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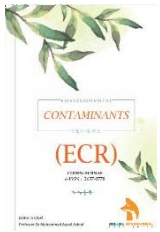

RESEARCH ARTICLE

INFLUENCE OF SOIL ORGANIC CONTENT ON SALT MARSH GROWTH IN THE NATURAL HABITAT OF SOUTH-EASTERN COAST OF BANGLADESH

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ABSTRACT

Salt marsh ecosystems are among the most productive environments on earth. Salt marsh grass is the most abundant salt-tolerant plant in most of the estuarine environment of Bangladesh and responsible for much of the marsh productivity. Growth of salt marsh *Porteresia coarctata* and effect of different ecological parameters especially organic content on growth at two stations in South-Eastern coastal salt marsh was determined. In addition, temporal and spatial variation of growth and physico-chemical parameters such as soil organic matter, soil pH, sediment deposition, temperature, salinity, NO2-N, PO4-P, SiO3-Si, sediment type etc. were analyzed. Growth of salt marsh *P. coarctata* ranged from 1.48±0.46– 14.08±1.48 cm. Organic content had insignificant positive relationship on the growth of salt marsh and salinity level, alkalinity, Nitrate Nitrogen and level of Silicate-Silicon. The variation of morphological parameters of *P. coarctata* between the sampling stations attributed to difference in habitat, soil organic matter and tidal action i.e. wave and current between the stations. Both sampling sites are in threat through various anthropogenic processes so it is the time to concentrate on salt marsh protection in the South-eastern coastal areas of Bangladesh.

KEYWORDS

Salt marsh, *Porteresia coarctata,* South-Eastern coast, Organic content.

1. INTRODUCTION

Bangladesh is blessed with an extensive coastline of about 710 km, which is mostly covered by varieties of coastal living resources such as mangroves, salt marshes, sea grasses, macro and micro algae and fisheries (Barua et al., 2017).

Coastal salt marsh is a mostly treeless floral community characterized by low succulent herbs and salt-tolerant grasses, rushes and sedges Coastal salt marsh occurs in intertidal zones that are permanently or intermittently open to inundation by marine tides, frequently on the landward side of mangrove stands. Salt marshes are features associated with non-tropical coastlines around the world. Salt marshes are highly productive ecosystems; primary production is as much as 8000 g/m2/yr in some marshes. These ecosystems are globally significant as they provide protection and habitat for fish and shellfish, including nursery habitat for a majority of commercially important species. Wading birds utilize salt marshes as feeding grounds and prey upon the juvenile fish as well as the large invertebrate populations (Abu Hena et al., 2007a). Salt marshes—positioned at the interface between terrestrial and marine environment—are highly dynamic and ecologically important systems. Chronic disturbances in adjacent land and sea, however, may degrade the quality of ecosystem services they provide. Shoreline erosion is one of the chronic pervasive disturbances, which has resulted in the loss of marsh meadows, specifically in coastal areas experiencing medium- to high-wave energy i.e., the areas exposed to strong, steady, zonal winds and fronts with high wave energies unprotected by shallow offshore topography (Sharma et al., 2016; Moody et al., 2013).

A study found that CO_2 fluxes varied significantly among the seasons, which also shows that for certain periods of the year the coastal salt marsh soils can act either as a sink or source for atmospheric CO_2 depending on the nature of the soils (Khan, 2016). Relatively high net emission of CO_2 from the Typic Sulfaquent under salt meadow was due to high microbial activities as induced by easily decomposable organic matter of the sediments. It is expected that effects of climate change, particularly sea level rise, will lead to large-scale shifts in communities and within estuaries, as well as geographic shifts in vegetation types (Wasson et al., 2013). Associated with sea level rise is increased salinity penetration and inundation frequency, which are often co-determinants of zonation of salt marsh species. Furthermore, increases in groundwater and sediment salinity can lead to extirpation of species because migration into less saline lower tidal zones is not possible (Semeniuk, 2013; Wasson et al., 2013). Predicting the combined effects of these climate change variables at broad geographical scales on habitat area, fragmentation, and connectivity is required to inform management and ensure the preservation of healthy, functioning and intact ecosystems (Tabot and Adams, 2013).

