

Physico-chemical parameters of water and sediment during spring period in parts off bay of Bengal, Bangladesh

Abstract

The present investigation encompassed to give a quick overview of some physico-chemical parameters of water and sediment in the northern part of Bay of Bengal during spring period in March and April. The physico-chemical parameters water temperature (23–32°C), salinity (22–34‰), pH (6.0–7.8) and DO (1.94–6.32ml/l) and sediment temperature (17–23°C), salinity (3.9–6.7‰), pH (6–7.5), organic carbon (0.98–3.63%) and organic matter (1.68–6.24%) were recorded. Sediment salinity was inversely correlated with water salinity ($r = -0.576$, $P < 0.05$, $df = 10$) and sediment pH showed a positive relation with water pH ($r = 0.68$, $P < 0.05$, $df = 10$). No published report was found on physico-chemical parameter of subsurface water and surficial sediment in the Bay of Bengal off Bangladesh coast. Therefore, the present results focus a baseline data for developing water and sediment quality index of the coastal zone in Bangladesh territory.

Keywords: physico-chemical parameters, water, sediment, Bangladesh coast, baseline

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Introduction

The coastal oceans have become very important places for outdoor research around the world from geological, hydrological and biological point of view. Hydrological features, bio-productivity of coastal transition zones is so dynamic that variations take place monthly, daily and even hourly. Physico-chemical factors of coastal waters, mainly the salinity, temperature, dissolved oxygen content are variable condition due to the tides and also freshwater discharge by network of rivers.¹ The ecology of the Bay of Bengal has been studied in relation to coastal edaphic features by Islam.² The physicochemical conditions of water of the coastal zone are not well known but the environmental condition of the Bay of Bengal may be considered as representing those of coastal areas.² In order to understand the fertility of any aquatic system for its possible use, a study on its physicochemical characteristics of water and sediment is indispensable. Many workers conducted investigations to record physical, chemical and biological parameters of the Bay of Bengal near Bangladesh but information available in Bangladesh showed about only water qualities Mahmood et al.³ Bangladesh situated one of the world's largest delta and is interlaced with an intricate system of rivers and many tidal channels, which carry downstream a large quantity of sediment. The annual load carried in suspension is approximately 1.7 billion tons.⁴ This sediment plays an important role in the nutrient regeneration and primary productivity of Bangladesh coast. Sediment pH is the most important factor of nutrient availability⁵ and the organic carbon is directly related with mud percentage in sediment.⁶ The amount of organic carbon in sediments is influenced by both physical and biological factors and may in turn influence the quality and availability of food sources benthic faunal communities. Zafar et al.⁷ reported organic carbon as the index of sediment fertility. Estuaries and others coastal ecosystems forms a

significant component of global carbon balance as intense processing of organic matter, originating from fluvial inputs, local production or lateral inputs from marshes and mangrove take place.⁸ Organic matter binds mineral particles in to granules that are largely responsible for the loose, easily manage condition of productive sediment and is the main source of energy for sediment organism. Texture is the relative proportions of the different size groups of separates. The rate and extent of many important physical and chemical reactions in sediment are governed by texture.⁹ The objectives of the present research work were to determine physico-chemical parameters of subsurface water and surficial sediment of the most productive and vulnerable coastal ocean of Bangladesh.

Materials and methods

Water samples were collected randomly from six stations located in between 21°39'00"N to 22°10'00"N latitude and 91°22'10"E to 91°50'10"E longitude during March 2007 and from five stations located in between 21°02'00"N to 21°38'00"N latitude and 89°36'00"E to 91°37'00"E longitude in April 2007 from northern part of the Bay of Bengal¹⁰ (Figure 1). Samples were collected by Nansen bottle from subsurface level (≥ 4 m, ranged between 05 to 16m) and sampling depths were detected by sounding technique (Eco-sounder: Model-EURO 3000). Concurrently water temperature, Salinity, pH were recorded by using a thermometer, refractometer (model: 0~100^{0/00}, ATAGO, Japan) and a digital pen pH meter (Model: S237734, Hana Instruments) respectively. Dissolved oxygen content in water samples were analyzed as following the Winkler's method.¹¹ piece of foil paper in a thin layer and kept on a shelf in the sediment preparation room until it was air-dry. Sediment salinity was determined following the methods of Petersen.¹² Sediment texture was detected following the procedure described by Bouyoucos.¹³ Sediment Organic carbon was determined according to the method of Jackson.¹⁴ Sediment

Organic Matter was determined according to the method followed by Belaluzzaman.¹⁵ Correlation and regression analysis were done to assess the relationship among various physico-chemical parameters of water and sediment.



