ZINC, MANGANESE AND COBALT CONTENTS OF SOME MARINE BIVALVES FROM BOMBAY*

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Levels of zinc, manganese and cobalt were determined in the soft parts of six species of marine bivalves to study their suitability as 'indicator organisms' for the radioisotopes of these elements in sea-water. It is found that the oyster, *Crassostrea gryphoides* accumulates zinc from sea-water by factors ranging from 5,500 to 13,000 and may be utilized as an indicator for radioisotopes of zinc in sea-water. Likewise, the clam, *Sunetta donacina,* shows a high affinity for manganese and may be used for a similar purpose in the study of contamination of sea-water by radioisotopes of manganese. The concentration factors for cobalt in these bivalves range from 30 to 1,730; and, among the species studied, no suitable indicator for cobalt was noticed.

INTRODUCTION

A large number of chemical elements are present in 'trace' concentrations in sea-water. These include zinc, manganese and cobalt which have acquired added significance in recent years due to the presence of their radioisotopes (Zn-65, Mn-54 and Co-60) in the marine environment. For example, Lowman (1963) found, six weeks after the nuclear weapons test series in 1958, that radioisotopes of manganese, iron, cobalt and zinc contributed 73·6 per cent of the total radio-activity in the plankton and almost 100 per cent in tunas. The detection of these pollutant radioisotopes is rendered difficult by the very small concentrations in which they are present in water. To overcome this difficulty, some marine organisms have been used as indicators of radioactive contamination, in view of their ability to accumulate trace elements to very high levels.

Vinogradov (1953) reported high concentrations of zinc and manganese in marine lamellibranchs. Chipman (1960) also mentioned the great concentrating ability of lamellibranchs for pollutant metal radionuclides. No information is available on the zinc, manganese and cobalt contents of Indian marine animals. In view of this, work was initiated on the determination of

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these elements in marine invertebrates from Bombay. Preliminary results on the zinc content of some bivalves and barnacles were reported by Sastry and Bhatt (1965).

MATERIAL AND METHODS

The following marine bivalves from Bombay shores have been studied:

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

Crassostrea gryphoides is cultivated in an oyster farm at Kelva (80 km north of Bombay) and is transplanted to the rocky shore at Mahim (Bombay) prior to marketing. It is available in Bombay only between November and May. The other species, excepting *M. viridis*, are common along the Bombay coast.

The freshly collected samples (each sample a composite of 30 to 50 specimens) were washed free of extraneous matter with filtered sea-water, after removal of the shells. The soft parts were dried in a hot-air oven at 100° C. Zinc was estimated in this dried material by the dithizone mixed colorimetric method (Sandell 1959) after wet-ashing with nitric and perchloric acids. The rest of the dry material was ashed at 550° C in a muffle furnace. Manganese in the ash was oxidized to permanganate using periodate and estimated colorimetrically. Cobalt in the ash was estimated by the Nitroso-R-salt method (Sandell 1959).

For estimating zinc in sea-water, the dithizone mono-colour method of Fonselius and Koroleff (1963) was adopted. Manganese in sea-water was coprecipitated with magnesium hydroxide, oxidized to permanganate and estimated colorimetrically (Koroleff 1947). Cobalt in sea-water was first coprecipitated with magnesium hydroxide and then estimated by the Nitroso-R-salt method as described by Sandell (1959). The contents of zinc and cobalt were read off from appropriate calibration curves.

RESULTS AND DISCUSSION

The results of analyses are given in Table I. The concentration factors (CF) were obtained by dividing the concentration of the element in soft parts of the animal by the average concentration of the same element in sea-water, and are given in Table II.

The concentration of zinc in the venerid clams and mussel are similar to those cited by Vinogradov (1953). Among the three species of clams, the zinc content in *Meretrix meretrix* remains fairly constant in the narrow range of 12·0 to 15·9 p.p.m.

