In recent years, the usage of biological indicators has a profound impact in pollution monitoring studies. Molluscs are the sensitive bio-indicator species of heavy metal pollution because they are sedentary and they have enormous capabilities to accumulate metals. The tolerance capacity of the organism is dependent on its own characteristics and by a set of environmental characteristics within which it is confronted along with the lethal agent. Temperature not only influences the toxic transport of metals among the tissues but also other physiological processes including rate of metal equilibration and metal availability. The metal toxicity is also influenced by salinity in marine organisms through changes in osmoregulation and transport of ions. According to Cresenti & Marino, the size of the animal also alters the metal toxicity in addition to environmental variables.

The coastal waters of Visakhapatnam are being contaminated with pollutants from the nearby harbour, which receives the discharges of effluents from industries and domestic sewage. Of all the metal pollutants, cadmium ranges from 0.21 to 2.11 µg/l in the coastal waters of Visakhapatnam. In the natural habitat, Turbo intercostalis experiences a seasonal variation of temperature (24 to 32°C) and salinity (24.4 to 35.2‰). Therefore, the present investigation was carried out to study the effect of cadmium on medium-sized T. intercostalis at different temperatures and salinities under laboratory conditions. In addition, the influence of cadmium was also determined on small-sized T. intercostalis.

Materials and Methods

Turbo intercostalis were collected from Lawson’s Bay area of Visakhapatnam (17°40’30” N to 17°45’N and 83°16’15” E to 83°21’30” E) on east coast of India. Animals were collected from the same tidal level and maintained in the laboratory at ambient environmental conditions (29±1°C, 32‰) with continuous aeration for 48 hr before experimental use. A stock solution of CdCl₂.5H₂O (GR) was prepared by dissolving a known amount of salt in distilled water and this stock solution was used to prepare different concentrations of the metal.

Experiments were conducted by placing 10 snails in each trough containing 3 liters of seawater. The temperature (29±1°C), salinity (32‰) and pH (7.5) were maintained constantly during the experimental period except for salinity and temperature-related experiments where the change in respective parameters was mentioned. The snails were exposed...
to cadmium for a period of 96 hr and the mortality rates were recorded for every 24 hr. At every 24 hr, the dead animals were removed and the seawater in each trough was renewed with respective concentrations of cadmium. Parallel controls were run along with each experiment. There was no mortality in the controls at different salinities or temperatures. Range-finding tests were conducted earlier to determine the exposure concentrations of cadmium and the ranges of salinity or temperature.

Small (width of the shell: 1.2 to 1.4 cm) and medium (3.4 to 3.8 cm) sized individuals were used for the bioassay experiments. Each group was exposed to five different concentrations of cadmium. They were 1.4, 2.5, 3.2, 5.0 and 6.2 ppm for small size and 2.5, 5.0, 7.5, 10.0 and 12.5 ppm for medium size group. The temperature and salinity were kept constant, at 29±1°C and 32%, throughout the experimental period.

Two ranges of temperature namely, high (33°C) and low (25°C) were chosen for this study. Medium sized-snails (3.4 to 3.8 cm) were exposed to different cadmium concentrations at the above temperatures. Four different concentrations namely 0.2, 0.6, 1.0 and 2.0 ppm were selected for exposure at 25°C. Similarly at high temperature (33°C) the exposure concentrations were 0.02, 0.04, 0.10 and 0.2 ppm. Separate controls were run for both the temperatures.

Tolerance studies were made with medium-sized individuals (3.4 to 3.8 cm) at two different salinities of 35% (high) and 20% (low). At 20%, four concentrations of cadmium were used and they were 0.5, 1.0, 2.0 and 4.0 ppm. Another set of four concentrations namely 0.1, 0.5, 1.0 and 1.5 ppm was chosen for exposure at 35%. Controls were maintained for both the salinities separately. Temperature (29±1°C) was kept constant throughout the experimental period by using a BOD incubator.

The average rates of mortality and LC50 values were determined by adopting Probit method12. The lethal concentrations together with standard error and fiducial limits were also calculated12. The LC50 values of medium sized individuals were compared with other values obtained for different parameters by Students' 't' test13.

Results and Discussion
The data indicate that the mortality rates increased with increase in cadmium concentrations at all the parameters studied. There was no mortality in the controls. In the exposed snails, mucous secretions were observed and this was found to be more at high concentrations of cadmium.

The LC50 value for 96 hr was 6.1844 ppm for medium and 2.774 for small sized T. intercostalis. These values along with the other lethal concentration and fiducial limits were presented in Table 1.

