DISTRIBUTION OF Zn, Mn, Fe AND Cu IN EDIBLE MARINE GASTROPODS ALONG THE SOUTH EAST COAST OF INDIA

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ABSTRACT
Zn, Mn, Fe and Cu were measured in edible gastropods Babylonia spirata, Helix aspersa, Rapana venosa, Xerocrinus pyrum and Melo melo sampled during October 1994 to September 1995 at 4 sites along the Southeast coast of India. The animals from heavily polluted sites showed high levels of metal. High concentrations of all metals were recorded during the rainy monsoon whereas concentrations were low during the dry summer.

INTRODUCTION
Heavy metal enrichment of aquatic environment has become a matter of great concern. Monitoring the concentration of heavy metals in marine and freshwater has received much attention in recent years because of environmental persistence, toxicity and ability to be incorporated into the food web. Marine organisms from heavy metal contaminated environments are capable of accumulating very high levels of metals in their tissues with no obvious biological effects (Goldberg et al. 1978). Among molluscs, the bivalves accumulate heavy metals to levels far in excess of those in the hydrosphere (Brooks & Runshby 1965) and a number of species have since been evaluated as potential indicator species. Even though some gastropods also have a clear potential as indicators of trace metals (Ireland & Wotton 1977) relatively few reports are available on heavy metal accumulation in marine gastropods (Segur et al. 1971; Ireland & Wotton 1977; Ireland 1979; Newell et al. 1987; Nassem et al. 1990; Nicolaidou & Nott 1990; Nott & Nicolaidou 1989, 1990 and Athalye & Gokhale 1994). Studies on this subject from Indian marine environment are scanty. We have measured heavy metals Zn, Cu, Mn, Fe in edible gastropods along the south east coast of India to compare metal concentrations with amounts of pollution.

MATERIALS AND METHODS
Description of sampling sites
Increasing urbanisation and industrialisation in Madras metropolitan area (13°36′N; 80°17′E) have resulted in drastic increase in pollutants in coastal waters. Several metal sources are involved amongst these pollutants. Other general sources, which may also contribute to total pollutants are oil refining activities, fishing activities and harbour activities such as dredging, cargo handling, dumping of ship waste, spilling of cargoes such as chemical and metal ores and oil transport.

Cuddalore (11°42′N; 79°46′E) is located on

Figure 1. Map of the study areas.
the Coromandel coast of Bay of Bengal. The Small Industries Promoting Corporation of Tamil Nadu (SIPCOT) along this coastal belt are dumping their untreated and partially treated effluents into the near-shore area. Besides, municipal wastes are also drained into the sea.

Mandapam (9°17'N; 80°8'E) is a narrow strip of mainland located in the Gulf of Mannar region. This station is relatively less polluted as there is no industrial waste disposal. The domestic sewage alone is the only source of pollution in these coastal waters. Tuticorin (8°45'N; 78°46'E) is an important industrial town situated in the Gulf of Mannar area. The coastal area is heavily polluted with municipal wastes and effluents of various industries such as Tuticorin Thermal Power Station (TTPS), Tuticorin Alkali Chemicals and Fertilizers Ltd. (TAC), Heavy Water Plant (HWP), Dhubangadhara Chemical Works Ltd. (DCW), Southern Petrochemical Industries Corporation Ltd. (SPIC), Madura Coats (P) Ltd. and various allied chemical industries. Apart from this the shipping harbour and various shrimp culture industries are also adding pollutants to these coastal waters.

**Collection**

The edible gastropods *Babulonia spirata*, *Hemifusus pugilinus*, *Rapania rapiformis*, *Xancus pyrum* and *Melus melo* were collected from trawls during October 1994 - June 1995. For each species 20 animals were collected and brought to the laboratory and kept in clean sea water over night. Next, soft bodies were removed and pooled for each species. The pooled samples were rinsed and dried in an oven at 80 °C for 48 h. All species from each station were analysed in triplicate. Metals were extracted from dried material by nitric acid digestion and measured using Atomic Absorption Spectrophotometer (AAS).

**RESULTS**

The concentrations of metals in different gastropods collected from various stations and seasons are shown in Fig. 2-6. The gas-
Figure 3. Concentration of Zn, Mn, Fe, and Cu in *Babylonia spirata*.

Figure 4. Concentration of Zn, Mn, Fe, and Cu in *Baptaea rupicola*.
Figure 5. Concentration of Zn, Mn, Fe, and Cu in Exuviae pygmea.

Figure 6. Concentration of Zn, Mn, Fe, and Cu in Hemifusia papillaris.
### Table 1. Two-way analysis of variance of concentrations of metals between species and stations.

<table>
<thead>
<tr>
<th>Species</th>
<th>Zn</th>
<th>Mn</th>
<th>Fe</th>
<th>Cu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stations</td>
<td>F</td>
<td>P</td>
<td>F</td>
<td>P</td>
</tr>
<tr>
<td></td>
<td>15.335</td>
<td>&lt;0.005</td>
<td>11.012</td>
<td>&lt;0.005</td>
</tr>
</tbody>
</table>

### Table 2. Two-way analysis of variance of concentrations of metals between species and stations.

<table>
<thead>
<tr>
<th>Species</th>
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<th>Cu</th>
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<td>P</td>
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<tr>
<td></td>
<td>15.335</td>
<td>&lt;0.005</td>
<td>11.012</td>
<td>&lt;0.005</td>
</tr>
</tbody>
</table>

