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Bioaccumulation of Heavy Metals in Some Tissues of Fish, *Clarias batrachus* Exposed to Sub-lethal Concentration of Nickel Sulphate and Potassium Dichromate

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ABSTRACT

Heavy metal pollution is a global problem growing at an alarming rate and aquatic organisms are continuously exposed to elevated levels of metals seriously threatening the whole ecosystem. The objective of the present study is to determine the bioaccumulation of heavy metals in some organs of the freshwater fish, *Clarias batrachus* exposed to heavy metal, nickel and chromium contaminated water. The experimental fish was exposed to Cr and Ni at sublethal concentrations for periods of 30 days. The result revealed that the concentration of both heavy metals was significantly high in the gill, kidney and liver of metal exposed fish in comparison to the tissues of respective organs of control fish. The order accumulation of heavy metal, nickel in the tissues was liver>kidney>gills whereas chromium also accumulate in the order liver> Kidney> gill.

Keywords: Bioaccumulation, *Clarias batrachus* ,Chromium, Nickel.

INTRODUCTION

The contamination of freshwater ecosystems with a wide range of pollutants has become a matter of public concern in recent times. Anthropogenic activities continuously increase the number of heavy metals in the environment, especially in the aquatic ecosystem. Pollution of heavy metals in aquatic ecosystem is growing at an alarming rate and has become an important worldwide problem for the health of the aquatic ecosystem (Abdel-Baki *et al.,* 2011).

The excessive occurrence of heavy metals in natural loads has nowadays become a matter of concern for the health of the aquatic ecosystem. Heavy metals like Copper, Lead, Mercury, Cadmium, Nickel and Chromium are mainly responsible for water pollution. Heavy metal contamination may cause devastating effects on the ecological balance of the recipient environment and its diversity of aquatic organisms (Mastan, 2014). Metals have the tendency to accumulate in various organs of the aquatic organisms, especially fish, which in turn may enter into the human metabolism through consumption causing serious health hazards (Yousafzai *et al*., 2009).

In recent years, world consumption of fish has increased simultaneously with the growing concern about their nutritional and therapeutic benefits. In addition to its important source of protein, fish typically have rich contents of essential minerals, vitamins and unsaturated fatty acids. Fish is an important source of animal proteins for the human body and heavy metal bioaccumulation in the human food chain must be constantly monitored to assess the health risk. Due to the ability to accumulate a variety of contaminants, fish are excellent indicators of ecosystem assessment of water pollution (Svecevicius *et al.,* 2014). Fish accumulate 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 (Joystu *et al*., 2017).

Exposure to metals may modify the fish's behaviour, metabolism, physiology, growth and reproduction (Gohil and Mankodi, 2013). Metals contaminated waters are adversely affecting the ecological balance and biodiversity of the recipient environment (Joshi, 2014). Fish are among the major components of aquatic habitats therefore, they may act as bio-indicators of metal pollution in the aquatic ecosystems. Conservation of fish in their natural habitat makes it essential to determine their growth potentials and ability to bio-accumulate metals during acute exposure to water borne metals (Javed*et al*., 2017). Thus accelerated release of heavy metals into the aquatic environment leads to serious water pollution problems, persistence and bioaccumulation.

In the present investigation uptake of nickel and chromium in different tissues of *Clarias batrachus* were studied, to understand the extent of bioaccumulation by different tissues as critical research need in developing an understanding to establish a correlation between the availability of heavy metals in contaminated water and exposure based accumulation pattern in vital organs of fish such as liver, kidney and gill.

