

Heavy metal distribution in Pondicherry harbour, southeast coast of India

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Attempt was made to evaluate the extent of distribution of selected heavy metals (Cu, Zn, Cd and Pb) in water, sediment and plankton over a period of two years from Pondicherry harbour (lat.11°47' N, long.79°50'E). A distinct seasonal variation in the distribution of metals in the ambient water, sediment and plankton was observed. The metals were high during monsoon and low during summer. The order of metal abundance in water, sediment and plankton was Zn>Cu>Pb>Cd. Plankton showed greater adsorption and absorption capacity for most of the heavy metal as revealed by the concentration factor. A significant linear relationship was also observed between metal level in the ambient water and plankton. Salinity plays an important role in the distribution of metal in the study area.

Information on the level of heavy metal pollution in the marine environment is important as they cause serious environmental health hazards. These elements are magnified in the food chain and reach human beings causing deleterious effects¹. Plankton, one of the basic food resources in marine system, are known to concentrate heavy metals in large quantities². They play an active role in removal of metals from the ambient seawater³ and also act as an indicator for pollution⁴. Plankton are also known to concentrate metal from the ambient medium and pass them on to higher tropic levels. Attempts have been made to relate heavy metal levels in seawater directly with metal concentration in plankton^{2,4}. These studies highlight the potential of using plankton as a tool to monitor heavy metal pollution in the marine environment. The present study is undertaken with the objective of obtaining baseline data and to assess the distribution of heavy metals, copper, zinc, cadmium and lead in water, sediment and plankton and the extent of contamination, if any, at Pondicherry harbour (lat.11°47'N, long.79°50'E), along southeast coast of India.

Materials and Methods

Samplings were made from the harbour area of Pondicherry at monthly intervals from October, 1994 to September, 1996 and the distribution of heavy

metals in water, sediment and plankton were monitored. Surface water samples were collected with precleaned polythene bottles. The samples' pH were adjusted to 4 ± 0.1 using 50% HNO₃ in the field and brought to the laboratory and filtered immediately through 0.4µ millipore HA membrane filter. Metals were then preconcentrated by APDC and MIBK⁵ chelation and solvent extraction technique and quantified using an atomic absorption spectrophotometer (Perkin-Elmer model 373). The precision was found to be ± 0.05 for Cu and Zn and ± 0.01 for Cd and Pb.

The sediment samples were collected with the aid of Peterson grab and placed in polythene bag and frozen in the laboratory until further treatment. For estimation of the metals, the preserved sediment samples were dried at 110°C to constant weight and extracted using acid digestion procedure.

The plankton samples were collected using plankton net no. 25 made of bolting silk 164. The samples were cleaned, filtered and dried in an oven to constant weight at 95°C and powdered. For estimation of metals from the dried samples of sediment and plankton, an improved acid digestion procedure was adopted⁷. The percentage recovery of metals from NIES reference sediment were 95, 96, 94, 94 for Cu, Zn, Cd and Pb respectively. The percentage recovery using NIES no. 6 reference

biological tissue material were 95, 97, 96 and 95 for Cu, Zn, Cd and Pb respectively.

Results and Discussion

Monthly mean distribution pattern of Cu, Zn, Cd and Pb in water, sediment and plankton from the Pondicherry harbour are shown in Fig. 1. For all the metals in the study area, the level in water, sediment and plankton were higher during monsoon (Oct.-Nov.) and lower in summer (April-June) (Fig. 1) as observed earlier in the estuaries of southeast coast of India⁵. The higher concentration during monsoon could be mainly due to the land runoff and influx of metal rich freshwater which in turn reflects in the metal concentration in sediment and plankton. 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 monsoon⁵. Lower concentration during summer might be due to the meagre runoff during the period.

Salinity of the ambient medium (24.5 to 35.6‰) plays an important role in the distribution of metal in the study area. The metal concentration in the water and sediment was high during low salinity period (Oct-Dec) indicating a significant inverse relationship (Zn: $P < 0.01$; Cd, Pb: $P < 0.001$). Similar observations were reported earlier in Zuari estuary⁸

and Uppanar, Vellar and Kaduviar estuaries of southeast coast of India⁵. The inverse relationship between metal levels in water and salinity was attributed to the dilution of metal rich fresh water near the study area and by metal impoverished seawater and the high sedimentation processes in the estuary. The sharp change in salinity as the fresh water mixes with seawater would result in the precipitation and coagulation of colloidal clay particles and coprecipitation of metal with/or adsorption on to the particles resulting in the removal of considerable amount of metals from the solution phase⁹. Metal concentration in the plankton also showed an inverse relationship with the salinity of the ambient media (Cu, Zn: $P < 0.01$; Cd: $P < 0.001$). Similar observations were made in the case of plankton of the Northwest Mediterranean¹⁰, Uppanar, Vellar and Kaduviar estuaries⁴.

Significant linear relationship was noticed between metal concentration in plankton and ambient water fraction (Cu, Cd: $P < 0.001$). Similar results were observed in the plankton from the estuaries of southeast coast of India⁵ and in the cells of *Synechococcus* sp.¹¹ indicating that plankton accumulate metals proportionate to the ambient dissolved metal concentration through adsorption and absorption processes and act as indicator of heavy metal pollution¹².

