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Research Article

Bioaccumulation of heavy metals in the common carp (*Cyprinus carpio*) in Vellar estuary, Mudasalodai and Muzhukuthurai coastal waters, Tamil Nadu, India

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Abstract

Heavy metal residues (Zn, Cu, Cr, Cd and Pb) were determined in chosen tissues common carp (*Cyprinus carpio* L.) from Vellar estuary, Mudasalodai and Muzhukuthurai coastal waters, Tamil Nadu, India. Bioaccumulation of metals exhibited spatio-temporal variations. In general, the accumulation was 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.

Keywords: Heavy metals, *Cyprinus carpio,* Bioaccumulation, Vellar estuary, Mudasalodai and Muzhukuthurai.

Introduction

Coastal and estuary 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 so. 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. In urban areas, the careless disposal of industrial effluents and other wastes in river and lakes may contribute greatly, to the poor quality of coastal water (Emongore *et al*., 2005). Among environmental pollutants, metals are of particular concern due to their potential toxic effect and ability to bioaccmulate in aquatic ecosystems (Censi *et al*., 2006). Heavy metals including both essential and nonessential elements have a particular significance in ecotoxicology, to be toxic to living organisms (Storelli *et al*., 2005). 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 (Saleshrani and Prabhahar, 2013). Fishes are notorious for their ability to concentrate heavy metals in their muscles and since they play important role in human 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 (Agash *et al*., 2009). The accumulation of heavy metals in freshwater ecosystems has been a major concern. Heavy metals generally enter the aquatic environment through natural (atmospheric deposition, erosion of geological matrix) or anthropogenic activities caused by industrial effluents, domestic sewage mining and agriculture wastes (Vutukuru, 2005). 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 are taken up by organisms including fish (Farombi *et al*., 2007).

The 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 (Osman *et al*., 2007). The 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. The 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 (Osman *et al*., 2007). Heavy metals are normal constituents of marine environment that occur as a result of pollution, principally due to the discharge of untreated 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 (Mansour and Sidky, 2002). The 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. Bioaccumulation (Ashraf, 2005) also showed that the concentration of metals was a function of fish species as it accumulates more in some fish species than others.

The metal pollution from multifarious sources like effluents from industries, agricultural runoff and untreated sewage system has adverse effects on aquatic ecosystem. The metal contamination in aquatic ecosystem is yet considered to be unsafe not only for the human beings, but also for the wild organisms. Fish living in the metal contaminated waters may accumulate toxic trace metals via their food. Heavy metals are taken up through different organs of fish because of the affinity between them. In this process, many heavy metals are concentrated at different levels in different organs of the body (Mendil and Uluozlu, 2007).

Materials and Methods

The common carp (*Cyprinus carpio*) is a widespread freshwater fish in eutrophic waters, estuary and rivers. The wild common carp are typically slimmer, domesticated forms, red flesh and forward protruding mouth. They can eat a vegetarian diet of water plant, but prefer to scavenge the bottom for insects, crustaceans, crawfish and benthic worms. It is omnivorous. The study was carried out at in Vellar estuary, Mudasalodai and Muzhukuthurai coastal water (St. I, St. II and St. III) at Parangipettai during the period July 2012 – June 2013. 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 100°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 $\mu g/g^{-1}$ metal per dry weight (Suhaimi *et al*., 2005).

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 4 hours. The dried samples were later ashed at 500°C for 12 hours inside a muffle furnace (THERMCONCEPT, Germany). The cooled ashes were digested with 1.5 mL of concentrated analytical grade 65% HNO3 (Merck Chemicals, Germany) 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 glasswares and porcelain crucibles were soaked and sanitized in aqua regia of 1:1 analytical grade 37% HCl and 65% HNO_3 (Merck Chemicals, Germany) 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 Analyst 100). Detected metals were expressed as mg/kg wet weight (Suhaimi *et al*., 2005).

