TRACE ELEMENTS (Zn, Mn, Cu & Fe) AT THREE TROPHIC LEVELS IN A CHICOREUS RAMOSUS HABITAT ON THE TUTICORIN COAST, SOUTHEAST INDIA. - A PILOT STUDY

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INTRODUCTION

Plankton organisms are capable of concentrating large quantities of heavy metals from sea water. These metals may be passed on and concentrated at higher trophic levels through the food chain. The soft bodies of molluscs are known to be permeable to ions (Bowen, 1966), and the gills are coated with a layer of carbohydrate sulphate which acts as an ion exchanger. Many bivalves are suspension feeders. Hence the level of metals found in the tissues of such molluscs is probably a function of the amount of sea water passing the gills during filtration as well as the higher concentration found in the ingested phytoplankton. Metals are transferred to the next trophic levels when preyed upon by carnivorous gastropods, such as the TMMP target species, Chicoreus ramosus, or taken for human consumption.

Investigators do not agree as to whether assimilation from food or uptake from water is the principal pathway for the accumulation of heavy metals by marine organisms. The food chain view point is supported by laboratory experiments of the transfer of $^{65}$Zn from Carteria to Artemia salina (Rice, 1963), from Artemia to post larval flounder of the genus Paralichthys (Hoss, 1964) and from Arenicola to Carcinus maenas (Bryan, 1967). Baptist and Lewis (1969) studied the transfer of radio-active zinc ($^{65}$Zn) through a four step food chain and noted that post larval, Micropogon undulatus and Fundulus heteroclitus accumulated more zinc from food chain than from water during an equal time interval. Hardisty et al. (1974) suggested that the majority of trace elements have been found to be accumulated via the food chain and also opined that the differences in the values of body burdens of the various species may be related to diet. Townsley, et al. (1960) who performed experiments on the transfer of radio active zinc from Clamydomonas to Artemia to reef food chain suggested that these metals are principally accumulated directly from sea water. However, Lowman, et al. (1971) criticized the concept of direct uptake from sea water. In the present study, assorted phytoplankton in the marine environment was taken as the first trophic level measured against the background level of metal concentration in sea water. The suspension feeding bivalve Modiolus metcalfi was selected as a primary consumer, because this species is a preferred food by C. ramosus in captivity. Moreover, M. metcalfi constituted about 60% of the total amount of bivalves collected in the vicinity of C. ramosus during a one hour diving.

Description of the study area

Tuticorin (Lat. 8° 45’N; Long. 78° 46’E) is located in the Gulf of Mannar region. The sea is rough from April to August. The northeast monsoon prevails from October to December. The current is swift in this area. The tidal amplitude is about 1.1 metre. There is a large diurnal tidal inequality. The inequality may advance or delay the timing of high and low tides extending to about an hour or more. The sea bottom is mostly rocky in nature having vast coral reef resources and abundance of molluscan fauna. A thermal power station, a heavy water plant, a Union Carbide factory and a petrochemical industry are located in the area. The industrial wastes discharged into the sea are the major source of pollutants to the environment.

MATERIALS AND METHODS

Surface water samples were collected in precleaned and acid washed polypropylene bottles of one litre capacity, stored in an ice box, and
Table 1. Concentrations of Mn, Zn, Cu and Fe in water, phytoplankton, bivalve (M. metcalfei) and gastropod (C. ramosus).

<table>
<thead>
<tr>
<th>MS</th>
<th>Water (µg l⁻¹)</th>
<th>Plankton (µg g⁻¹)</th>
<th>Bivalve M. metcalfei (µg g⁻¹)</th>
<th>C. ramosus mantle (µg g⁻¹)</th>
<th>C. ramosus gill (µg g⁻¹)</th>
<th>C. ramosus foot (µg g⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mn</td>
<td>2.5</td>
<td>114.86</td>
<td>80.5</td>
<td>142.2</td>
<td>112.3</td>
<td>52.5</td>
</tr>
<tr>
<td>Zn</td>
<td>42.2</td>
<td>188.8</td>
<td>87.0</td>
<td>146.5</td>
<td>126.3</td>
<td>56.6</td>
</tr>
<tr>
<td>Cu</td>
<td>4.0</td>
<td>144.4</td>
<td>66.6</td>
<td>75.7</td>
<td>133.7</td>
<td>49.5</td>
</tr>
<tr>
<td>Fe</td>
<td>16.5</td>
<td>1860.0</td>
<td>1450.0</td>
<td>320.2</td>
<td>1485.5</td>
<td>302.0</td>
</tr>
</tbody>
</table>

Transported to the laboratory. The water samples were then filtered through Millipore filtering unit (pore size, 0.4 µ). The filtered water samples were concentrated with APDC-MIBK extraction procedure.

