

## Metal concentration in mussel *Perna viridis* (Bivalvia/Anisomyaria) and oyster *Crassostrea madrasensis* (Bivalvia/Anisomyaria) from some parts in southeast coast of India

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The concept of mussel watch has been applied to monitor the levels of heavy metals in the southeast coast of India covering a distance of 250 km. The data reflected a definite seasonal variation with an increased metal load during the monsoon period and decreased level during the summer period. The order of metal accumulation was found to be  $Zn > Cu > Pb > Cd > Hg$ . Salinity of the media was found to play an important role in the accumulation of metals in tissue. A linear relationship was found between the metal level in the tissues and that in the dissolved fractions. Oyster showed maximum concentration factor (CF) when compared to mussels. Both animals showed high adsorption and absorption capacity for heavy metals as revealed by the CF, suggesting that they can be used as indicator for water quality and heavy metal pollution on a long-term basis.

Oyster and mussels have been extensively used for water quality assessment in the coastal environment as they are potential bioaccumulators of heavy metals<sup>1-3</sup>. However, from the tropical coasts reports are only scarcely available on heavy metal pollution in bivalve<sup>4-7</sup>. The objective of this study is to understand the spatial and temporal variation in metal loads in the body tissue of the bivalve, and to identify the severity of pollution through biological indicator species viz. mussel *Perna viridis* (Linnaeus) and oyster *Crassostrea madrasensis* (Preston) in the 250 km stretch on the east coast of India from Pondicherry to Nagapattinam.

### Materials and Methods

Samples of mussel and oyster were collected monthly for three years (October 1986 to September 1989) from the harbour area of Pondicherry (lat.  $11^{\circ}53'N$ ; long.  $70^{\circ}50'E$ ), Cuddalore (lat.  $11^{\circ}42'N$ ; long.  $70^{\circ}46'E$ ), Nagapattinam (lat.  $10^{\circ}46'N$ ; long.  $79^{\circ}51'E$ ) and

the Vellar estuary of Parangipettai (lat.  $11^{\circ}29'N$ ; long.  $70^{\circ}46'E$ ) (Fig. 1). These stations were selected as they receive discharges from agricultural fields, industrial units, untreated sewage and domestic wastes and from harbour. Ten animals of similar size ( $6 \pm 1$  cm length) were

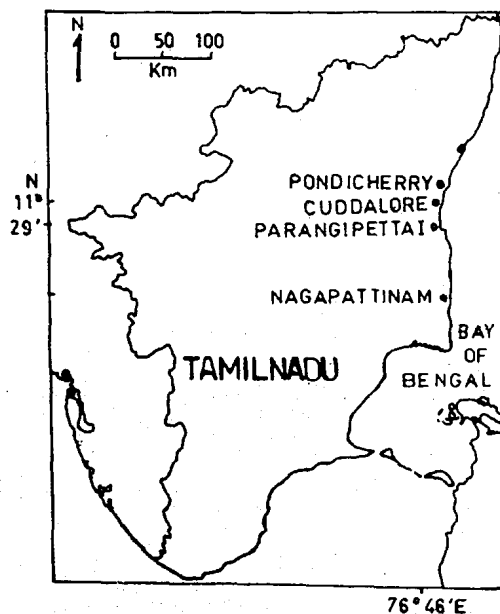


Fig. 1—Map showing the location of the study areas

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washed and kept in filtered seawater system to purge the gut content. Whole body tissues of animals were removed, washed with deionized water and brought to the laboratory in frozen condition and stored in the deep freezer at  $-20^{\circ}\text{C}$  for further analysis. At the time of analysis, the tissues were washed and dried in an oven at  $95^{\circ}\text{C}$  to constant weight and powdered. Samples were analyzed for Cu, Zn, Cd and Pb by acid digestion<sup>8</sup> and quantified using atomic absorption spectrophotometer (Perkin Elmer Model 373). Hg was determined in the samples using cold vapour technique<sup>9</sup> by employing mercury analyzer (ECIL, M A 5800 D). The percentage recovery using NIES no.6. reference material for biological tissues was found to be 95, 97, 96, 95 and 96 for Cu, Zn, Cd, Pb and Hg, respectively.

Water samples were also collected from all the study areas simultaneously. The salinity<sup>10</sup> and metals in the water samples<sup>11</sup> were estimated using standard procedures. Data obtained for salinity and metal distribution in water medium have been used in the discussion part wherever necessary.

