Indian Journal of Marine Sciences
Vol. 23, March 1994, pp. 52-54

## *Short Communications*

# Metal pollution in harbour and coastal sediments of Visakhapatnam, east coast of India

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Received 29 June 1993, revised 1 November 1993

Extent of metal pollution in harbour sediments and its impact on the coastal region of Visakhapatnam have been evaluated using pollution load index (PLI). High PLI values of inner harbour (4.5) indicates a highly polluted zone which can be attributed to the discharge of untreated domestic sewage and industrial effluents. Further, decreasing trend of pollution load index values from harbour to coastal region suggests dispersion and dilution of metal pollutants.

Metal pollution in harbour and coastal environment usually occurs due to land runoff, shipping and dredging activities, and anthropogenic inputs. Sediment in such polluted body not only record its history, but also the degree of pollution[1]. Degree of contamination of aquatic sediments has been earlier quantified by comparing with an uncontaminated natural background for a specific constituent[2,3]. The pollution indicator, geoaccumulation index[4], takes into account not only the natural background but also its variation with rock types (lithogenic effect). Tomlinson *et al.*[5] however, employed a simple method based on pollution load index (PLI), to assess the extent of pollution by metals in the estuarine sediments. Although concentration levels of major and minor elements in the sediments of Visakhapatnam harbour have been reported[6] earlier, the degree of metal pollution has not quantitatively been evaluated in this region. The present communication deals with the evaluation of metal pollution in the sediments of harbour and coastal region of Visakhapatnam using PLI.

Sediment samples were collected from Visakhapatnam coast in September, December 1986 and April 1987 using a peterson grab from five transects perpendicular to the coast (Fig. 1). For trace metal analysis about 10 g of the uncontaminated sediment was collected from the central portion of the grab sample using a clean plastic spatula and then transferred into a polythene bag. The samples were

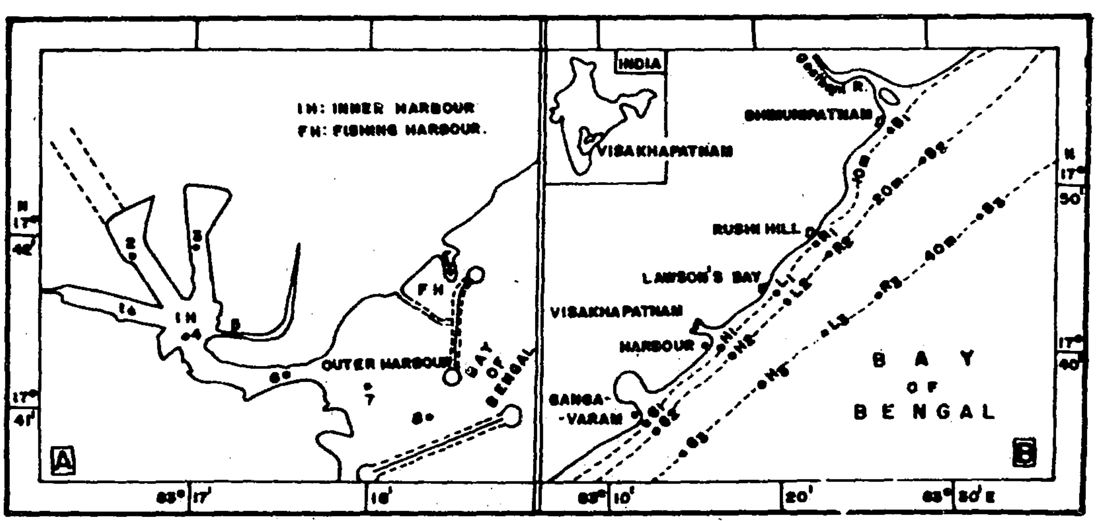


Fig. 1—Station locations in (A) Visakhapatnam harbour, and (B) Visakhapatnam coast

washed with distilled water for removal of salts, air dried and finely powdered. Concentration of Fe, Mn, Cu, Co, Ni, Zn, Pb and Cd were determined using atomic absorption spectrophotometer (Varian-AA-1475) after digestion[7] with a mixture of HF and aqua regia. The coefficient of variation of elements from replicate (six) analysis of USGS reference rock (AGV-1) standard was found to be Fe = 2.8%, Mn = 4.5%, Cu = 2.4%, Co = 3.2%, Ni = 1.9%, Zn = 1.7%, Pb = 2.6% and Cd = 3%. Pollution load index (PLI) was evaluated using the equation

$$\mathrm{PLI} = \sqrt[n]{\text{Product of n number of CF values}} \quad \ldots (1)$$

where CF = contamination factor, and n = number of metals. The contamination factor (CF) can be obtained from the equation

$$\mathrm{CF} = \frac{\text{Metal concentration in polluted sediment}}{\text{Background value of that metal}} \quad \ldots (2)$$

