6

Heavy Metal Pollution in Sediments at Ship Breaking Area of Bangladesh

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Abstract: The research was carried out to assess the trace metal concentration in sediments of ship breaking area in Bangladesh. The study areas were separated into Ship Breaking Zone and Reference Site for comparative analysis. Metals like iron (Fe) was found at 11,932 to 41,361.71 $\mu g.g^{-1}$ in the affected site and 3393.37 $\mu g.g^{-1}$ in the control site. Manganese (Mn) varied from 2.32 to 8.25 $\mu g.g^{-1}$ in the affected site whereas it was recorded as 1.8 $\mu g.g^{-1}$ in the control area. Chromium (Cr), nickel (Ni), zinc (Zn) and lead (Pb) also varied from 22.89 to 86.72 $\mu g.g^{-1}$; 23.12 to 48.6; 83.78 to 142.85 and 36.78 to 147.83 $\mu g.g^{-1}$ respectively in the affected site whereas these were recorded as 19, 3.98, 22.22 and 8.82 $\mu g.g^{-1}$ in the control site. Copper (Cu), cadmium (Cd) and mercury (Hg) concentration varied from 21.05 to 39.85, 0.57 to 0.94 and 0.05 to 0.11 $\mu g.g^{-1}$ in the affected site and 33.0, 0.115 and 0.01 $\mu g.g^{-1}$ in the control site. It may be concluded that heavy metal pollution in sediments at ship breaking area of Bangladesh is at alarming stage.

Key words: Trace metal, affected area, control site, heavy metal, alarming stage, ship breaking area.

INTRODUCTION

The marine environment of the coastal water is vital to mankind on a global as

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well as on local basis concerning energy. The Bay of Bengal which is a potential bode of marine life as well as for its vast coastal communities is now continually polluted by different types of pollutant through influx of land base and other sources and put an alarming signal of awareness about pollution in the sea. The coastal areas of Chittagong, Bangladesh, support a complex trophic organization, sustain a high biodiversity including some endemic species and are highly susceptible to interference from activities. Coastal ecosystem makes a sustainable livelihood particularly to coastal fishing communities.

Ship breaking yards along the coast of Chittagong (Faujdarhat to Kumira), confined in an area of 10 km, has become of a paramount importance in the macro- and micro-economic context of poverty-stricken Bangladesh. Ship breaking activity presents both challenge and opportunity for coastal zone management in holistic manner. Ship breaking activities offer direct employment opportunities for about 25,000 people. Moreover about 200,000 are also engaged in different business related to ship breaking activities in Bangladesh (YPSA, 2005).

The Department of Environment (DoE) has categorized the Ship Breaking Industry (SBI) as ‘Red’ in 1995 (EIA guidelines for the Industries, 1997). Ship breaking operation is generally carried out in the beach along the coast of any country. Any discharge like spillage of oil, lubricant, grease, PoPs etc. are spilled or thrown into the coast during the ship breaking operation (Hossain and Islam, 2006).

Heavy metal concentration in aquatic environment is of critical concern, due to toxicity of metal and their accumulation in aquatic habitats. Heavy metals, in contrast to most pollutants, are not biodegradable and they undergo a global ecological cycle in which natural waters are the main pathways. A large part of the heavy metal input ultimately accumulates in the estuarine zone and continental shelf, since these areas are important sinks for suspended marine and associated land-derived contaminants.

Heavy metals (Fe, Cu, Zn, Pb, Cr, Cd, Hg and Ni) introduced into the environment by dumping domestic and municipal wastes, industrial effluents, urban run off, agricultural run-off, atmospheric deposition and mining activities as well as upstream run-off are absorbed on to depositions and incorporated into the marine sediments. A large part of the heavy metal input ultimately accumulates in the estuarine zone and continental shelf. These areas are important sinks for suspended matter and associated land-derived contaminants (Yeats and Bewers, 1983).

Sediments act as indicators of the burden of heavy metals in a coastal environment, as they are the principal reservoir for heavy metals (Fitchko and Hutchinson, 1975). Sediments are the sources of organic and inorganic matter in the river, estuaries, oceans and the other water supply systems. Aquatic organisms living in the sediments accumulate heavy metals to a varying degree (Bryan and Hummerstone, 1977). The bioavailability of heavy metals may widely depend on sediment characteristics, water chemistry, hydrography and biological factors etc. (Ahmed et al., 2002). The effect of toxic metals on marine biota like fish, mollusk, coelenterate, crustaceans, birds and benthic organisms are increasing nowadays (Sadiq, 1992) (Table 1).

