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81. EFFECT OF MERCURY EFFLUENTS ON MARINE BIVALVES

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ABSTRACT

High concentration of mercury and acidity have been noticed in the effluents of Dharangadara Chemical Works and Plastic Resins and Chemical Centre near Kayalpatnam, south of Tuticorin. The bar mouth of the polluted lagoon is opened during November-January and the discharges of heavy metal toxicants in the open sea is of great concern in the management of marine and nearby ecosystems. Sea water in the industrial coastal area contains mercury in the range 18-70 µg/ml. Marine organisms such as bivalves have a particularly high capability for concentrating heavy metals. Investigations have been carried out on the survival of two important bivalves of the region *Crassostrea madrasensis* and *Mesodesma glabratum* of different size groups by abruptly exposing to different concentrations from sharp lethal to non-lethal concentrations of the industrial effluents, Samples of these two species have also been exposed to different sublethal conentrations for varying durations to study the uptake and rate of accumulation of mercury in the tissues of the bivalves. The results of the observations are discussed. The study provides information as to when exactly the bivalves are brought under stress and for planning preventive measures to protect the valuable resources.

INTRODUCTION

The marine environment, which offers one of man's great hopes for future food supplies is not excempt from the adverse effects of pollution. Among different abuses of this environment, the discharging of the industrial effluents is considered to bring about deleterious effects on the ecosystem especially when the effluents contain heavy metals like mercury, lead, nickel and cadmium. In India, the pollution problems of Tamil Nadu coast have been reported by several workers (Natarajan et al 1982; Nammalwar 1983, 1984; Nammalwar et al 1985). Ganapathi (1975) has stressed that in the face of industrialization, discharges of heavy-metallic toxicants are of great concern in the management of marine and estuarine ecosystem. The majority of the metal toxicants are absorbed by marine animals and stored in them. The concept of the use of sentinel organisms as indicators of the state of pollution in the coastal waters is receiving wide approval as it not only helps to assess the bioavailability of pollutants, but for better management of the environment as well. Establishment of chemical industries like Dharangadara Chemical Works (DCW) and Plastic Resins and Chemical Centre near Kayalpattinam has led to the discharge of effluents of these industries into the coastal water of Tuticorin. Consequently it is felt that studies on the effects of these effluents on the ecosystem is highly essential to keep a constant watch on the extent of damages caused to the marine environment as these effluents have been reported to contain mercury and are highly acidic also (Marichamy and Rajapackiyam, M.S). Keeping these points in view, present study was undertaken on the effect of these effluents on the survival of two bivalves, *Crossostrea madrasensis* and *Mesodesma glabratum* and also the rate of accumulation of mercury in tissues of these species. Information on these aspects is expected to be very useful for suggesting regulatory measures for conservation of the environment.

MATERIALS AND METHODS

Two hundred specimens of *C. madrasensis*, measuring 68 to 132 mm DVM, obtained from the oyster culture farm of CMFRI., Tuticorin and 200 specimens of *M. glabratum*, measuring 18 to 32 mm DVM, collected from the sandy intertidal beach of Hare island at Tuticorin were used for this study and the test animals were maintained in the laboratory in sea water (35 ppt) for a minimum period of 7 days before experimentation. No mortality occurred in the holding stock and this served as control.

Effluent water was collected from the lagoon adjacent to DCW near Kayalpatinam and used

as test medium. The required percentage of effluent mix was obtained by appropriate dilution with sea water. Different hydrological factors such as temperature, salinity, oxygen content, pH and mercury content were estimated in each test medium. A set of 10 samples, each containing 10 animals were drawn from the stock and abruptly exposed to different concentrations from 10% to 1% of effluent water. All through the experiments, a close observation was maintained and the time to death of each animal was recorded. The exposure time was fixed as 10.000 minutes (approximately 7 days). Cessation of response to external stimuli is taken as the index of death. The dead animals were removed immediately and the length and weight were noted down. The data on time to death were initially treated on probability charts to obtain the median lethal time (TLM 50). Median lethal time is the time at which 50% of the sample suffer mortality at a particular dose. The median lethal concentration (LC 50) is the dose in which 50% of the population suffer mortality and this divides the lethal and non-lethal concentrations. The data on median lethal time which bring about 100 to 0% mortality were used to estimate the LC50 by regression analysis (Snedecor and Cochran, 1967).

