TOXICITY OF MERCURY, COPPER AND ZINC TO THE PRAWN *METAPENAEUS DOBSONI* (MIER)

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ABSTRACT

Acute toxicity of mercury, copper and zinc to the juvenile and maturing stages of *Metapenaeus dobsoni* was evaluated individually by static renewal bioassay. The 48, 72 and 96-hr LC_{50} values and potency ratios with 95% confidence limits were calculated and the level of toxicity was found to be Hg $\gg$ Zn $\geqslant$ Cu.

INTRODUCTION

The biological and toxicological effects of trace metals in marine and coastal ecosystems have become the focus of an increasing number of review articles and bibliographies[1–3]. The present study was undertaken to investigate the acute toxic effects of Hg(II), Cu(II) and Zn(II) to an economically important prawn *Metapenaeus dobsoni* (Mier) abundant in Cochin backwaters.

MATERIALS AND METHODS

Static renewal bioassay renewing 50% sea water once in 24 hr was conducted following the guidelines given in APHA[4] and Ward and Parrish[5]. *Metapenaeus dobsoni* collected from Cochin backwaters were acclimatized at room temperature (28 ± 1°C) and salinity 15×10^{-3} for 5 days prior to the experiment. Polythene tubs (10 lit capacity and 35 cm diameter) with lids were used as test chambers. Filtered sea water was used for the bioassay; the water quality characteristics were: salinity 15×10^{-3}, pH 7.5 ± 0.2, temperature 27.5 ± 1°C. The D.O. concentration was always kept above 60% saturation and organism loading was maintained at 0.8 $g l^{-1}$ of sea water. Eight or ten animals of two size groups 30–50 mm, the juvenile and 50–70 mm, the maturing, *M. dobsoni* were exposed to a range of six concentrations each of Hg(II), Cu(II) and Zn(II) (range determined by conducting range finding tests) for 96 hr. Metal stock solutions were prepared by dissolving AR grade $HgCl_2$, $CuSO_4.5H_2O$ and $ZnSO_4.7H_2O$ in distilled water. Animals were fed with boiled egg during acclimation and bioassay to avoid cannibalism. Mortality in each concentration was recorded and dead animals were removed every 12 hr. Death criteria was the cessation of movement even after gentle prodding. Data were analysed according to the method of Litchfield and Wilcoxon[6].

RESULTS AND DISCUSSION

The LC_{16}, LC_{50} and LC_{84} values for 48, 72 and 96 hr and 95% confidence limits of LC_{50} and slopes with 95% confidence limits for Hg(II), Cu(II) and Zn(II) for the juvenile and maturing *M. dobsoni* are given in table 1. Potency ratios and their 95% confidence limits examined in pairs were Cu/Hg 42.0 (22.11–79.8), 64.29 (36.74–112.5); Zn/Hg 30.0 (18.63–48.3), 48.57 (29.44–80.14) and Cu/Zn 1.4 (0.72–2.73), 1.32 (0.74–2.36) for the juvenile and maturing stage respectively. Mercury was found to be 64 times toxic than Cu(II) and 49 times toxic than Zn(II) to the maturing stage and 42 times toxic than Cu and 30 times toxic than Zn to the juveniles. The juvenile and maturing stages were 1.4 times and 1.3 times more sensitive to Zn(II) than Cu(II).

Among Hg, Cu and Zn tested with marine invertebrates, mercury tended to be more toxic than Cu and Cu more toxic than Zn[2, 7–9]. A wide range of variation in toxicity of copper and zinc to some species has been reported[10, 11]. These species have been found to be more sensitive to copper than zinc with the exception of *Carcinus maenas* (L), where the adults are less sensitive to copper than to zinc. In the present study zinc was slightly more toxic than copper to *M. dobsoni* and the order of toxicity was Hg $\gg$ Zn $\geqslant$ Cu. Calabrese *et al*[12] pointed out that the order and degree of metal toxicity vary not only with such parameters as salinity and metal salt form, but also with life stage and the type of species.

