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Acute toxicity of sodium arsenate and its effects on the behaviour of a catfish, *Heteropneustes fossilis* (Bloch)

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Abstract

Bioassay experiment were carried out to determine the acute toxicity of sodium arsenate to a freshwater catfish, H. fossilis. The estimated value of 24, 48, 72 and 96h LC50 were 67.06, 49.52, 36.24 and 26.36 mgL^{-1} respectively; The presumably (safe) harmless concentrations of toxicants to this fish was 8.10 mgL-1. Heteropneustes fossilis exhibited behaviouoral responses such as hyperexitability, restlessness and erratic swimming movements on exposure to toxicant sodium arsenate but these symptom is more prominent at 96h exposure.

Keywords- freshwater catfish, photoperiod, acute doses, toxicants

Introduction

The aquatic environment is particularly susceptible to the toxic contaminants because a considerable amount of the chemicals used in industries, urbanization and agriculture enters into marine and other freshwater environments. The discharge of potentially toxic trace metals into the marine and freshwater environments has become a global trouble. Historically we have regarded the air, water, and soil that surround us as waste receptacles and have given little consideration to the ecological consequences of our actions. As a result, wildlife populations are confronted with a bewildering array of pollutants that we release into the environment either by intent or accident. Arsenic is ubiquitous in the global environment and occurs at low background levels in all environmental media. Arsenic contamination is mainly caused by the use of the arsenic pesticides, industrial activities and mining operations (Chakraborty *et al.* 1998). Due to increasing levels of arsenic in the ground water in Bengaladesh, West Bengal, and District Ballia Uttar Pradesh considerable attention has been given to the study of the effect of arsenic on human beings and selected mammals (Biswas et al. 1998). Fishes are the richest source of an essentially heathy diet. They are however endangered by diet- borne pollutants transferred along the food chain. Fish appear to be particularly susceptible to arsenic toxicity as they are continually exposed to it through gill and intake of arsenic- contaminated food. The toxic effects of arsenic depend on oxidation state, chemical species, exposure and dose, solubility in the biological media, and rate of excretion. Arsenic exists in both trivalent and pentavalent ionic forms,

and is often given as either sodium arsenate (As (V)) or arsenic trioxide (As (III)), with sometimes opposing results. Physiological effects of arsenic on fish were severe. However, there are only a few reports on the physiological and biochemical responses of fish to arsenic (Leah *et al.* 1992). The objectives of this paper were to evaluate the effect of sodium arsenate toxicant on behavioural changes on a freshwater catfish, *Heteropneustes fossilis* after exposure to different dose and time intervals. This information would be useful tool for the management and control of natural area with respect to the input of toxic metals and their bioavailability.

Materials and methods

The catfish (average wt. 32.50±2.25g; length 12.25±1.50cm) were collected locally and acclimated in tap water (pH 7.8, chloride 7.5m ML^{-1}, hardness 146.65 mgl^{-1} as $CaCO_3$ and BOD 17.50 mgl^{-1}) for 10 days under natural photoperiod and ambient temperature in glass aquaria. They were fed daily *ad libitum* on wheat flour and pellets of ground dried shrimp. The stock solution of cadmium chloride and mercuric chloride was prepared in water; both the metals are technical grade (95 to 98% purity). Acute toxicity bioassays were performed for the determination of median lethal concentrations for sodium arsenate for 24, 48, 72 and 96h exposure periods under static test condition (APHA, 2005). Ten fish were exposed to metals concentrations. The LC 50 values as well as 95% confidence limits were calculated according Litchfield and Wilcoxon, (1949). The fish were not fed during the bioassays experiments. The presumably harmless (safe) concentrations of the metals were estimated by the formula of Hart *et al.* (1945) which was found to be 8.10 mgl^{-1} for sodium arsenate. The behavioural changes of the fish also observed in different toxicants and compare with control fish, kept in tap water.

Results and discussion

Standard acute toxicity tests with fish have long played a major role in aquatic hazard and risk assessments, especially at a "screening" level of evaluation. The LC0, LC50 and LC100 values of sodium arsenate for the catfish, *H. fossilis* for 24, 48, 72 and 96 h. intervals are presented in table 1. The estimated values of presumably harmless (safe) concentrations of sodium arsenate 8.10 was mg L^{-1}(1/22nd of 96h LC50 value) for the catfish, *H. fossilis* . The behavioural response of control catfish, *H. fossilis*, kept in glass aquaria is the tendency to move together. They are come to the surface of water at regular intervals to gulp air or rest at the bottom and swim along the sides of the aquaria. *Heteropneustes fossilis* showed behavioural changes against sodium arsenate intoxication. These were increased opercular movement, sluggish, lethargic and abnormal swimming, and muscular tetany. The treated fishes also showed fading of their body colour. These behavioural changes can be considered as symptoms of stress on account of the toxicological nature of the environment. The above symptoms are more prominent in case of acute doses in comparison to subacute and sublethal doses.

