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BIOACCUMULATION OF HEAVY METALS IN THE MUSCLES OF GREY MULLET, *MUGIL CEPHALUS* IN KADALUR COASTAL ZONE TAMIL NADU, INDIA

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ABSTRACT

Heavy metals residues (i.e. Zn, Cu, Cr, Cd, Pb α Hg) were determined in chosen tissues grey Mullet, (*Mugil Cephalus*) from Kadalur coastal zone. The impact of feeding habit on metal accumulations in different tissues as well as the respective contribution of water and food to metal uptake by fishes were considered. Generally, there was no statistically significant relationship between the metal content of the tissues and the fish length for both species. On cases all the amounts of the metals in the flesh of the species were fish than those in commercially important fishes from kadalur coastal zone. However, they were below the recommended levels for human consumption.

Key words: Heavy metals, *Mugil cephalus*, Bioaccumulation, Kadalur Coastal Zone.

1. INTRODUCTION

The accumulation of heavy metals in freshwater ecosystems has been a major concern. Heavy metals generally enter the aquatic environment through natural (atmospheric desposition, erosion of geological matrix) or anthropogenic activities caused by industrial effluents, domestic sewage mining and agriculture wastes, (Connell and miller, 1984, vautukuru, 2005). The metal contaminats in the equatic system were reported to remain either in soluble or suspension form and finally tend to settle down to the bottom sediments or are taken up by organisms including fish (amiard, 1975).

The progressive and irreversible accumulation of these metals in the various organs of freshwater organisms ultimately leads to metal related problems in the long run because of their toxicity, thereby endangering the aquatic biota including fish (Farkas *et al.*, 2002). Fishes being one of the main aquatic organisms in the food chain may often accumulate large amounts of certain metals above the levels in the aquatic environment (Deb and Santra, 1997). Essentially, fishes have been reported to assimilate these heavy metals through ingestion of suspended particulates, food materials and or by constant ion – exchange process of dissolved metals across lipophilic membranes such as the gills, absorption of dissolved metals on tissue and membrane surfaces. (oguzie, 1999; oguzie and okosodo, 2008). This is largely due to their non – biodegradability and tendency to accumulate in plants and animals tissue. As a result metal bio accumulation is a major route, through which increased levels of the pollutants are transferred across food chains web,creating public health problems wherever man is involved in the food chain therefore, it is important to always determine the bioaccumulation capacity for heavy metals by organisms especially the edible ones, in order to assess potential risk to human health. (Otitoloju. 2002)

Chromium Heavy metals such as zinc, copper, lead, cadmium more specifically mercury are potentially harmful to most organisms even in very low concentrations and have been reported as hazardous environmental pollutants able to accumulate along the aquatic food chain with severe risk for animal and human health.

The present work was carried out to study the bioaccumulation of heavy metals (Zn, Cu, Cr, Cd, Pb and Hg) in selected organs viz. gills, intestine, liver, kidney and muscles of the edible fish grey mullet, *Mugil cephalus* collect from the three stations Palar River, Palar estuary and Kadalur Sea Coast (India) during the present study June 2009 to July 2010.

MATERIALS AND METHODS

For the purpose of the present study fish grey mullet, *Mugil cephalus* of 10 – 12 cm length and 23 ± 2 gm weight were collected from all the three stations at monthly intervals. Different organs viz. gill, intestine, liver, kidney and muscle were dissected cut and separated into different petridishes. All the tissues were dried at temperature 120˚C for 24 – 48h and were ground to fine powder using a pistle and mortar. Later, known quantities of the fine powder were taken into crucibles

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and were ashed in a muffle furnace at 550˚C for 2h. The ash was digested with concentrated nitric, perchloric and sulfuric acids. Following the digestion, the samples were cooled and dissolved in 1N nitric acid and made up to 10ml. Determination of the heavy metals concentration was carried out by atomic absorption spectrophotometer (AAS – Model - 802) as suggested by (Topping, 1973). The results were expressed as µg/g dry wt. Mercury analysis was quantified by cold vapour technique in mercury analyser (Model 5800 D - 209).

