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A COMPARATIVE TOXICITY ANALYSIS OF CADMIUM COMPOUNDS ON MORPHOLOGICAL AND BEHAVIORAL ASPECTS IN AIR BREATHING FRESHWATER FISH *CHANNA PUNCTATUS*

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ABSTRACT
Cadmium compounds are serious pollutants of aquatic environment because of their environmental persistence and ability to be accumulated by aquatic organisms. In the present study, the acute toxicity of cadmium compounds (chloride, sulphate, and nitrate) and their toxicological effects on morphology and behavior of widely consumed Indian snakehead fish *Channa punctatus* was observed for 24 h. In this study percentage mortality was recorded in freshwater fish via treatment with various concentrations of cadmium compounds. Freshwater fish *Channa punctatus* was exposed to various concentration of cadmium chloride (600ppm to 650ppm), cadmium sulphate (600ppm to 850ppm) and cadmium nitrate (900ppm to 990ppm) for 24 hour. The LC_{10}-LC_{90} value for all the three compounds were calculated according to Probit analysis and $CdCl_2$ was shows low LC_{50} value as compared to $CdSO_4$ and $CdNO_3$.Among morphological changes when fish exposed to various concentration of $CdNO_3$ a discoloration of skin, thin white layer sedimentation on the bottom of test aquaria was observed above 900ppm. In $CdCl_2$ and $CdSO_4$ the similar changes occurred in the lower concentration as compared to $CdNO_3$ (<800ppm). Level of toxicity (lethality) was higher for $CdCl_2$ as compared to $CdSO_4$. In conclusion, the present study observations clearly shows that among three tested compounds of cadmium, $CdCl_2$ was highly toxic while $CdNO_3$ was comparatively less toxic to freshwater fish *Channa punctatus.*

KEYWORDS: Cadmium toxicity, *Channa punctatus*, LC_{50}, Morphological changes, Behavioral changes.

INTRODUCTION

In developing countries like India, the amounts of pollutions in the aquatic environment have been increased by the industrial activities. Toxic pollutants including heavy metals are ubiquitous in polluted aquatic environment. Fishes are relatively sensitive to changes in their surrounding environment. Among heavy metal pollutants, cadmium has been listed in "Black-list" of European community (Mason 1996) and it is non-essential, non corrosive in nature and highly toxic metal. Cadmium does not break down in the environment, and can bio-accumulate for many years after exposure to low levels of this metal. Fish may absorb metal directly from contaminated water or indirectly from feeding on living organisms in the contaminated water (Suedel et al. 1997, Javed, 2005). Several studies show their bioaccumulation in different fish tissues viz., skin gill, muscle, brain, liver, kidney, intestine, gonads etc. (Vinodini and Narayanan, 2008). The toxic pollutant affects water quality and feeding, swimming behavior of fish and also delays the hatching, maturation period (Srivastava and Srivastava, 1998 and Atif et al. 2005).

The snakehead air breathing fishes, *Channa punctatus*, are exclusively fresh water with a wide distribution and found as a valuable food fish. This fish is a useful bio-indicator organism of heavy metal contamination of water (Singh and Goswami 2010).The main objective of this study was to determine the lethal concentration (LC_{50}) of cadmium compounds at 24 h (instant toxicity) and the behavioral and morphological alterations due to action of toxicant on snakehead fresh water air breathing fish *Channa punctatus* (Bloch, 1793).

MATERIALS AND METHODS

Freshwater air breathing fish *Channa punctatus* were collected from local fish markets of Lucknow region and kept in the laboratory for acclimatization in normal photoperiod & temperature. They were starved for 24 h prior to experimentation.

