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HEAVY METAL DISRTIBUTION IN THE COASTAL SEDIMENT OF CHENNAI COAST

Ramanibai Ravichandran and Shanthi Manickam*

Aquatic Biodiversity Unit, Department of Zoology, University of Madras, Guindy Campus, Chennai 600 025, INDIA

ABSTRACT

Chennai coast is located on the eastern end of east coast of India known as second largest beach of the world. It receives quite good number of inlets, exhibit unique water quality features especially in the near shore coastal areas are of ecologically important. Metals like Pb, Cd, Zn, Ni, Co and Cu were analyzed in sediment collected during pre monsoon season. Present study showed that the heavy metal concentrations were recorded high at near shore station of Ennore during pre monsoon season. This might be due to discharged of industrial effluents, land-based anthropogenic inputs and municipal sewage through the Ennore estuary. The results of the present study suggested the need for a regular monitoring program of the Chennai coast which will help to improve the quality of near shore coastal environment.

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KEY WORDS

Heavy metals distribution; Chennai coast; Bay of Bengal.

***Corresponding author:** Email: jmshanthi@gmail.com; Tel: +91-9444743885

[I] INTRODUCTION

Industrial activities, economic development and urbanization in metropolitan cities all over the world have grown very rapidly in recent years and significant amount of contaminants are introduced in rivers, estuarine and coastal regions. Among the various contaminants heavy metals are serious pollutants of aquatic ecosystems, because of their environmental persistence, toxicity and ability to be incorporated into food chains [1, 2].

Numerous studies have demonstrated from marine sediment are highley polluted by heavy metals; therefore the evaluation of metal distribution in surface sediment is useful to assess pollution in the marine environment [3, 4]. Elevated metals concentrations (e.g. Hg, Cd, Pb, Cu, Ni and Zn) in marine environment are often considered indicators of anthropogenic influence and are themselves of potential risk to the natural environment. Therefore, it is important to assess and track the abundance of these heavy metals in coastal ecosystem [5].

Understanding transfer and distribution of toxic metals between the sediment and water columns is of great importance. Once heavy metals introduced into the aquatic environment, it redistributed throughout the water column, deposited or accumulated in sediments [6]. Heavy metal concentrations profiles in sediments used to identify the history and sources of pollution. The sources of major and minor elements in aquatic sediments area combination of natural weathering, run-off and riverine and atmospheric input, affected by anthropogenic impact [7, 8].

The Bay of Bengal (BOB) is a semi-enclosed tropical basin in the northern Indian Ocean. It is bounded by the Indian Peninsula and Sri Lanka on the west and by the Andaman–Nicobar Islands and Burma on the east [9]. Chennai (N 13° 15' latitude and E 80º 17' longitude) is a beautiful metropolitan city with high density population of above five millions, and also a major industrial hub in south India. The coastal city where the pollution problem is acute, particularly in the north and central part of the city due to the stress caused by domestic and industrial effluents. Point sources of pollution are mainly from North Chennai Thermal Power Plant, Ennore Port activities, other nearby industries and untreated urban wastes from Chennai Metropolitan [10].

The ever expanding city of Chennai offloads a million liters of sewage, which carried a wide variety of pollutants everyday into the adjoining sea. The information on the coastal hydrograph of Chennai coast is essential in the context of coastal pollution and consequent productivity of the Bay. The present study was therefore undertaken with a view to provide much needed information on the heavy metal distribution in the coastal ecosystem of Chennai and its relation to the prevailing environmental conditions..

THE IIOAB JOURNAL
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[II] MATERIALS AND METHODS

2.1. Study area and sampling stations

The study area covers a part of Chennai coast starting from Ennore (80 25 E; 13 14 n) to Kovalam (80º 16' E; 12º 49' N) covering approximately 25km stretch. Fifteen sampling stations were fixed along the Chennai Coast **[Table–1]**. Stations 1, 4, 7, 10 and 13 representing near shore stations and its distance covered from 3km from the shore. Stations 2, 5, 8, 11 and 14 represent middle stations where distance covered was 5 km away from the near shore stations. Similarly stations 3, 6,9,12 and 15 represent off shore stations with a distance covered 5 km away from middle shore stations **[Figure–1]**.