RESULTS AND DISCUSSION

The result on bioaccumulation of heavy metals in muscles of fish observed during the different seasons and organs, station1 (Palar River), station 2 (Palar estuary) and station 3 (Kadalur Sea Coast) during the present study (July 2009 to June 2010) is given in Table1, Table 2 and Table 3. Concentration of zinc was minimum (4.46µgl^{-1}) during summer season and the maximum (9.28µgl^{-1}) during monsoon season at Station. 1. Concentration of zinc was minimum (7.2µgl^{-1}) during post monsoon season and the maximum (33.77µgl^{-1}) during monsoon season at station. 2. Concentration of zinc was minimum (5.12 µgl^{-1}) during summer season and the maximum (18.94µgl^{-1}) during monsoon season at Station 3. Muscle showed minimum accumulation of Zinc and maximum concentration was found in the intestine.

Minimum (2.78µgl^{-1}) and maximum (8.79µgl^{-1}) values of chromium in fish tissues were recorded during summer and monsoon seasons at Station 1. Minimum (1.9µgl^{-1}) and maximum (5.8µgl^{-1}) values of chromium in fish tissues were recorded during summer and monsoon seasons at Station 2. Minimum (0.23 µgl^{-1}) and maximum (2.08 µgl^{-1}) values of chromium in fish tissues were recorded during summer and monsoon seasons at Station 3. Muscle showed minimum accumulation of Chromium and maximum concentration was found in the intestine.

Minimum (2.28µgl^{-1}) and maximum (6.9µgl^{-1}) values of Copper in fish tissues were recorded during summer and monsoon seasons at Station 1. Minimum (5.74µgl^{-1}) and maximum (12.76µgl^{-1}) values of Cu were recorded during summer and monsoon seasons at Station 2. Minimum (31.86µgl^{-1}) and maximum (55.37µgl^{-1}) were recorded during summer and monsoon seasons at Station 3. Kidney showed minimum accumulation of copper and maximum concentration was found in the intestine.

Concentration of Cadmium was minimum (0.032µgl^{-1}) during summer season and the maximum (0.048µgl^{-1}) values of chromium in fish tissues were recorded during summer and monsoon seasons at Station 1. Concentration of cadmium was minimum (0.202µgl^{-1}) during summer season and the maximum (0.368µgl^{-1}) during premonsoon season at Station

Table 1 Bioaccumulation of selected Heavy metals in different Seasons and Organs and Station 1 (Palar river) during the Present Study (July 2009 to June 2010)

Heavy Metals	Season	Organ					Annual Average
		Gill	Intestine	Liver	Kidney	Muscle	
Zn	Premonsoon	13.66	20.24	5.08	4.82	2.64	9.28
	Monsoon	43.28	66.89	12.88	6.98	4.44	26.894
	Postmonsoon	–	–	–	–	–	4.464
	Summer	4.63	12.94	2.03	1.64	1.08	4.46
	Total	20.52	25.02	4.99	3.36	2.04	
Cr	Premonsoon	5.84	9.64	3.11	2.18	1.84	3.35
	Monsoon	12.83	8.94	6.24	4.64	3.33	8.79
	Postmonsoon	–	–	–	–	–	–
	Summer	1.66	1.10	4.83	3.47	2.86	2.78
	Total	5.08	4.92	3.54	2.57	2.00	–
Cu	Premonsoon	5.11	8.08	2.06	1.44	5.09	4.35
	Monsoon	8.42	10.45	4.62	2.05	8.96	6.9
	Postmonsoon	–	–	–	–	–	6.9
	Summer	2.45	2.86	0.85	0.63	4.62	2.28
	Total	3.99	5.34	1.88	1.03	4.65	
Cd	Premonsoon	0.046	0.03	0.032	0.033	0.069	0.042
	Monsoon	0.064	0.043	0.05	0.041	0.044	0.048
	Postmonsoon	–	–	–	–	–	–
	Summer	BDL	0.026	0.022	0.06	0.055	0.032
	Total	0.027	0.025	0.026	0.033	0.042	
Pb	Premonsoon	–	–	–	–	–	–
	Monsoon	–	–	–	–	–	–
	Postmonsoon	–	–	–	–	–	–
	Summer	–	–	–	–	–	–
	Total	–	–	–	–	–	–
Hg	Premonsoon	0.003	0.040	0.008	0.001	0.0115	0.013
	Monsoon	0.006	0.008	0.011	0.016	0.142	0.036
	Postmonsoon	–	–	–	–	–	–
	Summer	0.001	0.012	BDL	0.008	0.080	0.02
	Total	0.002	0.015	0.005	0.006	0.059	0.069

