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Bioaccumulation of Sub Lethal Concentration of Chromium in Different Tissues of Grass Carp

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Abstract- Aim of this study was to investigate Cr toxicity by using a commercially valuable freshwater fish, Grass Carp, Ctenopharyngodon idella. Investigation included bioaccumulation of Cr in various tissues. For this purpose the fish was exposed to sub lethal concentration of hexavalent chromium for 14 days, following all the ethical issues. Twelve fish of about 70.45±2.91 g weight and 7.32±0.16 inches length were used in the experiments. Dry commercial food pellets were used to feed the fish. Chromium was estimated after acid digestion of the sample tissues taken and further analyzed through atomic absorption spectrophotometer. Results of the current study showed that the order of Cr accumulation in various organs was in the order of intestine>liver>gills>skin>muscles>swim bladder.

Keywords: Bioaccumulation, chromium, grass carp.

I. INTRODUCTION

Heavy metals are mainly noxious pollutants and are of special concern due to their diversified effect, persistence nature in the environment, ability to be accumulated by aquatic organisms and the range of concentration which stimulate toxic ill effect to aquatic fish fauna (Livingstone, 2001). Heavy metal pollution rigorously hampers ecological balances of an ecosystem and creates devastating consequences for environmental quality. An anthropogenic action like waste disposal directly adds burden to environmental degradation (Farombi et al., 2007). Toxicity tests indicate the body's sensitivity to a particular toxin that can help to find out the permissible limit of a toxin in an ecosystem (Shuhaimi-Othman et al., 2010). Hence knowledge of the concentration and variable distribution of heavy metals and their compounds in diverse sections of the environment is a main concern for good environmental management programme all over the globe (Don-Pedro et al., 2004).

Heavy metals like chromium has gained ample interest in the scientific community because of its potential danger to human health in recent years (Shuhaimi-Othman et al., 2010).Chromium exists naturally in rocks, soil, volcanic dust, grains, yeast, plants and animals. Chromium compounds are very persistent in the aquatic environment, typically bound to sediments and soil. Chromium is a greatly toxic, mutagenic and carcinogenic metal contaminant, extremely mobile and an incorporating metal in food chain (Goldoni et al., 2006).

The most common types of chromium that occurs in natural waters in the environment are trivalent and hexavalent Cr. Among them hexavalent chromium (Cr (VI)) is the most toxic form. It is considered as an eminent carcinogen, and mutagen owing to its high solubility, ability to penetrate the cell membrane and strong oxidizing ability (Shanker and Pathmanabhan, 2004). Chromium can enter the body via the lungs, gastrointestinal tract, and to a lower level through skin. United States Environmental Protection Agency recorded Cr (VI) among list of the 18 hazardous air pollutants (HAPs) (Ho Yu et al., 2014). It is extremely harmful and due to which it is considered not only a health problem but also an environmental problem due to its high solubility, mobility, and toxicity (Xu and Wang, 2012).

Fishes are considered as good accumulators of organic and inorganic pollutants. Both physical and chemical parameters of the environment influence the rate of bioaccumulation of trace elements in fish. The effect of exposure to any detrimental substance depends upon the dose type, duration and mode of exposure and presence of other chemicals (Adekola and Eletta, 2007).

Keeping in view the hazardous effect of chromium the present study was conducted to assess the bioaccumulation of Cr in various organs of grass carp (Ctenopharyngodon idella).

II. MATERIALS AND METHODS

Sample collection

Fish from a hatchery were brought in oxygenated bags to the laboratory. Fish of almost equal weight and size were selected and placed in aquaria containing 50 litres of water. Twelve fish of about 70.45±2.91 g weight and 7.32±0.16 inches length were used in this study. A group of 6 fish was exposed to the sub-lethal

concentration of chromium (100mg/L) for 14 days and was considered as the test group, another group of 6 fish was kept without feeding Cr and was called control group. Both groups were provided clean tap water from the same source. Different parameters of tap water were analyzed and their mean values were noted (pH 7.6, water temperature 18.2°C, total hardness 91.7mg/L, dissolved oxygen 7.4mg/L, total alkalinity 163.7mg/L. Dry commercial food pellets were used to feed the fish. Potassium dichromate salt was used as source of chromium.

