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Trends in heavy metal concentrations in sediment, finfishes and shellfishes in inshore waters of Cochin, southwest coast of India

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Abstract

Profile of Cadmium, Zinc, Copper and Lead in sediment and tissues from four species of finfishes and shellfishes from estuarine and inshore regions of Cochin were analysed from the monthly data, collected for ten years since 1990. Annual mean levels of Zinc in *Nemipterus japonicus* registered a gradual decreasing trend towards 1998 with a peak (35 ppm) during 1992. Similar trend was also observed in *Metapenaeus dobsoni* and *Sunetta scripta*. However, an increasing trend was noticed in *Otolithus ruber,* registering a peak (9 ppm) during 1995. Lead concentrations were higher in *M. dobsoni* followed by *N. japonicus* with an increasing trend. On the other hand, Cadmium and Copper levels showed a decreasing trend with peak levels in *Nemipterus* (Cd 0.58 ppm, Cu 10. 43 ppm) and *M. dobsoni* (Cd 1.16 , Cu 8.87 ppm) than the molluscs and the croaker species. Levels of these four metals in sediment were higher in inshore regions than in the estuarine areas. Copper, Lead and Cadmium content in sediments of estuarine as well as the inshore regions showed an increasing trend over the ten years period. However, the levels of Zinc showed no significant variation in the inshore areas and a marked decreasing trend in the estuarine regions. The profile of metals in tissues and sediment samples were correlated in relation to the state of health of these resources and ecosystem in the light of increasing port and anthropogenic activities.

Key words: Heavy metals in sediment, finfish and shellfish, water quality

Introduction

Water and sediment quality is a vital aspect for the survival and well being of the living resources, especially in the coastal and estuarine areas. Some of these areas are now under the direct threat from the increasing load of various pollutants. Among them, the heavy metal needs special mention as they are indicators of the impact of industrialization. Several water bodies in the country are in mortal changes of pollution caused by excessive sewage, industrial effluents, fertilizer and pesticide run-off. The seas around India have several hot spots with regard to thermal wastes, nuclear wastes and oil pollution.

Status of coastal pollution can be assessed with the three-tier detection mechanism from water, sediment and tissue samples. Muralidharan and Ouseph (1989) have studied the distribution of certain major, minor and trace elements in the near shore sediment off south west coast of India and they noticed that the concentration of trace elements varied with sediment texture and organic matter content. Ramachandran and Natarajan (1989) reviewed coastal marine pollution in Tamilnadu. Sediments are indicators of the quality of water overlaying them and hence their study is useful in assessing the environmental pollution.

Wesley and Sanjeevaraj (1983) studied heavy metal concentration in various tissues of green mussel, *Perna viridis* from the intertidal waters of Kalpakkam, Chennai. Senthilnathan and Balasubramanian (1999) have evaluated the extent of distribution of Cu, Cd, Zn and Pb in water, sediment and plankton from Pondicherry Harbour. The present study was undertaken with the objective of unraveling the levels of distribution of Cd, Pb, Cu and Zn in sediment from estuarine and inshore areas of Cochin (Fig. 1) and the extent of bioaccumulation in some commonly available finfish and shellfish species.

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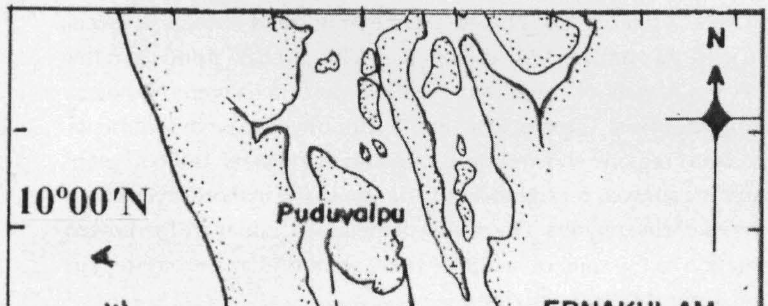

