Chapter 5

TOXIC EFFECT OF HEAVY METALS ON HEART RATE

5.1. INTRODUCTION

Rapid industrialization lead to contamination of natural waters with metals due to dumping of untreated wastes in the aquatic habitats, causing deleterious effects of aquatic organisms (Javed, 2003). The accumulation of metals in an aquatic environment has direct consequences to man and to the ecosystem also. Intensive activity in industrial and agricultural sectors has inevitably increased the levels of heavy metals in natural waters (Jardao et al., 2002). Heavy metals play a major role among pollutants of environmental concern (Singer et al., 2005). Heavy metals are serious pollutants of the aquatic environment because of their environmental persistence and ability to be accumulated by aquatic organisms (Veena et al., 1997). Due to bioaccumulative property, the bivalves have gained great importance as indicator organisms.

The heart beat of bivalves is an useful physiological rate function since it can easily be monitored together with valves movements and pumping activity (Trueman et al., 1973). Various techniques are used to study the continuous activity of heart movements of bivalves in the laboratory and under field conditions (Hoggarth and Trueman, 1967; Vero and Salanki, 1969; Coleman, 1974; Earll and Evans, 1974 and Brand, 1976) and these works stimulated interest in the physiological and biochemical adaptations associated with behavioural changes.
The electronic techniques are advantageous over previous studies, which involved cutting of holes in the shell to observe the heart or the use of a cumbersome system of threads and levers to record valve movements. Without cutting the shells, the heart activity can be observed through the almost transparent shell of young individuals. Hers (1943) etched away the outer shell layers of older *Anodonta* with acid and viewed the heart through thin, transparent, inner nacreous sheet. Although these modification of the shell hole technique might reduce interference with the animal, the direct observation is time consuming and impractical in the field.

A relationship between heart rate and valve movement was demonstrated many years ago by Koch (1917). Whenever the bivalves faced the environmental stress, they immediately closed down the shells. Therefore, the heart rate was reduced. This phenomenon has been reported in a number of other bivalves molluscs (Bayne, 1971; Coleman, 1974; Brand, 1976; Akberali, 1978; Deitz and Tomkins, 1980; Akberali *et al.*, 1981).

A decrease of heart beat was observed in *L. margiknalis* after exposures to lethal and sublethal concentrations of heavy metals has been reported by Radhakrishnaiah, 1988; Radhakrishnaiah *et al.*, 1991; Senthilmurugan *et al.*, 1994; Pillay *et al.*, 1997 and Ramana Rao *et al.*, 1983. However, the percent suppression in the heart beat was much greater in the mussels exposed to lethal concentration, and it increased with the increase in exposure period. Whereas in sublethal concentration, the percent suppression was relatively less, and it decreased with the increase in exposure period.
In bivalve molluscs, high levels of heart rate are associated with periods of activity as indicated by valve gaping, high rates of respiration and filtering and pumping activity whereas periods of inactivity are associated with a low heart rate (Akberali and Trueman, 1985).

Oxygen tension in the mantle cavity may have a decisive influence on heart rate. Schleiper (1957) suggested that bradycardia (reduced heart rate) may be effected by a build up of carbon-di-oxide whereas Bryan (1971) postulated that depletion of oxygen within the mantle cavity was responsible.

Since the heart rate is closely related to the pumping activity, it may be utilized as a means of monitoring the environmental stress in aquatic animals. Hence, an attempt was made to study the effects of heavy metals on the rate of heart beat in *L. marginalis*.

**5.2. MATERIALS AND METHODS**

Specimens of *L. marginalis* with shell length 57±5 mm were collected from Sivankovil Pond. All adherent materials on the shell of bivalve species were scraped and they were acclimatized in their respective medium for three days before the commencement of the experiments. 30% sublethal concentration of heavy metals were prepared using 96 hr. LC 50 concentration as 100%.

Twenty bivalves were exposed to 10 litres of each sublethal concentration of a specific metal for a period of 30 days. Multiple sets of experiments and control were run
simultaneously. At the interval of 10, 20 and 30 days, the heart rate of the exposed bivalves was measured. For the measurement of heart rate, right valve of the exposed bivalve was removed and immersed in test medium for a period of 15 minutes to recover completely.

The number of heart beats per minute was counted using a stop watch. Five estimates were made and the results were averaged and expressed as number of beats/minutes. Similar estimation was also made for control bivalves of each experiment.

The data were treated with two way ANOVA to test the significance of toxic effect at various levels of sublethal concentration.

5.3. RESULTS

Exposure of *L. marginalis* to graded sublethal concentrations of copper, cadmium and synergistic showed either an acceleration or a decrease in heart rate. The data on these experiments are presented in Fig (4,5,6).