Metal extraction

After the exposure period of 14 days fishes were dissected and gills, liver, skin, swim bladder and intestine were taken out. A portion of muscle was also separated. These organs were weighted and kept in oven at 120°C for one hour to get dry. The dried tissue was then cooled in a desiccator. One gram from each cooled sample was weighted through electric balance and transferred to beakers of 50mL capacity already washed with distilled water. After this 10mL concentrated HNO3 + 20mL HCl was added to each beaker containing specific organ samples and they were heated gently on a hot plate 200–250°C to digest the samples completely. The hot plate was kept in ventilation hub because of acidic fumes that originate from the samples and was heated until the solution became clear and transparent. The solution was evaporated up to 0.5mL until dense white fumes started after the brown fumes. This was an indication that the digestion process was completed. The solution was diluted to 10mL by adding distilled water. The samples were stored in a 15mL falcon tube for further analysis. The heavy metal chromium was then determined by using Atomic Absorption Spectrophotometer (ShimadzuAA- 6601). Mean values of the measured concentrations were expressed in μg/g.

III. STATISTICAL ANALYSIS:

Data collected from the experiment was expressed in the form of mean and standard error of mean and the means of control and treated group was compared through paired t- test by using the Statistical Package for the Social Sciences (SPSS). In all cases, *P<0.05 was the accepted significant level, **P≤0.01 more significant and ***P≤0.001 highly significant and values above these were represented as non significant.

Chromium concentration in different tissues of Grass carp after 14 days exposure to potassium dichromate

Bioaccumulation of chromium in different organs of grass carp was investigated and the results are presented in (Table 1; Fig. 1). In skin mean values for control and treated groups were 0.041±0.023 and 0.084±0.003, test group exhibiting 104.87% increase. The quantity of chromium in swim bladder for test group was 0.037±0.009 while in control no chromium was detected. In intestine it was 0.021±0.012 in control and 0.556±0.125 in test group (significant increase of 2486.05%). In liver mean value of chromium in control was 0.057±0.001 and in test sample was 0.359±0.079 (a significant increase of 529.82%). In gills chromium was 0.035±0.020 in control while 0.349±0.035 in test group (a significant increase of 883.09%). In muscle chromium for control and test group was 0.048±0.027 and 0.046±0.005 respectively showing incline of 16.66%. Overall the accumulation of chromium in various tissues of grass carp after 14 days exposure follows the logical order as intestine > liver > gills > skin > muscles > swim bladder.

In the current study the bioconcentration of chromium in the fish intestine was acknowledged to be maximum followed by the liver, gills and skin, while it was minimal in the muscular tissues and in the swim bladder. Metals are considered to be non biodegradable in nature and bioconcentration can be carried out in tissues of fish from the ambient water through metabolic processes and biosorption (Hodson, 1988). Fish that accumulate heavy metals from food, display elevated level of metals in the digestive tract in comparison to gills (Ney and Van Hassel, 1983). Our findings are in line with Yousafzai et al. (2012) who reported highest accumulation of heavy metals in intestine of Cyprinus carpio followed by skin, liver, gills and least in muscles signifying that the major target organ of heavy metals here is the intestine. Grass carp is an herbivore voracious fish; accordingly the intestine being the target organ of chromium bioaccumulation does make sense. Bury et al. (2003) also investigated that in gold fish, the intestine worked as the bulk path for the uptake of metals like zinc. The outcomes of this study clarify that grass carp being voracious therefore, the main route of absorption of metals was food rather than water. The literature review proposes that fish can accumulate metals almost 100 times the concentration of metals in water. However, Onwumere and Oladimej (1990) stated that the fish, Orechromis niloticus exposed to petroleum refinery effluents, reported heavy metals (Pb, Fe, Zn, Cu, Mn, Cr, Ni and Cd) a thousand times more than those existing in the exposure medium.

The liver is a principal storage and detoxification site for chromium. It is suggested that chromium is stored in liver, attached to specific proteins and smaller peptides like glutathiones (Gauglhofer and Bianchi, 1991). In the current study liver is the second organ of Cr accumulation followed by gills. According to Mertz (1969), fish excrete chromium in their feces, as was shown by substantial amounts in the bile of fish during

and after the ingestion of contaminated water or food (Heath, 1987). However, higher concentration specifically in the liver and gills could be as a consequence of the slow elimination rate of chromium by the fish when it has accumulated. Borvoest et al. (2001) also reported greater accumulation of copper in the liver of Gasterosteus aculeatus. The gill is a crucial site for the entry of heavy metal that provokes lesion and gill damage (Bols et al., 2001).