2. Concentration of cadmium was minimum ($0.47 \mu g l^{-1}$) during post monsoon season and the maximum ($1.01\ \mu g l^{-1}$) during monsoon season at station 3. Intestine showed minimum accumulation of cadmium and maximum concentration was found in the gill. Concentration of Lead at Station 1 in all the tissues in all the seasons was at the Not Detectable (ND) level. Concentration of lead at Station 2 showed minimum ($0.064\ \mu g l^{-1}$) and maximum ($0.17\ \mu g l^{-1}$) values during post monsoon and premonsoon seasons respectively. Concentration of lead at Station 3 was minimum ($0.67\ \mu g l^{-1}$) and maximum ($1.19\ \mu g l^{-1}$) during summer and post monsoon seasons respectively. Kidney showed minimum accumulation of lead and themaximum concentration was found in the muscle.

At Station1, concentration of Mercury in tissues varied from 0.013 to 0.036 $\mu g l^{-1}$. Minimum ($0.013\ \mu g l^{-1}$) was recorded during premonsoon season and the maximum ($0.036\ \mu g l^{-1}$) during monsoon season. At Station 2, concentration of mercury in tissues varied from 0.076 to 0.214 $\mu g l^{-1}$. Minimum ($0.076\ \mu g l^{-1}$) was recorded during summer season and the maximum ($0.214\ \mu g l^{-1}$) during monsoon season. At station 3, concentration of mercury in tissues varied from 0.016 to 0.31 $\mu g l^{-1}$. Minimum ($0.16\ \mu g l^{-1}$) was recorded during summer season and the maximum ($0.31\ \mu g l^{-1}$) during monsoon season. Gill showed minimum accumulation of Mercury and the maximum concentration was found in the intestine. In general, it is noteworthy that minimum and maximum accumulations of the selected heavy metals were observed during summer

Table 2 Bioaccumulation of selected Heavy metals in different Seasons and Organs at Station 2 (Palar estuary) during the Present Study (July 2009 to June 2010)

Heavy Metals	Season	Organ					Annual Average
		Gill	Intestine	Liver	Kidney	Muscle	
Zn	Premonsoon	24.23	56.04	10.12	8.92	8.08	21.48
	Monsoon	42.40	88.58	18.62	12.82	6.44	33.77
	Postmonsoon	2.94	7.79	7.05	6.00	12.22	7.2
	Summer	10.06	14.80	6.66	4.74	2.83	7.82
	Total	19.9	41.8	10.61	8.12	7.39	
Cr	Premonsoon	6.09	8.80	2.86	2.04	2.22	4.4
	Monsoon	8.88	12.85	4.46	4.15	3.69	6.8
	Postmonsoon	0.96	2.36	3.18	2.90	0.86	2.05
	Summer	2.22	4.05	1.05	0.95	1.24	1.9
	Total	4.54	7.01	2.89	2.15	2.00	
Cu	Premonsoon	14.14	19.86	2.83	4.54	4.64	9.2
	Monsoon	16.49	28.84	4.62	6.92	6.94	12.76
	Postmonsoon	12.04	8.04	3.11	3.90	1.85	5.79
	Summer	6.56	14.14	3.86	1.66	2.48	5.74
	Total	12.3	39.0	3.6	4.25	3.97	
Cd	Premonsoon	0.61	0.45	0.18	0.39	0.21	0.368
	Monsoon	0.72	0.36	0.11	0.22	0.18	0.318
	Postmonsoon	0.55	0.62	0.21	0.16	BDL	0.308
	Summer	0.03	0.09	0.46	0.34	0.09	0.202
	Total	0.48	0.38	0.24	0.28	0.12	
Pb	Premonsoon	0.09	0.34	0.14	0.13	0.16	0.172
	Monsoon	0.06	0.26	BDL	0.09	BDL	0.082
	Postmonsoon	0.08	0.16	0.08	BDL	BDL	0.064
	Summer	0.14	0.08	0.11	0.10	0.14	0.114
	Total	0.092	0.21	0.082	0.08	0.075	
Hg	Premonsoon	0.032	0.342	0.065	0.058	0.22	0.143
	Monsoon	0.046	0.680	0.109	0.096	0.16	0.218
	Postmonsoon	0.028	0.269	BDL	0.100	0.140	0.143
	Summer	0.006	0.108	0.206	BDL	0.06	0.076
	Total	0.028	0.349	0.095	0.063	0.145	

