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Trace Metals in Littoral Sediments from the North East Coast of the Bay of Bengal along the Ship Breaking Area, Chittagong, Bangladesh

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Abstract: The composition of trace metals (Cd, Cu, Zn, Fe, Mn, Cr and Pb) in the sediments of the intertidal zone of ship breaking area of the north east coast of the Bay of Bengal has been determined using Flame Atomic Absorption Spectrophotometer. The mean values of trace metals are 0.88 $\mu g.g^{-1}$ for Cd, 32.91 $\mu g.g^{-1}$ l for Cu, 33.54 $\mu g.g^{-1}$ for Zn, 5272.13 $\mu g.g^{-1}$ for Fe, 556.10 $\mu g.g^{-1}$ for Mn, 78.09 $\mu g.g^{-1}$ for Cr and 23.18 $\mu g.g^{-1}$ for Pb. The levels of trace metals in the sediments of the study area have been compared with the recommended values unpolluted sediments. Correlations coefficients of different trace metals have ranged between 0.05 to 0.87 and it is observed that Cd is negatively correlated with virtually all the trace metals present. Geoaccumulations of metals indicate that, Cd is the most enriched metal followed by Pb and Cu. This high level of Cd indicates Cd might contaminate the sediments through anthropogenic sources. As per analysis and subsequent determinations, the beach of the ship breaking area has been indicated as polluted zone.

Key words: Trace metal, littoral sediment, ship breaking area, Bay of Bengal, Bangladesh

Introduction

Marine sediments play an extremely important role in the interaction of man and the sea. Sediments act both as historical record of man's effect on the marine environment, in particular the effect of intense biological and chemical activities at the sediment-water interface, and as wealth of mineral resources. The main input of trace metals, in the coastal sediments comes from rivers and the atmospheric depositions. The distribution of trace metal concentration in sediments, water and biological materials is of great importance in environmental pollution studies (Martincic ***et al.***, 1985; 1986b and 1989). Sediment analysis offers certain advantages over water analysis for the control and detection of metal pollution in estuaries (Frostner and Wittman, 1981; Luoma, 1990). Trace metals are mainly associated with fine grain particles (Donazzolo ***et al.***, 1984; Martincic ***et al.***, 1985) either by absorption or by complex forming part of the particle structure (Laxen, 1983) causing a lot of exchange in the physico-chemical and biological environment of the sea.

Bangladesh is situated at the apex of the Bat of Bengal. It is one of the most densely populated countries of the world. Approximately 24 billion people or 23% of the total production lives in the coastal zone (BBS, 1991). Most of the industries and factories are situated on the banks of the Karnafully River or very close to a river system. About 1273 manufacturing industries are situated near the coastal area, which is about 27.87% of the total industries of the country (Paul and Rahman, 1992). None of the industries have any waste treatment facilities and they discharge their untreated waste into the nearest water bodies, which finally find their way into the Bay of Bengal through different river systems. Annually about 1216 ships and 45-60 oil tankers are handled in the Chittagong port, and power driven trawlers and boats engaged in fishing is about 3110 in the coastal areas of Bangladesh. For the last few years, dismantling of old ships for selling component, there of for various uses, has been progressing steadily along the sea shore, Chittagong. As a result, various refuse and disposable materials are being discharged and spilled from scraped ships often get mixed with the beach soil. The scrap from ships is stacked haphazardly on the shore leaving behind an accumulation of metal fragments and rust in the soil (Islam and Hossain, 1986).

The problems associated with trace metals contamination were first highlighted in the industrially advanced countries because of their larger industrial discharges, and especially by incidence of mercury and cadmium pollution in Sweden and Japan (Kurland ***et al.***, 1960; Nitta, 1972; Goldberg ***et al.***, 1978).Trace metal contaminants in sediments have become a problem of increasing concern, in recent years due to dismantling of old ships, industrialization, and untreated wastes of domestic effluents.

In view of the economic importance of the coastal regions and the adverse effects of metal pollution on living resources, the present study was carried out to investigate the potential accumulation of trace metal in the sediments with regard to ship breaking activity along the ship breaking area of the Karnafully River mouth up to north east coast of the Bay of Bengal.

Materials and Methods

Area of Study

Karnafully the most important river of Chittagong, originates from the lofty ranges of Lusai Hills of Assam in India at Lat. 22°54' N and Long. 92°27' E (O'Mallery, 1908) and enters the district of Chittagong from the north eastern side. The total length of the Karnafully River is about 170 miles and empties into the Bay of Bengal. The river during its course to the Bay of Bengal receives a larger number of tributaries on its left and right banks among which Halda, Ischamatie, Boalkhali etc. are mentionable (Mahmood, 1976).

The study area presents a great interest because a lack of proper sanitation and waste collection facilities, sewage from all over the Chittagong City finally find their way into the Karnafully River through five major drainage systems. The study area receives the untreated wastes of 19 tanneries, 26 textile mills, I oil refinery, I TSP plant, I Urea plant, 2 chemical industries, I DDT plant, 5 fish processing plants, I asphalt bitumen plant, I steel mill, I soft manufacturing factory, 2 cement factories, I paper mill and rayon complex, 2 soap and detergent plants, 2 pesticides manufacturing plants, 4 paint and dye manufacturing units and 75 other light industries (ESCAP, 1988).

