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Bioaccumulation of heavy metals in organs of fresh water fish *Cyprinus carpio* (Common carp)

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ABSTRACT: The objective of the present study is to determine the bioaccumulation of heavy metals in various organs of the fresh water fish exposed to heavy metal contaminated water system. The experimental fish was exposed to Cr, Ni, Cd and Pb at sublethal concentrations for periods of 32 days. The elements Cd, Pb, Ni and Cr were assayed using Shimadzu AA 6200 atomic absorption spectrophotometery and the results were given as µg/g dry wt. The accumulation of heavy metal gradually increases in liver during the heavy metal exposure period. All the results were statistically significant at $p < 0.001$. The order of heavy metal accumulation in the gills and liver was Cd > Pb > Ni > Cr and Pb > Cd > Ni > Cr. Similarly, in case of kidney and flesh tissues, the order was Pb > Cd > Cr > Ni and Pb > Cr > Cd > Ni. In all heavy metals, the bioaccumulation of lead and cadmium proportion was significantly increased in the tissues of *Cyprinus carpio* (Common carp).

Key words: *Toxicity, pollutants, exposure period, gills, liver, kidney, flesh*

INTRODUCTION

The contamination of fresh waters with a wide range of pollutants has become a matter of concern over the last few decades (Vutukuru, 2005; Dirilgen, 2001; Voegborlo *et al.*, 1999; Canli *et al.*, 1998). The natural aquatic systems may extensively be contaminated with heavy metals released form domestic, industrial and other man-made activities (Velez and Montoro, 1998; Conacher, *et al.*, 1993). Heavy metal contamination may have devastating effects on the ecological balance of the recipient environment and a diversity of aquatic organisms (Farombi, *et al.*, 2007; Vosyliene and Jankaite, 2006; Ashraj, 2005). Among animal species, fishes are the inhabitants that cannot escape from the detrimental effects of these pollutants (Olaifa *et al.*, 2004; Clarkson, 1998; Dickman and Leung, 1998). Fish are widely used to evaluate the health of aquatic ecosystems because pollutants build up in the food chain and are responsible for adverse effects and death in the aquatic systems (Farkas *et al.*, 2002; Yousuf and El-Shahawi, 1999). The studies carried out on various fishes have shown that heavy metals may alter the physiological activities and biochemical parameters both in tissues and in blood (Basa and Rani, 2003; Canli, 1995; Tort and Torres, 1988). The toxic effects of heavy metals have been reviewed, including bioaccumulation (Waqar 2006; Adami *et al.*, 2002; Rasmussen and Anderson, 2000; Rani, 2000; Aucoin *et al.*, 1999). The organisms developed a protective defense against the deleterious effects of essential and inessential heavy metals and other xenobiotics that produce degenerative changes like oxidative stress in the body (Abou EL-Naga *et al.*, 2005; Filipovic and Raspor, 2003). Cichlidae species are the most popular and highly economic fish. In the present research, *Cyprinus carpio* (Common carp) was selected due to its adoption in polluted aquatic environment. The purpose of this research is to quantify the accumulation of heavy metals in various organs in *Cyprinus carpio* (Common carp).

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MATERIALS AND METHODS

The freshwater *Cyprinus carpio* (Common carp) (10-13 cm length and 35.70 ± 0.60 g) was collected from ponds of southern districts of Tamilnadu, India, and was acclimated to laboratory conditions for a week. The 12 h photo period was maintained throughout the experimental work. Twenty to twenty-five individuals were used for the experiments. The fish was fed with standard powdered feed and were starved for 24 h prior to the experimentation. Analytical graded cadmium

