

Concentration of metals in fishes from Thane and Bassein creeks of Bombay, India

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Concentration of Cu, Zn, Cd, Pb and Ni in different tissues of 10 species of fishes from Thane and Bassein creeks were estimated for a period of 15 months. The trend in bioaccumulation indicated that irrespective of species Cu and Zn contributed 42-58% to the total metals accumulated. Maximum concentration of all metals was found either in liver or in alimentary canal with lowest level in muscle tissue. Though metal accumulation was found to be species specific maximum concentrations were found in bottom feeders, compared to plankton feeders and other pelagic carnivores. In general, fish from Bassein creek showed higher concentration of metals than those collected from Thane creek. As Thane-Bassein creek system experiences stress due to anthropogenic waste input the present baseline data can be used for future monitoring and comparison of the ecosystem.

The tendency of metals to get accumulated in organisms is one of the important properties of metals and bioavailability of trace metals is the key factor determining tissue metal concentrations¹. In marine organisms trace metal uptake occurs directly from the surrounding seawater across the permeable body surface, from food and imbibed seawater entering the gut². The fishes form an important target for biomagnification of metals as they are at the top of the food pyramid and act as a possible transfer media to human beings. The determination of metals in marine organisms received added impetus due to increased awareness of the dangers of pollution. Even though studies have been made on the toxicity of metals under experimental conditions not much work has been done on the concentration of metals in fishes from the Indian coast for evaluating the levels of contamination in natural populations along the coastal zone which is prone to waste water contamination³⁻⁸. This problem is more significant in the nearshore waters of heavily industrialised city like Bombay. Hence, in the present study, the fishes were collected from polluted natural environment of Thane-Bassein creek system off Bombay to study the metal concentrations in different tissues. Distribution of metals in isolated tissues of fish is useful to identify specific organs that may be particularly selective and sensitive to accumulation of heavy metals.

Materials and Methods

Two locations were selected along the Thane creek-Bassein creek, a vital system joining the Arabian Sea through Bombay harbour at the south and via Bassein mouth on the northern side (Fig. 1). The first station was

situated at the upper reaches near the Thane railway bridge while station 2 was located off Bassein. The depth at this area ranged from 6 to 12 m during different tidal conditions.

The fish samples were obtained every month by regular trawling at both the locations during March 1986 to February 1987. A high opening bottom trawl net of 20.7 m (636 meshes of 50-mm when stretched) was used and trawling was done for 1 h. The fishes were segregated, kept in poly-