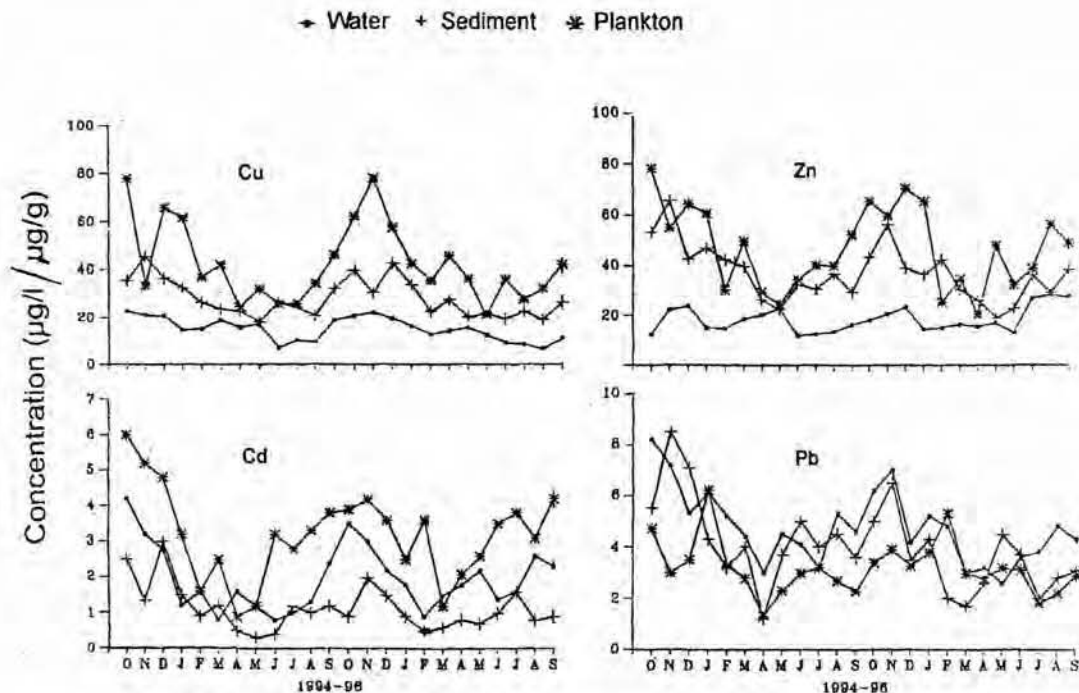


Fig. 1—Monthly mean values of metal concentration in water ($\mu\text{g.l}^{-1}$), sediment and plankton ($\mu\text{g.g}^{-1}$) from Pondicherry harbour

A significant positive correlation was observed between metal concentration in water and sediment (Cd: $P < 0.01$; Cu, Pb: $P < 0.001$). The metal concentration in sediment is dependent on the nature, adsorption and retention capacity of the substratum¹³, apart from the effect of flocculation and coagulation causing the particulate matter to settle down to the bottom¹⁴. The metal enrichment in the sediment is related to the removal of metal from the solution by terrestrial organic matter which eventually becomes incorporated into sediment¹⁵. The results also show a significant linear relationship between metal concentration in plankton and sediment (Cu, Zn, Cd: $P < 0.01$) suggesting the availability of metal to plankton from sediment. Similar observations were also reported from the Tranquebar and Nagapattinam coasts⁴.

Plankton concentrates heavy metal to an order of 10^3 from the ambient medium through passive adsorption and ion exchange processes³. In the present study, correlation between the heavy metal level in water and plankton can be made by calculating the concentration factors (CFs)¹⁶. Concentration factor values in plankton and sediment varied among metals, as below.

Samples	Cu	Zn	Cd	Pb
Sediment	1.85×10^3	2.00×10^3	3.44×10^3	0.87×10^3
Plankton	2.83×10^3	3.08×10^3	1.68×10^3	0.89×10^3

The order of CF was Zn>Cu>Cd>Pb for plankton and Zn>Cu>Pb>Cd for sediment. It is noteworthy that the high CF was exhibited for essential metals Cu and Zn rather than the nonessential metals Cd and Pb.

Concentrations of Zn and Cu were higher in water, sediment and plankton when compared to cadmium and lead levels. This may be due to the higher levels of these metals in the discharges from agricultural area containing fertilizer, pesticide and rodenticide residues¹⁷. The concentration of cadmium and lead is low as the source for these metals is found lacking in the vicinity of study area. Although the metal levels observed in the present study is notable, they are well within threshold limits and ISI limits (copper: 3 mg.l^{-1} ; zinc: 5 mg.l^{-1} ; cadmium: 2 mg.l^{-1} and lead 0.1 mg.l^{-1}), recommended for the discharge of

industrial effluent into the surface water including estuaries¹⁸, suggesting comparatively less metal contamination in the study area. However, as these metals are capable of posing threat over a period of time, present level of contamination has to be dealt with care.

From the present investigation, it is concluded that plankton can be used as monitors of heavy metal pollution as they show greater adsorption and absorption capacity¹² as revealed by the concentration factors. The present study further implies the need for continuous regular monitoring of coastal waters, which are vulnerable to metal pollution.

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