# Trace Metal Concentration in Four Species of Edible Fishes from the Southwest Coast of India

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Concentrations of Cu, Zn, Ni, Cd, Pb and Hg in four species of edible fishes *viz., Saurida tumbil, Nemipterus japonicus, Epinephelus diacanthus* and *Priacanthus hamrur* collected during pre-monsoon period, from 60 m depth, off southwest coast of India (Lat. 8°42'-9°05'N; Long. 76°21'-76°10'E) (Cruise No. 184 of *FORV Sagar Sampada*), were determined using Inductively Coupled Plasma Emission Spectrometer (ICP-AES). In all the species analysed, concentration of Zn was found higher. Maximum concentration of all the metals studied was found in liver, followed by gills and muscle tissues. Highest concentration of Hg was found in *Nemipterus japonicus*. However, Hg was not detected in *Saurida tumbil* and *Epinephelus diacanthus*. Considerable difference in concentration levels of trace metals was observed in the samples analyzed. The levels of trace metals in the samples analysed were found well within the safe limits prescribed by WHO and FAO.

**Key words : Trace metals, *Saurida tumbil, Nemipterus japonicus, Epinephelus diacanthus, Priacanthus hamrur***

The occurrence of inorganic contaminants such as metals in surface seawater continues to be one of the most important environmental issues of our time. Though metals have exerted a profound influence on the course of biological evolution, their modern day industrial usage, mainly during the course of last fifty years has led to their bioaccumulation in the environments (Moore *et al.*, 1991). Many of these metals find their way into the living systems through air, water and food and tend to accumulate in the body. Some of them even in minor concentrations threaten to affect the metal dependent enzyme catalyzed reactions in the body.

Trace metals reach the marine environment via river runoff carrying discharged heavy metals from industries, mining activities, shipping, dredging activities and through other anthropogenic inputs (Manhan, 1984). From surrounding seawater, food and through the imbibed seawater these get accumulated in marine organisms directly (Depledge *et al.*, 1990). They are accumulated in body, in several times higher than their concentration in an equivalent weight of seawater (Eisler *et al.*, 1981; Rainbow *et al.*, 1990).

In fishes occupying trophic levels near the top of the food pyramid, there is maximum likelihood of biomagnification. Even though a good amount of data on the distribution of trace metals in the Indian seas are available (Braganca *et al.*, 1980; Sanzgiri *et al.*, 1981; Rajendran *et al.*, 1982; Satyanarayana *et al.*, 1985), much work has not been done on the concentration of these metals in fishes from the Indian coast, for evaluating the levels of contamination from the natural environments (Matakar *et al.* (1981), Singbal *et al.* (1982), Kureishy *et al.* (1983). In the present study, an attempt was made to determine the distribution of trace metals namely Cu, Zn, Cd, Pb, Ni and Hg in the tissues of four species of edible fishes from the southwest coast of India.

## Materials and Methods

Four species of edible fishes namely, *Saurida tumbil, Nemipterus japonicus, Epinephelus diacanthus* and *Priacanthus hamrur* were selected for the study. The samples were collected from stations located in the southwest coast of India, Lat. 8°42'-9°05'N, Long. 76°2'- 76°10' E, by demersal trawling, at a depth of 60 m, using High Speed Demersal Trawl developed by the Central Institute of Fisheries Technology. The sampling was done in the pre monsoon season during cruise No. 184 of the Fisheries Oceanography Research Vessel of the Department of Ocean Development, *FORV Sagar Sampada*. Five samples of each species of almost the same size were kept in polyethylene bags and stored in the freezer at -20°C, until further analysis. The fishes were dissected and liver, gills and muscle tissue were separated for the trace metal estimation in each of these tissues. A pre-weighed wet sample was digested with a mixture of conc. nitric acid and conc. sulphuric acid (25:6) and the digested mixture was filtered and made up to 100 ml. (AOAC, 1975). These were directly fed into the Inductively Coupled Plasma Emission Spectrometer (ICP-AES) for determining the concentration of the metals.

## Results and Discussion

The details of the concentration of the analyzed metals in liver, gills and muscle tissue of the fish samples are given in Tables 1 to 3.

