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RESEARCH ARTICLE

BIOACCUMULATION OF HEAVY METALS IN THE SELECTED ORGANS OF COMMON CARP (CYPRINUS CARPIO) IN VETTAR ESTUARY, NAGAPATTINAM COASTAL AREA, TAMILNADU, INDIA

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ABSTRACT

The bioaccumulation of heavy metals in fish *Cyprinus carpio* such as zinc, chromium, copper, cadmium and lead were evaluated during the year of July 2011 to July 2012 from Vettar Estuary, Nagapattinam Coastal area, Tamilnadu. The fish organs *viz*., gill, intestine, liver, kindey and muscle from the selected freshwater fish was carefully dissected for determination of heavy metals. Bioaccumulation of metals exhibited spatio-temporal variations. In general, the accumulation is maximum during the monsoon season and minimum during summer season. Such a relationship may be due to the background level of metals and due to the presence of favourable environmental physico-chemical characteristics. Gill and intestine exhibited maximum levels of accumulation owing to the route of entry via water and food. In monsoon season even the muscle, edible part of the fish, exhibited higher levels of non-essential metals, which exceeded the FAO's safe permissible limits. The levels of heavy metals were determined using Clicos Sl- 176 double beam Atomic Absorption Spectrophotometer (AAS). The heavy metals accumulated in freshwater fish species might be due to increase in agricultural influx waters, domestic waters and anthropogenic activities.

INTRODUCTION

Rivers and estuaries are very important part of our natural heritage. One of the most significant man made changes has been the addition of chemicals, containing a lot of heavy metals, to the waters. Such inputs to water can be derived from a variety of sources, some of them are obvious and others less. They can be varied so that the concentrations of chemicals in water are rarely constant. Contaminated sediments are significant water pollution. Water is also a vital resource for agriculture, manufacturing and other human activities. Fishes being one of the main aquatic organisms in the food chain may ofte accumlate large amount of certain metals above the levels in the aquatic environment (Prabhahar et al., 2011). In urban areas, the careless disposal of industrial effluents and other wastes in river and lakes may contribute greatly, to the poor quality of river water (Ugochukwu, 2004). Among environmental pollutants, metals are of particular concern due to their potential toxic effect and ability to bioaccmulate in aquatic ecosystems (Storelli *et al,* 2005). Heavy metals including both essential and non-essential elements have a particular significance in ecotoxicology, to be toxic to living organisms (Prabhahar *et al.,* 2012). Bioaccumulation and magnification is capable of leading to toxic level of these metals in fish even when the exposure is low. The presence of metal pollutant in freshwater is known to disturb the delicate balance of the aquatic systems. Fishes are notorious for their ability to concentrate heavy metals in the muscles and since they play important role in human for nutrition, they need to be carefully screened to ensure that unnecessary high level of some toxic trace metals are not being transferred to man through fish consumption (Adeniyi and Yusuf, 2007).

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. The metal contaminates in the aquatic 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 (Farombi *et al*., 2007). Heavy metals such as zinc, copper, lead, cadmium, chromium and 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 (Osmen *et al.,* 2007).

Fish accumulate toxic chemicals such as heavy metals directly from water and diet, and contaminant residues may ultimately reach concentrations hundreds or thousands of times above those measured in the water, sediment and food. Heavy metals are normal constituents of marine environment that occur as a result of pollution, principally due to the discharge of untreated

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wastes into rivers by many industries. Bioaccumulation of heavy metals in tissues of marine organisms has been identified as an indirect measure of the abundance and availability of metals in the marine environment (Kucuksezgin *et al*., 2006). For this reason, monitoring fish tissue contamination serves an important function as an early warning indicator of sediment contamination or related water quality problems and enable us to take appropriate action to protect public health and the environment. Multiple factors including season, physical and chemical properties of water can play a significant role in metal accumulation in different fish tissues Karthikeyan *et al.* (2007) have also indicated that fish are able to accumulate and retain heavy metals from their environment depending upon exposure concentration and duration as well as salinity, temperature, hardness and metabolism of the animals. Adeniya and Yusuf (2007) have also showed that the concentration of metals was a function of fish species as it accumulates more in some fish species than others. Therefore in the present study aimed to find act bioaccumulation of heavy metals such as zinc, chromium, copper, cadmium and lead in the selected organs *viz*., gills, intestine, liver, kindey and muscle in the edible fish, *Cyprinus carpio* collected from the three station 1,2 and 3 in Vettar estury, Nagappattinam coastal area.