Fig. 1. *Location of study*

Material and methods

Distribution of metals in sediment and their accumulation by organisms were studied from the port area and the inshore areas of Cochin (Fig. 1) at monthly intervals from January 1990 to December 2000 on board R.V. *Cadalmin*. Tissue samples of fishes such as *Nemipterus japonicus*, *Otolithus ruber* and the prawn *Metapenaeus dobsoni* were collected from the bottom trawl (15 to 20 m) by R.V. *Cadalmin* and the clam *Sunetta scripta* from the intertidal region of Cochin using a hand operated grab (eight to ten animals each species per month). Tissues from the abdomen of *M. dobsoni,* the fillet from *N. japonicus* and *O. ruber* as well as the soft part of the muscle from *S. scripta* were removed and dried in an oven to constant dry weight at 80 ± 2°C. Sediment samples were collected with the aid of a van Veen grab and brought to laboratory in polythene bags. These samples were dried at 90 ± 3° C to constant weight. Metals from tissue and sediment samples were extracted using acid digestion procedure (Dalziel and Baker, 1984). The metals extracted from the tissues and sediments were detected on a Perkin Elmer AAS (Model 2380) in an air-acetylene flame. The precision of the analysis was within 10% and the percentage recovery of metals from the spiked samples was found to be 88%, 94%, 94% and 96% for Cu, Zn, Pb and Cd respectively when Spectrosol (BDH England) for sediment standard and soft tissue parts of *M. dobsoni* were used. The percentage deviation from true value was –3% for Cd and –11% for Pb in tissue samples and 55% for Cd and –21% for Pb in sediment samples.

Results

Cadmium

Cadmium concentrations in sediment of estuarine and inshore areas of Cochin registered highest value (2.4 ppm) during 1996 and a lowest of 0.02 ppm during 1991. Sediment from inshore areas showed

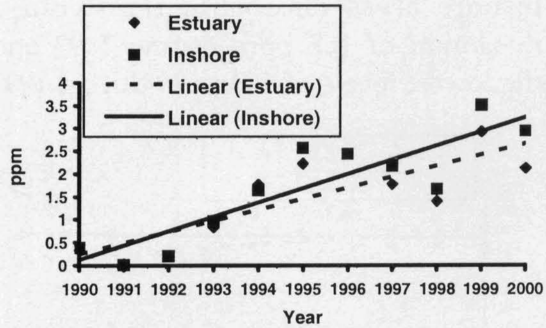

Fig. 2. *Distribution trend of Cadmium in sediments*

a higher value of 1.3 ppm compared to 1.2 ppm in the estuarine areas (Fig. 2). The levels of Cd were maximum in *S. scripta* showing a mean of 0.6 ppm that ranged from 0.07ppm during 1994 to 1.11 ppm during 1997. Tissues of *O. ruber* recorded the lowest concentration of Cd showing a mean of 0.04 ppm and ranged from 0.01 ppm during 1993 to a maximum of 0.07 ppm during 1995. *N. japonicus* showed a range of 0.08 ppm during 1998 to 0.6 ppm during 1994 and *M. dobsoni* registered 0.24 ppm with a maximum of 1.16 ppm during 1992 and 0.04 ppm during 1993-1994 (Fig.3).

Zinc

The sediments of estuarine as well as

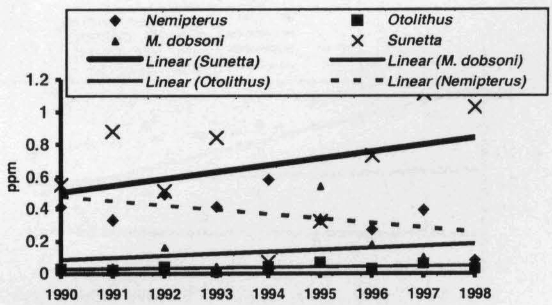

Fig. 3. *Distribution trend of Cadmium in different tissues*

inshore areas of Cochin registered a maximum of 157 ppm during 1993 and the lowest levels of 108 ppm during 1997

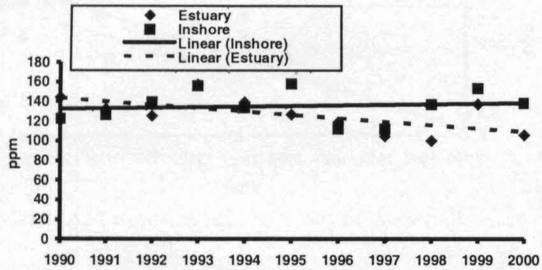

Fig. 4. *Distribution trend of Zinc in sediments*

(Fig.4). Inshore sediments registered higher levels (133 ppm) than that of the estuarine region (127 ppm). The Concentration in *N. japonicus* and in clam showed decreasing trend from 1990 to 1998 and the levels in them were higher than that of *M. dobsoni* (16.4 ppm) and *O. ruber* (5.2 ppm). Levels of Zn in the fillet of *N. japonicus* showed a mean value of 24 ppm, which ranged from 16.3 - 35.5 ppm and in the prawns showed a mean of 16 ppm during the early '90s (Fig.5).

