

## TRACE METAL CONCENTRATION IN SOME MARINE ALGAE OF THE MAHARASHTRA COAST (INDIA)

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### ABSTRACT

74 marine algal species representing Chlorophyta, Phaeophyta and Rhodophyta from ten different stations along the Maharashtra coast were analysed for the concentration of Mn, Fe, Co, Ni, Cu, Zn and Pb. Concentration varies with species and also from station to station. The concentration of Fe shows a wide range from 115-31380 ppm, followed by Mn from 41-739 ppm. Co, Ni, Cu, Zn and Pb were comparatively lower than Fe and Mn.

Statistical analysis indicates significant variation of trace-metal concentration in different species and no variation with algal groups. In general filamentous algae show more concentration of all the seven metals. The effect of pollution on algae is discussed in relation to the concentration of trace metals.

### INTRODUCTION

Marine algae are considered as important primary producers in the coastal region. Several marine algal species are being used as raw material for various economically important products and this has resulted in their increasing demand.

Marine algal species also have been suggested to be the indicators of pollution (Bryan & Hummerstone 1973, Preston *et al.* 1972, Nickies *et al.* 1972, Melhus *et al.* 1978, Morris and Bale 1975). Keeping in view the importance of marine algal species for direct or indirect human as well as cattle consumption, it is necessary to monitor the bioaccumulation of certain toxic trace elements in these species.

Untawale *et al.* (1979) have surveyed the Maharashtra coast for the marine algal resources, and indicated the possible effect of pollution on seaweeds, and Patel *et al.* (1980) have studied some trace and heavy metals in a brown alga *Sargassum teneurimum* from Tarapur (Maharashtra) area. Along the west coast of India, Zindge *et al.* (1976) have studied the concentration of Arsenic, Copper,

Zinc and Manganese in marine flora and fauna of the Goa coast while Agadi *et al.* (1978) have analysed about 33 marine algal species of Goa coast for seven trace metals.

### MATERIALS AND METHODS

74 algal samples were collected from the ten different stations along the Maharashtra coast (Fig. 1).

All the stations were free from industrial pollution, except Bombay, in the northern region of Maharashtra coast.

During seaweed survey of Maharashtra coast in 1977, 74 algal species belonging to Chlorophyta, Phaeophyta and Rhodophyta groups were collected. The samples were prepared for the analysis of Mn, Fe, Co, Ni, Cu, Zn and Pb (Agadi *et al.* 1978) by absorption spectrophotometry. The results are the mean values of triplicate determinations and are expressed as ppm dry weight (Table 1).

