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EFFECTS OF SALINITY ON THE TOXICITY OF COPPER AND ZINC TO THE FISH *THERAPON JARBUA* (FORSSKAL)

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ABSTRACT

Knowledge of acute toxicity of a pollutant can be used in predicting and preventing the possible damage to organisms, which help in regulating toxic waste discharges into the waters in which they live. Toxicity tests were carried out on the fish *Therapon jarbua*, the common species found along the near shore waters of Mumbai. Toxicity of Cu, Zn and mixtures of Cu and Zn at 22 ± 2 ‰ and 32 ± 2 ‰ salinities were studied. The response of the fish was found to be varying very little between 24 and 48 h while at 72 and 96 h the difference was appreciable. It was evident from the experiments that salinity plays a significant role in the toxicity of metals to estuarine and marine organisms. The LC_{50} values of Cu were found to be 2-3 times less toxic in 22 ± 2 ‰ salinity than that observed at 32 ± 2‰. The LC_{50} values of Zn were 1.1-1.7 times less in lower salinity than that observed at higher salinity.

INTRODUCTION

Pollution of the marine ecosystems by metals is a worldwide problem and ecologists try to identify various ways to control and monitor metal pollution in order to maintain the natural equilibrium of the ecosystem. Data on toxicity by bioassay tests of heavy metals and their effects on aquatic organisms are basic for determination of ecotoxicological risks of heavy metals for the aquatic ecosystems. Knowledge of acute toxicity of a pollutant can be used in predicting and preventing the possible damage to organisms, which help in regulating toxic waste discharges into the waters in which they live. Copper and Zn are essential elements playing a vital role in the physiological and metabolic processes of many organisms. However, in high concentrations they can be toxic. Although acute toxicity of heavy metals to marine organisms has received considerable attention (Brown & Dalton 1970, Eisler & Gardner 1973, Selvakumar 1981, Veena et al. 1997, Bu-olayan & Thomas 2005), the effect of varying salinities received little attention. Salinity and temperature are important factors for determining the rate of many physiological functions (Bahner 1974) of estuarine and marine organisms. In Mumbai salinity variations are well defined due to the influence of the monsoon, varying between 219 to 35.7 ‰ (Krishnamurti & Nair 1999). Considering this fact, the present study was undertaken to assess under two different salinities the toxicity of Cu and Zn, individually and in combination, which contributed to the major percentage of the metals to fish from the Thane-Bassein Creek system (Krishnamurti 1991).

MATERIALS AND METHODS

Toxicity tests were carried out following the standard methods (FAO 1977). *Therapon jarbua* (Forsskal), the common species of fish found along the near shore waters of Mumbai was used for the tests. The fish were collected from a clean area and acclimatized for a period of one week. They were fed except for a day preceding the test. The length and weight of the fish selected for the experiment varied from 3-5 cm and 1-2 g respectively. Seawater collected from a clean location was

filtered and aerated before the experiment. Continuous slow aeration was used throughout the experiment to keep the DO content above 5 mg/L. Toxicity of Cu, Zn and mixtures of Cu and Zn at 22 ± 2 ‰ and 32 ± 2 ‰ salinities were studied. 10 fish were placed in each tank. Each concentration was tested in triplicate and a control was maintained along with each test. Each test was repeated thrice. Mortality was noted and dead fish were removed immediately. Observations were continued for 96hrs and LC_{50} values were calculated by probit analysis. Relevant parameters like DO and pH were monitored during the experiment. All the experiments were conducted at room temperature.

RESULTS AND DISCUSSION

During the experimental period, pH of the test water varied from 7-7.5, while the DO from 6.0-8.5 mg/L. The temperature during the experiment was 29.5 ± 1.5°C. The LC_{50} values are given in Table 1 and Fig. 1 for Cu and Zn, and Table 2 and Fig. 2 for the effect of Cu and Zn in combination.

