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Acute toxicity of mercury to the fingerlings of Indian major carps (catla, rohu and mrigal) in relation to water hardness and temperature

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Abstract: *In the present study short-term (96 hr) toxicity of mercury in relation to water hardness (270 and 560 mg/l) and temperature (16°C and 35°C) to the fingerlings of Indian major carps, i.e. catla, rohu and mrigal has been evaluated using static bioassay. The LC_{50} indicates that both water hardness and temperature played significant role in mercury toxicity. The test fishes were found most resistant with water hardness of 560 mg/l at 16°C as compared to that of water hardness of 560 mg/l at 35°C and water hardness of 270 mg/l at both the temperatures, i.e. 35 and 16°C. Whereas the order of relative sensitivities of these fishes for mercury ions were recorded as catla>rohu>mrigal. The safe concentrations of mercury were ranged in between 12.133 to 19.689 µg/l for catla; 64.039 to 82.555 µg/l for rohu and 73.510 to 89.585 µg/l for mrigal for both the water hardness and temperature.*

Key words: *Acute toxicity, Mercury, Catla, Rohu, Mrigal, Water hardness, Temperature.*

Introduction

It is well known that heavy metals are toxic to aquatic animals affecting their behaviour, growth and reproductive capacity. Toxic effects of mercury ions for different fish species have also been studied (Gupta and Rajbanshi, 1995; Buhl, 1997; McCrary and Heagler, 1997; Sukhovaskaya *et al.,* 2001). However, limited reports are available on the toxicity of mercury in relation to water hardness and temperature (Ayfer and Jacobs, 1995; John *et al*., 1996; Mathieson *et al.,* 1996). In view of this an attempt has been made to investigate the acute toxicity of mercury in relation to water hardness and temperature to the fingerlings of Indian major carps, i.e. catla, rohu and mrigal using static bioassay (96 hr).

Materials and Methods

The 96 hr static bioassays of mercury (as $HgSO_4$) for the fingerlings of Indian major carps, i.e. catla (*Catla catla*), rohu (*Labeo rohita*) and mrigal (*Cirrhinus mirigala*) were conducted in two seasons, i.e. summer (35°C) and winter (16°C) following standard method of APHA (1989). In each season two types of water of different hardness, i.e. 270 and 560 mg/l collected from different sources, *viz*. supply of P.H.E.D.and bore well were used. This water were also analysed for their physical and chemical characteristics, *viz.* pH, temperature, conductivity, D.O., total alkalinity, total hardness, free carbondioxide, nitrates (NO_3-N) and phosphates (PO_4-P).

The bioassay tests were conducted in plastic tubs of 20 litres capacity. These experimental units were filled with mercury toxicants and placed in three rows. Each container was labelled with the details of the experiment such as concentration, name of fish, replicate number, date and time of the experiment. The acclimatized fishes were transferred to these containers after about 20 minutes of the preparation of the solution. Ten test fishes were placed in each experimental container. Proper controls were run simultaneously. The average length and weight of the fingerlings of catla, rohu and mrigal were: 3.7, 5.4, 5.8 cm and 0.825, 1.930, 2.352 gm, respectively.

The LC_{50}'s of mercury for different water hardness and temperature for the fingerlings were estimated for time intervals of 24, 48, 72 and 96 hr by probit analysis (Finney, 1971). Presumable safe or harmless concentration and safe dischargeable concentration have been also calculated by using the formula of Hart *et al*. (1945).

Results and Discussion

Physico-chemical characteristics of the diluent water revealed that the same are standard ones as in natural conditions; it did not contain any toxic substances. However, few changes have been observed in the quality of water at two temperatures were mainly dissolved oxygen, total alkalinity, electrical conductivity and hardness (Table 1). The 24, 48, 72 and 96 hr LC_{50}'s of mercury for the fingerlings of catla, rohu and mrigal have been summarized in Table 2. The fingerlings of catla were found most sensitive in comparison to the fingerlings of rohu and mrigal as revealed from the lower values of LC_{50}. Further, variations in LC_{50} were also observed with the change in water hardness and temperature. The LC_{50}'s of mercury ions for these fingerlings were increased with the increase in water hardness (Table 2). Whereas in comparison to catla, rohu fingerlings were found less sensitive as revealed from the higher LC_{50} values. Further, LC_{50} values of mercury showed that fingerlings of mrigal were more hardy in comparison to fingerlings of catla and rohu (Table 2).