Comparatively higher LC_{50} values for the large size group to Cu and Zn may be due to precipitation of metals to a noticeable extent. Brown *et al*[13] showed

Table 1 *Comparative values of LC_{16}, LC_{50}, LC_{84} and 95% confidence limits for median lethal concentration and slope with 95% confidence limits for mercury, zinc and copper to M. dobsoni.*

Metal	Size group (mm)	Time (hr)	LC_{16} (mg/l)	LC_{50}(mg/l) and 95% confidence limits	LC_{84} (mg/l)	Slope and 95% confidence limits
Hg	30–50	48	0.019	0.032 (0.0257–0.0399)	0.052	1.6546(1.38–1.997)
		72	0.012	0.023 (0.0166–0.0317)	0.043	1.893 (1.32–2.715)
		96	0.01	0.02 (0.0149–0.0267)	0.038	1.95 (1.40–2.718)
	50–70	48	0.029	0.04 (0.0318–0.0502)	0.056	1.3896 (1.2553–1.538)
		72	0.029	0.04 (0.0318–0.0502)	0.056	1.3896 (1.2553–1.538)
		96	0.0215	0.035 (0.0251–0.0487)	0.056	1.6140 (1.323–1.968)
Zn	30–50	48	0.66	1.6 (1.0277–2.4910)	3.8	2.3996 (1.537–3.746)
		72	0.41	1.0 (0.6331–1.5796)	2.5	2.4695 (1.582–3.855)
		96	0.29	0.60 (0.4103–0.8769)	1.3	2.1178 (1.527–2.937)
	50–70	48	2.10	4.00 (2.586 –6.1872)	7.4	1.8774 (1.493–2.360)
		72	0.86	1.95 (1.3148–2.8920)	4.3	2.2363 (1.591–3.143)
		96	0.78	1.70 (1.1689–2.4723)	3.6	2.1486 (1.565–2.950)
Cu	30–50	48	0.78	3.0 (1.8206–4.9434)	10.0	3.589 (1.795–7.175)
		72	0.42	1.40 (1.6802–2.3522)	4.5	3.27 (1.76 –6.076)
		96	0.23	0.84 (0.4856–1.4527)	2.8	3.493 (1.67 –7.304)
	50–70	48	*	–	–	–
		72	1.0	2.85 (1.838–4.4175)	7.4	2.72 (1.501–4.929)
		96	0.78	2.25 (1.4389–3.5181)	6.0	2.775 (1.467–5.249)

* No significant mortality (< 65%)

Table 2 *Lethal concentrations of mercury, zinc and copper for some marine crustaceans*

Metal	Species	Time (hr)	LC_{50} $mg\,l^{-1}$	Size group	Source (Reference No.)
Hg	*Palaemonetes pugio*	96	0.06	Adult	18
	Penaeus setiferus	96	0.02	Post larvae	19
	Palaemonetes vulgaris	48	0.0156	Larvae	20
	Crangon crangon	48	0.01	Larvae	10
	Metapenaeus dobsoni	96	0.02	30–50 mm	Present study
	Metapenaeus dobsoni	96	0.035	50–70 mm	Present study
Cu	*Homarus amaericanus*	96	0.048	Larval stage-1	21
	Callianasa australiensis	96	1.0	Adult	9
	Paragrapsus quadridentatus	96	0.17	Larvae	11
	Penaeus indicus	120	0.37	25–45 mm	22
	Penaeus indicus	120	0.3	45–65 mm	22
	Metapenaeus dobsoni	96	0.84	30–50 mm	Present study
	Metapenaeus dobsoni	96	2.25	50–70 mm	Present study
Zn	*Paragrapsus quadridentatus*	96	11.0	Adult	23
	Callianasa australiensis	96	10.2	Adult	9
	Paragrapsus quadridentatus	96	1.23	Larvae	11
	Metapenaeus dobsoni	96	0.6	30–50 mm	Present study
	Metapenaeus dobsoni	96	1.7	50–70 mm	Present study

that metals act largely on the gill surfaces, where they cause thickening of the epithelial walls and ultimately death by suffocation as oxygen consumption is impeded. If such a damage did not occur, sufficient precipitate would possibly gather around the gills ultimately causing suffocation[14].

A toxicity curve gives an overall picture of test progress and indicates when acute toxicity has ceased.