Salt marshes provide services such as shoreline stabilization, flood and storm surge protection, and maintenance of coastal water quality (Zedler 2003, Costanza et al. 2008, Gedan et al. 2011). Consequently, understanding how marshes respond to multiple stressors is critical for the health and economic well-being of coastal communities worldwide

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(Millennium Ecosystem Assessment 2005). To keep pace with sea-level rise, marshes must accumulate sediment and organic matter, while resisting erosion from waves and storm surges. Both features of resilient marshes depend on well-developed root systems (Nyman et al. 2006, Perillo et al. 2009, Pratolongo et al. 2009).

Poteresia coarctata is the dominant macrophyte in salt marshes on the South East Coast of Bangladesh . There are two growth forms of *P. coarctata* that create distinct zonation patterns within the marsh. The tall-form of is *P. coarctata* located in well-drained areas along creek banks and the edges of bays (low marsh), where as the short- form is located in the more inland areas (high marsh). The salt marsh grass *Porteresia's* successful adaptations enable it to live where only few other plants could survive. It has narrow and tube-shaped stem, tough leaf blades and special glands that secrete excess salt, making it ideal to withstand the high heat and daily exposure to sea water. Some herbivores feed directly on salt marsh, especially cattle, and a substantial fraction of plant carbon enters into the coastal and estuarine food web through the microbial process of litter and particulate organic detritus (Abu Hena et al., 2007a and 2007b). The high primary production rates of salt marsh are closely linked to the high production rates of associated fisheries in the study area of South-Eastern coast of Bangladesh in exception to middle part because of indiscriminate growth of ship breaking industries, Chittagong. There are also some threats associated to coastal development in the salt marsh in this area are listed in the present research work. Semi-diurnal movement of tidal water alters biotic and abiotic environments in intertidal sediments over short time intervals.

Soil organic matter is often viewed as the thread that links the biological, chemical and physical properties of a soil. Salt marsh ecosystems are maintained by the dominant macrophytes that regulate the elevation of their habitat within a narrow portion of the intertidal zone by accumulating organic matter and trapping inorganic sediment. Pore water of salt marsh bed will give an important feature of the environment of the coastal area of South-eastern Bangladesh. This study will also provide the sediment properties of the salt marsh bed in the coastal area. Information on the salt marsh in the coastal environment is necessary to determine the extent of pollution and coastal zone management .Unfortunately research in this line is meager and limited information is available with regard salt marsh in Sitakund, Chittagong which is located in the South-Eastern coast of Bangladesh. So it is important to undertake research work on this issue. Keeping this philosophy in mind, the research work is carried out which can be a useful source of information and a gap filling initiative for knowing the organic content on the growth of salt marsh with some physio-chemical parameters of pore water and sediment. The present study was carried out for determine the growth, water and soil quality of the salt marsh *Porteresia coarctata* in the study area and identify the major threats for salt marsh bed at the study area.

2. Materials and Methods

2.1 Study Area

The Study areas Salimpur and Muradpur are two unions of Sitakunda Upazilla of Chittagong district. Faujdarhat (Salimpur) is well known for ship breaking activities and Muradpur (Sitakunda) is also known as undisturbed area, both sides are blessed with Natural Salt marsh (*Porteresia coarctata*). Faujdarhat (Salimpur) is situated about 10 km north of Chittagong City gate and Muradpur (Sitakunda) is about 25 km north of Chittagong city Gate. Both the sides adjacent to Sandwip Channel and besides Dhaka-Chittagong Trunk Road (Figure 1).

2.2 Sampling Design

The present study was based on observations from June, 2018to December 2018. The authors were taken 7 samples in seven months with 4 replicate samples by zoning the intertidal salt marsh bed as low marsh, low-mid marsh, high-mid marsh and high marsh zonation.

2.3 Growth Monitoring of Salt marsh

Growth of the salt marsh were monitored on monthly basis by zoning the sites as low marsh, low-mid marsh, high-mid mash, and high marsh areas as the sediment and pore water samples were taken. Height of salt marsh was measured by using meter tape. About 20-25 salt marsh height were measured during sampling in each zone of each sampling sites.