and monsoon seasons at all the stations in all the tissues of fish. In the present study, metals were accumulated at higher level in gills and intestine. The possible reason for the high levels of metals in gills may be due to route of entry through active or passive diffusion between the gill membrane and actual medium as gills are active sites of respiration. Denton and Breck (1981) explained high Hg levels in gills as due to mucus secreting ability since it can absorb Hg and other polyvalent cations from sea water.

The higher levels of metals in kidney can be explained as follows: Kidney, as an excretory organ, is a major route of accumulation. It showed a particularly of high affinity for metals, relative to other organs, thus suggesting a prominent role in the metal metabolism (Tulasi *et al.,* 1992). Increased synthesis of metallothioneins and their storage as a constitutent of liver and kidney cytoplasm might have resulted in the increased accumulation of metals in liver and kidney (Vincent and Ambrose, 1994). According to Kasthuri and Chandran (1997) high levels of metals in liver is due to the enhanced capacity of liver to accumulate more of toxic metals.

Table 3 Bioaccumulation of selected Heavy metals in different Seasons and Organs and Station 3 (Kadalur Sea coast) during the Present Study (July 2009 to June 2010)

Heavy Metals	Season	Organ					Annual Average
		Gill	Intestine	Liver	Kidney	Muscle	
Zn	Premonsoon	38.12	18.62	8.88	3.94	3.11	14.534
	Monsoon	44.18	31.3	12.32	4.98	1.92	18.946
	Postmonsoon	6.16	3.11	6.04	5.03	5.23	5.114
	Summer	10.93	9.03	2.45	2.11	0.98	5.1
	Total	24.84	15.51	7.54	4.01	2.81	
Cr	Premonsoon	2.94	3.04	1.32	BDL	0.06	1.47
	Monsoon	5.16	4.38	0.42	0.43	0.02	2.08
	Postmonsoon	3.04	2.18	0.16	BDL	BDL	1.07
	Summer	0.96	BDL	BDL	0.19	BDL	0.23
	Total	3.02	2.4	0.47	0.15	0.02	
Cu	Premonsoon	84.49	9.11	12.05	5.04	10.18	40.37
	Monsoon	120.62	112.64	18.91	6.52	18.19	55.37
	Postmonsoon	69.92	65.66	11.11	4.87	16.14	33.54
	Summer	76.92	62.10	9.23	1.66	9.32	31.86
	Total	87.99	82.63	12.97	4.52	13.46	
Cd	Premonsoon	0.84	0.71	0.82	0.11	0.16	0.53
	Monsoon	1.93	1.32	0.66	0.90	0.24	1.01
	Postmonsoon	0.83	0.66	0.55	0.24	0.09	0.47
	Summer	1.86	1.18	0.09	0.33	0.13	0.72
	Total	1.36	0.97	0.55	0.39	0.15	
Pb	Premonsoon	0.99	1.84	0.32	0.24	1.64	1.01
	Monsoon	1.24	0.94	0.44	0.19	2.21	1.00
	Postmonsoon	1.88	1.36	0.15	0.26	2.32	1.19
	Summer	1.35	1.11	0.09	0.10	0.68	0.67
	Total	1.36	1.14	0.25	0.197	1.75	
Hg	Premonsoon	0.524	0.555	0.102	0.061		0.25
	Monsoon	0.705	0.664	0.095	0.102	–	0.313
	Postmonsoon	0.498	0.492	0.208	0.093	–	0.26
	Summer	0.321	0.269	0.132	0.084	–	0.161
	Total	0.51	0.49	0.132	0.118	–	–

The higher levels of metals in intestine can be attributed to the feeding habits of fish. Since the fish *Mugil cephalus* is detritus feeder and feed either by sucking up the surface layer of the mud or by grazying on the rock surfaces leaving to the transfer of mineral particles into the system along with food. The sediments are usually enriched with trace metals and as a result, detritus feeders are exposed to more quantity of metals than fishes that are pelagic in nature (Zingde *et al.*,1976; Kumaraguru, 1980; Nair *et al.*,1997 and Krishnakumar *et al.*,1998). The elevated levels of metals also can be attributed to the feeding habits. Since fishes largely prey on invertebrates – like crustaceans and mollusus – which also accumulate metals. Similar observations were also made by Babu (1995).

