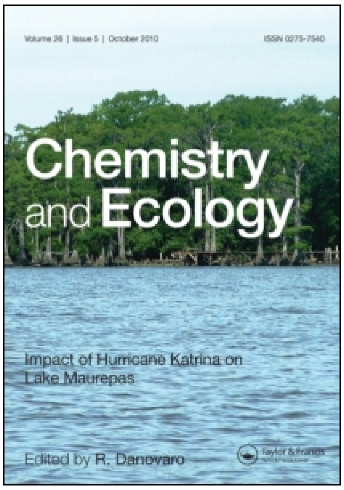

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HEAVY METALS IN PLANKTON OF UPPANAR, VELLAR AND KADUVIAR ESTUARIES OF SOUTHEAST COAST OF INDIA

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Spatial and temporal variation of copper, zinc, cadmium and lead were determined in plankton collected over a period of two years from the Uppanar, Vellar and Kaduviar estuaries of southeast coast of India. Differences in metal levels were observed between sampling sites and during different seasons. Higher and lower values were found during monsoon and summer, respectively. Salinity was found to play an important role in the distribution of metals in plankton. A linear relationship was found between the metal levels in plankton and that in the dissolved fraction. The order of metal accumulation in plankton were found to be zinc > copper > lead > cadmium.

KEY WORDS: Plankton, heavy metals, estuaries, South-east India

INTRODUCTION

Plankton are known to concentrate heavy metals in large quantities in marine waters (Martin and Knower, 1973; Riley and Roth, 1971). Bioconcentration of metals by plankton is one of the chief processes significant in the removal of metals from sea water and this has often been employed as a tool to measure the biologically available metal concentration in solution. Attempts have also been made to relate heavy metal levels in sea water directly with metal concentration in plankton (Menzel and Spaeth, 1962; Alexander and Corcoran, 1967). Reports have also shown the major role played by plankton in the biogeochemical cycle of trace elements (Boyle and Edmond, 1975; Bruland *et al.*, 1978; Romeo and Laumond, 1980). Plankton not only concentrate large quantities of heavy metals from sea water and pass them along the food chain, but they could also redistribute the metal at different depths during their sinking. In the present study, the levels of copper, zinc, cadmium and lead were determined in the plankton collected from Uppanar, Vellar and Kaduviar estuaries of the southeast coast of India (Figure 1), in order to understand the trend of distribution of metals in plankton and to assess the extent of any contamination.

The Uppanar estuary (Lat. 11°42′N; Long. 79°46′E), is subjected to many human activities. The Cuddalore Harbour is situated near the mouth of the estuary where cargo ships and fishing craft are under constant operation. Drainage of municipal and domestic sewage in and around Cuddalore town, and wastes from coconut husk retting grounds are discharged to the estuary. In addition, effluents from the nearby SIPCOT industrial complex are also released into the mid stream of this estuary. The Vellar estuary (Lat. 11°29′N; Long. 79°46′E) is bordered by extensive stretches of agricultural land. This estuary receives, mainly, drainage from the adjacent 4000