MATERIALS AND METHODS

The study was carried out at in Vettar River, Vettar estuary and Coastal water (St-I,II, and St-III) at Nagapattinam coastal area during the period July 2011 –June 2012.. Fish samples, specimen of uniform size were collected in order to avoid the possible error due to size differences. The different organs (Gills, liver, Intestine and Kidney) were carefully dissected after rinsing with double distilled water and oven dried at 1100 C. The heavy metal concentrations in the dried samples were estimated after acid digestion following standard methods as laid down in using Atomic Absorption spectrophotometer. The results were expressed in µg/g metal per dry weight.

Fish samples were de-scaled and rinsed with ultrapure water before dissection for the isolation of the following internal organs as test samples: Gills, Intestine, Kidney, Liver and flesh Muscles. Care was taken during dissection of the internal organs to prevent any injuries and metal contaminations of the organ samples by using stainless steel dissecting kits. The isolated organs were manually cut into small pieces with stainless-steel scissor and weighed accurately to 3.00 ± 0.05 g (wet weight basis) into individual sanitised porcelain crucibles and subsequently subjected to oven drying at 180°C for 4hours. The dried samples were later ashed at 500°C for 12 hours inside a muffle furnace (THERMCONCEPT, Germany). The cooled ashes were digested with 1.5mL of concentrated analytical grade 65% HNO_3 and subsequently diluted with ultrapure water to 30 mL. Diluted final test solution samples were filtered through Whatman No. 1 filter paper prior to AAS analysis. All glass wares and porcelain crucibles were soaked and sanitized in aqua regia of 1:1 analytical grade 37% HCl and 65% HNO_3 solution, subsequently rinsed with ultrapure water, and were air-dried for 12 hours prior to usage. Sample blanks were prepared in the similar way to the test samples for background correction. Standard solutions for Cd and Pb were prepared from stock solutions (100 ppm). The test solution samples were then analysed thrice for Cd and Pb using air acetylene Flame AAS (Perkin Elmer Analyser 100).Detected metals were expressed as mgl^{-1} wet weight (Suhaimi *et al.,* 2005).

RESULTS

Concentration of zinc was minimum 3.01(mgl^{-1}) during summer season and the maximum 18.73 (mgl^{-1}) during monsoon season at Station 1. Concentration of zinc was minimum 3.52 (mgl^{-1}) during post monsoon season and the maximum 25.63 (mgl^{-1}) during monsoon season at Station 2.

Table 1 Bioaccumulation of selected Heavy Metals in different Seasons and Organs at Station – I during the Present Study July 2011 to June 2012

Heavy metals (µg/g)	Season	Organ					Annual average
		Gill	Intestine	Liver	Kidney	Muscle	
Zn	Premonsoon	13.36	21.19	8.05	6.28	4.42	10.66
	Monsoon	39.81	64.26	12.26	8.21	5.61	26.03
	Postmonsoon	4.86	11.42	9.07	4.14	2.92	6.482
	Summer	4.92	13.37	5.02	2.88	2.62	5.762
	Total	62.95	110.24	34.4	21.51	15.57	48.802
Cr	Premonsoon	6.33	7.42	2.88	2.22	1.77	4.124
	Monsoon	10.88	6.99	5.11	3.25	2.23	5.692
	Postmonsoon	1.09	1.02	4.07	1.89	1.52	1.918
	Summer	1.66	1.22	3.88	2.25	2.76	2.354
	Total	19.96	16.65	15.94	9.61	8.28	14.088
Cu	Premonsoon	6.11	8.67	2.88	1.99	1.97	4.324
	Monsoon	8.22	8.99	3.98	2.27	4.55	5.602
	Postmonsoon	3.07	3.21	1.02	0.91	3.29	2.3
	Summer	2.99	2.28	0.82	0.68	3.96	2.134
	Total	20.39	23.09	8.7	5.85	13.77	14.36
Cd	Premonsoon	0.089	0.031	0.062	0.067	0.088	0.0674
	Monsoon	0.076	0.032	0.077	0.055	0.069	0.0618
	Postmonsoon	0.026	0.037	0.021	0.031	0.062	0.0354
	Summer	0.021	0.025	0.016	0.037	0.066	0.033
	Total	0.212	0.125	0.176	0.19	0.285	0.1976
Pb	Premonsoon	0.097	0.044	0.039	0.098	0.065	0.069
	Monsoon	0.017	0.031	0.069	0.039	0.058	0.0428
	Postmonsoon	0.026	0.041	0.058	0.068	0.077	0.054
	Summer	0.033	0.049	0.065	0.071	0.071	0.0597
	Total	0.173	0.165	0.231	0.273	0.273	0.2257

Table 2 Bioaccumulation of selected Heavy Metals in different Seasons and Organs at Station – II during the Present Study July 2011 to June 2012