This observation is in agreement with earlier works on heavy metal toxicity profiles. According to (otitoloju and Don – Pedro 2002), lead was found to be consistently the least toxic test metal compared to Hg, Cd, Cu and Zn when tested against *Tympanotonus fuscatus, Clibanarius africanus* and *Mugil cephalus*. Other workers (Dallinger *et al.*,2000) have demonstrated the relatively higher toxicity of copper compound than lead when tested against *Helix aspersa.* They reported that the higher toxicity of copper may be due to its ability to form complexes with anions and also because Cu (II) induces the oxidation of quinine and may be a factor in the oxidative activation and toxicity of hydroquinone in target cells. According to (Oyewo 1998), and (otitoloju 2001) the low toxicity of Pb mayble due to low penetratability in exposed organisms and the ability of the exposed animals to accumulate the Pb ions in its body tissue without ill effects or lethal action.

Bioaccumulation of heavy metals does not only depend on the structure of the organ, but also on the interaction between metals and the target organs (Sorenen, *et al.*,1980). (Mersch *et al*., 1993*)* stated that fish could accumulate trace metals and act as indicators of pollution.

Iron is on abundant and important element, unsupressed by any other heavy metals in the earth's crust (Ibrahim and Tayai 2005). The increase of iron accumulation in fish liver in this study may be related to the increase of total dissolved iron in Nile water and consequently increase the free metal iron concentration and thereby lead to an increase in metal uptake by different organs (Tayel, 2008). (Haggag *et al.*, 1993 and (Yacoub, 2007) observed accumulation of iron ligand protein (Hemosidrin) scattered in liver section of fish exposed to high iron concentration.

Copper is a fundamental micronutrient to all forms of life in enzyme activity or random rearrangement of natural protein (Bower 1979). The elevation of copper accumulation in this study may be due to industrial and sewage wastes. These results agree with those obtained by Ibrahim and Mahmoud 2005) and (Tayel *et. al., 2008*) who revealed that this increase is anticipated to industrial, drainage and sewage effluents. Also, it may be due to elevated metal- binding protein synthesis as recorded by (Yacoub 2007).

Zinc is an essential element and is a common pollutant as well. Mining smelting and sewage disposal are major source of zinc pollution. Fish take it up directly from water, especially by mucous and gills (Skidmore 1964). The high accumulation of zinc in studied fish liver agrees with (Hamed 1998). (Ibrahim and Mahmoud 2005) revealed that this increase is anticipated to industrial effluents from Talkha Electricity station and sewage from El-Rahway drain respectively.

The relatively higher Zinc concentration in the liver of the different fish species may be due to the role of Zinc as an activator of numerous enzymes present in the liver as recorded by (Yacoub,2007) and (Cogun *et al., 2005*) Manganese functions as an essential constituent for bone structure, reproduction and normal functioning of the enzymes system (Sarkka *et al.*,1978). It is toxic only when present in higher amount, but at low level is considered as micronutrient (Fleck, 1976).

Lead is non-essential element and higher concentrations can occur in aquatic organisms close to anthropogenic sources. It is toxic even at low concentrations and has no known function in biochemical processes (Burden, 1998). It is known to inhibit active transport mechanisms, involving ATP, to depress cellular oxidation-reduction reactions and to inhibit protein synthesis (Waldorn and stofen, 1974). Lead was found to inhibit the impulse conductivity by inhibiting the activities of monoamine oxidase and acetylcholine esterase to cause pathological changes in tissue and organs (Rubio *et al*., 1991) and to impair the, embryonic and larval development of fish species (Dave and Xiu 1991). Cadmium is highly toxic non - essential heavy metal and it does not have a role in biological processes in living organisms. Thus even in low concentration, cadmium could be harmful to living organisms (Burden *et al*., 1998).

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