

ORIGINAL ARTICLE

HEAVY METAL TOXICITY AND BIOACCUMULATION OF CHROMIUM IN FRESH
WATER FISH, *CATLA CATLA*

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ABSTRACT

Heavy metal Chromium is a common pollutant from tannery industries and it is directed into freshwater bodies which in turn taken part in biological magnification through food chain. It is frequently found in high concentration in freshwater fishes. The present study is undertaken to gauge the accumulation of chromium in the organs of *Catla catla*, when the fingerlings of *catla catla* is subjected to sub lethal dosage of effluent chromium for the period of 10, 20, 30 days in controlled environment. The tissues of gill, liver and kidney were subjected to Atomic Absorption spectroscopy for assessing the amount of chromium found in tissues at the end of 10, 20 and 30 days. Maximum concentration of chromium was accumulated in the liver and kidney. The minimum accumulation was found in gill. *Catla catla* is used to us bioindicators because it tends to accumulate heavy metals and so their effects. As it is edible fish, this findings urges greater regulations for industrial effluent discharge

Keywords: Heavy Metal toxicity, Bioaccumulation, *Catla catla*

1. INTRODUCTION

The *catla catla* is one of the Indian major carps and extensively consumed by the people in India. *Catla catla* is cultured in maximum part of the India. It can tolerate wide range of a temperature and has a higher survival level. But it is highly susceptible to aquatic pollutant in general and heavy metals in particular. Present study aim on the estimate of accumulation of chromium in the tissues of *Catla catla*.

2. MATERIALS AND METHODS

Live fingerlings of *Catla catla* were collected from fish farm from Poondi Reservoir and acclimated in the laboratory for a month in the tank. Two batches were maintained as control and experimental. The experimental pages were subjected to sub lethal dose of filtered effluent chromium. A batch of *catla catla* was sacrificed after 10, 20 and 30 days. Finally the tissue sample were collected and prepared and subjected to Atomic Absorption Spectroscopy (AAS) as per the method of (Curry *et al.*, 1969). Accordingly 5mg of tissue was taken in a 125ml Erlenmeyer Flask and glass beads were added with 25ml of deionized water, then 10ml of the sample was mixed

with 1:1 conc. HNO₃ and HClO₄. The sample was boiled until the solution was clear and subsequently transferred to a 100ml volumetric flask and diluted with deionized water. The

chromium concentration in the tissues were measured with a Carlzeiss Jena and modal AAS3 Atomic Absorption Spectrophotometer by direct aspirations of the solution into a nitrous oxide acetylene flame (Singhanan *et al.*, 1996). The tissues of gill, liver and kidney were isolated from the experimental fish and subjected to standard histological technique of Culling (1974). For this purpose the tissue were fixed in Bouin's fixative (Formaldehyde 15ml + picric acid 80ml + acetic acid 5ml) for 24 hours, dehydrated, cleared, sectioned to have 4-6 micron thickness. The slides were stained and selected parts were photographed using Carl Zeiss photo microscope.

3. RESULT

Bioaccumulation of chromium in gill, liver and kidney

The chromium concentrations accumulated in the tissues of gill, liver and kidney of the fish, exposed to various concentrations (0.1%, 0.3%, 0.5% & 0.7%) for the period of 10, 20 and 30 days is tabulated.

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Table : 1 Mean concentration \pm SD(μ g) of chromium in the tissues of *catla catla* exposed to different concentration of filtered tannery effluent for ten days

Sample	Control	Treatments Mean \pm SD			
		0.1%	0.3%	0.5%	0.7%
Gill	0.054 \pm 0.04	0.462 \pm 0.08	0.640 \pm 0.03	0.7644 \pm 0.05	0.6244 \pm 0.62
Liver	0.196 \pm 0.06	0.748 \pm 0.32	0.983 \pm 0.16	1.073 \pm 0.32	1.423 \pm 0.35
Kidney	0.147 \pm 0.44	0.660 \pm 0.33	0.890 \pm 0.43	0.994 \pm 0.83	1.212 \pm 0.03
Total uptake	0.397	1.870	2.513	2.831	3.259

