

Occurrence of heavy metals in abiotic and biotic components of the Mangrove ecosystem of Thane creek

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ABSTRACT

Thane Creek long, 72°55 to 73°E and Lat. 19°00 to 19°15" N) is 26 km long creek having highly industrialized and urbanized Thane Mumbai Complex along its banks. It receives high amount of untreated domestic sewage and industrial effluent 294 mld and 145 to 260 mld respectively (TMC Report 2000). The present study was carried out during 2001-2002, to assess the heavy metals Zinc, Copper, Cadmium, Lead and Iron in different abiotic and biotic components of mangrove ecosystem of the creek. It was observed that - concentration of the metals Copper, Lead, Zinc and iron was very high in the abiotic and the biotic components while that of Cadmium were negligible, high metal concentration was observed in the crabs *Illoplax gangetica* and *Uca* ssp., the gastropods *Assiminia berricula*, *Hamina crocata*, *Melampus signaporensis* and unidentified gastropod, the polychaetes *Nereis glandicinta* and an unidentified polychaete indicating the tolerance of these organisms to the heavy metals, the leaves of *avicennia marina* showed accumulation of zinc, while the stem samples had high concentration of iron. Compared to the past data, the concentration of metals was found to be growing in the abiotic and biotic components of Thane creek. All these observations indicate deteriorating conditions of the creek and emphasises the need to check the pollution in the creek.

Keywords : Mangroves, Heavy metals, Thane creek, Copper, Lead, Zinc, Cadmium, Iron.

Introduction

Heavy metals are among the most dangerous contaminants of environments. They exist naturally in the earth's crust and in rivers, oceans and soil. In right quantities some are essential for life, others are so poisonous that only a few millionths of a gram can be lethal (Hakim, 1983).

Environmental pollution by 'toxic' heavy metals has become an issue of great concern in modern industrial world. The release of metals in measurable concentration into the environment is called contamination. Whereas the manifestation of measurable effects produced by metals on the living systems is referred as pollution. According to Neiboer and Richardson (1980), a metal is regarded to be toxic if it impairs growth, reproduction and metabolism of an

organisms when supplied above a certain concentration. When the metals come into the environment and interact with the living organisms they tend to accumulate and are passed through food chain leading to biomagnification. Thus even a small amount of contaminant can go a long way affecting the eco-system (Asthana, 1988). In mangrove ecosystems, according to Gulati and Nagpal, (1979), the mangroves collect the heavy metals from the soil and water and accumulate them in different parts. However, with the leaf fall, these metals in different forms are again added to water and sediment. Some of the heavy metals that would enter the food chain in toxic concentration include Arsenic, Cadmium, Cobalt Chromium, Copper, Iron, Mercury,

Manganese, Molybdenum, Nickel, Lead, Vanadium and Zinc (Lisk, 1972).

Creeks and estuaries are tidally influenced ecosystems and hence have good flushing ability. Due to this they are considered ideal locations for industrial development, which further leads to urbanization. As a consequence, they are being used for releasing huge quantities of industrial effluents and domestic sewage leading to pollution of different kinds including metals.

Thane creek (Long, 72° to 73° E and Lat. 19°00 to 15'N) has Asia's biggest industrial belt and Thane Mumbai urban complex along its banks. Due to this it is recipient of huge quantities of industrial effluents and sewage (145 to 260 mld & 294 mld respectively TMC - ES report 20000). Mohapatra (1985) investigated the metals in the waste water released in the Thane creek and reported negligible amount of cadmium (0.012 - 0.05 µg/L) and objectionable amounts of copper (0.023-0.705 µg/L) and zinc (0.026-0.264 µg/L). Sahoo and

Table 1. Average concentrations of heavy metals in water (mg / g) of Thane creek.