The relative sensitivities of the test fishes have also been studied in between different factors (Table 3). All the test fishes were found more sensitive at high temperature and low

Table – 1: Physico - chemical characteristics of the different diluent water used in short-term toxicity tests for mercury.

Characteristics	Average values			
	Summer		Winter	
Water temperature (°C)	**35**	**35**	**16**	**16**
Dissolved oxygen (mg/l)	5.0	5.0	7	6.5
pH	8.5	8.6	8.0	8.2
Free carbondioxide (mg/l)	Nil	Nil	Nil	Nil
Total alkalinity (mg/l)	700	810	560	715
Total hardness (mg/l)	**270**	**560**	**270**	**560**
Electric conductivity (μ mhos/cm)	830	820	835	830
Nitrates NO_3-N (mg/l)	1.61	1.69	1.57	1.61
Phosphates PO_4-P (mg/l)	0.04	0.05	0.03	0.05

water hardness as compared to low temperature and high water hardness as revealed from 24, 48, 72 and 96 hr LC_{50} values. However, among the same water hardness, all the test fishes were found more sensitive at high temperature. The presumable safe concentrations of mercury for the fingerlings of Indian major carps were ranged in between 12.133 to 19.689 μg Hg/l for catla; 64.039 to 82.555 μg Hg/l for rohu; and 73.510 to 89.585 μg Hg/l for mrigal (Table 4). Whereas safe dischargeable concentrations were ranged in between 1.133 to 1.220 for catla ;1.051 to 1.106 μg Hg/l for rohu ; and 1.091 to 1.183 μg Hg/l for mrigal (Table 4).

The 96 hr LC_{50}'s of mercury with water hardness of 560 mg/l at 16°C for the fingerlings of catla, rohu and mrigal, were 72.729, 278.347 and 312.909 μg Hg/l respectively. These 96 hr LC_{50} values of mercury for such fishes were considerably

Table – 2: LC_{50}'s (24, 48, 72 and 96 hr) of fingerlings of catla, rohu and mrigal for mercury with different water hardness and temperature.

Test fishes	Water hardness / Temp.	LC 50's (μg/l) with water hardness of 270 mg/l				LC 50's (μg/l) with water hardness of 560 mg/l			
		24hr	48hr	72hr	96hr	24hr	48hr	72hr	96hr
Catla	35°C	59.969	52.904	46.921	43.922	73.578	60.261	57.418	47.707
	16°C	83.288	69.696	60.677	52.755	107.816	91.357	77.869	72.729
Rohu	35°C	289.470	261.493	218.239	194.612	293.130	267.714	250.347	222.069
	16°C	297.822	283.247	273.064	228.157	343.459	318.938	294.371	278.347
Mrigal	35°C	342.164	306.050	283.530	268.141	378.826	347.083	304.450	281.449
	16°C	392.569	358.341	341.174	308.456	453.363	383.142	342.601	312.909

Table – 3: Relative sensitivity ( ) among the tested fingerlings of Indian major carps based on LC_{50} values for 96 hr at different water hardness and temperatures.

Test fishes	Relative sensitivity ( ) between some water hardness at different temperatures			
Water hardness (mg/l)	270	270	560	560
Temperature (°C)	35	16	35	16
Catla	43.922 (1)	52.755 (1.20)	47.707 (1)	72.729 (1.52)
Rohu	194.612 (1)	228.157 (1.17)	222.069 (1)	278.347 (1.25)
Mrigal	268.141 (1)	308.456 (1.15)	281.449 (1)	312.909 (1.11)

Table – 4: Presumable safe or harmless concentration (C)* and safe dischargeable concentration (S)* of mercury (μg/l) for fingerlings of Indian major carp, *Catla catla, Labeo rohita* and *Cirrhinus mrigala* with different water hardness and temperature.