The mean concentration \pm SD(μ g/g) of chromium in the gill, liver and kidney tissues exposed to 0.1% of effluent for 10 days is observed to be 0.462 \pm 0.08, 0.748 \pm 0.32 & 0.660 \pm 0.33 respectively. The mean chromium concentration \pm SD(μ g/g) in the tissues exposed to 0.3% effluent concentration for 10 days is noticed to be 0.640 \pm 0.03, 0.983 \pm 0.16 & 0.890 \pm 0.43 respectively. The mean chromium concentration \pm SD(μ g/g) in tissues exposed to 0.5% effluent concentration for 10 days are 0.764 \pm 0.05, 1.073 \pm 0.32 & 0.994 \pm 0.83 respectively. The mean chromium concentration \pm SD(μ g/g) in tissues exposed to 0.7% effluent concentration for 10 days are found to be 0.624 \pm 0.62, 1.423 \pm 0.35 & 1.212 \pm 0.03. The chromium found in the control tissues exposed for 10 days are 0.054 \pm 0.04 μ g/g, 0.196 \pm 0.06 μ g/g & 0.147 \pm 0.44 μ g/g. The total uptake of chromium in all tissues exposed to 0.1%, 0.3%, 0.5% & 0.7% & control for 10, 20 & 30 days are 1.870 (μ g/g), 2.513 (μ g/g), 2.831 (μ g/g), 3.259 (μ g/g) & 0.397 (μ g/g) respectively (Table 1)

Table : 2 Mean concentration \pm SD(μ g) of chromium in the tissues of *catla catla* exposed to different concentration of filtered tannery effluent for 20 days

Sample	Control	Treatments Mean \pm SD			
		0.1%	0.3%	0.5%	0.7%
Gill	0.062 \pm 0.04	0.512 \pm 0.03	0.742 \pm 0.12	0.812 \pm 0.08	0.673 \pm 0.12
Liver	0.318 \pm 0.42	0.872 \pm 0.08	1.032 \pm 0.10	1.582 \pm 0.32	1.824 \pm 0.34
Kidney	0.162 \pm 0.07	0.848 \pm 0.07	1.012 \pm 0.23	1.124 \pm 0.12	1.243 \pm 0.14
Total uptake	0.542	2.232	2.786	3.618	3.740

Mean chromium concentrations \pm SD(μ g/g) in the tissues of gill, liver and kidney exposed to 0.1% for 20 days are 0.512 \pm 0.03, 0.872 \pm 0.08 & 0.848 \pm 0.07. Similarly the mean chromium concentrations \pm SD (μ g/g) in the tissues exposed to 0.3% concentrations for 20 days are 0.742 \pm 0.12, 1.032 \pm 0.10 & 1.012 \pm 0.23. Likewise the mean chromium concentrations \pm SD (μ g/g) in the tissues exposed to 0.5% concentration for 20 days are 0.812 \pm 0.08, 1.582 \pm 0.32 & 1.124 \pm 0.12. Similarly the mean chromium concentrations \pm SD(μ g/g) in the tissues exposed to 0.7% concentrations for 20 days are 0.673 \pm 0.12, 1.824 \pm 0.34 & 1.243 \pm 0.14. The mean chromium concentrations \pm (μ g/g) in the tissues of control are 0.062 \pm 0.04, 0.318 \pm 0.42 & 0.162 \pm 0.07. Finally the total uptaking all tissues exposed to 0.1%, 0.3%, 0.5% & 0.7% effluent concentrations and control are 2.232 (μ g/g), 2.786 (μ g/g), 3.618 (μ g/g), 3.740 (μ g/g) & 0.542 (μ g/g) respectively (Table 2).

Table :3 Mean concentration \pm SD(μ g) of chromium in the tissues of *catla catla* exposed to different concentration of filtered tannery effluent for 30 ten days

Sample	Control	Treatments Mean \pm SD			
		0.1%	0.3%	0.5%	0.7%
Gill	0.067 \pm 0.03	0.582 \pm 0.41	0.826 \pm 0.72	0.852 \pm 0.05	0.710 \pm 0.07
Liver	0.289 \pm 0.05	0.924 \pm 0.28	1.435 \pm 0.21	1.642 \pm 0.03	1.973 \pm 0.02
Kidney	0.348 \pm 0.12	0.868 \pm 0.43	1.123 \pm 0.54	1.329 \pm 0.48	1.478 \pm 0.32
Total uptake	0.704	2.374	3.384	3.823	4.161