Figure 1 Map showing the geographical location of the sampling spots in the Bay of Bengal.

Source www.googleearth.com 2007 (modified).

Table 1 Physico-chemical parameters of water and sediment in the offshore area of Bangladesh coast

Period	St. no	Lat (N)	Lon (E)	Sampling depth (m)		Salinity (‰)		pH		Temperature (°C)		Water D.O (ml/l)	Sediment		
				W	S	W	S	W	S	W	S		Org. C (%)	Org. Matter (%)	
March 2007	1	21°40'35"	91°22'11"	6.8	6.8	26.5	6.6	6.1	6.1	28	23	5.9	0.98	1.68	
	2	21°50'31"	91°33'55"	10.33	10.33	29	6.7	6.7	6.4	28	20	5.5	1.04	1.78	
	3	21°39'07"	91°22'37"	11	11	24	5.1	6.3	6.2	31	20	6.1	1.85	3.18	
	4	21°48'54"	91°22'51"	8.8	8.8	22	5.5	6.5	6	28	22	5.8	1.76	3.03	
	5	21°52'44"	91°50'05"	14	14	25	5.6	6.6	6.5	29	20	6.32	1.92	3.3	
	6	22°09'48"	91°45'26"	10.5	10.5	25	5.2	6	6.6	30	21	5.7	1.97	3.39	
	7	21°38'00"	91°37'00"	5	12.5	32	4.3	6.9	6.9	32	20	4.03	1.95	3.35	
April 2007	8	21°08'01"	91°07'05"	7.01	14.5	34	3.9	6.9	7.1	28	19	2.75	1.81	3.11	
	9	21°02'01"	90°34'09"	16.45	66.6	32	4.5	7.7	7.5	27	17	1.94	3.63	6.24	
	10	21°13'51"	90°08'02"	14.32	23	31	4.2	7.8	6.7	25	19	2.5	1.72	2.96	
	11	21°30'07"	89°36'06"	10.7	10.7	29.5	4.2	6.8	6.8	23	21	2.41	1.47	2.53	
Mean	10.45	17.16	28.18	5.07	6.8	6.62	28	20	4.45	1.83	3.14
±SD	3.32	16.14	3.72	0.92	0.6	0.43	2	11	1.66	0.66	1.13

NB:W,Water; S, Sediment; Org.,Organic

Hydrogen ion concentration (pH)

In the present investigation pH value fluctuates in minor magnitude, ranged from 6.0 to 7.8 with an average 6.75 ± 0.55 (Table 1). The pick value was recorded during April in station 10 which is in the Swatch of No Ground area and lower value was noticed during March in station 06 at lower Meghna estuary.

Dissolved oxygen (DO)

In the investigated area the mean DO content in subsurface water

Results

Physico-chemical parameters of subsurface water viz. salinity, temperature and dissolved oxygen content, pH were recorded and concurrently sediment temperature, salinity, pH, organic carbon and organic matter were also determined.

The recorded water and sediment parameters stated as:

Physico-chemical parameters of subsurface water

Temperature

In the present investigation the average subsurface water temperature was recorded as $28.02 \pm 2.49^\circ\text{C}$ (Table 1) and varied between 23–32°C. The maximum (32°C) value was recorded in the southeastern coast (station 07, down part of Sandip Island) in April and minimum (23°C) was also observed in April at station 11 near the downstream area of Khulna Sundarban.

Salinity

The mean water salinity was observed as $28.18 \pm 3.72\text{‰}$ (Table 1) and ranged between 22–34‰. The highest value (34‰) was noticed in a location in the Middle Fishing Ground area at station 08 during April and lowest (22‰) was observed at station 04 in March near the lower parts of the Hatiya Island.

was recorded $4.45 \pm 1.66\text{ml/l}$ (Table 1). The DO content in subsurface water fluctuates greatly during April and minimum value was found 1.94 ml/l at about 16.45m water depth in the Middle Fishing Ground area (station 09) during April.

Surficial sediment parameters

Temperature

The average temperature was recorded $20.18 \pm 10.7^\circ\text{C}$ (Table 1) in all sampling stations. The highest temperature was recorded 17°C at

station 1 during March and the lowest was recorded 23°C at station 9 in April (Table 1).

