

Geochemical partitioning of lead in sediments of the coastal environment, Bay of Bengal

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ABSTRACT

Geochemical partitioning of lead in sediments of the coastal environment of Rushikulya estuary, Gopalpur coast and Bahuda estuary, Bay of Bengal has been carried out over a period of one year. Percentage of dissolved and particular fractions of lead showed significant variations in different seasons because of their involvement in the biochemical cycles. The transport of these fraction of lead into the coastal environment have been explained on the basis of adsorption.

Key words: Geochemical partitioning, lead, Bay of Bengal.

INTRODUCTION

The level of trace metals in the water and particulate matter of Cochin estuary were reported by Nair et al. (1990) and sediments were reported by Nair et al., (1991). Nair (1992) obtained various fractions of trace metals in the sediments of the southern and northern arm of Cochin estuary. The reports available on trace metal distribution from the estuaries of Indian subcontinent Paul and Pillai (1983a) in Cochin estuary, Satyanaryana et al.(1985) in Visakhapatnam harbour.

Although some efforts have been made to evaluate the partitioning of trace metals in the waters of Rushikulya estuary, no attempt have been made so far on the chemical partitioning of trace metals in the sediments of coastal ecosystem of Ganjam, Orissa in east coast of India comprising of riverine, estuarine and coastal regions. Therefore, the present geochemical study has been undertaken with an aim to trace out the nature, mechanism and process of incorporation of elements into the sediments, various external and internal controls and their response as reflected in lithological, chemical and mineralogical composition of the sediments depositing in the various aquatic environments such as riverine, estuarine and

coastal regions of Ganjam coast by subjecting the sediment samples to partition studies.

MATERIAL AND METHODS

At each station sediments samples weighing about one kilogram were collected using a Peterson's grab during pre-monsoon, monsoon and post-monsoon periods, during 1995 undistributed sub samples were taken immediately from the centre with polythene scoop. All the samples so collected were put in pre-rinsed one-liter wide mouth polythene bottles and the bottles were filled without tapping any air bubbles. The samples were numbered and were kept frozen at -4°C for a maximum period of two weeks prior to use.

In the laboratory, all the sediment samples were washed with water thoroughly to remove salts, then dried in an oven at 100°C for 6 hours. The sample were mixed thoroughly and split (by Oring and Quartering method to get the desired weight of 100gm) of samples. A representative sample of about 10 gm were transferred to 500ml beaker followed by the addition of 50 ml of hydrogen peroxide (6%) and 2N hydrochloric acid in order to destroy the organic matter and carbonates as described by Van Andel and Postma (1954). Each

sample was washed several times with distilled water until free from salts (tested with 0.0N AgNO₃). These samples were dried, weighed and were then soaked in about 150cc sodium hexa metaphosphate solution 0.025 N for about 2 to 24 hours in order of disaggregate the flocculated clay particles and dissolve any more amounts of salt which might tend to cement the grains (Shepard and Moore, 1955 and Banse, 1959). All the samples were then dispersed by soaking in ammonia (7-8%) solution (for over night) and then was sieved by passing through 230 mesh (62 micron) ASTM sieve distilled water after stirring thoroughly (5 minutes) with magnetic stirrer into 1000 ml cylinder. The material retained on the sieve (+230) was transferred into a previously weighed beaker, washed and subsequently dried in an air oven at 100 °C (5°C) which gave rise to the percentage of sand (w/w).

The temperature of the water sample was recorded with a sensitive mercury thermometer (0-50.0°C) by holding the bulb just below the surface of water. The atmospheric temperature was obtained through the courtesy of the India Meteorological Department, Government of India, Bhubaneswar, Orissa.

A finely ground, dried sediment sample of 1gm was weighed accurately in a teflon bomb and wetted with 1ml of aquaregia, 6ml of con. HF was added slowly and bomb was heated in an air oven (90-100 °C) for one hour. After cooling the contents were washed into a 100ml volumetric flask containing 5.6gm or boric acid that has been shaken with 20ml of distilled water. The flask was shaken to complete the dissolution made up to volume (Loring and Rantala, 1977). The filter was transferred into the teflon with plastic tweezers and squashed it at the bottom of the vessel, wetted with 1ml of aquaregia and 2ml of HF was added and heated the bomb in an air oven (90-100 °C) for one hour. After cooling the contents were decanted through a funnel into a 25ml volumetric flask containing 0.93 gm boric acid and 5ml glass distilled water. The filter paper remaining in the teflon vessel was washed several times with small volumes of water. Finally the flask was shaken to complete the dissolution and made up to tile volume. The blank solution was prepared in the similar manner without the sample.

