Bull. Environ. Contam. Toxicol. (1987) 39:45–49

Bulletin of Environmental Contamination and Toxicology

Zinc Sensitivity of a Freshwater Snail, *Lymnaea luteola* L., in Relation to Seasonal Variations in Temperature

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The aquatic environment has numerous physical and chemical parameters that may influence the physiology and chemical toxicity to freshwater organisms (Fry 1971; Count and Pruderer 1973; Heath 1973; Cairns et al. 1975). Temperature is one of these factors having a marked influence on heavy metal toxicity to fishes and macroinvertebrates (Cairns and Scheier 1958; Gupta et al. 1980; Khangarot 1980). There is a limited and scattered information available on temperature induced changes in acute toxicity of zinc compounds to freshwater pond snails (Wurtz 1962; Cairns et al. 1978). This information is essential because there are large temperature differences with season and latitudes and the aquatic organisms are subjected to seasonal temperature changes of 20-25°C or even more. It is proposed to study the effect of seasonal changes in temperature on zinc toxicity to a freshwater pond snail, Lymnaea luteola (Lamarck), which form an important link in aquatic food chain(s) and are widely distributed in lakes, ponds and rivers of India.

MATERIALS AND METHODS

Adult L. luteola were collected prior to each experiment from a freshwater pond and acclimatized to laboratory conditions for 7-10 days before experimentation. The specimen used for study averaged 2.1 cm (range 1.92-2.25 cm) in mean height and 0.52 g (range 0.46-0.72 g) in wet weight. The zinc salt used was the reagent grade $ZnSO_4.7H_2O$ and was added to achieve a graded series of concentrations as recommended in standard methods (APHA 1975). The snails were fed daily with algae and aquatic plants but feeding was discontinued 48 h prior to static bioassay. The temperature variations were achieved by conducting the experiments over different seasons from November (warm) to July (hot) months. The range of temperature during these months is given in Table 1. Ten snails were exposed at a time to each concentration and for every concentration there were two replicates. The toxicant solution and the control water were replaced every 24 h.

The criterion for death was the failure of snails to respond to prodding of their 'foot' with a needle. The dead specimens were removed and recorded. The LC 50 values and their 95% confidence limits were

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calculated by moving-average-angle procedure (Harris 1959). The test solution were analysed every 24 h for physico-chemical properties. The alkalinity, hardness and dissolved oxygen were determined by routine procedures (APHA 1975).

RESULTS AND DISCUSSION

The physico-chemical properties of testwater are depicted in Table 1. Temperature variations in the test jar in a particular season was same as in pond water from where the snails were collected. pH value ranged from 7.2 to 7.6 Decrease in pH values was noticed at higher Zn concentrations, but these values were never greater than 0.4 pH unit.

Table 1. Mean and range of physico-chemical properties of test water

Characteristics	Unit	January	April	July	November
Air temperature	°C	19.5[a] (17-21)	28 (26-31)[b]	34 (31-36)	24.5 (22-26.5)
Water temperature	°C	17.5 (15.5-18.5)	26 (24-27)	32 (30-33.5)	22 (21-23)
pH		7.4 (7.2-7.6)	7.6 (7.4-7.8)	7.3 (7.2-7.6)	7.4 (7.3-7.5)
Conductivity	µM/cm	900 (880-920)	950 (930-990)	960 (940-1020)	890 (880-930)
Dissolved oxygen	mg/L	7.5 (7.2-8.0)	6.8 (6.0-7.4)	5.6 (5.2-6.1)	6.2 (5.8-7.1)
Alkalinity	mg/L as $CaCO_3$	152 (144-170)	174 (164-180)	180 (165-190)	176 (166-180)
Hardness	mg/L as $CaCO_3$	195 (165-210)	205 (180-220)	203 (175-230)	198 (182-208)

a = Values of mean
b = Values given in parenthesis represent the range

All the organisms in control aquarium survived except at 32°C(July) where 10% mortality observed in test period, i.e. 96 h. Per cent mortality of snails at different temperatures of the test water at 96 h of exposure at different concentrations of zinc are presented in Table 2.