Sampling and Analysis

Surface sediment samples were collected from twelve stations of the littoral zone were selected along the ship breaking area during a cruse with a landing craft tent (LCT) of Bangladesh Navy (March, 1996) using an Ekman grab sampler. The samples were sealed in precleaned glass jars and transferred to the laboratory of chemistry division, Atomic Energy Center, Dhaka for further analysis.

The samples were air dried 'in an appropriate clean room to avoid contamination. All the samples were digested with aqua regia following the published procedures (Berrow and Stem, 1983). A parallel blank experiment was also carried out under similar experimental conditions to quantify possible contamination.

Reagents

Atomic absorption standard solutions of Cd, Cu, Zn, Fe, Mn, Cr and Ph were from Fisher Scientific Company, Middleburg, USA-All reagents and chemicals were of analytical grade. Double distilled deionized water was used during this work.

Apparatus

All determinations were made using a Perkin-Elmer 3110 Atomic Absorption Spectrophotometer (AAS) with an air acetylene flame, and hollow cathode single and combination lamps as light source for the metals under test were used in this work. The following wave lengths were used: Cd 228.8, Cu 324.8, Zn 213.9, Fe 248.3, Mn 279.5, Cr 357.9 and Pb 283.3 run.

Results and Discussion

The results of trace metal concentrations are shown in Table 1. Correlation matrix of the concentrations of different trace metals are shown in Table 2. The concentrations of different trace metals at all the stations are not uniform. The concentration of Cd was always higher in all the stations compared to the other metals. The mean value of Cd concentration was recorded as 0.88 $\mu g.g^{-1}$ which is 8 times higher than the recommended value (0.11$\mu g.g^{-}$) of unpolluted marine sediments (GESAMP, 1982; Salomons and Froster, 1984; IAEA, 1989). Table 3 represents comparison of this work values with recommended values of unpolluted sediments. This high level of Cd in the present study might be due to the runoff from agricultural areas using Cd containing phosphate fertilizer (Ray and Macknight, 1989), dismantling of old ship activities and discharge of untreated sewage effluents (Ismail and Awad, 1984) with recent deposits of organics and fine grain sediments (Khan ***et al.***, 1992) as a result of local fishing and other anthropogenic activities (UNEP; FAO; WHO; IAEA, 1989). The anthropogenic activities include ship breaking activity which has been discharging untreated effluents into the Bay of Bengal.

Cu is intimately related to the aerobic degradation of organic matter (Das and Nolting, 1993). The concentration of Cu was lower near the Kamafully River mouth (station 5 and 6) and higher in the ship breaking area. This high level of Cu indicates a higher input of organic matter deposited in the north east coast of the Bay of Bengal which comes from domestic sewage and

Table 1: Trace metal concentrations in sediments collected from the Karnafully River mouth up to north east coast of the Bay of Bengal, along the ship breaking area, Chittagong

Metal/Station	Cd	Cu	zn	Fe	Mn	Cr	Pb
1	0.76	29.67	33.46	4834.57	544.47	78.19	22.93
2	0.87	25.98	32.82	4473.10	543.98	79.34	20.83
3	0.73	31.32	32.93	4364.42	550.42	74.78	22.90
4	0.87	34.94	34.18	4452.40	553.82	73.11	24.00
5	0.91	27.05	34.16	5647.16	558.10	80.16	25.10
6	0.78	28.92	34.46	5940.90	569.83	78.77	25.31
7	0.88	34.36	35.59	5426.54	554.93	76.37	23.17
8	1.22	35.34	33.99	5759.91	563.08	83.03	26.58
9	0.82	35.05	33.67	5835.16	569.83	81.88	21.48
10	1.38	39.71	32.83	5916.57	562.33	78.23	23.20
11	0.71	36.04	32.76	5465.63	557.05	77.29	21.58
12	0.61	36.57	31.58	5149.22	549.88	75.97	21.08
Mean	0.88	32.91	33.54	5272.13	556.10	78.09	23.18
S.D.	0.22	4.24	1.04	600.02	8.12	2.84	1.81

Table 2: Correlation matrix of trace metals in the sediments, collected from the Karnafully River mouth up to north east coast of the Bay of Bengal

Metal	Zn	Pb	Cd	Mn	Fe	Cr	Cu
Zn		0.43	0.35	0.24	0.53	-0.21	0.42
Pb			-0.32	0.58	0.68	-0.16	0.73
Cd				-0.55	-0.28	-0.35	-0.46
Mn					0.70	0.31	0.87
Fe						0.38	0.69
Cr							0.05
CU							

Table 3: Comparison of detected values of trace metals with recommended values of unpolluted sediments (values in $\mu g.g^{-1}$)

Metal	This Work	Recommended value ($\mu g.g^{-1}$)
Cd	0.88	0. 11 (GESAMP, 1982; IAEA,?)
Cu	32.91	33.00 (GESAMP, 1982)
Zn	33.54	95.00 (Salomons and Froster, 1984)
Fe	5272.13	41000.00 (GESAMP, 1982; Salomons and Froster, 1984)
Mn	556.10	770.00 (Salomons and Froster, 1984)
Cr	78.09	77.20 (IAEA, ?)
Pb	23.18	19.00 (Salomons and Froster, 1984)

alters the sediment composition (Das and Nolting, 1993). Hence, the concentration of Cu found in the present investigation was harmfid for the soil and the inhabiting biota.

