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# Trace Metals Concentration in Water and Sediment off Bangladesh Coast in the Bay of Bengal

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**Abstract:** The Coastal-Oceanic ecosystem of Bangladesh contains a highly functional and structurally diverse ecology. The present study focusses an overview of trace metals concentration in subsurface water and surficial sediment off Bangladesh coast in the Bay of Bengal. Samples were collected during spring on March and April 2007 and the concentration of trace metals in water were recorded as Ca 593.71 ± 59.28 µg/L, Mg 1029.02 ± 104.77 µg/L, Cu 0.56 ± 0.22 µg/L, Fe 11.84 ± 2.77 µg/L, Mn 4.74 ± 2.24 µg/L and Zn 1.66 ± 1.18 µg/L and in sediment Ca 10.54 ± 2.50 µg/g, Mg 5.55 ± 1.42 µg/g, Cu 10.59 ± 7.47 mg/g, Fe 20.50 ± 7.42 mg/g, Mn 29.55 ± 7.91 mg/g and Zn 0.59 ± 0.17 mg/g respectively. Correlation co-efficient showed that trace metal in water and sediment were significantly interrelated. One-way ANNOVA showed that there is no significant differences in trace metals distribution in water and sediment throughout the Bangladesh coast. The finding of the present study is a baseline reference for developing water and sediment quality index of the coastal oceanic zone of Bangladesh.

**Key words:** Trace metals, water, sediment, Bangladesh coast, Bay of Bengal.

## Introduction

The ocean is providing a relatively constant chemical and physical environment for life. Marine organisms do not have to contend with the large variations of temperature and amounts of nutrients that bother terrestrial life. Iron, copper and zinc present in trace quantities in the seawater are essential for the effective functioning of many physiological and biochemical processes, hence for growth, reproduction etc. (Caddy and Griffiths, 1992). Copper is presumably homeostatically controlled in sea and is an essential trace metal for plants growth (Khan et al., 1992). The precipitation and dissolution of iron in response to change of pH and Eh are believed to be an important buffer mechanism regulating the levels of phosphorus and trace metal in aquatic environments (Hutchinson, 1967). Calcium is an essential component of bone, cartilage and the crustacean exoskeleton and magnesium is the major cation of intracellular fluid and regulates intracellular osmotic pressure and acid base balance (Tacon, 1990). Physico-chemical factors of coastal waters, mainly the salinity, temperature, and dissolved oxygen content, are variable condition due to the tides and also freshwater discharge by network of rivers (Zafar, 1992). Urban and industrial activities in the coastal areas of Bangladesh introduce significant amount of nutrients into the Bay of Bengal.

Bangladesh is interlaced with an intricate system of rivers and many tidal channels, which carry downstream a large quantity of sediment. This sediment plays an important role in the nutrient regeneration and primary productivity of Bangladesh coast. The amount of trace metals in sediments is influenced by both physical and biological factors and may in turn influence the quality and availability of food sources for benthic faunal communities. In order to understand the fertility of any aquatic system for its possible use, a study on its physico-chemical characteristics of water and sediment

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is indispensable. The ecology of the Bay of Bengal has been studied in relation to coastal edaphic features (Islam, 2001). The physico-chemical 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 (Islam, 2001). 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., 1976). Though the neritic zone is highly productive, information and investigation in this regard are scant.

## Materials and Methods

Water and sediment samples were collected randomly from six stations (Table 1) located in between 21°39′00″ N to 22°10′00″ N latitude and 91°22′10″ E to 91°50′10″ E longitude and from five stations (Table 1) located in between 21°02′00″ N to 21°38′00″ N latitude and 89°36′00" E to 91°37′00" E longitude during March 2007 and April 2007 at the offshore area of Bangladesh in the Bay of Bengal (Figure 1). Samples were preserved in refrigerator at 0°C temperature for laboratory analysis. In the laboratory, freeze water and sediment samples were placed on shelf until the samples reached room temperature. Trace metals concentrations were determined following the methods as mentioned in APHA (1976). Correlation and regression analysis was done to assess the relationship among the various trace elements in terms of their concentration. One-way analysis of variance (ANNOVA) was used for testing the differences among the parameters of different sampling stations.

