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Effect of Salinity on the Toxicity of Mercury in Mangrove Clam, *Polymesoda erosa* (Lightfoot 1786)

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Abstract

The present study reports the effect of salinity on the toxicity of mercury in mangrove clam *Polymesoda erosa*. The toxic effect was found to be influenced by different salinities and mortality increased with an increase in salinity. The 96 hour LC_{50} were 0.58, 0.35 and 0.26 ppm Hg in 10, 20 and 30 ppt salinity, respectively at room temperature. The LT_{50} values also suggested high mortality with increasing Hg concentration. Accumulation of Hg in the tissue of the clam was greater in the gills than in any other parts. The amount of Hg in the tissues was dependent on the concentration in the medium and length of exposure. This behavior of Hg was related to affinity to certain body organs and changing rate of adsorption after methylation and chemical speciation. Accumulation was maximum in higher salinity (30 ppt).

Introduction

Mercury is a source of metal pollution both in inorganic and organic forms. It has attracted more attention after the famous Minimata Disease when it was recognized as a highly toxic element to aquatic organisms (Chin and Chen 1993). Many studies have pointed out that sublethal concentrations of mercury have minimal effects on organisms in optimum conditions. However, it becomes toxic under stressful conditions such as extreme temperature and salinity (Denton and Burdon-Jones 1981). Synergism between mercury and salinity has been shown in invertebrates (McLusky et al. 1986).

Bivalves have been recognized as useful indicators of heavy metal pollution. However, there has been no study on metal uptake in the mangrove clam, *Polymesoda erosa* (Lightfoot 1786). This clam inhabits the mangrove mud flats, which are under the constant influence of varying environmental stresses. Generally this clam lives in estuarine mangrove flats where annual fluctuation in salinity is very large (7 to 22 ppt). It is an economically important species and grows from 6 to 8 cm size (Ingole et al 1994). This species has been selected in studying the effect of salinity on the toxicity of mercury.

Materials and Methods

Juveniles of *P. erosa* were obtained from the mangrove swamps at Chorao Island, a bird sanctuary in the Mandovi estuary of Goa, India (latitude 15º 30' N and longitude 73º 55' E). Prior to exposure to mercury, the clams were acclimatized in glass fiber tanks of 20 L for eight days at different salinities (10, 20, 30 ppt) at room temperature. Waters of different salinity were prepared by diluting seawater with distilled water. Water was changed every other day. The experimental clams had an average shell length of 3.27 ± 0.55 cm and weighed 38.25 ± 2.76 g. During the period of acclimation, the clams were not fed but supplied with aeration to maintain optimum oxygen level.

Mercury stock solution was prepared by dissolving 1.36 g of mercuric chloride (reagent grade) in one liter distilled water containing 1 ml concentrated nitric acid to make 1000 $mg \cdot l^{-1}$ Hg. It was diluted to desired concentrations using filtered seawater. Four nominal concentrations of 0.12, 0.25, 0.50 and 0.75 $mg \cdot l^{-1}$ were selected by running trials in the narrowing orders of 0.05 to 2.50 $mg \cdot l^{-1}$ concentration. Twenty clams were introduced into each of a series of 8 l glass jars having different mercury concentrations. Initial concentrations of Hg recorded in the test solutions were 0.097, 0.22, 0.47 and 0.71 $mg \cdot l^{-1}$. All experiments were run in duplicate and a control was maintained for each set. Three sets of experiments were carried out but only the data of the best result is presented. Static bioassay tests were run with slow aeration (APHA 1985) and all test solutions were renewed daily. In all the test solutions, water temperature was maintained at 29 ± 1ºC. Dissolved oxygen and salinity were measured following the method of Strickland and Parsons (1972). The values of DO and pH varied from 4.5 to 6.2 $ml \cdot l^{-1}$ and 7.2 to 8.3, respectively.

Mortality of clams was recorded at 24, 48, 72 and 96 hours and death was determined when both valves showed gaping after a mechanical disturbance. Acute toxicity and LC_{50} values were assessed following the method of probit analysis (Finney 1971). Accumulated mortality curve was established and LT_{50} (time taken to kill 50% of the clams) was determined. The LT_{50} values were also calculated by extrapolation wherever necessary. For the study of accumulation of mercury, some clams were treated separately in 0.12 $\mu g \cdot l^{-1}$ Hg concentration at salinities of 10, 20 and 30 ppt. These concentrations were selected based on the 96 h LC_{50}. After five days exposure, the clams were removed and the mercury concentration in the tissue (adductor, gill, mantle, viscera) was analyzed according to the method given in Topping (1973).

Results and Discussion

The acute toxicity of mercury to *P. erosa* in different salinities is shown in figure 1. As may be expected, the greater is the mercury concentration, the greater is the mortality. In green mussel *Perna viridis*, rapid initial uptake of Hg has been reported at higher concentration (Lakshmanan and Nambisan 1989). The toxicity of Hg to the animal was significantly affected by salinity; hence mortality increased with an

increase in salinity. It suggests that at higher salinity even low concentration can be toxic to the clams.