chloride, lead nitrate, potassium chromate and nickel sulphate supplied by BDH (in India) was used as the metal toxicant in this experiments. Fish were divided into five groups, with the first group serving as control and other groups as experimental groups. The experimental groups were administered with a sublethal concentration of 5 ppm of combined metal solution ($1/10^{th}$ of LC_{50} / 48 h) daily for 1, 8, 16 and 32 days. Fish from each group were dissected to separate organs (flesh, gills, liver and kidney) according to FAO methods (Dybem, 1983). The separated organs were put in petri dishes to dry at 120 °C until reaching a constant weight. The separated organs were placed into digestion flasks and ultrapure concentrated nitric acid and hydrogen peroxide (1:1 v/v) (SD fine chemicals) was added. The digestion flasks were then heated to 130^0C until all the materials were dissolved. Digest was diluted with double distilled water appropriately. The elements Cd, Pb, Ni and Cr were assayed using Shimadzu AA 6200 atomic absorption spectrophotometer and the results were given as µg/g dry wt. For cadmium and lead a palladium-magnesium nitrate matrix modifier was employed. The detailed analytical procedures for metal determinations were given in the literature (Ritterhoff and Zauke, 1997). Data obtained from the experiments were analyzed and the results were expressed as mean ± S.D. The results were evaluated using Student's t-test. Values of $p < 0.001$ were considered statistically significant.

RESULTS AND DISCUSSION

The heavy metals such as chromium (Cr), nickel (Ni), cadmium (Cd) and lead (Pb) were analyzed in different organs like gills, liver, kidney and flesh of the control fish surviving in natural water system. The accumulation of heavy metals in fish species were analyzed at the end of the experimental period and compared with the experimental fish, which were exposed to the selected heavy metals (Table 1). The gill is an important site for the entry of heavy metals that provokes lesions and gill damage (Bols *et al.*, 2001; Lock and Overbeeke, 1981). The range of Cr was 2.25 ± 0.05 – 3.566 ± 0.015, Ni was 3.17 ± 0.075 – 3.938 ± 0.035, Cd was 6.23 ± 0.041 – 6.938 ± 0.025 and Pb was 4.28 ± 0.025 – 4.996 ± 0.0255 µg/g dry wt, respectively during initial to 32 days of exposure. The results indicate that lead and cadmium accumulation was relatively higher than other metals in gills (Fig. 1). The liver accumulates relatively higher amounts of heavy metals. The range of Cr was 2.663 ± 0.031 – 4.273 ± 0.015, Ni was 3.750 ± 0.026 – 4.80 ± 0.025, Cd was 4.816 ± 0.015 – 5.643 ± 0.012 and Pb was 7.336 ± 0.032 – 8.743 ± 0.031µg/g dry wt, respectively. The results indicate that the heavy metal accumulation gradually increases during the exposure period (Fig. 2). The higher accumulation in liver may alter the levels of various biochemical parameters in liver. This may also cause severe liver damage (Ferguson, 1989; Mayers and Hendricks, 1984). Kidney is the gateway for heavy metal detoxification in body. In kidney tissue, considerable amounts of heavy metals were accumulated. The range of Cr was 2.773 ± 0.031 – 3.233 ± 0.031, Ni was 1.873 ± 0.025 – 2.426 ± 0.025, Cd was 4.310 ± 0.026 – 5.320 ± 0.026 and Pb was 6.333 ± – 6.943 ± 0.015 µg/g dry wt, respectively. These results indicate that lead and cadmium strongly accumulated rather than chromium and nickel in kidney (Fig. 3). Flesh is one of the ultimate parts for heavy metal accumulation. The range of Cr was 1.543 ± 0.021 – 2.143 ± 0.015, Ni was 0.146 ± 0.015 – 1.613 ± 0.031, Cd was 1.110 ± 0.017 – 1.653 ± 0.021 and Pb was 2.056 ± 0.025 – 2.730 ± 0.010 µg/g dry wt, respectively. The heavy metals were uniformly spread over the body muscles. Hence, the observed values were relatively lower than the other potential organs. The presence of higher amounts of heavy metals in any parts of the body will definitely induce changes in biochemical metabolisms and other induced stresses (Fig. 4). Studies on the accumulation of heavy metals in various organs of the fresh water fish exposed to sublethal concentrations were very much important.

Table 1: Heavy metal analysis in the different organs of control fish (µg/g.d.wt)

Heavy metals	Gills	Liver	Kidney	Flesh
Cr	0.790 ± 0.026	0.863 ± 0.015	0.943 ± 0.021	1.083 ± 0.021
Ni	1.043 ± 0.021	0.973 ± 0.021	0.790 ± 0.010	0.633 ± 0.015
Cd	1.883 ± 0.015	1.693 ± 0.015	1.166 ± 0.015	0.646 ± 0.025
Pb	1.400 ± 0.020	2.000 ± 0.017	1.900 ± 0.020	1.460 ± 0.036

Note: The values were statistically significant at $p < 0.001$.

