ACCUMULATION OF MERCURY BY THE MUSSEL *Perna viridis* LINNAEUS

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**ABSTRACT**

*Perna viridis* exposed to different concentrations of HgCl$_2$ accumulated Hg in their tissues from sea water. The rate of uptake and distribution pattern of Hg in various tissues were studied. While the rate of uptake increased with increasing Hg concentration in water, the highest concentration factors occurred at the lowest Hg concentrations in the water indicating greater uptake efficiency at lower concentrations. Gillis of the mussel were found to be the major sites of Hg accumulation. Mercury levels above 0·1 ppm in the medium were found to be extremely toxic to the mussel and a 96 hr LC$_{50}$ value was found to be 0·35 ppm. The major fraction of the accumulated Hg was ethanol (70%) insoluble, suggesting that Hg is forming strongly bonded macromolecular complexes.

**INTRODUCTION**

MERCURY pollution in the aquatic environment has been recognized in many areas of the world and high concentrations of mercury have been found in many species of fish. Molluscs are noted for their ability to concentrate trace metals from the environment to a very high level relative to the concentration in water. A quantitative estimation of such samples could be useful in providing an index or measure of environmental pollution by heavy metals. Smith et al. have studied the uptake of Hg by some fresh water clams (*Unionidae family*) and Irukayama et al. have recorded varying Hg levels in different organs of bivalves from Minamata Bay. The accumulation and acute toxicity studies have been conducted for some marine fishes by other workers.

The studies reported here include:

(i) Hg-toxicity to the mussel, *Perna viridis* under the habitat salinity, pH and temperature conditions.

(ii) The accumulation of Hg by the animal at different concentrations of mercury (Hg$^{II}$) and the distribution characteristics in various organs.

**MATERIALS AND METHODS**

*Perna viridis* of the same age group (length 52–56 mm), collected from Narakkal, about 10 km north of Cochin barrel-mouth, were used in all the experiments. The mussels were acclimatized to laboratory conditions for a week. The characteristics of the water used were:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salinity</td>
<td>25%</td>
</tr>
<tr>
<td>Dissolved O$_2$</td>
<td>95 ± 5% saturation</td>
</tr>
<tr>
<td>Temperature</td>
<td>29-4-30-5°C</td>
</tr>
<tr>
<td>pH</td>
<td>7.5-7.8</td>
</tr>
<tr>
<td>Hg($^{II}$)</td>
<td>0.002 ppm</td>
</tr>
</tbody>
</table>

The toxicity studies:

Ten animals were kept in each trough containing 4 litres of millipore filtered sea water containing varying amounts of Hg, added as an aqueous solution of HgCl$_2$ ranging from 0·05 to 0·2 ppm. It was aerated and water in each tank was changed daily and fresh HgCl$_2$ solution added. Mortality was noted at every 24 hr (dead animals were removed from the system) for a period of 96 hr. A control was always kept.

At the time intervals indicated in Fig. 2 three animals were sacrificed from each tank (0·05 ppm, 0·1 ppm, 0·2 ppm and control) and the whole soft part was analysed for Hg.

In another series of experiments, mussels were maintained in sea water containing 0·1 ppm Hg($^{II}$). They were dissected and treated as Mantle (mantle + gonad), Muscle (adductor muscle + foot), gills and the remaining part was taken as visceral mass. Hg analysis was performed on these organs after exposing the animals for definite intervals of time (Table II). Samples were kept in deep freezer in polythene bags until analysis.

The tissue was digested with HNO$_3$: H$_2$SO$_4$ (4:1 V/V) under reflux in a Bathje apparatus. Mercury was analysed using a Mercury Analyser (Model MA-77 ser. No. 005, designed by Analytical Chemistry Division, BARC, Bombay) by Cold Vapour atomic absorption technique using SnCl$_2$ as reducing agent. Air, free from Hg was used as a carrier gas. A standard graph was prepared from HgCl$_2$ solutions.

To study the biochemical characteristics of the Hg accumulated, mussels from 0·1 ppm solution were sacrificed and cold extracted for 24 hr using 70% ethanol. Then, it was centrifuged and the insoluble mass as well as the extract were analysed for Hg.

The reagents and chemicals used were all of analytical grade. Triplicate measurements were made in each case of analysis.

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RESULTS AND DISCUSSION

Mercury (Hg²⁺) above 0.1 ppm in the medium proved to be very toxic to the mussel, *Perna viridis*. Mortality occurred in all experimental tanks having Hg concentrations of 0.2 ppm and above, during a 96 hr period. Two animals died in 0.2 ppm solution on the fourth day (96 hr) of the experiment; other animals in the same tank had become quite inactive. 100% mortality occurred in 0.5 ppm solution within 96 hr. The mussels closed their valves and secreted mucus. It seems that the amount of mucus exuded by the animal was dependent on the extent of irritation. The 96 hr LC₅₀ value was determined graphically and was found to be 0.35 ppm (Fig. 1).

