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# Some Heavy Metals in Fishes from the Andaman Sea

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Muscles, liver, gills and heart of several fishes and some zooplankton (whole sample) collected from the Andaman Sea were analysed for Cu, Mn, Zn, Fe, Ni and Co. The concentrations of practically all the metals were highest in the liver. The edible portion of the fish (muscles) had lower concentrations as compared to other tissues. Concentrations of each metal in various tissues of the same species had no correlation with the size of the fish. However, there was a positive correlation between the Cu concentrations in the liver of Tuna of different sizes.

The present study deals with the estimation of heavy metals (Cu, Mn, Zn, Fe, Co and Ni) in the muscles, liver, gills and heart of the various fishes collected during the 51, 52 and 66 to 68 cruises of *R V Gaveshani* to the Andaman Sea and adjacent areas of Bay of Bengal. This study forms a part of the on-going institutional project on the protection of marine environment and monitoring of pollutants in the seas around India.

## Methods

The fish were caught by trawling lines, hook and line and scoop net. Zooplankton samples were collected by the Indian Ocean Standard Net and Neuston net. The fish were dissected, for various tissues, immediately after the catch. Not all the tissues, mentioned above, were sampled from all the fishes. Small fishes were sampled only for muscles. A portion of the dorsal muscle, liver, heart (whole) and gill filaments were removed carefully, to avoid contamination of the samples as far as possible, using stainless steel knives and forceps. The samples were preserved in acid-washed glass tubes with plastic covers and deep frozen at $-5$ to $-10$°C on board until analyses. During cruises 51 and 52, the samples were macerated, dried at 60°C to constant weight and powdered.

The analysis was done using the standard digestion procedure followed by the atomic absorption spectrophotometry. Roughly, 1.5 to 2.5 g of wet weight (0.4-0.5 g dry powder) was digested with 15-20 ml of nitric acid (A.R.) in conical flasks at 100°C for 12 hr. Additional nitric acid was added if the sample was getting charred. Towards the end, 1 ml of perchloric acid was added and the flasks were brought to near dryness. The blanks were run with each set. The solutions were made to 10 ml each, in a measuring flask with distilled water. The samples were then aspirated in a Hilger and Watts Atomspek H-1550. Standards were run simultaneously. The recovery by this procedure was 80-90% for the reference fish meal. Standard deviation for each metal was calculated by analysing some samples in triplicate, which when given as coefficient of variation is below 10% for all the metals except Ni for which it is 24%. The results are expressed in ppm wet weight, however, as some samples were analysed after drying, a conversion factor of 5 was applied for the conversion to ppm wet weight, assuming the water content at an average of 80%.

## Results and Discussion

The results are given in Tables 1-3. The area of the catch is marked in Fig. 1. The concentration factor calculated by dividing concentration in the sample by

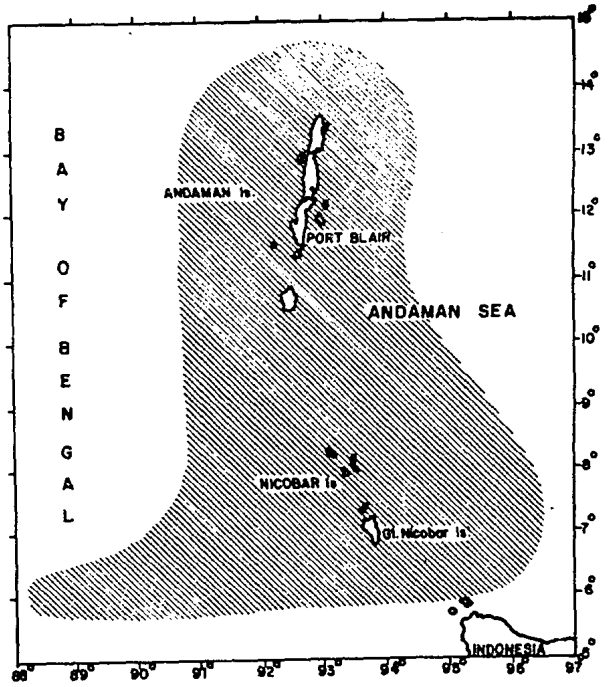


Fig. 1—The area from where the fishes were collected

Table 1—Heavy Metal Concentrations in Fishes

[Values are given in ppm wet weight]