Data on the concentration levels of trace metals (Fe, Mn, Cu, Co, Ni, Zn, Pb, and Cd) of harbour sediments was taken from earlier report[6]. While computing the CF of harbour and coastal sediments, the world average concentration of these elements reported for shale[8] were taken as their background values.

Concentration levels of Fe, Cu and Co (except sts. 7 and 8), Zn, Pb and Cd in harbour sediments were higher than those of world average concentrations of shale[8] (Table 1). This was reflected in relatively higher contamination factors (> 1) in harbour sediments which can be attributed to their incorporation by anthropogenic inputs such as industrial effluents and domestic sewage into the harbour[6]. Similarly (except

Table 1—Average concentration, contamination factors of elements and pollution load index (PLI) of the sediments of harbour and coastal region of Visakhapatnam

| St No | Fe | | Mn | | Cu | | Co | | Ni | | Zn | | Pb | | Cd | | PLI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | B | A | B | A | B | A | B | A | B | A | B | A | B | A | B | |
| | | | | | | | | World shale average[8] | | | | | | | | | |
| | 4.67 | – | 0.09 | – | 45 | – | 19 | – | 68 | – | 95 | – | 20 | – | 0.3 | – | – |
| | | | | | | | | Harbour region | | | | | | | | | |
| 1 | 6.28 | 1.34 | 0.05 | 0.56 | 111 | 2.47 | 35 | 1.84 | 35 | 0.51 | 7512 | 79 | 136 | 6.8 | 42 | 140 | 4.36 |
| 2 | 6.47 | 1.39 | 0.04 | 0.44 | 126 | 2.80 | 40 | 2.11 | 64 | 0.94 | 5549 | 58 | 613 | 30 | 54 | 180 | 5.67 |
| 3 | 6.86 | 1.47 | 0.06 | 0.67 | 120 | 2.67 | 20 | 1.05 | 51 | 0.75 | 5717 | 60 | 213 | 10 | 27 | 90 | 4.28 |
| 4 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| 5 | 6.42 | 1.37 | 0.04 | 0.44 | 119 | 2.64 | 26 | 1.37 | 50 | 0.74 | 10905 | 115 | 221 | 11 | 47 | 156 | 4.87 |
| 6 | 7.01 | 1.50 | 0.05 | 0.56 | 63 | 1.40 | 11 | 0.58 | 41 | 0.60 | 5887 | 62 | 183 | 9.2 | 20 | 66 | 3.33 |
| 7 | 6.86 | 1.47 | 0.05 | 0.56 | 36 | 0.80 | 11 | 0.58 | 39 | 0.57 | 4347 | 46 | 81 | 4.1 | 9 | 30 | 2.43 |
| 8 | 7.18 | 1.54 | 0.05 | 0.56 | 25 | 0.55 | 10 | 0.53 | 32 | 0.47 | 2487 | 26 | 48 | 2.4 | 5 | 16 | 1.82 |
| | | | | | | | | Coastal region | | | | | | | | | |
| $G_1$ | 4.30 | 0.92 | 0.07 | 0.77 | 67 | 1.49 | 59 | 3.10 | 56 | 0.82 | 646 | 6.8 | 75 | 3.8 | 4.5 | 15 | 2.38 |
| $G_2$ | 4.04 | 0.87 | 0.07 | 0.77 | 63 | 1.40 | 50 | 2.63 | 52 | 0.76 | 737 | 7.8 | 74 | 3.7 | 2.2 | 7 | 2.10 |
| $G_3$ | 6.49 | 1.39 | 0.13 | 1.44 | 80 | 1.78 | 60 | 3.16 | 79 | 1.16 | 781 | 8.2 | 95 | 4.7 | 2.8 | 9 | 2.86 |
| $H_1$ | 2.92 | 0.63 | 0.06 | 0.66 | 62 | 1.38 | 54 | 2.84 | 56 | 0.82 | 751 | 7.9 | 65 | 3.2 | 1.8 | 6 | 1.94 |
| $H_2$ | 2.87 | 0.61 | 0.06 | 0.66 | 69 | 1.53 | 41 | 2.16 | 50 | 0.74 | 758 | 7.9 | 57 | 2.8 | 2.0 | 6 | 1.84 |
| $H_3$ | 3.00 | 0.64 | 0.08 | 0.88 | 74 | 1.64 | 47 | 2.47 | 69 | 1.01 | 800 | 8.4 | 82 | 4.1 | 1.8 | 6 | 2.16 |
| $L_1$ | 1.82 | 0.39 | 0.07 | 0.77 | 58 | 1.29 | 38 | 2.00 | 46 | 0.68 | 651 | 6.8 | 67 | 3.4 | 2.3 | 7 | 1.74 |
| $L_2$ | 1.07 | 0.23 | 0.05 | 0.56 | 44 | 0.98 | 24 | 1.26 | 30 | 0.44 | 646 | 6.8 | 57 | 2.9 | 1.3 | 4 | 1.23 |
| $L_3$ | 4.43 | 0.95 | 0.10 | 1.11 | 65 | 1.44 | 51 | 2.68 | 63 | 0.93 | 712 | 7.5 | 76 | 3.9 | 2.3 | 7 | 2.30 |
| $R_1$ | 1.25 | 0.27 | 0.04 | 0.44 | 36 | 0.80 | 30 | 1.58 | 27 | 0.40 | 549 | 5.8 | 59 | 2.9 | 2.0 | 6 | 1.25 |
| $R_2$ | 1.28 | 0.27 | 0.09 | 1.00 | 53 | 1.18 | 35 | 1.84 | 28 | 0.41 | 499 | 5.3 | 61 | 3.1 | 1.3 | 4 | 1.41 |
| $R_3$ | 4.23 | 0.91 | 0.10 | 1.11 | 55 | 1.22 | 60 | 3.16 | 62 | 0.91 | 562 | 5.9 | 68 | 3.4 | 2.5 | 8 | 2.21 |
| $B_1$ | 1.79 | 0.38 | 0.04 | 0.44 | 59 | 1.31 | 25 | 1.32 | 33 | 0.49 | 775 | 8.2 | 72 | 3.6 | 4.0 | 13 | 1.64 |
| $B_2$ | 1.24 | 0.27 | 0.06 | 0.66 | 39 | 0.87 | 21 | 1.11 | 22 | 0.32 | 587 | 6.2 | 57 | 2.9 | 3.5 | 11 | 1.35 |
| $B_3$ | 3.85 | 0.82 | 0.10 | 1.11 | 67 | 1.49 | 56 | 2.95 | 60 | 0.88 | 568 | 5.9 | 73 | 3.7 | 4.0 | 13 | 3.37 |