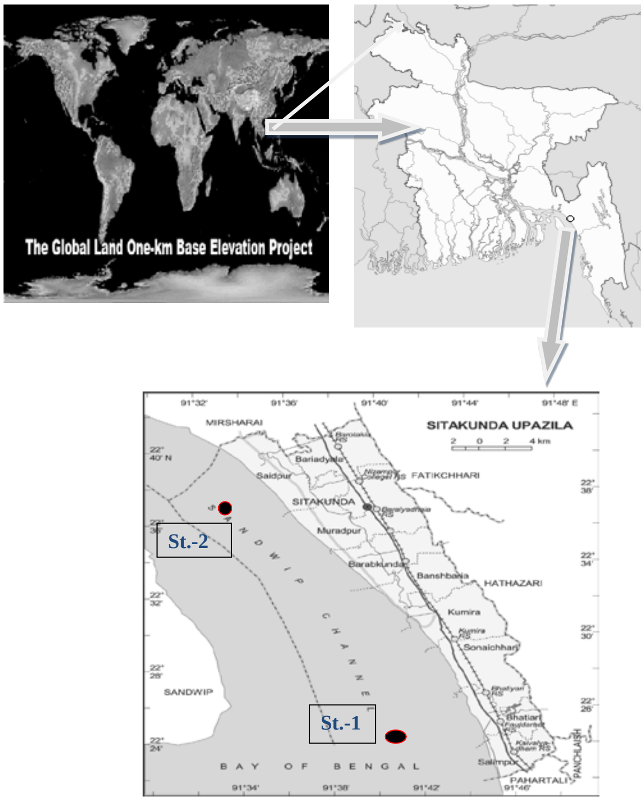

Figure 1: Map showing the sampling Stations in Sitakunda, Bangladesh.

2.4 Preservation of pore water and soil samples

The collected pore water samples were preserved fixed and analyzed as recommended in the standard procedures considering analysis of different parameters. The sediment samples were taken in plastic polythene without addition of any chemicals. The preserved samples were analyzed in the chemical laboratory of Bangladesh Scientific and Chemical Industries Research (BSCIR), on the following day after arriving. All the frozen samples in the Icebox were analyzed in the laboratory after attaining room temperature. 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 pH meter. Water salinity was determined by using a hand held refract meter (ATAGO, S/Mill, Salinity 2-100‰. Japan). Sediment deposition in the salt marsh bed were monitored on monthly basis by zoning the sites as low marsh, low-mid marsh, high-mid mash, and high marsh areas as the sediment and pore water samples were taken. Four wooden pools and concrete pillars were installed to monitor the sedimentation in the salt marsh bed in both sites of the sampling areas.

2.5 Laboratory Analysis

Sediment samples were mixed thoroughly in equal proportion to prepare a composite sample. Sediment samples were dried in air and then the sediment particles were passed through a 2 mm mesh size sieve. Before analysis, soil samples were finely dried in an oven at 105^0C for 24hours.

PH of sediment collected was determined by digital p^H meter in wet condition. Soil Texture was measured followed by the hydrometer method (Gee, 2002). Total organic carbon and organic matter was derived from oxidizable organic carbon by assuming that OM contains 58% of organic carbon (Estefan et al., 2013).

The relevant hydrological parameters in connection to shrimp culture are surface water salinity, pH, temperature, dissolved oxygen (DO), BOD (3-day at 27^oC), nitrate, phosphate, silicate and sediment organic carbon (for the present site). Surface water salinity was measured in the field by refractometer and cross-checked by argentometric method. Water pH was measured by a portable pH meter (sensitivity = ± 0.02). Surface water temperature was measured by a Celsius thermometer. DO, BOD, Alkalinity, Nitrite-Nitrogen (NO_2 –N), Phosphate-Phosphorus (PO_4 –P) and Silicate-Silicon (SiO_3-Si) of the pore water sample were measured as per the procedure stated in APHA (2012).

2.6 Statistical Analysis

Correlation co-efficient analysis was applied for the relationship between growth of salt marsh and soil parameters; salt marsh growth and pore water parameters. One way ANOVA classification was applied to assess the difference between the stations and also among the months.

3. Results

3.1 Salt marsh growth monitoring

Growth of Salt marsh *Porteresia corctata* was monitored on monthly basis during the present study. Growth varied from Station to Station and month to month. Highest growth was recorded in St-1 at June and lowest in St-2 at September (Figure 2). Mean values of growth in station-1 are 14.08±1.48 cm, 11.43±0.92 cm, 4.68±1.76 cm, 2.58±0.70 cm, 6.05±1.07 cm, 2.80±0.80 cm, 2.83±0.62 cm at June to December respectively and in Station-2 are 8.48±1.52cm, 5.28±2.10 cm, 2.70±0.50 cm, 1.48±0.46 cm, 6.20±0.88 cm, 4.70±1.79 cm, 4.08±1.58 cm at June to December respectively (Table 1).