Zn is one of the earliest known heavy metal. Zn concentration was lower than the recommended values of unpolluted sediments. Its variation in concentration depends on characteristics of the sediments. The extensive human and mechanical activities of ship probably enhanced the concentration of Zn as observed in this investigation.

The mean concentration of Fe (5272.13 $\mu g.g^{-1}$ does not exceed the recommended values of unpolluted sediments (GESAMP, 1982; Salomons and Froster, 1984; IAEA, 1989). This finding is in

Table 4: Comparison of mean trace metal concentrations in sediments of various rivers, estuaries and marine sediments ($\mu g.g^{-1}$)

Location	Cd	CU	Zn	Fe	Mn	Cr	Pb	References
Chittagong coast, Bay of Bengal.	0.88	32.91	33.54	5272.13	556.10	78.09	23.18	Present study.
Saint John Harbor(Inner)	0.16	16	53	---	296	---	24	Ray *et al.*, 1989.
Fly River delta, Papua New Guinea.	---	20-71	58-111	---	---	---	10-20	Baker and Harris, 1991.
Ganges Estuary,India	---	26	71	31036.0	553	67	29	Subramanian *et al.*, 1988.
Varnasadhara River Estuary, India.	---	23.1	33.4	---	---	123	65	Verma *et al.*, 1993.
Vetter River Estuary, India	---	9	104	---	619	68	50	Mohanchandran, 1988.
Pater River, India	---	64	---	---	11-3-1	-338	45	Mohanchandran, 1988,
Tamarni River, India.	---	20	60	---	370	65	70	Mohanchandran, 1988.
Cauvery River, India.	---	12	26	---	316	111	39	Mohanchandran, 1988.
Knysna Lagoon, South Africa.	0.23	6.7	40.6	---	---	---	48.4	Watling and Watling, 1982a.

well agreement with the findings of Banu (1995) in the sediments of the Karnafully River mouth. Fe has frequently been used as an indication of natural changes in the heavy metal carrying capacity of the sediments (Rule, 1986) and its concentration has been related to the abundance of metal reactive compounds supposedly not significantly affected by men's action (Luoma, 1990).

Mn is an element of low toxicity having considerable biological significance. It is one of the more biogeochemical and active transition metals 'in aquatic environment (Evans ***el al.***, 1977). Evidence has been presented (Uthe and Blish, 1971) that it accumulates in certain species of fish. Behavior of Mn in estuaries has been studied by Duinker and Nolting (1978), and Trefry and Presley (1982).

Cr distribution in the study area was very complex in nature. The concentration of Cr did not follow any regular pattern of distribution. The mean values are almost similar in the coastal and estuarine sediments of the Seto inland sea, Japan (Hirata, 1992). The concentration of Cr near the ship breaking area was significantly higher than near the Karnafully River, This higher concentration could be due to waste disposal of various refuse materials, lubricants, oil residue, floatable grease ball etc. discharged from ship breaking activities.

The concentration of Pb, a poisonous element, 'in all the stations was uniform. The mean concentration of Pb in the present study was recorded as 23.18 $\mu g.g^{-1}$ and the range (20.83-26.58 $\mu g.g^{-1}$) was remarkably similar to that observed by Baker and Harris (1991) in the sediments of the Fly River delta, Papua New Guinea. In all stations Pb concentrations exceeded the recommended values of unpolluted sediments. This could be attributed to the combined effect of boat exhaust systems, spillage of oil, other petroleum from mechanized boats employed for fishing, and the discharge of sewage effluents into water (AbuHilal, 1987; Laxen, 1983). Further anthropogenic activities, prevalent in this study area might also play a key role in the accumulation of Pb in the sediments (Ashraf ***et al.***, 1992) along with mineralization of organic matter. The use of leaded gasoline has been mainly responsible for the Pb pollution load during the 20th century in urban areas, and long-rang transport of Pb has been reported (Mukai ***et al.***, 1994).

Although industrial effluents, spillage of oil and wastes were discharged into the Bay of Bengal, fishes do not seem to be contaminated at present as far as Pb and Cd are concerned (Sharif ***et al.***, 1993). In future, this loading of trace metals in the sediments might increase so as to contaminate the standing stock of different kinds of fisheries. From the above discussion, it follows that trace metal concentrations around the ship breaking area are higher than near the Karnafully River mouth, which may be due to the influence of untreated effluents discharged by various ship breaking industries located in the north east coast of the Bay of Bengal.

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