The LC_{50} values decreased with increasing salinity (Table1). These facts suggest that higher salinity is a stressful condition that may accelerate the toxicity of mercury. Chin and Chen (1993) recorded 96 hours LC_{50} values of 0.328 µg·L Hg in *Meretrix lusoria* and reported that the clam becomes more sensitive to mercury poisoning at a salinity higher than its preference level of 15 to 18 ppt. The 6 to 10 days LC_{50} value for *Venus japonica* was 100 to 500 µg·L Hg (Irukayana et al. 1962). The reason for less toxicity in low salinity is not fully understood. In another study Denton and Burdon-Jones (1981) observed greater accumulation of mercury at low salinity in the oyster.

When the concentration of mercury increased, it had a more serious effect on survival time as shown in figure 2. It can be seen that lethal time decreased as concentrations increased. The LT_{50} values also decreased as salinity increased. It suggests that LT_{50} values depended on salinity. Dillon (1977) reported that mercury appeared to be much less toxic to the euryhaline clam *Rangia*

Table 1. The LC_{50} values of mercury for *P.erosa* in different salinities. Values are in mg·l Hg.

Time(hr)	10 ppt	20 ppt	30 ppt
24	0	0	0
48	0	0	0
72	0	0.62	0.50
96	0.58	0.35	0.25

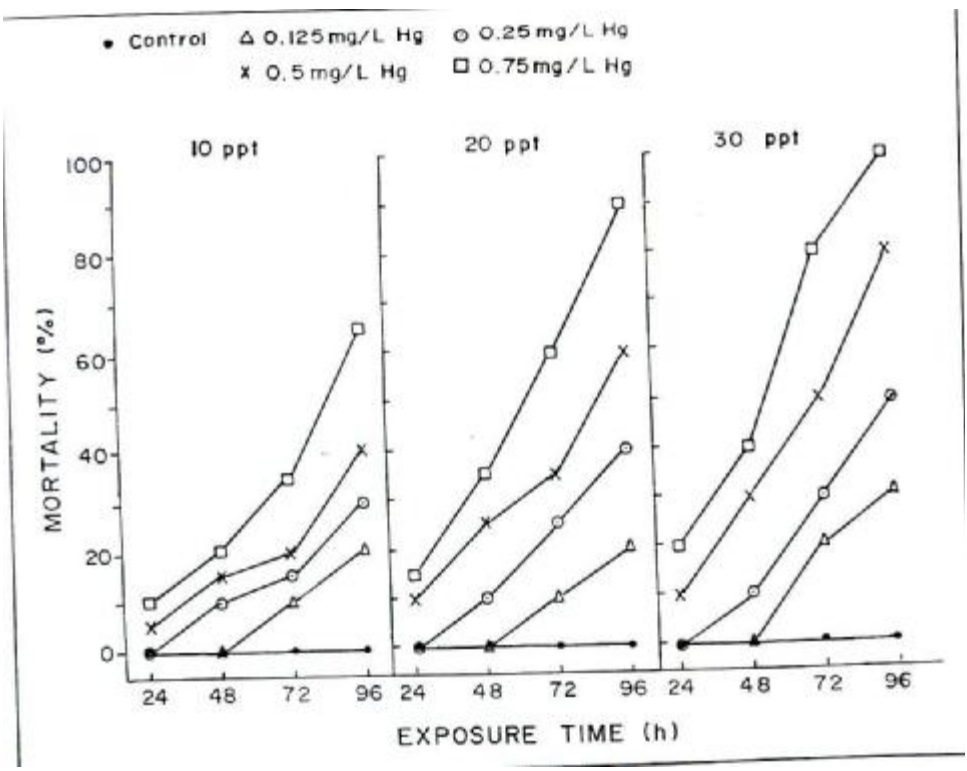

Fig. 1. Percent mortality of *Polymesoda erosa* in different mercury concentrations and under different salinities.

cuneata acclimated in 2 ppt salinity than those acclimated in 15 ppt salinity. These studies corroborate the present findings. In a lower salinity of 10 ppt, the clam can tolerate even the 0.75 mg·L concentration without achieving 50% mortality. Again, it is not fully understood why mercury is less toxic in lower salinity. Dillon and Neff (1978) on the other hand suggested that the decrease of mercury in lower salinity could be due to the enhanced ability of the clam to eliminate mercury from the body. General integumentary permeability may decrease at salinity in which body fluids are hyper-osmotic to the medium. Thus increased water flow at low salinity may help the clam to depure the excess of Hg deposited. Furthermore under stressed condition, increased ventilation rates may increase the rate of metal uptake. It is also possible that salinity changes may affect the chemical forms and chemical interaction of metal in seawater, which in turn may affect its bioavailability (Wright 1977).

There are different reports on the effect of salinity on mercury uptake. Experimental studies proved otherwise. It has been demonstrated that survival of juveniles of bay scallop *Argopecten irradians* was significantly affected by mercury at different salinities (Nelson et al. 1977). It was suggested that the increased toxicity of heavy metals to marine organisms under unfavorable conditions is related to changing rates of absorption. This rate varies with experimental conditions, species tested and life stage of the test animal (Langston 1982). Toxicity of Hg was higher in osmoregulating marine organisms at lower salinity (Bianchini and Gilles 1996).