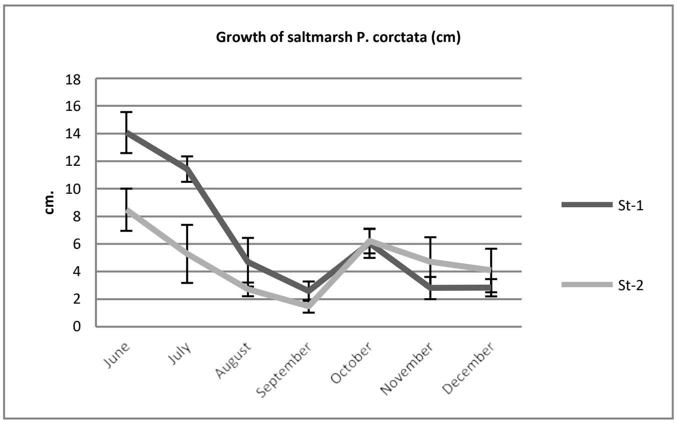

Figure 2: Growth of salt marsh *Porteresia corctata* in different months at Sitakunda

Table 1: Growth monitoring of salt marsh (cm.) in different months

	Station-1					Station-2				
	Replication 1	Replication 2	Replication 3	Replication 4	Mean ±SD	Replication 1	Replication 2	Replication 3	Replication 4	Mean ±SD
June	14.30	15.70	14.20	12.10	14.08±1.48	8.20	10.10	9.10	6.50	8.48±1.52
July	12.70	11.50	10.70	10.80	11.43±0.92	4.70	8.20	5.00	3.20	5.28±2.10
August	4.50	7.10	2.90	4.20	4.68±1.76	2.10	2.50	3.20	3.00	2.70±0.50
September	2.40	3.60	2.00	2.30	2.58±0.70	1.00	1.20	2.00	1.70	1.48±0.46
October	6.20	7.50	5.30	5.20	6.05±1.07	6.50	7.20	6.00	5.10	6.20±0.88
November	3.50	3.40	2.50	1.80	2.80±0.80	6.70	5.40	4.20	2.50	4.70±1.79
December	2.70	3.20	3.40	2.00	2.83±0.62	4.20	5.20	5.10	1.80	4.08±1.58

3.2 Sediment Analysis

Organic matter of the sediment ranged from 0.84- 3.26 %. Highest value was recorded at Station-1 during June and lowest value was also recorded at station-1 during June. Mean values of OM in station-1 are 2.79±0.35%, 2.97±0.60%, 3.17±0.51%, 3.06±0.39%, 1.44±0.60%, 1.75±0.84%, 2.09±1.00% during June to December respectively and in Station-2 are 1.52±.055%, 1.60±0.73%, 2.43±0.30%, 2.21±0.33%, 1.18±0.18%, 1.03±0.08%, 1.26±0.43% during June to December respectively. (Table 2).

3.2 Sediment Analysis

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Table 2: Organic Matter of Soil of salt marsh bed (%) in different months

	Station-1					Station-2				
	Replication 1	Replication 2	Replication 3	Replication 4	Mean ±SD	Replication 1	Replication 2	Replication 3	Replication 4	Mean ±SD
June	3.26	2.43	2.66	2.81	2.79±0.35	1.66	0.93	2.21	1.27	1.52±.055
July	2.12	3.51	3.14	3.12	2.97±0.60	2.69	1.22	1.26	1.24	1.60±0.73
August	3.42	3.61	2.45	3.21	3.17±0.51	1.98	2.66	2.51	2.55	2.43±0.30
September	3.42	2.50	3.10	3.21	3.06±0.39	2.44	2.49	1.78	2.12	2.21±0.33
October	1.87	0.94	2.04	0.90	1.44±0.60	1.32	0.96	1.09	1.33	1.18±0.18
November	0.84	2.86	1.84	1.45	1.75±0.84	0.96	1.12	1.08	0.97	1.03±0.08
December	0.92	1.58	2.96	2.88	2.09±1.00	1.24	0.89	1.87	1.02	1.26±0.43

Organic Carbon (OC) of the sediment ranged from 0.44- 1.72 %. Highest value was recorded at Station-1 during June and lowest value was also recorded at station-1 during June. Mean values of OC in station-1 are 1.47±0.19%, 1.57±0.31%, 1.67±0.27%, 1.61±0.21%, 0.75±0.32%, 0.92±0.45%, 1.10±0.53% during June to December respectively and in Station-2 are 0.80±0.29%, 0.84±0.39%, 1.28±0.16%, 1.16±0.17%, 0.62±0.09%, 0.54±0.03%, 0.66±0.23% during June to December respectively. (Table 3).