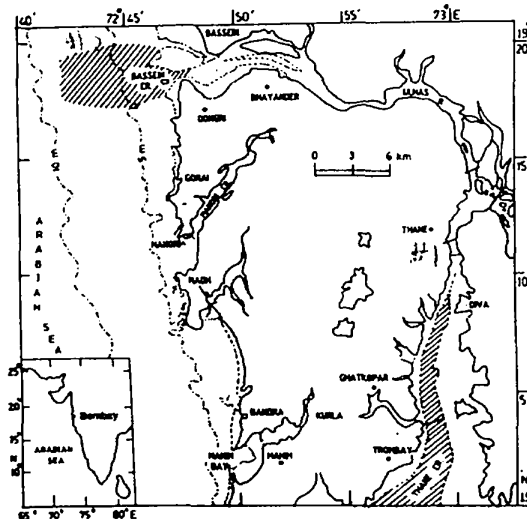


Fig. 1—Map showing location of stations

ethylene bags and stored in an ice box. In the laboratory the fishes were immediately identified following FAO identification sheets⁹. The fishes selected for the study were the carnivores *Arius tenuispinis*, *A. caelatus*, *Johnius glaucus*, *Otolithes argenteus*, *Harpodon nehereus*, *Lates calcarifer* and *Eleuthernema tetradactylum*; the plankton feeders *Coilia dussumieri* and *Pellona felligera* and the detritus feeder *Valamugil seheli*. The total length and weight of thawed fish were noted. The fish was cut open, samples of alimentary canal, liver, gills and muscle tissues were taken. Care was taken to clean the alimentary canal thoroughly and all food particles removed. The samples were dried separately at 70° C until a constant weight was obtained. The dried tissue was finely powdered and digested in conc. HNO₃ followed by perchloric acid¹⁰. The digested samples were examined for copper, zinc, cadmium, lead and nickel using an atomic absorption spectrophotometer (Make GBC 1000). Copper and zinc were determined by direct aspiration using air-acetylene flame while cadmium, lead and nickel were determined using a graphite furnace model GP 902. Along with collected samples, samples of fish tissue supplied by the International Laboratory of Marine Radioactivity (I.A.E.A), Monaco was also analysed to test the accuracy of the procedure adopted. The results were in good agreement with the certified values given by I.A.E.A (error ± 5%). The values of concentration of different metals are presented as ppm dry weight.

Along with trawling water, samples were collected from the surface and bottom for the estimation of temperature, salinity, pH, DO, BOD, nitrite, nitrate and phosphate following standard methods^{11,12}. To evaluate the seasonal difference the data were segregated into premonsoon (February-May), monsoon (June-September) and postmonsoon (October-January) periods.

Results and Discussion

Temperature variation was not drastic during different seasons with lowest for the postmonsoon period (Table 1). During monsoon period salinity values reduced to 21.9 and 31.8‰, respectively at sts 1 and 2. Dissolved oxygen (DO)

was invariably low at st. 1 (2.7 to 4.0 mg/l) as compared to st. 2 (6.6 to 6.8 mg/l). Relatively high values of BOD and nutrients at st. 1 indicated the prevailing unhealthy water quality of the area.

Metals in different tissues of fishes collected from Thane and Bassein indicated wide variations (Table 2). Irrespective of species, Cu and Zn contributed 42-58% to the total metals accumulated. In general most of the metals showed relatively higher concentrations in liver than the other tissues. In the muscle tissue maximum average concentration of Cu was observed in *H. nehereus* (8.4 ppm) while that for Zn was observed in *A. tenuispinis* (63.1 ppm). Seasonal variation of different metals did not indicate any consistent pattern and very few species were found during all the three seasons to make a comparison.

Seasonally, at Thane *A. tenuispinis* showed high percentage contribution of Cu in liver during the postmonsoon and monsoon periods than the premonsoon period. In the same species percentage contribution of Zn in different tissues were comparable for premonsoon and postmonsoon periods while during the monsoon period the levels in liver was relatively high. In Bassein *C. dussumieri* showed low percentage contribution of Cu in liver during monsoon period than the other two seasons. In *H. nehereus* from Bassein Cu level in liver was unusually high during the postmonsoon period.

The percentage composition of Zn in all the tissues and species of fishes was the highest at both Thane (58.4-90.4%) and Bassein (39.3-95.2%). Copper showed the next highest percentage ranging from 7.4 to 39.8 and 4.4 to 51.6 respectively at Thane and Bassein. Ni, Cd and Pb contributed very little to the percentage composition. The pattern of accumulation of different metals can be expressed as Zn > Cu > Ni > Pb > Cd.

Correlation between length/weight of fish with different metals/tissues were statistically tested. Significant positive correlation was observed in muscle tissue of fishes (Table 3).

The bioaccumulation of metals in any organism varies according to the bioavailability, the uptake rate, their

Table 1—Average values of selected water quality parameters during different seasons at stations 1 and 2

Season	Temp. (°C)	Salinity (‰)	pH	DO (mg/l)	BOD (mg/l)	Phosphate (µg at/l)	Nitrite (µg at/l)	Nitrate (µg at/l)
Station 1								
Premonsoon	29.9	35.4	7.7	3.6	2.8	9.8	10.1	24.1
Monsoon	28.3	21.9	7.8	4.0	2.2	9.5	17.1	28.1
Postmonsoon	24.2	33.5	7.6	2.7	3.1	9.6	10.4	13.3
Station 2								
Premonsoon	28.9	35.4	8.0	6.7	2.4	1.6	0.2	16.9
Monsoon	27.8	31.8	7.9	6.8	1.8	1.5	0.6	12.7
Postmonsoon	23.8	35.7	7.9	6.6	2.0	1.6	0.7	18.6

