Database on trace metal levels in the Indian marine ecosystem: decadal trends of lead and cadmium in sediment off Cochin

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The Fishery Environment Management Division (FEMD) of Central Marine Fisheries Research Institute (CMFRI), Kochi, has been documenting the real-time data on total concentration of metals *viz.*, Pb, Cd, Cu, and Zn since 1994, in sediments off Cochin and since 2002, data on Pb, Cd, Ni, Hg, Cu, Cr, Zn, Mn and Fe, in sediments from different regions of the Indian coast. Database on these vital parameters determining the sediment quality with respect to environmental toxicity is available in the FEM Division of CMFRI since 1994. The locations of data collection included three sites each from Veraval (Gujarat), Mumbai (Maharashtra), Karwar and Mangalore (Karnataka), Mandapam, Tuticorin and Chennai (Tamil Nadu), Visakhapatanam (Andhra Pradesh) and four sites from Cochin (Kerala) covering the Indian coast from different regional/ research centres as well as headquarter of CMFRI. The data were collected as part of the inhouse projects entitled "Monitoring marine pollution in relation to protection of living resources" (FEM/MP/1) from 1994-2002 and "Monitoring the environmental contaminants from coastal water with reference to bioaccumulation and bio-magnification in fishes" (FEM/02) from 2002 onwards. Recently, analysis of these data was done to understand the decadal trends in the content of lead and cadmium in sediment in the coastal waters of Central Kerala. Summary of the salient findings of this analysis is given below.

Sediment samples were collected from four stations (two stations belonging to the estuarine waters and two stations belonging to the inshore waters), off Cochin, using Van Veen Grab having an area of 0.05 m^2. The samples after processing and digestion were used to quantify total lead and total cadmium concentrations (μg g^{-1}) using atomic absorption spectrophotometer (AAS). Quality check, quality control and quality assurance procedures were maintained throughout.

Lead accumulation in sediment

The result of the analysis of total lead (μg g^{-1}) are plotted in figures 1 and 2. As per the sediment quality guidelines issued by NOAA (National Oceanographic and Atmospheric Administration, USA) based on assessment of the potential for biological effects of sediment adsorbed lead, the probable effects level is 112 μg g^{-1} in marine conditions. The NOAA sediment quality guidelines are non-regulatory guidelines for use in interpreting chemical data. The probable effect level indicates a potential risk from the concerned contaminants to the biological field. The concentration of lead in sediment (μg g^{-1}) in harbour and barmouth (Fig. 1) did not go above probable effect level (PEL) in Cochin, except in 2002, during January to April (pre-monsoon).

Lead as a contaminant enters the marine ecosystem from different sources. The natural sources are atmosphere and intrinsic content in

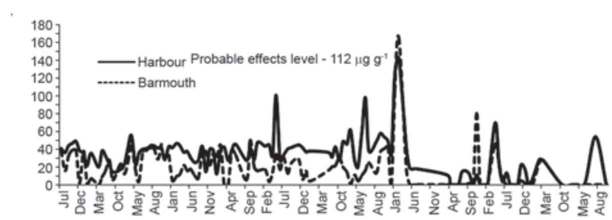

Fig. 1. Decadal trend of lead (μg g^{-1}) in sediment in Vembanad Estuary

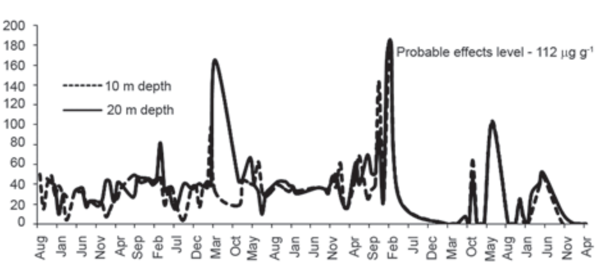

Fig. 2. Decadal trend of lead (μg g^{-1}) in nearshore sediment, off Cochin

lithosphere reaching the hydrosphere. Lead also enters the hydrosphere through anthropogenic activities including industrial effluent discharge. Lead is widely used in battery casings, pipes and lead based additives in fuels. High levels of lead have been reported in marine life near areas of car density in California and UK (Law *et al.*,1992). Toxic quantities of lead consumed by humans can cause anaemia, hypertension, cardiac disease, immune system suppression (antibody inhibition) and neurological damage.