Table 1: The effects of toxic metals on marine biota

Organisms	*Effects*
Fish	At 1 µg-cd/L earlier hatching occurs (Javeen et al., 1998) Increase mortality Reduction in body defense system
Coelenterates	At 1 µg-cd/L ctenophores loss growth and survivality Irregular cell division
Mollusk	At 5 µg-cd/L *Crassorstrea virginia* gets slightly delayed development Delayed the maturation system
Crustaceans	Increase mortality and delay development (Mirkes et al., 1978) Effects occur on the shell development Irregular cell division
Sea birds	Mortality increase Reduction in body defense Retardation of growth Loss of breeding capacity Reduction of shell thickness of eggs
Benthos	Irregular structure Acute toxic condition at the bottom Retardation of growth

METHODOLOGY

Flow Chart Methodology

The full activity of the research has been depicted in flow chart (Fig. 1A).

Site Selection for the Experiment

The ship breaking areas from Bhatiari to Kumira of Chittagong coast extending about 10 km and the eastern side of Sandwip island have been selected as the study area considering Bhatiari-Kumira as the most affected site and Shiberhat to Guptachar ghat of the eastern side of Sandwip as the control site (Fig. 1). The eastern side of Sandwip has been considered as the control site because these are diagonally opposite and off the SBYs and the water and soil qualities are apparently free from pollutants as revealed from the earlier studies.

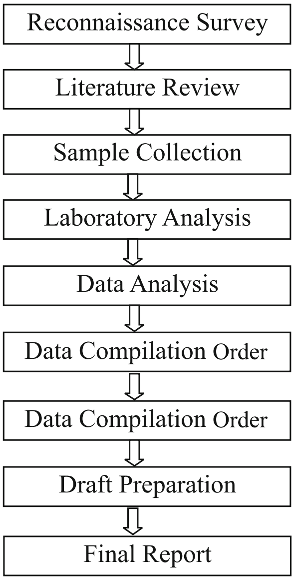

Fig. 1A: Working plan of the research.

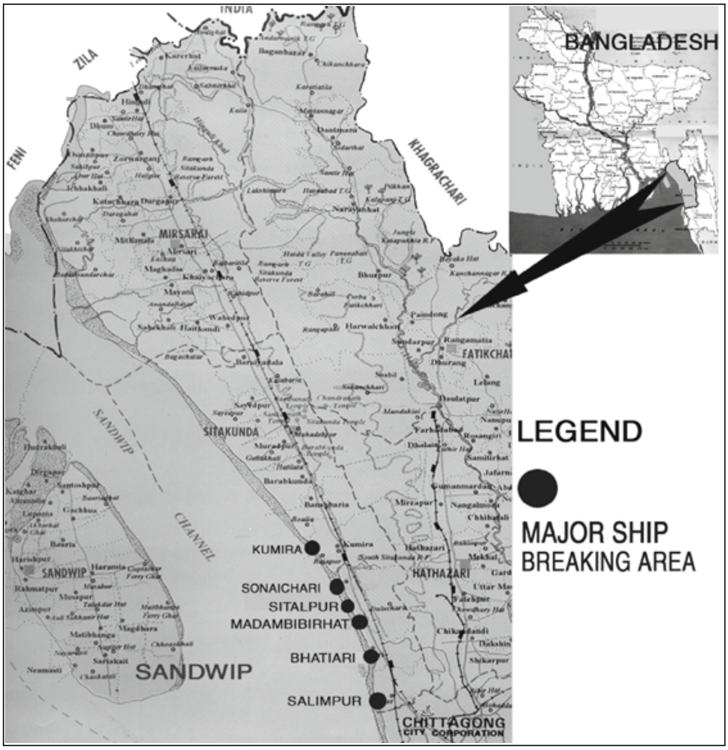

Fig. 1: Map of ship breaking area Chittagong, Bangladesh indicated by black spots and Sandwip Island as control area.

Sample Collection and Preparation

Sea water and bottom sediments from inter-tidal zone were collected simultaneously during high tide from the four sampling stations of the affected sites—Salimpur, Bhatiari, Sonaichari and Kumira. Sea water samples were collected with the nansen bottle and preserved in two-litre glass stopper bottles and soil samples with grab sampler in airtight polythene bags. All the samples were collected both at pre-monsoon and monsoon. Sediment samples were collected with the help of Ekman Grab Sampler. Then samples were digested by adding HCl, nitric, sulfuric and perchloric acids. The standard solution of the elements Fe, Cu, Hg, Zn, Pb, Cr, Cd and Ni were prepared by pipetting the required amount of the solution from the stock solution, manufactured by Fisher-Scientific Company (USA). The standard solution was prepared before every determination of the analysis of the present work. The water samples were then analyzed by using air acetylene flame with combination as well as single element hollow cathode lamps into an atomic absorption spectrophotometer (Shimadzu, AAS- 6800). The samples were injected by an automatic sampler and the absorbance and concentration data were automatically printed out and displayed. The analysis of sediment was carried out in BUET and BCSIR laboratories, Chittagong.

