (PO_4-P) in the pore water of salt marsh bed ranged from 46.26 to 63.25 µg/L. The mean values of Phosphate-Phosphorus (PO_4-P) are 46.26±0.18, 46.50±1.44, 49.22±0.46, 51.98±0.40, 51.04±1.27, 51.18±0.16 µg/L in Station 1, 60.00±0.38, 60.70±0.52, 61.32±0.73, 63.25±0.74, 62.55±0.35, 62.97±1.10 µg/L in Station 2, 54.91±1.39, 50.99±0.59, 54.40±0.71, 58.19±1.15, 59.92±0.18, 59.89±0.15 µg/L in Station 3 and 52.05±0.16, 52.54±0.46, 50.38±0.40, 54.50±0.53, 51.93±1.08, 54.16±0.94 µg/L in Station during March to August respectively. Lowest value was observed in March at Station 1 and highest value was observed in June at Station 2.

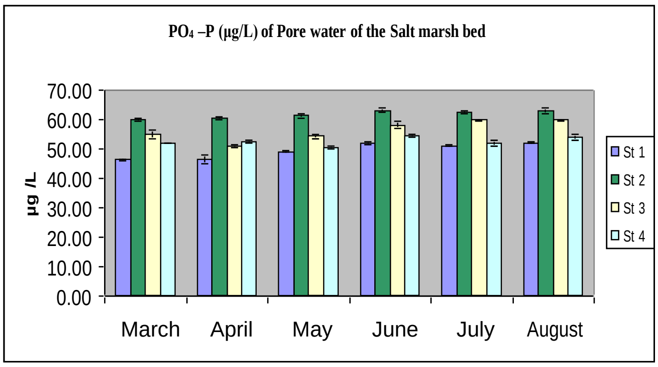


Figure 6 Phosphate-Phosphorus of pore water of the salt marsh bed in different months

Silicate-Silicon (SiO_3-Si)

Silicate-Silicon (SiO_3-Si) in the pore water of salt marsh bed ranged from 284.20 to 1901.68µg/L. The mean values of Silicate-Silicon (SiO_3-Si) are 1808.75±1.91, 1789.14±3.18, 1753.29±5.95, 1864.71±2.01, 1901.68±1.63, 1873.54±1.61 µg/L in Station 1, 1079.98±1.33, 1105.10±1.33, 985.92±4.07, 1047.13±4.28, 1203.90±1.75, 1201.19±1.o0 µg/L in Station 2, 1147.61±o.39, 1095.73±2.80, 1050.94±0.99, 1093.45±3.10, 1140.78±1.28, 1106.22±0.98 µg/L in Station 3 and 284.20±0.78, 301.16±1.09, 296.39±1.63, 321.87±2.78, 336.58±1.20, 326.65±3.05 µg/L in Station during March to August respectively. Lowest value was observed in March at Station 4 and highest value was observed in July at Station 1.

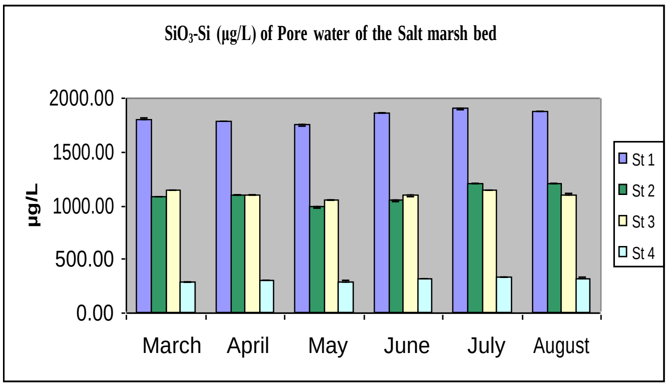


Figure 7 Silicate-Silicon of pore water of the salt marsh bed in different months

Carbonate (CO_3^{-})