| Fish (species name) | Wt in kg | Length in cm | Sex | Tissue analysed | Cu | Mn | Zn | Fe | Ni | Co |
|---|---|---|---|---|---|---|---|---|---|---|
| Zooplankton* | — | — | — | W | 31.95 | 5.32 | 95.68 | 426.49 | 3.12 | 6.7 |
| do | — | — | — | W | 4.59 | 5.91 | 367.09 | 335 | 2.41 | 8.48 |
| do | — | — | — | W | 6.91 | 3.01 | 7.78 | 94.11 | 0.23 | 0.32 |
| do | — | — | — | W | 2.6 | 6.99 | 27.86 | 150.61 | 0.36 | ND |
| do | — | — | — | W | 2.14 | 4.06 | 10.89 | 36.36 | 2.12 | 2.03 |
| do | — | — | — | W | 4.85 | 5.12 | 30.9 | 34.7 | 3.22 | 4.23 |
| Deep sea prawn (unidentified) | — | — | — | M | 3.25 | 2.75 | 11.96 | 11.58 | 0.29 | 1.65 |
| Perch trumpeter* (*Pelates quadrilineatus* Bloch) | — | — | — | M | 0.3 | 0.09 | 6.09 | 29.09 | 0.47 | ND |
| Perch* (unidentified) | — | — | — | M | 0.23 | ND | 3.4 | 5.87 | 0.33 | ND |
| Japanese thread† in bream* (*Nemipterus japonicus* Bloch) | — | — | — | M | 0.36 | 0.06 | 2.56 | 8.95 | 0.2 | 0.56 |
| Bony Jewfish* (3 fish)† (*Johnius osseus* Day) | — | — | — | M | 0.79 | 10.31 | 4.77 | 5.78 | ND | 0.75 |
| Jewfish* (unidentified) | — | — | — | M | ND | 0.33 | 3.96 | 7.84 | ND | 1.14 |
| Mackerel* (*Rastrelliger kanagurta* Cuvier) | — | — | — | M | 0.96 | 0.09 | 6.09 | 11.62 | ND | 1.84 |
| Squid* | — | — | — | M | 1.83 | 0.28 | 8.73 | 4.07 | ND | 0.94 |
| Sardine* (2 fish)† (*S. longiceps* Valenciennes) | 0.5 | 26 | — | M | ND | 0.19 | 6.3 | 9.74 | ND | 1.13 |
| do* (5 fish)† | — | — | — | M | 0.3 | 0.23 | 4.51 | 8.19 | ND | 0.74 |
| Pilot fish (*Naucrates ductor* Linnaeus) | — | — | — | M | 0.2 | ND | 3.96 | 5.62 | 0.42 | 0.92 |
| Sucker fish (*Remora remora* Linnaeus) | — | — | — | W | 1.2 | ND | 10.57 | 13.66 | 0.4 | 0.43 |
| Myctophid | — | — | — | W | 1.19 | 5.59 | 19.19 | 12.55 | 1.11 | 1.83 |
| Juvenile dolphin fish | — | 15 | — | M | 1.36 | 0.06 | 9.18 | 17.53 | 0.63 | 1.04 |
| do | — | 19 | — | M | 1.74 | 0.29 | 7.21 | 20.37 | 1.16 | 1.9 |
| do | — | 29 | — | M | 1.17 | ND | 6.06 | 13.09 | 0.72 | 0.63 |
| Malabar trevally* (*Carangoides malabaricus* Bloch) | 0.55 | 34 | — | M | 0.36 | 8.63 | 4.74 | 5.49 | ND | ND |
| do* (3 fish)† | | | | M | 0.17 | 0.76 | 2 | 6.99 | ND | 0.2 |
| | 0.7-0.75 | 44-45 | — | L | 6.48 | 1.42 | 45.42 | 289.73 | ND | 1.68 |
| do* (3 fish)† | 1.5-1.7 | 54-60 | — | M | ND | 0.14 | 4.72 | 7.08 | 0.13 | 1.14 |
| | | | | L | 11.78 | 1.42 | 50.94 | 175.48 | 0.39 | ND |
| | | | | G | 1.74 | 1.4 | 11.81 | 62.48 | 0.32 | 1.07 |
| Yellow fin tuna (2 fish)† (*Neothunnus macropterus* Schlegel) | 1.8-2 | 42-46 | ♀ | M | 2.93 | 0.76 | 11.6 | 25.12 | 3.72 | 0.74 |
| | | | | L | 6.51 | 3.68 | 19.02 | 80.35 | ND | ND |
| | | | | H | 4.65 | 1.95 | 14.37 | 97.9 | 0.25 | 1.06 |
| do | 1.5 | 37 | ♀ | M | 0.6 | 0.53 | 4.01 | 10.87 | 0.43 | 1.5 |
| | | | | H | 5.88 | 0.89 | 14.37 | 69.99 | 1.53 | 0.78 |
| Dolphin fish* (*Coryphaena hippurus* Linnaeus) | 8.3 | 120 | — | M | 0.24 | 3.09 | 5.4 | 14.22 | 0.13 | 0.56 |
| | | | | L | 9.4 | 7.45 | 27.78 | 80.16 | ND | 0.73 |
| do* | 8.8 | 115 | ♀ | M | 0.4 | 1.63 | 5.04 | 38.95 | 0.32 | ND |
| | | | | L | 5.26 | 1.3 | 17.82 | 45.1 | ND | 0.97 |
| | | | | G | 1.84 | 2.14 | 18.96 | 112.99 | 1.13 | 1.47 |
| do | 12 | 137 | ♀ | M | 1.45 | 2.81 | 6.14 | 20.52 | 0.37 | ND |
| | | | | L | 12.48 | 7.11 | 33.3 | 88.22 | 1.19 | 0.94 |
| | | | | H | 3.65 | 1.40 | 15.08 | 72.95 | 0.92 | 1.1 |
| Barracuda* (*Sphyraena picuda* Bloch) | 2.8 | 86 | ♀ | M | 0.12 | 0.24 | 5.76 | 16.76 | 0.27 | 1.89 |
| | | | | L | 33.64 | 1.58 | 88.32 | 53.88 | 0.13 | ND |
| | | | | G | 1.72 | 12.36 | 22.02 | 196.77 | 0.66 | 1.46 |
| do* (2 fish)† | 6.7 | 110 | — | M | 0.49 | 3.09 | 5.4 | 14.22 | 0.13 | 0.56 |
| | | | | G | 1.54 | 1.29 | 11.66 | 73.95 | 0.66 | 3.48 |
| do | — | — | — | M | 0.42 | 0.21 | 3.29 | 4.26 | 0.39 | 1.33 |
| | | | | L | 10.12 | 1.96 | 177.15 | 79.66 | 0.29 | 0.83 |
| | | | | H | 2.88 | 1.48 | 20.42 | 83.64 | 0.19 | ND |