Copper

Copper in sediments of inshore and

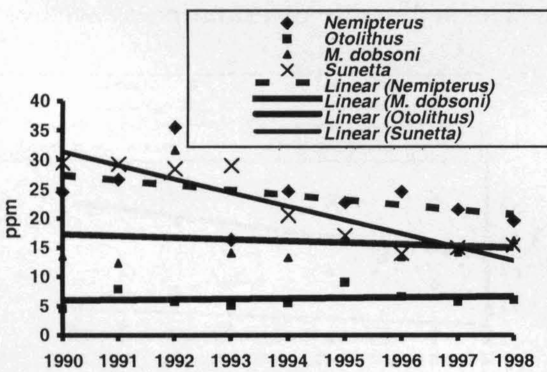

Fig. 5. *Distribution trend of Zinc in different tissues*

estuarine regions showed a maximum of 64 ppm during1994 and a minimum of 24 ppm in 1991. Inshore areas are laden with higher levels (37.82 ppm) than the estuarine region (Fig. 6). Tissues of *N. japonicus* accumulated the highest concentration than the other three species studied, showing a maximum (10 ppm) during 1995. Fillets of *O. ruber* accumulated lowest levels (0.6 ppm) ranging from 0.27 – 1.3 ppm (Fig. 7). The levels were maximum in 1994-95 and the lowest during 1998.

Lead

Inshore and the estuarine sediments from Cochin recorded a maximum of 37 ppm in 1996 and a lowest of 22 ppm during 1992 (Fig.8). Sediments from inshore areas registered higher level (31

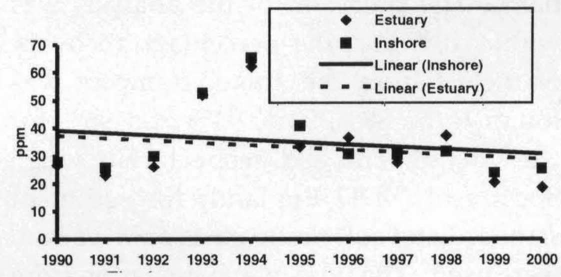

Fig. 6. *Distribution trend of Copper in sediment*

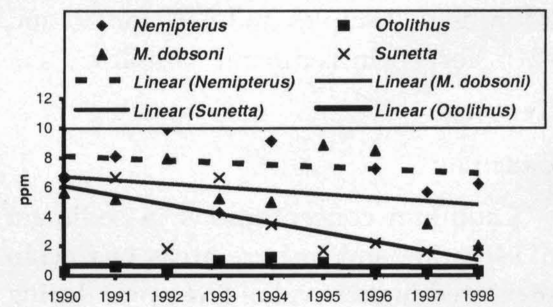

Fig. 7. *Distribution trend of Copper in different tissues*

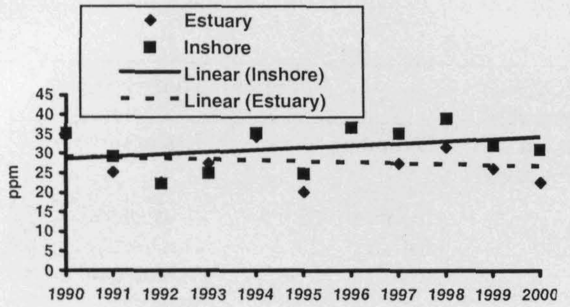

Fig. 8. *Distribution trend of Lead in sediments*

ppm) of lead than that of the estuary (29 ppm). Annual mean concentration of Pb in the tissues ranged from 0.38 ppm in *O. ruber* to 0.65 ppm in *M. dobsoni* registering the maximum during 1993. The accumulation in *N. japonicus* showed a mean 0.62 ppm registering a peak of 1.46 ppm during 1993. Whereas the meat of *S. scripta* showed a mean value of accumulation 0.53 ppm with a range of 0.3 ppm and 1.01 ppm during 1992 and 1997 respectively (Fig. 9).