Salinity

Mean salinity was recorded $5.07 \pm 0.92\%$ in all the sampling station. Highest salinity was found 6.7‰ at station 2 during March and lowest value 3.9‰ was recorded at station 8, during April 2007 (Table 1). Sediment salinity was inversely correlated with water salinity ($r = -0.576$, $P < 0.05$, $df = 10$).

Hydrogen ion concentration (pH)

The average pH of surficial sediment was recorded 6.62 ± 0.43 in all sampling stations. pH was obtained maximum 7.5 at station 9 in April and minimum value was recorded 6.0 at station 4 in March 2007 (Table 1). Sediment pH was positively correlated with water pH ($r = 0.68$, $P < 0.05$, $df = 10$).

Organic carbon

The average organic carbon was recorded $1.83 \pm 0.66\%$ in all sampling stations. The highest organic carbon was recorded 3.63% at station 9 in April and the lowest was recorded 0.98% at station 1, during March (Table 1).

Organic matter content

The mean organic matter was recorded $3.14 \pm 1.13\%$ in all sampling station. The highest (6.24%) organic matter was recorded at station 9 in April and the lowest (1.68%) organic matter was recorded at station 1, during March (Table 1).

Sediment texture

The average texture of surficial sediment as sand 87.01 ± 7.57 , silt 5.23 ± 1.99 and clay 8.5 ± 7.64 were recorded in the all sampling stations (Table 2). The highest (94.58%) sand was recorded at station 2 in March and the lowest (67.38 %) was recorded at station 9 during April (Table 2). The highest (9.9%) silt was recorded at station 3 and the lowest (2.49 %) was recorded at station 5 in March (Table 2). The highest (27.85%) clay was recorded at station 9 during April and the lowest (0.57 %) was recorded at station 2 in March (Table 2).

Table 2 Sediment texture in the northern part of Bay of Bengal in Bangladesh coast

Period	Station	Sand (%)	Silt (%)	Clay (%)
March, 2007	1	90.95	6.86	2.19
	2	94.58	4.85	0.57
	3	88.55	9.9	1.55
	4	91.53	2.55	5.92
	5	82.11	2.49	15.4
	6	88.32	4.21	7.47
	7	88.49	4.88	6.63
April, 2007	8	79.68	5.39	14.93
	9	67.38	4.77	27.85
	10	91.88	6.95	1.17
	11	93.68	4.69	1.63
Mean	—	87.01	5.23	8.57
±SD	—	7.57	1.99	7.64

Discussion

Physico-chemical parameter of subsurface water

Temperature

Mahmood et al.¹⁶ reported the water temperature ranges in between 25.25–27.60°C off the coast of Bangladesh in March. Temperature distribution was found relatively uniform in subsurface water. This result is closely agreed with the findings of Kumar et al.¹⁷ He stated that the temperature distribution in subsurface water showed thermally homogeneous in the upper 30 m layer. Sasamal¹⁸ reported on hydrography of the northern Bay of Bengal, recorded water temperature $>28^\circ\text{C}$ in the eastern side and $<26^\circ\text{C}$ at about 50m depth in a position 19°N and 86°E. He also observed mixed layer depth (MLD) was about 75m in the coastal region along 20°30'N and 40–50m along 19°N. But still there is scant information about the subsurface water temperature off the Bangladesh coast in the Bay of Bengal.

Salinity

Mahmood et al.¹⁶ recorded the water salinity ranges in between 19.68–31.98‰ off the coast of Bangladesh during March. Zafar¹ stated that the average salinity 28.13‰ in March and 25.13‰ in April in surface water in the northeastern Bay of Bengal. Kumar et al.¹⁹ found a strong gradient of vertical salinity distribution in the upper 30m, ~1.5psu in the south and ~7psu in the north of 17°N, with considerable freshening towards the north between 30 and 100meter the salinity changes with depth were gradual and below 100meter were homogenous. Pati¹⁸ recorded the maximum salinity from April to June and minimum in October in the Bay of Bengal off the Balashore coast, India. The findings of the present investigation are apparently harmonious with the above-mentioned results.

Hydrogen Ion Concentration (pH)

Zafar¹ recorded an average pH value 8.3 in March and 7.92 in April at surface water of the northeastern part of the Bay of Bengal. Islam, (2001) recorded pH values 8.2 at (22°N, 91°45'E), 8.1 at (21°N, 91°15'E), 8.3 at (22°N, 91°45'E), 8.1 at (20°N, 92°15'E), 7.1 at (21°N, 89°42'E), 8.0 at (21°N, 89°30'E) respectively in the subsurface water. Generally the alkaline value of pH in the coastal water of Bangladesh is 6–9.²⁰ The outcome of present study shows similar trend of results. There is no available report on subsurface water pH off the Bangladesh coast in the Bay of Bengal.