**Table 1. Trace metal concentration in the muscle tissue of the fishes** (in mg.g$^{-1}$ wet weight)

| Species | Cu | Zn | Cd | Pb | Ni | Hg |
|---|---|---|---|---|---|---|
| *Saurida tumbil* | 3.50 | 16.10 | 0.36 | 1.20 | 0.50 | BDL |
| *Nemipterus japonicus* | 2.20 | 7.50 | 0.20 | 4.28 | 0.60 | 0.27 |
| *Epinephelus diacanthus* | 0.23 | 10.09 | BDL | 3.31 | 1.00 | BDL |
| *Priacanthus hamrur* | 1.00 | 2.50 | 1.50 | 3.37 | 0.64 | 0.006 |

**Table 2. Trace metal concentration in the liver tissues of the fishes** (in mg.g$^{-1}$ wet weight)

| Species | Cu | Zn | Cd | Pb | Ni | Hg |
|---|---|---|---|---|---|---|
| *Saurida tumbil* | 88.00 | 214.00 | 0.50 | 1.80 | 0.50 | 0.10 |
| *Nemipterus japonicus* | 35.80 | 125.00 | 0.25 | 5.20 | 1.50 | 0.50 |
| *Epinephelus diacanthus* | 5.40 | 134.00 | 0.50 | 4.50 | 2.50 | BDL |
| *Priacanthus hamrur* | 10.80 | 48.40 | 1.70 | 4.9 | BDL | BDL |

**Table 3. Trace metal concentration in the gills of the fishes** (in mg.g$^{-1}$ wet weight)

| Species | Cu | Zn | Cd | Pb | Ni | Hg |
|---|---|---|---|---|---|---|
| *Saurida tumbil* | 2.50 | 95.50 | BDL | 0.80 | 0.50 | 0.20 |
| *Nemipterus japonicus* | 0.30 | 78.00 | 0.20 | 5.15 | 0.80 | BDL |
| *Epinephelus diacanthus* | BDL | 66.60 | 0.10 | 3.20 | 2.00 | .008 |
| *Priacanthus hamrur* | 3.70 | 39.00 | 0.10 | 4.50 | BDL | 0.25 |

**Table 4. Permitted levels of trace metals in fish compared with the levels in the samples analysed** (in ppm)

| Metal | Permitted level* | Observed level |
|---|---|---|
| Copper | 100 | 0.23-3.5 |
| Zinc | 250 | 2.5-16.1 |
| Cadmium | 0.5-2.0 | BDL-1.5 |
| Lead | 2-5 | 1.2-4.28 |
| Mercury | 0.5-1.0 | BDL-0.27 |

BDL-Below Detection Level; * FAO/WHO (1983)

Metal concentration in the four species of fishes varied widely. In all the species, Cu and Zn together accounted for more than 50% of the total of the five metals estimated. The relative concentration of various metals in the tissues can be represented as Zn > Cu > Pb > Ni > Cd > Hg. This is in agreement with the earlier reported results in *Crassostrea madrasensis* by Senthilnathan (1998).

Of the five metals estimated Zn recorded the highest concentration in all the species. The maximum concentrations of Cu and Zn were observed in the species *S. tumbil* (3.5 ppm and 16.09 ppm, respectively). The concentrations of both these metals were the highest in the liver compared to gill and muscle tissue. In the case of *S. tumbil*, the liver to muscle ratio for Zn and Cu were 13:1 and 22:1, respectively. One of the major sources of Cu and Zn in the aquatic environment is the leaching of these metals from antifouling paints and galvanized Zinc coatings used in the trawlers. However, the concentration of Zn in the muscle tissue does not very much reflect the changes in the surrounding environment, since the fish actively regulates Zn concentration in the muscle (Cross *et al.* 1973). Therefore the high levels of Zn in the samples may be due to the incomplete regulation of Zn by the fish. Most reports place total Zn at <50 $mg.kg^{-1}$ wet weight with a range of 1-100 $mg.kg^{-1}$, much higher levels, 100-300 $mg.kg^{-1}$ weight can be found in liver and kidney (Overnell *et al.*, 1987; Mohopatra, 1993). Zn is moderately toxic to most species of fishes, inhibiting larval development and growth (Moore *et al.* 1993). But Zn is essential in several enzymes and enzyme functions, DNA, RNA and protein synthesis, cell division and growth. The recommended daily allowance for man is 15 mg. For Zn, the maximum permitted level in fish for human consumption is given by Krishnamurti *et al.* as 250 $mg.kg^{-1}$. So the fishes studied here form safe sources of Zinc in the diet.

Even though Cu is an essential element in human nutrition, it is one of the most toxic metals to fishes in higher concentrations. Studies have shown that the $LC_{50}$ for Cu range from 0.02 to 1 $mg.l^{-1}$ in freshwater. Toxicity is enhanced synergistically by combinations of Cu/Cd/Zn and Cu/Cd/Ni/Zn (Moore *et al.*, 1993). Copper residue in fish muscle tissue is generally low. In the present study liver and gill tissues accumulated more Cu. Ashraf & Jaffer (1998) working on 6 species from the Arabian Sea recorded muscle levels of only 0.10–0.51 $mg.kg^{-1}$ weight. Most of the fish samples analysed in the present study showed Cu content between 0.23-3.5 ppm in their muscle. The recommended daily allowance of Cu is 1 mg. Many nations use a standard for the lowest observed adverse effect level in man for Cu as 5.3 mg per day (Federal Register, 1985). The permitted tolerance level for Cu in fish is 100 ppm ((McKee & Wolf, 1963). So the levels found in the species studied are well below the tolerance limits prescribed. Metals like Cd, Hg and Pb are more toxic and are suspected to induce even carcinogenic effects in the organisms exposed to them (Muramota, 1981). They combine with cell membranes and alter their permeability, displace elements that are important structurally or electrochemically to the cells.