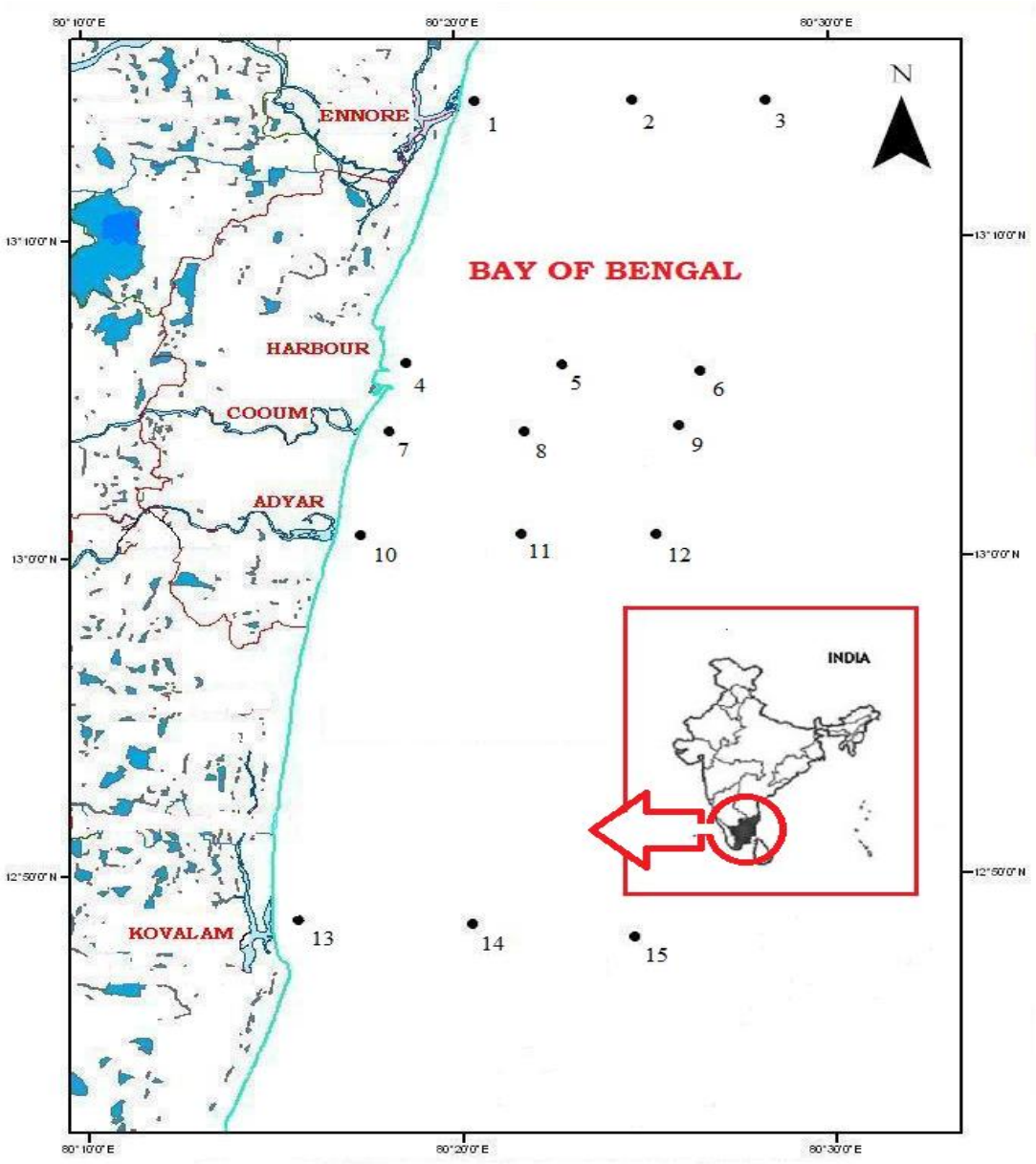

Fig: 1. Location of sampling sites in the study area

Near shore stations - 1, 4, 7, 10 and 13
Middle stations - 2, 5, 8, 11 and 14
Offshore stations - 3, 6, 9, 12 and 15