Each of the leaches from sequential extraction treatment and acid digested sediments samples for total fraction was analysed by flame AAS (Perkin Elmer Model 2380) for Pb by graphite furnace.

The precision of the analytical techniques and the reproducibility of data were checked by comparing the values of each fraction for the triplicate analysis of every sample. It was observed that the percentage variation recorded for most of the samples for pb showed variations up to 20% for a number of samples indicating low precision coupled with very low concentrations of the analysis. The reproducibility of the date was quite good and comparable with values reported earlier (Gupta and chen, 1975).

RESULT AND DISCUSSION

Lead is a cumulative poison to human being. The large affinity of pb² for thiol and phosphate containing ligands inhibits the biosynthesis of haeme and there by affects membranc permeability in kidney, liver and brain cell. This results in either reduced functioning or complete breakdown of these tissues. Lead is non-essential elements occurring in all tissues and organ of mammal. The main sources of input of lead are atmospheric fallout smelting operations and highway run off along with sewage sludge.

Table 1 and figures 1.1, 1.2 and 1.3 gives the seasonal distribution patterns of various fraction of pb in the sediments of the studied enviroment. The total lead content in different seasons of study period of the coastal sediments of Gopalpur from 50.8 to 111.6 µg g⁻¹, from 46.6 to 128.2 µg g⁻¹ in the sediments of Rushikulya estuary and from 28.6 to 62.2 µg g⁻¹ in the sediments of Bahuda estuary. The order of total metal concentration found to be : Rushikuly estuary>Gopalput estuary > Bahuda estuary. In the coastal sediments Pbl fraction was observed to be below detection limit for all the stations due to percipitation of Pb Cl, because of high activity of chloride ions in the coastal water, as the concentration of metal ion in the inital stages of percipitation is primarily dependent upon the activity of the anionic species in the solution. Pbl values varued from 2.5 to 9.2 µg g⁻¹ with a relative

Table - 1: Pb absolute concentration ($\mu\text{g g}^{-1}$). Total metal and percentage to total metal of partitioning pattern of sediment samples of the study environment

Centre	Station	Pre-monsoon						Monsoon						Post-monsoon								
		Total I	II	III	IV	V	VI	Total I	II	III	IV	V	VI	Total I	II	III	IV	V	VI			
Rushikulya Estuary	1	78.9	6.3	8.1	2.5	17	18	27	57.1	3.1	5	1	12	14	22	81.1	5.2	6	-	18	16	36
		7.89	10.26	3.16	21.54	22.81	34.22	5.42	8.75	1.75	21.01	24.51	38.52	18.71	7.38	-	22.16	19.70	44.33			
	2	128.2	9.2	3	1	28	22	65	91.9	5.4	2	1.5	21	20	42	120.6	7.5	3	2.1	24	26	58
3		7.17	2.34	0.78	21.84	17.16	50.70	5.87	2.17	1.63	22.85	21.76	45.70	6.21	2.48	1.74	19.90	21.53	48.09			
		63.5	2.5	6	-	8	15	32	46.6	1.6	4	-	9	11	21	55	3	4	-	11	13	24
		3.93	9.44	-	12.59	23.62	50.39	3.43	8.58	-	19.31	23.60	45.06	9.09	7.27	-	20	23.63	43.63			
Gopalpur Coast	4	111.6	-	5.5	-	8.1	52	46	84.1	1.8	3.9	3.1	7.3	22	46	106.6	-	4.1	2.5	10	41	49
		-	-	4.92	9	7.25	46.59	41.21	2.14	4.63	3.68	8.68	26.15	54.69	-	3.84	2.34	9.38	38.46	45.96		
	5	86.3	-	4.2	5.1	12	28	37	103.22	-	3.2	2.02	10	40	48	107.7	-	6.3	5.3	15.1	50	31
6		-	-	4.86	5.90	13.90	32.44	42.87	-	3.10	1.95	9.68	38.75	46.50	-	5.84	4.92	14.02	46.42	28.78		
		61.71	-	3.5	3.01	10.2	20	25	50.8	-	2.5	-	8.3	15	24	61.5	-	3.2	-	11.3	21	26
		-	-	5.67	4.87	16.52	32.40	40.51	-	4.92	-	16.33	31.49	47.24	-	5.20	-	48.37	34.14	42.27		
Bahuda Estuary	7	71.7	3.6	5	2.1	15	20	26	49.3	2.4	4	1	9	10	23	74.1	3.1	10	4	16	12	29
		5.02	6.97	2.92	20.92	27.89	36.26	5.07	8.11	2.02	18.25	20.28	46.65	4.18	13.49	5.39	21.59	16.19	39.13			
	8	92.2	4.2	8	-	6	22	52	90.2	3.2	7	-	16	18	46	87.8	3.8	7	1	9	18	49
9		4.55	8.67	-	6.50	23.86	56.39	3.54	7.76	-	17.73	19.95	50.99	4.32	7.97	1.13	10.25	20.50	55.80			
		35.3	2.1	9	0.2	4	8	12	28.6	1.6	5	-	3	9	10	38.2	2.2	4	-	7	11	14
		5.94	25.49	0.56	11.33	22.53	33.99	5.59	17.48	-	10.48	31.46	34.96	5.75	10.47	-	18.32	28.79	36.64			