Heavy metals (□g/g)	Season	Organ					Annual average
		Gill	Intestine	Liver	Kidney	Muscle	
	Premonsoon	24.38	55.27	13.54	11.24	9.99	22.884
	Monsoon	41.2	78.26	19.29	15.28	8.12	32.43
Zn	Postmonsoon	3.29	7.69	9.24	8.17	12.26	8.13
	Summer	12.21	14.11	8.55	6.44	4.44	9.15
	Total	81.08	155.33	50.62	41.13	34.81	72.594
	Premonsoon	6.52	7.61	2.57	2.62	3.28	4.52
	Monsoon	8.21	12.89	4.11	4.53	4.69	6.886
Cr	Postmonsoon	0.97	2.89	2.99	3.05	0.99	2.178
	Summer	3.01	4.99	1.69	0.94	1.31	2.388
	Total	18.71	28.38	11.36	11.14	10.27	15.372
	Premonsoon	16.37	22.04	4.23	5.99	6.01	10.928
	Monsoon	19.09	31.52	6.97	7.84	8.99	14.882
Cu	Postmonsoon	13.79	9.96	5.24	5.01	2.99	7.398
	Summer	9.01	14.28	5.21	2.92	2.72	6.828
	Total	58.26	77.8	21.65	21.76	20.71	40.036
	Premonsoon	0.87	0.59	0.99	0.68	0.44	0.714
	Monsoon	0.97	0.91	0.95	0.82	0.69	0.868
Cd	Postmonsoon	0.67	0.77	0.51	0.39	0.11	0.49
	Summer	0.08	0.09	0.51	0.43	0.08	0.238
	Total	2.59	2.36	2.96	2.32	1.32	2.31
	Premonsoon	0.033	0.047	0.051	0.061	0.099	0.0582
	Monsoon	0.047	0.059	0.67	0.078	0.094	0.069
Pb	Postmonsoon	0.103	0.091	0.069	0.084	0.071	0.0836
	Summer	0.129	0.103	0.099	0.091	0.084	0.1012
	Total	0.312	0.3	0.286	0.314	0.348	0.312

Concentration of Zinc was minimum 8.67(mgl^{-1}) during summer season and the maximum 40.85(mgl^{-1}) during monsoon season at Station 3. Muscle showed minimum accumulation of zinc and maximum concentration was found in the intestine. Minimum 1.85(mgl^{-1}) and maximum 4.89 (mgl^{-1}) values of chromium in fish tissues were recorded during summer and monsoon seasons at Station 1. Minimum 2.61 (mgl^{-1}) and maximum 7.71(mgl^{-1}) values of chromium in fish tissues were recorded during summer and monsoon seasons at Station2.

Minimum 0.18(mgl^{-1}) and maximum 3.51(mgl^{-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 0.02(mgl^{-1}) and maximum 6.01(mgl^{-1}) values of copper in fish tissues were recorded during summer and monsoon seasons at Station 1. Minimum 4.9(mgl^{-1}) and the maximum 18.87 (mgl^{-1}) values of Cu were recorded during the summer and monsoon seasons at Station2.

Table 3 Bioaccumulation of selected Heavy Metals in different Seasons and Organs at Station – III during the Present Study July 2011 to June 2012

Heavy metals (□g/g)	Season	Organ					Annual average
		Gill	Intestine	Liver	Kidney	Muscle	
	Premonsoon	37.29	18.22	9.21	4.37	3.79	14.576
	Monsoon	43.28	31.21	15.66	6.38	3.96	20.098
Zn	Postmonsoon	7.31	4.64	7.03	6.21	6.39	6.316
	Summer	11.63	9.72	2.55	2.89	1.07	5.572
	Total	99.51	63.79	34.45	19.85	15.21	46.562
	Premonsoon	3.51	4.21	3.34	2.19	0.39	2.728
	Monsoon	7.99	4.89	0.69	0.99	0.59	3.03
Cr	Postmonsoon	4.72	2.99	0.97	0.19	0.021	1.7782
	Summer	0.091	0.069	0.069	3.384	1.012	7.587
	Total	4.07775	3.03975	1.26725	0.846	0.253	1.89675
	Premonsoon	92.37	97.66	33.78	16.07	12.49	50.474
	Monsoon	123.6	116.17	28.78	16.39	23.17	61.622
Cu	Postmonsoon	72.26	71.22	19.23	15.33	19.7	39.548
	Summer	83.55	77.125	13.19	13.04	11.34	39.648
	Total	371.78	362.17	94.98	60.83	66.7	191.292
	Premonsoon	0.98	0.89	0.67	0.39	0.19	0.624
	Monsoon	2.39	2.67	1.37	1.29	1.14	1.772
Cd	Postmonsoon	0.91	0.31	0.61	0.69	0.94	0.692
	Summer	2.39	1.21	1.77	0.97	0.99	1.466
	Total	6.71	5.18	4.52	3.44	3.29	4.628
	Premonsoon	1.14	1.96	0.99	0.87	0.37	1.066
	Monsoon	1.68	0.89	0.31	0.37	0.99	0.848
Pb	Postmonsoon	1.97	1.21	0.69	0.39	2.11	1.274
	Summer	1.67	1.99	0.91	0.71	0.61	1.178
	Total	6.46	6.05	2.9	0.34	4.08	4.366