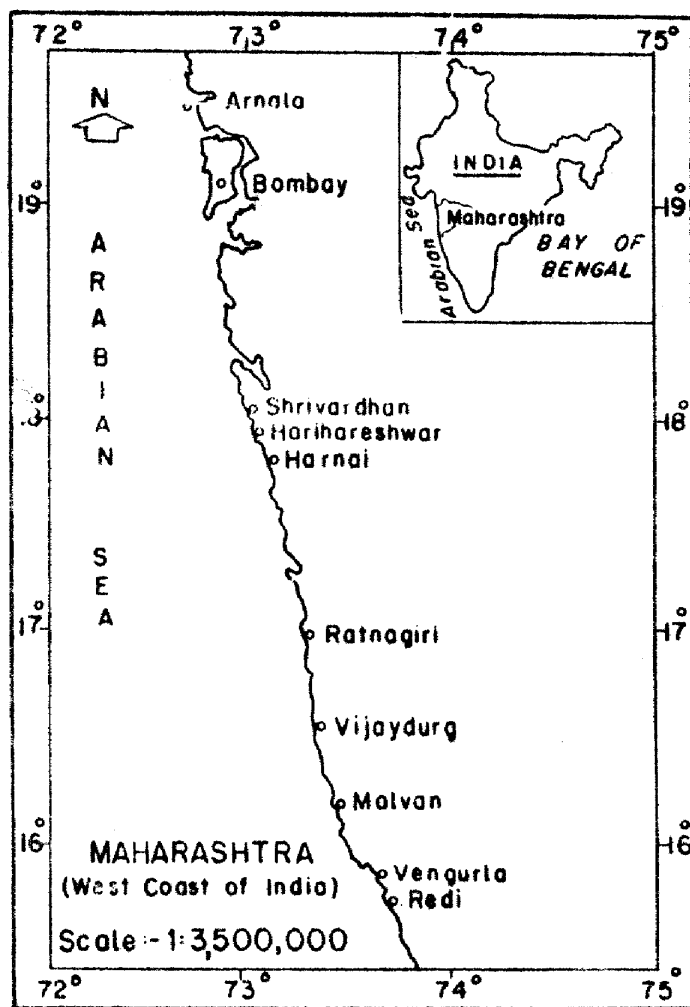


Fig. 1. Map of the Maharashtra coast showing the localities of algal collection.

**Table. 1. Trace Metal Concentration in the Marine Algae of Maharashtra Coast**

(Values expressed in ppm dry weight)

Stations	Sl. No.	Name of species	Mn	Fe	Co	Ni	Cu	Zn	Pb
I — REDI	1.	<i>Enteromorpha flexuosa</i>	595.4	5602.0	7.7	10.0	20.1	146.5	24.1
	2.	<i>Ulva fasciata</i>	88.3	1764.0	5.3	5.2	12.1	87.8	12.8
	3.	<i>Chaetomorpha media</i>	68.5	1064.0	9.4	7.2	20.3	113.2	9.6
	4.	<i>Bryopsis hypnoides</i>	145.2	5717.0	3.3	6.1	26.3	116.0	0.7
	5.	<i>Sphacelaria furcigera</i>	739.2	31380.0	10.0	22.3	29.1	104.1	20.0
	6.	<i>Padina tetrastromatica</i>	266.8	2380.0	9.4	13.8	14.8	105.6	9.6
	7.	<i>Sargassum duplicatum</i> (?)	64.6	1200.0	10.6	17.7	14.0	43.7	17.6
	8.	<i>S. polydystum</i> (?)	163.7	1150.0	14.4	21.6	19.2	60.6	15.2
	9.	<i>S. wightii</i>	43.0	214.4	7.7	7.2	8.6	49.7	27.3
	10.	<i>Hypnea musciformis</i>	287.3	5960.0	4.0	19.6	15.0	87.0	20.0
	11.	<i>Centroceras clavulatum</i>	578.3	18407.0	9.0	14.7	31.6	77.3	35.5
II — VENGURLA	1.	<i>Ulva fasciata</i>	88.6	761.2	12.6	5.4	11.5	97.8	7.2
	2.	<i>Chaetomorpha media</i>	41.6	1779.0	9.4	18.8	17.7	99.8	7.9
	3.	<i>Sargassum tenerrimum</i>	100.4	2112.0	11.1	26.2	17.7	74.0	21.0
	4.	<i>Gelidium pusillum</i>	135.4	1804.0	4.0	14.7	12.6	78.8	12.0
	5.	<i>Grateloupia lithophila</i>	65.1	654.0	6.1	9.2	11.2	64.0	23.4