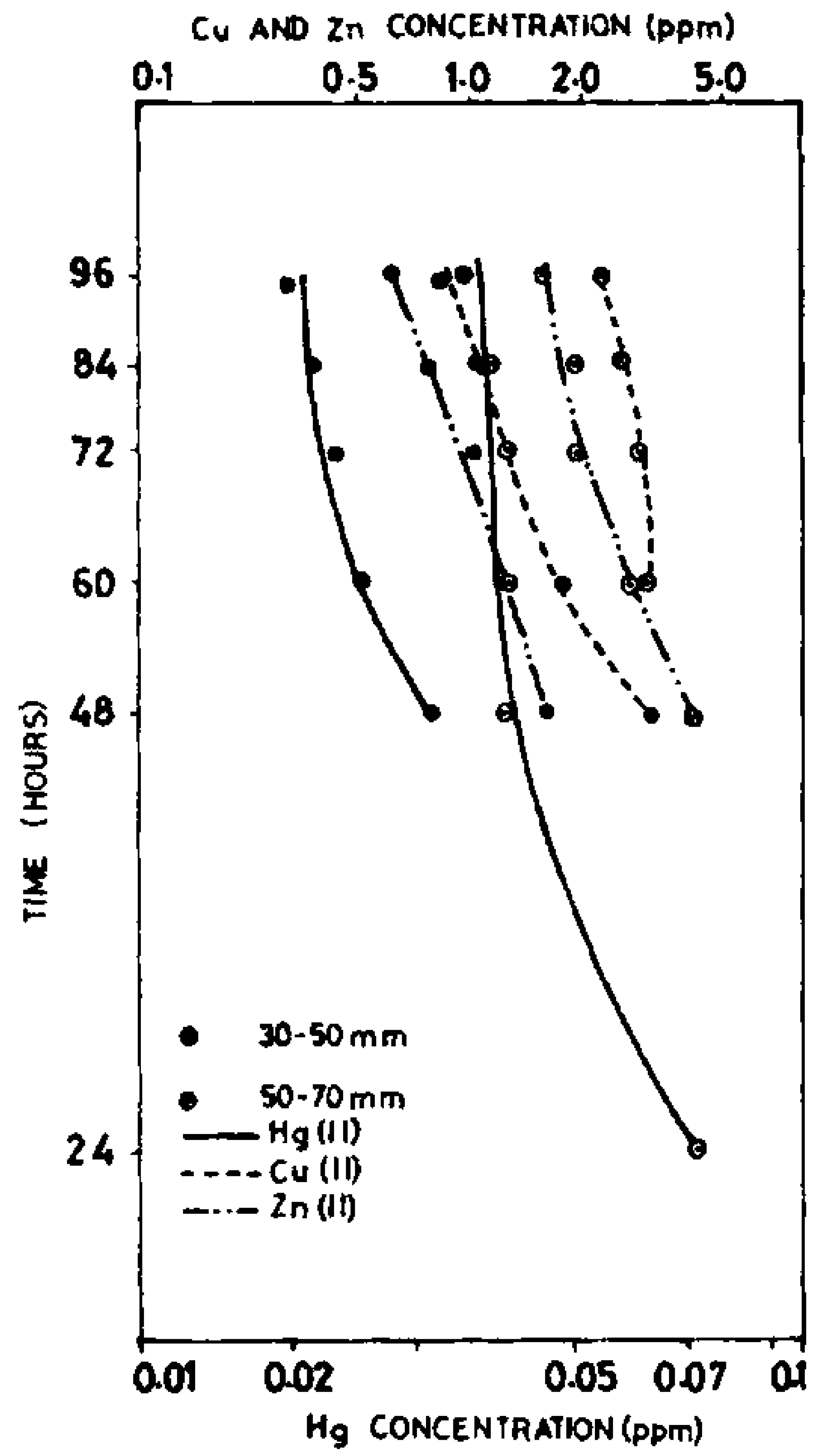

Figure 1. Toxicity curve of Hg(II) Zn(II) and Cu(II) to *M. dobsoni.*

This is indicated by the curve becoming asymptotic to the time axis[15]. In the present study the curves for maturing stage approaches an asymptote for all the metals (figure 1). For juveniles the toxicity curve for Hg(II) alone is nearing to be asymptotic. Hence 96 hr exposure would be sufficient to arrive at incipient LC_{50} for maturing stage and a longer duration will be required for juveniles. Sprague[15] recommended an exposure time of 96–168 hr for determining the asymptotic LC_{50} for most macro-invertebrates and fish.

The LC_{50} values of Hg(II), Cu(II) and Zn(II) for *M. dobsoni* are comparable with the acute toxicity information available for some marine crustaceans (table 2). *M. dobsoni* was tolerant to Cu(II) and the sensitivity to Zn(II) was greater than the other species reported. The LC_{50} values of Hg(II) were within the range reported earlier.

Results of static bioassays are highly variable as the changes in biological and environmental factors influence the toxicity. Factors such as salinity and temperature can have a marked effect on toxicity tests[16]. Acute toxicity tests have been recommended in deriving 'safe' concentrations by applying a factor of 0.01 to the 96-hr LC_{50} values for most indigenous organisms[17]. In the absence of long term studies on chronic effects to the most susceptible species and life stage, to recommend a minimal risk concentration in conjunction with application factors, the acute toxicity tests will remain as a method for maintaining the water quality criteria in aquatic environment management.