*Contd*

Table 1—Heavy Metal Concentrations in Fishes—*Contd*

[Values are given in ppm wet weight]

| Fish (species name) | Wt in kg | Length in cm | Sex | Tissue analysed | Cu | Mn | Zn | Fe | Ni | Co |
|---|---|---|---|---|---|---|---|---|---|---|
| Giant sea pike* (*Sphyraena jello* Cuvier) | 12 | 125 | ♂ | M | 0.78 | 0.09 | 5.67 | 8.39 | 0.13 | 0.55 |
| | | | | G | 1.04 | 2.86 | 29.81 | 84.72 | 1.17 | 2.33 |
| Trevally (unidentified) (2 fish)† | 2 | 64 | ♀ | M | 0.74 | 1.69 | 4.58 | 10.69 | 0.61 | 1.24 |
| | | | | L | 27.14 | 2.57 | 76.39 | 132.57 | ND | 0.93 |
| | | | | H | 5.45 | 6.5 | 19.6 | 93.71 | 1.52 | ND |
| | | | | O | 3.63 | 0.7 | 212.09 | 16.47 | 0.56 | 2.22 |
| Seer fish *Acanthocybium solandri* Cuvier) | 12 | 129 | ♀ | M | 0.57 | 1.48 | 4.44 | 6.19 | 0.31 | 1.23 |
| | | | | L | 144.03 | 4.03 | 441.5 | 227.66 | 0.93 | 0.52 |
| | | | | H | 2.77 | 1.09 | 24.13 | 55.29 | 0.3 | ND |
| Grey dog shark (*Scoliodon palasorrah** Cuvier) | 3 | 48 | — | M | ND | 0.33 | 2.43 | 10.24 | ND | 1.12 |
| Shark, Elliots grey* (*Eulamia ellioti* Day) | 19 | 60 | ♀ | M | 0.18 | ND | 4.5 | 9.89 | ND | ND |
| | | | | G | 0.79 | 1.4 | 7.94 | 110.38 | ND | 0.56 |
| do* | 45 | 188 | — | M | 0.39 | 0.55 | 7.07 | 13.15 | 0.33 | ND |
| do | 35 | 107 | ♀ | M | 1.12 | 1.99 | 9.74 | 56.70 | ND | 2.26 |
| | | | | L | 9.49 | 3.41 | 30.29 | 292.39 | 0.27 | 0.06 |
| | | | | H | 4.35 | 1.27 | 25.24 | 56.95 | 0.39 | 1.47 |
| do | 75 | 200 | ♀ | M | 0.46 | 0.8 | 12.54 | 25.3 | 0.26 | 3.8 |
| | | | | L | 3.61 | 0.77 | 10.47 | 66.65 | 1.02 | ND |