Results and Discussion

The concentration of zinc was minimum (0.8 mg l^{-1}) during summer season and the maximum (32.91 mg l^{-1}) during pre monsoon season at station 1. The concentration of zinc was minimum (0.53 mg l^{-1}) during summer season and the maximum (30.12 mg l^{-1}) during pre monsoon season at station 2. The concentration of zinc was minimum (0.25 mg l^{-1}) during post monsoon season and the maximum (18.25 mg l^{-1}) during monsoon season at Station 3. Muscles showed minimum accumulation of zinc and maximum concentration was found in the intestine. Minimum (0.54 mg l^{-1}) and maximum (30.38 mg l^{-1}) values of copper in fish tissues were recorded during post monsoon and monsoon seasons respectively at station 1. Minimum (0.69 mg l^{-1}) and the maximum (29.5 mg l^{-1}) values of Cu were recorded during the post monsoon and pre monsoon seasons respectively at station 2. Minimum (0.16 mg l^{-1}) and maximum (23.90 mg l^{-1}) were recorded during the post monsoon and monsoon seasons respectively at station 3. Kidney showed minimum accumulation of copper and maximum concentration was found in the intestine. The analyzed bioaccumulations of heavy metals in the coastal water during different seasons were geographically represented in Figs. 1 to 5. ANOVA between heavy metals in the coastal water showed a significant value whereas with in the metals significant. Correlation coefficient for the bioaccumulation of heavy metals in the coastal water shows a significant values whereas, within the metals insignificant. The concentration of cadmium was minimum (1.10 mgl^{-1}) during post monsoon season and the maximum (1.61 mgl^{-1}) during monsoon season at station1. The concentration of cadmium was minimum (1.16 mg l^{-1}) during monsoon and the maximum (1.27 mg l^{-1}) during post-monsoon season at station 2. The concentration of cadmium was minimum (0.31 mg l^{-1}) during summer season and the maximum (0.93 mg l^{-1}) during pre monsoon season at station 3. Intestine showed minimum accumulation of cadmium and maximum concentration was found in the gill.

The concentration of lead was minimum (0.15 mg l^{-1}) during summer season and the maximum (0.71 mg l^{-1}) during pre monsoon season at station1. The concentration of Lead was minimum (0.55 mg l^{-1}) during summer season and the maximum (1.65 mg l^{-1}) during pre-monsoon season at station 2. The concentration of lead was minimum (0.7 mg l^{-1}) during post monsoon season and the maximum (0.82 mg l^{-1}) during monsoon season at station 3.

The kidney showed the minimum accumulation of lead and the maximum concentration was found in the muscle. In the present study, significant positive correlations in Zn, Pb, Fe, Cu and Cd were studied. The remaining factors studied are negatively associated with it. The heavy metals in fish tissues during monsoon season may be attributed to the physiology of the fish, as these fishes shows higher feeding rates between the months October to December as the breeding season or prespawning period occurs between these months (Angelo *et al*., 2007). The cadmium is highly toxic non–essential heavy metal and it does not have a role in biological process in living organisms (Prabhahar *et al*., 2011). Thus even in low concentration, cadmium could be harmful to living organisms. The levels of Cd present in the selected organs of five freshwater fish may be due to industrial and agricultural operations in the investigated area (Ambedkar and Muniyan, 2011). 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 investigated area (Fernandes *et al*., 2007). The copper is an essential element that serves as a cofactor in a number of enzymes systems 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 species may be due to the presence of domestic waste, Agricultural and industrial waste in the study area (Azarbad *et al*., 2002; Baskaran and Prabhahar, 2013). The 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