RESULTS AND DISCUSSION

The maximum concentration of iron (Fe) was observed 41,361.71 $\mu g.g^{-1}$ at Bhatiari of the affected sites and the minimum was as 3393.37 $\mu g.g^{-1}$ at Sandwip which is significantly lower than that of unpolluted marine sediment (27,000 $\mu g.g^{-1}$). Fe concentrations in sediments varied from 11,932.61 $\mu g.g^{-1}$ to 41,361.71 $\mu g.g^{-1}$ in the affected area and 3393.37 $\mu g.g^{-1}$ at the control site. The minimum and maximum concentrations were recorded at Sandwip and Sonaichari. The average value of Fe in the affected site was 27,370.63 $\mu g.g^{-1}$ (Table 2). This finding is in well agreement with findings of Banu (1995) in the sediment of the Karnafully River mouth. Fe has frequently been used as an indication of natural changes in the heavy metal carrying capacity of the sediment (Rule, 1986) and its concentration has been related to the abundance of metal reactive compounds not significantly affected by man's action (Luoma, 1990) (Table 2, Fig. 2).

Manganese (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 et al., 1977). Mn concentration in sediment samples varied from 2.32 $\mu g.g^{-1}$ to 8.25 $\mu g.g^{-1}$ in affected area. Maximum level of Mn was observed as 8.25 $\mu g.g^{-1}$ in the affected site, Bhatiari and minimum as 1.80 $\mu g.g^{-1}$ in the control site Sandwip which is significantly higher than that of unpolluted marine sediment (1.17 $\mu g.g^{-1}$), recommended by IAEA (1990) but reflects the works of Mehedi (1994), Khan (2003) and Hossain (2004). The mean value of Mn in experimental area was 5.03 $\mu g.g^{-1}$ (Table 2, Fig. 2).

Table 2: Trace metals concentrations of sediment at both the affected and control sites

	Stations	*Heavy Metal Concentration* *Fe* (µg/g)	*Mn* (µg/g)	*Cr* (µg/g)	*Ni* (µg/g)	*Zn* (µg/g)	*Pb* (µg/g)	*Cu* (µg/g)	*Cd* (µg/g)	*Hg* (µg/g)
Affected sites	Salimpur	11932.61	2.64	68.35	23.12	83.78	36.78	21.05	0.57	0.015
	Bhatiari	35216.35	8.25	86.72	35.12	102.05	122.03	39.85	0.83	0.02
	Sonaichhari	41361.71	6.89	78.36	48.96	142.85	147.83	30.67	0.94	0.117
	Kumira	20971.86	2.32	22.89	25.36	119.86	41.57	28.01	0.59	0.05
Control site	Sandwip Standard	3393.37	1.8	19	3.98	22.22	8.82	2.05	0.19	0.02
	Standard	27000 a	1.17 b	77.2 a	56.1 a	95.0 b	22.8 b	33.0 b	0.115 a, b	0.02 a

Legend: a = IAEA (1990), b = GESAMP (1982)

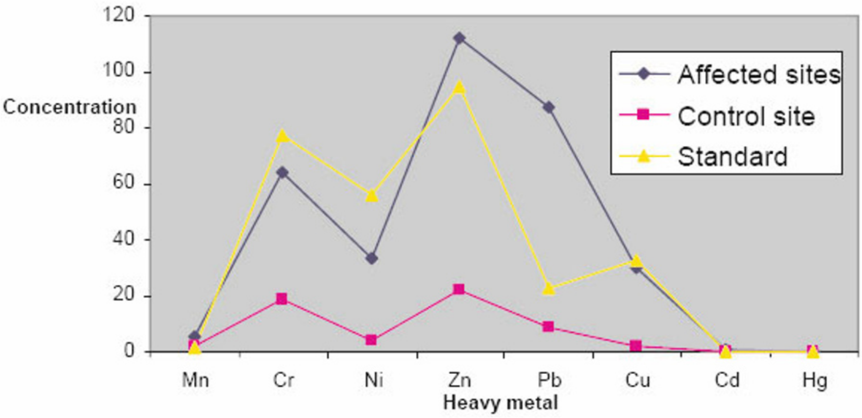

Fig. 2: Comparison of trace metals in affected, controlled and standard values.