**Table 1: Geographic position of the sampling stations off Bangladesh coast**

| *Station no.* | *Latitude (N)* | *Longitude (E)* | *Station no.* | *Latitude (N)* | *Longitude (E)* |
|---|---|---|---|---|---|
| 01 | 21°40′35″ | 91°22′11″ | 07 | 21°38′00″ | 91°37′00″ |
| 02 | 21°50′31″ | 91°33′55″ | 08 | 21°08′01″ | 91°07′05″ |
| 03 | 21°39′07″ | 91°22′37″ | 09 | 21°02′01″ | 90°34′09″ |
| 04 | 21°48′54″ | 91°22′51″ | 10 | 21°13′51″ | 90°08′02″ |
| 05 | 21°52′44″ | 91°50′05″ | 11 | 21°30′07″ | 89°36′06″ |
| 06 | 22°09′48″ | 91°45′26″ | | | |

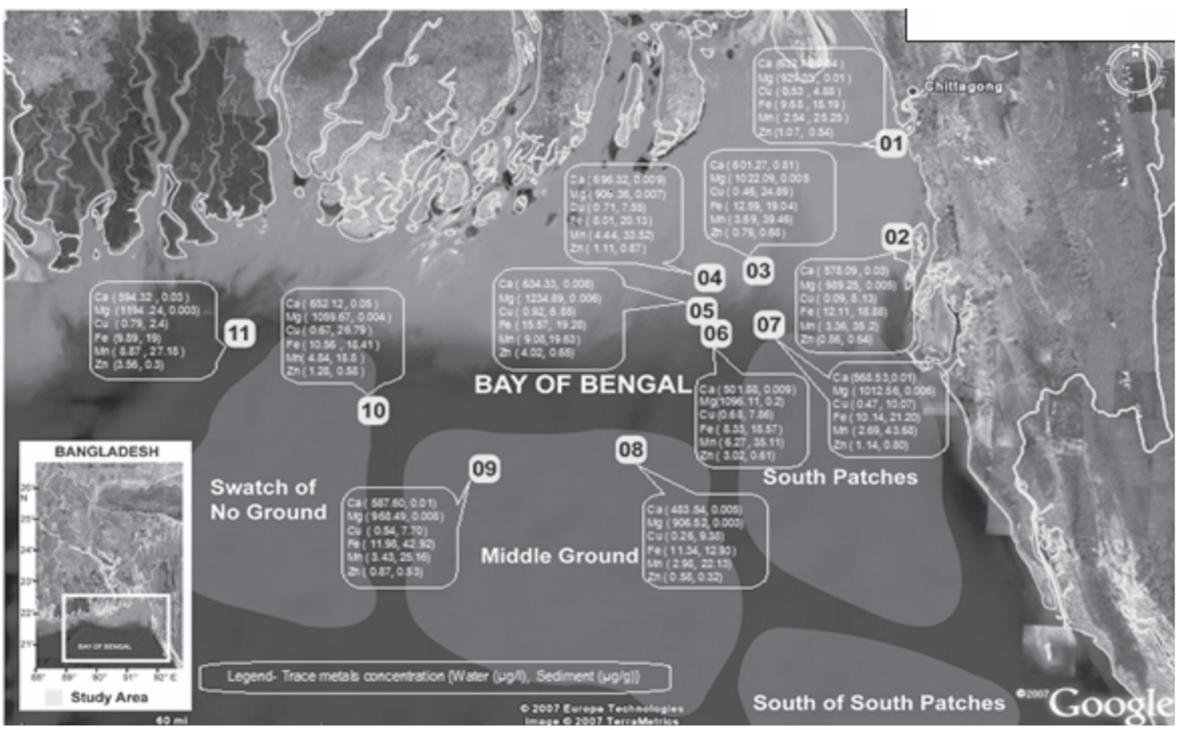


**Figure 1: Trace metals concentration in water and sediment in different sampling station off Bangladesh coast.**

## Results

Concentration of some trace metals in subsurface water viz. Ca, Mg, Cu, Fe, Mn and Zn were recorded and concurrently the concentration of the same elements were also determined in sediment. The recorded water and sediment parameters are described here.

