# TRACE ELEMENT DISTRIBUTION IN SOME MOLLUSCA FROM BOMBAY COAST

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VINOGRADOV[1] reported that many marine organisms especially those of molluscan family accumulate various trace elements several thousand-fold from their ambient medium. Though data are available on the uptake, accumulation and loss of some trace elements under laboratory conditions[2,3] corresponding data for field or environmental conditions for tropical zones are very meagre[4-6]. The presence of radioisotopes of some trace elements in marine environment and their interaction and incorporation in marine biota are discussed by Lowman[7]. In this connection it is important to note that many of these trace elements have biological significance[8-10]. The present work reports on the concentrations of copper and chromium in some molluscan species and discusses the patterns of the enrichment factors, taking into consideration the data for zinc and manganese reported by Bhatt *et al.*[11].

## Materials and Methods

The following marine bivalves from Bombay coast have been collected for the study.

| | | |
|---|---|---|
| Clams: | *Katelysia marmorata* (Lam.) | (Fam. Veneridae) |
| | *Meretrix meretrix* Linn. | ( do. ) |
| | *Sunetta donacina* Gmelin | ( do. ) |
| Mussel: | *Mytilus viridis* Linn. | (Fam. Mytilidae) |
| Oyster: | *Crassostrea madrasensis* | (Fam. Ostreidae) |
| Ark-shell: | *Anadara granosa* | (Fam. Arcidae) |

The outer shells of the freshly collected organisms were removed and the soft parts washed with filtered sea-water. After washing, the soft parts were dried in hot oven at 100° C and then ashed at 550° C. The ash was utilised for the estimations.

Copper and chromium were estimated by Atomic Absorption Spectrophotometer after dissolution of ash in dilute hydrochloric acid and making up the volume of the solution to the optimum concentration with glass distilled water free from the trace elements under study. The estimations were carried out using Perkin Elmer Model 303 Atomic Asorption Spectrophotometer at the wavelengths sensitive for their determinations.

## Results and Discussions

The details of sample collection and percentage dry weights are given in Table I. Table II gives the trace element contents of mollusca in ppm on dry weight basis. Table III gives the concentrations of trace elements in sea-water. The values for copper, zinc and manganese contents are those for coastal sea-water of Bombay reported by various authors[12-14]. The chromium value given is that reported by Goldberg[15] for oceanic water, as no value for coastal sea-water was available. Tables IV and V give the specieswise elemental contents and enrichment factors respectively. (Enrichment factor is the ratio of the concentration of an element in the organism to that in sea-water.)

From the above tables, it is evident that copper and zinc are concentrated by oysters. Similar observation is also made by Brooks and Runsby[16]. The values for enrichment factors reported by them for various molluscan species are presented in Table VI for comparison. Manganese is found to be concentrated maximum by family Veneridae and specifically by species *Sunetta donacina*. Hence zinc-65 and manganese-54 contaminations of sea-water can be indicated by measurement of these isotopes in oysters and *Sunetta donacina* respectively. The enrichment factors for chromium in all families of mollusca are found very high ranging from $26 \times 10^4$ to $50 \times 10^4$. This is also reported by Brooks and Runsby[16]. Chromium may have a role in these organisms similar to that of vanadium in Ascidians[17]. As chromium has got radioisotope Chromium-51 of moderate half life, ($T\ 1/2 = 28\,d$) mollusca as a class can serve as Indicators for this radioisotope in marine environment. Similar to seaweeds, studied by Fukai and Broquet[18] variations in the chromium contents in mollusca do not exhibit any definite dependence on species, seasons or locations.

The following are the familywise orders of enrichment factors for various trace elements in mollusca.

Cu- - -Ostreidae > Veneridae > Mytilidae-Arcidae

Zn- - -Ostreidae > Veneridae > Mytilidae-Arcidae

Cr- - -Veneridae > Arcidae > Mytilidae > Ostreidae

Mn- - -Veneridae > Arcidae > Mytilidae > Ostreidae.

From this it is seen that there is a similarity in the uptake of elements copper and zinc by various molluscan families. Similarity in the uptake of elements manganese and chromium is also observed. Family Ostreidae has maximum enrichment factors for divalent elements copper and zinc and minimum enrichment factors for polyvalent elements manganese and chromium compared to other molluscan families.