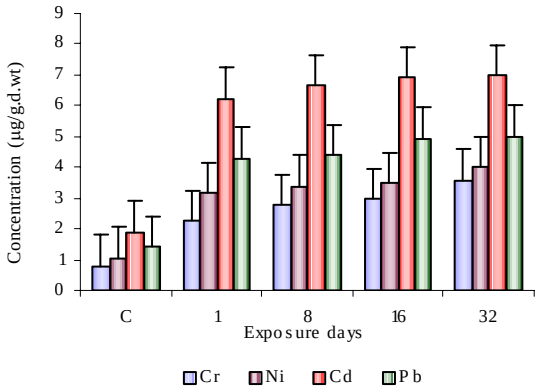

Fig. 1: Accumulation of heavy metals in gills

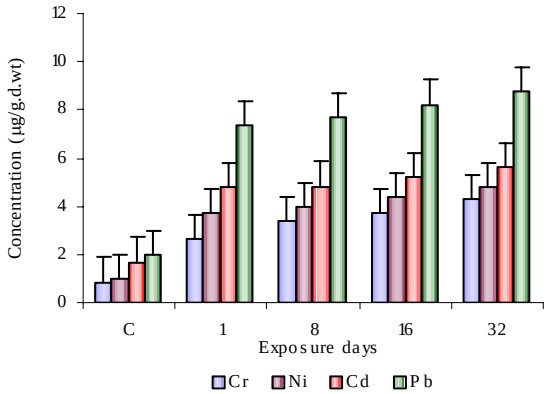

Fig. 2: Accumulation of heavy metals in liver

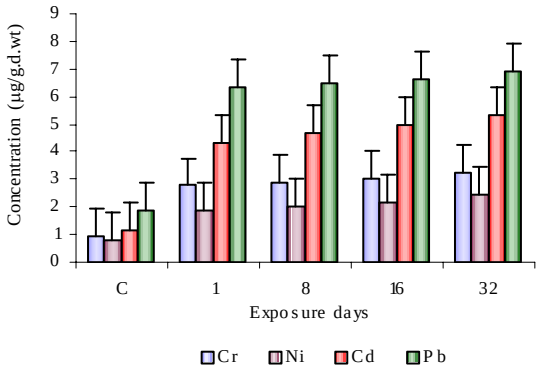

Fig. 3: Accumulation of heavy metals in kidney

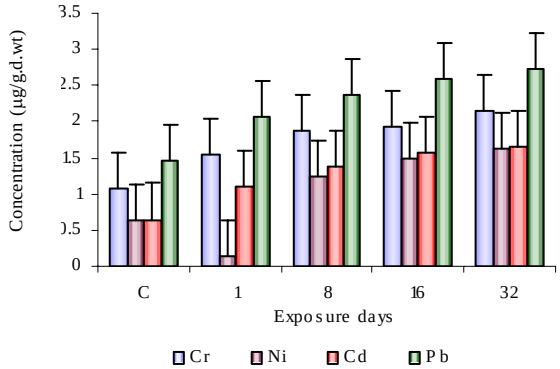

Fig. 4: Accumulation of heavy metals in flesh

The information can be used to evaluate the biochemical changes in the fish metabolism. In this study, the order of heavy metal accumulation in the gills and liver was Cd > Pb > Ni > Cr and Pb > Cd > Ni > Cr. Similarly, in case of kidney and flesh tissues, the order was Pb > Cd > Cr > Ni and Pb > Cr > Cd > Ni. In all heavy metals, the bioaccumulation of lead and cadmium proportion was significantly increased in the tissues of *Cyprinus carpio* (Common carp). Nickel and chromium produce a combined effect in altering the metabolic functions of the fresh water fish. The result indicates that the heavy metal contamination definitely affects the aquatic life of the fresh water fish. Hence, a scientific method detoxification is essential to improve the health of these economic fish in any stressed environmental conditions. Further research studies on the variations in antioxidant enzyme system, due to the influence of heavy metal toxicity in the affected fish, have to be evaluated.

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