Test fish	Temperature 35 °C				Temperature 16 °C			
	Water hardness 270 mg/l		Water hardness 560 mg/l		Water hardness 270 mg/l		Water hardness 560 mg/l	
	C	S	C	S	C	S	C	S
Catla	12.360	1.133	12.133	1.220	14.642	1.195	19.689	1.180
Rohu	64.039	1.106	67.040	1.094	76.899	1.051	82.555	1.076
Mrigal	73.510	1.118	87.426	1.091	89.585	1.095	82.101	1.183

*μg/l

higher than those reported for *Rasbora daniconius* (LC_{50} – 0.08 mg Hg/l; Gupta and Rajbanshi, 1995), *Notemigonus crysoleuces* and *Gambusia affinis* (LC_{50} – 16.75 and 52.62 μg Hg/l respectively; McCrary and Heagler, 1997). The 96 hr LC_{50} values of mercury with water hardness of 270 mg/l at 35°C for catla, rohu and mrigal, i.e. 43.922, 194.612 and 268.141 μg Hg/l respectively have been found minimum. Gupta and Rajbanshi (1991) have also suggested that the level of tolerance of the

fish, *Heteropneustes* to metallic ions (Cu and Cd) tested was temperature specific. Further, Gupta and Rajbanshi (1991) have also noticed that *Heteropneustes* were more susceptible to Cu and Cd at higher temperature as revealed by threshold concentration, MATC and LC_{50} values.

It is interesting to note that 96 hr LC_{50} values of mercury with both the water hardness were lower as compared to that of Cd ions in hard water for fathead minnow (0.56 – 1.01 mg/l; Pickering and Henderson, 1965); *Heteropneustes fossilis* and *Channa punctatus* (14.60 – 20.60 mg/l and 6.81 – 7.40 mg/l; Gupta and Rajbanshi, 1991) and rainbow trout (2.6 mg/l; Pascoe *et al*., 1986).

Buhl (1997) studied the toxic effects of four metals, *viz.* mercury, cadmium, hexavalent chromium and lead to larvae and juvenile stages of endangered colarado squafish (*Ptychocheilus eucius*), bony tail (*Gila elegans*) and razor back sucker (*Xyrouchen taxanus*). He (op. cit.) found that larvae of each species were sensitive or more sensitive than juvenile to cadmium, hexavalent chromium and mercury ions. Further, Sukhovaskaya *et al. (*2001) observed that male of perch are more sensitive than female to elevate mercury concentration during chronic exposure. Weir and Walter, (1976) found that immature *Physa gyrina* were three times more sensitive than mature one to cadmium. Results of present study showed the following trend of relative sensities for mercury ions to the fingerlings of Indian major carps ; i.e. catla>rohu> mrigal.

The safe concentrations of mercury for the fingerlings of Indian major carps were ranged in between 12.133 to 19.689 µg Hg/l for catla, 64.039 to 82.555 µg Hg/l for rohu, and 73.510 to 89.585 µg Hg/l for mrigal for both the water hardness and temperature. The values of presumable safe and dischargeable concentration are interesting and significant since they are not constant with succeeding experiments for both the water hardness and temperature. Davies (1979), McKim *et al.* (1979) and Gupta *et al*. (1991) also reported similar pattern of safe concentration for different metallic ions separately and in combination for different fish species. The 24hr and 48hr LC_{50} values in the present study varied greatly for the calculation of presumable safe concentration or harmless concentration. Probably some of the variation may be due to the chemical reaction between mercury salt and diluent water and this in turn affect the sensitivity of the test fishes. The bioassays which were conducted with a diluent water of 270 mg/l hardness as $CaCO_3$ at 35°C revealed that mecury ions were highly toxic for the test fishes. The present results agreed with Carroll *et al*. (1979) who suggested that Ca ions was most effective component of hard water in protecting fish brook trout against cadmium. Varanasi and Gmur (1978) have also concluded that increased concentrations of calcium either in water or in the food reduces the lead (Pb) uptake from water in *Oncorhynchus kisutch*. Further, Pascoe *et al.* (1986) demonstrated, toxicity tests with rainbow trout and confirmed that cadmium is less toxic in hard water (96 hr LC_{50} – 2.6 mg Cd/l) than soft water (96 hr LC_{50} – 1.3 mg Cd/l).

References

APHA (American Public Health Association): Standard Methods for the Examination of Water and Wastewater. 18th Edn. American Water Works Association and Water Pollution Control Federation, APHA. Washington D.C. (1989).