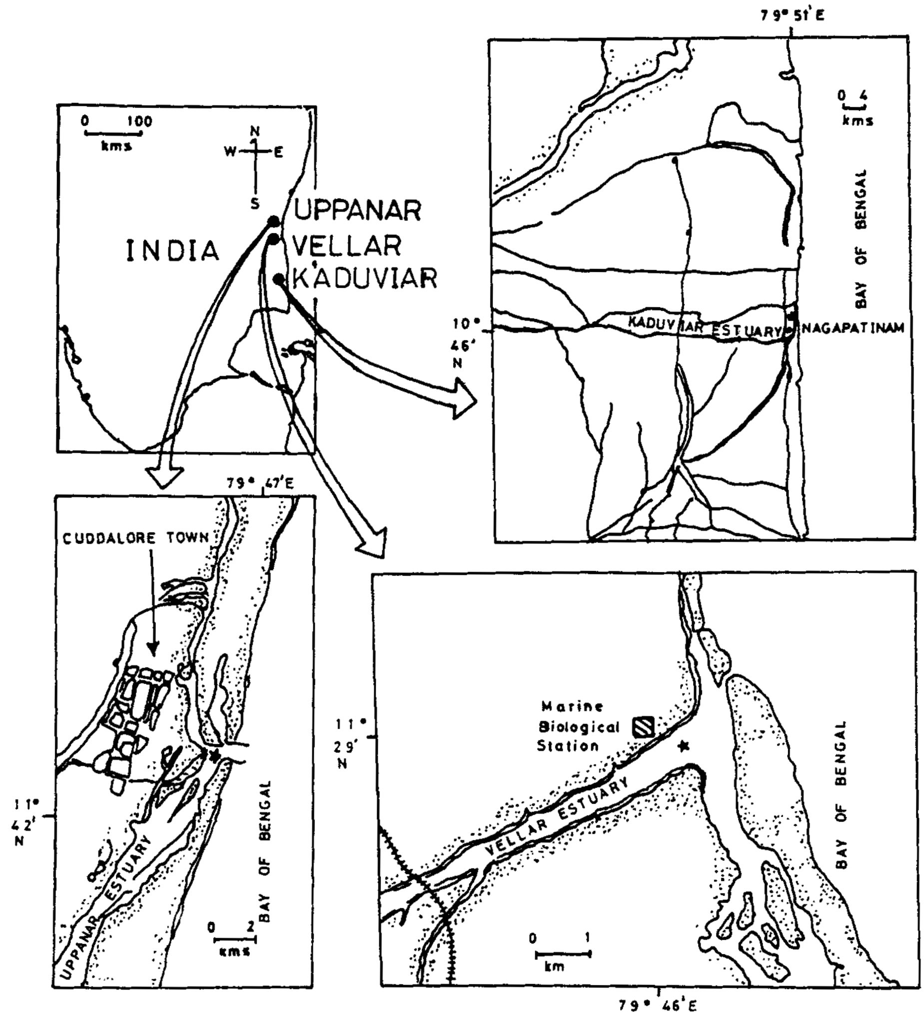

Figure 1 Map showing the location of the study area; sample sites are indicated, *.

hectares of agricultural land, along with municipal wastes and domestic sewage reaching the rivers. The Kaduviar estuary (Lat. 10°49′N; Long. 79°46′E) offers a natural harbour where moderate harbour activities such as movements of cargo, and loading and unloading from fishing vessels are routine operations. Domestic and municipal sewage from Nagapatnam town are also drained into the estuary.

MATERIALS AND METHODS

The sampling was carried out at monthly intervals for a period of two years, from October 1986 to September 1988, and the distribution of heavy metals in plankton was monitored. Plankton were collected using a plankton net no. 25 made of bolting silk 164. The samples were cleaned, then filtered and dried in an oven to constant weight at 95°C and powdered. Analysis of four metals, copper, zinc, cadmium and lead, in the dried samples was carried out by following an acid digestion technique, quantified in AAS as originally described by Watling (1981). The accuracy of the method was verified using biological tissue reference material (NIES No. 6) of the National Institute of Environmental Studies, Japan, and recovery trials are given below:

Sample (μg/g)	*copper*	*zinc*	*cadmium*	*lead*
NIES No. 6 Certified values	5.04 ± 0.17	108 ± 20	0.80 ± 0.03	0.91 ± 0.04
Conc. found	4.80 ± 0.30	102 ± 10	0.75 ± 0.05	0.87 ± 0.03
Recovery Trial %	95	97	96	95

The concentration values are expressed in μg/g on dry weight basis. For each metal, the concentration obtained in the different sampling stations and seasons were compared by analysis of variance (ANOVA).