	6.	<i>Gracilaria corticata</i>	298.0	1876.0	26.0	28.1	10.6	96.0	38.6
III — MALVAN	1.	<i>Enteromorpha flexuosa</i>	212.2	9295.0	5.6	20.8	16.2	68.3	14.4
	2.	<i>Ulva fasciata</i>	41.1	164.0	5.0	10.7	10.6	61.6	15.2
	3.	<i>Chaetomorpha media</i>	35.7	222.0	1.1	7.7	11.0	67.7	4.8
	4.	<i>Bryopsis hypnoides</i>	189.2	4728.0	5.6	14.7	16.8	64.0	17.0
	5.	<i>Caulerpa peltata</i>	125.4	2555.0	7.2	17.3	15.6	62.0	17.6
	6.	<i>Sphacelaria furcigera</i>	754.1	5743.2	15.0	31.6	27.7	58.0	16.1
	7.	<i>Dictyota dichotoma</i>	145.2	2198.0	7.2	20.8	16.5	115.0	23.4
	8.	<i>D. dumosa</i>	204.3	7292.0	30.4	28.4	36.6	73.1	28.8
	9.	<i>Padina tetrastromatica</i>	625.5	4111.0	23.0	16.2	14.2	75.4	37.3
	10.	<i>Sargassum ilicifolium</i>	97.7	4046.0	20.2	29.4	20.0	80.8	7.6
	11.	<i>Gelidium pusillum</i>	93.5	573.0	11.0	11.4	11.8	43.1	11.5
	12.	<i>Grateloupia filicina</i>	54.7	115.4	20.7	17.6	6.7	4.0	22.0
	13.	<i>Gracilaria corticata</i>	184.7	697.2	9.6	11.5	5.0	21.2	19.2
	14.	<i>Hypnea musciformis</i>	291.7	6514.0	26.8	18.2	17.1	55.0	34.6
	15.	<i>Centroceras clavulatum</i>	319.9	5739.0	20.7	26.4	17.5	22.0	22.0
IV — VIJAYDURG	1.	<i>Padina tetrastromatica</i>	487.0	8846.0	22.1	12.8	18.1	131.3	16.5
	2.	<i>Sargassum ilicifolium</i>	259.8	8868.0	17.4	44.1	21.8	81.8	18.0
	3.	<i>S. wightii</i>	64.6	1140.0	19.3	15.6	21.0	141.5	33.4
	4.	<i>Gelidopsis variabilis</i>	359.5	2505.0	18.5	24.3	21.3	73.8	14.2