*=Converted to ppm wet weight from ppm dry weight
†=Composite sample
ND=Not Detectable
G=gill; H=heart; L=liver
M=muscle; O=ovary; and W=Whole.

Table 2—Heavy Metals in Flying Fish (*Cypselurus comatus*, Michtill) of Different Sizes

[Muscle is analysed. The results are expressed in ppm wet weight]

| Length (cm) | Cu | Mn | Zn | Fe | Ni | Co |
|---|---|---|---|---|---|---|
| 18 | 0.72 | ND | 10.35 | 9.86 | 0.67 | 1.45 |
| 20 | 0.13 | ND | 6.51 | 5.78 | 0.95 | 0.76 |
| 25 | 0.06 | 0.25 | 6.34 | 4.14 | 0.49 | 0.72 |
| 30 | 0.39 | 0.37 | 10 | 6.77 | 0.32 | 0.71 |
| 35 | 0.60 | 0.32 | 20.76 | 6.25 | 0.42 | 0.18 |
| 53 | 0.67 | 3.74 | 3.95 | 62.14 | ND | 1.32 |

concentration in sea water from the Andaman Sea for each metal[1] is given in Table 4.

*Zooplankton*—In an earlier study of trace metals in zooplankton from Bay of Bengal[2] high concentrations of practically all metals were observed, particularly that of Cu. Zooplankton (Table 1) showed high concentrations of practically all the metals, thus supporting the earlier observation[2].

*Small fish*—Fishes <25 cm, deep sea prawn to juvenile dolphin fish, in Table 1 are discussed. An unidentified deep sea prawn showed highest concentration for practically all the metals. Cu and Co show significantly high concentrations in the muscles. Ni is low and so is Mn, but significantly high concentrations of Mn are found in Bony Jewfish and Myctophid. Fe and Zn, though high, show a similar pattern.

*Large fish*—The fishes discussed in this category are Malabar trevally to shark, Elliots grey, in Table 1. These fishes are generally fast swimmers with a high metabolic rate and highly carnivorous in feeding habits. The analyses of various tissues of these fishes give varied results.

Cu: Copper was comparatively high in the muscles (av. 0.67 ppm). Concentration of Cu in various tissues follows the pattern: Liver > heart > gills > muscles. The liver to muscle ratio ranges in various fishes as: yellowfin tuna—1:2; sharks—1:8; dolphin fish—1:20 (av. of all 3 values); trevallies—1:37; barracuda—1:24 and 1:280; and seer fish—1:252.

Mn: Concentration of this element in muscles is quite high. Liver had the highest concentrations. Mn distribution in various tissues follows the pattern: Liver > heart > gills ≥ muscles. The liver to muscle ratio ranges from 1:2-1:10 in all the fishes.

Zn: Concentration of Zn in different tissues follows the pattern: Liver > heart > gills > muscles. Concentrations of Zn in muscles of different fishes do not show much of a variation; range being 2 ppm to 12.57 ppm with majority of the readings in the range of 4.01 to 6.17 ppm. The muscle to liver ratio in different fishes being: sharks and yellowfin tuna 1:2-1:3; dolphin fish 1:5; trevallies 1:17 (average); barracuda 1:5 and 1:54 and seer fish 1:99.