For experiment analytical grade Cadmium compounds (viz., cadmium chloride, cadmium sulphate and cadmium nitrate) were used as toxicant. The solution prepared in tap water (having Dissolved Oxygen=16.0 ppm; pH=7.2; Carbon Dioxide=25.0 ppm and room temperature 30±2^oC) for acute toxicity were performed over a period of 24 h using various concentration of cadmium chloride (600 ppm to 650 ppm), cadmium sulphate (600 ppm to 850 ppm) and cadmium nitrate (900 ppm to 990 ppm). The fish were divided into two groups, one is control and another is experimental group and each group contains ten fishes. The experiment was carried out according to guidelines of U. S. EPA (1994) and replicated thrice. LC_{50} was calculated as probit analysis (by Bio-stat software). Behavioral and morphological alterations were recorded at interval. After 24 h each fish were examined and mortality was recorded.

RESULTS

LC_{50}

The results indicated different mortality rate of fishes which ranged from 0 % to 100 % and increased with a corresponding increase in the concentration of cadmium compounds. The fish *Channa punctatus* showed 50 % mortality on the basis of probit analysis for cadmium

chloride at 620.09±3.7 ppm, for cadmium sulphate at 695.10±2.0 ppm and for cadmium nitrate at 943.51±4.8 ppm after 24 h of exposure (Table-1).

Behavioral Manifestations

The behavior and condition of fishes in both the control and experimental was noted in intervals during 24 h. The fishes showed a marked change in their behavior when exposed to various concentration of the chemical (Table-2). The intensity of toxicity of cadmium chloride concentrations was most obvious than cadmium sulphate and cadmium nitrate in the first hour of exposure. Just after introduction to the test aquaria of chemical fishes showed interestingly try to jump out of aquarium to avoid the chemical followed by increased swimming, restlessness, surfacing and hyper activity. In lower concentration of cadmium compound the fishes showed slow swimming than the control group. Behavioral manifestation of acute toxicity like erratic swimming, restlessness and surfacing movement were observed in *Channa punctatus* (Bloch, 1793) exposed to higher concentration of cadmium compounds to the 24 h. After 24 h fishes exhibited lathery and erratic swimming suggesting loss of equilibrium at higher concentration. At the time of death transient hyper activity was also observed. The reaction and survival of aquatic animal depand not only the biological state of animals and physiochemical characteristics of water but also on the kind, toxicity, type of exposure to the toxicants.

Morphological Manifestation

During this study, we documented the specific site of cadmium compounds action. Among morphological changes, discoloration of skin, chemical deposition on skin and aquarium, lesions were recorded and effects were concentration dependent (Table-3). Among cadmium compounds, cadmium chloride caused maximum morphological changes in comparatively low concentration than the cadmium sulphate and cadmium nitrate. The schooling is the characteristic of this fish was found weakened in the cadmium chloride and cadmium sulphate while in cadmium nitrate it is not affected during study. At higher chemical concentration, scale depletion start, skin lesion observed from dorsal to lateral side of the body of fish and these were deepens, copious mucous, clumping of gills increases with the increasing of concentration of toxicant. The skin lesions around the head region, base of caudal fins and pectoral fins were prominent in the 90 % of the fish in higher concentrations. The fishes lost their natural coloration and become almost pale yellow in color.

TABLE 1- Comparative LC_{50} of $CdSO_4$, $CdCl_2$ and $CdNO_3$ at 24 h exposure period by probit analysis in fresh water fish *Channa punctatus*.

Chemical	$CdCl_2$ (ppm)	$CdSO_4$ (ppm)	$CdNO_3$ (ppm)
LC_{50} (Mean ± S.E.M.)	620.09±3.7	695.10±2.0	943.51±4.8

TABLE 2- Comparative behavioral responses given by freshwater fish *Channa punctatus* after exposure of different cadmium compound.

Sl. No.	Behavioral response	Various cadmium compound			
		Control	$CdCl_2$	$CdSO_4$	$CdNO_3$
1.	Blinking of eye	-	++++	++	+
2	Jumping	-	++++	+	+
3	Un-coordinate Swimming	-	++++	++++	++++
4	Schooling	-	++	+++	++++
5	Restlessness	-	++++	++++	++++
6	Loss of balance in the column of aquarium	-	++++	++++	++++

Note: *Symbol (-) ---> Normal response, Symbol (+) ---> Abnormal response, Symbol (++) ---> Mild increase response, Symbol (+++) ---> Moderate increase response, Symbol (++++) ---> Maximum increase response***Table 3-**

TABLE 3- Morphological changes of freshwater fish *Channa punctatus* of different cadmium compounds.