The lead accumulation level in nearshore sediments off Cochin were well below the level of potential risk (*i.e.*, the probable effect level of 112 $\mu g\ g^{-1}$) except in November 2001 and in January – February 2002 at 20 m depth (post and pre-monsoon). The incidence of lead above PEL is 2.4% of the total observations (N = 421). These stray occurrences of higher accumulation of lead, during particular periods of one to three months in post and /or pre-monsoon might be from anthropogenic origin. The index for anthropogenic accumulation of metals worked out as "enrichment factor" for lead in sediment was high in post and pre-monsoon seasons whereas it was practically nil in monsoon seasons. This can be a sign of potential risk for lead accumulation in sediment in post and pre-monsoon seasons in estuary as well as inshore areas and dilution in monsoon. It also shows that the resident time of potential lead contamination is less and the threat for biota for exposure to the potential risk level is too little. There is no permanent binding of lead by the sediment at the potential risk concentration. Hence the sediments can be considered as generally in the state of safe environment as far as lead accumulation is considered.

Cadmium accumulation in sediment

Cadmium enters the aquatic system as contaminant in many ways. Cadmium was used widely in electroplating, in solder and as a pigment for plastics, but less frequently now due to health concerns. Main sources presently are as by-product of zinc mining, nickel-cadmium battery production, burning of coal and oil, wearing down of car tyres, corrosion of galvanized metal, phosphatic fertilizers and sewage sludge. Out of the cadmium input into the oceans, around 50% is anthropogenic.

In human beings, cadmium in high levels can cause depressed growth in children, kidney damage, cardiac enlargement, hyper tension, foetal deformity and cancer. In humans, cadmium concentration above 200-400 ppm in kidney tissue can lead to renal damage. Kidney malfunction has been reported in cetaceans when liver concentrations of Cd exceeded 20 ppm wet weight (Fujiso *et al.*, 1988).

Decadal trend of Cd ($\mu g\ g^{-1}$) in sediment in Vembanad Estuary is plotted based on the data recorded at FEM Division, CMFRI, from 1994 – 2006. The Cd concentration was above the NOAA probable effect level (above 4.2 ppm) in harbour region, during October to January in 1999, 2001, 2003 – 2004 and 2006 (Fig. 3).

In the barmouth region, the concentrations were above PEL (above 4.2 ppm) in October 2001, October - December 2003, January – February 2004 and October 2006 (Fig. 3).

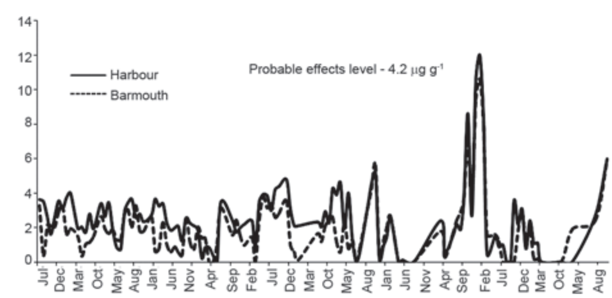

Fig. 3. Decadal trend of Cd ($\mu g\ g^{-1}$) in sediment in Vembanad Estuary

In 10 m depth inshore sediment, the concentrations were above PEL (above 4.2 ppm) in December 1998, September 1999, November 2000, September – October 2001, September – December 2003 and January-February 2004 (Fig. 4). The inshore sediment at 20 m depth showed concentrations above PEL (above 4.2 ppm) in September–November 1999, December 2000, September 2001, October – December 2003 and January – February 2004 (Fig. 4). The incidence of cadmium above PEL is 9.5% of the total observations (N = 421). Here also, the occurrence of levels above PEL was mainly during post-monsoon and pre-monsoon months and the resident time did not exceed 3-4 months. With the onset of monsoon, the level of metal became low and therefore no permanent binding of the metal occurs. The enrichment factor for cadmium also showed values of high anthropogenic influence in post and pre-monsoon seasons which became nullified in monsoon. The inherent metal content of these sediments did not reach level for potential risk.

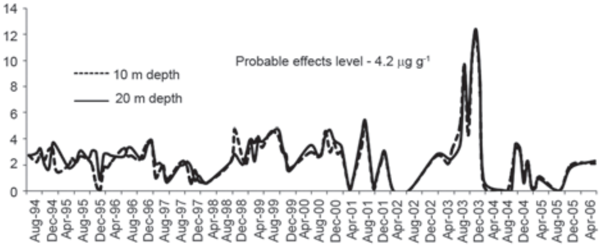

Fig. 4. Decadal trend of Cd ($\mu g\ g^{-1}$) in nearshore sediment off Cochin

Though the estuarine and inshore sediments off Cochin came within the class of unpolluted to slightly polluted, over the decadal analysis, the importance for continuous investigation for potential risk does not cease, since the anthropogenic and industrial pressure increases invariably in the present scenario in Cochin. Hence the need for surveillance as well as control increases. Creating awareness of the potential setback among the public, industrialists, fishermen, youth and policy makers through participatory approach for reducing the contamination through regulatory and non-regulatory volunteer practices becomes a must in current approach for management of this crisis.