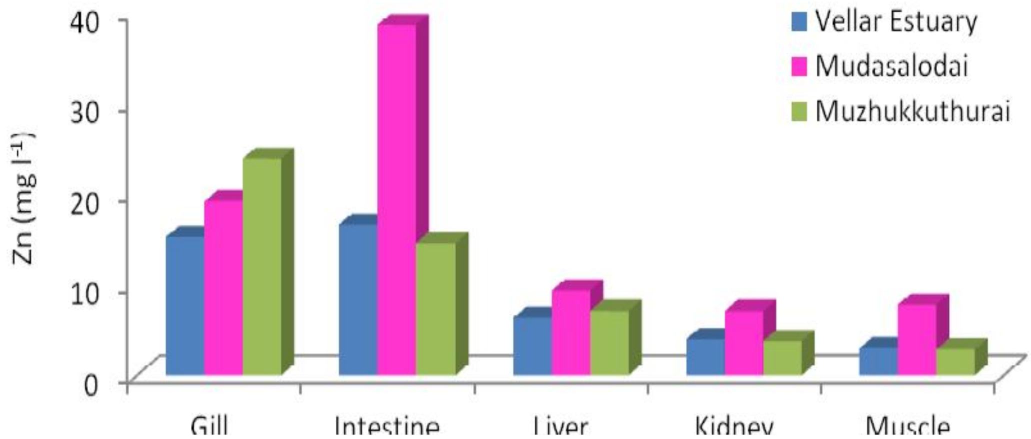

Fig. 1. Showing the annual average organs values of selected heavy metals zinc in different organs of fish at selected station 1, station 2 and station 3 from July 2012 to June 2013

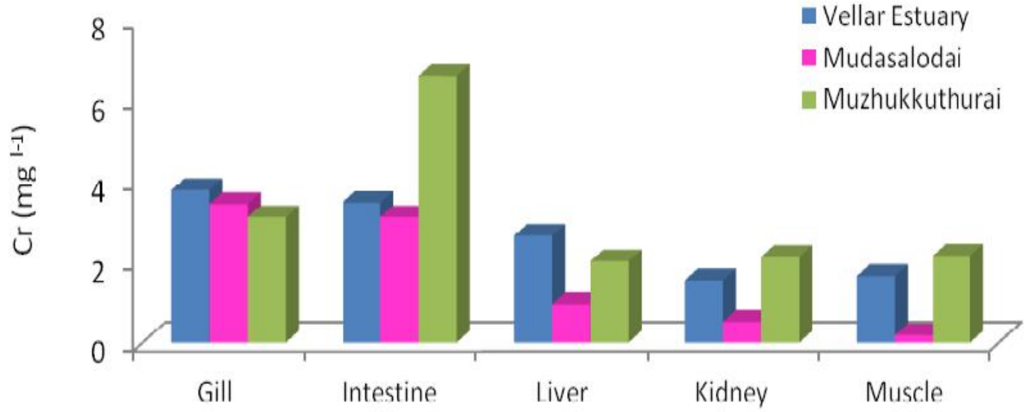

Fig. 2. Showing the annual average organs values of selected heavy metals chromium in different organs of fish at selected station 1, station 2 and station 3 from July 2012 to June 2013

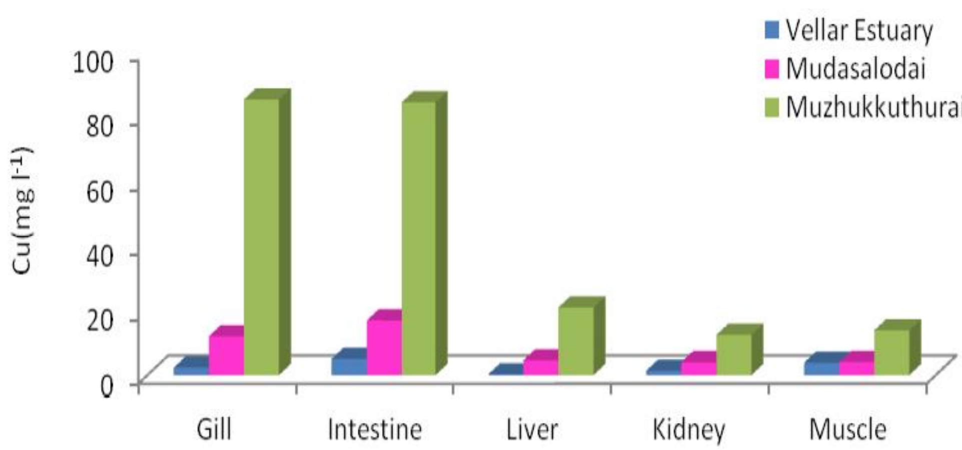

Fig. 3. Showing the annual average organs values of selected heavy metals copper in different organs of fish at selected station 1, station 2 and station 3 from July 2012 to June 2013

