Evaluation of Acute Toxicity of Zinc, Lead and Cadmium to Zooplanktonic Community

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ABSTRACT

Acute toxicity of Zinc, Lead and Cadmium to fresh water zooplankters was assessed after conducting static bioassay. Whole zooplanktonic communities were exposed to different heavy metal stresses. Exposed zooplanktonic community included nine planktonic forms i.e. *Heliodiaptomus viduus, Mesocyclops hyalinus, Heterocypris, Daphnia lumholtzi, Moina, Brachionus, Monostyla, Filinia.* Cadmium was found to be most toxic and Zinc was least toxic to zooplankton. Ostracods and Cyclops were resistant forms and rotifers were sensitive forms in relation to metallic exposure. Sensitivity pattern observed during laboratory experiments was found to be in accordance with biodiversity variation of zooplankton in different ponds of Berach river system.

INTRODUCTION

Being key elements in our life zinc, lead and cadmium have been widely used by the people for different purposes. Besides their use by common people, these find a myriad application in industries manufacturing different products. Mineral based industries related with zinc, lead and cadmium are common in and around Udaipur. These industrial units have been reported to cause heavy metal pollution (Sharma & Selvaraj, 1994 and Sharma *et al.*, 2000). Heavy metal pollutants are affecting aquatic life in their surrounding waters. Berach river system is starting from Gogunda and its vicinity area and terminating at Sarjana tank Fig 1. This river is consisting of many small and large lakes and ponds. Biodiversity of Berach river system was specially affected by these pollutants (Sharma *et al.*, 2000).

Since zooplankters are sensitive microscopic animals and these form primary food source for several species of fish and their juveniles, it is considered useful to find out metal toxicity effects on their survival. Most of the work has been done on toxicity of heavy metals to freshwater fishes but only few workers observed toxic effects of metal on zooplankters (Tabata, 1969a & 1969b ; Christensen, 1971 ; Winner and Farrell, 1976 ; Winner and Gauss, 1986 ; Arnott and Ahasanullah, 1978 ; Marshall *et al.*, 1983 ; Rune, 1986 ; Kulshreshta *et al.*, 1989 ; Filenko and Lazareva, 1989 ;

Sharma and Selvaraj, 1994 and Sharma *et al.*, 2000 & 2001). But up to now much toxicity research was focused on acute and chronic experiments conducted to know responses of either single zooplankton species to single metal or single zooplankton species to multiple metals. Present study is aimed at observing acute responses of natural zooplankton community or assemblages to heavy metals. These responses can explain effects of pollutants on ecosystem health in better way as community assemblage is exposed in a group. Fresh water zooplanktonic community is mainly composed primarily of rotifers and crustaceans which can be further divided into copepods, cladocerans and ostracods. Present studies is based on exposure of representatives belonging to all these groups found in lakes of Udaipur.

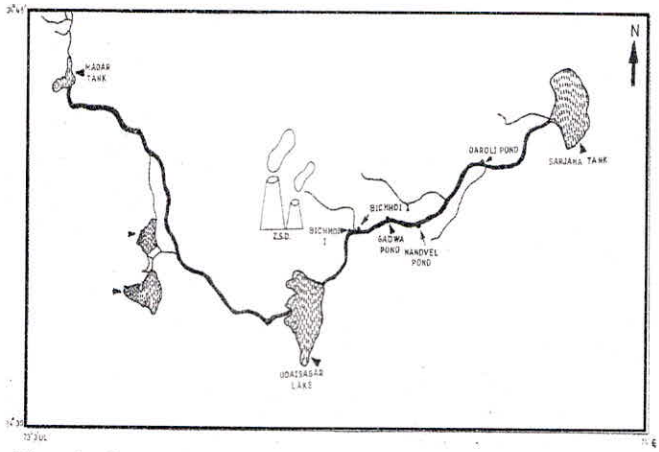

Fig. 1 : Sampling Stations in Berach River System

MATERIALS AND METHODS

Toxic effects were determined by conducting short term as well as long-term bioassay tests. These tests were based on guidelines suggested by ASTM (1974) and APHA (1989). Diluent water used was taken from Science college well. The physico-chemical characteristic of diluent water is depicted in Table 1. Fresh water zooplankters selected for study were as follows

1. *Brachionus*
2. *Monostyla*
3. *Filinia*
4. *Heliodiaptomus viduus*
5. *Mesocyclops hyalinus*
6. *Heterocypris*
7. *Daphnia lumholtzi*
8. *Ceriodaphnia*
9. *Moina*