Table 2. Mean percentage mortality at 96 h of exposure in L. luteola at varying temperatures in different months of the year

Concentration (in mg/L of Zn)	Percent mortality in the month of			
	January (17.5°C)	April (26°C)	July (32°C)	November (22°C)
28	100	100	100	100
21	100	100	100	100
15.5	80	100	100	95
11	60	80	100	60
7	40	60	100	50
5	20	40	100	15
3	0	10	55	10
1	0	0	40	0
Control	0	0	10	0

At 17.5°C, with concentrations of 21, 15.5, 11 mg/Lof zinc, the mortality at 96 h of exposure was 100, 80 and 60% respectively. However, at 32°C mortality was 100% in all three zinc concentrations. This indicated that the acute toxicity value of zinc for the snail differed with change in temperature of the test water in accordance with the time of the year.

LC50 and their 95% confidence limits are shown in Table 3. The 96 h LC50's indicated that at 17.5°C, the zinc was less toxic, while at 32°C, it was high toxic. It was also observed that 96 h LC50 values at 32°C were 6.55, 4.77 and 2.98 times lower than those obtained for snails tested at 17.5, 22 and 26°C. The results suggested that the zinc toxicity increased with the increase in temperature from winter (cold) to summer (hot) seasons (Table 3).

Table 3. LC50 values and 95 per cent confidence limits of zinc at different temperatures

Mean temperature (°C)	LC50 values and 95% confidence limits at (in mg/L of Zn)			
	24 h	48 h	72 h	96 h
17.5	21.81[a] (18.41-24.55)	15.40 (13.27-19.17)[b]	11.40 (9.9-12.76)	11 -[c]
22	16.29 (14.56-18.45)	11.58 (9.13-13.80)	8.01 (6.65-9.45)	8.01 (6.65-9.45)
26	9.14 (7.44-11.54)	6.75 (6.12-7.88)	6.65 (6.12-7.88)	5 -[c]
32	7 -[c]	3.80 (2.87-5.22)	3.80 (2.87-5.22)	1.68 (1.15-2.37)

[a] Values of LC50

[b] Values given in parenthesis represent the 95% confidence limits of LC50

[c] 95% confidence limits cannot be determined

The snail showed characteristic changes in behavior when exposed to various concentrations of zinc. In higher concentrations snail spent most of their time at the bottom and died without showing any movement. However, in lower concentrations and in control jars, most of the animals swam at the surface of the water or attached at the wall of the test container. In all the zinc concentrations, snails first sank to the bottom before death.

Results of this experiment clearly indicated that seasonal changes in temperature may alter the acute toxicity of zinc to L. luteola. It is possible that zinc toxicity is controlled by temperatures of water in similar ways that enzyme kinetics are controlled. This, however, needs further study. It was noticed that rising in temperature from 17°C to 32°C reduced the 96 h LC50 of snail from 11 to 1.68 mg/L of zinc thereby increasing the toxicity by a factor of 6.55. These results agree in general with those in literature. For example, Wurtz (1962) reported that rise in temperature increased the zinc toxicity in hard water to ramshown snail (Helisoma capannulatum). However, the picture becomes somewhat less clear when the information of other studies of Wurtz

(1962) is considered wherein he claimed that in the case of another species of a freshwater pond snail (Physa heterostropha), rise in the temperature tended to decrease zinc toxicity in hard water, but had no effect in soft water. This could perhaps be a case of differential resistance depending on the species characteristics. Johnson (1968) reported that increase in water temperature enhanced the toxicity in some cases and decreased it in others, depending upon the nature of the toxicant and to a lesser extent on the animal species. Results of our study are in close agreement with the data obtained for the effect of seasonal changes in temperature on the acute toxicity of copper to a pond snail, Viviparus bengalensis (Gupta et al., 1980) and to fish, Puntius sophore on exposure to zinc (Khangarot 1980).

The mechanism underlying the increased susceptibility of snail to zinc (at higher temperatures) may be the increased oxygen demand by snail accompanied by lowered solubility of oxygen in the water at higher temperature (Kaungo and Prosser 1950). It is reported that increase in temperatures may potentiate the toxicants that acts on cellular enzymes (Cairns et al. 1975). The greater mortality at higher temperature may have been due to changes in several physiological and metabolic processes. The increased metabolism would also increase the uptake of zinc which circulates in the body system, thereby causing higher toxicity (Skidmore 1970; Hodson 1975).

Acknowledgments. BSK is thankful to the Council of Scientific and Industrial Research, New Delhi, for providing the financial assistance to carry out this work. We thank Mr. L.K. Goswami for excellent secretarial assistance.

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Received September 2, 1986; accepted February 2, 1987.