Table 3: Organic content (%) of soil of salt marsh bed in different months

	Station-1					Station-2				
	Replication 1	Replication 2	Replication 3	Replication 4	Mean ±SD	Replication 1	Replication 2	Replication 3	Replication 4	Mean ±SD
June	1.72	1.28	1.40	1.48	1.47±0.19	0.87	0.49	1.16	0.67	0.80±0.29
July	1.12	1.85	1.65	1.64	1.57±0.31	1.42	0.64	0.66	0.65	0.84±0.39
August	1.80	1.90	1.29	1.69	1.67±0.27	1.04	1.40	1.32	1.34	1.28±0.16
September	1.80	1.32	1.63	1.69	1.61±0.21	1.28	1.31	0.94	1.12	1.16±0.17
October	0.98	0.49	1.07	0.47	0.75±0.32	0.69	0.51	0.57	0.70	0.62±0.09
November	0.44	1.51	0.97	0.76	0.92±0.45	0.51	0.59	0.56	0.51	0.54±0.03
December	0.48	0.83	1.56	1.52	1.10±0.53	0.65	0.47	0.98	0.54	0.66±0.23

C/N ratio of the present study ranged from 5.88:1 to 16.89:1. Highest and lowest ratio was observed during December in Station-1 &Station -2 respectively (Table 4).

Table 4: C/N ratio of the soil of Salt marsh bed in different months										
	Station-1					Station-1				
	Replication 1	Replication 2	Replication 3	Replication 4		Replication 1	Replication 2	Replication 3	Replication 4	
June	9.05:1	9.14:1	7.78:1	8.71:1		8.70:1	7.00:1	12.89:1	9.57:1	
July	9.33:1	11.56:1	12.69:1	10.93:1		10.14:1	8.00:1	8.25:1	5.91:1	
August	10.00:1	12.67:1	11.73:1	10.56:1		9.45:1	8.75:1	8.80:1	10.31:1	
September	15.00:1	7.33:1	9.59:1	9.94:1		14.22:1	10.01:1	8.54:1	9.33:1	
October	7.53:1	6.13:1	10.70:1	7.83:1		6.27:1	7.29:1	8.14:1	7.00:1	
November	6.29:1	10.07:1	10.78:1	9.50:1		7.29:1	8.43:1	8.91:1	6.38:1	
December	6.86:1	10.37:1	10.47:1	16.89:1		6.50:1	5.88:1	9.80:1	6.75:1	

Soil P^H of the sediment observed in the study area was varied from 3.6 to 7.4. Highest in Station-1 during October and lowest in also in Station-2 during August. Abu Hena *et. al., (*2007) found (6.32±0.5) in the salt marsh bed of *porteresia coractata* at Bakkhali estuary, Cox's Bazar. Sediment deposition in the salt marsh bed ranged from -14.20 to 12.30 cm with mean values -2.43±0.75cm, -1.50±0.23 cm, -0.98±1.51 cm, +1.83±0.60, cm +1.33±1.69 cm, +3.33±1.12 cm, +2.78±1.16 cm during June to December respectively and in Station-2 -8.58±2.59 cm, -9.15±4.86 cm, -3.58±0.74 cm, +0.83±2.47 cm, +5.05±0.93 cm, +9.48±2.90 cm, +8.85±3.14 cm during June to December respectively. (Table 5)

Table 5: Sediment Deposition rate in Sampling Stations (cm.) in different months										
	Station-1					Station-2				
	Replication 1	Replication 2	Replication 3	Replication 4	Mean ±SD	Replication 1	Replication 2	Replication 3	Replication 4	Mean ±SD
June	-3.40	-2.20	-2.50	-1.60	-2.43±0.75	-11.10	-10.50	-6.60	-6.10	-8.58±2.59
July	-1.50	-1.40	-1.30	-1.80	-1.50±0.23	-14.20	-12.40	-5.50	-4.50	-9.15±4.86
August	-1.20	-2.20	-1.70	+1.20	-0.98±1.51	-4.10	-4.30	-3.10	-2.80	-3.58±0.74
September	+1.50	+1.40	+2.70	+1.70	+1.83±0.60	-2.80	+2.10	+2.60	+1.40	+0.83±2.47
October	-1.20	+2.10	+2.10	+2.30	+1.33±1.69	+4.10	+5.10	+6.30	+4.70	+5.05±0.93
November	+2.40	+4.80	+3.60	+2.50	+3.33±1.12	+9.40	+12.30	+10.70	+5.50	+9.48±2.90
December	+1.8	+1.80	+4.10	+3.40	+2.78±1.16	+9.20	+10.50	+11.40	+4.30	+8.85±3.14