Table 1: Physico-chemical characteristics of test water

1.	Water temperature	-	26 °C
2.	pH	-	7.9
3.	Alkalinity	-	512 ppm
4.	Chlorides	-	298 ppm
5.	Hardness	-	582 ppm
6.	T.D.S.	-	1.256 g/l
7.	Sulphates	-	147 ppm
8.	Electrical cond	-	2.125 milli mhos
9.	Flurorides	-	0.185 ppm
10.	Dissolved oxygen	-	6.99 ppm
11.	Zinc	-	0.08 ppm
12.	Cadmium	-	0.005 ppm
13.	Lead	-	0.0214 ppm

Zooplankton selected for the study were collected form different Lakes viz. Fatehsagar, Udaisagar and Madar pond. These plankton were acclimatized in the laboratory for one week in the glass aquaria. Once separated from other forms, their culture was maintained according to methods suggested by Boudowin and Scoppa (1974), Committee on methods for toxicity tests with aquatic organisms (1975) and Shirgur (1981).

A probit analysis was carried out to calculate median lethal concentration. The LC-50 values were obtained by graphical interpolation based on observed percentage of mortality plotted on logarithmic scale. Other standard indices calculated were Threshold concentration, Maximum acceptable toxicant concentration (MATC) and Application factor. Zinc concentration in test water, exposed animal and well water were detected by Atomic Absorption Spectrophotometer. Perkin Elmer 2380 Atomic Absorption spectrophotometer was used during present study and Zn, Cd and Pb were read on 213.9 nm, 226.50 nm and 220.50 nm wave length respectively.

RESULTS

During present study varied responses of different zooplankters were observed to different metals. Tables 2, 3 and 4 Figs 1, 2 and 3 show that out of three metals undertaken for study cadmium was the most toxic to *Monostyla, Brachionus, Filinia, Heliodiaptomus viduus, Mesocyclops hyalinus, Heterocypris, Daphnia,* and *Moina.* Zinc was found more toxic to *Ceriodaphnia* as compared to cadmium and lead. In general, following trend of metal toxicity was observed in relation to freshwater zooplankters: -

Cadmium > Lead > Zinc

Table 2: Acute toxicity of zinc to fresh water zooplankters.

S. No.	Name of Zooplankters	48 hr LC-50 (mg/l)	MATC (mg/l)	T.C (mg/l)	AF at 48 hr
1.	*Heliodiaptomus viduus*	0.5	0.045	0.075	0.09
2.	*Mesocyclops hyalinus*	4.0	0.08	1.4	0.02
3.	*Heterocypris*	5.25	0.045	0.8	0.009
4.	*Daphnia lumholtzi*	2.3	0.025	0.45	0.011
5.	*Ceriodaphnia*	1.4	0.025	0.14	0.018
6.	*Moina*	1.2	0.05	0.1	0.042
7.	*Brachionus*	0.24	0.025	0.45	0.104
8.	*Monostyla*	0.12	0.025	0.14	0.208
9.	*Filinia*	0.15	0.025	0.1	0.167

MATC - Maximum acceptable toxicant concentration
TC - Threshold concentration
AF - Application factor

Table 3: Acute toxicity of lead to fresh water zooplankters.

S. No.	Name of Zooplankters	48 hr LC-50 (mg/l)	MATC (mg/l)	T.C at 48 hr (mg/l)	AF
1.	*Heliodiaptomus viduus*	3.1	0.045	0.14	0.01
2.	*Mesocyclops hyalinus*	8.0	0.25	2.5	0.03
3.	*Heterocypris*	5. 5	0.14	1.4	0.025
4.	*Daphnia lumholtzi*	5.5	0.045	0.45	0.008
5.	*Ceriodaphnia*	2.3	0.14	0.25	0.06
6.	*Moina*	0.92	0.025	0.25	0.01
7.	*Brachionus*	0.11	0.025	0.45	0.01
8.	*Monostyla*	0.05	0.020	0.14	0.017
9.	*Filinia* 0.1	0.025	0.1	0.25	

Table 4: Acute toxicity of Cadmium to fresh water zooplankters

S. No.	Name of Zooplankters LC-50 (mg/l)	48 hr (mg/l)	MATC at 48 hr (mg/l)	T.C	AF
1.	*Heliodiaptomus viduus*	0.15	0.03	0.045	0.17
2.	*Mesocyclops hyalinus*	0.87	0.05	0.08	0.05
3.	*Heterocypris*	2.15	0.03	1.5	0.012
4.	*Daphnia lumholtzi*	0.28	0.03	0.045	0.089
5.	*Ceriodaphnia*	1.9	0.08	0.45	0.042
6.	*Moina*	0.58	0.05	0.08	0.086
7.	*Brachionus*	0.05	0.03	0.45	0.50
8.	*Monostyla*	>0.05	0.025	0.14	-
9.	*Filinia*	>0.05	0.02	0.1	-