MATERIAL AND METHODS

Clarias batrachus (average length 8-10 cm and average weight 15-20 gm)were collected locally from the non-polluted freshwater body and dipped in 0.1% of potassium permanganate solution for 2 minutes. The fishes were acclimatized in laboratory conditions for 15 days in a glass aquarium filled with dechlorinated water. The fishes were fed with a commercial diet, egg albumin and small insects. The sublethal concentrations of both heavy metals (0.4, 0.8 and 1.2 mg/l for nickel and 2.0, 4.0, and 6.0 mg/l for chromium) were prepared from the stock solution that was prepared by dissolving analytical grade nickel sulphate ($NiSO_4$ from E-Merck) and Potassium dichromate ($K_2Cr_2O_7 \cdot 7H_2O$ from E-Merck) in double-distilled water and 15 fishes was kept in each rectangular glass aquaria separately for estimating the bioaccumulation of nickel and chromium in the tissues of experimental fish. For estimating the concentration of both heavy metals gill, liver and kidney of both control and metal exposed fishes were dissected out then gill, liver and kidney were put in Petri dishes to dry at 120 °C until reaching a constant weight. 5 g of dry tissue or organ was digested in analytical grade HNO_3:$HClO_4$: HCl (3:2:9) for 4- 6 hours on a hot plate. Digestion was carried out at 80°C on a hot plate. Then, the digested samples were cooled and filtered through the What man No. 42 filter paper. The samples were diluted up to 50 ml of distilled water for analysis (Maurya *et al*., 2019).The elements Ni and Cr were assayed using Atomic Absorption Spectrophotometer and the results were given as µg/g.dry weight. Data obtained from the experiments were analyzed and the results were statically evaluated using SPSS.

RESULT AND DISCUSSION

Table1. Bioaccumulation of Chromium in certain tissues (µg/g dw) of *Clarias batrachus* exposed to sublethal concentrations of Potassium dichromate (N=3).

Experiment Set.	Period of Exposure		
	10 Days	20 Days	30 Days
		Gill	
Control	0.109±0.002	0.110±0.003	0.111±0.002
2 mg/l	0.215±0.028	0.301±0.008	0.422±0.010
4 mg/l	0.457±0.013	0.552±0.010	0.726±0.020
6 mg/l	0.623±0.011	0.745±0.014	0.944±0.013
		Liver	
Control	0.109±0.001	0.112±0.002	0.112±0.001
2 mg/l	0.547±0.031	0.690±0.004	0.888±0.039
4 mg/l	0.688±0.039	0.890±0.004	1.082±0.011
6 mg/l	0.883±0.045	1.1823±0.046	1.716±0.366
		Kidney	
Control	0.112±0.002	0.109±0.004	0.112±0.005
2 mg/l	0.372±0.010	0.474±0.011	0.661±0.015
4 mg/l	0.582±0.012	0.721±0.014	0.885±0.011
6 mg/l	0.715±0.010	0.882±0.008	1.148±0.022

Table2. Summary of analysis of variance (ANOVA) showing the level of significance in the pattern of bioaccumulation of Chromium in Gill, Liver and Kidney of *Clarias batrachus*.

Parameters (Tissues)	Source	Sum of square (ss)	df	Mean square (ms)	F	P
Gills	Between groups	0.761	3	0.254	18.189	0.001
	Within groups	0.112	8	0.014		
	Total	0.872	11			
Liver	Between groups	2.067	3	0.689	11.189	0.003
	Within groups	0.493	8	0.062		
	Total	2.559	11			
Kidneys	Between groups	1.078	3	0.359	15.589	0.001
	Within groups	0.184	8	0.023		
	Total	1.262	11			

All values of ANOVA are significant at 0.05

Table 3. Bioaccumulation of Nickel in certain tissues (µg/g dw) of *Clariasbatrachus* exposed to sublethal concentrations of Nickel sulphate (N=3).