Carbonate (CO_3^{--}) in the pore water of salt marsh bed ranged from 0.000203 to 0.000765 gm/L. The mean values of Carbonate (CO_3^{--}) are 0.000655±0.000013, 0.000688±0.000014, 0.000628±0.000006, 0.000704±0.000005, 0.000765±0.000014, 0.000705±0.000007 gm/L in Station 1, 0.000318±0.000016, 0.000298±0.000003, 0.000309±0.000007, 0.000313±0.000013, 0.000378±0.000022, 0.000342±0.000009 gm/L in Station 2, 0.000603±0.000010, 0.000576±0.000014, 0.000608±0.000011, 0.000615±0.000008, 0.000629±0.000012, 0.000630±0.000018 gm/L in

Station 3 and 0.000240±0.000009, 0.000218±0.000007, 0.000203±0.000006, 0.000258±0.000008, 0.000268±0.000007, 0.000280±0.000009 gm/L in Station during March to August respectively. Lowest value was observed in May at Station 4 and highest value was observed in July at Station 1.

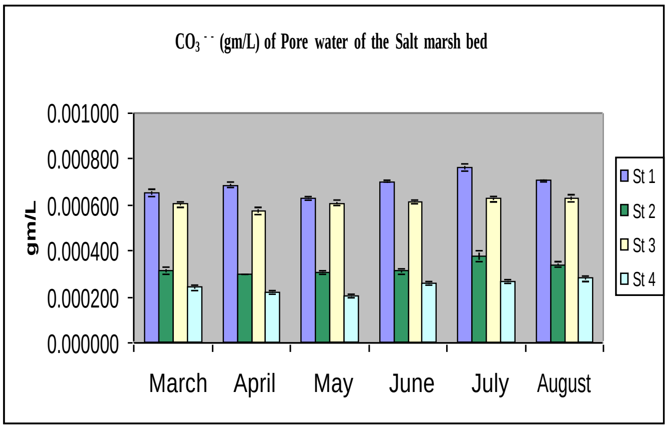


Figure 8 Carbonate of pore water of the salt marsh bed in different months

Pore Water P^H

P^H of the pore water of salt marsh bed ranged from 6.20 to 7.27. The mean values of Pore Water P^H are 6.70±0.10, 6.40±0.10, 6.90±0.00, 7.10±0.10, 7.27±0.15, 7.07±0.06 in Station 1, 6.80±0.10, 6.87±0.12, 6.57±0.06, 7.07±0.12, 7.17±0.06, 7.07±0.06 in Station 2, 6.57±0.06, 6.20±0.10, 6.63±0.06, 6.93±0.06, 7.17±0.12, 7.07±0.06 in Station 3 and 6.67±0.12, 6.73±0.21, 6.97±0.06, 7.07±0.06, 7.17±0.06, 7.07±0.06 in Station4 during March to August respectively. Lowest value was observed in April at Station 3; highest value was observed in July at Station 1.

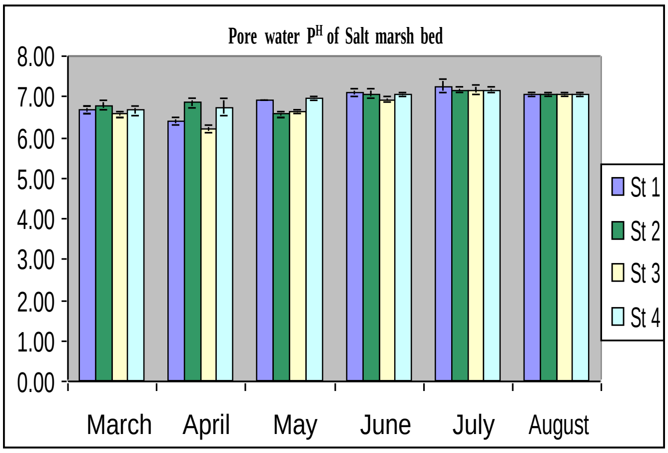


Figure 9 Pore Water P^H of the salt marsh bed in different months

Water Temperature

Water temperature varied from 25.1°C to 31.5°C in the present study area. Highest value was recorded in July and lowest value was recorded in March.