### Results and Discussion

Monthly metal concentration in the tissues of mussel and oyster were recorded and the minimum and maximum concentrations along with mean values for the entire study period are given in

Table 1. The metals except Hg load in *Perna viridis*, were higher at Cuddalore harbour when compared to other stations and this could be due to increased discharges of dyes, sulphur and other chemical industries from the nearby SIPCOT industrial estate. The Zn and Pb load in *C. madrasensis* was highest in Nagapattinam harbour when compared to other study areas. This may be mainly due to the harbour activity and also the discharges from the nearby agricultural fields containing fertilizers rich in zinc and pesticide residues.

Mercury level in both bivalves were high at Pondicherry harbour when compared to other areas.

The metal level in the molluscan species usually varied with size, sex, feeding habits, reproductive condition, seasons and extent of pollution in the ambient medium<sup>12,13</sup>. In the present study, a clear significant seasonal pattern of metal load in the tissues of mussel and oyster was observed with high level during the monsoon (Oct.-Dec.) period (Tables 2, 3). Similar observations were made in *Mytilus edulis* and oyster from Bay of Bourgneuf, France<sup>14</sup> and from Narragansett Bay<sup>15</sup>. It is well known that the river runoff adds to the metals input considerably during the monsoon period<sup>13</sup>. The lower metal load in tissue during summer (April-

Table 1—Metal concentrations ( $\mu\text{g metal/g dry weight}$ ) in *Perna viridis* and *Crassostrea madrasensis*  
(Mean values are given in parenthesis)

| Location      | Cu                  | Zn                             | Cd                 | Pb                 | Hg                     |
|---------------|---------------------|--------------------------------|--------------------|--------------------|------------------------|
|               |                     | <i>Perna viridis</i>           |                    |                    |                        |
| Pondicherry   | 5.5-64<br>(37.32)   | 16-96<br>(60.42)               | 0.5-3.2<br>(1.59)  | NDL-7<br>(4.15)    | 0.025-0.229<br>(0.074) |
| Cuddalore     | 10-79<br>(49.2)     | 34-154<br>(94.10)              | 0.5-16.5<br>(4.40) | 2.1-14.7<br>(6.92) | 0.021-0.495<br>(0.032) |
| Parangipettai | 30-72<br>(46.76)    | 52-126<br>(76.26)              | 0.5-7.6<br>(4.24)  | 1.3-4.2<br>(2.48)  | 0.019-0.109<br>(0.054) |
| Nagapattinam  | 8.5-68.5<br>(33.59) | 16.1-157.4<br>(81.08)          | 0.5-6.4<br>(2.74)  | 2.4-13<br>(6.71)   | 0.026-0.108<br>(0.069) |
|               |                     | <i>Crassostrea madrasensis</i> |                    |                    |                        |
| Pondicherry   | 42-142<br>(83.57)   | 223-675<br>(372.42)            | 1.3-4.0<br>(2.7)   | NDL-8.6<br>(4.55)  | 0.092-0.478<br>(0.197) |
| Cuddalore     | 56-210<br>(101.79)  | 104-1025<br>(440.10)           | 0.5-13.5<br>(5.57) | NDL-18<br>(5.62)   | 0.069-0.265<br>(0.133) |
| Parangipettai | 44-199<br>(121.03)  | 163-571<br>(315.50)            | 3-13.1<br>(6.17)   | 1.3-10.3<br>(5.40) | 0.042-0.154<br>(0.085) |
| Nagapattinam  | 41-198<br>(103.47)  | 264-1648<br>(786.75)           | 2.5-12.5<br>(5.49) | 2.5-18.8<br>(7.49) | 0.086-0.318<br>(0.169) |

Table 2—Seasonal variation of metal concentration (ug/g) in mussel *P. viridis* and oyster *C. madrasensis*.

