AQUACULT Vol 3 (2) 143-148, 2002 ISSN - 0972 - 2262

Acute toxicity of some heavy metals to the shrimp *Penaeus monodon*

K. O. Joseph, K. K. Krishnani, B. P. Gupta and M. Muralidhar
Central Institute of Brackishwater Aquaculture, 75, Santhome High Road, R A. Puram, Chennai - 600 028, India

(Accepted for Publication - 16th August, 2002)

Abstract

Static bioassay tests for acute toxicity of five heavy metals to the shrimp *Penaeus monodon* in brackishwater medium (salinity 15 ± 1 0 ppt) were conducted The 96 h LC_{50} values of metals such as Cr, Zn, Cu, Cd and Hg were found to be 4 20, 1 50, 1 20, 0 15 and 0 03 ppm respectively for shrimp of size group 33-46 mm Using the safe concentration factor of 0 01, the allowable safe concentration for Cr, Zn, Cu, Cd and Hg were 0 042, 0 015, 0 012, 0 0015 and 0 0003 ppm respectively In order to assess the contamination of heavy metals, water samples were collected from inflow, pond and discharge of shrimp farm in Pudiparthi area of Andhra Pradesh and Tuticorin area of Tamil Nadu Except mercury, the concentration of other heavy metals were below detection level of the Instrument used Based on the LC_{50} values and derived safe concentrations, Tuticorin inflow sea water appeared to be safe at present levels of Mercury at 0 0003 ppm

Key Words Heavy metals, Acute toxicity, *Penaeus monodon*

Introduction

The increasing impairment of coastal water quality resulting from the discharge of domestic, agricultural and industrial wastes in coastal waters has affected the aquaculture profitability in certain areas (Federico *et al*, 1998), of which heavy metal pollution is recent interest The addition of these metals through number of industrial waste waters including those from the textiles, leather tanning, electroplating etc into water bodies poses serious problems of its possible entry into the food chain (Khasim and Nand Kumar, 1989) The impact of heavy metal pollution to coastal and estuarine areas could be substantial because of the variety of inputs and this can cause physiological defects to the aquatic species (Callaway *et al*, 1998) Toxicological studies of the pollutants upon aquatic organisms are very important from the view point of environmental consequences Acute toxicity studies offer substantial help in detection, evaluation and abatement of pollution by providing reliable estimates of safe concentration from which water quality criteria can be derived (Asnulah, 1981) Utilisation of acute toxicity studies for assessing water quality can be employed by examining different life stages of important aquatic species (NAS/NAE, 1973) Such basic toxicity information, particularly, on larvae is necessary because, larvae are usually more sensitive than adults and the survival of larvae forms becomes questionable at concentration suitable to adult forms (Conner, 1972) Hence, the present study has been undertaken to determine the acute effect of five heavy metals to the juveniles of *Penaeus monodon* (size group 33-46 mm) in brackishwater medium A study has also been conducted to assess the heavy metals in the coastal waters in Andhra Pradesh and Tamil Nadu

e-mail ciba@tn nic in

Materials and Methods

Chemicals and glass wares : E Merck chemicals ($CuSO_4$, $5H_2O$, $ZnSO_4$, $7H_2O$, $CdSO_4$, $HgCl_2$

and $K_2Cr_2O_7$ were used. Metals stock solutions were prepared and serial dilutions of stock solutions were made with brackishwater of 15 ± 1.0 ppt salinity to get the desired concentrations for experiments.

Rearing of animals : The test animals, *P. monodon* of size group 33-46 mm were acclimatized to laboratory conditions in brackishwater (salinity 15±1.00 ppt) system for one week prior to the experiment and during acclimatization, they were fed with boiled egg pieces to avoid cannibalism. Feeding by natural plankton and other food was suspended two days before the experiments.

Experimentation : Static bioassay test were conducted following the standard method (APHA, 1989). The shrimps were exposed to metal concentrations for 96 h. Duplicates were run for each metal. Ten shrimps were used in each tank containing 75 l brackishwater with a separate set of controls. Observations for mortality were made every 8 h intervals upto 96 h of experimentation. The criteria employed to find out mortality was absence of any movement when pored gently with a glass rod. 96 h LC_{50} values were calculated using the method of Probit analysis (Reish and Oshida, 1987). The physico-chemical characteristics of water during the experimentation were water temperature 28 ± 2°C, pH 8.5 ± 0.2, dissolved oxygen 7.0 ± 0.2 ppm, salinity 15 ± 1 ppt and total alkalinity 143 ± 5 ppm.

Analysis of heavy metals : Composite water samples collected from the sampling sites were preserved by acidifying with nitric acid. The determination of heavy metals was carried out by Atomic absorption spectrophometry (APHA, 1989). Mercury was analysed by cold vapour atomic technique on AAS.