The mean chromium concentration \pm SD (μ g/g) in the tissues of gill, liver and kidney exposed to 0.1% for 30 days are 0.582 \pm 0.41, 0.924 \pm 0.28 & 0.868 \pm 0.43 respectively. The mean chromium concentrations \pm SD (μ g/g) in the tissues

exposed to 0.3% for the period of 30 days are 0.826 \pm 0.72, 1.435 \pm 0.21 & 1.123 \pm 0.54. The mean chromium concentrations \pm SD (μ g/g) in the tissues exposed to 0.5% for 30 days are 0.852 \pm 0.05, 1.642 \pm 0.03 & 1.329 \pm 0.48. In the same way the mean chromium concentration \pm SD (μ g/g) in the tissues exposed to 0.7% for 30 days are 0.710 \pm 0.07, 1.973 \pm 0.02 & 1.478 \pm 0.32. The total chromium uptake in all tissues exposed to 0.1% , 0.3%, 0.5%, 0.7% effluent concentration and control for 30 days are 2.374 (μ g/g), 3.384 (μ g/g), 3.823 (μ g/g), 4.161 (μ g/g) & 0.704 (μ g/g) respectively (Table 3).

4.DISCUSSION

In the river, fish are often at the top of the food chain and have the tendency to concentrate heavy metals from water (Mansour and Sidky, 2002). Therefore bioaccumulation of heavy metals in fish can be considered as an index of metal pollution in aquatic bodies (Javid, 2005; Tawari-Fufeyin and Ekaye, 2007; Karadde-Akin and Unlu, 2007) that could be a useful tool to study the biological role of metals present at higher concentrations in fish(Dural et al., 2007). In the present study, accumulation of chromium is high in liver and kidney and the minimum accumulation of chromium is found in the gill Dural et al., (2007) and Ploetz et al., (2007) reported highest level of Cadmium, Lead, Copper, and Zinc in the liver of fish species viz., *Mugil cephalus* and *Sparus aurea*. Yilmaz et al., (2007) reported that in *Leutiscus cephalus* and *Lefornis gibbosus* Cadmium, Cobalt and Copper accumulations in the liver and gill were maximum while these accumulations were least in the fish muscle. The higher levels of trace elements such as Lead, and Chromium in liver related to other tissue may be attributed to the affinity of metallothionein protein with these elements (IKEM et al., 2003) and consequently interfere with the metabolism. By exposing fingerlings of *Catla catla*, *Labeo rohita* and *Cirrhinus mrigala* to sub lethal concentration of manganese for 30 days, Hayat et al., (2007) proved negative growth with weight decrement value of -0.22, -0.72 and -3.90 grams respectively in them. Furthermore they concluded that stressed major carps under sub-lethal concentrations of manganese showed significantly lower values of weight and total length than control fish in semi intensive culture system. Fish fauna are good bioaccumulators and they concentrate metals to a level that makes them easier to deduct. The ultimate level of pollutant that entered in to an organism is governed by the ability of the organism to extract the pollutant and store the same. However, physiological processes, exists specifically for regulating and removing such interfering cat ions so that the accumulation of metals in different organs represents the end product of detoxification process. The overall factors influencing the accumulation and concentration of metals in an aquatic medium can be due to absorption of ions on membrane interface (Romesil, 1995) as it happens in gills and other tissue samples. Chromium has preferred for ligands such as nitrogen, oxygen and sulphur. The tissue load of chromium increases with increased duration of exposure to the metal in all the tissues, studied. Since the liver is endowed with a variety of kinetic traps, the accumulation proceeds by a cascade of binding to ligands of ever increasing strength. Uptake, distribution in the tissues and retention of chromium in this study reveals the same pattern as in rainbow trout, *salmo gairdneri* (Putte et al.,