Table 3—Correlation between length/weight of fish with different metals/fishes

Species	Metal and length/weight	Level of significance
Station 1		
<i>Arius tenuispinis</i>	Cu and length	95%
	Cu and Weight	99%
<i>Arius coelatus</i>	Cd and length/weight	99%
<i>Valamugil seheli</i>	Ni and length/weight	95%
Station 2		
<i>Coilia dussumieri</i>	Zn and length/weight	95%
	Cu and weight	99%
	Cd and length	95%
	Cd and weight	99%
<i>Harpodon nehereus</i>	Zn and length	95%
	Ni and length	95%
<i>Johnius glaucus</i>	Pb and length/weight	99%
	Ni and length/weight	95%

threshold limit and physiological efficiency of the organism to excrete excess metals. Hence most of the fishes indicated differential accumulation of metals in a given organ system at different places. However, *Arius coelatus* showed same accumulation trend except for higher accumulation of metals in liver in a specimen from Thane and Bassein.

Trace metal concentrations in tissues of marine organisms vary enormously even among individual species¹³. Though the large variation between minimum and maximum values for the concentration of each metal indicates seasonal variation in the present study a consistent pattern was not observed in any species. Patel *et al.*⁸ attributed the failure to identify any systematic seasonal variation in elemental composition in shellfish and fish from Bombay harbour to the absence of wide fluctuations in ambient temperature. In the present study *H. nehereus* from st. 2 showed consistently high values of Cd, Pb, Ni in all the tissues during low saline monsoon season while *Johnius*

Table 4—Concentration of different metals (ppm/dry wt.) in different species of fishes from Thane and Bassein creeks. (Ratio is given in parentheses)

Species	Thane creek					Bassein creek				
	Liver	Intestine	Gill	Muscle	Average	Liver	Intestine	Gill	Muscle	Average
<i>Pellona felligera</i> (Plankton feeder)	169.5 (3.6)	290.7 (6.1)	180.2 (3.8)	47.3 (1.0)	171.9	278.8 (7.3)	111.0 (2.9)	135.0 (3.5)	38.2 (1.0)	140.7
<i>Coilia dussumieri</i> (Zooplankton feeder)	--	--	--	--	--	279.7 (7.6)	259.3 (7.1)	136.4 (3.7)	36.4 (1.0)	177.9
<i>Arius tenuispinis</i> (Carnivore bottom feeders)	503.8 (19.0)	236.1 (8.9)	141.8 (5.3)	26.6 (1.0)	227.1	744.0 (11.5)	256.5 (4.0)	322.5 (5.0)	64.4 (1.0)	346.9
<i>Arius coelatus</i> (Carnivore bottom feeder)	246.0 (11.3)	117.1 (5.4)	71.4 (3.3)	21.7 (1.0)	114.0	128.8 (6.4)	110.1 (5.5)	61.2 (3.1)	20.0 (1.0)	80.0
<i>Valamugil seheli</i> (Detritus feeder)	194.9 (7.0)	214.3 (7.7)	86.3 (3.1)	27.8 (1.0)	130.8	—	—	—	—	—
<i>Lates calcarifer</i> (Carnivore)	195.7 (8.9)	87.8 (4.01)	69.0 (3.2)	21.9 (1.0)	93.6	—	—	—	—	—
<i>Johnius glaucus</i> (Carnivore)	109.0 (5.3)	132.9 (6.5)	105.5 (5.1)	20.6 (1.0)	92.0	206.9 (7.9)	159.3 (6.0)	108.9 (4.2)	26.1 (1.0)	124.8
<i>Otolithoides biauritus</i> (Carnivore)	81.6 (3.0)	100.2 (3.6)	49.5 (1.8)	27.5 (1.0)	64.7	492.1 (26.8)	149.1 (8.1)	117.5 (6.4)	18.4 (1.0)	194.3
<i>Eleuthernema tetradactylum</i> (Carnivore)	88.7 (1.8)	89.8 (1.8)	135.7 (2.8)	49.0 (1.0)	90.8	—	—	—	—	—
<i>Harpodon neherus</i> (Carnivore)	—	—	—	—	—	221.4 (5.4)	207.0 (5.1)	160.2 (3.9)	40.8 (1.0)	157.3

glaucus showed high values of Pb and Ni only in alimentary canal and liver. At a defined trace metal exposure, whole body levels in organisms vary with species, age, size, sex, physiological state, temperature and salinity². Hence it is difficult to attribute the significance of a specific metal load.