![Fig. 1](image)

**Fig. 1.** Determination of 96 hr LC₅₀ value by plotting % survival of *Perna viridis* at 96 hr period against concentration of mercury (in ppm).

Hg content of the whole soft tissues of the mussel in all the experimental tanks increased considerably, when compared to the background level of Hg in the body. It increased from a background level of 0.1 mg Hg/kg wet wt. to 25-18 mg/kg wet wt. in 0.2 ppm Hg solution within 5 days (Fig. 2).

The closeness of fit of the regressions of the observed data could be seen from Fig. 2.

It is seen that the uptake was linear in 0.05 ppm solution throughout the experimental period (Fig. 2). At higher concentrations there was rapid initial uptake, and in subsequent days the rate decreased, presumably owing to the lethal effect of the metal. The concentration factor was maximum in 0.05 ppm (403.6 in 6 days) and there was a gradation in the concentration factors with increasing concentration (Table I).

### Table I

Concentration factors* attained by *Perna viridis* when exposed to HgCl₂ in sea water of salinity 25% for varying lengths of time

<table>
<thead>
<tr>
<th>Hg in the medium (ppm)</th>
<th>Time of exposure (in days)</th>
<th>C.F.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>0.05</td>
<td>50.01</td>
<td>132.00</td>
</tr>
<tr>
<td>0.10</td>
<td>60.04</td>
<td>115.00</td>
</tr>
<tr>
<td>0.20</td>
<td>48.78</td>
<td>83.50</td>
</tr>
</tbody>
</table>

*C.F. = \( \frac{\text{mg Hg/kg wet weight}}{\text{mg Hg/1 sea water}} \)

**Distribution of Hg in Organs**

The distribution pattern of Hg in the different organs at certain intervals of time and their concentration factors are given in Table II. Mercury rapidly accumulated in all the organs, but gills had the highest concentration of mercury at all times. Hg was distributed rather uniformly in all other tissues. The rapid accumulation and large concentration of Hg and other trace metals in gill tissues were observed by other workers as well.

The mercury accumulated by the mussel was very little extracted by 70% ethanol. This suggests that Hg is forming strongly bonded macro-molecular complexes. The ethanol soluble fraction of Hg was found to be negligible (Table III).

The present study reveals that mercury if present in the aquatic environment, both at the lethal and sublethal concentrations can cause great hazard by the bio-accumulation of the metal.
**TABLE II**

Distribution of Hg among various tissue components (mg Hg/kg tissue wet wt.) in the mussel, *Perna viridis* exposed to 0.1 ppm HgCl₂ in sea water of salinity, 25%o (expressed as mg Hg/kg wet wt.)

<table>
<thead>
<tr>
<th>Organ</th>
<th>% of body weight</th>
<th>Control</th>
<th>Time of exposure</th>
<th>C.F. after 5 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Muscle</td>
<td>26.71</td>
<td>0.075</td>
<td>2.80</td>
<td>8.780</td>
</tr>
<tr>
<td>2. Mantle</td>
<td>29.47</td>
<td>0.077</td>
<td>2.76</td>
<td>8.844</td>
</tr>
<tr>
<td>3. Gill</td>
<td>19.79</td>
<td>0.195</td>
<td>23.05</td>
<td>40.475</td>
</tr>
<tr>
<td>4. Viscera</td>
<td>24.04</td>
<td>0.082</td>
<td>2.64</td>
<td>5.650</td>
</tr>
</tbody>
</table>

**TABLE III**

Biochemical characteristics of Hg, accumulated by the mussel, *Perna viridis* exposed to 0.1 ppm HgCl₂ in sea water of salinity, 25%o (expressed as mg Hg/kg wet wt.)

<table>
<thead>
<tr>
<th>Days of exposure</th>
<th>EtOH soluble Hg</th>
<th>EtOH insoluble mercury</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>0.03888</td>
<td>7.052</td>
</tr>
<tr>
<td>4</td>
<td>0.06448</td>
<td>14.172</td>
</tr>
<tr>
<td>6</td>
<td>0.5338</td>
<td>23.855</td>
</tr>
</tbody>
</table>

**Acknowledgements**

The authors gratefully acknowledge the interest and advice of Prof. Dr. C. V. Kurian, Head of the Department of Marine Sciences. They are also thankful to the Director, MPEDA, Cochin, for his permission to use their Mercury Analyser and to the University Grants Commission for giving financial assistance.


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During the first International Colloquium on Cecidology at Strasbourg, France, it was suggested that a cecidological newsletter should be started so as to enable all the students of Cecidology to keep abreast with all recent developments in the subject. The Entomology Research Unit at the Loyola College, Madras, has brought out the first number of this newsletter in June 1979. A number of features such as news about research activities of fellow cecidologists and notes on current literature pertaining to gall research, etc., are included in this. This attempt bridges the communication gap among cecidologists. Further details can be had from the Editor A. Ramana, Entomology Research Unit, Loyola College, Madras 600 034.