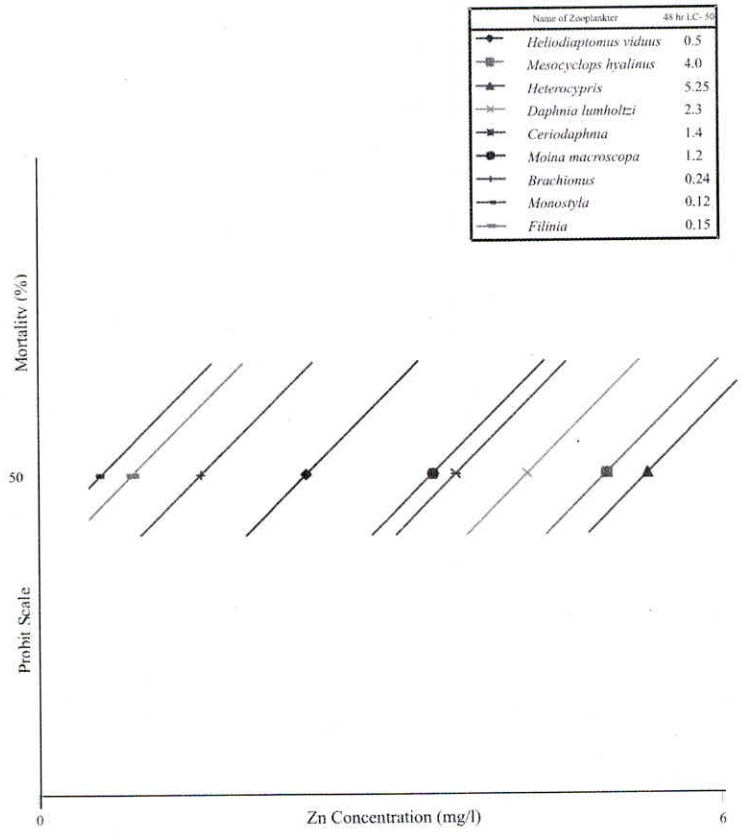

Fig. 2 : Acute toxicity of zinc to fresh water zooplankters

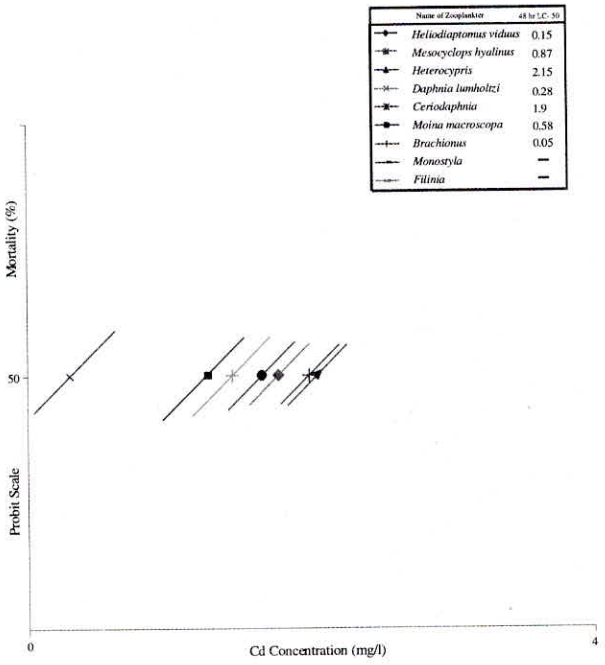

Fig. 3: Acute toxicity of Cadmium to fresh water zooplankters

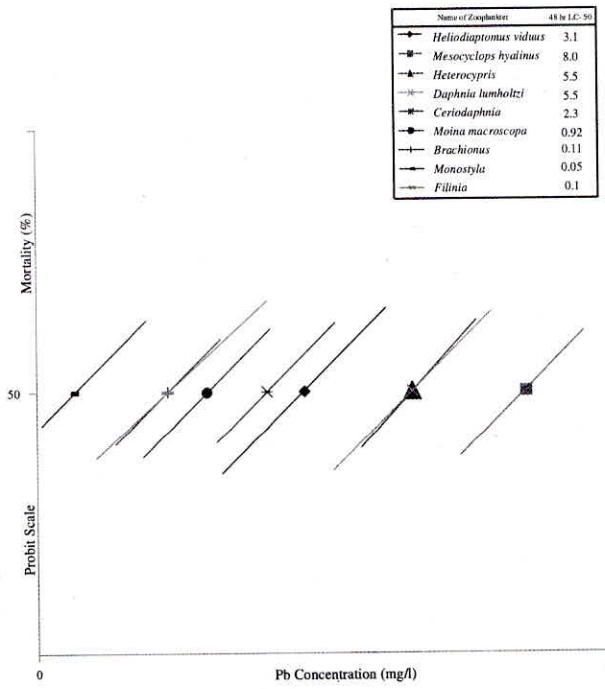

Fig. 4: Acute toxicity of lead to fresh water zooplankters

Median lethal concentration of cadmium in relation to different freshwater zooplankters were in the range of 0.05 to 2.15 mg/l. high range (0.05 – 8.00 mg/l) of LC-50 values have been noted in the case of lead. Although LC-50 values of zinc especially maximum one was little lower in relation to freshwater zooplankters *i.e.* 0.15 to 5.25 mg/l but this was due to *Mesocyclops hyalinus* and *Heterocypris* which were more sensitive to zinc as compared to lead. Sensitivity pattern shown by different experimental zooplankters in relation to zinc, lead and cadmium was as follows: -

Zinc

Monostyla > Filinia > Brachionus > Heliodiaptomus viduus > Moina > Ceriodaphnia > Daphnia lumholtzi > Mesocyclops hyalinus > Heterocypris

Lead

Monostyla > Filinia > Brachionus > Moina > Ceriodaphnia > Heliodiaptomus viduus > Heterocypris = Daphnia lumholtzi > Mesocyclops hyalinus

Cadmium

Monostyla = Filinia > Brachionus > Heliodiaptomus viduus > Daphnia lumholtzi > Moina > Mesocyclops hyalinus > Ceriodaphnia > Heterocypris

As evident from above mentioned sensitivity patterns, it is clear that except little deviation rotifers were most sensitive followed by calanoids, cladocerans, *Mesocyclops hyalinus* and ostracods. Among rotifers *Brachionus* was most resistant followed by *Monostyla* and *Filinia*. Out of the cladocerans under taken for study *Moina* was most sensitive followed by Daphnia lumholtzi and *Ceriodaphnia*. Many workers have used planktonic crustaceans to assess toxicity of metals. Baudouin & Scoppa (1974) observed 48 hr LC-50 of zinc as 2.5 and 0.055 in respect to *Daphnia lumholtzi rosea* and *Daphnia lumholtzi hyalina* respectively. Wilson (1980) observed 96 hr LC-50 of 0.444 mg/l cadmium for *Mesocyclops hyalinus bicuspedatus thomsi*. Lolande and Alloul (1984 & 1985) tested effect of cadmium and zinc to *Daphnia lumholtzi rosea* and observed that 48 hr LC-50 values of cadmium and zinc were 0.609 and 2.501 for this