RESULTS AND DISCUSSION

Figure 2 shows the distribution pattern of the copper, zinc, cadmium and lead concentrations in plankton samples collected from Uppanar, Vellar and Kaduviar estuaries. The results from the sampling campaigns showed that there was no uniformity in the metal distribution between stations. The concentration of metals in

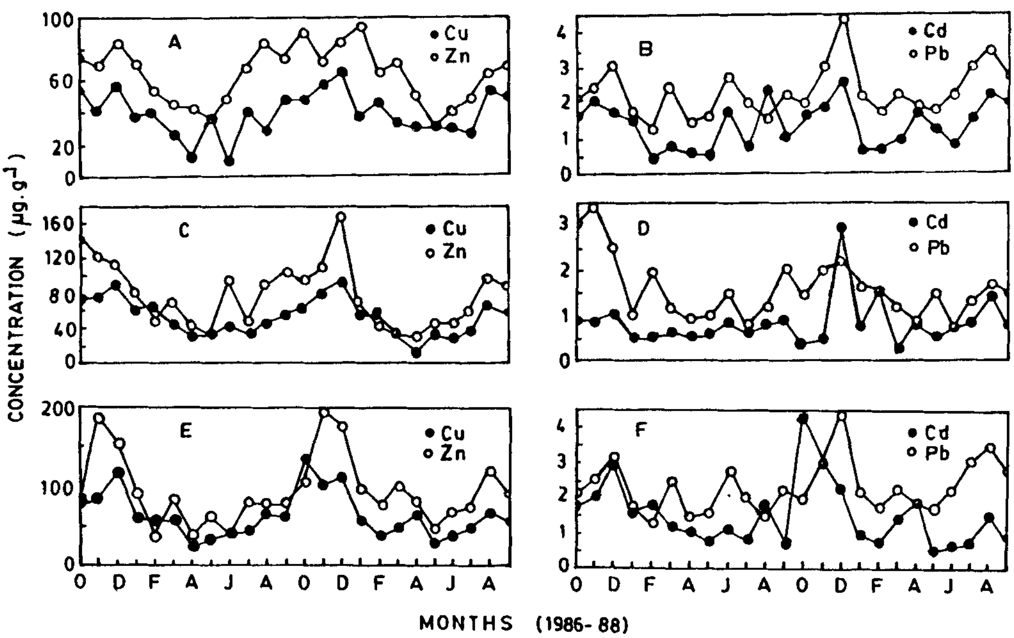

Figure 2 Monthly profiles of copper, zinc, cadmium and lead (μg/g, dry weight) in the plankton of Uppanar (A, B), Vellar (C, D) and Kaduviar (E, F) estuaries of southeast coast of India.

plankton of Kaduviar estuary (Cu – 63.70, Zn – 94.44, Cd – 1.50, Pb – 2.90 μg/g) was found to be higher than in the Vellar estuary (Cu – 52.41, Zn – 79.51, Cd – 0.81, Pb – 1.59 μg/g) or in the Uppanar estuary (Cu – 39.28, Zn – 64.39, Cd – 1.36, Pb – 2.31 μg/g). This could be due mainly to the influx of domestic and industrial wastes from the nearby Nagapatnam town, in addition to discharges associated with harbour activities. However, zinc and cadmium showed statistically insignificant values between stations (Table I).

Table I Analysis of variance between metal concentration in plankton samples in different seasons and estuaries.

Description	*copper*	*zinc*	*cadmium*	*lead*
seasons	14.755*	11.069*	4.248	14.310*
estuaries	7.265*	3.893	3.416	23.609*

* $P < 0.05$

The analysis of monthly values (Figure 2) for each element showed a distinct seasonal variation with higher levels of metals during the monsoon period (October–December) and lower levels during summer (April–June) (Table II). The results of ANOVA (Table I) also demonstrated a significant difference between seasons. The higher levels during monsoon could be due to the influx of metal-rich fresh water reaching the estuaries which also brings domestic, agricultural and industrial wastes from the

Table II Seasonal, annual and total mean of metal concentrations in plankton (μg/g dry weight)