Ayfer, Y. and J. Jacobs : Synergestic effects of temperature, oxygen and water flow on accumulation and tissue distribution of mercury in carp (*Cyprinus carpio* L.). *Chemosphere,* **31 (11-12),** 4437-4453 (1995).

Buhl, J. : Relative sensitivity of three endangered fishes, Colorado squa fish, bony tail, and razor back sucker, to selected metal pollutants. *Ecotoxicol. Environ. Saf.*, **37 (2),** 186-192 (1997).

Carroll, J.J., S.J. Ellis and W.S. Oliver : Influence of hardness constituents on the acute toxicity of cadmium to brook trout (*Salvelinus fontinalis*). *Bull. Environ. Contam. Toxicol*., **22,** 575-581 (1979).

Davies, P. : Cadmium, review of the EPA red book : Quality criteria for water. Water quality section. Am. Fish. Soc., Bethesda. Maryland, U.S.A. pp. 51-66 (1979).

Finney, D.J.: Probit analysis. University Press, Cambridge, (1971).

Gupta ,A.K., C.B. Sajini and M.S. Champawat : Acute toxicity of Cu-Cd-Pb-Zn to a freshwater teleost, *Poecilia reticulata* (Peters). Proc. IIIrd Asian Fish. Forum, Asian Fish. Soc., Manila, Philippines, pp. 499-502 (1991).

Gupta, A.K. and V.K. Rajbanshi: Toxicity of copper and cadmium to *Heteropneustes fossilis* (Bloch). *Acta Hydrochim. Et. Hydroboil*., **19 (3) ,** 331-340 (1991).

Gupta, A.K. and V.K. Rajbanshi: Mercury poisoning: Architectural changes in the gill of *Rasbora daniconius* (Ham.). *J. Environ. Biol*., **16(1),** 33-36 (1995).

Hart, W.B., P. Doudoroff and J. Greenbank : The evaluation of the toxicity of industrial wastes, chemical and other substances to freshwater fishes. Atlant. Refinding Co. (Phill), (1945).

John, P.R., V. Rena and D.J. McQueen : Uptake rates of food-chain and waterborne mercury by fish : Field measurements, a mechanistic model and an assessment of uncertainties. *Can. J. Fish. Aquat. Sci*., **53 (2),** 395-407 (1996).

Mathieson, S., S.G George and D.S. Mclusky, : Temporal variations of total mercury concentrations and burdens in the liver of eel pout *Zoarces viviparus* from the fourth estuary, Scotland : Implications for mercury biomonitoring. *Mar. Ecol. Prog. Ser*., **138,** 41-49 (1996).

McCrary, J.E. and M.G. Heagler : The use of simultaneous multiple species acute toxicity tests to compare the relative sensitivities of aquatic organisms to mercury. *J. Environ. Sci. health (Part A). Environ. Sci. Eng.* & *Toxic & Hazard. Subst. Cont.*, **32 (1),** 73-81 (1997).

McKim, J.M., R.L.Anderson, D.A.Benoit, R.L.Spehar and G.N. Stokes : Review of the EPA red book: Quality criteria for water. Water quality section, Am. Fish. Soc, Bethesda, Maryland, USA, pp. 293-303 (1979).

Pascoe, D., A. Sain, S. Evan and J.Woodworth: Heavy metal toxicity to fish and the influence of water hardness. *Arch. Environ. Contam. Toxicol*., **15,** 481-487 (1986).

Pickering, Q.H. and C. Henderson : The acute toxicity of some heavy metals to different species of warm water fishes. Proc. 19th. Indust. Waste Conf., Purdue Univ., pp. 578-591 (1965).

Sukhovaskaya, I.V., L.P.Smirnov, N.N. Nemova and V.T. Komov : Effect of mecurium on the fractional composition of the low-molecular peptides of musculature in the perch, *Perca flaviatilis*. *Voprosy Ikhtiol*., **41 (5),** 699-703 (2001).

Varanasi, V. and D.J. Gmur : Influence of water-borne and dietary calcium on uptake and retention of lead by coho salmon (*Oncorhynchus kisutch*). *Toxicol. Appl. Pharmacol*., **45,** 56-75 (1978).

Weir, C.F. and W.M Walter : Toxicity of cadmium in the freshwater snail *(Physa gyrina). J. Environ. Qual*., **5 (4),** 359-362 (1976).

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