Table 3—Heavy Metals in Tuna (*Katsuwonus pelamis* Linnaeus) of Different Sizes

(Values are expressed in ppm wet weight)

| Wt (kg) | Length (cm) | Sex | Tissue | Cu | Mn | Zn | Fe | Ni | Co |
|---|---|---|---|---|---|---|---|---|---|
| 1.2 | 30 | ♀ | M | 1.28 | 0.38 | 4.48 | 48.98 | 0.13 | ND |
| | | | L | 6.24 | 0.90 | 45.41 | 303.98 | 0.57 | ND |
| | | | G | 2.05 | 4.47 | 31.08 | 108.42 | 0.97 | 3.84 |
| 1.8*† | 51 | ♀ | M | 1.13 | 0.56 | 7.4 | 18.66 | 0.19 | ND |
| | | | L | 8.01 | 1.25 | 67.11 | 98.81 | ND | 0.16 |
| | | | G | 3.05 | 1.91 | 73.61 | 115.76 | 1.20 | 2.76 |
| 1.95* | 55 | ♂ | M | 0.49 | 0.09 | 7.57 | 22.06 | ND | 0.75 |
| | | | L | — | — | — | — | — | |
| 2.75 & 3.2† | 52 & 56 | ♂ | M | 1.22 | 1.30 | 4.54 | 164.26 | 0.14 | 1.10 |
| | | | L | 86.93 | 4.24 | 54.92 | 143.35 | ND | ND |
| | | | H | 5.16 | 1.61 | 11.87 | 90.42 | ND | ND |
| 3† | 47 & 49 | ♂ | M | 0.32 | 7.50 | 6.97 | 14.57 | ND | 3.25 |
| 6 & 7† | 66 & 68 | ♀ | M | 0.28 | 1.63 | 3.75 | 24.45 | 0.22 | ND |
| | | | L | 31.82 | 3.01 | 74.79 | 420.53 | 1.37 | 1.29 |
| | | | H | 5.67 | 1.37 | 14.11 | 93.11 | 1.03 | ND |
| 7.5 | 69 | ♀ | M | 0.61 | 0.40 | 4.55 | 7.63 | 1.03 | 1.03 |
| | | | L | 46.06 | 2.90 | 75.39 | 318.12 | 0.87 | 0.34 |

G = gill, H = heart, L = liver and M = muscle.
* = converted to ppm wet weight from ppm dry weight
† = composite sample.

Table 4—Concentration Factors for Different Elements (Range)

| Metals | Zooplankton | Small fish | Large fish | | | |
|---|---|---|---|---|---|---|
| | | | Muscle | Liver | Heart | Gills |
| Cu | 1531 | 72-1181 | 43-1065 | 1312-52374 | 1007-2138 | 287-1109 |
| Mn | 579 | 7-1179 | 16-987 | 88-852 | 102-744 | 147-1414 |
| Zn | 4896 | 362-2714 | 283-1773 | 1480-62446 | 1678-3570 | 1123-10411 |
| Fe | 25575 | 580-4143 | 607-23361 | 6424-59904 | 7876-13945 | 8900-28029 |
| Ni | >1910 | >200 | >130 | >130 | >190 | >320 |
| Co | >4400 | >430 | >200 | >60 | >780 | >560 |

Fe: In different tissues Fe follows the pattern: Liver > gills > heart > muscles. The muscle to liver ratio being: sharks, yellowfin tuna and dolphin fish 1:3-1:4; barracuda 1:3 and 1:20; trevallies showed an inverse relationship with size and weight, 1:44 (0.75 kg and 45 cm); 1:24 (1.6 kg and 56 cm) and 1:13 (2 kg and 64 cm); and seer fish 1:38.

Ni and Co: No general pattern was observed in the distribution of these metals. In general, Ni was higher in the gills and heart than in muscles and liver. Co was higher in muscles and gills with lower values in liver and heart. High concentrations of Co (0.2-3.80 ppm; av. 1.38) were observed in the muscles of the fishes analysed.

Tables 2 and 3 give the heavy metal values for different tissues in flying fishes and Tuna (of the same species) of different sizes. The idea was to see whether any correlation is obtained between the concentrations in different tissues and the size of the fish. No correlation was, however, obtained. There was a positive correlation as regards Cu in the liver of tuna (Table 3) of different sizes, but for one comparatively high value of 86.93 ppm (Table 3).

Almost all the heavy metals were found to be highest in liver with the lowest concentrations observed in muscles, the edible portion of the fish. Generally speaking, the trend is liver > heart > gills > muscles for practically all the elements analysed. The principle source of uptake seems to be the absorption of these elements through the gill filaments as all the samples of gills analysed showed appreciable concentrations of practically all the metals.

Though this study is not complete as regards the heavy metal concentrations in the various tissues of the

marine fish from the Indian Ocean, it can be considered as a baseline study for the region. Furthermore, it fills in the lacunae created by the total lack of data on the concentrations of essential metals in various tissues of fishes from the Indian Ocean.

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