**Trace Metals Concentration in Subsurface Water**

In present study concentration of calcium in subsurface water varied significantly and average value was recorded 593.71±59.28 µg/L (Table 2). Pick value (696.32 µg/L) was recorded near the lower parts of the Hatiya Island and least 483.54 µg/L was recorded in the Middle Fishing Ground area during April. Magnesium concentration in water varied significantly in the present study at the northern part of the Bay of Bengal. The average Mg concentration was 1029.02±104.77 µg/L (Table 2) and the maximum was found in the downward parts of the Hatiya Island. In the present study the concentration of Mg in water showed a high degree of positive correlation with Cu ($r = 0.64, p < 0.5$), Mn ($r = 0.902, p < 0.001$) and Zn ($r = 0.907, p < 0.001$) concentration in water. Average concentration of Cu was observed 0.56±0.23 µg/L during present investigation (Table 2). Cu concentration was found significantly lower at station 2 in off shore area of Kutubdia Island. Variation in concentration of Cu was observed positively related with Mn ($r = 0.76, p < 0.01$) and Zn ($r = 0.75, p < 0.01$). The concentration of iron was ranged between 8.01 and 15.57 µg/L and the pick value was recorded at station 5 in the downward parts of the Hatiya Island (Table 2). Manganese concentrations in subsurface water varied significantly and mean value was estimated 4.75±2.24 µg/L (Table 2); maximum was found at station 5 and minimum at station 1. Significant variation in zinc concentration was observed in subsurface water and average value was found 1.67±1.18 µg/L (Table 2) where the highest value was recorded at station 5 and lowest was at station 8 in the middle Fishing Ground Area of the Bay of Bengal. During the present study period zinc concentration was found positively varied with Mn concentration ($r = 0.95, p < 0.001$) in water.

**Trace Metals Concentration in Surficial Sediment**

Significant variation in calcium concentration in surficial sediment was observed during the present investigation at the northeastern part of the Bay of Bengal. The average Ca concentration was 10.54±2.503 µg/g. Maximum value was 151.33 µg/g found at location 2 while minimum concentration was 22.12 µg/g in location 8 (Table 3). The average magnesium concentration was 5.55±1.428 µg/g. Maximum value was 20.34 µg/g found at location 9 while minimum concentration was 8.11 µg/g in location 5 (Table 3). Highest concentration was found in sediment collected from the middle fishing ground area. Fluctuation in copper concentration was observed in surficial sediment during present investigation. An unusual value of copper concentration 2.40 µg/g was observed at station 11, which was lowest value while maximum concentration was recorded 26.79 µg/g at station 10**.** Average copper concentration was observed 10.59±7.467 during present investigation (Table 3).

No significant variation in iron concentration was observed in the overall study area except in the middle fishing ground area of the Bay. Both highest (42.92 µg/g) and lowest (12.93 µg/g) values of iron were found in the middle fishing ground areas in stations 9 and 8 respectively. Average concentration of iron was observed 20.50±7.418 during present investigation (Table 3). Concentration of manganese in southern bay was found

**Table 2: Trace metals concentration in subsurface water off Bangladesh coast**

| *Station No.* | *Ca (µg/L)* | *Mg (µg/L)* | *Cu (µg/L)* | *Fe (µg/L)* | *Mn (µg/L)* | *Zn (µg/L)* |
|---|---|---|---|---|---|---|
| 01 | 632.76 | 929.03 | 0.53 | 9.68 | 2.54 | 1.07 |
| 02 | 578.09 | 989.25 | 0.09 | 12.11 | 3.36 | 0.86 |
| 03 | 601.27 | 1022.09 | 0.46 | 12.59 | 3.69 | 0.79 |
| 04 | 696.32 | 906.36 | 0.71 | 8.01 | 4.44 | 1.11 |
| 05 | 634.33 | 1234.89 | 0.92 | 15.57 | 9.08 | 4.02 |
| 06 | 501.88 | 1096.11 | 0.68 | 8.33 | 6.27 | 3.02 |
| 07 | 568.53 | 1012.56 | 0.47 | 10.14 | 2.69 | 1.14 |
| 08 | 483.54 | 906.52 | 0.26 | 11.34 | 2.98 | 0.58 |
| 09 | 587.60 | 968.49 | 0.54 | 11.98 | 3.43 | 0.87 |
| 10 | 652.12 | 1059.67 | 0.67 | 10.56 | 4.84 | 1.28 |
| 11 | 594.32 | 1194.24 | 0.79 | 9.89 | 8.87 | 3.56 |
| Mean | 593.71 | 1029.02 | 0.56 | 11.84 | 4.744 | 1.67 |
| ±SD | 59.28 | 104.77 | 0.23 | 2.773 | 2.240 | 1.18 |

