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Bioaccumulation of heavy metals in three species of fresh water fish from Weras Ganga : evidence for bio magnification

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Abstract:

This paper reports the evidence for biomagnification in three species of fresh water fish: *Oreochromis mossambicus, Ophiocephalus striatus and Heteropneustes fossilis with* different feeding habits, from Weras Ganga in the Colombo District.

The muscle, gills, kidney, gonad and liver of fish were analyzed by the X-ray fluorescence method and the mean concentrations of heavy metals in each species, were computed in µg/g dry organ weight.

It was seen that the piscivore *(Ophiocephalus striatus)* had much higher levels (aggregated means for all the organs) of Cu (131.6±7.10), Zn (639.2±12.30), Cr (3.03±1.23), Ni (11.06±2.35) and Ti (18.6±2.30) than both the omnivore *(Oreochromis mossambicus)* and the detritivore *(Heteropneustes fossilis)*, showing evidence of biomagnification. The concentrations of Fe (1463.4±22.70) and Mn (183.9±7.07) were highest in *Oreochromis mossambicus*. Further studies of its feeding habit may provide an explanation for this. The lowest concentration of all metals was recorded in the detritivore.

Key words: Bioaccumulation, heavy metals, fresh water fish

1. Introduction

Many fresh water bodies in the Colombo district are subject to heavy metal pollution through the discharge of industrial effluents, and fish from these water bodies are being caught for human consumption. Three water bodies from the Colombo district were selected for a study of various aspects of bioaccumulation of heavy metals in fresh water fish. This paper deals with the study of bioaccumulation of heavy metals in three species of fish, with different feeding habits, from Weras Ganga.

Biomagnifiaction, whereby pollutants show an increase in trophic level, has been used to explain the high concentration of some pollutants (e.g. DDT) in top carnivores such as raptors (Leblance, 1995). As fish occupy an important position in aquatic food chains, and are being consumed by humans it would be useful to gain an insight into the potential risks from the consumption of fish occupying different trophic levels in a food chain. The three species of fish selected for the study were, *Ophiocephalus striatus,* a piscivore, *Oreochromis mossambicus,* an omnivore and *Heteropneustes fossilis,* a detrivore.

2. Materials and methods

The fish used in this study were collected from the Weras Ganga between 6 and 8 am during the period from March to April, 1995. All the individuals of the three species were young adults. On collection, the fish were immediately packed with ice in polythene bags, transported to the laboratory, and stored at - 20°C. The total number of fish subjected to the analysis were *Oreochromis mossambicus* 56, *Heteropneustes fossilis* 15 and *Ophiocephalus striatus* 11. When taken for analysis the fishes were thawed and the individuals of each species were divided into three composite samples. The gills, gonads, kidney, liver, and a section of the muscle were dissected out, washed thoroughly, oven dried to a constant weight at 105 °C, and their weights were recorded. The samples were then ashed at 400 °C for six hours in a muffle furnace and stored in a dessicator. The temperature was kept at 400 °C as a higher temperature could cause the loss of volatile elements (IAEA, 1980 & APHA, 1980).

The metal analysis was done by the energy dispersive X-ray fluorescence multi-element analyzing method (Bearse *et al.,* 1974) using the model SEA 2010L XRF Element Monitor version 3.1, at preset conditions of 3000 seconds, 10μm aperture and 26μA current. The metal concentrations of each composite sample were calculated as μg/g dry organ weight. The data from three composite samples for each organ were used to calculate the mean concentration for the different organs. The mean concentration for each species was then computed from the means of the heavy metal concentrations in different organs.

Analysis of data

A one-way ANOVA was applied to the mean concentrations of the three species to determine whether the levels of the metals were significantly different in the three species. In instances where a statistically significant result was obtained with ANOVA the data were subject to HSD test to determine whether the difference in levels between any two species, was significant.

3. Results:

The heavy metals in the three species of fish are given in Table 1. It was seen that *Ophiocephalus striatus* (piscivore) had significantly higher concentration ($p<0.05$: ANOVA and HSD) of Cu, Cd, Cr, Ni and Ti than both the omnivore and the detritivore. Further, Cr was recorded only in the *Ophiocephalus striatus*. However, the concentrations of Fe and Mn were highest in the *Oreochromis mossambicus.* Except for Cu and Ti, the lowest levels were recorded in the *Heteropneustes fossilis* (see Table 1).

4. Discussion

The interesting feature noted in the study was that *Ophiocephalus striatus* accumulated a higher amount of most of the metals analyzed (Cu, Zn, Cd, Cr, Ni, and Ti). The highest trophic levels in a food chain consist of carnivores and include piscivorous species such as *Ophiocephalus striatus.* In piscivorous species it has been found that the concentration of heavy metals in the prey influence the concentration of heavy metals in the predator (Berg *et al.,* 1993), which suggests that for fish, the uptake of heavy metals via food can be very substantial (Dallinger *et al.*, 1987). Hence, *Ophiocephalus striatus* being a predator, one is justified in interpreting the higher concentrations of the heavy metals as evidence of biomagnification.

Ophiocephalus striatus, being a predator, can be expected to have a much more active life style and metabolic rate than the omnivore and the detritivore. This may have resulted in a higher intake of metals (compared to the other two species), via the gills in particular directly from the water (bioconcentration) which may have contributed to the elevated level of heavy metals in *Ophiocephalus* as recorded in the present study.

The life span of animals at higher trophic levels is usually greater than that of organisms at lower trophic levels (Martin and Coughtrey, 1982). However, it is unlikely that, in the present study, age related enrichment may have affected the heavy metal concentrations in the different trophic levels since the individuals of the three species were in nearly the same age class.

The high Mn and Fe levels in the omnivore *Oreochromis mossambicus* could not be explained and further investigations would be required to elucidate the cause of this.

5. Conclusion

As the path of ingestion is known to serve as an important route of uptake of heavy metals, the higher concentration of Cu, Zn, Cr, Ni, and Ti in the piscivore *(Ophiocephalus striatus)* compared to the omnivore *(Oreochromis mossambicus)* and the detritivore *(Hetepneutes fossilis)* provides evidence for biomagnification.

Table 1: Mean concentration (μg/g dry wt.) metals in *Heteropneustes fossilis, Ophiocephalus striatus* and *Oreochoromis mossambicus* of Weras Ganga.

	Heteropneustes fossilis	*Ophiocephalus striatus*	*Oreochromis mossambicus*
Cu	80±6.75	131.64±7.1	8.885±2.09
Zn	71.55±5.03	639.2±12.3	116.57±3.9
Fe	229.28±7.74	1130.23±21.89	1463.38±22.7
Mn	43.09±2.32	93.19±3.66	183.90±7.07
Cd	ND	18.81±1.84	0.225±0.33
Cr	ND	3.03±1.23	ND
Ni	0.42±0.34	11.06±2.35	0.47±0.48
Ti	8.28±1.95	18.6±2.3	1.975±0.993

Values below detectable limits are denoted by ND

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