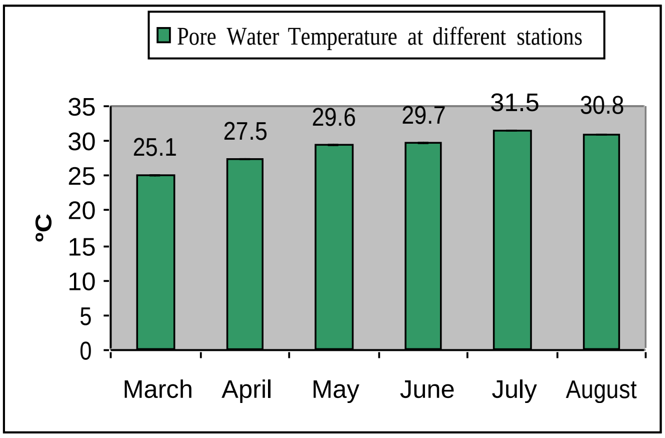


Figure 10 Pore Water Temperature of the salt marsh bed in different months

Table 2 Correlations Matrix of pore water parameters

		Water Temp	Water PH	Salinity	NO_2-N	PO_4-P	SiO_3-Si	CO_3^{--}	DO	BOD
Water Temp	Pearson Correlation	1	.749**	-.660**	.040	.272	.031	.089	.819**	-.806**
	Sig. (2-tailed)		.000	.000	.851	.199	.884	.681	.000	.000
	N	24	24	24	24	24	24	24	24	24
Water PH	Pearson Correlation	.749**	1	-.666**	.036	.262	.022	-.016	.797**	-.793**
	Sig. (2-tailed)	.000		.000	.867	.217	.918	.943	.000	.000
	N	24	24	24	24	24	24	24	24	24
Salinity	Pearson Correlation	-.660**	-.666**	1	-.353	-.193	-.641**	-.573**	-.839**	.774**
	Sig. (2-tailed)	.000	.000		.090	.366	.001	.003	.000	.000
	N	24	24	24	24	24	24	24	24	24
NO_2-N	Pearson Correlation	.040	.036	-.353	1	.491*	.516**	.032	.101	-.097
	Sig. (2-tailed)	.851	.867	.090		.015	.010	.880	.639	.651
	N	24	24	24	24	24	24	24	24	24
PO_4-P	Pearson Correlation	.272	.262	-.193	.491*	1	-.147	-.317	.061	-.062
	Sig. (2-tailed)	.199	.217	.366	.015		.492	.131	.776	.773
	N	24	24	24	24	24	24	24	24	24
SiO_3-Si	Pearson Correlation	.031	.022	-.641**	.516**	-.147	1	.843**	.266	-.184
	Sig. (2-tailed)	.884	.918	.001	.010	.492		.000	.209	.390
	N	24	24	24	24	24	24	24	24	24
CO_3^{--}	Pearson Correlation	.089	-.016	-.573**	.032	-.317	.843**	1	.242	-.141
	Sig. (2-tailed)	.681	.943	.003	.880	.131	.000		.254	.510
	N	24	24	24	24	24	24	24	24	24
DO	Pearson Correlation	.819**	.797**	-.839**	.101	.061	.266	.242	1	-.977**
	Sig. (2-tailed)	.000	.000	.000	.639	.776	.209	.254		.000
	N	24	24	24	24	24	24	24	24	24
BOD	Pearson Correlation	-.806**	-.793**	.774**	-.097	-.062	-.184	-.141	-.977**	1
	Sig. (2-tailed)	.000	.000	.000	.651	.773	.390	.510	.000	
	N	24	24	24	24	24	24	24	24	24

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 3 One way ANOVA of different parameters among the months