Total Metal = I + II + III + IV + V + VI,

I = E.F., II = C.F., III = E.R.F., IV = M.R.F., V = O.S.F. VI = R.F.;

- = Below Detection Limit

concentration upto 18.71 to the total Pb content of the sediments of Rushikulya estuary in post-monsoon.

Relatively higher percentage of Pb² was noted in the coastal sediments of Gopalpur and found to be below detection limits which might be due to the preferential precipitation of PbCl₂, since the solubility product of PbCl₂ is very low compared to other heavy metal and alkali metal chlorides.

Low Pb in the easily reducible fraction was found below detection limits for some of the sediment samples of the coastal and estuarine regions. The absolute value ranged from below detection limit to 5.1, 5.2 and 5.3 and 4µg g⁻¹ and relative values 5.90, 3.16 and 5.39% in Gopalpur coast, Rushikulya and Bahuda estuary respectively.

High percentage of Pb⁵ in the coastal sediments of Gopalpur was found to be bound with

organic and sulphidic fraction ranging from 16 to 52s µg g⁻¹.

In the sediments of Rushikuly estuary Pb⁶ values ranged from 21 to 65 µg g⁻¹, contributing 34.22 to 50.70% to the PbT. High percentage of Pb⁶ in the sediments receiving anthropogenic input of lead showed that the labile fraction of lead in the estuarine environment has only a very small residence time, which got converted rapidly to the stable residual form at the size of input itself.

Figures 1.1, 1.2 and 1.3 exhibit the spatial distribution pattern of various fraction of Pb in the sediments of Rushikulya estuary, Gopalput coast and Bahuda estuary.

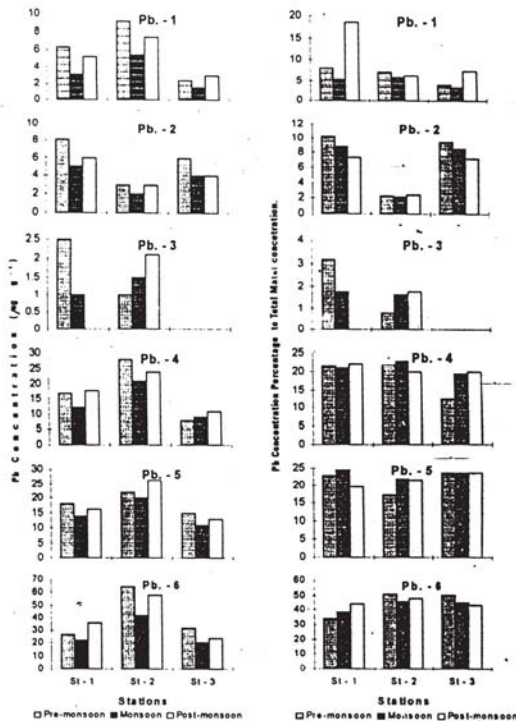


Fig. - 1: Pb absolute concentration (µg g⁻¹) and percentage (%) to Total Metal of partitioning pattern of sediment samples from Rushikulya Estuary

