

Mercury, Cadmium & Lead in Different Tissues of Fishes & in Zooplankton from the Andaman Sea

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Several fishes, representing different trophic levels, and some zooplankton samples were analysed for Hg, Cd and Pb. There is a wide variation in the concentrations of these elements. Hg is quite low in practically all the tissues. Cd and Pb show increased levels in some tissues. Of particular importance are the elevated Cd levels in liver of almost all fishes which show a positive correlation with the size of the fish.

Information on the abundance and distribution of heavy metals in various segments of the coastal and open ocean is necessary to understand the natural biogeochemical flux of these elements through the ecosystems. There are indications of a possible build-up of heavy metals in invertebrates and fish from coastal areas but not much is known about these in organisms from the open sea¹. The present study deals with the analysis of Hg, Cd and Pb in the muscles, liver, gills and heart of several fishes collected during cruises 51, 52, 67, 68 and 69 of *R V Gaveshani* to the Andaman Sea and the adjacent areas of the Bay of Bengal. In addition some zooplankton samples were also collected and analysed for the same metals.

While sampling, guidelines elaborated by Bernhard² and Grice *et al.*³ were strictly followed. Zooplankton samples were collected by the Indian ocean standard net and Neuston net. All the fishes were caught by trawling lines, hook and line and scoop net from the area inbetween long. 5° to 15°E and lat. 88° to 97°N. The fishes were dissected for various tissues immediately after the catch and the tissues were deep frozen at -5° to -10°C on board in glass tubes with plastic covers. Some of the samples, collected during cruises 51 and 52 were dried to constant weight at 40°-50°C, powdered and stored on board. The samples (dried 1-2 g and wet 2-3 g) were digested in conc. HNO₃ (15-25 ml) followed by perchloric acid until a clean solution was obtained. Blanks were run along with the samples. The acid volume, reduced to 1-2 ml, was made to 10 ml with glass distilled water. The solutions were analysed for Cd and Pb using standard atomic absorption techniques using Hilger and Watts Atomspek H 1550. Calibration curves were prepared for each metal using standards made up in dilute HNO₃. Hg was also analysed using earlier methods⁴. Some samples were, however, aspirated in the mercury analyser, developed by BARC, (samples from cruise 51 and 52). Standard deviation was calculated by

analysing some of the samples in triplicate, which when given as coefficient of variation is <10% being the least in Hg 3%. The detection limits ($\times 10^{-6}$) for different metals are -0.001 for Hg, 0.04 for Cd and 0.5 for Pb. Values below 1×10^{-6} for Pb are expressed as $<1 \times 10^{-6}$ in the table considering the uncertainties in the readings for Pb in the instrument.

All the results are expressed in wet weight $\times 10^{-6}$. In samples analysed on a dry weight basis, a conversion factor of 5, assuming the water content of the samples at an average of 80%, was applied to convert the values from dry weight ($\times 10^{-6}$) to wet weight ($\times 10^{-6}$).

Table 1 gives the values obtained in zooplankton and a wide variety of fishes, while Tables 2 and 3 give results obtained in flying fishes and skipjack tuna of different sizes.

Mercury was analysed as total Hg. In small fishes (<25 cm) the range of Hg is non-detectable to 0.026×10^{-6} (av. 0.021×10^{-6}). In large fishes, which are fast swimmers having high metabolic rate and voracious eating habits, the average values ($\times 10^{-6}$) in various tissues are, muscles 0.07, liver 0.009, gills 0.015 and heart 0.022. One ovary sample and all the zooplankton samples showed non-detectable Hg. There is no trend observed in Hg concentrations in different tissues but in general the muscles showed high concentration than other tissues. Similar values were obtained in an earlier study⁴. Hg concentration in fishes from the Indian Ocean region are less compared to values obtained by some workers in fishes from other oceanic areas⁵⁻⁹. Hg was non-detectable in all the zooplankton analysed.

