Mercury in the Biotic & Abiotic Matrices along Bombay Coast

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Studies conducted during 1983-84 revealed that maximum Hg accumulation was in the surface sediment deposited in the vicinity of discharge zones, towards the northern region of the Thana creek. The levels in sediment decreased gradually downstream towards the mouth of the creek. Furthermore, no positive correlation between organic matter and Hg was evident in the sediment samples. Arcid blood clam *Anadara granosa* (Order: *Tegulacea*) and gobiid mudskipper *Boleophthalmus boddaerti* from Trombay coast (Bombay) monitored at monthly intervals showed an average body burden of 0.8 ± 0.3 and 0.63 ± 0.1 μg.g⁻¹ dry weight edible tissue respectively. *A. granosa* displayed strong seasonal variation in bioaccumulation of Hg with the highest level being recorded during monsoon months and the lowest in premonsoon period. Bioaccumulation of Hg (total) in the blood clams per unit dry weight was independent of body weight. Total Hg in 24 species of pelagic fish including sharks and teleosts sampled from commercial landings varied in the range of 0.03 to 0.82 μg.g⁻¹ dry tissue.

About 180 tonnes of Hg and its compounds are introduced into the Indian coastal environment per annum. High levels of Hg were reported in the sediment and biota from Ulhas river and its tributaries opening into the Thana creek region¹⁻³, Bombay coast. However, only a few attempts seem to have been made on the distribution of Hg in the benthic and pelagic-fish and shell-fish varieties harvested from the Thana creek and coastal waters around Bombay.

The studies were, therefore, initiated to understand the distribution of Hg and its impact on the marine ecosystem around Bombay coast. This included monitoring of surface deposited sediment, an arcid blood clam *Anadara granosa* (L) and a gobiid mudskipper *Boleophthalmus boddaerti* (Cuv. & Val.). In addition, a large variety of pelagic fish and shell-fish from commercial landings at Bombay were also analysed for Hg content.

Materials and Methods

Surface sediment samples from different stations along the Bombay coast (Fig. 1) were scrapped with a plastic scoop during low tide. Arcid clam *Anadara granosa* and the gobiid mudskipper *Boleophthalmus boddaerti* were sampled from intertidal mud flats off Trombay during spring low water periods at monthly and quarterly intervals respectively, during February 1983 to December 1984. To evaluate the body burden of Hg in relation to the size of *A. granosa*, a group of 10-15 animals in the range 2.7-6.4 cm in length and 5-95 g gross weight, were sampled.

The sediment samples were stored deep frozen (−40° C), then lyophilized, powdered, homogenized and kept in airtight vials. Each powdered sample was ignited for 4 h at 500° C and organic matter determined from the loss of weight.

Clams (10 to 15) of the same size (4-6 cm shell length) and age group (2-3 y) were dissected, soft tissues pooled, homogenized, freeze dried and powdered in an agate pestle and mortar. The fish samples were descaled, evicerated, boneless fillets were prepared and lyophilized.
Appropriate weight of lyophilized sediment was wet ashed in a Bethge apparatus or under reflux at 80°C on a heating mantle, using HNO₃ and H₂SO₄ (5:1). This treatment was followed since it was reported to leach out Hg completely even though it did not solubilize the silica fraction. The digest was made up to the volume and Hg content determined within 24 h. Tissue samples were also processed following the same wet digestion process except that 5 parts hydrogen peroxide was added to ensure complete oxidation of organic matter. To test Hg losses a known amount of ²⁰³Hg was added to biological and sediment samples and recoveries were measured. The recoveries were better than 95% confidence limits. For better statistics at least 5 recovery tests were carried out. Hg content in the digested samples was determined using flameless atomic absorption spectrometry (Mercury Analyser, ECIL). The level of Hg in each of the samples was read off from previously prepared calibration curve using mercury chloride as a standard. All the samples along with the blank were prepared in triplicate. Variation between individual analysis was < 10%. The water content in the samples varied from 20-25% in case of clams and fish samples. However, the results are expressed in terms of μg.g⁻¹ dry wt tissue.

Results

Sediment—The Hg level (Table 1) in the sediment was the highest from the northern most region (Fig. 1) of the Thana creek (2.4 ± 0.3 μg.g⁻¹). In the samples off Trombay coast (st 5) Hg levels dropped appreciably at least by 4 times (0.63 ± 0.08 μg.g⁻¹). The samples from other regions in the creek except along Sewri mud-flats (0.34 μg.g⁻¹, st 6), contained more or less the same amount of Hg, around 0.2 μg.g⁻¹. In the surface sediment from Tarapur (st 7), 100 km north of Bombay, Hg content was around 0.43 ± 0.15 μg.g⁻¹, very close to the levels observed along Trombay coast.