cladoceran. These authors also studied toxicity of cadmium and zinc to *TropoMesocyclops hyalinus prasinus* and found that 48 hr LC-50 values were 2.233 and 2.934 mg/l respectively. Similar study on copepods have been also made by Munawar and Lolande (1985). They opined that predatory cyclopoid copepods are far less sensitive to metals than filter feeding cladocerans. Fatma (1996) worked on zinc toxicity to different freshwater animals and she compared sensitivity of fish, tadpole, *Moina*, and *Notonecta*. Median lethal concentration observed by her after 96 hr exposure of *Moina* was 0.57 mg/l. Similar studies have been also made by Barber (1997) and noted 96 hr LC-50 of cadmium for *Moina* as 0.35 mg/l. Sharma *et al* (2000) observed that sensitivity of *Daphnia lumholtzi* to zinc, lead and cadmium under

thermal stress was higher than *Mesocyclops hyalinus* and *Heterocypris*. No literature is available about metal toxicity in respect to rotifers except that of Buikema *et al* (1974) who noted 48 hr and 96 hr zinc LC-50 values of 0.9 and 1.2 mg/l for a deltoid rotifer *Philodina auticocornis*.

Findings of present study and observations of Fatma (1996) regarding sensitivity of different freshwater zooplankters were compared with biodiversity variations in zooplankters of water belonging to Berach river system.

Laboratory bioassay results were found to be in accordance to following field observations.

(i) Rotifers were the most sensitive to heavy metal pollution
(ii) Among rotifers, *Brachionus* was most resistant and this is confirmed by the fact that species of *Brachionus* especially *B. calyciflorus* started appearing in moderately polluted Gadwa and Daroli ponds.
(iii) Among crustaceans *Heterocypris* and *Mesocyclops hyalinus* were resistant forms and these showed their appearance in polluted ponds also.
(iv) Sensitivity of *Heliodiaptomus viduus* was also confirmed during sampling of water bodies belonging to Berach river system as no calanoid form was observed in polluted water bodies.
(v) Moina showed its sensitivity in relation to zinc smelter effluent also and it was found to occur in recovery zone of Sarjana tank where pollution load is considerably reduced.

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