Copper: At 19 mg/L 100% mortality was observed within 24 h, while 100% mortality was recorded at a concentration of 14 mg/L during 96 h period at 22 ± 2 ‰ salinity.

The response of the fish was found to be varying very little between 24 and 48 h while at 72 and 96 h the difference was appreciable. At a salinity of 32 ± 2 ‰ there was a well defined decrease in toxicity. The fish died within a few hours at a concentration of 10 mg/L. 100% mortality was observed at concentration of 7.5 mg/L after 24 h while at 6 mg/L the same was recorded at 96 h.

Zinc: At a salinity of 22 ± 2 ‰, 100% mortality was observed after 24 h at a concentration of 25 mg/L while after 96 h the 100% mortality was observed at a concentration of 20 mg/L. At a salinity of 32 ± 2 ‰ 100% mortality was observed at a concentration of 25 and 16 mg/L respectively after 24 and 96 h.

Synergistic effect: Different combinations of Cu and Zn were tested and the LC_{50} values were calculated according to Brown (1968) and Brown & Dalton (1970). The predicted concentrations of the mixture tried ranged from 0.5-2 mg/L for both salinities. When the test concentration was based on the LC_{50} values obtained for individual metals, 100% mortality occurred within a few hours. When the concentration of Cu + Zn was 2 mg/L, 100% mortality was observed at about 96 h.

It was evident from the experiments that salinity plays a significant role in the toxicity of metals to estuarine and marine organisms. The LC_{50} values of Cu were found to be 2-3 times less in 22 ± 2‰ salinity than that at 32 ± 2‰. The LC_{50} values of Zn were 1.1-1.7 times less in lower salinity than that at higher salinity. The 96 h LC_{50} values of Cu reported earlier in *T. jarbua* were found to be 56 to 74.6 times lower at 30 ± 2 ‰ than the values recorded in the present study (Selvi 1978, Kumaraguru 1980, Selvakumar 1981). However the present results are close to the values reported by Krishnakumari

Table 1: LC_{50} values of Cu and Zn (mg/L) for 24, 48, 72 and 96 h to *Therapon jarbua* at different salinities. Values given are in average with ranges in parenthesis.

Salinity (‰)	LC_5 24h	48h	72h	96h
Copper				
22 ± 2	6.57 (6.02-6.76)	6.01 (4.78-7.41)	6.10 (4.67-7.97)	4.26 (3.98-4.46)
32 ± 2	3.16 (2.95-3.31)	3.23 (3.16-3.23)	2.57 (2.13-3.00)	2.24 (1.99-2.45)
Zinc				
22 ± 2	19.45 (17.78-19.95)	17.78 (16.59-18.62)	17.37 (16.21-18.19)	14.45 (13.48-15.13)
32 ± 2	17.38 (16.21-18.62)	13.70 (12.73-14.12)	11.75 (11.45-12.61)	8.70 (8.12-9.54)

Table 2: LC_{50} values (mg/L) for mixture of Cu and Zn for 96h to *Therapon jarbua* at different salinities. Values given in average and range (in parenthesis).

Salinity(‰)	96 h
22 ± 2	1.14 (1.05-1.24)
32 ± 2	1.17 (1.09-1.26)

et al. (1983) for *T. jarbua* in 35‰ salinity. The LC_{50} values of Zn were comparable to earlier reports (Kumaraguru 1980, Selvakumar 1981, Krishnakumari et al. 1983). The synergistic effect of Cu and Zn obtained from predicted LC_{50} values did not show appreciable variation with salinity difference. However, the LC_{50} values were at a lower concentration than that obtained for individual concentrations.