![Fig. 1—Comparison of dose-mortality regression lines for small and medium sized T. intercostalis exposed to cadmium.](image-url)
significant difference (P < 0.05) was noticed between two size groups at each lethal concentration. The regression lines between the two size groups show that small-sized individuals were found to be sensitive than medium-sized snails to cadmium (Fig. 1).

The LC50 values for 96 hr were 0.3629 and 0.0577 ppm for low and high temperatures respectively. These values were found to be significantly low (P<0.05) from that of ambient temperature (6.1844 ppm) (Table 1) indicating more toxicity. A comparison of the other lethal concentrations at both the temperatures with those at ambient temperature also revealed a significant difference (P<0.05). Figure 2 represents a comparison of the regression lines obtained at low and high temperatures with that of ambient and this indicated that cadmium was more toxic at high temperature for these snails. The toxicity

![Graph](image)

**Table 1.—Lethal and safe concentration of cadmium for T. intercostalis in relation to size, temperature and salinity.**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>LC50 (ppm ± SE)</th>
<th>LC50 (ppm ± SE)</th>
<th>LC50 (ppm ± SE)</th>
<th>Safe concentration (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium (3.4-3.8cm)</td>
<td>2.8171 ± 0.6491</td>
<td>6.1844 ± 0.7842</td>
<td>13.5831 ± 2.6035</td>
<td>0.062</td>
</tr>
<tr>
<td>Small (1.2-1.4cm)</td>
<td>0.9513 ± 0.1684</td>
<td>2.773 ± 0.2056</td>
<td>8.091 ± 1.1956</td>
<td>0.028</td>
</tr>
<tr>
<td>Low temperature (25°C)</td>
<td>0.0519 ± 0.0243</td>
<td>0.3629 ± 0.0530</td>
<td>2.535 ± 0.7316</td>
<td>0.004</td>
</tr>
<tr>
<td>High temperature (33°C)</td>
<td>0.0136 ± 0.0025</td>
<td>0.0577 ± 0.0074</td>
<td>0.3221 ± 0.0728</td>
<td>0.0006</td>
</tr>
<tr>
<td>Low salinity (20%)</td>
<td>0.4272 ± 0.0669</td>
<td>1.154 ± 0.0952</td>
<td>3.119 ± 0.4298</td>
<td>0.012</td>
</tr>
<tr>
<td>High salinity (35%)</td>
<td>0.0375 ± 0.0178</td>
<td>0.3722 ± 0.0666</td>
<td>3.6930 ± 1.3747</td>
<td>0.0048</td>
</tr>
</tbody>
</table>

*Fig. 2—Comparison of dose-mortality regression lines at low, high and ambient temperatures for T. intercostalis exposed to cadmium.*
was in the order of high temperature>low temperature>ambient temperature.

A similar change in LC₉₀ values was observed with salinity ranges and these values were also significantly low when compared to the ambient salinity (Table 1). The regression lines obtained at low and high salinities were compared with that of ambient in Fig. 3. The snails were found to be sensitive at both low and high salinities than that of ambient.

The results clearly indicate that mortality rates increase with increasing concentrations of the metal in medium and small sized T. intercostalis. Similar trend was noticed at both the temperatures and salinities. Chung³ investigated the effect of cadmium and some other metals on Nerita fulgures and observed that an increase in metal concentration increases the toxicity. The gastropod, Cerithium scabridum exposed to cadmium showed a similar result¹⁴. Axiax & Schembri¹⁵ also demonstrated the temperature effect on the toxicity of cadmium in Monodonta turbinata. In a freshwater snail Potamopyrgus antipodorum a similar trend of more toxicity was observed at high temperature¹⁶. Kulkarni¹⁷ reported an increased toxicity of cadmium at low salinities in the clam, Katelysia mornorata.

In the present study, a comparison of LC₉₀ values of T. intercostalis showed that the effect of temperature was more at higher ranges. The increase in toxicity of cadmium with increase in temperature in T. intercostalis might be due to an increase in the metabolism. It was already reported that the metabolism of T. intercostalis increases with increasing temperature¹⁸. Yen-wan¹⁹ also attributed the temperature-dependent toxicity to the metabolic rate and other physiological processes that occur due to change in temperature.

With response to salinity regimes, high salinity was found to be more toxic in these snails. This might be due to changes in osmoregulation or metabolism or due to stress on the animal.

However, the safe values of cadmium calculated for different environmental variables²⁰ were well above the concentrations noticed in the habitat except for high temperature (Table 1). This investigation also gives an indication that the cadmium concentration in coastal waters is almost nearing the safe concentration levels of these snails at other regimes of environmental conditions.

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References