**Table 3: Trace metals concentration in sediment off Bangladesh coast**

| *Station No.* | *Ca (µg/g)* | *Mg (µg/g)* | *Cu (mg/g)* | *Fe (mg/g)* | *Mn (mg/g)* | *Zn (mg/g)* |
|---|---|---|---|---|---|---|
| 01 | 43.85 | 12.49 | 4.88 | 15.19 | 25.25 | 0.54 |
| 02 | 151.33 | 12.32 | 8.13 | 18.88 | 35.20 | 0.64 |
| 03 | 47.33 | 13.78 | 24.89 | 19.04 | 39.46 | 0.68 |
| 04 | 39.59 | 17.69 | 7.55 | 20.13 | 33.52 | 0.87 |
| 05 | 34.47 | 16.11 | 6.85 | 19.28 | 19.63 | 0.65 |
| 06 | 52.46 | 12.37 | 7.86 | 18.57 | 35.11 | 0.61 |
| 07 | 42.16 | 15.26 | 10.07 | 21.20 | 43.68 | 0.80 |
| 08 | 22.12 | 9.33 | 9.38 | 12.93 | 22.13 | 0.32 |
| 09 | 52.14 | 20.34 | 7.70 | 42.92 | 25.16 | 0.53 |
| 10 | 47.61 | 10.67 | 26.79 | 18.41 | 18.80 | 0.58 |
| 11 | 27.81 | 8.12 | 2.40 | 19.00 | 27.18 | 0.30 |
| Mean (µ) | 10.54 | 5.55 | 10.59 | 20.50 | 29.56 | 0.59 |
| ± SD | 2.503 | 1.428 | 7.467 | 7.418 | 7.913 | 0.17 |

lower than the northeastern bay. Maximum value (43.68 µg/g) was observed at station 7 and minimum value (18.80 µg/g) was found at location 10. Average value was estimated as 29.56±7.913 µg/g (Table 3). No significant variation in zinc concentration was observed in surficial sediment. Average value was found 0.59±0.17 µg/g. Highest concentration was 0.87 µg/g observed at station 4 and lowest value was 0.30 µg/g at station 11 (Table 3).

## Discussion

### Trace Metals Concentration in Subsurface Water

Dissolved calcium is very important constituent for bioactivity. Calcium values ranges from 610.24 mg/l to 935.80 mg/l in Bakkhali and Naaf river estuary respectively during spring (Mahmood et al., 2002). Findings of the present investigation are exclusively agreed with the above-mentioned work. Magnesium controls many biological activity of marine organism. Concentration of magnesium varied in between 635.23 mg/l and 1210.24 mg/l during spring in Bakkhali and Naaf river estuary (Mahmood et al., 2002). Present result also agreed with the above-mentioned work. The maximum concentration of Cu was recorded as 0.324 µg/l during monsoon and the minimum 0.089 µg/l during pre-monsoon period at Shitakunda coast, Chittagong (Mahmood et al., 2002). Recommended value of Cu for near-shore seawater is 0.517±0.062 µg/ml (NRCC, 1995). The standard value of Cu concentration for the coastal water of Bangladesh is 0.5 µg/ml (EQS, 1991). So the present result agreed with that of NRCC (1995) and EQS (1991).

The concentration of Fe as 67.90 µg/ml at the Foujderhat coastal zone Chittagong and values were high due to the discharge of metal rust (iron) and various types of refuge and disposable materials from the scrap ships (Mahmood et al., 2002). Standard values of Fe recommended for near-shore seawater is 1.26±0.17 µg/ml by NRCC (1995). The EQS value of Fe for coastal water of Bangladesh is 2.00 mg/l. The concentration of Fe found in the present investigation is lower than the recommended value of EQS (1991). So, the concentration of Fe found in the present study may not affect the aquatic life. Recommended values of Mn in near-shore seawater is 2.51 ± 0.36 µg/ml (NRCC, 1995). The concentration of Mn was 0.672 µg/ml in Sitakunda coastal zone of the Bay of Bengal during monsoon and 0.376 µg/ml during post-monsoon period (Mahmood et al., 2002). The EQS value of Zn for Bangladesh coastal water is about 5.00 mg/l. Concentration of Zn in the estuarine region of northeastern Bay of Bengal was reported ranging between 64.28 and 135.70 mg/l by Mahmood et al. (2002). In the present investigation concentration of Zn was observed in between 0.58 and 4.02 µg/l, which indicates that marine life is in a safe condition till now in regard of Zn concentration in water.

### Trace Metals Concentration in Surface Sediment

The values of Ca was 2250, 2100, 2350, 2300 and 590 µg/g; Mg values 680, 550, 650, 600 and 590 µg/g; and K values 49, 45, 65, 70 and 62 µg/g at geographic locations (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 in the surficial sediment as recorded by Mahmood et al. (2002). During the present study Mg concentration in surficial sediment was found varied in a strong linear form with K concentration ($r$ = 0.93912, $P < 0.001$). The maximum concentration of Cu was observed as 35.628 µg/g during pre-monsoon and the minimum was 16.635 µg/g during post-monsoon by

Mahmood et al. (2002). Trace metals in sediments of Eastern Mississippi Bight were determined by Presley et al. (1992) and Cu concentrations were found as 1.0 to 23.0 µg/g. Another observation was made by Morse et al. (1993) on sediments of Galveston Bay and Cu concentrations was recorded as 2.0 to 15.5 µg/g. Finding of the present investigation was more or less similar with the aforesaid authors. Recommended values of Cu in marine sediments are 33.00 µg/g reported by GESAMP (1982) and Salomons and Forster (1984); and 32.7 µg/g reported by IAEA (1990). In the present investigation Cu concentrations were lower than the recommended values during pre-monsoon period, which indicates that the sediment is not polluted in respect to copper concentration.