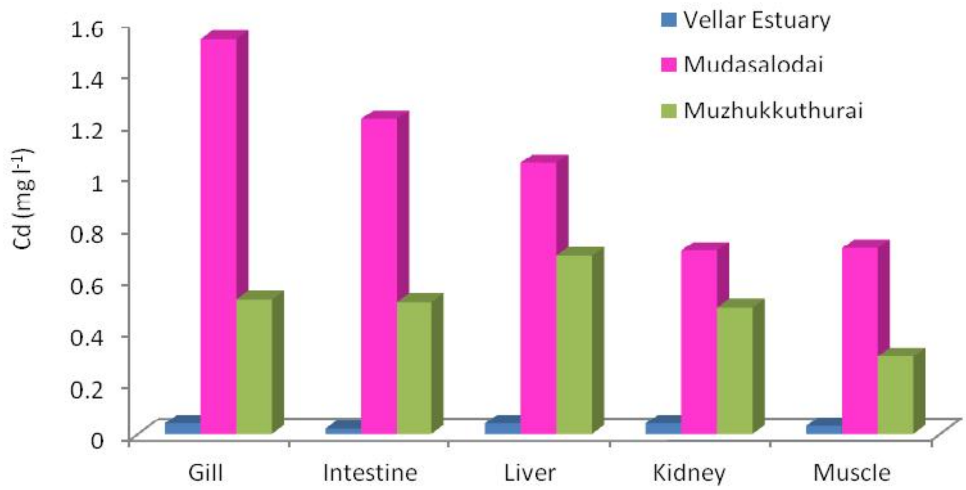

Fig. 4. Showing the annual average organs values of selected heavy metals cadmium in different organs of fish at selected station 1, station 2 and station 3 from July 2012 to June 2013

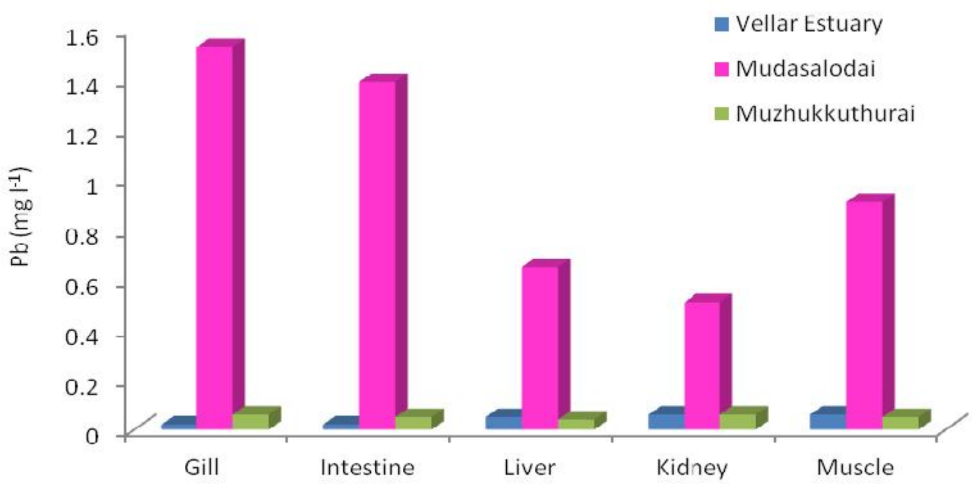

Fig. 5. Showing the annual average organs values of selected heavy metals lead in different organs of fish at selected station 1, station 2 and station 3 from July 2012 to June 2013

background levels under the favourable physico-chemical conditions (Malik *et al*., 2010; Muraleetharan *et al*., 2010).

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