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Physiological observation on activity recovery of mercury exposed fresh water fish by using aquatic weed

Seema Trivedi[1], Aarti Sharma[1], S. Shrivastava[2] and A. Shukla [2]

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Abstract

Physiological observation on activity recovery of mercury exposed fresh water fish were done by using aquatic weeds. Five weeds constitute two floating weeds *Eichhornia* and *Salvinia* in surface layers, *Chara* and *Hydrilla* in the column layer and *Vallisneria* in bottom layer. Five experimental groups constituting five selected weeds were subjected to establish fish lethal concentration of mercury for a period of 48h, 96h, 144h, 192h and 240h to facilitate mercury absorption. All the data shows that mercury removal efficiency increases with increased time exposure. The present results indicate that maximum quantity of mercury was accumulated by weeds of IAMB rapidly up to 144h of exposure.

Keywords:- *Detoxification, Eichhornia, Fish, Freshwater, Heavy metal, Macrophyte*

Introduction

Heavy metals are present in all phases of the environment- air, water and land, when these substances are released in the water phase of the environment, they are transported by the fluid motion, and transferred to the atmosphere and bed, are subject to various physico-chemical and biochemical reactions and are assimilated by all levels of the aquatic food chains. They are also transmitted by direct ingestion through the food chain to higher organisms and ultimately to humans. Between the naturally occurring and the industrial pollutants mercury is highly toxic to both human and animals. The aquatic weed plants absorb and incorporate the dissolved materials (both inorganic and organic compound) into their own body tissues so rapidly and effectively that they are now considered for use in waste treatment (Wolverton *et al.*, 1975; Chaphekar and Mhatre 1981; Kaiser, 1993). Shrivastava and Rao (1997) proposed an Integrated Aquatic Macrophyte Base (IAMB) system in which combination of weed groups constituting different types of weeds *viz.* floating, emergent and submerged types were used. This IAMB system recorded better results when compared to using individual weed plant. This study aims to assess mercury detoxification by IAMB system based on fish activity recovery observed by relative physicochemical factors of the stored tap water, fish mortality, fish behaviour, and oxygen consumption rate of fish in different experimental groups.

Author's Address

[1]Govt. Madhav Science College, Vikram University, Ujjain ✉

[2]School of Studies Zoology Vikram University, Ujjain

Materials and Method

The fish *Oreochromis mossambicus* was selected as test animal, these fishes were collected from Government Fisheries Department, Ujjain (M.P.) Ten test animals were kept in each aquarium containing 10 litres of water. IAMB system was designed and assembled in the laboratory, constituting two floating weeds *Eichhornia, Salvinia* in the surface water layers, *Chara* and *Hydrilla* in column layer and *Vallisneria* in bottom layers. The five weeds used for different experimental groups were 20 gm for 10 litres of toxicant. Mercuric chloride was used as toxicant material. The LC-100, concentration of mercuric chloride to fish were obtained with earlier experiments. Lethal concentration 1.00 ppm of mercuric chloride was selected as toxicant

concentration for all the experimental groups. Five experimental groups constituting five selected weeds were subjected to established fish lethal concentration of mercury for a period of 48 h, 96 h, 144 h, 192 h, and 240 h to facilitate mercury absorption. The fishes were then introduced. The details of experimental groups are as per details given under:-

1. Control Group:- Equal weight of five weeds (20 gm each), tap-water and fishes.

2. Lethal Concentration Group:- LC-100 concentration of $HgCl_2$, tap-water and fishes

3. Experimental Group 1:- Equal weight of five weeds (20 gm exposed for 48 h) in LC-100 concentration of $HgCl_2$, tap-water and fishes.

4. Experimental Group 2:- Equal weight of five weeds (20 gm exposed for 96h) in LC-100 concentration of $HgCl_2$, tap-water and fishes.

5. Experimental Group 3:- Equal weight of five weed (20 gm, exposed for 144 h) in LC-100 concentration of $HgCl_2$, tap-water and fishes.

6. Experimental Group 4:- Equal weight of five weeds (20 gm, exposed for 192 h) in LC-100 concentration of $HgCl_2$ tap-water and fishes.

7. Experimental Group 5:- Equal weight of five weeds (20 gm, exposed for 240 h) in LC-100 concentration of $HgCl_2$ tap-water and fishes.

The mercury detoxification study was based on physicochemical characteristics of stored tap water, fish mortality, fish behaviour and oxygen consumption rate of fish of different experimental groups. Fish mortality rate was observed at 12 h up to 96 h of experimentation. Oxygen consumption rate was determined by Winkler's method.The analysis of physicochemical parameters of experimental water were made according to method of APHA (1998) and Khanna and Bhutiani (2004).

Results and Discussion

Experiment as per details described above were set up in stored tap water. The physico-chemical characteristics of selected tap water is given in Table-1. Fish mortality, oxygen consumption were recorded as given in Table-2 and Table-3 and Fig.1 respectively.