Table. I. (Contd.)

Stations	Sl. No.	Name of species	Mn	Fe	Co	Ni	Cu	Zn	Pb
V — RATNAGIRI	1.	<i>Enteromorpha flexuosa</i>	71.4	1590.0	19.3	17.6	18.1	52.5	23.0
	2.	<i>Ulva fasciata</i>	75.1	2963.0	11.0	17.6	18.5	67.6	00.0
	3.	<i>Chaetomorpha media</i>	40.0	943.0	12.4	19.0	18.5	40.8	10.3
	4.	<i>Caulerpa peltata</i>	179.5	6855.0	10.4	14.2	13.7	183.3	17.0
	5.	<i>Sphacelaria furcigera</i>	1737.0	39496.0	31.4	34.4	96.5	92.6	26.0
	6.	<i>Dictyota dumosa</i>	157.3	3468.0	15.1	8.3	10.7	74.2	22.0
	7.	<i>Padina tetrastrumatica</i>	456.5	2312.0	24.1	6.0	11.0	98.5	21.0
	8.	<i>Sargassum tenerrimum</i>	195.6	2749.0	12.7	6.0	8.2	39.5	14.0
	9.	<i>S. Wightii</i>	43.6	798.0	13.1	2.3	6.1	90.4	21.0
	10.	<i>Gelidium pusillum</i>	175.5	754.0	17.6	2.3	1.8	53.7	22.0
	11.	<i>Gracilaria corticata</i>	267.4	1381.0	8.8	6.0	1.0	31.8	21.0
	12.	<i>Hypnea musciformis</i>	313.0	2319.0	12.7	8.3	6.4	76.3	26.0
	13.	<i>Centroceras clavulatum</i>	642.0	13609.0	15.7	19.5	31.6	86.6	20.0
	14.	<i>Acanthophora specifera</i>	384.7	6037.0	21.5	8.3	19.2	57.9	22.0
	15.	<i>Gelidiopsis variabilis</i>	273.4	792.0	15.7	15.7	6.4	69.2	32.5
VI — HARNAI	1.	<i>Enteromorpha flexuosa</i>	89.7	9004.0	17.6	16.0	12.3	53.7	19.0
	2.	<i>Ulva lactuca</i>	71.8	1808.0	14.7	7.1	19.2	72.8	12.5
VII — SRIVADHAN	1.	<i>Enteromorpha flexuosa</i>	229.1	13609.0	16.2	16.6	34.8	77.0	24.5
	2.	<i>Rhizoclonium sp.</i>	110.6	5832.0	19.6	6.0	9.1	179.5	28.0
VIII — HARIHARESHWAR	1.	<i>Ulva lactuca</i>	92.7	2353.0	8.8	4.0	9.4	87.0	12.0
	2.	<i>Rhizoclonium sp.</i>	221.3	4911.0	9.8	20.1	2.7	295.5	28.0
	3.	<i>Dictyota dichotema</i>	83.7	2660.0	14.3	9.0	9.8	125.1	16.0
	4.	<i>Padina tetrastrumatica</i>	227.3	8083.0	15.1	11.8	7.3	99.0	10.0
	5.	<i>Grateloupia lithophila</i>	49.6	754.0	14.7	1.0	0.4	35.3	23.0
	6.	<i>Gracilaria Corticata</i>	123.8	2476.0	8.8	0.0	0.0	76.7	9.0
	7.	<i>Hypnea musciformis</i>	95.7	5934.0	17.6	8.3	3.6	123.0	27.0
	8.	<i>Centroceras clavulatum</i>	151.3	11562.0	7.8	7.1	17.0	63.2	65.2
IX — BOMBAY (BANDRA)	1.	<i>Enteromorpha flexuosa</i>	317.1	18827.0	16.2	22.5	13.2	157.3	23.0
	2.	<i>Ulva lactuca</i>	139.4	3851.0	5.8	10.0	7.3	130.0	20.0
	3.	<i>Grateloupia filicina</i>	83.7	3399.0	17.6	4.1	2.7	287.0	9.0
	4.	<i>Centroceras clavulatum</i>	277.3	7162.0	10.4	4.7	11.4	139.0	11.0
X — ARNAI	1.	<i>Ulva lactuca</i>	357.2	2773.0	12.7	5.3	6.0	151.7	16.0
	2.	<i>Rhizoclonium sp.</i>	470.3	6270.0	9.8	4.1	3.6	159.3	16.6
	3.	<i>Gracilaria sp.</i>	88.0	1276.0	5.8	0.0	0.0	94.7	14.0
	4.	<i>Gracilaria sp.</i>	484.6	2312.0	11.7	5.1	1.0	80.5	19.0
	5.	<i>Hypnea musciformis</i>	203.4	5934.0	11.1	6.0	3.6	116.0	27.0
	6.	<i>Acanthophora specifera</i>	111.8	948.0	13.1	2.3	2.7	96.8	18.0
	7.	<i>Chondria tenuissima</i>	146.6	2734.0	14.7	8.3	1.3	116.0	32.0

By the two way analysis of variance (ANOVA) technique, the variations in 7 trace metals in the algal species and groups were examined. All the calculations were carried out with the third generation computer (TDC-316).

## RESULTS

Analysis of 7 trace metals - Mn, Fe, Co, Ni, Cu, Zn and Pb in the 74 marine algal species collected from 10 different places of Maharashtra coast (Table. 1) are discussed below.

### Station. 1. Redi

11 marine algal species were collected. Of these 4 belonged to chlorophyta, 5 to phaeophyta and 2 to rhodophyta.

The concentration of Fe was found to be maximum followed by Mn, Zn, Cu, Ni and Co. It has been observed that the rhodophyta members showed a tendency to concentrate trace metals in larger quantity, excepting Co and Zn which are more in phaeophyta and chlorophyta respectively.

### Station. 2. Vengurla

Six marine algal species were collected from Vengurla coast, out of which 2 were represented by chlorophyta, only one phaeophyta and 3 rhodophyta.

The concentration of Fe in all the 6 algal species was the highest followed by Mn, Zn, Pb, Ni, Cu and Co.