1981). The high accumulation of chromium in the liver and kidney of the treated fish suggest, that Chromium (III) bound to proteins in the effluent may be responsible for the above accumulation and the fact that the liver accumulated the highest concentration of chromium in all the treatments may be due to the uptake, which is the primary route of accumulation as suggested by Andrew and O' Halloran (1997). Therefore the soluble Chromium (III) proteins would have to be initially converted in to particulate from prior to the uptake. Depending on the routes of uptake, the metals come in to contact with different tissues before reaching the major sites of detoxification and the metals may thus interact with other cellular molecules, before being sequestered by metallothioneins. Most of the degradation of metallothioneins has been shown to occur in the liver, hence in the present study, liver revealed maximum accumulation or concentration of chromium. Sobha et al., (2007) evaluated toxicity of cadmium and its impact on the biochemical constituents like glucose, glycogen total proteins, lipid and free amino acids in the edible carp *Catla catla* using acute toxicity test for 96 hours. They performed Cacl2 toxicity experiment on the fingerlings and LC50 was determined using simple and probit graphics and regression. They also recorded significant fall in all the biochemical constituents in muscle, gill, liver, heart and kidney excepting the glucose prompting to suggest that fish cultured in the aquatic ecosystem close to industrial locations would not have expected nutritive value. The elevated levels of glucose are apparently indicative of the organism's response to the toxicant stress. Kidneys also accumulated the highest concentration of chromium next to liver. Since kidney is also rich in sulphhydryl groups, chromium binds with these ligands. It accounts for higher concentration of chromium in the kidney. Liver and Kidney are thus capable of acting as diverse sites for chromium accumulation. An increase in Sodium and Potassium level in the haemolymph of prawn was mainly due to the accumulation of the metal ions in the kidney (Vijayaramanan, 1998). Gills, although a primary route of uptake (Simkiss et al., 1982; and Wicklund –Glynn et al., 1992) accumulated only little amounts of chromium. Some form of ligand exchange for chromium(III) occurs in fish tissues subsequent to the uptake of chromium and this appears particularly evident in the gills, such a process has been proposed for cadmium –organic complexes(George and Coombs, 1977) and whether such complexes exist for chromium(III) has to be elucidated. Atomic absorption spectroscopic and electrohoretic analysis of Jyotsna Singh et al., (2008) disclosed the accumulation of heavy metal Cadmium in the fish tissues of liver, gill, muscle and kidney when exposed sub lethal dose (Cadmium) for a period of 15 to 60 days in controlled environment of aquaria. Accordingly the tissues of Mrigala are more resistant to accumulation of Cadmium than those of Catla and maximum accumulation is found in the gills and liver, followed by muscle while minimum accumulation was seen in kidneys. The present study also confirms that the concentration of chromium in the muscle tissue of the treated fish is much lower than in other organs and it coincides with the report of (Sinha et al., 2002). A significant content of chromium in some of the tissues of fish may indicate that its restraint capacity has been exceeded (Pereira, 1995). Chromium (III) has been shown to be available to fish and its predominance in the effluent indicates a possible role in the accumulation of chromium observed in the present study.

However, chromium (III) is insoluble in water and the reason for enhanced solubility appears to be ligation with dissolved protein across the membrane. The source of protein may be residual dissolved protein or bating enzymes leaching from the hide. It appears that during the mixing process, the organic ligands complete with hydroxyl groups for the ionic chromium (III) present resulting in the formation of dissolved organic chromium (III). This form of chromium (III) permeates through the membranes. Similarly Rauf (et al., 2009) revealed various concentrations of heavy metals in different tissues/organ. Accordingly fish liver appeared to have significantly higher tendency for the accumulation of Cadmium and Chromium, while gills had minimum concentration of these metals. Thus the accumulation of the heavy metal, chromium in the different organs reveals the following sequence: Liver> Kidney > and Gill. Accumulation of chromium is least regulated by the fish species and hence the tissues such as liver, kidney, intestine, gill and muscles are susceptible to pathogenicity or damage. Chromium thus has a preferential site of accumulation, susceptibility limiting its transfer to other organs. Chromium though present in traces and being lipophilic tends to bio accumulate and biomagnify and causes toxic effects. Hence, precautions need to be observed as these fish species are extensively used for human consumption. Current finding also urges either greater regulation of industrial effluents or resorting to alternate fish species which can metabolize these heavy metals.