			Seasonal Means					
Metal/Estuary		*Year*	*Monsoon*	*Post monsoon*	*Summer*	*Pre monsoon*	*Annual means*	*Total means*
Cu	Uppanar	1986–87	52.57	36.13	19.43	38.70	36.71	
		1987–88	56.20	38.20	30.87	42.10	41.84	39.28
	Vellar	1986–87	79.67	55.80	34.87	44.90	53.82	
		1987–88	78.46	48.30	25.20	52.07	51.01	52.41
	Kaduviar	1986–87	92.43	58.63	34.10	58.67	60.96	
		1987–88	117.47	47.27	43.23	57.77	66.43	63.70
Zn	Uppanar	1986–87	76.10	57.45	42.90	76.15	63.15	
		1987–88	82.93	77.70	40.80	61.10	65.63	64.39
	Vellar	1986–87	128.80	69.27	58.87	82.03	84.74	
		1987–88	124.60	50.43	41.17	80.94	74.29	79.51
	Kaduviar	1986–87	141.90	72.63	46.11	79.77	85.34	
		1987–88	158.83	93.20	66.16	95.99	103.55	94.44
Cd	Uppanar	1986–87	1.80	0.88	0.95	1.38	1.25	
		1987–88	2.05	0.70	1.24	1.90	1.47	1.36

Table II (*Cont'd*)

Metal/Estuary		*Year*	*Seasonal Means* *Monsoon*	*Post monsoon*	*Summer*	*Pre monsoon*	*Annual means*	*Total means*
	Vellar	1986–87	0.90	0.53	0.62	0.75	0.70	
		1987–88	1.24	0.79	0.69	0.97	0.92	0.81
	Kaduviar	1986–87	2.26	1.50	0.93	1.07	1.44	
		1987–88	3.17	1.02	1.07	0.98	1.56	1.50
Pb	Uppanar	1986–87	2.58	1.83	1.92	1.92	2.06	
		1987–88	3.15	2.06	1.97	3.07	2.56	2.31
	Vellar	1986–87	3.00	1.40	1.13	1.32	1.71	
		1987–88	1.86	1.44	1.03	1.50	1.46	1.59
	Kaduviar	1986–87	3.25	2.25	2.08	2.28	2.47	
		1987–88	4.91	2.67	2.98	2.75	3.33	2.90

adjacent areas. The increased particulate matter along with suspended sediment load brought in by the river would also be a possible reason for the abnormally high values during the monsoon season. The lower levels observed during summer period could be due to the decreased influx of fresh water and relatively larger population of plankton taking up the available metals.

The metal concentrations in the plankton of study areas were found to be higher during low salinity months and vice-versa. This is shown statistically by a significant inverse relationship between the metal concentration in plankton and salinity of the ambient medium (Cu: $P < 0.001$; Zn: $P < 0.001$; Cd: $P < 0.05$; Pb: $P < 0.05$). Romeo and Laumond (1980) also reported similar observations in the plankton of the northwest Mediterranean, indicating an effect of rain water discharge in influencing heavy metal concentration in plankton.

The results also show a significant linear relationship between metal level in plankton and metal level in the ambient dissolved fraction (Cu: $P < 0.05$; Zn: $P < 0.01$; Cd: $P < 0.01$; Pb: $P < 0.001$) indicating that the bioconcentration of metals in plankton would be mainly from the dissolved fraction. Romeo and Nicolas (1986) opined that the concentration of cadmium and lead in macroplankton organisms could reflect their concentration in sea water and act as a indicator of heavy metal pollution. Fisher (1985) reported that in *Synechoccus* sp., cells accumulate metals in proportion to the ambient dissolved metal concentrations.

The order of metal concentration in the plankton showed the same pattern in all the three study areas: Zn > Cu > Pb > Cd. Bowen (1966) reported that plankton showed greater affinity for certain metals among cations with the order of affinity Zn > Pb > Cu > Mn > Co > Ni > Cd among the divalent transition elements. In the present study, the metal distribution pattern was found mainly influenced by the extent of heavy metal discharges from the nearby area and where agricultural discharges contain more copper and zinc. The lower values of lead and cadmium observed might be due to the lack of significant sources of these two metals in the vicinity.

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