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Changes in Food [*Chlorella*] Levels and the Acute Toxicity of Cadmium to *Daphnia carinata* (Daphnidae) and *Echinisca triserialis* (Macrothricidae) [Crustacea: Cladocera]

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With increased number of industries such as chemicals, fertilizers etc. being set up in India, several heavy metals including cadmium have been detected in the freshwaters of India (Agarwal et al 1980), including major riverine systems (Agarwal et al 1978, Somashekar & Ramaswamy 1982). Inasmuch as cadmium is known to be toxic to both fish and aquatic invertebrates (Forstner & Wittmann 1983) due to bioaccumulation and biomagnification potential, the present study was initiated to determine the acute effects of cadmium on two cladoceran species - Daphnia carinata and Echinisca triserialis commonly found in freshwaters of Delhi. The two species being in the extreme ends of the size continuum (D. carinata : adult size = 2.7 ± 0.2 mm, E. triserialis : adult size = 0.8 ± 0.1 mm) were chosen to determine the magnitude of toxicity in relation to body size. As extraneous abiotic and biotic factors such as temperature, pH, food have been shown to greatly modify a pollutant stress (Cairns, 1981), the present study was conducted with the objective of determining if differences in food levels could modify the acute toxicity effects of cadmium on these cladocerans. An attempt has also been made to compare these results with previous studies on cadmium toxicity.

MATERIALS AND METHODS

The two cladoceran species were selected from blooms appearing in different seasons (July-September for E.triserialis and November-March for D.carinata) from the freshwaters of Delhi and were reared parthenogenetically for several generations. They were maintained in the laboratory at a temperature of 24 ± 1°C, pH 7.0 ± 0.2 and food at 1-2 x 10^6

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Chlorella cells/mL medium. Mass cultures of Chlorella were maintained in the laboratory on Kuhl's medium (Kuhl and Lorenzen 1963). The cultures were changed into a fresh medium every alternate day at the optimal temperature-pH-food ranges. The static bioassay tests were conducted on neonates (age < 24h) produced by adults separated from the cultures a day earlier.

Initially a broad range of cadmium (Cd) concentrations of 0.1-100 ppm (mg/L) was set which was narrowed to 100-500 ppb (µg/L) for Echinisca triserialis and 100-1000 µg/L for Daphnia carinata. The required cadmium concentrations were prepared by serial dilution with distilled water from a 1000 mg/L stock solution of cadmium of analytical grade cadmium chloride ($CdCl_2.2\frac{1}{2}H_2O$) in distilled water. Chlorella from the larger cultures were harvested at densities of approximately 25 x 10^6 cells/mL, centrifuged for 5 min at 932 g, washed repeatedly in distilled water and resuspended in the medium consisting of distilled water. A cadmium range of 0,100,200, 300,400 and 500 µg/L was set for E.triserialis and D. carinata at each of these food level. For both species, into each of the 54 treatment combinations (6 cadmium levels x 3 food levels x 3 replicates) consisting of 100 mL beakers, were introduced 40 neonates (age < 24h). Mortalities were recorded every 24-h and the test was terminated after 96-h as recommended in Sprague (1971). The surviving animals were transferred to fresh media everyday. Absence of heart-beat for a continuous 10-sec period was the criterion used for death. The analysis was conducted as given in Finney (1971).

RESULTS AND DISCUSSION

The 48-h and 96-h LC50 cadmium levels estimated from probit graphs for E.triserialis (Fig 1) were 345 and 70 µg/L at low food level, 370 and 58 µg/L at medium food level and 460 and 340 µg/L at high food level (Table 1). For D.carinata (Fig 2) they were 265 and 110 µg/L at low food level and 350 and 235 µg/L at medium food level. 48-h LC 50 was not achieved by D.carinata at high food level but at 96-h, a 50% mortality was achieved at 480 µg/L Cd level. Thus the LC50 values for E.triserialis were lower than those of D.carinata at all the three food levels tested. For both species, the survival of cadmium stressed populations observed every 24-h was greatly affected by food stress. For example, the 96-h LC50 value for E.triserialis at high food level was nearly five times more than that at low food levels. For D.carinata the 96-h LC50 value at high food level was nearly 4.4 times more than that at low food levels.

Cladocerans at high cadmium levels became moribund after being a couple of hours in the toxicant medium. Feeding

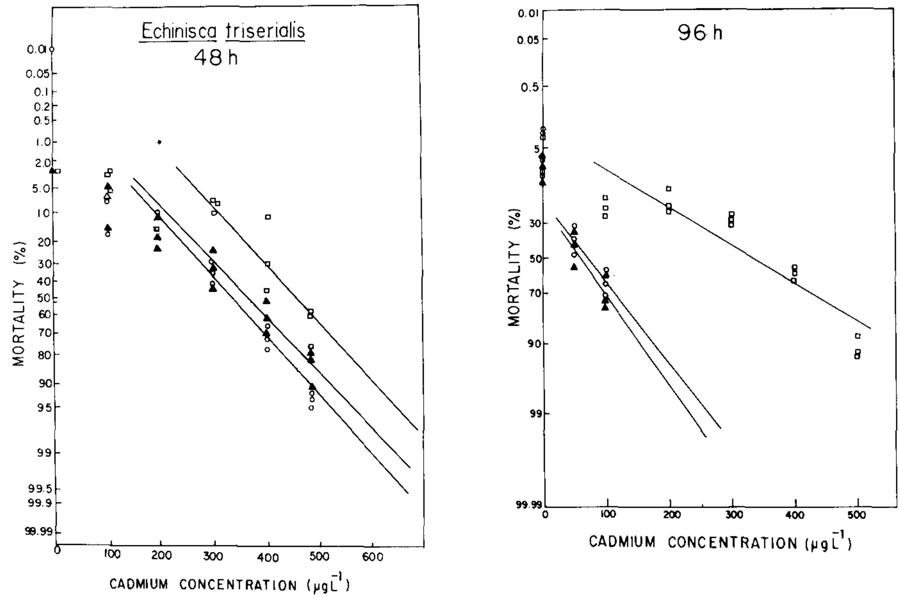

Figure 1. The 48-h and 96-h acute toxicity levels of cadmium at 0 to 500 µg/L range on *Echinisca triserialis* at three food levels of 0.5 (○), 1.5 (▲) 4.5 (□) x 10^6 cells *Chlorella*/mL.