Another set of 10 experiments were conducted in each species by exposing different size groups in 2.5 ng/ml, a non-lethal mercury concentration for a period of one week to study the rate of accumulation of mercury in the tissues of these species. Mercury Analyser MA-5800 A, manufactured by the Electronic Corporation of India Ltd, was used for the estimation of mercury content in water and tissues.

RESULTS AND DISCUSSION

Different hydrological parameters of the test media, the data on the percentage mortality, median lethal time (TLM 50) and mercury accumulation in tissue of *C. madrasensis* and *M. glabratum* are given in Table 1 and 2 respectively. The hydrological parameters indicate that salinity and oxygen content of the test media were within normal range of tolerance. However, pH was observed to be on the lower side varying from 6.75 to 2.68 (Table 1) and 6.36 to 2.72 (Table 2) in the test media for *C. madrasensis* and *M. glabratum* respectively. This acidic nature of the test media might have also increased the lethal nature of the effluent in addition to mercury. *C. madrasensis* suffered mortality in mercury concentration of 3 ng/ml and above and *M. glabratum* died even in 2.2 ng/ml of mercury concentration. Median lethal time increased with the increase in pH and decrease in mercury concentration in both the species. TLM 50 of *C. madrasensis* increased from 5258 minutes in 7.4 ng/ml of mercury to 9282 minutes in 5.2 ng/ml whereas TLM 50 of *M. glabratum* was 3034 minutes in 7.4 ng/ml which increased to 5220 minutes in 3.0 ng/ml. As seen from the median lethal time, *C madrasensis* could resist mercury for a longer duration

TABLE 1 *Percentage survival and median lethal time (TLM 50) of* C. madrasensis *in different concentration of mercury and other hydrological factors*

Experiment No.	1	2	3	4	5	6	7	8	9	10
Mercury ng/ml	7.4	6.7	5.9	5.2	4.4	3.7	3.0	2.2	1.5	0.7
Oxygen ng/ml	4.1	5.2	4.5	4.3	4.2	4.4	3.7	3.6	3.8	3.8
Salinity %	37.58	39.30	38.79	38.10	38.62	38.10	36.89	36.20	36.72	36.72
pH	2.68	2.76	2.82	2.89	2.95	3.06	3.58	6.35	6.58	6.75
Percentage mortality	100	100	50	50	30	10	10	0	0	0
TLM 50	5258	8144	9210	9282	—	—	—	—	—	—
Mercury in tissue ng/g	17.40	14.29	15.11	15.64	9.78	10.85	10.75	18.83	12.83	15.17

TABLE 2 *Percentage survival and median lethal time (TLM 50) of* M. glabratum *in different concentration of mercury and other hydrological factors*

Experiment No.	1	2	3	4	5	6	7	8	9	10
Mercury ng/ml	7.4	6.7	5.9	5.2	4.4	3.7	3.0	2.2	1.5	0.7
Salinity %	38.10	38.10	37.93	37.84	37.76	37.41	37.24	36.89	36.55	36.20
Oxygen ml/l	5.26	5.65	3.67	4.86	3.90	5.37	4.35	4.63	4.18	4.63
pH	2.72	2.78	2.87	2.92	3.00	3.09	3.24	3.50	5.44	6.36
Percentage mortality	100	100	100	100	100	80	60	30	0	0
TLM 50	3034	3684	2936	3091	4076	4325	5220	—	—	—
Mercury in tissue Ng/g	21.8	46.5	32 4	36.2	32.7	59.3	23.1	29.6	29.9	24.8

TABLE 3 *Accumulation of mercury in tissues of* C. madrasensis *and* M. glabratum *expossed to 2.5 ng/ml of mercury for one week*