In general, the rate of heart beat increased in all sublethal concentrations during short term exposure of 10 days. In 10 days exposure, the heart rate increased with the increasing concentrations of heavy metals in the test medium. But there was a decline in the rate of heart beat when the exposure period was extended to 20 and 30 days. The decreasing order of metals affecting the heart rate was copper followed by cadmium and...
synergistic metals. ANOVA revealed that variation in heart rate between the concentrations of metal and the duration of exposure was significant at 0.01 level. (Table 3).

**Copper**

The heart beat of control mussels recorded 28 beats/min. The sublethal concentration of copper accelerated the rate of heart beat in *L. marginalis* on exposure for a period of 10 days. The heart recorded were 41 beats/min in 30% sublethal concentrations of copper. The heart rate increased to a maximum level (41 beats/min) on exposure for 10 days and decreased to a minimum level (17 beats/min) after 30 days of exposure in 30% concentration.

**Cadmium**

It had more effect on the rate of heart beat next to copper. Acceleration in heart beat was recorded in *L. marginalis* exposed to all the sublethal concentrations after 10 days of exposure. Increased rate in heart beat (39 beats/min) was observed in 30% concentration exposed for 10 days, while the control mussel showed 28 beats/min. The rate of heart beat decreased to a minimum of 20 beats/min. in *L. marginalis* exposed to 30% concentration for 30 days.

**Synergistic**

Sublethal concentrations of synergistic metals showed less effect on the heart rate of *L. marginalis* than that of copper and cadmium. It showed a similar pattern of
increased heart beats in a 30% sublethal concentrations after 10 days of exposure as in the case of other metals. The heart rate increased to a maximum of 31 beats/min. after 10 days of exposure and it decreased to minimum of 21 beats/min. after 30 days of exposure to 30% sublethal concentration.

5.4. DISCUSSION

The effects of sublethal concentrations of heavy metals on the heart rate of *L. marginalis* was observed. The bivalves subjected to chronic exposure showed an increase in the rate of heart beat after 10 days of exposure and thereafter decrease in the rate of heart beat was recorded only in higher concentrations. Among the metals, copper and cadmium depressed the heart rate more sharply than synergistic metals. The rate of heart beat was slightly decreased, observed in synergistic treated mussel. The similar observation was reported by Radhakrishnaiah, 1988; Amsath *et al.*, 2003; Pillay *et al.*, 1997 and Amanulla Hameed, 1995.

A decrease was observed in the rate of heart beat of *L. marginalis* after 1, 2 and 3 days of exposures to lethal and 1, 5 and 10 days of exposures to sublethal concentrations of heavy metals. However, the percent suppression of heart beat was much greater in the mussels exposed to lethal concentration, and it increased with the increase in exposure period. Whereas in sublethal concentration, the percent suppression was relatively less, and it decreased with the increase in exposure period. The results indicated an irreversible suppression in the physiological activities of the mussels exposed to lethal
concentration and an initial suppression with a gradual recovery in those exposed to sublethal one (Radhakrishnaiah, 1988).

In the present investigation it was observed that there was an initial acceleration (after 10 days) in the heart beat in all the sublethal concentrations of the metals. The higher heart rate was an index of higher physiological activity of organisms. Akberali and Trueman, (1985) reported that the periods of activity in bivalves were associated with valve gaping, high rate of respiration and filtering and pumping activity. In the present study the *L. marginalis* showed an increased rate of oxygen uptake after 10 days of exposure in all the sublethal concentration of metals indicating higher activity including filtering and pumping. As an initial response to the presence of metals in the medium, these bivalves increased the pumping and filtering activity to eliminate the metals out of their body. Consequently the heart rate also increased.

Conversely during long term exposure, the freshwater mussel slowed down the heart beat rate. This was due to closure of valves and reduced activity of the bivalves. A decrease in the activity of bivalves was also evidenced by the low level of oxygen consumption during long term exposure to metals. Schleiper, (1955) showed that when shells of *Mytilus edulis* were closed, the heart rate was reduced by fourteen times. Scott and Major (1972) observed that in *M. edulis*, no change was found in the rate at lower concentrations of 0.2 mg/l of copper but in higher concentrations a general dose response was clearly apparent. Akberali and Trueman (1985) emphasized that *Scrobicularia plana* closed their valves on prolonged exposure to 0.01− 0.5 mg/l of copper and this led to
drop in the heart beat rate. They further reported that *S. plana* did not behave differently from those of controls at low concentrations. But at higher concentrations the siphons were withdrawn and valves remain closed with a marked lowering in the rate of heart beat. Therefore in the present study the minimum rate of heart beat observed was due to the chronic effect of heavy metals. ANOVA showed significant variations in heart beat between different periods of exposure and different concentrations of metals.

From these studies, it is well understood that the heavy metal stress caused an initial elevation in heart beat rate associated with higher activity of bivalves and a decrease thereafter in heart beat rate associated with inactivity. Therefore the rate of heart beat could be used to study the impact of metal pollutants on organisms.