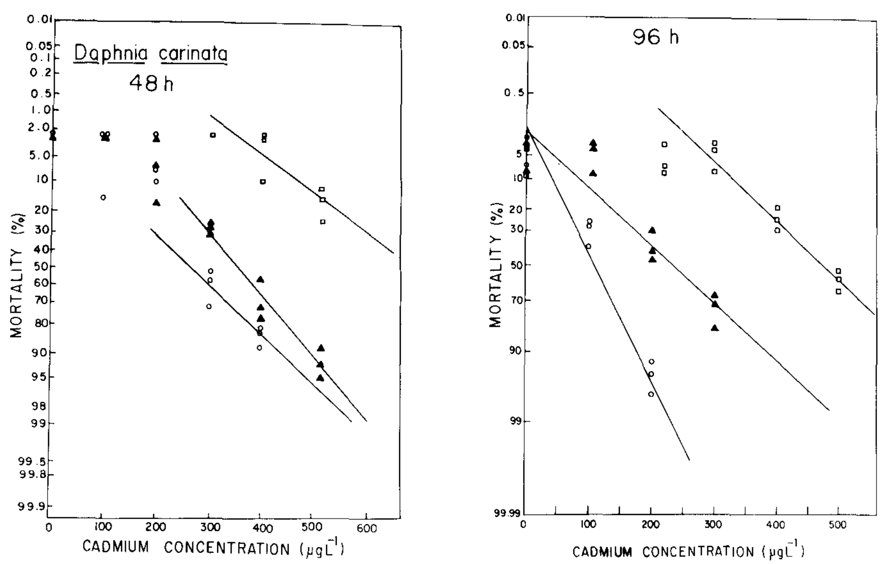

Figure 2. The 48-h and 96-h acute toxicity levels of cadmium at 0 to 500 µg/L range on *Daphnia carinata* at three food levels of 0.5 (○), 1.5 (▲) and 4.5 (□) x 10^6 cells *Chlorella*/mL.

Table 1. Acute Toxicity of Cadmium in some Cladocera

Species	Food	Av. size (mm)	LC50 (ug/L) 24-h	48-h	96-h	References
Ceriodaphnia reticulata	Daphnia 'chow', + Selanastrum capri-cornutum	0.6	-	90	-	Hall et al (1986)
C. reticulata		0.6	-	66	-	Mount & Norberg (1984)
Echinisca triserialis	Chlorella (0.5,1.5, 4.5 x 10^6 cells/mL)	0.8	-	345	70	Present study
				370	58	
				460	340	
Daphnia cucullata	Not mentioned	1.5	-	200	-	Canton & Adema (1978)
D. pulex	Not mentioned	2.5	-	145	-	Canton & Adema (1978)
D. pulex	Chlorella & yeast	2.5	-	-	47	Bertram & Hart (1979)
D. pulex		2.5	-	68	-	Mount & Norberg (1984)
D. pulex		2.5	-	145	-	Lewis & Weber (1985)
D. pulex	Daphnia 'Chow'+ Selanastrum capricornutum	2.5	-	30	-	Hall et al (1986)
D. carinata	Chlorella (0.5,1.5, 4.5 x 10^6 cells/mL)	2.8	-	265	110	Present study
				350	235	
				-	480	
D. magna	No food	3.0	-	65	-	Biesinger & Christensen (1972)
D. magna	Not mentioned	3.0	-	47	-	Canton & Adema (1978)
D. magna		3.0	-	36	-	Chapman (1980)
D. magna	Chlorella vulgaris	3.0	58.16	203.8	-	Attar & Maly (1982)
D. magna	Chlorella vulgaris	3.0	5.0	30	-	Canton & Sloof (1982)
D. Magna		3.0	-	32	-	Schuytema et al (1983)
D. magna		3.0	-	118	-	Mount & Norberg (1984)
D. magna		3.0	-	25	-	Lewis & Weber (1985)
D. magna	Daphnia 'chow'+Alga	3.0	-	66	-	Hall et al (1986)

process which is more or less continuous in the filter-feeding cladocerans was found to be affected as the gut was found to be only partially filled in varying degrees. The appendages which cause the feeding current was immobilised in the moribund individuals which slowly sank to the bottom.

The LC50 values presented here for cadmium are compared with those obtained for other cladocerans (Table 1). Because of the differences in the quantity and quality of the food provided and in other testing conditions, there appears to be no clear cut range of cadmium toxicity for the small sized cladocerans such as Ceriodaphnia reticulata, Echinisca triserialis and for the large sized cladocerans such as D.pulex, D.magna and D.carinata. It is however clear that cladoceran populations are drastically reduced within 48 h by as much as 50% when cadmium levels in the waters increase to 30 µg/L or above.

It is concluded that factors such as availability of food in the natural waters may severely affect pollutants such as cadmium in either enhancing it or mitigating it. If cadmium levels increase to 50 µg/L or more, especially in summer conditions, when food levels are low, the small sized (< 1 mm) cladocerans may be eliminated, affecting the trophic structure of the ecosystem as many invertebrates such as insect larvae feed primarily on them.

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