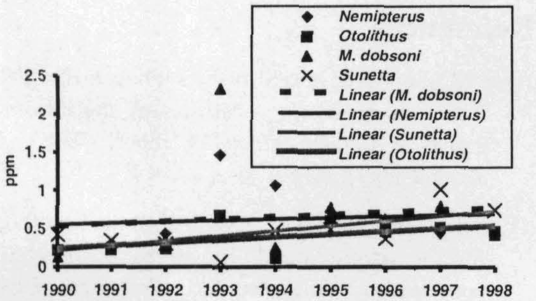

Fig. 9. *Distribution trend of Lead in different tissues*

Fig. 9. *Distribution trend of Lead in different tissues*

Discussion

In general, the tissue and sediment samples from estuarine as well as the inshore areas of Cochin showed the order of metal levels as Zn> Cu> Pb> Cd. Sediment from the inshore areas contained higher levels of these metals than in the estuarine regions which might be due to flocculation and settlement of suspended metals to the bottom as accelerated by increasing salinity (Webster, 1995). In the tissue samples studied, finfishes and prawn accumulated higher levels during 1993-94 period, whereas in the sediment higher levels of these metals occurred during 1994-'95. The clam *S. scripta* tends to accumulate more metal during monsoon season and in smaller individuals against relatively higher load of metals from that of the larger ones (Pillai and Valsala, 1995). Bioaccumulation of Zn and Cu were much higher in *N. japonicus*, Cd in *S. scripta* and Pb in *M. dobsoni.* On the other hand they were observed to be least in the meat of *O. ruber* (Figs.3,5,7&9).

Krishnakumar *et al.* (1990) found that the oyster *Crassostrea cucculata* was more effective accumulator of Zn, Cd and Cu, while the green mussel *Perna viridis* and the seaweed *Sargassum tenerrimum* were excellent accumulators of Pb and Mn. The levels of Cu, Cd and Pb recorded from sediment and the tissue samples of shellfishes and finfishes over a period from 1990 to 1998 revealed that these levels were well within the permissible limit (Table 1) recommended for sediment (Long *et al.*, 1995) and fish and seafood products (WHO., 1987). The earlier results available for Cochin (Iyer, 1994) and that of

Table 1. *Comparative account of metal concentration (μg/g dry wt) in marine sediment and tissues of finfishes and shellfishes*

Metals	Iyer, C.S.P (1994)	Long *et al.* (1995) Sediment	WHO(1987) Permissible limit in fish and seafood	Present study			
				Sediment		Tissue samples	
Cu	-	108	130	Inshore	35	*N. japonicus*	7.5
				Estuary	33	*O. ruber*	0.6
						M. dobsoni	5.8
						S.scripta	3.6
Cd	1- 6.7	4.2	9	Inshore	1.7	*N. japonicus*	0.4
				Estuary	1.5	*O. ruber*	0.04
						M. dobsoni	0.2
						S. scripta	0.7
Zn	-	271	217	Inshore	135	*N. japonicus*	24
				Estuary	126	*O. ruber*	5.3
						M. dobsoni	16.1
						S. scripta	22
Pb	0- 90	112	9	Inshore	31	*N. japonicus*	0.6
				Estuary	28	*O. ruber*	0.4
						M. dobsoni	0.7
						S. scripta	0.5

the current study are compared with the recommended permissible levels for sediment and fish samples (Table 1).

Significant correlation ($P > 0.01$) between Cu levels in *O. ruber* and that of Sediment ($r = 0.9$) could be established. Similarly Senthilnathan and Balasubramanian (1999) reported a linear relationship between Cu and Cd of Phytoplankton with ambient water. *Villorita cyprinoides* var *cochiensis* was reported to accumulate 0.5 ppm Cu and the LC_{50} for 240 hr period was 2ppm in the laboratory conditions (Lakshmanan and Nambisan, 1977). Sub adults of *Channa punctatus* exposed to mercuric nitrate for a brief period of 120 hrs at concentrations as low as 0.02 ppm induced chromosomal aberrations (Ansy and Shrinivas, 2003). Although the levels of metals distributed in the sediment and fish tissue from Cochin were well below the permissible levels (Table 1) their effect on the ambient biota may be undesirable in the long run.

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