A = Average concentration (Fe and Mn in % and others in ppm), B = contamination factor

Fe) all these elements showed relatively higher concentrations than those of world average shale background resulting in higher contamination factors in the coastal sediments. Further, the contamination factors showed a decreasing trend from harbour to coastal sediments suggesting dilution and dispersion of metal pollutants in the latter. Among the coastal stations they recorded an increasing trend from coast to innershelf in each transect indicating greater accumulation which can be attributed to fine texture of the innershelf sediments as reported earlier[9].

Similar trends were evident more clearly in the PLI values. PLI of different zones showed that inner harbour (PLI = 4.5) was the most polluted zone. Of the stations in the inner harbour, st. 2 which receives industrial effluents was highly polluted (PLI = 5.67) than st. 5 which receives domestic sewage. Stations 1 and 3 which receive wastes from naval installations, unloading of bulk cargo such as coal, coke, sulphur, Zn-Pb concentrates etc. also registered higher PLI values. Further, they showed a decrease from harbour to coastal region indicating dispersion and dilution of metal pollutants. Sediments of coastal region with large lithogenic influx were less polluted (PLI = 1.92) than harbour (PLI = 3.67). Among different transects in the coastal region, Gangavarm (sts $G_1$-$G_3$) recorded higher PLI values than others indicating the flow of pollutants towards south of Visakhapatnam. Further, the index values in each transect registered an increasing trend from coast to innershelf suggesting higher accumulation of metals in relatively fine grained sediments (sand-silt-clay) of inner shelf than the coarse sediments of the coast which comprises of predominantly sands[9].

Two authors (PKP and SDS) are grateful to the Department of environment, Govt. of India for financial support.

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