### Table 3. Two-way analysis of variance of comparisons of metals and stations for all the species.

<table>
<thead>
<tr>
<th>Species</th>
<th>Zn</th>
<th>Mn</th>
<th>Fe</th>
<th>Cu</th>
</tr>
</thead>
<tbody>
<tr>
<td>M. melo</td>
<td>F</td>
<td>P</td>
<td>F</td>
<td>P</td>
</tr>
<tr>
<td>Season</td>
<td>34.14</td>
<td>NS</td>
<td>3.591</td>
<td>NS</td>
</tr>
<tr>
<td>Station</td>
<td>14.961</td>
<td>&lt;0.005</td>
<td>14.257</td>
<td>&lt;0.005</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.157</td>
<td>N.S</td>
<td>19.669</td>
</tr>
<tr>
<td>B. spirata</td>
<td>1.734</td>
<td>NS</td>
<td>0.952</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>9.083</td>
<td>&lt;0.005</td>
<td>14.126</td>
<td>&lt;0.005</td>
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<tr>
<td></td>
<td></td>
<td>1.860</td>
<td>N.S</td>
<td>34.101</td>
</tr>
<tr>
<td>R. rapiformis</td>
<td>3.518</td>
<td>NS</td>
<td>2.307</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>7.977</td>
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<td>16.543</td>
<td>&lt;0.005</td>
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<tr>
<td></td>
<td></td>
<td>3.121</td>
<td>N.S</td>
<td>31.299</td>
</tr>
<tr>
<td>X. pyrum</td>
<td>1.816</td>
<td>NS</td>
<td>2.719</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>13.987</td>
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<td>6.415</td>
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<td>1.955</td>
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<td>H. pulchellus</td>
<td>3.194</td>
<td>NS</td>
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<td>NS</td>
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<tr>
<td></td>
<td>15.659</td>
<td>&lt;0.005</td>
<td>56.654</td>
<td>&lt;0.005</td>
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</table>

**trophods from Tuticorin and Madras stations had much higher concentration of metals than the other two stations, Cuddalore and Mandapam. Relatively low concentrations of metals were encountered in gastropods from Mandapam. In all stations high values of metals were observed during monsoon (October to December) and low values during summer (April to June). Among the 4 metals analysed Fe was very high in all stations followed by Zn, Mn and Cu.**

Comparison of concentration of metals between species and stations were made by two way analysis of variance and results are given in Tab. 1. The concentrations of metals did not vary between species. However, other than Fe, all other metals varied significantly between stations.

The results of two ways analysis of variance between seasons and stations from all five species are presented in Tab. 2. In *M. melo*, except for Fe, other metals differed highly significantly (*P < 0.005*) between stations while Fe and Cu concentration alone exhibited a 5% level of significance between seasons. In *B. spirata* a significant was found between stations for Zn, Mn and Cu (*P < 0.005*). Significance was present between metal concentrations and season except for Cu. In *R. rapiformis*, concentrations of Zn and Mn were significantly different between stations alone, while Cu values exhibited significance for seasons (*P < 0.025*) as well as stations (*P < 0.005*). Fe did not show difference with seasons and stations. In *X. pyrum* two way analysis of variance revealed a high significance between stations (*P < 0.005*) for Zn and Cu concentrations. For Mn, only a 2.5% level of significance was evident between seasons except for Cu concentration. The concentrations of all 4 metals were significantly different station wise in
H. pugilinus but for season a 5 % level of significance was noted only for Fe concentrations.

Tab. 3 depicts results of a two way analysis of variance of comparison of metals and stations for all species. The results revealed a significant difference between metal concentrations for all 5 species (P < 0.005). Highly significant differences were also evident between stations for M. melo, B. spirata, and R. rapiformis. In X. pyrum and H. pugilinus a 5 % level of significance was found between stations.

DISCUSSION

The 5 gastropod species examined in the present study had concentrations of heavy metals in the order of Fe, Zn, Mn and Cu. Two-way analysis revealed that, in all species, concentrations of metals varied significantly between stations. At Tuticorin and Madras, metal concentrations were high in all the gastropods confirming that the harbour as well as the industrial wastes pollute these coastal waters. Ganesan (1992) also found high concentrations of Cu and Zn in Tuticorin. The relatively low metal concentrations in Mandapam were related to lower anthropogenic activity, in agreement with Ganesan (1992).

The concentrations of all four metals were high during monsoon and low in summer. The higher concentrations during monsoon might be due to effluents carried by freshwater discharge, while low concentration in summer might be due to lack of rainfall. The reason for this relationship is not fully understood but several explanations have been proposed over the years. Atkins (1955), Chalapathi Rao & Sathyanarayana Rao (1971), Lakshmanan & Namisban (1983), Rajan et al. (1986, 1991), Diouc & Kasiathan (1992), Athalye & Gokale (1994) and Pillai & Velayudhan (1995) opined that seasonal variations of metal concentrations in aquatic biota are due to changes in physicochemical characteristics of the surrounding medium. Zirino & Yamamoto (1972) and Subramanian et al. (1979) suggested that low pH during monsoon (a consequence of low salinity) may facilitate dissolution of precipitated forms of metals (hydroxide, carbonate or chloro-complexes). Phillips (1976) stated that many metals, available in low saline media, have higher capacity to maintain metals either in the form of solution or suspension. Bryan & Hummerstone (1977) have explained that changes on salinity of the environment resulted in different rates of trace metal uptake by biota, due to grass physiological changes in the linkage of fluxes that occur on the body surface of an organism. The salinity not only has a direct effect on metal concentration but also has indirect effects such as controlling phytoplankton productivity in the environment. Among metals analysed, Fe concentrations were high. Rajan et al. (1986) have also observed high concentrations of Fe in the clam Koteloa spina. They suggested that high concentrations might be due to stirring of bottom terrogenous materials by tide induced current.

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