Results and Discussion

The 96 h LC_{50} values, 95% fiducial limits, LC_{16}, LC_{84}, slope function and 95% confidence limits obtained in probit method are given in Table 1. Percent mortality for different exposure times was plotted against the metal concentrations to get the response curve (Fig. 1). The 96 h LC_{50} values of Hg, Cd, Cu, Zn and Cr for shrimp of size group 33-46 mm were found to be 0.03, 0.15, 1.20, 1.50, 4.20 ppm respectively.

Toxicity of the metals were compared using toxicity curves obtained by plotting changes in LC_{50} values with respect to different exposure times (Fig. 2). The rank order of toxicity of metals for *Penaeus monodon* juveniles was found to be Hg>Cd>Cu>Zn>Cr. The toxicity curve for mercury is steeper which indicates that mercury is the most pollutant followed by cadmium for shrimp *P. monodon* as evidenced from the present study and previous reports for other aquatic organisms (Selvakumar *et al*, 1996; Conner, 1972). Toxicity curves for Cu, Zn and Cr indicate that chromium is least toxic for shrimp *P. monodon*.

The LC_{50} values showed gradual decrease with increase in time (Fig. 2). In general the increase in percent mortality was related to both time and metal concentrations. The highest mortality occurred

Table 1 : Acute toxicity of five heavy metals of *P. monodon*.

Heavy metal (ppm)	LC_{50} value	95% fiducial limits		Slope	LC_{16} ppm	LC_{84} ppm	95% confidence limit
		Maximum	Minimum				
Hg	0.03	0.102	0.009	3.9	0.005	0.056	3.42
Cd	0.15	0.447	0.05	3.4	0.03	0.27	2.98
Cu	1.2	2.98	0.484	2.83	0.3	2.0	2.48
Zn	1.5	3.76	0.598	2.86	0.37	2.50	2.51
Cr	4.2	8.21	2.15	2.23	1.4	6.1	1.95