Station 1 located at Ennore receives industrial effluents and station 4 located at harbour receives cargo waste and oil pollution from this region. Station 7 located near the Cooum river mouth and receives large quantities of domestic sewage and industrial effluents through the river Cooum. Station 10 located near the Adyar river mouth and receives domestic and sewage wastes from the river Adyar. Station 13 located at Kovalam, fishing and saltpans are the unique activities carry over here. Station 13 is less polluted when compared with other stations.

THE IIOAB JOURNAL
ISSN: 0976-3104

Table: 1. Sampling points

Station	Longitude	Latitude
1	80º 20' 25" E	13º 14' 09" N
2	80º 24' 00" E	13º 14' 11" N
3	80º 28' 06" E	13º 14' 10" N
4	80º 19' 95" E	13º 08' 15" N
5	80º 23' 95" E	13º 08' 06" N
6	80º 27' 91" E	13º 08' 22" N
7	80º 20' 06" E	13º 04' 01" N
8	80º 24' 09" E	13º 24' 09" N
9	80º 28' 00"E	13º 04' 00" N
10	80º 18' 14" E	13º 00' 97" N
11	80º 24' 09" E	13º 00' 99" N
12	80º 27' 00" E	13º 01' 00" N
13	80º 16' 98" E	12º 48' 93" N
14	80º 20' 98 E	12º 49' 04" N
15	80º 24' 88" E	12º 49' 00" N

2.2. Sampling and storage

Fifteen sediment samples were collected from Chennai coast, Bay of Bengal. The sampling cruise was conducted pre monsoon (March) 2006 by using the National Institute of Ocean Technology (NIOT) research vessel Sager Pachmi. The sampling locations included areas with different environmental backgrounds for example industrial areas, port, fishing, urban and agriculture areas. The samples from each station were collected using grab. Samples were taken from the central part of the grab sampler to avoid any metallic contamination from the metallic sampler and it was frozen at -4ºC immediately onboard until further analysis.

2.3. Sample digestion and Instrumentation

Sediment samples were dried at 105ºC for at least 16h until a constant dry weight. Afterwards the dried samples were homogenized with a pestle and mortar in order to normalize for various in grain size. The homogenized samples were sieved through a 250 mm screen and kept in clean plastic container for further analysis. For each sample a known quantity (1 g) of sediment was digested with a solution of concentrated $HClO_4$ (2 ml) and HF (10 ml) to near dryness. Subsequently, a second addition of $HClO_4$ (1 ml) and HF (10 ml) was made and the mixture was evaporated to near dryness. Finally, $HClO_4$ alone was added and the sample was evaporated until white fumes appeared. The residue was dissolved in concentrated HCl and diluted to 25 ml [11].

Heavy metal concentrations Pb, Zn, Co, Ni, Cr and Cu were measured using a flame atomic absorption spectrophotometer (Perkin-Elmer AA700) equipped with a deuterium background corrector. Suitable internal chemical standards (Merck Chemicals, Germany) were used to calibrate the instrument. All the reagents used were analytical grade of high purity. The results of the heavy metal concentrations were determined on a dry weight basis µg g-1.

[III] RESULTS AND DISCUSSION

The accumulation of heavy metals Pb, Zn, Co, Ni, Cr and Cu were presented in **Figure 2a-2c** and **Table–2**. The metal concentration in the near shore stations (1 – 13), heavy metals Pb varied from 22.5 to 19.1 µg g-1 ; Zn 109.02 to 86.3 µg g-1; Co 7.3 to 1.7 µg g-1 ; Ni 71.1 to 36.6 µg g-1; Cr 88 to 43.7 µg g-1 ; Cu 92.3 to 40.1 µg g-1 respectively **[Figure–2a]**. The metals accumulation was recorded high at station 1and 4. The near shore station (1 and 4) received large quantity of untreated effluents from the industrialized regions. Similarly the metal concentrations were registered low at station 10 and 13.