TABLE I

Levels of Zn, Mn and Co in the soft parts of bivalves and in sea-water (concentrations in biomaterial on wet-weight basis)

Species	Zinc (p.p.m.)		Manganese (p.p.m.)		Cobalt (p.p.m.)	
	Range	Mean	Range	Mean	Range	Mean
K. marmorata ..	5·9– 44·2	17·9	0·9–10·6	4·2	0·01–0·24	0·10
M. meretrix ..	12·0– 15·9	14·8	3·3–27·6	11·5	0·09–0·52	0·25
S. donacina ..	10·8– 72·3	41·3	59·0–83·9	73·9	—	0·06
M. viridis ..	11·0– 39·9	25·4	4·2– 8·1	6·1	—	—
C. gryphoides ..	171·0–403·0	292·5	4·2– 5·7	4·9	—	0·06
A. granosa ..	—	20·6	—	7·2	—	0·11
Sea-water ..	0·028–0·035	0·031	0·002–0·021	0·007	0·0001–0·0012	0·0003

TABLE II

Concentration factors for Zn, Mn and Co in bivalves

Species	Concentration factors (range)		
	Zinc	Manganese	Cobalt
K. marmorata ..	190– 1430	130– 1510	30– 800
M. meretrix ..	390– 510	470– 3940	300–1730
S. donacina ..	350– 2330	8430–11990	200
M. viridis ..	350– 1290	600– 1160	—
C. gryphoides ..	5520–13000	600– 810	200
A. granosa ..	660	1030	370

Sastry and Bhatt (1965) indicated that oysters accumulate zinc from sea-water by factors of about 10,000. Analyses performed on samples of *C. gryphoides* have also shown high levels of zinc ranging from 171 to 403 p.p.m. with CF's in the range of 5,500 to 13,000. This high degree of accumulation indicates that *C. gryphoides* would be a good indicator of zinc-65 in sea-water. The zinc levels in this species are in agreement with those given for *C. virginica* Gmelin by Vinogradov (1953), but are lower than those reported for *C. virginica* by Chipman *et al.* (1958) and Fitzgerald and Skauen (1963). The variation in the zinc content in *C. gryphoides* from Bombay, between November 1964 and May 1965 (Fig. 1), shows a trend similar to that of variation in its phosphorous content as shown by Durve and Bal (1961).

In regard to manganese, it is seen that the manganese content of the soft portions of Bombay shell-fish is of the same order of magnitude as those for members of the same families from other parts of the world (Vinogradov 1953; Brooks and Rumsby 1965), except in the case of *Sunetta donacina.* In *S. donacina*, the manganese content is significantly high, ranging from 59·0 to 83·9 p.p.m., the CF's ranging from approximately 8,400 to 12,000. This tends to show that this species may prove to be useful as an indicator of radio-isotopes of manganese.

Few data are available on the cobalt contents of marine bivalves. Our values of cobalt in bivalves are much higher than the few values given by

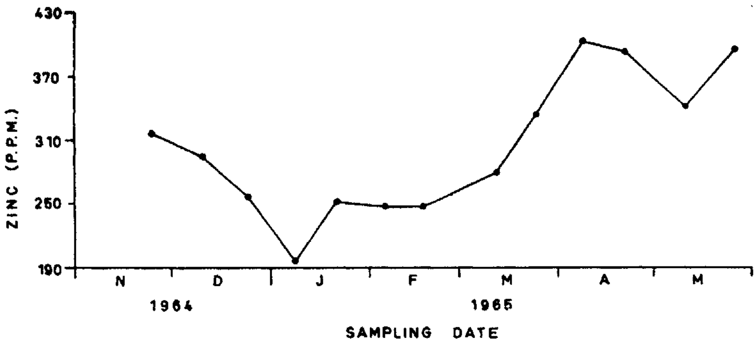

FIG. 1. Variation in the zinc content of *Crassostrea gryphoides.*

Vinogradov(1953). However, the CF's for cobalt in bivalves from Bombay are low and no suitable indicator species for cobalt was noticed. Underwood (1956) also mentions that cobalt is poorly retained by the tissues and is rapidly eliminated by animals.

From the above data it is evident that there is considerable accumulation of these trace elements by the organisms investigated. Furthermore, there is usually a wide intraspecific variation in the amounts of these elements. In general, the quantities of zinc in the soft parts, for a species, are greater than those of manganese, which is greater than cobalt. The solitary exception is *S. donacina* in which the level of manganese is higher than that of zinc.

According to Goldberg (1957), the general order of the relative CF's in the marine biosphere as compared to sea-water, for the divalent ions, is: Pd > Cu > Ni > Pb > Co > Zn > Fe > Cd > Mn > Mg > Ca > Sr > Ba > Ra. During the present study, the following orders were observed for the mean CF's for the three trace metals.

K. marmorata *S. donacina* *A. granosa*	Mn > Zn > Co
M. viridis	Mn > Zn
M. meretrix	Mn > Co > Zn
C. gryphoides	Zn > Mn > Co

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