The effect of salinity was also seen in the accumulation pattern of mercury in various body components (Table 2). The combination of sublethal dose

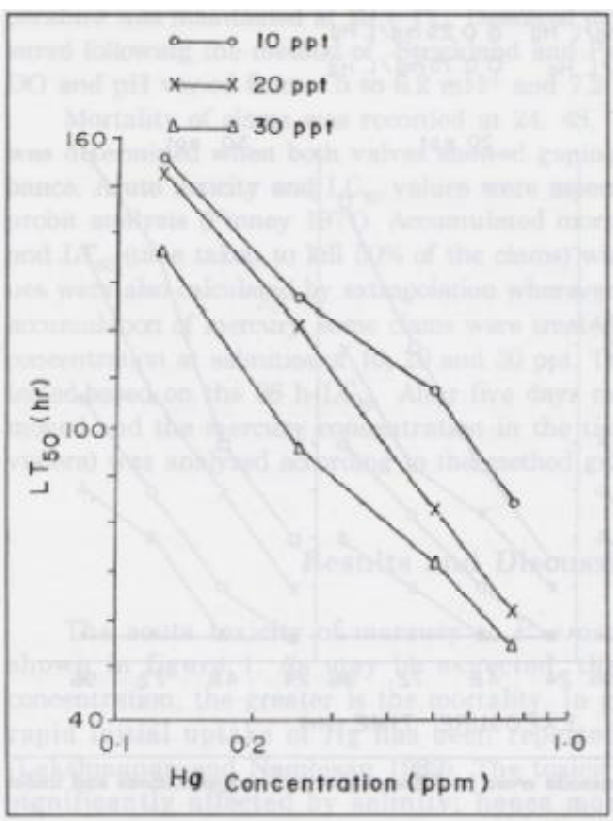

Fig. 2. Acute toxicity of mercury to *Polymesoda erosa* under different salinities.

of Hg with salinity seems to act synergistically which bring changes in the rate of absorption and mortality. Due to the affinity of certain metals towards the muscles of organisms, different accumulations were observed in different body parts. The order of accumulation of mercury after five day exposure was gills >mantle > viscera > adductor. Higher concentration of Hg in gills can be explained considering that Hg can be adsorbed on the external integument. The larger accumulation in gills disturb the respiratory function, leading to impairment (Bianchini and Gilles 1996). Accumulation was greater at 30 ppt as compared to 10 and 20 ppt salinity. Zauke (1977) demonstrated lower Hg levels in several benthic invertebrates from Elbe Estuary when compared to those from the marine region. On the other hand Kendall (1962) did not find significant difference in the Hg concentration of benthic invertebrates on a salinity gradient of an estuary. High concentration in the mantle may be due to its direct contact with the exposure medium and its large surface area. Chin and Chen (1993a) also reported higher accumulation of mercury in the gills and viscera than in other body parts. Several workers have shown that bivalves generally concentrate heavy metals to a greater degree in the gills and visceral mass compared with the mantle and adductor muscle (Denton and Burdon-Jones 1981). It is suggested that under stressed conditions, the absorption of metal increases in the animal and the uptake of dissolved metals occurs mainly in the gills (Roesijadi et al. 1974). High water turnover/intake due to osmoregulatory activities would favor faster Hg accumulation and therefore result to higher toxicity.

Generally the bivalves filter water through the gills in a very short time thus the extraction of mercury by ctenidia can be significant in the bioaccumulation by gill tissue. It is reported that under stress, mercury can be accumulated in high concentration, depending on its bioavailability and environmental condition and may therefore cause severe damage to the organism (Kureishy and D'Silva 1993). The concentration of Hg in the tissue of different body parts may be due to its interference with enzymatic function and chemical speciation of Hg leading to some favorable conformational changes.

This study clearly indicates the ability of clam to accumulate high concentration of heavy metal from the ambient water, depending on its bioavailability and exposure period. However, the accumulation strategies may vary between species. The rate of accumulation and acute toxicity of mercury is related to the time of exposure and the concentration in various tissues (Pringle et al. 1968). The incorporation of mercury in the tissues of edible bivalves over a certain period even in very low concentrations, may also lead to biomagnification at higher trophic levels. This can have serious detrimental effects on the biota as well as to the ecosystem.

Table 2. Accumulation of mercury in body parts of *P. erosa* under different salinities after 5 days exposure to 0.125 mg·l Hg. Values are in ng·g dry weight .

Salinity	Adductor	Gill	Mantle	Viscera
10 ppt	961 ± 43	1485 ± 107	1216 ± 67	1256 ± 84
20 ppt	1027 ± 129	1618 ± 112	1217 ± 44	1385 ± 117
30 ppt	1572 ± 126	2412 ± 115	1682 ± 102	1075 ± 138

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