REFERENCES

- Andrew, R.Walsh, and John O' Halloran (1997) the accumulation of chromium by mussels, *Mytilus edulis* as a function of valency, solubility and Ligation. *Marine. Environ. Res.*, 23(2):41-53.
- Curry A.S., Read J.F and Knott A.R (1969): *Analyst* - 94.746.
- Dural, M., M.Z.L., Goksu and A.A. Ozak, (2007) , Investigation of heavy metal levels in economically important fish species captured from the Tuzla Lagoon, *Food Chem.*, 102:415-421.
- George, S.G., Pirie, B.J.S., and Coombs, T.L (1976), the kinetics of accumulation and exertion of ferric hydroxide in *Mytilus edulis* and its distribution in the tissues. *J.Exp. Mar.Biol.Ecol.*, 23 71-84.
- Hayat, S., M .Javed and S.Razzaq, (2007) Growth performing of metal stressed major carps viz., *Catla catla*, *Labeo rohita* and *Cirrhinus mrigala* reared under semi-intensive cultur system, *Pakistan Vet. J.*, 27(1):8- 12.
- Ikem, A., N.O. Egiebor and K. Nyavor, (2003.), Trace elements in water, fish and sediments from Tuskegee Lake, Southeastern USA. *Water Air Soil. Pollut.*, 149:51-75.
- Javed, M., 2005. Heavy metal contamination of freshwater fish and bed sediments in the river Ravi stretch and related tributaries .*Pakistan. J.Biol.Sci.*8 (10):1337-1341.
- Jyotsna Singh, K.Kant, H.B.Sharma and K.S.Rana, (2008), Bioaccumulation of Cadmium in tissues of *Cirrhinus mrigala* and *Catla catla*. *Asian J.Exp.Sci.*, Vol, 22, No.3; 411-414.
- Karadede-Akin, H. and E. Unlu, (2007), Heavy metal concentration in water, sediments, fish and some benthic organisms from Tigris River, Turkey. *Environ. Monit.Assess.* 131:323-337.

- Mansour, S.A. and M.M.Sidky, (2002), Ecotoxicological studies. 3: Heavy metals contaminating water and fish from Fayoum Governorate, Egypt. Food Chem., 78:15-22.
- Pereria, J.C (1995) Avaliacao da contamination domeio ambiente por metais pesados Na regio do vale do Aco (MG). Department of Quimica; University Federal de Vicoso, Tese de Mestrado: 117.
- Ploetz, D.M., B.E. Fitts and T.M. Rice, 2007, Differential accumulation of heavy metals in muscles and liver of a marine fish(King Mackerel, *Scomberomorus cavalla*, Cuvier) from the northern Gulf of Mexico, USA, Bull. Environ, Contam. Toxicol, 78:134-137.
- Putte, I.D., Lubers, and Kolar, Z (1981) Effect of pH on uptake, tissue distribution and retention of hexavalent chromium in rainbow trout, (*Salmo gairdneri*). Aq. Toxicol., 1:3-18.
- Rauf R, M.Javed and M. Ubaidullah (2009), Heavy metal levels in three major carps (*Catla catla*, *Labeo rohita* and *Cirrhinus mrigala*) from the river Ravi Pakistan, Pakistan Vet.J., and 29(1):24-26.
- Romesil (1995) Trace metal in sediments and bivalves in Southampton. Water, Rev. Inst. Oceanogr.Med, CERBON. 33:31-47.
- Simkiss, K., Taylor, M., and Mazon, A.Z (1982) Accumulation of heavy metals in various tissues in *Tilapia*. Mar. Biol. Letts., 3:187-190.
- Sinha, A.K., Dasgupta, P., Chakrabarthy, S., Bhatta charyya and Bhattacharjee, S(2002) Bioaccumulation of heavy metals in different organs of some of the common edible fishes of Kharkai River, Jamshedpur. Ind.Jour.EnvIRON. Health., 44(2) 102-107.
- Sobha , K., Poornima , A., Harini, P., Veeraiah, K,(2007), A study on Biochemical changes in the fresh water fish, *Catla catla*(Hamilton) Exposed to the heavy metal toxicant Cadmium Chlorine. Journal of Science, Engineering and Technology, Vol, Nov IV.
- Tawri-Fufeyin P. and S.A.Ekaye, 2007. Fish species diversity as indicator of pollution in Ikpopa River Benin City, Nigeria. Rev. Fish Biol. Fisheries, 17:21-30.
- Vijayaraman, K., G.John, P.Sivakumar and R.R. Mohammed, 1998. Accumulation and depuration of heavy metals by fresh water prawn *Macrobrachium malcolmsonii* (Milne Edwards). Ind. J.Experim. Biol., 36:1120-1124.
- Wicklund-Glynn, A., Haux, C., and Hogstrand, C(1992) Chronic toxicity and metabolism of Cd and Zn in juvenile minnows ,(Phoxinus phoxinus) exposed to Cd & Zn Mixture Candian. Jour. of Fisheries Aq.Sci 49:2070-2079.
- Yilmaz, F., N.Ozdemir, A.Demirak and A.L. Tuna, (2007), Heavy metal levels in two fish species *Leuciscus cephalus* and *Lepomis gibbosus*. Food Chem., 100:830-835.