| Metal                          | Season* | Pondicherry | Cuddalore<br><i>Perna viridis</i> | Parangipettai | Nagapattinam |
|--------------------------------|---------|-------------|-----------------------------------|---------------|--------------|
| Cu                             | M       | 47.38       | 65.78                             | 61.59         | 49.10        |
|                                | PoM     | 34.65       | 41.19                             | 44.86         | 28.48        |
|                                | S       | 28.96       | 30.58                             | 37.54         | 23.02        |
|                                | PrM     | 38.39       | 52.27                             | 54.03         | 34.18        |
| Zn                             | M       | 71.74       | 107.78                            | 112.73        | 100.34       |
|                                | PoM     | 58.03       | 93.66                             | 75.11         | 76.48        |
|                                | S       | 42.91       | 64.07                             | 62.43         | 62.52        |
|                                | PrM     | 64.92       | 110.38                            | 80.36         | 74.10        |
| Cd                             | M       | 2.13        | 4.81                              | 5.29          | 3.72         |
|                                | PoM     | 1.38        | 3.54                              | 4.25          | 2.79         |
|                                | S       | 1.05        | 2.58                              | 3.30          | 1.83         |
|                                | PrM     | 1.58        | 4.38                              | 3.86          | 2.74         |
| Pb                             | M       | 5.26        | 8.77                              | 5.33          | 9.63         |
|                                | PoM     | 4.45        | 6.52                              | 4.58          | 5.74         |
|                                | S       | 2.72        | 3.88                              | 1.95          | 4.59         |
|                                | PrM     | 4.70        | 5.39                              | 2.39          | 6.69         |
| Hg                             | M       | 0.112       | 0.036                             | 0.075         | 0.088        |
|                                | PoM     | 0.055       | 0.025                             | 0.051         | 0.073        |
|                                | S       | 0.046       | 0.031                             | 0.037         | 0.059        |
|                                | PoM     | 0.071       | 0.034                             | 0.056         | 0.067        |
| <i>Crassostrea madrasensis</i> |         |             |                                   |               |              |
| Cu                             | M       | 105.87      | 145.58                            | 152.89        | 143.73       |
|                                | PoM     | 82.79       | 100.72                            | 106.61        | 86.22        |
|                                | S       | 66.43       | 67.99                             | 91.93         | 71.64        |
|                                | PrM     | 78.33       | 93.39                             | 132.52        | 124.50       |
| Zn                             | M       | 521.44      | 661.93                            | 460.87        | 1172.01      |
|                                | PoM     | 434.71      | 496.94                            | 298.09        | 853.60       |
|                                | S       | 287.08      | 256.67                            | 230.78        | 471.68       |
|                                | PrM     | 337.05      | 364.19                            | 283.46        | 650.22       |
| Cd                             | M       | 3.27        | 7.76                              | 8.74          | 8.22         |
|                                | PoM     | 2.35        | 5.40                              | 5.61          | 4.97         |
|                                | S       | 2.11        | 3.90                              | 4.54          | 3.73         |
|                                | PrM     | 2.85        | 5.48                              | 5.69          | 4.97         |
| Pb                             | M       | 6.95        | 7.72                              | 6.72          | 10.96        |
|                                | PoM     | 3.81        | 5.73                              | 4.87          | 7.62         |
|                                | S       | 2.80        | 3.70                              | 4.37          | 5.94         |
|                                | PrM     | 4.58        | 5.08                              | 5.62          | 6.62         |
| Hg                             | M       | 0.295       | 0.206                             | 0.120         | 0.206        |
|                                | PoM     | 0.155       | 0.129                             | 0.080         | 0.139        |
|                                | S       | 0.125       | 0.078                             | 0.071         | 0.106        |
|                                | PoM     | 0.226       | 0.152                             | 0.078         | 0.161        |

\*M-Monsoon: Oct.-Dec.; PoM-Postmonsoon: Jan.-March;  
S-Summer: April-May; PrM-Premonsoon: July-Sept.

Table 3—Summary of mean level of the salinity (‰) and metal concentration (µg/l) in water medium.

| Study area    | Cu    | Zn    | Cd   | Pb   | Hg    | Salinity  |
|---------------|-------|-------|------|------|-------|-----------|
| Pondicherry   | 18.76 | 15.22 | 1.34 | 4.32 | 0.103 | 24.5-36.3 |
| Cuddalore     | 20.30 | 19.20 | 1.43 | 5.72 | 0.079 | 23.5-34.8 |
| Parangipettai | 18.28 | 25.51 | 0.84 | 4.92 | 0.059 | 10.5-35.0 |
| Nagapattinam  | 17.40 | 14.75 | 1.99 | 5.09 | 0.089 | 9.2-34.9  |

June) (Tables 2, 3) was probably due to the meagre influx of metal rich fresh water into the study area.