Concentration of Cadmium in the muscle ranged from below detection limit to 1.5 ppm. The maximum concentration was found in *P. hamrur* (1.5 ppm). In the case of cadmium also, liver showed maximum concentration. A study of fish from the Great Barrier Reef in Australia shows that Cd in liver exceeded 20 $mg.kg^{-1}$. (Denton & Jones, 1986). High contents of Cd (0.213 and 0.402 ppm) were reported in squid and Cuttlefish by Lakshmanan (1998) from west coast of India. The concentration of Cd in the muscle tissue of fishes obtained during the present study is slightly higher than the earlier reported value from Andaman waters by Khasim (1993) and Krishnamoorthy & Nair (1999). Metals like Cd is low in the juvenile stages but it is accumulated with age. The size and maturity stage of the fishes influence its accumulation levels. Cd concentration in the muscle tissue is found to increase with the size of the fishes (Bordin *et al.*, 1992). The higher concentration of Cd in liver compared to gill and muscle shows that the main route of uptake of cadmium is through food and water. Numerous sub-acute effects have been reported in both fresh water and marine fishes like decreased growth, morphologic changes in the gut etc. due to Cd toxicity (Moore *et al*, 1993). Reports show that chronic exposure to Cd in human beings lead to renal toxicity, such as proteinurea. A tissue residue in excess of 0.285 $mg.g^{-1}$ usually causes renal dysfunction. The daily allowed dietary intake for Cd per kg weight for a man is given by WHO (1975) as 0.95 mg. The permitted tolerance limit for Cd in fish is 0.2-2 ppm (FAO, 1983). In the present study the level of Cd in all the species were below 2 ppm. This does not pose any threat to human health.

Level of Pb in muscle tissue ranged from 1.2 ppm in *S. tumbil* to 4.2 ppm in *N. Japonicus*. Organic complexes of lead are more toxic to marine fish. Experimental evidence exists for the carcinogenicity of inorganic lead following oral ingestion at high dozes in rat (Moore *et al.*, 1993). The recommended daily allowance for lead is 7.15 $mg.kg^{-1}$ body weight and the maximum permitted limit in the fish for human consumption is 2-5 ppm.

Concentration of Nickel varied from 0.5 to 1 ppm in the muscle tissue. The earlier reported values for Nickel in fishes from Thane ranged from 0.4 to 1.2 ppm (Krishnamoorthi & Nair, 1999). Hg was detectable in the muscle tissue of *N. Japonicus* and *P. hamrur* only where the value was 0.275 and 0.006 ppm, respectively. The earlier reported value for Hg in fishes from the Indian Ocean ranged from 0.005- 0.093 ppm (Desai *et al.* 1975). The value for Hg obtained for *N. Japonicus* in the present study is slightly higher than the earlier reported values (Khasim, 1993) but it is well below the limit permitted for seafoods. The permitted tolerance limit for Hg in fish is 0.5-1 ppm (FAO, 1983).

Irrespective of the species concerned, concentration levels of Cu, Zn, Cd, Pb and Ni were more in liver followed by gills and musculature. This is in agreement with the earlier reports of Pentreath *et al.* (1973) and Harding and Goyette (1989). Higher levels of all the metals in liver also show that the metal accumulation is occurring mostly via food chain rather than by direct contamination and that most of the metals were accumulated in a fat-soluble form. As all of these fishes are carnivores which feed mainly on crustaceans and other epi-benthos which already might have an insidious buildup of metals in their tissues, there is maximum chances of magnification through the food chain (Krishnamoorthi & Nair *et al.* (1999). The musculature, which forms the edible part, showed much lower concentration of all the metals. The comparatively lower metal concentration in fish muscle was reported by Kureishy *et al.* (1983) and Harding & Goyette (1989).

Different ecological and biological factors control concentration of trace metals in fishes. In the area studied there is a notable influence from the Ashtamudy lake and Attingal river (Lat. 8°42'N; Long. 76°09'E) which carry the sewage and industrial effluents from Kollam city and this might contribute to the heavy metal load in the seawater. Size, maturity stage and feeding habits of the fishes are other major factors, which influence the metal concentration in the tissues. Metals like Cd is low in the larval stage and accumulate with age. Concentration of Cd present in the muscle tissue of *P. hamrur* was very near the threshold limit of 2 ppm set by FAO/WHO. The comparison of the levels of the metals found in the fishes with the maximum limits permitted in fishes designated for human consumption (Table 4) shows that the concentration levels of all the metals are well below the limits prescribed except for Cd where the observed concentration level was very near to the threshold limit.

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