Dissolved oxygen (DO)

The standard DO value of the coastal water of Bangladesh is 6 ml/l.²⁰ Mahmood et al.¹⁶ recorded the DO content in water ranges in between 4.20–4.84 ml/l off the coast of Bangladesh in March. Sasamal¹⁸ reported that the values of D.O were high at about 50m depth in the southern part of central region and low in the western part of the Bay of Bengal along 20°30'N, oxygen around 0.39 ml/l was observed in the Swatch of No Ground. The 4ml/l contour was located around 30m depth in the west and around 75m in the east along 19°N, which extend 50m depth along 20°30'N. The findings of the present study are exclusively agreed with the above mentioned report. In the present study DO in water was found positively correlated with water temperature and negatively with salinity of water. Similar relationship was also found by Satyanarayana et al.²¹ in the fishing ground of Mukka-kaup. Zafar¹ also found positive correlation with water temperature and DO in the northeastern part of the Bay of Bengal.

Surficial sediment parameters

Sediment salinity

Hosain⁶ recorded average 2.01‰ salinity at selected off shore locations of the St. Martin's Island during pre-monsoon. In the present study sediment salinity showed an inverse relationship with salinity of water ($r = -0.57$, $P < 0.05$). Such inverse relationship occurred due to tidal frictional current action in surface water salinity high, but low salinity in sediment comes from rivers, upstream sources where fresh water is existed.

Hydrogen ion concentration (pH)

Grant²² recorded the inter-tidal sediment pH ranged from 7.6 to 8.1 from the inter-tidal sand flat of North Inlet, South Carolina, U.S.A. Islam²³ recorded pH values ranged from 6.35 to 6.85 in bottom sediment collected from lower Meghna river estuary during premonsoon. Hosain⁶ found mean pH value 7.29 at offshore areas of the St. Martin's Island during pre-monsoon. Islam, (2001) recorded pH values 6.5, 6.8, 6.8, 6.2 and 7.8 at location (21°85'N, 89°89'E), (22°10'N, 89°84'E), (21°89'N, 90°62'E), (21°52'N, 91°91'E) and (21°45'N, 92°51'E) respectively. Chowdhury²⁴ recorded soil pH ranged from 5.2 to 6.5 from sediment sample of Naff river estuary. The findings of present study coincide with the above mentioned results. In the present investigation the surficial sediment pH showed a positive relation with water pH ($r = 0.68$, $P < 0.05$).

Organic carbon

Islam²³ reported sediment organic carbon varied from 0.21% to 0.83% in a study at the lower Meghna river estuary. High percentage of organic carbon (0.795% to 2.379%) was recorded by Chowdhury (2006) at the Naff river estuary. In the present research work organic carbon content in sediment showed a similar pattern of distribution except a high value 3.63% at station 9 in the middle fishing ground area (21°02'01"N, 90°34'09"E). These results are harmonious with findings of present investigation.

Organic matter content

Kondalarao²⁵ reported that organic matter of intertidal zone of the Kinda bay, east coast of India was 0.70% to 2.17% which differ with the present observation where organic matter varied from 1.69% to 6.24% (Table 1). Alam²⁶ reported that 0.952% to 2.615% of total organic matter at Haliashahar coast. These results showed close agreement with the present findings.

Sediment texture

Vizakat et al.²⁷ expressed that the texture of sediment as silty clay's and silts; silty sand of the subtidal soft sediment of the west coast of India. Alam²⁶ recorded the seasonal variation of sediment percentage in the Haliashahar coast; Chittagong and he also found maximum sand percentage in monsoon and minimum in winter, which is similar with the present investigation. Hosain⁶ stated the coarser fragments (sandy) were deposited near the shore and the finer particles (clay, silt) at a distance. In the present investigation percentage of clay is higher in the northern part of the Bangladesh coast. Mahadevan et al.²⁸ reported highest percentage of sand than silt and clay in the inter-tidal zone in Godavari estuary at maximum sampling stations. Similar findings were also observed in present study.

Conclusion

Till now there is no available report on physico-chemical parameter of subsurface water and surficial sediment of the Bay of Bengal off the Bangladesh coast. Therefore the present study would be a baseline reference for developing water and sediment quality index of the coastal oceanic zone of the Bangladesh territory.

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Conflict of interest

The author declares there is no conflict of interest.

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