	Zn	Cu	Pb	Cd	Fe
Water	571	534	275	54	1124
Sediment	492	541	108	3	7819
Organisms					
Sea anemone	2706	6110	42	88	19700
Nematodes	226	1387	700	-	-
Insect Larva	1407	1136	171	40	1797
Polychaetes					
Ceratonereis burmensis	710	-	-	-	6865
Lycastic indica	-	1818	156	-	2886
Nereis glandicinta	734	553	115	8	5934
Unidentified polychaete	23235	2859	284	8	7180
Crustaceans					
Illyplax gangetica	2095	-	88	-	3078
Uca spp.	2773	-	61	-	18500
Molluscs					
Assiminea berwickia shell	871	777	73	50	15972
Assiminea berwickia biomass	1375	5495	76	71	2084
Nerita (Dostia) violacea shell	-	127	13	1254	
Nerita (Dostia) violacea biomass	-	7752	-	12	-
Hamina crocata shell	-	-	-	34	142
Hamina crocata biomass	8094	-	-	-	36602
Melampus singaporensis shell	319.3	1212	49	4.25	1764
Melampus singaporensis biomass	994	-	45	20	5911
Onchidium	1394	-	-	-	1669
Unidentified Bivalve shell	-	-	-	-	-
Unidentified Bivalve biomass	-	-	-	-	-
Unidentified gastropod shell	900.5	1430	-	-	409067
Unidentified gastropod biomass	916477	-	-	-	-
Mangroves Avicennia marina					
Twig	45	-	12	-	2090
Leaf	239	-	11	-	-

Table 2. Concentration factors of the metals in the organisms and mangrove part with respect to metals in sediment. ^{rk}

	Zn	Cu	Pb	Cd	Fe
Organisms					
Sea anemone	5.5	11.31	0.39	28.14	2.57
Nematodes	0.46	2.57	6.46	0	0
Insect Larva	2.86	2.1	1.58	12.86	0.23
Polychaetes					
Ceratonereis burmensis	1.44	-	-	-	0.88
Lycastic indica	0	3.36	1.44	0	0.37
Nereis glandicinta	1.49	1.02	1.06	2.57	0.76
Unidentified polychaete	6.58	5.29	2.62	2.66	0.92
Crustaceans					
Illyplax gangetica	4.26	-	0.82	-	0.39
Uca spp.	5.64	-	0.56	-	2.37
Molluscs					
Assiminia bervicula shell	1.77	1.44	0.67	16.08	2.04
Assiminia bervicula biomass	2.8	10.17	0.7	2.3	0.27
Nerita (Dostia) violacea shell	-	-	1.17	4.18	0.16
Nerita (Dostia) violacea biomass	-	14.34	0	3.86	0
Hamina crocata shell	-	-	-	10.93	0.19
Hamina crocata biomass	16.46	-	-	-	4.68
Melampus singaporensis shell	0.65	2.24	0.45	1.37	0.22
Melampus singaporensis biomass	2.02	-	-	-	0.21
Onchidium	2.84	-	-	-	-
Unidentified Bivalve shell	-	-	-	-	-
Unidentified Bivalve biomass	-	-	-	-	-
Unidentified gastropod shell	0.02	-	-	-	1.11
Unidentified gastropod biomass	1.83	2.65	-	-	52.36
Mangroves Avicennia marina					
Twig o	0.09	-	0.11	-	0.27
Leaf	0.49	-	0.1	-	0

(-) Could not be calculated as metals in organisms were below detectable level.

Khopkar (1985, 87) reported significant amounts of copper, zinc, cadmium and lead in the ambient waters and the sediments of Thane creek. Tandel (1986) and Pejaver (1987) recorded negligible amount of metals in the water of Thane creek however, they observed high concentration of metal in tissues of fish *Mystus gulio* and prawn *Metapnaeus monoceros* respectively. Athalye (1988) revealed high levels of zinc

In the present study the metals zinc, copper, cadmium, lead and iron in the abiotic and biotic components of the mangrove ecosystem of Thane creek are assessed.

Material and Methods

Samples of water, sediment organisms and mangrovplants parts were collected from 4

different stations selected along the 26 km stretch of Thane creek one station was on the extreme riverine end of the creek, one was on the seaward end and two stations were in the middle zone. The collection was done during four seasons namely monsoon (June-September), early post monsoon (October-November), late postmonsoon (December-February) and premonsoon (March-May). The sediment, samples, organisms and mangrove parts were dried at 50°C and then powdered. The samples were pooled together in equal proportion for detection of metals. They were processed to remove organic matter using acid digestion technique (APHA, AWWA, WPCE, 1981). For water 100 mL filtered sample was used for soil and plant parts 0.5g dried and powdered material was used; whereas for organisms, 100 mg to 500 mg dried tissue powder as per availability was used. In case of molluscs, the samples were processed for the shell and shell free body tissue. Blank was prepared with every processed set. The analysis of metals was done on LUNICAM Solar Atomic Absorption Spectrometer at the Pollution Control Cell Laboratory of Thane Municipal Corporation.