The organic content (OC) in all the sediment samples (Table 1) varied between 1-2 % eventhough the Hg levels varied significantly (10-12 times); the levels being higher in those from northern region compared to those from other locations within Thana creek. Similarly, in the sediments from Belapur (st 4) although OC was practically within the same range as observed in those from Station 1, the Hg levels were appreciably lower (about 10 times). However, in the sediments from Vashi (st 2) and Thurbe (st 3) both Hg and OC contents were low. Nevertheless, the percentage reduction in OC was only marginal about 10%, compared to 92% decrease observed, in the Hg concentration with reference to the sediment collected from station 1.

Arcid clam and mudskipper—A. granosa population from Trombay coast contained an average body burden of 0.82 ± 0.27 μg Hg.g⁻¹ dry wt (Table 2). The Hg content in the Trombay population was marginally higher compared to that from Sewri (0.64 ± 0.21 μg.g⁻¹). Furthermore, the Hg content in the clam population showed seasonal variation (Table 3); being lowest in the animals analysed during pre-monsoon months (0.56 ± 0.02 μg.g⁻¹). This level increased practically two fold over the following monsoon months (1.13 ± 0.1 μg.g⁻¹), and once again dropped to 0.75 ± 0.06 μg.g⁻¹ during the post monsoon months (Table 3). The absolute levels of Hg in the soft tissues of A. granosa can be related to its body weight (Hg = a Wα, where a is the slope and 'a' the intercept). It will be seen from the data presented in Fig. 2 that Hg content in the soft tissues increased with the weight of the animal (α > 1.0).

**Table 1—Distribution of Hg in Surface Sediments from the Intertidal Zone around Bombay* and Tarapur**

<table>
<thead>
<tr>
<th>St No.</th>
<th>Station</th>
<th>Location</th>
<th>Mean ± SD (n = 10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Thana</td>
<td></td>
<td>Hg (μg.g⁻¹ dry wt)</td>
</tr>
<tr>
<td>2</td>
<td>Vashi</td>
<td></td>
<td>2.40 ± 0.32</td>
</tr>
<tr>
<td>3</td>
<td>Thurbe</td>
<td></td>
<td>0.19 ± 0.05</td>
</tr>
<tr>
<td>4</td>
<td>Belapur</td>
<td></td>
<td>0.18 ± 0.04</td>
</tr>
<tr>
<td>5</td>
<td>Trombay</td>
<td></td>
<td>0.20 ± 0.08</td>
</tr>
<tr>
<td>6</td>
<td>Sewri</td>
<td></td>
<td>0.63 ± 0.08</td>
</tr>
<tr>
<td>7**</td>
<td>Tarapur</td>
<td></td>
<td>0.34 ± 0.09</td>
</tr>
</tbody>
</table>

*Stn. 1-6 are within Thana creek, Bombay
**St. 7 is at Tarapur 100 km north of Bombay

**Table 2—Distribution of Hg (total) in Fish and Shellfish from Thana Creek**

<table>
<thead>
<tr>
<th>Species</th>
<th>No. of samples analysed</th>
<th>Hg (Mean ± SD, μg.g⁻¹ dry)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anadara granosa</td>
<td>20</td>
<td>0.82 ± 0.27</td>
</tr>
<tr>
<td>Trombay</td>
<td>15</td>
<td>0.64 ± 0.21</td>
</tr>
</tbody>
</table>

**Table 3—Temporal Distribution of Hg (total) in the Soft tissues of A. granosa from Thana Creek**

<table>
<thead>
<tr>
<th>Season</th>
<th>Hg (μg.g⁻¹ dry) Mean ± SD (n = 10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-monsoon (Feb.-May)</td>
<td>0.56 ± 0.02</td>
</tr>
<tr>
<td>Monsoon (June-Sept.)</td>
<td>0.13 ± 0.10</td>
</tr>
<tr>
<td>Post-monsoon (Oct.-Jan.)</td>
<td>0.75 ± 0.06</td>
</tr>
</tbody>
</table>
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Fig. 2—Distribution of mercury (total) in the arcid blood clam *Anadara granosa* as a function of its weight (● = μg Hg; ○ = μg·g⁻¹ dry tissue).