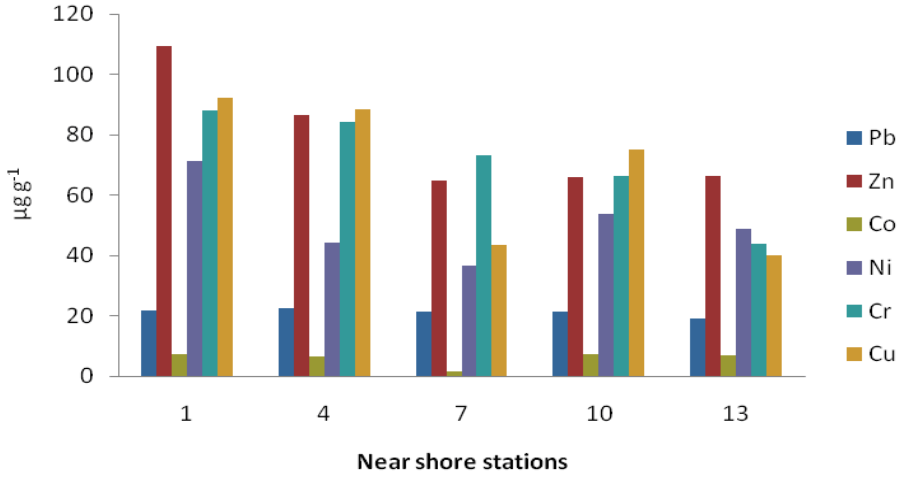

Fig: 2a. Heavy metal concentrations in the near shore sediment samples of Chennai coast

THE IIOAB JOURNAL
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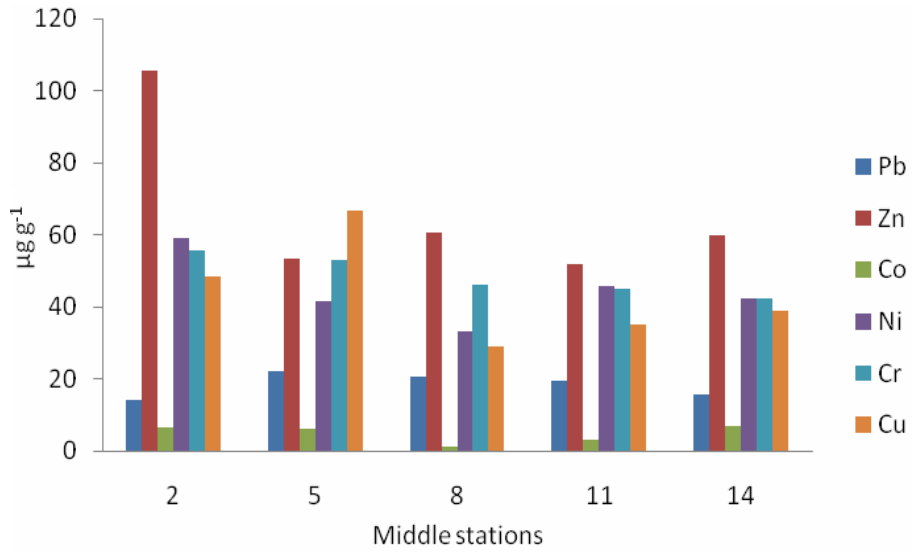

Fig: 2b. Heavy metal concentrations in the middle stations sediment samples of Chennai coast