Results and Discussion

The average concentration of metals zinc, copper, lead, cadmium and iron in water samples ($\mu\text{g/l}$) sediment, organisms and mangrove plant sample ($\mu\text{g/g}$) are presented in Table 1. The concentration factors of the metals in the organisms with reference to sediments and water are presented in Table 2 and 3 respectively.

Zinc

Zinc is found abundantly in the earth's crust. It is an essential element for body system and functioning of certain enzymes. Its average concentrations in water and sediment of Thane creek were 751 $\mu\text{g/L}$ and 492 $\mu\text{g/g}$ respectively, which are high as compared to 86 $\mu\text{g/L}$ and 199 mg/g respectively reported by Sahoo and

Khopkar (1985, 1987). This shows growing pollution in the creek. The zinc concentration though was not high in mangrove leaves and twigs; it was significantly high; in the organisms. Mahajan et al. (1987) reported average zinc in gastropods, polychaetes and crabs of Thane to be 454 $\mu\text{g/g}$, 296 $\mu\text{g/g}$ and 324 $\mu\text{g/g}$ respectively. As compared to these, the present concentrations are very high (Table 1). This suggests growing concentration of metals in abiotic and biotic components of the creeks. Some organisms like sea anemone, unidentified insect larvae, unidentified polychaete, crab *Llyoplax gangetica* and *Uca* spp., gastropod *Hamina crocata* showed high concentration factors with soil and water (Table 2 and 3), indicating bioaccumulation of zinc in their bodies. In mollusks the metal level was higher in the body tissue as compared to shell.

Copper

It occurs in the earth's crust in its native state or from its ores depending upon the geographical location and proximity to industry. Copper is an essential element for body building and enzyme activity. But excessive large doses may lead to mucosal irritation and corrosion, widespread capillary damage, hepatic and renal damage and depression of central nervous system. It can cause necrotic changes in the liver and kidney. Excess of copper in water has unpleasant and astringent taste.

The average concentration of copper in the water and sediment of Thane creek were 534 $\mu\text{g/L}$ and 541 $\mu\text{g/g}$ respectively (Table 1) which are much higher as compared to the concentration before 20 years (10 $\mu\text{g/L}$ and 108 $\mu\text{g/g}$ respectively), reported by Sahoo and Khopkar, 1985 and 1987. Significant copper was not detected in mangrove tree parts but it was much higher in the organisms. Mahajan et al. (1987) reported the copper levels as 34 $\mu\text{g/g}$ in gastropods, 53 $\mu\text{g/g}$ in polychaetes and

Table 2. Concentration factors of the metals in the organisms and mangrove part with respect to metals in sediment.

	Zn	Cu	Pb	Cd	Fe
Organisms					
Sea anemone	4.47	11.45	0.15	1.62	17.53
Nematodes	0.4	2.6	2.54	-	-
Insect Larva	2.46	2.16	0.62	0.74	1.6
Polychaetes					
Ceratonereis burmensis	1.24	-	-	-	6.11
Lycastic indica	-	3.41	0.57	-	2.57
Nereis glandicinta	1.29	1.04	0.42	0.15	5.28
Unidentified polychaete	5.67	5.36	1.03	0.15	6.39
Crustaceans					
Illyplax gangetica	3.67	-	0.32	-	2.73
Uca spp.	4.86	-	0.22	-	16.46
Molluscs					
Assiminia bervicula shell	1.52	1.46	0.27	0.93	14.21
Assiminia bervicula biomass	2.41	10.29	0.28	0.13	1.85
Nerita (Dostia) violacea shell	-	-	0.46	0.24	1.12
Nerita (Dostia) violacea biomass	-	14.52	-	0.22	-
Hamina crocata shell	-	-	-	0.63	0.13
Hamina crocata biomass	14.18	-	-	-	32.56
Melampus singaporensis shell	0.56	2.27	0.18	0.08	1.57
Melampus singaporensis biomass	1.74	-	0.16	0.37	5.26
Onchidium	2.44	-	-	-	1.48
Unidentified Bivalve shell	-	-	-	-	-
Unidentified Bivalve biomass	-	-	-	-	-
Unidentified gastropod shell	1.58	2.68	-	-	363.94
Unidentified gastropod biomass	2.86	-	-	-	-
Mangroves Avicennia marina					
Twig o	0.08	-	0.04	-	1.86
Leaf	0.42	-	0.4	-	0