The phytoplankton sample was collected by a plankton net, 62 µ mesh size. The net was fitted with a stainless steel ring, nylon bridles and rope. Immediately after collection, the plankton sample was dried in an oven at 60°C until constant weight. Ground and redried sample (250 mg) was digested in concentrated HNO₃ and 10% of H₂O₂. After centrifugation, to remove silica fractions, the solution was diluted to 25 ml with double distilled water. The bivalve M. metcalfei and gastropod C. ramosus were collected by diving. The animal tissues were dissected out, washed thoroughly in distilled water, the moisture blotted out, and weighed. The tissues were then acid digested following the method described by Topping (1973) and the resulting solution was used for measuring heavy metals using an atomic absorption spectrophotometer with adequate standards.

The concentrations of some metals (Cu, Fe, Mn & Zn) in the water, plankton, whole body of a bivalve and various organs the carnivorous gastropod (C. ramosus) showed that all organisms had much higher values than the sea water where the organisms lived. The variation in the metal content between different trophic levels is very distinct. The extent to which a relationship exists between the concentration of metals in different trophic levels will to a large extent depend upon the ways in which metals are trapped within the tissue of the body. The present study also shows that particular tissues have the ability to accumulate specific metals more than other parts.

**DISCUSSION**

The Gulf of Mannar area is generally considered to be unpolluted. However the Tuticorin coastal waters which is part of the Gulf of Mannar area receives a vast amount of effluents from the industries situated near the shore.

In water, iron and zinc were found in higher concentrations than copper and manganese. The concentration of copper was found within the lower range of 0.2-22 µg l⁻¹ given by Pytkowicz and Kester (1974) for sea water. Low concentration of dissolved manganese was observed as compared to the value reported for the Laccadive Sea (12 µg l⁻¹) by Sujata and Caroline (1979). The study of both iron and manganese has received greater attention among

RESULTS

Concentrations of the heavy metals (Zn, Mn, Cu and Fe) were examined in water, phytoplankton, whole body tissue of the bivalve (M. metcalfei) and the mantle, gill and foot tissues of the gastropod (C. ramosus). The data are shown in Table 1.
the heavy metals, because they have a tendency to form hydrous oxides with dissolved oxygen in water and these hydrous oxides are chief carriers of other heavy metals such as Zn, Cu, Co & Ni.

Plankton plays a major role in the biogeochemical cycles of trace elements by bioaccumulation and by transfer to higher trophic levels (Gajbiyi et al., 1985). Moreover marine planktonic organisms are good accumulators of trace metals. (Morris, 1971). As shown in Table 1 high concentration of metals in the phytoplankton was recorded in the present study. Davies (1967) found that plankton particularly phytoplankton rapidly adsorbed freshly formed ferric oxides. Phytoplankton accumulated more zinc and copper than the bivalve and gastropod studied.

The whole body tissues of the bivalve M. metcalfei showed higher concentration of iron than manganese, zinc and copper. With regard to manganese, it is seen that the Mn content of M. metcalfei is of the same order of magnitude as values recorded in Sunnetta donacina (83.9 ppm) (Brooks and Rumsky 1965). In general the quantities of iron in the whole body tissues were greater than those of zinc, which were greater than manganese, while copper had the lowest concentration.

In C. ramosus, the different body parts displayed very different metal concentrations. Bruce (1975) suggested that high iron content in the mantle of bivalves and gastropods may be due to the cell cytosomes, which maintain the iron level. A higher rate of all metals in the mantle and gill would be anticipated. Pringle et al. (1968) suggested this to be caused by active and passive absorption in the tissue epithelium or to be associated with the mucus layer covering these organs. They also stated that this layer consists of complex carbohydrate sulphates with possible ion exchange properties, thus facilitating a rapid exchange across the cell membranes. Thus the accumulation level is generally highest in gill tissue. Much lower concentrations in the foot mussel may reflect a passive uptake.

The present study revealed that variations in concentrations of the trace metals zinc, manganese, copper and iron are very distinct at various trophic levels in the C. ramosus habitat. Further laboratory studies are necessary to evaluate the rate of uptake of these metals and to what extent the concentrations reflect pollution at each trophic level of the C. ramosus food chain.

REFERENCES