(- Means erosion, + means accretion)

3.3 Water Quality Analysis

Dissolve oxygen in the study area varied from 4.54 ml/l to 8.71ml/l while Lowest value was observed in September at Station-1 and highest value was observed in October at Station-2. p^H in the study areas varied from 5.40 to 7.54. 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.

Pore water Salinity in the salt marsh bed ranged from 0.50 to 40‰ in the study area. Highest salinity was recorded in December in Sation-2 and lowest in July & August in both Station-1 & 2. 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 and Faujdherhat, Chittagong. Present investigation had the similar result. Water alkalinity level in the salt marsh bed ranged from 70 to 140 ppm in the study area. alkalinity was recorded in October at Sation-2 and lowest in June & August in both Station-1. Nitrate Nitrogen (NO_2-2) in the pore water of salt marsh bed in both stations ranged from 0.04 to 4.10μg/L. Lowest value was observed in June at Station-2; highest value was observed in October at satation-2. Phosphate-Phosphorus (PO_4-P) in the pore water of salt marsh bed in both station ranged from 0.23-3.44 μg/L. Lowest value was observed in June at Station-1 &2; highest value was observed in June at Station-2. Silicate-Silicon (SiO_3-Si) in the pore water of salt marsh bed in both station ranged from 1.36 to 3.65μg/L. Lowest value was observed in December at Station-1; highest value was observed in July at Station-1 & October at Station-2. Biological Oxygen Demand (B.O.D) of the pore water for 24 hours of salt marsh bed in both stations ranged from 0.42 to 1.92 mg/L. Lowest value was observed in November at Station-2; highest value was observed in August at Station-1. Chemical Oxygen Demand (C.O.D) of the pore water of salt marsh bed in both stations ranged from 12.80 to 33.60 mg/L. Lowest value was observed at Station-1 in different months; highest value was observed at Station-2 in different months.

3.4 Statistical Result

Organic content had insignificant positive relationship on the growth of salt marsh. Significant difference was observed among the months in growth of salt marsh. No significant difference was observed between the stations. Organic Carbon has insignificant positive relationship with salt marsh growth. There were significant dereference observed among the months and stations. Positive significant relationship was observed between Nitrogen and growth of the salt marsh. Significant difference were observed among the months and stations (Table 6 and 8).

Table 6: Correlations Matrix of Growth of Salt marsh and Sediment parameters								
	Growth	Organic Carbon	Nitrogen	Soil pH	Deposition	Clay	Silt	Sand
Growth	1	.140	.232*	-.267*	-.272*	-.493**	-.443**	.517**
Organic Carbon	.140	1	.844**	-.195	-.303*	-.119	-.128	.140
Nitrogen	.232*	.844**	1	-.117	-.262*	-.149	-.133	.157
Soil pH	-.267*	-.195	-.117	1	.582**	.350**	.336**	-.381**
Deposition	-.272*	-.303*	-.262*	.582**	1	.482**	.357**	-.462**
Clay	-.493**	-.119	-.149	.350**	.482**	1	.606**	-.868**
Silt	-.443**	-.128	-.133	.336**	.357**	.606**	1	-.921**
Sand	.517**	.140	.157	-.381**	-.462**	-.868**	-.921**	1

*. Correlation is significant at the 0.05 level (1-tailed);
**. Correlation is significant at the 0.01 level (1-tailed).

Negative significant relationship was found between the growth of salt marsh and soil pH. Significant difference was observed among the months but insignificant difference was observed between two sites also. Negative significant relationship was found between salt marsh growth and clay particle and silt particles but positive insignificant relationship was observed between salt marsh growth and sand particles. Significant difference was observed among the months of clay particles, Silt particles and sand particles. But insignificant difference was observed between the Station of clay, silt and sand particles (Table 6 and 8). On the other hand, Negative significant relationship was found between salt marsh growth and sediment deposition. Significant difference was observed among the months of sediment deposition but insignificant difference was observed between the stations (Table 6 and 8).