TABLE I

*Details of the collection and percentage dry wt. of the molluscan samples*

| Sl. No. | Species | Date of collection | Place of collection | % dry wt. |
|---|---|---|---|---|
| 1. | *Katelysia marmorata* .. | June 1962 | Mahim | 24·74 |
| 2. | ,, .. | June 1962 | ,, | 25·02 |
| 3. | ,, | July 1962 | ,, | 18·39 |
| 4. | ,, .. | August 1962 | ,, | 18·75 |
| 5. | ,, .. | September 1962 | ,, | 13·04 |
| 6. | ,, .. | November 1962 | ,, | 24·05 |
| 7. | ,, .. | March 1963 | ,, | 23·00 |
| 8. | ,, .. | June 1963 | ,, | 20 91 |
| 9. | ,, .. | July 1963 | ,, | 20·64 |
| 10. | ,, .. | August 1963 | Dadar | 14·81 |
| 11. | ,, .. | September 1963 | Mahim | 17·17 |
| 12. | ,, .. | October 1963 | ,, | 20 80 |
| 13. | ,, .. | December 1963 | ,, | 15·08 |
| 14. | ,, .. | January 1964 | ,, | 16·51 |
| 15. | ,, .. | February 1964 | Dadar | 19·10 |
| 16. | ,, .. | May 1964 | Mahim | 17·51 |
| 17. | ,, .. | September 1964 | ,, | 13·58 |
| 18. | *Meretrix meretrix* .. | July 1962 | ,, | 17·23 |
| 19. | ,, .. | January 1963 | ,, | 15·04 |
| 20. | ,, .. | June 1963 | Dadar | 18·55 |
| 21. | ,, .. | September 1963 | ,, | 19·70 |
| 22. | *Sunetta donacina* .. | September 1963 | ,, | 11·69 |
| 23. | ,, .. | September 1963 | ,, | 20·36 |
| 24. | ,, .. | November 1963 | Mahim | 22·31 |
| 25. | *Mytilus viridis* .. | January 1963 | ,, | 16·11 |
| 26. | ,, .. | December 1963 | ,, | 14 96 |
| 27. | *Crassostrea madrasensis* .. | February 1963 | Kelwa-Mahim | 26·17 |
| 28. | ,, .. | May 1963 | Mahim | 26·05 |
| 29. | ,, .. | September 1963 | Cuffe parade | 22 67 |
| 30. | *Anadara granosa* .. | September 1963 | Sewree | 11·69 |

TABLE II

*Concentration of copper, chromium, manganese and zinc in mollusca from Bombay*

| Sl. No. 1 | Copper ppm (dry) 2 | Chromium ppm (dry) 3 | Manganese ppm (dry) 4 | Zinc ppm (dry) 5 |
|---|---|---|---|---|
| 1. | 23 | 9 | 9 | 52 |
| 2. | 21 | 15 | 5 | 47 |
| 3. | 30 | 7 | 6 | 51 |
| 4. | 27 | 13 | 23 | 38 |
| 5. | 34 | 11 | 11 | 46 |
| 6. | 23 | 15 | 11 | 75 |
| 7. | 48 | 18 | 44 | 26 |
| 8. | .. | .. | 9 | 67 |
| 9. | 19 | 7 | 5 | 61 |
| 10. | 31 | 8 | 7 | 86 |
| 11. | 28 | 13 | 20 | 139 |
| 12. | 23 | 14 | 35 | 757 |
| 13. | 30 | 22 | 41 | 293 |
| 14. | 46 | 29 | 64 | 256 |
| 15. | 31 | 25 | 50 | 70 |
| 16. | 17 | 25 | 14 | 198 |
| 17. | .. | .. | 18 | .. |
| 18. | 17 | 29 | 20 | 91 |
| 19. | 74 | 30 | 493 | 103 |

TABLE II (*Contd.*)

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| 20. | 31 | 28 | 18 | 86 |
| 21. | 24 | 11 | 140 | 61 |
| 22. | 117 | 21 | 556 | 92 |
| 23. | 99 | 14 | 412 | 200 |
| 24. | 57 | 16 | 354 | 324 |
| 25. | 14 | 14 | 26 | 68 |
| 26. | .. | .. | 33 | 267 |
| 27. | 300 | 11 | 18 | 738 |
| 28. | 315 | 11 | 22 | 906 |
| 29. | 271 | 17 | 22 | 571 |
| 30. | 14 | 25 | 61 | 171 |

TABLE III

*Concentration of trace elements in sea water*

| Element | Mn | Cu | Zn | Cr |
|---|---|---|---|---|
| Concentration in ppm | 0·007 | 0·01 | 0·016 | 0 00005 |

TABLE IV

*Specieswise trace elemental contents of mollusca*

| Species | Family | Copper | | Chromium | | Manganese | | Zinc | |
|---|---|---|---|---|---|---|---|---|---|
| | | Range | Mean | Range | Mean | Range | Mean | Range | Mean |
| *Katelysia marmorata* | Veneridae | 17–48 | 29 | 7–29 | 15 | 5–64 | 22 | 26–757 | 141 |
| *Meretrix meretrix* | ,, | 17–74 | 37 | 11–30 | 25 | 18–493 | 168 | 61–103 | 85 |
| *Sunetta donacina* | ,, | 57–117 | 91 | 14–21 | 17 | 354–556 | 441 | 92–324 | 205 |
| *Mytilus viridis* | Mytilidae | 14 | 14 | 14 | 14 | 26–33 | 30 | 68–267 | 168 |
| *Crassostrea madrasensis* | Oystreidae | 271–315 | 295 | 11–17 | 13 | 18–22 | 21 | 571–906 | 738 |
| *Anadara granosa* | Arcidae | 14 | 14 | 25 | 25 | 61 | 61 | 171 | 171 |