The salinity of the ambient medium (Table 4) have a profound effect on the accumulation of metals in the tissue<sup>2,13,16,17</sup>. It was proved in the present investigation that the metal load in tissues were higher when the medium has lower salt content. The statistical analysis of the present data also confirmed a significant inverse relationship of metal body burdens and salinity (Cu:  $P < 0.05$ ; Zn, Cd, Pb and Hg:  $P < 0.01$  for oyster, Cu and Hg:  $P < 0.05$ ; Cd and Pb:  $P < 0.01$  for mussel). However, the uptake of Zn in *P. viridis* in the present study is found to be not related to salinity as observed in the case of *M. edulis*<sup>16</sup>.

The results also showed a significant linear relationship between metal levels in bivalves and that in the ambient dissolved medium (Table 4) (Cu, Cd and Pb:  $P < 0.01$ ; Zn and Hg:  $P < 0.05$  for mussel, Cu:  $P < 0.05$ ; Cd and Pb:  $P < 0.01$  for oyster). Study on *Ostrea edulis* from Linode canal<sup>18</sup> has suggested that the bioconcentration of metal in bivalve tissues would be mainly from dissolved fractions. Similar observations on the possible adsorption of metals by shellfishes from the ambient water medium, as they are exposed directly to the water, were reported by Bryan<sup>19</sup>. Hence, they are known to reflect metal concentrations in seawater and act as an indicator of heavy metal pollution. The higher inflow of water throughout the animal cavity and pump rate also increased the concentration of metal at the body surface. The surface of soft part of bivalve is capable of taking up various organic molecules<sup>20</sup> and also the organic ligand complexed metals<sup>21</sup>.

The concentrations of metals in tissues were in the order of Zn>Cu>Pb>Cd>Hg. High Zn and Cu load would be largely due to the discharges of agricultural wastes and river runoff from the nearby upland area and also due to their biological importance, as a constituent of metallo enzymes<sup>22</sup>. The Pb, Cd and Hg load in the tissues were found to be very less, because of the lack of source of these metals in the vicinity of the study area.

Correlation between the heavy metal in the water and tissue can be made calculating the concentration factor<sup>23</sup> (CF) (Table 4). In general, both mussel and oysters, concentrate heavy metals to an order of  $10^3$  to  $10^5$  from the ambient medium through adsorption and absorption processes. The

Table 4—Mean concentration factor (CF in  $10^3$ ) in bivalve from the sampling station.

| Study area                     | Cu   | Zn    | Cd   | Pb   | Hg   |
|--------------------------------|------|-------|------|------|------|
| <i>Perna viridis</i>           |      |       |      |      |      |
| Pondicherry                    | 2.49 | 3.27  | 0.84 | 0.88 | 0.72 |
| Cuddalore                      | 2.42 | 4.90  | 3.08 | 1.21 | 0.39 |
| Parangipettai                  | 2.56 | 2.99  | 5.05 | 0.50 | 0.93 |
| Nagapattinam                   | 2.22 | 5.50  | 1.38 | 1.32 | 0.77 |
| <i>Crassostrea madrasensis</i> |      |       |      |      |      |
| Pondicherry                    | 5.57 | 20.13 | 1.42 | 0.91 | 1.92 |
| Cuddalore                      | 5.01 | 22.92 | 3.89 | 0.98 | 1.62 |
| Parangipettai                  | 6.62 | 12.37 | 7.35 | 1.10 | 1.45 |
| Nagapattinam                   | 6.60 | 53.34 | 1.47 | 1.47 | 1.89 |

order of CF was Zn>Cu>Cd>Pb>Hg for mussel and for oyster Zn>Cu>Cd>Hg>Pb. Among the species, oyster showed higher CF than the mussel. In general, the bivalves showed higher CF for Zn when compared to other metals. Among the study areas, Nagapattinam showed higher CF with reference to Cu, Zn, Pb and Hg. With reference to Cd the CF was highest at Portonovo.

From the present investigation, it is concluded that both these bivalves can be effectively used as monitors of water quality with respect to heavy metals. It is apparent that the metal levels in both the mussel and oyster show a steady increase of metals in the tissues. However, the levels of all five metals in these organisms were well below the recommended levels for human consumption of seafood, indicating that the present study area is relatively less polluted.

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