Shrivastava and Rao (2000) proposed integrated aquatic macrophyte base system (IAMB) in which two floating weeds *Eichhornia* and *Salvinia* in surface layers, *Chara* and *Hydrilla* in column layer and *Vallisneria* in the bottom layer provides efficient mechanism of metal absorption through their roots and recorded better result when compared to using individual weed plant. The fish *Oreochromis mossambicus* was subjected to its lethal concentration

Table-1: Showing the Physico-chemical parameters of experimental water

Physico-Chemical Parameters of Experimental Water	Reading
Water Temperature (° C)	25.00
pH	8.40
Carbonate alkalinity (mg/l)	12.00
Bicarbonate alkalinity (mg/l)	240.00
Chloride (mg/l)	50.99
Calcium (mg/l)	16.83
Hardness (mg/l)	166.00
Dissolved Oxygen (mg/l)	8.00

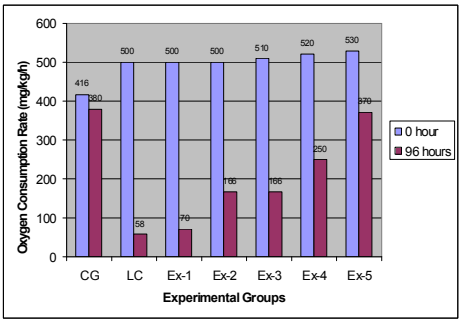

Fig. 1: Showing oxygen consumption rate in different experimental groups of an Integrated Aquatic Macrophyte Base System

of mercuric chloride (1ppm) recorded 100% mortality of fish at 96 h of experimentation. The same concentration was used in all experimental set up

Table-2: Showing the mortality responses of *O. mossambicus* in $HgCl_2$ at 96 h. of experimentation under an Integrated Aquatic Macrophyte Base System

Experimental Group	Time in Hour										
	00	12	24	36	48	60	72	84	96	(%) Mortality	(%) Recovery
Control Group	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	-
Lethal Conc. Group	10	05	10	20	10	05	10	20	10	100%	Nil
Experimental Group 1	10	10	10	Nil	Nil	Nil	Nil	Nil	Nil	30%	70%
Experimental Group 2	05	10	10	Nil	Nil	Nil	Nil	Nil	Nil	25%	75%
Experimental Group 3	10	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	10%	90%
Experimental Group 4	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	100%
Experimental Group 5	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	100%

Table-3: Showing the oxygen consumption rate in different experimental groups of an Integrated Aquatic Macrophyte Base System

Experimental Group	Experimental Time (Hours)	
	0 hour	96 hours
Control Group	416	380
Lethal Concentration Group	500	58
Experimental Group 1	500	70
Experimental Group 2	500	166
Experimental Group 3	510	166
Experimental Group 4	520	250
Experimental Group 5	530	370

(Table-2). Experimental group 1, 2 and 3 yielded low mortality rate 30%, 25% and 10% respectively in IAMB which were exposed for 48 h, 96 h and 144 h of experimentation. IAMB system which was exposed for 192 h and 240 h (Experimental Group 4 and 5) has shown no mortality at 96 h of experimentation. The present study indicates 100%, 90%, 75% and 70% fish mortality recovery in experimental group 5,4,3,2 and 1 which was exposed for 240, 192, 144, 96 and 48 h. All data show that mercury removal efficiency increases with increaseing time exposure.

The experimental animals within a short period of their introduction to the experimental tanks exhibits signs of distress. The gulping of air by hanging on the surface with the hind part of the body turned downwards was very evident even when sufficient amount of dissolved oxygen available in the water. This was however, not at all seen in the control group and experimental groups 4 and 5. Visible signs of poisoning were manifested by periodic bursts of erratic swimming, rapid opercular movements, surfacing and gulping of air. Disorder of central nervous system were observed when the fish in the lethal concentration, loss their sense of equilibrium and turned with their belly upward making jerky movements. Finally they sank to the bottom before death occurred. The symptoms of acute mercury poisoning in fish include rigidness of body, spread out fins, slow movement of the hind part of the body turned downwards (Boetius, 1960). These symptoms are followed by the loss of balance and finally sinking to the bottom before death occurs. All these symptoms were clearly visible in the test fish during the present study. One of the underlying problems with mercury pollution is the effect it provides to the nervous system by attacking the centre in the brain of human beings and other mammals (Suzuki, 1960). Whether such damage also occurs in the aquatic organism has not been clearly demonstrated. However, similar effect seems to prevail in fish also because some of the functions which are controlled by nervous system such as the maintenance of equilibrium have already been demonstrated to get disturbed with low concentration of mercury in the fish (Lindhal and Schwanbom, 1971).

Oxygen consumption rate of fish was observed in different experimental group (Table-3 and Fig.1). The effect of various pollutants on the respiratory physiology of fishes have been investigated in recent years by several workers, *viz*. Waiwood and Jonson, 1974; Kawastski and Mc Donald 1974; Hughes, 1975; Munshi *et al*., 1976; Singh and Singh, 1979; Kumar and Pandey, 2002; Gibson and Mathis, 2006; The recovery of oxygen consumption rate in the present study under IAMB system and mercuric chloride exposed fish revealed that 5 weed containing control group was having highest recovery 380 mg/kg/h. In experimental group 5, oxygen consumption rate was 370 mg/kg/h recorded. Experimental group 4 it is 250 mg/kg/h; experimental group 2 and 3 it is 166 mg/kg/h; experimental group 1, 70 mg/kg/h and lethal concentration group 58 mg/kg/h come next in order.

The present result indicates that maximum quantity of mercury was accumulated by weeds of IAMB system with greatest rapidly upto 144 h of exposure. After the critical period of 144 h, the rate of toxicant absorption suddenly reduces and becomes negligible. It is therefore suggested that moderate required plant growth after 144 h period can be harvested regularly, each time allowing the regrowth of a new crop, so that the IAMB water purification system becomes a continuous process. This study demonstrated that IAMB system performed very well in treating water contaminated with mercury. The IAMB system based biotechnologies are ideal for treating large quantities of industrial waste water.

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