Concentration of chromium (Cr) varied from 22.89 $\mu g.g^{-1}$ to 86.72 $\mu g.g^{-1}$ (Table 2) among the affected sites with the average of 46.53 $\mu g.g^{-1}$ in the affected sites whereas 19 $\mu g.g^{-1}$ in the control site. But the recommended value of Cr is 77.2 $\mu g.g^{-1}$ (IAEA, 1990) (Table 2, Fig. 2). Copper (Cu), nickel (Ni) and zinc (Zn) are essential heavy metals for living aquatic organisms. The value of Ni varied from 23.12 $\mu g.g^{-1}$ to 48.96 $\mu g.g^{-1}$ in the affected sites with the highest value at Sonaichhari whereas 3.98 $\mu g.g^{-1}$ at Sandwip (the control site) (Table 2) which are lower than the recommended concentration 56.1 $\mu g.g^{-1}$ (IAEA, 1990). This low concentration of Ni might be due to absorption of Ni from clay minerals. The mean value of Ni in the affected sites was 33.14 $\mu g.g^{-1}$. Cu is intimately related to the aerobic degradation of organic matter (Das and Nolting, 1993). The concentration of Cu ranged from 21.05 $\mu g.g^{-1}$ to 39.85 $\mu g.g^{-1}$ with the average value of 29.00 $\mu g.g^{-1}$ in affected sites with the highest value at Bhatiari and lowest at Salimpur. The present value is higher than that of recommended value 33.00 $\mu g.g^{-1}$ (IAEA, 1990). This finding showed that the Cu concentration is getting harmful for the inhibiting marine biota. The minimum concentration was recorded at Sandwip 2.05 $\mu g.g^{-1}$ (Table 2, Fig. 1).

The highest concentration of Zn was found at 162.05 $\mu g.g^{-1}$ at Bhatiari (the affected site) and 22.22 $\mu g.g^{-1}$ at Sandwip (the control site). Concentration of Zn were also higher compared to that of the recommended value of 95 $\mu g.g^{-1}$ (GESAMP, 1982). It is also mentionable that the level of Zn in soft water ranging from 0.1 to 1 $\mu g.g^{-1}$ is lethal to fish. The level of Zn in sediments of the affected area varied from 83.78 $\mu g.g^{-1}$ to 142.85 $\mu g.g^{-1}$ (Table 2) with the average value of 112.14 $\mu g.g^{-1}$. Literature survey indicates that marine sediment of Bangladesh contains higher amount of Zn than marine sediment from other parts of the world (Salomons and Forster, 1984; GESAMP, 1982) (Table 2, Fig. 2).

Lead (Pb) concentration in sediment samples of the affected areas varied from 36.78 $\mu g.g^{-1}$ to 147.83 $\mu g.g^{-1}$ with the average value at 87.05 $\mu g.g^{-1}$. The minimum concentration was recorded at Sandwip 8.82 $\mu g.g^{-1}$. Cadmium (Cd) concentration in sediment of the affected areas varied from 0.57 $\mu g.g^{-1}$ to 0.94 $\mu g.g^{-1}$ (Table 2) with the average value of 0.73 $\mu g.g^{-1}$. The minimum concentration was recorded at Sandwip 0.196 $\mu g.g^{-1}$. Mercury (Hg) level in the sediment samples of the affected sites varied from 0.115 $\mu g.g^{-1}$ to 0.942 $\mu g.g^{-1}$ (Table 2) with the average value of 0.356 $\mu g.g^{-1}$. In the control site it was recorded at 0.231 $\mu g.g^{-1}$.

The recommended value of lead (Pb), cadmium (Cd) and mercury (Hg) are 22.20, 0.11 and 0.01 $\mu g.g^{-1}$ respectively (GESAMP, 1982). The higher concentration of these elements were found to be 147.83, 0.94 and 0.942 $\mu g.g^{-1}$ respectively in the affected areas whereas 8.82, 0.196 and 0.231 $\mu g.g^{-1}$ in the control site. The present values are about six and half, eight and half and ninety four times higher than the certified values respectively. These could be attributed effects of oil and oil spoilage, petroleum hydrocarbon from ships, tankers, mechanized boats etc. as opined by Abu-Hilal (1987) and Laxen (1983) (Table 2, Fig. 2).

CONCLUSIONS

Wastes of the scrapped ships are drained and dumped into the Bay of Bengal. These wastes especially oil and oil substances, PCB's, TBT's, PAH's, etc. and different types of heavy metals (Fe, Cr, Hg, Zn, Mn, Ni, Pb and Cd) are being accumulated into the marine biota. As a result, marine fisheries diversity of Chittagong coastal region that supports highly diversified marine water fishes, mollusks and benthic organism etc. are at stake at this moment.

Finally, it could be said that the ship breaking operation involves serious environmental hazards. If the ship breaking industry is to develop in the country, the same may only be allowed ensuring minimization of pollution effect. A longer stretch along the seashore is in no way justified for continuation of this business, rather a certain separate zone like a dockyard should be selected by the competent authority. Preventive measures against environmental and health hazards, inherent in the process of ship breaking, should be undertaken at the right time, before it is too late.

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