Negative insignificant relationship was found between salt marsh growth and dissolve oxygen. Significant differences were observed between the dissolved oxygen and among the months as well as stations. Positive insignificant relationship was found between salt marsh growth and Biological Oxygen Demand (BOD). Significant difference was observed among the months and stations with Biological Oxygen Demand (BOD) (Table 7 and 8). Negative significant relationship was found between salt marsh growth and alkalinity insignificant difference was observed among the months of alkalinity. But significant difference was observed between the stations (F= 65.860, P= 0.000). Positive insignificant relationship was found between salt marsh growth and P^H. Significant difference was observed among the months of pH. But insignificant difference was observed between the stations (Table 7 and 8).

Table 7: Correlation Matrix between Growth of Salt marsh and Water Quality

	Growth	DO	BOD	COD	NO_2-N	PO_4-P	SiO_3-Si	Alkalinity	Temperature	Salinity	pH
Growth	1	-.155	.070	.218	-.149	-.127	.383**	-.273*	.131	-.327**	.124
DO	-.155	1	-.484**	-.313**	.313**	.076	.068	.606**	-.139	.067	.032
BOD	.070	-.484**	1	.098	-.159	-.113	.031	-.545**	.381**	-.244*	-.036
COD	.218	-.313**	.098	1	-.022	.001	-.085	-.240*	-.203	.103	.035
NO_2-N	-.149	.313**	-.159	-.022	1	.106	.018	.175	-.157	.122	-.152
PO_4-P	-.127	.076	-.113	.001	.106	1	-.079	.073	.239*	-.178	.012
SiO_3-Si	.383**	.068	.031	-.085	.018	-.079	1	.091	.032	-.013	-.054
Alkalinity	-.273*	.606**	-.545**	-.240*	.175	.073	.091	1	-.131	.022	.063
Temperature	.131	-.139	.381**	-.203	-.157	.239*	.032	-.131	1	-.882**	.389**
Salinity	-.327**	.067	-.244*	.103	.122	-.178	-.013	.022	-.882**	1	-.385**
pH	.124	.032	-.036	.035	-.152	.012	-.054	.063	.389**	-.385**	1

**. Correlation is significant at the 0.01 level (1-tailed); *. Correlation is significant at the 0.05 level (1-tailed).

Table 8: One way ANOVA of different parameters among the months and Stations

Parameters	**Months**		**Stations**	
	F	**Significant**	**F**	**Significant**
Growth	18.559	.000	2.896	.095
Organic Carbon	5.529	.000	18.099	.000
Nitrogen	4.154	.002	11.295	.001
Soil pH	9.293	.000	2.664	.108
Sediment Deposition	16.719	.000	.081	.776
Clay	7.568	.000	.142	.707
Silt	8.093	.000	.022	.883
Sand	10.853	.000	.086	.771
DO	.485	.816	58.306	.000
BOD	3.074	.012	39.352	.000
COD	2.698	.024	24.656	.000
NO_2-N	3.965	.003	.393	.533
PO_4-P	1.033	.415	.801	.375
SiO_3-Si	1.642	.156	.318	.575
Alkalinity	.182	.981	65.860	.000
Salinity	387.416	.000	.002	.960
Water pH	5.200	.000	.158	.693

Positive insignificant relationship was found between salt marsh growth and chemical Oxygen Demand (COD). Significant difference was observed among the months of Chemical Oxygen Demand (COD) and significant difference was also observed between the stations. Negative significant relationship was found between salt marsh growth and Salinity. Significant difference was observed among the months of Salinity. But insignificant difference was observed between the stations (Table 7 and 8).

4. Discussion

Soil Organic matter in the areas was higher than the recorded values (0.2-0.4%) as reported by Rajyalakshmi and Chandra (1987) in Chika lagoon, India and in mangrove areas (0.5-1.7%) of Bangladesh (Zafar and Hasan, 2005). Abu Hena *et. al.*, (2007) found (2.5±0.79%) organic matter in the salt marsh bed of *porteresia coractata* at Bakkhali estuary Cox's Bazar. Present study were found more organic matter in the salt marsh habitat.