Cadmium concentrations in various tissues show interesting levels. In small fishes the average is 0.18×10^{-6} , while the average values ($\times 10^{-6}$) in different tissues in large fishes are, muscles 0.31, liver 15.37, heart 0.60 and gills 0.19. In general the concentration of this element in various tissues follows the pattern liver > muscles > heart > gills. The liver to muscle ratio

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Table 1—Concentrations of Metals in ppm Wet Weight

Fish sampled (species name)	Length cm	Tissue analysed	Hg	Cd	Pb
Zooplankton*	—	Whole	ND	1.96	11.22
do	—	do	ND	2.37	5.24
do	—	do	ND	0.69	4.36
do	—	do	ND	1.36	31.87
do	—	do	ND	1.53	4.27
do	—	do	ND	5.99	7.19
Deep sea prawn (unidentified)	—	M	0.009	3.24	3.66
Perch trumpeter*	—	M	0.026	0.08	<1
(<i>Pelates quadrilineatus</i> , Bloch)					
Perch* (unidentified)	—	M	0.1	ND	<1
Japanese threadfin bream*	—	M	0.06	0.08	<1
(<i>Nemipterus japonicus</i> , Bloch)					
Bony Jewfish* (3)†	—	M	0.006	0.42	<1
(<i>Johnius osseus</i> , Day)					
Jewfish* (unidentified)	—	M	0.007	0.19	1.14
Mackerel*	—	M	0.01	0.22	<1
(<i>Rastrelliger kanagurta</i> , Cuvier)					
Squid*	—	M	0.006	ND	1.25
Sardine* (2)†	26	M	0.012	0.74	<1
(<i>S. longiceps</i> , Valenciennes)					
Sardine* (5)†	—	M	ND	ND	<1
(<i>S. longiceps</i> , Valenciennes)					
Pilot fish	—	M	0.02	0.13	1.73
(<i>Naucrates ductor</i> , Linnaeus)					
Sucker fish	—	W	—	0.72	2.38
(<i>Remora remora</i> , Linnaeus)					
Myctophid	—	W	0.006	0.32	2.52
Juvenile dolphin fish	15	M	0.015	0.10	2.95
do	19	M	0.03	0.23	3.42
do	29	M	0.01	0.03	2.14
Malabar Trevally*	34	M	0.018	ND	<1
(<i>Carangoides malabaricus</i> , Bloch)					
Malabar Trevallies* (3)†	44-45	M	0.06	0.57	<1
(<i>Carangoides malabaricus</i> , Bloch)		L	ND	23.87	<1
do* (3)†	54-60	M	0.08	0.5	<1
		L	ND	40.75	1.2
		G	0.03	0.11	2.16
Yellow fin Tuna (2)†	42-46	M	0.023	0.14	3.3
(<i>Neothunnus macropterus</i> , Schlegel)		L	0.003	16.74	2.63
do	37	H	0.007	0.99	2.84
		M	0.04	0.29	<1
		H	0.016	0.04	<1
Dolphin fish*	120	M	0.032	ND	<1
(<i>Coryphaena hippurus</i> , Linnaeus)		L	0.042	2.65	<1
do*	115	M	0.04	0.34	<1
		L	0.02	1.25	<1
		G	0.014	0.16	2.65
do	137	M	0.01	0.95	2.09
		L	0.01	3.48	1.39
		H	—	0.51	1.71
Barracuda*	86	M	0.062	0.28	<1
(<i>Sphyaena picuda</i> , Bloch)		L	0.008	3.75	<1
		G	0.034	0.33	6.96
do* (2)†	110	M	0.072	ND	<1
		G	0.014	ND	1.98
do	—	M	0.2	0.15	<1
		L	ND	2.43	<1
		H	0.08	0.37	3.08

Contd

Table 1—Concentrations of Metals in ppm Wet Weight—Contd

Fish sampled (species name)	Length cm	Tissue analysed	Hg	Cd	Pb
Giant sea pike* (<i>Sphyræna jello</i> , Cuvier)	125	M	0.11	ND	1.46
		G	ND	0.32	3.13
Trevally (unidentified) (2)†	64	M	0.03	0.62	<1
		L	ND	62.63	4.42
		H	0.02	1.91	1.82
		O	ND	0.76	<1
		M	0.89	0.43	1.5
Seer fish (<i>Acanthocybium solandri</i> , Cuvier)	129	L	ND	2.9	1.2
		H	0.017	0.03	3.44
		M	0.036	0.31	<1
Grey dog shark (<i>Scoliodon palasorrah</i> *, Cuvier)	48	L	ND	—	—
		M	0.1	ND	1.9
Shark, Elliots grey* (<i>Eulamia ellioti</i> , Day)	60	G	ND	0.27	<1
		M	0.154	0.09	<1
do	188	M	0.12	0.81	6.02
do	107	M	0.12	0.81	6.02
		L	ND	13.81	8.74
		H	0.02	0.36	<1
do	200	M	0.08	0.39	1.19
		L	0.04	10.19	<1

ND=Not detectable; * =Converted to wet weight ($\times 10^{-6}$) from dry weight ($\times 10^{-6}$); †=Composite sample of number of fish indicated; G=gill; H=heart; L=liver; M=muscle; O=ovary and W=whole.