Among the marine algae of Vengurla coast, chlorophyta members showed more concentration of Zn, while species of phaeophyta accumulated more Fe, Ni and Cu. However, the rhodophyta species were observed to have more concentration of Mn, Co and Pb.

### Station. 3. Malvan

From Malvan coast, 15 marine algal species were collected of which 5 each were of chlorophyta, phaeophyta and rhodophyta.

The higher concentration of Fe, in all the algal species was observed at Malvan also, which was followed by Mn, Zn, Ni, Pb, Cu and Co.

Marine algal species belonging to the phaeophyta showed higher concentrations of Fe, Mn, Co, Ni, Cu, Zn and Pb than chlorophyta and rhodophyta.

### Station. 4. Vijayadurg

Only 4 marine algal species were collected from this station of which 3 were of phaeophyta and 1 of rhodophyta.

Maximum concentration was found to be of Fe followed by Mn, Zn, Ni, Pb, Cu and Co. Species belonging to phaeophyta were observed with the highest concentrations of Fe, Co, Zn and Pb. However, rhodophyta members showed maximum Mn, Ni and Cu accumulation.

### Station. 5. Ratnagiri

In all 15 species were collected which consisted of 4 chlorophyta, 5 phaeophyta and 6 rhodophyta members.

Fe was found to be in maximum concentration in these algal species followed by Mn, Zn, Pb, Cu, Co and Ni.

In general, species of phaeophyta showed more concentrations in case of Mn, Fe, Co, Cu while chlorophyta members were observed to be more rich in Ni and Zn. The rhodophycean members were observed to concentrate more Pb.

### Station. 6. Harnal

Only two species of chlorophyta were collected and analysed. The Fe concentration was maximum followed by Mn, Zn, Cu, Pb and Ni.

### Station. 7. Shrivardhan

Two species of chlorophyta were studied from this coast for the trace metal concentrations. High concentration was observed in case of Fe which was followed by other elements like Mn, Zn, Pb, Cu, Co and Ni.

### Station. 8. Harihareshwar

In total 8 marine algal species, 2 each representing chlorophyta, phaeophyta and 4 rhodophyta, were collected and analysed.

Phaeophyta members in general, had more Fe, Co and Cu, while species of chlorophyta showed tendency to concentrate more Mn, Ni, and Zn. The rhodophyta members, however, showed maximum values for Pb.

### Station. 9. Bombay

Only 4 species from Bombay coast were analysed; 2 each of chlorophyta and rhodophyta.

The trace metal concentration trend was Fe followed by Mn, Zn, Pb, Co, Ni and Cu in these seaweed species.

In general, chlorophyta members were found to concentrate more Mn, Fe, Ni, Cu and Pb than the species of rhodophyta, which showed more Co and Zn.

#### Station. 10. Arnala

Seven marine algal species were collected from this nearshore island. Among them 2 were represented by chlorophyta and 5 rhodophyta.

The trend of concentration was found to be Fe, Mn, Zn, Pb, Co, Ni, Cu in all the seven species under

investigation.

In general chlorophyta species from Arnala showed a tendency to accumulate more Mn, Fe, Cu and Zn followed by rhodophyta, where Pb concentration was more. Co and Ni were found to be in similar concentration in both these classes of algae.

#### STATISTICAL ANALYSIS

Analysis of variance ('ANOVA') showed that for all the stations there is no statistical evidence to reject the null hypothesis ( $H_0$ : there is no variation in species/metals with respect to concentration of metals/algal species) at 1% level of significance (Table. II).

Table. II. Area Wise Variation in Species and Trace Metals

STATION	No. of species collected	No. of metals analysed	Variation in* species	Variation in* metals
1. Redi	11	7	NS (F = 1.06)	S (F = 5.43)
2. Vengurla	6	7	NS (F = 1.21)	S (F = 32.93)
3. Malvan	15	7	NS (F = 1.10)	S (F = 21.94)
4. Vijaydurg	4	7	NS (F = 1.06)	S (F = 6.64)
5. Ratnagiri	15	7	NS (F = 1.11)	S (F = 4.95)
6. Harnai	2	7	NS (F = 1.00)	NS (F = 2.23)
7. Srivardhan	2	7	NS (F = 1.01)	S (F = 6.18)
8. Harihareshwar	8	7	NS (F = 1.04)	S (F = 14.35)
9. Bombay	4	7	NS (F = 1.03)	S (F = 5.25)
10. Arnala	7	7	NS (F = 1.11)	S (F = 15.34)

\* From 'ANOVA' Analysis S = Significant NS = Not significant.