However, no such relationship could be established between the bioaccumulation of Hg and the weight of the animal when expressed per unit dry weight (α⁻¹ = 0.14) of the soft tissues. In mudskipper *B. boddaerti* the average level of Hg worked out to about 0.63 μg·g⁻¹ dry tissue (Table 2).

**Fish and shellfish from the offshore water**—The levels of total Hg present in the edible parts of different species of fish and shellfish harvested from the offshore waters (Arabian sea) are recorded in Table 4. Among the 24 pelagic species analysed the teleost *Sphyraena acutipinnis* showed the highest level of Hg (0.82 μg·g⁻¹). The hammer-headed shark *Zygaena malleus* and shark *Scoliodon laticaudus*, contained 0.36 and 0.19 μg·Hg·g⁻¹ dry tissue respectively. The lowest level of Hg was recorded in the mackerel *Rastrelliger kanagurta* (0.03 μg·g⁻¹). In the other pelagic species and cephalopods Hg was found to vary in the range of 0.05 - 0.2 μg·g⁻¹ dry tissue.

**Discussion**

Quantitative analysis of surface deposited sediment around Bombay coast showed appreciable degree of variation in Hg content. The high Hg levels observed in the sediment samples from extreme north (st 1) of the Thana creek are not surprising, since this region receives industrial and domestic effluents through the Ulhas river and its tributaries. It is estimated that about 11,000 kg Cu, 400,000 kg Zn, 7,000 kg Hg and 500 kg Cr per annum are discharged into the Ulhas river system. Because of oscillating pattern of tidal movements within the creek this load of heavy metals tend to sink and build up in the region of confluence and decrease as the water mass moves downstream along Trombay coast.

The levels of Hg are substantially higher in the Thana creek than those reported from areas free of Hg contamination. The levels of Hg in the sedimentary particles have been found to show positive correlation between organic matter and Hg concentration especially in estuarine sediment. During the present studies, however, no such definite correlation between sedimentary Hg and organic matter was evident. This may well be due to uniform distribution of organic matter in the sediments from different regions and oscillating tidal movements leading to churning and site specific drift of surface sediment in the creek. In addition, input of Hg over localized region could also be a major possible factor.

The increased concentration of Hg during monsoon period observed in the clam population could...
be explained in terms of churning and movement of sediment deposited at the head of creek towards Trombay clam bed due to flooding in the Ulhas river. Furthermore, in *A. granosa* population of various weight groups the absolute levels of Hg under environmental conditions increased with the weight of the animals (Fig. 2). However, the body burden of Hg in these groups when expressed per unit weight increased by about 2 times (0.3 - 0.5 μg·g⁻¹ dry), whereas the body weight increased about 20 times. This clearly indicates that the bioaccumulation per unit weight of the tissue was independent of the body size. Similar pattern suggesting bioaccumulation of Hg independent of body size has also been reported in many fish and shellfish species⁹⁻¹⁴.

Among the pelagic fishes (Table 4), in general carnivorous species showed the highest level of Hg. In *Sphyraena chrysostoma* and *S. sphyraena* from the Israel waters, Hg content was 0.62 and 0.36 μg·g⁻¹ (wet wt) respectively¹⁵, which is appreciably higher than that observed in *S. acutipinnis* from Indian waters (0.1 μg·g⁻¹ wet wt). On the other hand, Hg levels in *S. picuda* and *S. jello* from Andaman Sea were more or less the same as observed in *S. acutipinnis*¹⁶. Similarly, Hg levels reported in the mackerel *R. kanagurta* and in the squid *Loligo indica* are in agreement with the values obtained in the present study. However, in the shark species, higher Hg levels are reported in the previous study¹⁶.

The Hg levels in 24 species of pelagic fishes from the offshore waters of Arabian Sea were well below the permissible limit¹⁷ (0.5 μg·g⁻¹ wet wt). The transfer of Hg to human population through consumption of fish and shellfish is therefore considered as a remote possibility. The input of heavy metals including Hg into the near shore environment results only in localized buildup around the discharge zones. The natural processes operating are capable of detoxifying the impact of pollutants as long as these are within the limits of neutralisation. Hg residue found in pelagic forms during the present study cannot be considered as a result of anthropogenic discharges since the values are in good agreement with those reported in marine fauna from uncontaminated waters and therefore should be considered as natural.

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References