TABLE V

*Specieswise enrichment factors in mollusca*

| Species | Family | Copper | | Chromium | | Manganese | | Zinc | |
|---|---|---|---|---|---|---|---|---|---|
| | | Range $\times 10^3$ | Mean $\times 10^3$ | Range $\times 10^5$ | Mean $\times 10^5$ | Range $\times 10^3$ | Mean $\times 10^3$ | Range $\times 10^3$ | Mean $\times 10^3$ |
| *Katelysia marmorata* | Veneridae | 1·7– 4·8 | 2·9 | 1·4–5·8 | 3·0 | 0·7– 9·1 | 3·1 | 1·6–47·3 | 8·8 |
| *Meretrix meretrix* | ,, | 1·7– 7·4 | 3·7 | 2·2–6·0 | 5·0 | 2·5– 7·4 | 24·0 | 3·8–6·4 | 5·3 |
| *Sunetta donacina* | ,, | 5·7–11·7 | 9·1 | 2·8–4·2 | 3·4 | 50·6–79·4 | 63·0 | 5·7–20·2 | 12·8 |
| *Mytilus viridis* | Mytilidae | 1·4 | 1·4 | 2·8 | 2·8 | 3·7– 4·7 | 4·3 | 4·2–10·7 | 10·5 |
| *Crassostrea madrasensis* | Ostreidae | 27·1–31·5 | 29·5 | 2·2–3·4 | 2·6 | 2·6– 3·1 | 3·0 | 35·7–56·6 | 46·1 |
| *Anadara granosa* | Arcidae | 1·4 | 1·4 | 5·0 | 5·0 | 8·7 | 8·7 | 10·7 | 10·7 |

TABLE VI

*Enrichment factors for the trace-elements in mollusca*

| Species | Family | Cr $\times 10^5$ | Cu $\times 10^3$ | Mn $\times 10^3$ | Zn $\times 10^3$ |
|---|---|---|---|---|---|
| Scallop | Veneridae | 2·0 | 3·0 | 55·5 | 28·0 |
| Oyster | Ostreidae | 0·6 | 13·7 | 4·0 | 110·3 |
| Mussel | Mytilidae | 3·2 | 3·0 | 13·5 | 9·1 |

The fractionation factors as defined by Goldberg[18] (relative enrichment) for various elements in different molluscan families are found as following.

Veneridae---Cr > Mn > Zn > Cu
Mytilidae---Cr > Zn > Mn > Cu
Ostreidae---Cr > Zn > Cu > Mn
Arcidae---Cr > Zn > Mn > Cu

This supports the finding of Brooks and Runsby[16] that direct coordination of metal ions with suitable organic ligands is masked by some other factors such as contamination by, and particulate ingestion of sedimentary materials. The concentration of chromium seems to be due to the adsorption on the surface of the organisms. In addition to this the requirement of particular trace elements by different species of mollusca is also different for their metabolic activities. This is evident from the observation of different concentrations of trace elements manganese, copper and zinc in different species of the mollusca. In benthic organisms, the finding of Schubert[20] that the stability of complexes formed between divalent metal ions and ligands increases with the increasing basicity of the metal ion in the order : Pd > Cu > Ni > Pb > Co > Zn > Fe > Cd > Mn > Ca > Sr > Ba > Ra does not seem to be applicable.

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# STUDIES ON ACCUMULATION OF CITRATES IN INSECTS

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ABSTRACT

Citrate accumulation — termed as one of the systematic biochemical characteristics of insects — has been studied in four different insects. During metamorphosis, no significant rise or fall of citrate concentration has been noted and having once attained to the lowest level, it continues till adult emergence. During periods when the insect changes from embryo to larva, larva to pupa and from pupa to adult, marked utilization of citrate has been observed. This is assumed to occur either due to a reduced rate of citrate synthesis or due to an increased rate of utilization thereof on account of the sudden change from one phase to another.

Nevertheless, it is noteworthy that each insect hitherto investigated depicts its own pattern of citrate variation during development, although some similarities do exist in some.

## INTRODUCTION

HIGH concentration of citrates in insects termed as one of their "Systematic biochemical characteristics" by Levenbook and Hollis[1] was first recorded by Tsuji[2] who estimated it to be 48·5 mmol in *Bombyx mori* blood. Since then and until recently the only citrate analysis published in insects has been that of Levenbook[3]. He examined the larval haemolymph of *Gastrophilus intestinalis* and reported the value to be 45 mg/100 ml. Patterson[4] estimated the blood and tissue homogenate citrates of *Rhodnius prolixus* and *Tenebrio molitor* to be 44 mg and 97 mg/100 ml of haemolymph respectively. Patterson's studies on citrates and on α-amino nitrogen concentration carried out on the same samples of tissue homogenates of insects revealed that the citrate concentrations were maximum at the time of lowest activity and that at a time when least oxygen is utilized the *Tenebrio molitor* pupa accumulated citrate maximally, when the overall oxidative metabolism is increased the citrate concentration falls correspondingly. Patterson[5] also noticed that the accumulation of citrate in the pupal tissue was inversely proportional to the rate of oxygen utilization by a live pupa. This induced him to consider that the reactions of the tricarboxylic acid cycle—now well established for insect tissues by Sacktor[6] and by Rees[7]—of which citrate