Minimum 14.42(mgl^{-1}) and maximum 92.7 (mgl^{-1}) were recorded during the 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 0.01(mgl^{-1}) during summer season and the maximum 0.04(mgl^{-1}) during monsoon season at Station1. Concentration of cadmium was minimum 0.3(mgl^{-1}) during summer season and the maximum 0.71(mgl^{-1}) during premonsoon season at Station 2. Concentration of cadmium was minimum 0.75(mgl^{-1}) during post monsoon season and the maximum 1.61(mgl^{-1}) during monsoon season at Station 3.Intestine showed minimum accumulation of cadmium maximum concentration was found in the gill. Concentration of Lead was minimum 0.01(mgl^{-1}) during summer season and the maximum 0.05(mgl^{-1}) during monsoon season at Station1. Concentration of Lead was minimum 0.06(mgl^{-1}) during summer season and the maximum 0.07(mgl^{-1}) during premonsoon season at Station 2. Concentration of Lead was minimum 0.52(mgl^{-1}) during post monsoon season and the maximum 1.58(mgl^{-1}) during monsoon season at Station 3. Kidney showed minimum accumulation of lead and the maximum concentration was found in the muscle. The analysed concentration of bio accumulation of heavy metals in fish, graphically represented in [Fig. 1 to Fig. 5]. Correlation Coefficient values was significant in these elected bioaccumulation of heavy metals in fish.

DISCUSSION

The present results agree with the work of Boronkai *et al.* (2005) who have reported that the cadmium is highly toxic non–essential heavy metal and it does not have a role in biological process in living organisms. Thus even in low concentration, cadmium could be harmful to living organisms. The levels of Cd present in the selected organs of freshwater fish may be due to industrial and agricultural operations in the investigated area (Ambedkar and Muniyan, 2011).

The similar results was observed by the Fernandes *et al.* (2007) who have reported that the chromium bioaccumulation in fish has been reported to cause impaired respiratory and osmoregulatory functions through structural damage to gill epithelium. The concentration of chromium levels in the different organs of the freshwater fish and their presence could be attributed to waste water discharge from the agricultural related activities that take place high in the study area (Prabhahar *et al,* 2012)

The results of the present study is also in line with Sivaperumal *et al.* (2007) who stated that the copper is an essential element that serves as a cofactor in a number of enzymes system and necessary for the synthesis of hemoglobin but very high intake of Cu can cause adverse health effect problems for most living organism. The highest levels of copper in the different tissues of selected fish organs may be due to the presence of domestic waste, agricultural and industrial waste in the study area.

The present results agree with the work of Malik *et al*. (2010) who have reported that Muscles are the main edible part of fish and can directly influence human health. Therefore, most researchers have established that toxicological limits for heavy metals in seafood (Pallakani *et al*., 2006). According to WHO (2005), the allowable concentration for Pb, Cd and Cu were 200, 50 and 10000 ppb, respectively. However, such food limits are not defined to all the elements (Gupta *et al*., 2009). In the present study, bioaccumulation of heavy metals in zinc and lead were more during monsoon season. Hence, the occurrence of high bioaccumulation levels of metal in fishes during monsoon season can be attributed to the background levels under the favourable physico-chemical conditions (Muraleetharan *et al.,* 2010).

Angelo *et al.* (2007) have reported that the other possible reason for high levels of heavy metals in fish tissues, during monsoon season may be attributed to the physiology of the fish, as these fishes showed higher feeding rates between the months October to December as the breeding season or prespawning period occurs between these months (Prabhahar *et al,* 2012).

The higher levels of metals in intestine can be attributed to the feeding habits of fish. Since the fish *Cyprinus carpio* is detritus feeder and feed either by sucking up the surface layer of the mud or by grazing on the rock surface leaving to the transfer of mineral particles into the system along with food. These sediments are usually enriched of metals than fishes that are Pelagic in nature (Agan *et al.,* 2009). The elevated levels of metals also can be attributed to the feeding habits. Since fish largely prey on invertebrates like crustaceans and molluses, which also accumulate heavy metals. Similar observations were also made by Malik *et al.* (2010).

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