	Source of Variation	*Sum of Squares*	*df*	*Mean Sum*	*F*	*P-value*	*F crit*
Water Temp	Between Groups	2.84E-14	3	9.47E-15	1.70E-15	1	3.098391
	Within Groups	111.1733	20	5.558667			
	Total	111.1733	23				
Water PH	Between Groups	0.104583	3	0.034861	0.473764	0.704013	3.098391
	Within Groups	1.471667	20	0.073583			
	Total	1.57625	23				
Salinity	Between Groups	13.435	3	4.478333	3.756466	0.027377	3.098391
	Within Groups	23.84333	20	1.192167			
	Total	37.27833	23				
D.O.	Between Groups	1.194583	3	0.398194	1.090695	0.37591	3.098391
	Within Groups	7.301667	20	0.365083			
	Total	8.49625	23				
B.O.D.	Between Groups	570.4583	3	190.1528	1.061071	0.387731	3.098391
	Within Groups	3584.167	20	179.2083			
	Total	4154.625	23				
NO_2-N	Between Groups	202.6978	3	67.56592	133.5581	2.14E-13	3.098391
	Within Groups	10.11783	20	0.505892			
	Total	212.8156	23				
PO_4-P	Between Groups	506.8769	3	168.959	29.23886	1.64E-07	3.098391
	Within Groups	115.5715	20	5.778576			
	Total	622.4484	23				
SiO_3-Si	Between Groups	6944444	3	2314815	739.4305	1.20E-20	3.098391
	Within Groups	62610.75	20	3130.537			
	Total	7007055	23				
CO_3^{--}	Between Groups	8.28E-07	3	2.76E-07	221.2943	1.67E-15	3.098391
	Within Groups	2.49E-08	20	1.25E-09			
	Total	8.53E-07	23				
Soil P^H	Between Groups	0.054583	3	0.018194	0.576077	0.637397	3.098391
	Within Groups	0.631667	20	0.031583			
	Total	0.68625	23				
Organic Matter	Between Groups	11.5091	3	3.836367	46.93856	3.08E-09	3.098391
	Within Groups	1.634633	20	0.081732			
	Total	13.14373	23				
Organic Carbon	Between Groups	3.180433	3	1.060144	46.5486	3.32E-09	3.098391
	Within Groups	0.4555	20	0.022775			
	Total	3.635933	23				
Sand	Between Groups	57.36325	3	19.12108	0.981759	0.421183	3.098391
	Within Groups	389.5271	20	19.47635			
	Total	446.8903	23				
Clay	Between Groups	6.339213	3	2.113071	0.138001	0.936124	3.098391
	Within Groups	306.2396	20	15.31198			
	Total	312.5788	23				
Silt	Between Groups	60.10877	3	20.03626	1.360056	0.28358	3.098391
	Within Groups	294.6388	20	14.73194			
	Total	354.7475	23				

DISCUSSION

Khan and Hossain (1996), studied seasonal variation of trace metals (Cu, Ni, Zn, Cd, Fe, Cr etc.) concentration in water, sediment, fishes and crustacean shell fishes of the north eastern Bay of Bengal. They reported that the concentration of trace metals in water were low. Cadmium (Cd) exhibited the higher enrichment through the study area with peak values in the Karnafully estuary.

Dissolve oxygen in the study area varied from 0.51 mg/L to 2.73 mg/L. Lowest value was observed in Station 1; highest value was observed in Station 2. Negative relationship was found with salinity and dissolve oxygen (r=-.839, p=.000). No significant difference was observed among the months of dissolve oxygen (F=1.090695, P=0.37591). But significant difference was observed between the stations. P^H of the pore water of salt marsh bed ranged from 6.20 to 7.27. Abu Hena *et. al., (*2007) found water P^H (7.30±0.54) in the salt marsh bed of *Porteresia coractata* at Bakkhali estuary, Cox's Bazar. The result had similarity with the present investigation. Negative relationship was found between salinity and P^H (r=-.666, p=0.000). Significant difference was observed among the months of P^H (F=0.473764, P=0.704013). But insignificant difference was observed between the stations. Hydrogen Ion Concentration (p^H) varied from 8.2 to 8.5 in Karnafully River (Faruq, 2003).