The marine life found around the Mumbai coast is already under pollution stress and this will have its own impact even in fish collected from clean locations. This may lead to elevated levels of LC_{50} values compared to reports from unpolluted environment and such instances have been reported (Mathew 1989). However, the present LC_{50} values may serve to assess and monitor in future the coastal ecosystem of Mumbai. A comparison of the field data with that of the experimental values indicates comparable trend in the bioconcentration of Cu and Zn in

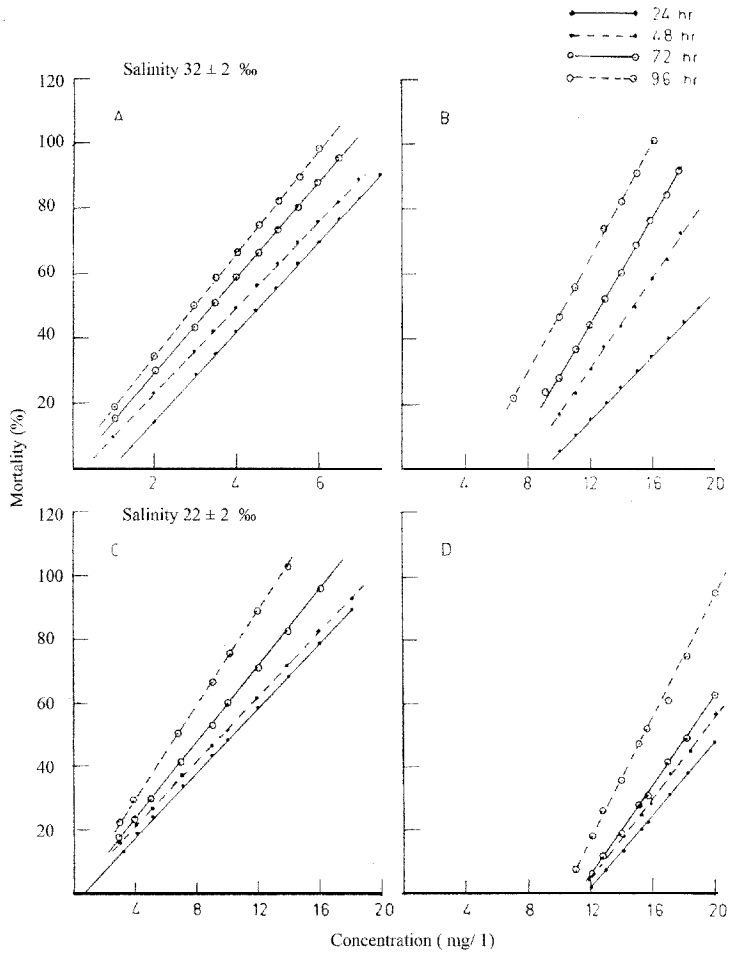

Fig. 1: Mortality rate of *Therapon jarbua* at different concentrations of Cu (A & C) and Zn (B & D).

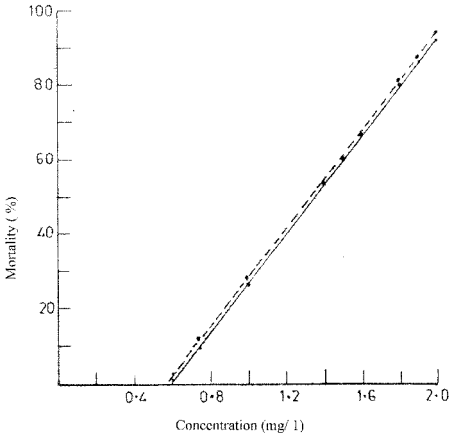

Fig. 2: Mortality of *Therapon jarbua* at different proportions of mixture of Cu and Zn for 96 h.

fishes from Thane creek which experiences marked variations in salinity (Krishnamurti & Nair 1999). The reported toxicity of Cu and Zn to freshwater fish (Pickering & Henderson 1966, Brungs et al. 1976) compared to the present study indicate higher tolerance in freshwater than seawater. The observed trend suggests that extrapolation of results obtained for freshwater fish to marine condition needs to be considered with caution. Toxicity criteria for aquatic organisms for freshwater and seawater need to be evaluated separately for monitoring the ecosystem.

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