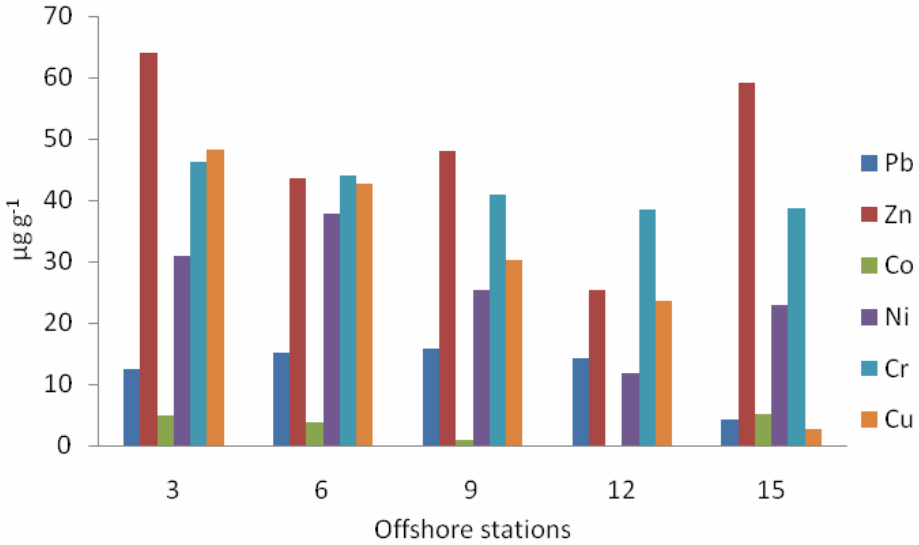

Fig: 2c. Heavy metal concentrations in the offshore sediment samples of Chennai coast

Sediment concentrations in the middle station (2-14), the concentration of metal Pb ranged between 22.1 – 14 µg g-1 ; Zn 105.4 – 53.4 µg g-1; Co 6.8 – 1.3 µg g-1 ; Ni 59.2 – 33.2 µg g-1 55.6 - 44.9 µg g-1 Cr; Cu 66.8 – 28.8 µg g-1 **[Figure–2b]**. The metals concentrations were moderately high at all the middle station mainly due to the circulation point from the upstream direction South of Buckingham canal was transporting the organic rich sediment to the meddle station. The metal concentrations were recorded low at station 2, 5 and 14 during the study period.

The offshore Stations (3-15), the metal concentrations were comparatively lower than the near and middle stations. The metal concentration varied from Pb 15.7 to 4.3 µg g-1 ; Zn 64.1 to 25.4 µg g-1; Co 5.2 to 0.12 µg g-1; Ni 37.8 to 11.8 µg g-1; Cr 46. 3 to 38.35 µg g-1 and Cu 48.2 to 2.7 µg g-1 **[Figure–2c]**. Among all the sampling stations, offshore station 12 and 15 showed low accumulation of heavy metals in the sediment samples. Overall the highest metal concentration Zn 109.02 µg g-1; Cu 92.3 µg g-1; Cr 88.0 µg g-1; Ni 71.1 µg g-1; Pb 21.6 µg g-1 and Co 7.3 µg g-1 were recorded high in the sediment samples collected from the near shore stations than the middle and offshore stations.

The high concentration of Pb at near shore station sediments of Ennore are directly related to heavy input of industrial effluents

THE IIOAB JOURNAL
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from the industrial regions of Ennore, north part of the city which are dominated by petrochemical, painting, thermal plant and other chemical industries which also exposed to wave and storm activities [12,13]. Maximum concentration of Zn 109.02 µg g-1 in sediment probably due to the discharges of effluents from the petrochemical, painting industries [14] in the Ennore region.

The high concentration of Ni 71.1 µg g-1 recorded at the near shore station of Ennore might be due to the petroleum-related activities [15]. Co showed the similar distribution pattern and high concentration in the near shore station of Ennore. This may be due to the discharge of markers of paint industries [12] many are presented in the Ennore region.

The elevated concentration of Cr 88.0 µg g-1 recorded in the near shore station 1, mainly from the industrial effluents and it is also associated with the organic particles [16]. Cu and Cr concentrations were elevated at all the near shore stations indicated that the Cu and Cr mainly discharge of the industry and domestic waste and also iron and steel industries and sewage contribute equally to the contamination in the near shore stations of the study area [17].