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1. Bryan, G. W., In: *Marine pollution*, (ed.) R. Johnston, Academic Press, London, 1976, p. 185.
2. Waldichuk, M., In: *Pollution and physiology of marine organisms*, (eds) F. J. Vernberg and W. B. Vernberg, Academic Press, New York, 1974, p. 1.
3. Eisler, R., O'Neill, D. J. Jr. and Thompson, G. W., U.S. Environmental Protection Agency, Rep. 600/3–78–005, 1978, 487 pp.
4. APHA., *Standard methods for the examination of water and waste water*, 15th edition. American Public Health Association, American Water Works Association and Water Pollution Control Federation, Washington, D. C., 1981.
5. Ward, G. S. and Parrish, P. R., *F.A.O., Fish Tech Pap.*, 1982 **185,** p. 23.
6. Litchfield, J. T. and Wilcoxon, F., *Pharmacol. Exp. Ther.*, 1949, **96,** 99.
7. Wisely, B. and Blick, R. A. P., *Aust. J. Mar. Freshwater Res.*, 1967, **18,** 63.
8. Arnott, G. H. and Ahsanullah, M., *Aust. J. Mar. Freshwater Res.*, 1979, **30,** 63.
9. Ahsanullah, M., Negilski, D. S. and Mobley, M. C., *Mar. Biol.*, 1981, **64,** 299.
10. Conner, P. M., *Mar. Pollut. Bull.*, 1972, **3,** 190.
11. Ahsanullah, M. and Arnott, G. H., *Aust. J. Mar. Freshwater Res.*, 1978, **29,** 1.
12. Calabrese, A., Thurberg, F. P. and Gould, E., *Marine Fisheries Rev.*, 1977, **39,** 5.
13. Brown, V. M., Mitrovic, V. V. and Stark, G. T. C., *Water Res.*, 1968, **2,** 255.
14. Portmann, J. E., In: *Marine pollution and sea life*, (ed.) Mario Ruivo, Fishing News, London, 1972, p. 212.
15. Sprague, J. B., *Water Res.*, 1970, **4,** 3.
16. Vernberg, W. B., De Coursey, P. J. and Padgett, W. J., *Mar. Biol.*, 1973, **22,** 307.

17. National Academy of Sciences/National Academy of Engineering, *Water quality criteria*, 1972, U. S. Government Printing Office, Washington, D. C., 1973, pp. 594.
18. Curtis, M. W., Copeland, T. L. and Ward, C. H., *Water Res.*, 1979, **13**, 137.
19. Green, F. A. Jr., Anderson, J. W. Petrocelli, S. R., Presley, B. J. and Sims, R., *Mar. Biol.*, 1976, **37**, 75.
20. Shealy, M. H. Jr. and Sandifer, P. A., *Mar. Biol.*, 1975, **33**, 7.
21. Johnson, M. W. and Gentile, J. H., *Bull. Envir. Contam. Toxicol.*, 1979, **22**, 258.
22. Mary Carmel, C. L., Nambisan, P. N. K. and Damodaran, R., *Indian J. Mar. Sci.*, 1983, **12**, 128.
23. Ahsanullah, M., *Aust. J. Mar., Freshwater Res.*, 1976, **27**, 187.

ANNOUNCEMENTS

SHANTI SWARUP BHATNAGAR AWARDS FOR 1984

Twelve scientists from various disciplines have been selected for the Shanti Swarup Bhatnagar awards for 1984 for the outstanding contributions in science and technology. Following are the award winners:— **Physical Sciences:** Prof. R. Cowsik, Tata Institute of Fundamental Research, Bombay and Prof. R. Shashidhar, Raman Research Institute, Bangalore; **Chemical Sciences:** Prof. P. Natarajan, University of Madras and Prof. K. J. Rao, Indian Institute of Science, Bangalore; **Biological Sciences:** Dr. K. R. K. Easwaran, Indian Institute of Science, Bangalore and Prof. T. J. Pandian, Madurai Kamaraj University, Madurai; **Engineering Sciences:** Dr. D. B. Bhawalkar, Bhabha Atomic Research Centre, Bombay and Dr. P. Ratnaswamy, National Chemical Laboratory, Pune; **Medical Sciences:** Dr. J. N. Sinha, K. G. Medical College, Lucknow and Dr. B. S. Srivastava, Central Drug Research Institute, Lucknow; **Earth Sciences:** Dr. S. K. Acharyya, Geological Survey of India, Calcutta and Dr. S. Krishnaswami, Physical Research Laboratory, Ahmedabad.

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International Conference on Metallic and Semiconducting Glasses will be held at University of Hyderabad, Hyderabad during 16 to 20 December 1986.

The activities of the conference consist of invited papers contributory talks and poster sessions presented by experts and young scientists/technologists. A few talks may also be arranged to introduce the subject of glasses to newcomers in the field. Panel discussions are also planned for the benefit of participants.

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