Skin is an essential excretory organ as metal accumulation is minimal in the skin. Our results are in consistent with the previous findings. Avenant-Oldewage and Marx (2000) reported less chromium accumulation in skin tissues and muscles and similar findings were noticed by (Kuhnert et al., 1976) in Salmo gairdneri.

Yousafzai et al., (2012) studied considerably much less amount of metals in the muscles of Cyprinus carpio while fish liver accumulated significantly larger concentrations of metals. Similar findings were reported by Shukla et al. (2007) that concentration of zinc, cadmium and copper was optimum in liver and minimal in muscles of Channa punctatus. Karadede-Akin and Unlu (2007) observed that the heavy metals in muscle tissues have been at lower levels in contrast with other organs. Solang et al. (2012) found that chromium is much more accumulated in gills than in the skin or muscles. In the present study, the swim bladder accumulated the lowest Cr burden compared to other organs.

Table I. Chromium accumulation in various tissues of grass carp after 14 days exposure to hexavalent chromium.

Tissues	Control Mean± SE n=6	Treated Mean± SE n=6
Skin	0.041± 0.023	0.084± 0.003
Swim bladder	0.00± 0.0000	0.037± 0.009*
Intestine	0.021± 0.012	0.556± 0.125*
Liver	0.057± 0.001	0.359± 0.079*
Gills	0.035± 0.020	0.349± 0.035**
Muscles	0.048± 0.027	0.056± 0.005

Values expressed as Mean±SE, Student' s "t" test; *Significant (P<0.05), ** more significant (P<0.01) vs control. n= sample size

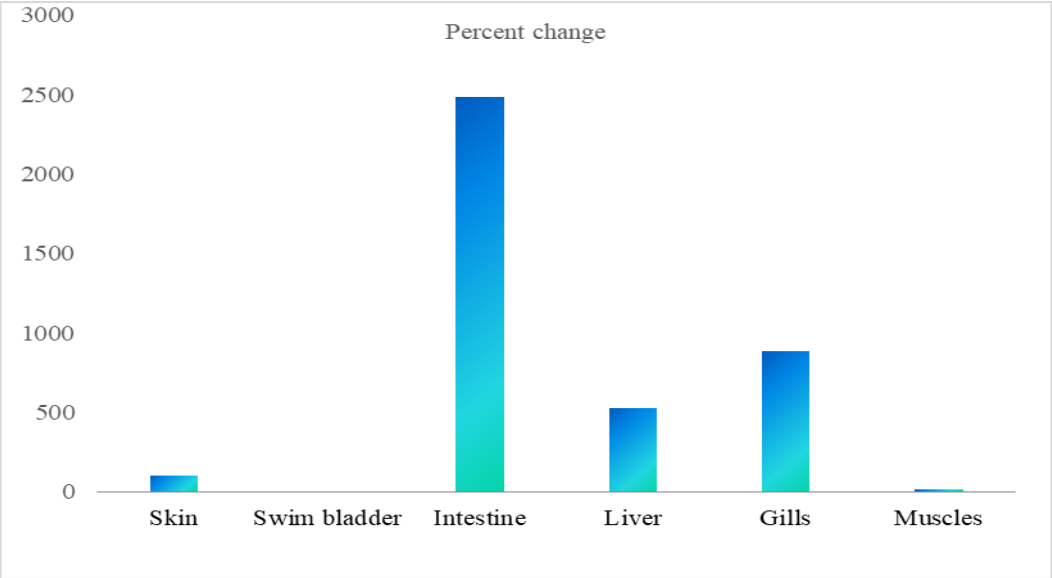

Fig. 1. Chromium concentration in different tissues of grass carp showing % increase (+) after 14 days treatment.

IV. CONCLUSIONS

In the current study the fish stored higher concentration of Cr in intestine and liver followed by gills while the least in muscles and swim bladder which indicated that the main route of metal intake was food rather than water. Chromium toxicity might cause deterioration of energy required for vital processes in the fish body.

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