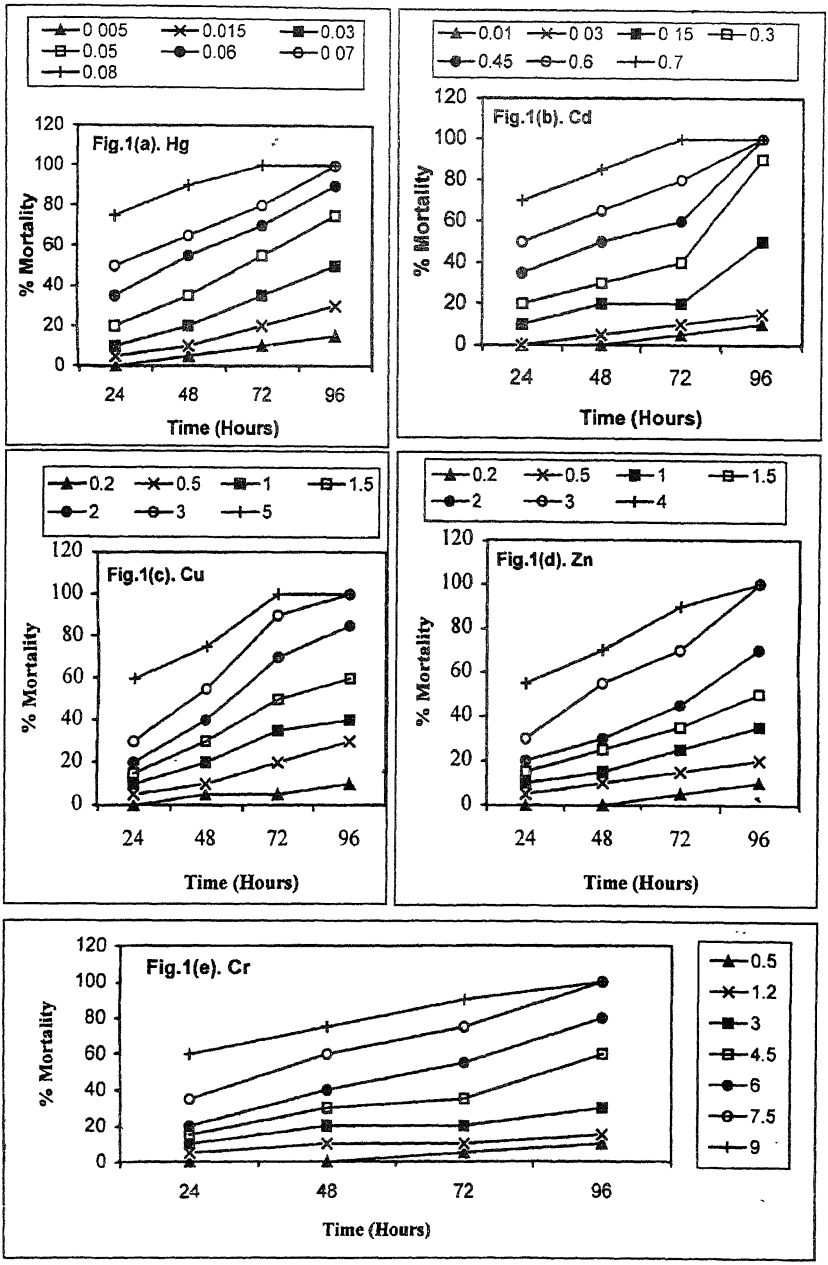

Fig. 1 : Response curve of heavy metals to *P. monodon.*

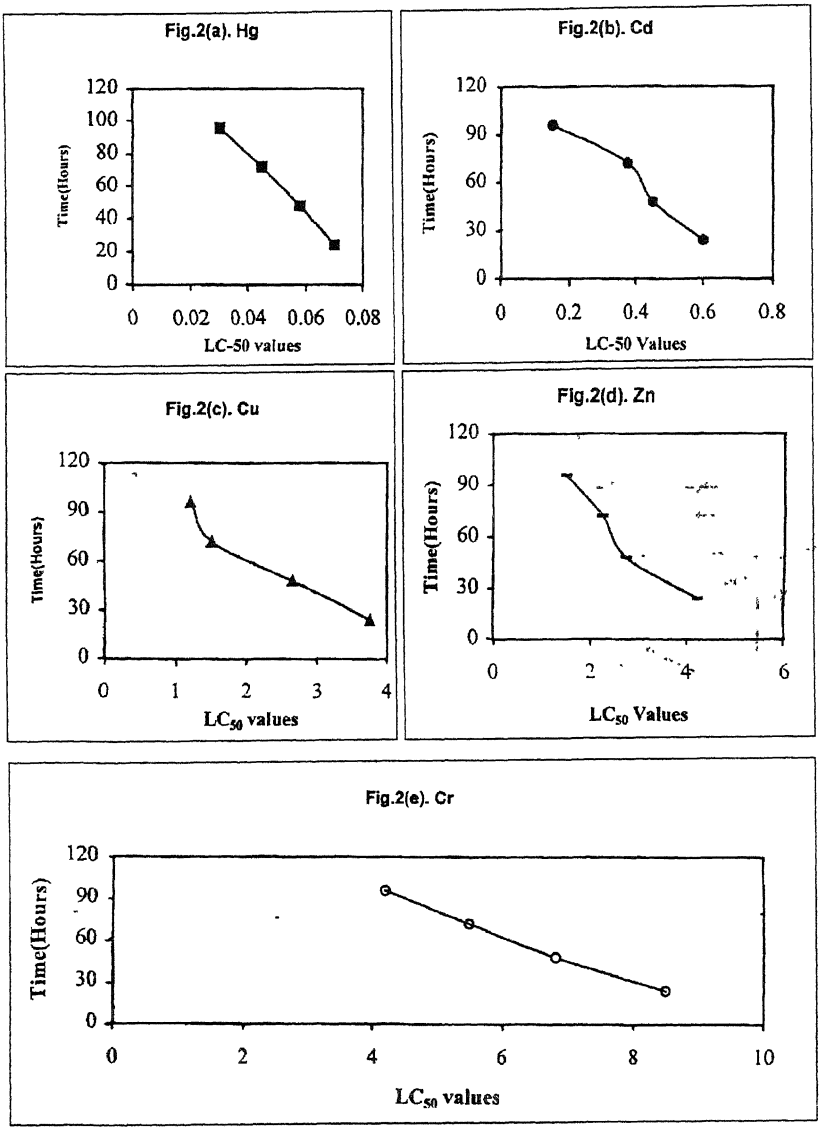

Fig. 2 : Toxicity curves of heavy metals to *P. monodon*.

between 48 and 96 hours especially in higher concentrations of the metals.

In the present study, 100% survival was observed up to 0.005 ppm of Hg and 0.01 ppm of Cd, 0.2 ppm of Cu, 0.2 ppm of Zn and 0.5 ppm of Cr for 24, 48, 24, 48 and 48 hours exposure times respectively. Survival rates subsequently started declining and after 96 hours, 100% mortality occurred at 0.07 ppm of Hg and 0.45

ppm of Cd, 3 ppm of Cu, 3 ppm of Zn and 7.5 ppm of Cr respectively.

Copper was found to be more toxic than cadmium to the Australian shrimp *Callianassa australiensis* (Ahsanullah *et al*, 1981). But in the present study, cadmium was found to be more toxic to *P. monodon* juveniles than copper. It is to be noted that despite its acute toxicity, a prolonged exposure to 50 ppb of copper actually stimulates the growth of the shrimp *P. indicus* (Carmel *et al*, 1983).