Water temperature varied from 25.1°C to 31.5°C in the present study area. Highest value was recorded in July and lowest value was recorded in March. Faruq (2003) investigated the parameters to assess the water quality of Karnafully River. He found that water temperature varied from 21^0C to 36^0C. Faruq (2003) investigated the parameters to assess the water quality of Karnafully River and he found that CO2 ranged from 7.93 to 26.73mg/l in the effluent discharged area of Karnafully River, whereas in the present research Carbonate (CO_3^{--}) in the pore water of Karnafully River salt marsh bed ranged from 0.000203 to 0.000765 gm/L. Pore water Salinity in the salt marsh bed ranged from 1.87 to 6.93 ppt in the study area. Highest salinity was recorded at Station 4 and lowest at Station 1. Abu Hena *et. al., (*2007) found 32.77±7.4‰ salinity in the pore water of the salt marsh in Bakkhali estuary, Cox's Bazar. Negative significant relationship was found with some parameters. Significant difference was observed among the months of Salinity (F=3.756466, P=0.027377). But insignificant difference was observed between the stations.

Nitrite Nitrogen (NO_2-N) in the pore water of salt marsh bed ranged from 5.51 to 14.44 µg/L. Lowest value was observed at Station 4; highest value was observed at Station 2. Negative relationship was found with salinity and Nitrite Nitrogen (NO_2-2) (r=-.353, p=.090). Highly significant difference was observed among the months of Nitrite Nitrogen (NO_2-2) (F=133.5581, P=2.14E-13). But insignificant difference was observed between the stations. Phosphate-Phosphorus (PO_4-P) in the pore water of salt marsh bed ranged from 46.26 to 63.25 µg/L. Lowest value was observed at Station 1 and highest value was observed at Station 2. Negative insignificant relationship was found with some parameters and Phosphate-Phosphorus (PO_4-P). Insignificant difference was observed among the months of Phosphate-Phosphorus (PO_4-P) (F=29.23886, P=1.64E-07). And insignificant difference was also observed between the stations. Silicate-Silicon (SiO_3-Si) in the pore water of salt marsh bed ranged from 284.20 to 1901.68µg/L. Lowest value was observed at Station 4 and highest value was observed at Station 1. Positive significant relationship was found with difference parameters and Silicate-Silicon (SiO_3-Si) except phosphate phosphorous. Insignificant difference was observed among the months of Silicate-Silicon (SiO_3-Si) (F=739.4305, P=1.20E-20). And insignificant difference was also observed between the stations.

CONCLUSIONS

An ecosystem may be sustainable when the parameters of soil water and biological organizations will be present in an appropriate ratio. When any of these is disturbed the whole ecosystem will be imbalanced because these elements interacting to each other. The biochemical composition is related

to the seasonal changes. During rainy season the pore water temperature relatively moderate, the water salinity is lower, the pore pH is alkaline and dissolve oxygen is higher. For this condition protein .fat, moisture and ash found higher than other seasons.
After rainfall, October-November, the protein, fat, moisture and ash are found relatively lower than other seasons. Because the pore water DO, temperature, pH is lower and salinity is higher.

In winter season December to January the pore water turn in to acidic (pH=6.4) and the salinity will be highest, DO is the lowest. The nutrients(NO_2-N,PO_3-P,Ca) is higher than other season .so the approximate composition is relatively lower than other seasons found in the salt marsh plant analysis in dry basis.
The present investigation is a baseline study for *Spartina alterniflora* in the southeastern coastal area of Bangladesh. This information is useful for *Spartina alterniflorta* importance of Bangladesh and also other tropical countries of the world.

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