Expt. No.	*C. madrasensis*		*M. glabratum*	
	Size (DVM) in mm ± 1 SD	H_g ng/g tissue ± 1 SD	Size (DVM) in mm ± 1SD	H_g ng/g tissue ± 1 SD
1.	128.3 ± 4.4	10.1 ± 0.6	29.2 ± 1.2	21.3 ± 1.2
2.	116.1 ± 7.2	11.4 ± 0 9	29.9 ± 1.1	23.3 ± 0.9
3.	100.2 ± 8.1	13.2 ± 1.0	27.1 ± 0.7	24.7 ± 1.1
4.	88.1 ± 5.2	14.9 ± 0.5	26.3 ± 0.9	29.0 ± 0.7
5.	79.7 ± 2.7	15.3 ± 0.2	25.9 ± 0.9	29.9 ± 1.4
6.	76.3 ± 1.3	16.4 ± 0.7	25.4 ± 1.0	32.0 ± 1.8
7.	74.0 ± 1.1	18.3 ± 0.8	25.0 ± 1.5	32.5 ± 1.3
8.	72.1 ± 1.0	20.9 ± 2.1	23.6 ± 1.9	36.2 ± 0.8
9.	70.2 ± 1.1	22.4 ± 1.5	20.8 ± 1.4	41.0 ± 1.2
10.	70.8 ± 1.2	25.7 ± 1.8	20.1 ± 1.3	51.2 ± 2.9

of time than *M. glabratum*. The median lethal concentration is estimated to be 5.1 ng/ml for *C. madrasensis* and 2.8 ng/ml for *M. glabratum* and this indicates that the later species is more susceptible for mercury as it dies in lesser time and lower concentration of mercury. The data on the mercury accumulation in tissue in the lethal study did not show any definite correlation with any of the hydrological factors as shown in Tables 1 and 2 and this may be due to multi-factorial variation such as time to death and size of the test animals.

The data on the rate of accumulation of mercury in tissues of *C. madrasensis* and *M. glabratum* exposed to non-lethal concentration of mercury are shown in Table 3. Size of the animal is found to exhibit a direct relationship on the rate of mercury accumulation in tissues in both the species as smaller animals have been recorded to accumulate more mercury and the rate of accumulation decreases as the size increases. The rate of mercury accumulation in *C. madrasensis* increased from 10.1 ng/g tissue among animals measuring 128.3 mm DVM to

25.7 ng/g tissue in oysters among 70.8 mm DVM size. Similarly in *M. glabratum* it increased from 21.3 ng/g in animals measuring 29.2 mm DVM to 51.2 ng/g in specimens of 20.1 mm DVM size. *M. glabratum* is observed to accumulate more mercury than C. *madrasensis* and this may be again owing to the use of smaller sized specimens in the experiments or perhaps due to species specificity. This may be one of the reasons for the higher intolerance of this species to mercury as pointed out already. Low tolerance of mercury compounds by molluscs, which in short-term experiments had toxic effects at 0.1 ppm was reported by several investigators (clarke 1943; wisely and Blick 1967). The reasons for higher accumulation of mercury in smaller animals may be due to varied nature of biological activities. Further study on the physiology including the metabolism of mercury by these animals may provide more information on the causative factors for the mortality of these species. Marine organisms having developed under relatively stable and uniform environment in their chemical composition are very sensitive to sudden changes (Prosser and Brown, 1962). The high toxicity of metallic mercury and mercury compounds was described in antiquity (Goldwater 1936; Bidsrrup 1964) but not until the mass poisioning known as Minamata disease did mercury investigations become concerned with the hamful effect of heavy metals released by man into the marine environment.

The biological effects of mercury is strongly dependent on its concentration, chemical form and the organism. Mercury enters organisms by absorption through free surfaces such as skin (Schamberg 1918) or gills (Harnnarz 1968), by intake of water or food containing mercury compounds.

Present study reveals that these species come under the heavy metal stress even at lower concentrations. The median lethal concentration indicates that the population of these species will suffer heavy mortality when the surrounding water happens to get effluents of mercury concentrations higher than LC 50 values as determined. Thus, the periodical monitoring of marine pollution in the coastal waters is the existing of marine pollution in the coastal waters in the existing situation becomes an obvious necessity.

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