The enrichment of heavy metals Zn, Cr, Cu, Ni and Pb in the sediment samples are mainly due to the coal powered thermal power plant, atmospheric deposition of fly ash and anthropogenic sources in the Ennore region of Chennai city, southeast coast of India [18]. Various studies **[Table–3]** showed the anthropogenic sources of the heavy metal in the Bay of Bengal.

In present study the heavy metals Pb, Cd, Zn, Cu, Co, Ni, and Cr concentrations were recorded high at Ennore and Harbour stations. The high concentrations of the metals during pre monsoon season mainly due to the heavy input of untreated industrial effluents from Ennore area through Pulicat channel and Buckingham canal entry points into the coast.

Table: 2. Concentrations of heavy metals in the sediment samples of Chennai Coast during pre monsoon season 2006.

	Pb (µg g^{-1})	Zn (µg g^{-1})	Co (µg g^{-1})	Ni (µg g^{-1})	Cr (µg g^{-1})	Cu (µg g^{-1})
Near shore stations						
1	21.6	109.2	7.3	71.1	88	92.3
4	22.5	86.3	6.5	44	84.2	88.5
7	21.3	64.6	1.7	36.6	73.1	43.3
10	21.5	66	7.2	53.7	66.4	75.2
13	19.1	66.4	7	48.9	43.7	40.1
Mean	21.2	78.5	5.94	50.86	71.08	67.88
Middle Stations						
2	14	105.4	6.3	59.2	55.6	48.3
5	22.1	53.4	6.1	41.4	52.9	66.8
8	20.4	60.6	1.3	33.2	46.17	28.8
11	19.4	51.8	3.1	45.8	44.9	35
14	15.7	59.7	6.8	42.4	42.4	38.9
Mean	18.32	66.18	4.72	44.4	48.394	43.56
Off shore stations						
3	12.5	64.1	5.1	31	46.3	48.2
6	15.2	43.6	3.8	37.8	43.9	42.7
9	15.7	48	1.1	25.3	40.8	30.3
12	14.3	25.4	0.12	11.8	38.55	23.5
15	4.3	59.1	5.2	23	38.57	2.7
Mean	12.4	48.04	3.064	25.78	41.624	29.48

[IV] CONCLUSION

The accumulation of heavy metals found to be high in the near shore sediment mainly due to the land based activities in general. The Chennai coastal region should be given great attention to control the anthropogenic input into the coastal environment. Continuous monitoring of the near shore coastal

THE IIOAB JOURNAL
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area of Chennai coast in particularly recommended for future studies.

Table: 3. Comparison of heavy metal concentrations (µg g^{-1}) estimated from sediment samples along the Bay of Bengal.

S.No	Sediment type	Place	Pb	Zn	Ni	Cu	Co	Cr	References
1	Shallow sediment	Madras coast	-	-	64	26	-	84	[19]
2	Intertidal sediment	SE Coast	5 - 130	13 -144	-	0 - 105	-	11-394	[20]
3	Near shore sediment	Madras coast	31.7	6.3	-	0.8	-	-	[21]
4	Shore sediment	Coromandel Coast							[22]
5	Core sediment	Madras coast							
6	1.0-5 interval,Muttukadu	East coast	1	68	49	-	8	48	[23]
7	2.0-1 cm interval,Mamallapuram	"	13	106	53	-	9	87	
8	3.0-1 cm inteval,Marakkanam	"	11	87	12	-	7	58	
9	Surface sediment	Gulf of Mannar	16	73	24	-	7	167	[15]
10	Shelf sediment	Gulf of Mannar	16	73	24	57	15	177	[24]
11	Innershelf sediment	Madras coast	16	71	30	20	9	57	[13]
12	sediments-Before tsunami	Poompuhar(SE coast)	N.D	5.9	N.D	31.4	N.D	-	[25]
13	Sediment	Ennore, Chennai Coast	24.9-40	71.3-201	19.8-53.4	385-657	-	148.6-243.2	[10]

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CONFLICT OF INTERESTS

Authors declare no conflict of interests.

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