Irrespective of the species and the area from which the fishes were caught generally the liver or alimentary canal showed the highest concentration of any given metal. This is in agreement with the earlier reports of Pentreath^{14,15}, Ismail & Samin¹⁶ and Harding & Goyette¹⁷. The cumulative levels of metals in intestine/liver compared to muscle was 8-27 times higher at Bassein while at Thane the figure amounted to 9-19 times. Hellou *et al.*¹⁸ reported higher concentration of Hg in the liver of cod and explained that it reflects the different rates of metabolism and/or elimination by different fish tissues. Higher levels of metals in liver also indicate that most of the metals were accumulated in the fishes in a fat soluble form¹⁹. Similarly muscle issue showed uniformly lowest values among all the metals. The comparatively low metal concentration in fish muscle was reported by Kureishy *et al.*^{5,6}, Ismail & Samin, Qasim & Sen Gupta¹⁹, Harding & Goyette¹⁷ and Peerzada *et al.*²⁰ reported low levels of metals in the muscles of prawn species. It would appear that total volume of tissue is much higher compared to the organs and this leads to spreading of the accumulated metals resulting in low level metal concentration in tissues.

The bioaccumulation of different metals at higher levels in the intestine and liver of fish suggested that the metal accumulation was effective through the food chain rather than by direct contamination. For comparison the cumulative average levels of all the metals was estimated for different species (Table 4). Cu and Zn collectively contributed more than 80% of the total metal accumulated in the tissue respectively at Thane and Bassein. Relatively higher level of metals was recorded in benthic organisms from Thane creek than Bassein creek²¹. Absorption of metals appeared to be effected at first in the intestine and later they are transported to the lipid pool in the liver. During this transitional stage it is possible that more concentration of metals may occur in the intestine than in the liver.

In general fishes from Bassein indicated higher bioaccumulation of metals than those collected from Thane creek. Even though waste input is more within the Thane creek system, the bioaccumulation trend indicated a reverse pattern. Metals entering the system in dissolved state are rapidly hydrolysed or get fixed to the particulate matter and removed from solution²². The suspended load at Bassein was about 9 times higher (av. 640 mg/l) than that observed at Thane (70 mg/l)²³. Added to this the topography and physical features of the area allow less effective flushing at Bassein creek as compared to the Thane creek²⁴. The levels of Cu, Zn and Ni in sediment from Thane creek were ob-

served to be lower compared to the values obtained for Bassein creek (NIO, unpublished data). The carnivores which feed mainly on crustaceans and other epibenthos already might have an insidious build-up of metals in their tissues as reported for macrobenthos²¹.

The standards for metal contaminants in fish muscle have been given by Krishnamurti²⁵ as 100 mg/kg, 250 mg/kg, 1 mg/kg and 10 mg/kg dry weight for Cu, Zn, Cd and Pb respectively. The recorded range in muscle of different species of fish at both the locations indicated that the levels had not exceeded the permissible limit prescribed for consumption.

The results indicated wide variations in the levels of metals between species. However the worked-out ratios indicated a better picture on the distribution pattern of metals in different parts of the body (Table 4). Compared to the muscle's concentration in intestine/liver was as high as 8-27 times at Bassein while in Thane the figure amounted to 9-19 times. Though the input of anthropogenic pollutants into the system has not affected the levels of metals in muscle to an alarming extent, this baseline data can be used for regular ecological monitoring considering the industrial growth around this prominent creek system of Bombay.

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