Experiment Set.	Period of Exposure		
	10 Days	20 Days	30 Days
	Gill		
Control	0.112±0.002	0.114±0.004	0.116±0.002
0.4 mg/l	0.512±.031	0.718±0.027	0.912±.027
0.8 mg/l	0.708±0.007	0.920±0.011	1.523±0.008
1.2 mg/l	1.116±0.012	1.531±0.023	2.274±0.014
	Liver		
Control	0.119±0.003	0.117±0.002	0.121±0.005
0.4 mg/l	0.543±0.027	0.762±0.010	0.986±0.008
0.8 mg/l	0.776±0.029	0.983±0.010	1.606±0.014
1.2 mg/l	1.436±0.017	1.734±0.012	2.693±0.010
	Kidney		
Control	0.115±0.010	0.121±0.005	0.121±0.006
0.4 mg/l	0.524±0.010	0.731±0.019	0.946±.030
0.8 mg/l	0.728±0.025	0.886±0.004	1.532±.002
1.2 mg/l	1.277±0.013	1.617±0.029	2.440±0.031

Table4. Summary of analysis of variance (ANOVA) showing the level of significance in the pattern of bioaccumulation of Nickel in Gill, Liver and Kidney of *Clarias batrachus*.

Parameters (Tissues)	Source	Sum of square (ss)	df	Mean square (ms)	F	P
Gills	Between groups	3.743	3	1.248	9.271	0.006
	Within groups	1.077	8	0.135		
	Total	4.819	11			
Liver	Between groups	5.272	3	1.757	10.533	0.004
	Within groups	1.335	8	0.167		
	Total	6.607	11			

Kidneys	Between groups	4.288	3	1.429	9.793	0.005
	Within groups	1.168	8	0.146		
	Total	5.456	11			

All values of ANOVA are significant at 0.05

Bioaccumulation of metals reflects the amount of toxin ingested by the organism, the pattern in which the metals are distributed through different organs and the extent to which the metals remained in each one of these organs (Mansouri *et al*., 2011). In the present study, the bioaccumulation of chromium in the fish tissues were found in the order of liver > kidney> gill (Table 1) where as the bioaccumulation of nickel was found in the order of liver > kidney> gill(Table 3). A similar type of bioaccumulation trend was reported for cadmium in 30 days of exposure (Gandhewar and Zade, 2019). In the case of chromium exposed fish, even though the quantity of chromium accumulation in tissue was less in the case of gill when compared to liver and kidney, but the pattern of accumulation showed a continuously increasing trend until the 30th day of exposure in all the tissues (Table 1).In the case of nickel exposed fish, even though the quantity of nickel accumulation in tissue was less in the case of kidney when compared to liver and gill, but the pattern of accumulation showed a continuously increasing trend until the 30th day of exposure in all the tissues (Table 3). This difference in accumulation may be attributed to the affinity of the tissue to the toxicant medium, the physiological state of the tissue, the presence of ligands having an affinity to heavy metals and/or the role of the tissue in the detoxification process. A similar correlation between bioaccumulation of heavy metals and exposure concentration, along with exposure period was reported by Giles (1988).Thus in the present study accumulation of heavy metals in the tissues depends upon the concentration of heavy metals in the medium and duration of exposure. In the ANOVA analysis, the ‘P’ value was found less than a significant level (< 0.05) showing that all the values of heavy metal accumulation in the tissues were statistically significant. The Fish liver showed a significantly (P<0.05) higher tendency to accumulate heavy metals than other tissues (Javed, 2012). The findings of the present study were similar to other workers that toxic metal bioaccumulation in fish is controlled by the balance between uptake and elimination and differential accumulation of these metals in various tissues (Wang and Rainbow, 2008).

In conclusion, significant differences were identified in the liver, kidney and gill of the fishes, *Clarias batrachus*in view of the bioaccumulation of the heavy metals, Cr and Ni but the accumulation of heavy metals in the tissues depends upon the concentration of respective heavy metals in the surrounding medium and duration of exposure. The order accumulation of heavy metal, nickel in the tissues was liver>kidney>gills whereas chromium accumulate in the order liver> Kidney> gill. During this investigation as the concentration of the test medium and duration of exposure increased, the accumulation pattern of both heavy metals in all three tissues also increased significantly.

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Conflict of interest:

No conflict of interest shown. All ethical guidelines were followed during this work.

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