Iron has frequently been used as an indicator of natural changes in the trace metal carrying capacity of the sediment and its concentration has been related to the abundance of metal reactive compounds not significantly affected by man's action (Luoman, 1990). The maximum and minimum concentration of Fe in an investigation at the northeastern part of the Bay of Bengal by Mahmood et al. (2002) was recorded 1645.38 µg/g during monsoon and 778.92 µg/g during post-monsoon respectively. In the present investigation the concentration of iron varied from 12.93 µg/g to 21.20 µg/g which is significantly lower than that of the unpolluted marine sediment (27.1 µg/g) recommended by IAEA (1990) except at station 9 having a value 42.92 µg/g which indicates that the location at the middle fishing area is in an alarming state in respect of iron concentration**.** Hirata (1992) found maximum Fe concentration as 986.00 µg/g and 1117.78 µg/g of coastal sediments of the Seto Inland Sea and north-eastern Bay of Bengal respectively which is extremely higher than the findings of the present investigation. Nutrient levels and heavy metals in mangrove sediments were reported by Mackey (1992) from the Brisbane river basin, Australia and who found that Fe was present in all the stations above 20.00 µg/g. Morse et al. (1993) reported Fe concentrations 1570 to 40,200 µg/g in and around Galvaston Bay which is higher than the present investigation. Interesting behaviour of iron was observed in the present investigation. The variation in the concentration of Fe was observed minimum but it showed an exclusively positive relation with organic carbon ($r = 0.8003$, $P < 0.01$) and increasing trend with increasing depth ($r = 0.92459$, $P < 0.001$)**.** The above mentioned findings may be a useful indication for the future researcher for rapid study of iron concentration and its fluxes in the middle fishing ground area of the neritic Bay of Bengal.

Manganese is an element of low toxicity and has considerable biological significance. It is one of the more biochemical and active transition metals in aquatic environment (Zafar, 1992). Study on sediments of Galvaston Bay was conducted by Morse et al. (1993) and Mn concentrations was recorded as 165 to 2365 µg/g. Presley et al. (1992) determined trace metals in sediments of Eastern Mississippi Bight and Mn concentrations were found as 40 to 1239 µg/g. Findings of the present investigation was lower than the aforesaid authors. The maximum concentration of Mn was 86.287 µg/g during monsoon and the minimum was 50.876 µg/g during pre-monsoon periods (Mahmood et al., 2002). Recommended value of Mn in unpolluted marine sediment is 1.17 µg/g (IAEA, 1990). But in the present investigation the maximum concentration of Mn is not harmful for sediment and inhibiting community and was found negatively related with pH ($r = -0.5851$). Zinc plays an important role as a micronutrient required for plant growth. The maximum concentration of Zn was observed 36.872 µg/g during monsoon and the minimum was 14.283 µg/g during post-monsoon by Mahmood et al. (2002). Recommended values of Zn in unpolluted marine sediments are 95.00 µg/g (GESAMP, 1982) and 74.80 µg/g (IAEA, 1990). Its variation in concentration depends on the genetic characteristics of the sediments. This concentration of Zn in the sediment possibly indicated that non-detrital source is not in the sediment as in Verma et al. (1993) and the sediment derived from siliceous materials.

Present results showed that the nutrient elements are interrelated in terms of their concentration at different magnitude in the overall sampling areas. However the One-Way Analysis of Variance (ANNOVA) test was done to test the differences in the distribution of various trace metals in different sampling station. The ANNOVA result (calculated value for water 0.014 and for sediment 0.069 where table value is 1.97 at 5% level of significance) showed that there is no significant variation in nutrients and trace metals distribution in subsurface water and surface sediment throughout the coastal oceanic zone of Bangladesh territory.

## Conclusion

Uncontrolled industrialization and population pressure at the coastal zone increases pollution load in the coastal oceanic ecosystem in and around Bangladesh. But till now there is no available report on trace metals concentration in subsurface water and surface sediment off the Bangladesh coast in the Bay of Bengal. So the findings of the present study would be a baseline reference for modelling water and sediment quality of the coastal oceanic zone of Bangladesh.

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