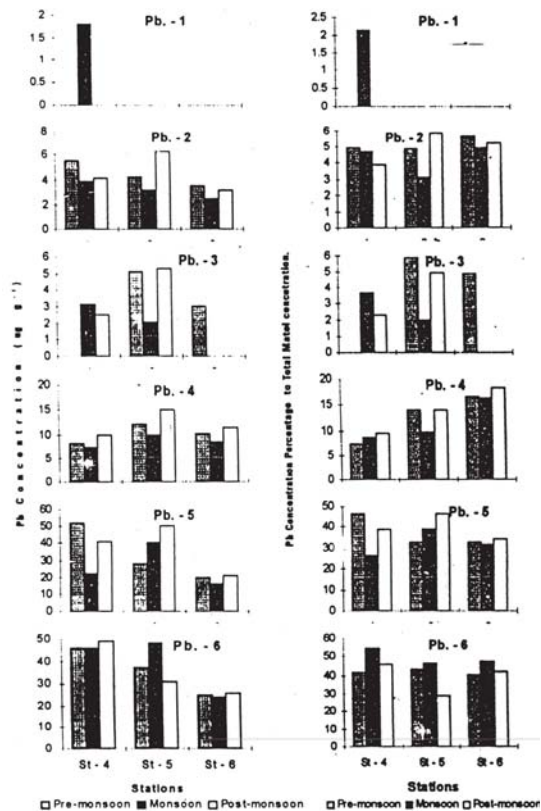


Fig. - 2: Pb absolute concentration (µg g⁻¹) and percentage (%) to Total Metal of partitioning pattern of sediment samples from Gopalpur Coast

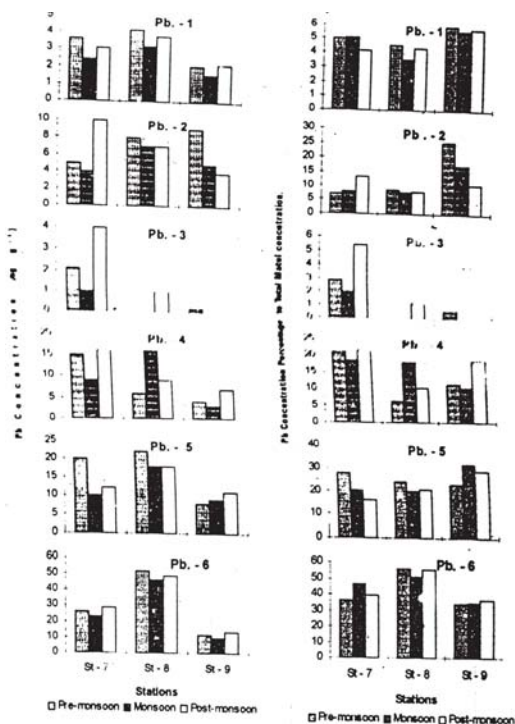


Fig. - 3: Pb absolute concentration ($\mu\text{g g}^{-1}$) and percentage (%) to Total Metal of partitioning pattern of sediment samples from Bahuda Estuary

Though lead is very toxic to biota, the present study showed that the 'bioavailability' of lead in the estuarine and marine environments is much reduced through the geochemical 'immobilization' of this metals in these environments.

The significance of the geochemical partitioning of the metals indicated that the seasonal abundance of the select metals follows the order :

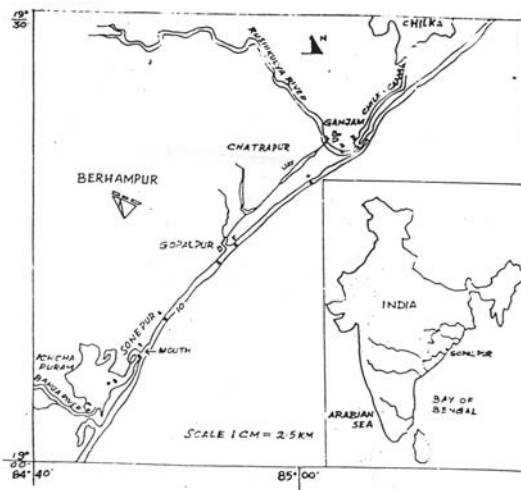


Fig. - 4

permonsoon > post-monsoon > monsoon. Further the accumulation of these metal fraction in the mid estuarine region were found to be more the upper and nearshore regions while a little deviation was observed in case Fe.

Conclusion

It can be said that lead appeared to be well below the threshold limits as recommended by FAO/WHO (1972) and thus at present poses no such alarming situation to the coastal ecosystem of Ganjam, Orissa. However, there is a greater likelihood that we may detect changes in trace contaminant concentration with an increase in the length of time due to rapid industrialization and urbanization there by causing serious hazardous for which suitable remedial measure should be taken Central/State Government/Private Sectors with the introduction of Pollution reduction plants.

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