(-) Could not be calculated as metals in organisms were below detectable level.

29 µg/g in crabs as compared to these, a significant rise in body concentration of metals is observed in the organisms. High concentration factors (with sediment and water) showed bioaccumulation of copper in organisms like sea anemone. Assiminia berroicula, Nerita violacea and unidentified polychaete and Lycastis indica (Table 2 and 3).

Lead

Lead has cumulative properties on human systems and exhibits toxicological symptoms.

It is one of the natural constituents of the earth's crust and exists in the form of galena (lead sulphide). The symptoms of acute poisoning are tiredness, lassitude, abdominal discomfort, irritability, anaemia

and behavioral changes (WHO, 1977). It has a property to bind with mitochondria resulting in interference in regulation of oxygen transport and energy generation (Drill, 1979). In many cases chromosomal aberrations were found (I.A.R.C., 1980).

In the present study, lead was significantly high in water (275 µg/L) and sediments (109 µg/g) of Thane creek as compared to the values 50 µg/39 µg/g respectively reported for the Thane creek by Sahoo and Khopkar (1985 and 1987). The organisms (nematode, unidentified polychaete) showed biomagnifications, as they had high concentration factors (Table 2 and 3). In the leaves and twigs of the mangrove *Avicennia marina* the lead concentration was 11 µg/g and 12 µg/g respectively.

Cadmium

Cadmium is found in earth's crust in a very trace amount. It is produced during the extraction of Zinc and is used in plating industry, pigments, in the manufacture of plastic material, batteries and alloys, water is contaminated with Cadmium by industrial discharge, leaches from land filled area. The symptoms of poisoning are proteinuria, glucosuria and aminoaciduria (U.S.F.P.A., 1980).

The concentration of cadmium in present investigation was 54 µg/L in water and 3 µg/g in the sediment. As compared to the concentration reported for Thane creek by Sahoo and Khopkar, 1985 (5 µg/L and 3 mg/g respectively) the present values indicate increased concentration in water and no change in the sediment cadmium levels. Some of the organisms like sea anemone, insect larvae and mollusks in general, showed high cadmium and also the concentration factors with soil and water greater than one. Cadmium was below detectable concentration in mangrove leaves and twigs.

Iron

Iron content in water and soil was quite high being, 1124 µg/L and 7819 µg/g respectively). Thus the sediment must be functioning as a sink for iron. It occurred in large quantities in all the organisms except the nematodes, the gastropods like *Nerita violacea* biomass and the unidentified bivalve. High iron was observed in the sea anemone 19700 µg/g, biomass of the gastropods *Hamina crocata* (36602 µg/g). Concentration of iron in the leaves of *Avicennia marina* was not detectable, but in the twigs it was 2090 µg/g.

Conclusion

Of the 5 metals studied, the concentration of copper, lead, zinc and iron was very high in the biotic and the abiotic components while that of cadmium was negligible.

In the organisms high metal concentration was observed in the crabs *Illyoplax gangetica* *Uca* spp. gastropods *Assiminea berricula* *Hamina crocata*, *Melampus signaporensis*, unidentified gastropod and the polychaetes *Nereis glandicinta* unidentified polychaete indicating the tolerance of these organisms to the heavy metals.

The leaves of *Avicennia marina* accumulated zinc while the stem showed high concentration of iron.

When compared with the past data it was evident that the concentration of metals is growing in the abiotic and biotic components of Thane creek. This is alarming and emphasizes the need to check the pollution in the creek.

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