Sl. No.	Morphological changes	Various cadmium compound			
		Control	$CdCl_2$	$CdSO_4$	Cd $(NO_3)_2$
1.	Discoloration of skin	-	++++	++++	++++
2.	Lesions on skin	-	++++	+++	+++
3.	Shedding of scale	-	++++	++++	++
4.	Mucus secretion	-	++++	+++	++
5.	Sedimentation of chemical on body	-	++++	++++	++++
6.	Muscular bleeding	-	++++	++	++
7.	Clumping of gills	-	++++	+++	++
8.	All fins damage	-	++++	++	++

Note: *Symbol (-) ---> Normal response, Symbol (+) ---> Abnormal response, Symbol (++) ---> Mild increase response, Symbol (+++) ---> Moderate increase response, Symbol (++++) ---> Maximum increase response*

DISCUSSION

Cadmium compounds poses toxic effects on the snakehead fish *Channa punctatus*. The fish mortality may have resulted by absorption, bio-accumulation of cadmium compounds or greater activity of chemical in body of fish. The differences in the 24 h LC_{50} value between *Channa punctatus* in present study and other reports (Maruthayanagam et al. 2002, Kasherwani et al. 2009) may be attributed to the fact that metal induced changes differ from metal to metal, species to species and from one experimental condition to other. Similarly the higher concentration of the toxicant may because of adoptive capacity of fish to heavy metal contaminated environment (Vinodini and Narayanan 2008). The difference in toxicity level among cadmium compounds might be related to change in sensitivity of chemo receptors (Suterlin 1974). The exact causes of death due to heavy metal poisoning are multiple and depend mainly on time-concentration combination.

Behavioral manifestation of acute toxicity in *Channa punctatus* were more or less similar to those reported in other fishes exposed to cadmium (Kasherwani et al. 2009). Behavioral changes have been established as sensitive indicator of chemically induced stress in aquatic organisms (Suedel et al. 1997, Remyla et al. 2008). Behavioral alterations like erratic swimming, restlessness and surfacing may be an avoiding reaction to the heavy metal narcotic effects or to change in sensitivity of chemo-receptors (Maruthanayagam et al. 2002, Atif et al. 2005).

The skin together with the gills of fishes is act as the outer most defense barrier against the surrounding environmental stress and toxicant (Ojha 1993). The mucous secretion plays important preliminary role in this defense mechanism that may cause the thin layer of chemical deposition on aquarium bottom that were observed during the experiment duration of cadmium compounds. Through respiration cadmium compounds circulate all over body and may become one of the causes of death of animal (due to hypoxia) (Maina, 1997). The injury or lesions, degenerative changes in the skin and muscle have been observed in fishes may be due to replacement by loose connective tissue elements (Banerjee 1997). It has been observed that acute toxicity of cadmium compounds to fish *Channa punctatus* is mainly caused due to gill damage, enabling the fish to obtain oxygen from water that result in anoxia (Maruthanayangam et al. 2002). Similarly, it has been stated that cadmium inhibits the action of acetyl-cholinesterase, causing death through paralysis of the respiratory muscle and/ or depression of respiratory system (Hollis et al. 1999).

The present findings suggest that $CdCl_2$ is more toxic than others two compounds, $CdSO_4$ and $CdNO_3$ even in low concentration. The cadmium compounds exhibit acute toxicity, behavioural and morphological changes in fishes which considered as good biomarker to access the health status of fresh water aquatic bodies in relation to metallic contaminants. Furthermore, studies under sub-lethal exposure are required to elucidate the subtle changes that occur in fishes due to cadmium compounds.

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