Zinc is generally known as a mildly toxic metal as evidenced from the present study, it has been found to be less toxic to *P. monodon* than copper and cadmium (Table 1).

The relative importance of acute toxicity tests with larval bioassay studies to derive sound-water quality criteria has been stressed by NAS/NAE (1973). In order to save the life of marine organisms, maximum permissible levels of the heavy metals were established by applying an application factor of 0.01 to 96 h LC_{50} values (Ahsanullah *et al*, 1981). Accordingly, calculated safe concentrations for Hg, Cd, Cu, Zn and Cr were 0.3, 1.5, 12, 15 and 42 ppb, respectively.

As for mercury toxicity, due to its high toxic nature compared with other metals, there is no information available on the application factor. The USEPA has recommended the minimal risk concentration of 0.1 ppb, however NAS/NAE (1973) suggested that the Hg concentration of 0.1 ppb is hazardous in marine environment.

Result of analysis of heavy metals in coastal waters of Andhra Pradesh and Tamil Nadu indicate that only mercury was found in the inflow sea water of Tuticorin, Tamil Nadu. Heavy metals were below detection level in water samples collected from pond and discharge points of shrimp farm in Tuticorin area of Tamil Nadu and inflow, pond and discharge points of shrimp farm in Pudiparthi area of Andhra Pradesh. Based on the LC_{50} values and derived safe concentrations, Tuticorin inflow sea water appeared to be safe at present level of Mercury at 0.0003 ppm.

Conclusion

The obtained experimental LC_{50} values provide data on comparative effect of pollutants and are useful in screening potentially toxic substances. From the present study, it may be concluded that among five metals studied, mercury is the most toxic and chromium is the least. Studies conducted on assessment of heavy metals in coastal shrimp farm areas of Tuticorin in Tamil Nadu and Pudiparthy in Andhra Pradesh indicates that coastal inflow water is safe to the shrimp *P. monodon*. However, further studies are required in the accumulation and depravation of heavy metals in the body of the animal.

Acknowledgement

Authors are thankful to Dr. G. R. M. Rao, Director, Central Institute of Brackishwater Aquaculture, Chennai for providing facilities and his encouragement. Financial assistant from ICAR, New Delhi (AP, Cess Fund) is gratefully acknowledge.

References

Ahsunullah, M., D. S. Negilsky and M. C. Mobley : Toxicity of Zinc, Cadmium and Copper to shrimp *Callianassa australiensis*. I. Effects of individual metals. *Mar. Biol.* 64 : 299-304 (1981).

APHA : Standard methods for the examination of water and waster water. (ed.) L. S. Clesceri, A. E. Greenberg, R. Rhodes Trussell, 17th edition, American Public Health Association, Washington D. C. (1989).

Callaway, John C., R. D. Delaune and H. William Patrick Jr. : Heavy metal chronologies in selected coastal wetlands from Northern Europe. *Mar. Pollut. Bull.* 36(1) : 82-96 (1998).

Carmel, N. C. L, P. N. K. Nambisan and R. Damodaran Effects of copper on juvenile *Penaeus indicus* H. Milne Edwards, *Indian J. Mar. Sci.* 12(2) : 128-130 (1983).

Conner, P. M. : Acute toxicity of heavy metals to some marine larvae. *Mar. Pollut. Bull.* 3 : 190-192 (1972).

EPA : Committee on the method for the toxicity tests with aquatic organisms, methods for acute toxicity tests with

high macro invertebrates and amphibians, pp. 1-61 (1975).

Federico Paez-Osuna, Guerrero-Galvan; R. Saul and Ruiz-Fernandez, C. Ana : The environmental effect impact of shrimp aquaculture and the coastal pollution in Mexico. *Mar. Pollut. Bull.* **36(1)** : 65-75 (1998).

Khasim Iman and N. V. Nanda Kumar : Environmental contamination of chromium in agricultural and animal products near chromate industry. *Bull. Environ. Contam. Toxicol.* **43** : 742-746 (1989).

NAS/NAE : National Academy of Science/National academy of Engineering : Water quality criteria, U. S. Environmental Protection Agency, Washington, D. C., U. S. Government Priting Office (1973).

Reish, D. L. and P. S. Oshida : Short term bio-assay. In : Manual of methods in aquatic environment research. FAO Fisheries Technical Paper No. 247, Part **10** : 1-62 (1987).

Selvakumar, S., A. S. Khan and A. K. Kumaraguru : Acute toxicity of some heavy metals, pesticides and water soluble frctions of diesel oil to the larvae of some brachyuran crabs, *J. Environ. Biol.* **17(3)** : 221-226 (1996).