Several workers have estimated LD/ LC50 values of individual pollutants like pesticides, dyes, detergents, fertilizers, arsenic and other metal at different time intervals for mammals and aquatic animals. The acute toxicity data on aquatic animals, especially on fish are scanty. However the 96h LC 50 values for the catfish, *H. fossilis* for arsenic in this study were found to be 26.36 mg L^{-1}. It may however, be pointed out that the toxicities of the individual toxicants to different species of fish are difficult to compare (Schimml and Wilson, 1977) because they are influenced by various factors such

as temperature, pH, hardness and dissolved oxygen of test water (Smith and Heath, 1979; Gluth and Hanke, 1983). The presumably harmless (Safe) concentrations of sodium arsenate for the catfish in this study were 8.10 mg L^{-1} (1/22th of 96h LC 50 value). These values can be considered safe to other Indian freshwater catfish species untill additional data on the safe concentration of nutritional metals are not available. In terms of environmental significance, concentrations of sodium arsenate in water at exceeding safe concentration must be considered hazardous to fish as they can accumulate residues of metals in their tissues when exposed to concentrations much lower than those which cause direct adverse effects to them.

Table -1 LC0, LC50 and LC100 values (mg L^{-1}) of sodium arsenate for the catfish, *H. fossilis*: 95% confidence limit are given in paranthesis

h	LC0	LC50	LC100
24	60.01	67.06 (63.50 ± 68.60)	70.24
48	42.01	49.52 (45.76 ±50.88)	52.26
72	33.25	36.24 (34.70 ± 35.18	40.12
96	21.18	26.36 (23.90 ± 28.37)	30.06

The behaviour of the catfish, *H. fossilis* observed during this study was similar to that observed by various workers for teleostean species under influence of several water pollutants, viz., pesticides, dyes detergents, fertilizers, arsenic and other metals. (Srivastava *et. al.* 1995c; Srivastava, 1999; Kumar *et al.* 1999; Pandey, 2000; Pathak *et el.,* 2006). The avoidance reaction by the fish has been one of the most commonly mentioned parameters in behavioural studies with individual and mixture of pollutants. The fish *H. fossilis* exhibited frequent jumping, erratic movement followed by convulsions, stiffening of the trunk muscle, secretion of excess mucus from the gills and body and depigmentation were observed as visible signs of poisoning.. The fishes appeared excited with a rapid rate of operculum movement accompanied by occasional gulping of air and ultimately loss of equillibrium on exposure to acute, subacute and sublethal concentrations of sodium arsenate toxicosis. This is in agreement with the reports of earlier investigations who recorded similar signs on exposure to pesticide (Kumar *et al.* 1999), dyes (Srivastava *et al*., 1995c), arsenic (Jankong *et al*.2007), metals (Hansen *et al*., 1999; Pedlar et al., 2002) detergent (Pandey, 2000; Pathak *et al.* 2006.) and fertilizer (Prakash, 1996; Naqvi and Singh, 2000) on freshwater fishes. Stehilk and Merriner, (1983) reported varying degree of scoliosis in fathead minnow and spots at subacute concentration of insecticide chlordecone. Scoliosis was, however, never noticed in the present study when the fish were exposed to acute, subacute and sublethal concentrations of sodium arsenate. The behavioural changes in fish were more prominent when exposed to higher concentrations as compared to that of lower concentrations of sodium arsenate.

Conclusion

The aim of the present study was to evaluate behavioural changes in the Indian freshwater catfish, *H.fossilis* following exposure to toxicants like highly toxic sodium arsenate for 24, 48, 72 and 96h terms. The observations made, therefore, have been compared with the corresponding values obtained from untreated control fish. The present time and dose related investigation on the effects of the sodium arsenate on the catfish, *H. fossilis* shows the behavioural disturbances like opercular movement, sluggish, lethargic and abnormal swimming, and muscular tetany due to the presence of sodium arsenate and in the external millieu. However, the fish apparently has the ability to compensate for the disturbances.

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