Abu Hena *et. al., (*2007) found (1.32±0.72%) organic carbon in the salt marsh bed of *Porteresia coractata* at Bakkhali estuary Cox's Bazar. Findings of present investigation were very close to this value. The range of C/N ratio of the present study was almost same on the finding of Hanson (1977) found 6.66:1 to 11.4:1 C/N ratio in Georgia.

Abu Hena *et. al., (*2007) found Soil $_P$H range 6.32±0.5 in the salt marsh bed of *porteresia coractata* at Bakkhali estuary, Cox's Bazar which is close to the present study. Pore water Salinity in the salt marsh bed ranged from 0.50 to 40‰ in the study area. 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 and Faujdherhat, Chittagong. Present investigation had the similar result. Water alkalinity level in the salt marsh bed ranged from 70 to 140 ppm in the study area.

Salt marsh vegetation in the coastal areas in Sitakunda is in threats. Experimental sites of my research both Salimpur (St-1) and Muradpur (St-2), various types of threats are detected which are retarding the proper growth of salt marsh. The threats which are identified during my research period are enlisted in the Table 9. From the Table it is found that shipbreaking activities are the major threat for salt marsh growth of Sitakunda area. Shipbreaking industry of Bangladesh is the world most production place of shipbreaking and due to unplanned expansion and coastal pollution, salt mash vegetation destroying enormously in the study areas. Domestic animals also observed threat for salt marsh vegetation. Besides, coastal embankment construction also threat for the important salt marsh vegetation of Sitakund coastal area.

Table 9: Major threats for Salt Marsh growth in the Study Areas

Study Area 1		Study Area 12	
Threats	**Management**	**Threats**	**Management**
Ship breaking	Proper site selection avoiding salt marsh	High wave Action	Increase the Mangrove plantation program.
	Creating safety enclosure	Erosion	Increase the Mangrove plantation program
	Maintaining IMO rules	Grazing	Stopping the indiscriminate grazing
Grazing	Exclude grazing cows by fencing off salt marsh.	Fishing	Fisher man should be careful to protect the Salt marsh vegetation
Oil Spilling	Ship breaking process should be modernized to protect oil spillage.	Cutting for fodder.	Using other food items to feed the cattle .
Walking way	Restrict access by walkers or walking in single way.		Stopping indiscriminate cutting
Sand mining	Avoiding salt marsh vegetation.		
Cutting for fodder.	Using other food items to feed the cattle.		
Coastal embankment	Proper site selection of developing embankment.		

5. 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 imbalance because these elements interacting each other. Factors that have been shown, or are thought, to monitor the growth of salt marsh in coastal salt marsh bed are numerous, and they can interact in complex ways .Because enrichment and pollution causes changes in growth it can be viewed as a perturbation that affects these factors. The recent trends of modern sciences are concentrating in the study of biodiversity of flora and fauna in assessing the condition of the environment. Growth monitoring of salt marsh *Porteresia coarctata* in the natural salt marsh bed of Sitakunda has been done during June to December with some physico-chemical parameters of the pore water and soil. From the above result it can be said that the growth of salt marsh *P. coarctata* is correlated with the parameter of pore water and soil of the salt marsh bed. Growth pattern show monthly variation. Physico-chemical parameters of the pore water and soil show monthly variation and also spatial variation.

6. Recommendations

The results obtained revealed that organic content had minor effect on the growth of salt marsh i.e. growth increase with the increase of Organic content but after few months growth of salt marsh decrease although the organic content high. Afterwards the amount of organic content reduced. Salt marsh growth has a negative relation with salinity that is the growth of salt marsh decrease with the increase of salinity. There are some threats detected during the study period, which lead the destruction of natural salt marsh vegetation. Sea level has already increased by 20 cm over the past 100 years and is projected to increase further in coming decades. Salt marsh sites will be able to migrate into terrestrial habitat areas; however, these sites are constrained by natural topography or developments like roads, urban areas, agriculture, and coastal embankment. Some salt marsh sites are already on the highest local land or on estuarine islands that will eventually submerge if sea level rise (SLR) continues.

The author recommended proper site selection and appropriate techniques for stopping oil spilage by shipbreaking activities for avoiding salt marsh and Creating safety enclosure by the shipbreaking owners, developed the barricade for easy movement of domestic animals for protection of salt marsh vegetation, restriction of walkers and tourists for walking in single way and avoiding salt marsh zone, using other food items to feed the cattles, proper site selection of coastal embankment development and establish mangrove afforestation program in the study areas for protect the area from coastal erosion with such a way salt marsh vegetation will be protect.

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