Table 2—Metal Concentrations in Flying Fish of Different Sizes

[Fish sampled, *Cypselurus comatus* M. and tissue analysed, muscle. Results represent values $\times 10^{-6}$]

Length cm	Hg	Cd	Pb
18	0.005	0.01	2.48
20	0.01	0.11	1.61
25	0.018	ND	2.90
30	0.014	0.13	3.80
35	0.038	ND	2.21
53	0.051	ND	1.08

ranges in various fishes are: dolphin fish—1:4; seer fish—1:7; barracuda—1:15; sharks—1:17 (107 cm) and 1:34 (200 cm); trevallies—1:40 (45 cm), 1:81 (56 cm) and 1:100 (64 cm); and yellowfin tuna—1:120. As compared to Hg, Cd values in zooplankton are quite high (av. 2.31×10^{-6}). These Cd values are quite high compared to the values obtained by other workers¹⁰⁻¹². These reports however indicated high concentrations of Cd in the liver. The differences may, however, be due to the different fishes analysed, the size and age of the fishes.

Lead in the muscles of small fishes was quite high (av. 1.45×10^{-6}). In larger fish the average values ($\times 10^{-6}$) in different tissues are, muscles 0.67, liver 1.13, heart 1.89 and gills 2.14. The pattern of Pb accumulation in various tissues is: gills > heart > liver > muscles.

Table 3—Metal Concentrations in Skipjack Tuna of Different Sizes (Fish sampled, *Katsuwonus pelamis* L.)

Length cm	Tissue analysed	Hg	Cd	Pb
30*	M	0.052	ND	<1
	L	ND	6.26	<1
	G	ND	0.43	3.13
52*†	M	0.06	ND	<1
	L	0.02	12.61	1.43
	G	0.014	0.4	3.1
55*	M	0.22	0.34	1.14
	L	ND	—	—
52 & 56†	M	0.03	0.29	1.40
	L	0.024	46.16	3.77
	H	0.02	0.03	<1
47 & 49†	M	0.03	0.36	<1
	M	0.07	0.05	1.19
66 & 68†	L	0.006	67.70	<1
	H	ND	0.84	<1
	M	0.035	0.30	<1
69	M	0.035	0.30	<1
	L	ND	83.74	<1

ND=non-detectable; *Converted to wet weight ($\times 10^{-6}$) from dry weight ($\times 10^{-6}$).

†=Composite sample containing 2 fish; —=not analysed; M =Muscle; L=Liver; G=Gills; H=Heart.

These concentrations are also high compared to values obtained by other workers¹³⁻¹⁴. Brooks and Rumsey¹⁰ found high concentrations of Pb in gills, which may be due to higher concentrations of the metal in particulate form.

Zooplankton samples also showed high concentrations of Pb (av. 6.05×10^{-6}).

Relationship between fish size and metal concentrations

An increase in Hg content is observed with size in flying fishes, though no definite correlation could be obtained (Table 2). In Skipjack tuna a clear positive correlation is obtained in the Cd concentrations in liver which increases with size. This correlation is observed in the liver samples of sharks and trevallies also. The observed distribution of Hg in muscles with respect to size of the fish has been shown to have a positive correlation by several workers^{9,15}. However, there is no established theory in this regard because much depends on the environmental characteristics of the area of the catch.

In general the concentrations of heavy metals found in various tissues of the fishes analysed are quite low. Hg, one of the most toxic metals, does not show elevated levels and is much below the W.H.O. prescribed limits of 0.5×10^{-6} for fishery products. The large fishes have somewhat higher concentrations of Hg than small fishes feeding generally on zooplankton. This shows the accumulation of mercury over time via the food chain. The situation is, however, quite different as regards Cd and Pb. Cd concentrations are alarmingly high in liver, though not an edible portion of the fish, which suggests the availability, mode of assimilation and retention of Cd. Pb too shows high concentrations. This suggests the possible build-up of these non-essential elements in the biota of the Bay of Bengal. Though no 'source' of entry can be pinpointed in the present study, since the area can be taken as more or less non-polluted, it can be mentioned that probably the 'aerial transport' of these metals may be responsible for the availability and high concentrations as evidenced by elevated concentrations in the zooplankton. The concentrations of

these metals in the sea water of the area are comparable to other oceanic areas¹⁶.

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