On the other hand there is a significant variation in the concentration of metals, with respect to the algal species, at all stations, except Harnai. Particularly, the variation in metals is highly significant at stations-Vengurla, Malvan, Harihareshwar and Arnala (Table. I.), and the same is true with the Maharashtra coast as a whole.

It is also observed that the concentration of trace metals does not vary with the algal groups

(chlorophyta, phaeophyta & rhodophyta) at 5 stations - Redi, Vengurla, Malvan, Ratnagiri and Harihareshwar. The 'ANOVA' for the entire coast also shows that there is no variation in concentration of elements with respect to algal groups.

#### DISCUSSION

The present results show wide variation in the accumulated concentration of all the 7 metals anal-

ysed in the 74 algal species and it is also confirmed by the statistical analysis (ANOVA). The accumulation of trace metals is stated to be unregulated in the marine waters (Young and Langile 1958, Gutknecht 1965) and the accumulation of metals in seaweeds is probably by the nonmetabolic absorption or an ion-exchange process (Gutknecht 1955, Baroda *et al.*, 1964) and are retained by organisms by strong chemical bonds (Goldberg 1957).

The highest concentration of Mn, Co and Cu were observed in a filamentous brown alga-*Sphacelaria furcigera* from Ratnagiri while Ni was more in *Sargassum ilicifolium* from Vijaydurg (Table 1). Except some fish processing units at Ratnagiri, there is no other prominent means of causing water contamination and hence the high metal concentration could not be explained. The extracellular polyanions like alginates have been shown to act as ion-exchange material (Myklestad 1969). The maximum concentration of Fe and Mn may also be due to the inflow of mine drainage, along with other contaminants, at the southern parts of Maharashtra coast. The concentration of Fe and Mn were found to be higher than the earlier reported values (Patel *et al.* 1980, Agadi *et al.* 1978).

The content of Zn and Pb were found to be more in filamentous green alga *Rhizoclinium* sp. and a red alga *Centroceras clavulatum* respectively, collected from Harihareshwar. This can probably be attributed to the influence of polluted waters of Bombay.

The present result reveals that the concentration of trace metals in the marine algae of Maharashtra coast are on the higher side as compared to the earlier reports on Goa coast (Agadi *et al.* 1978, Zingde *et al.* 1976). The reasons for higher concentration may be due to the pH, high temperature (Bryan 1976), salinity and other metal binding nutrients in seawater (Sivalingam 1978). This may also be due to high water movement (Provasoli 1963) and recycling of the mineral elements after the decomposition of organisms in the sea.

It is known that in minute quantities many trace metals are nutritive to the growth of marine algae (North *et al.* 1972). However, the present values are far exceeding as compared to the values for other marine plants (Bowen 1966). In spite of the high accumulation, of these metals no harmful effect was noticed on algae, except, towards the extreme northern parts of Maharashtra coast. The maximum effect of pollution on marine algae along this coast

was observed at Bombay and nearby areas, where large quantities of industrial, domestic and other types of pollutants find their way into the nearby marine waters. The algal flora which once flourished at Bombay (Boergesen 1935) is now drastically reduced to about 16 species (Untawale *et al.* 1972). This is mainly as a result of increased pollution around Bombay. The economically important brown algae are the worst affected. Since marine algae are useful as primary producers in coastal waters (Mann 1973) their reduction due to pollution would pose a threat to the next link in the food chain.

Based on the present investigation, in general, we can conclude that filamentous algae showed ability to concentrate more amount of trace elements, than foliaceous algae.

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