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Concentration & Toxicity of Some Metals in Zooplankton from Nearshore Waters of Bombay

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Zooplankton samples collected from 4 stations located in the nearshore waters of Bombay were analysed for Cu, Co, Mn, Ni and Cd. Concentrations of Co, Mn and Ni were more in copepods and gelatinous organisms than in mysids and decapods. High concentrations of Ni and Co were noticed in zooplankton from Thana Creek which receives considerable amount of industrial effluents. Concentration of Cu and Mn was more in zooplankton obtained from offshore area. Cd concentration was invariably constant in zooplankton collected from all stations. Bioassay tests were carried out for evaluating the acute toxicity of Cu and Ni on selected groups of zooplankton. Cu was more toxic than Ni. Among the different organisms tested *Sagitta*, *Lucifer*, ctenophores and Medusae were relatively more sensitive than *Acetes* and mysids.

The build up of metal concentrations in coastal areas receiving industrial effluents and sewage may affect the growth and development of plankton leading to decrease in the productivity of the region[1]. Again, the uptake of metals by plankton provides an entry into marine food chains. Information on the bioaccumulation of metals in zooplankton from the Indian Ocean is limited[2-6]. Knowledge on the acute toxicity of different metals is also necessary for evaluating permissible levels of these metals in the nearshore waters of India. Such data for zooplankton are not available except for a report on copepods[7]. Hence, in the present investigation concentration of some metals in zooplankton and toxicity of Cu and Ni in different groups of zooplankton have been estimated.

Materials and Methods

Zooplankton samples were collected in Dec. 1980 and March/May 1981 from 4 stations (Fig. 1). St 1 (Thana Creek) is polluted with discharge of industrial effluents while st 2 (Versova Creek) receives large quantities of sewage[8]. The other 2 stations (st 3, off Versova; st 4, off Mahim) are relatively unpolluted. The creek stations are characterised by low levels of dissolved oxygen and higher nutrient levels while sts 3 and 4 have comparatively high dissolved oxygen, high salinity and low nutrient values[8].

HT net (mouth area, 0.25 m^2; mesh size 0.3 mm) was used for zooplankton collection. During sampling, guidelines suggested by Bernhard[9] were strictly followed to avoid contamination. Immediately after collection samples were kept in ice box. On reaching the laboratory the samples were segregated into selected groups, washed with distilled water, dried at 70°C, powdered and stored. The dried samples (1-2g) were digested in conc. HNO_3 (15-25 ml) followed by perchloric acid until a clear solution was obtained. The volume of the solution was made to 10 ml with glass distilled water. The solutions were examined for Cu, Co, Mn, Ni and Cd using standard atomic absorption technique[10]. Blanks were maintained along with the samples.

Bioassay tests for 50% survival in different groups of zooplankton for 24 h were obtained from standard static bioassay test[11,12] conducted during March to May 1981. These tests were done for $CuSO_4.5H_2O$ and $NiSO_4.7H_2O$. Zooplankton were collected from the offshore area acclimatised to laboratory conditions for a day. Different groups were carefully segregated and used in the experiment. Loading of the organisms was done at the level of 20 per litre in the case of copepods and zoea and 10 per litre for the remaining groups. Each concentration was run in duplicate and a control

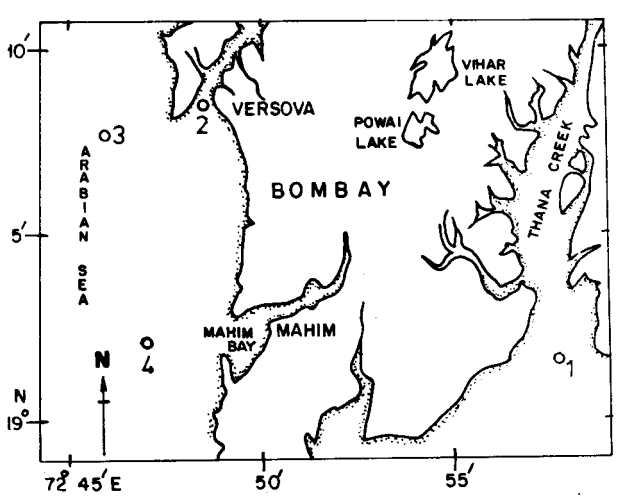

Fig. 1—Location of stations

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was also maintained to monitor the experiment. Experiments were repeated thrice. The values were averaged and cumulative number of dead organisms after 24 h was plotted against the concentration and regression line fitted. By interpolating the graph at 50% survival levels, the expected lethal concentrations of the given metal were obtained.

Results

Heavy metals—Concentrations (ppm dry wt) of different metals in selected groups of zooplankton are presented in Table 1. High concentrations of Cu were obtained from zooplankton collected from sts 3 and 4. Relatively low level of Cu was recorded at st 1. The present range of 16.25 (st 1) - 305 (st 4) ppm dry weight is comparable with that reported[2] from the west coast of India (3-228 ppm). Average concentrations of Cu in mysids, decapods, copepods and gelatinous organisms (chaetognaths, medusae and ctenophores) did not show much variations and the values were respectively 48.75, 50, 40.63 and 35 ppm.

Co ranged from 5 (st 2) to 20.63 (st 3) ppm and the recorded upper limit is far lower than that reported (73 ppm) for zooplankton from Arabian Sea[2]. In general, values obtained from st 1 was invariably high. Mean values of Co in copepods (13.91 ppm) and gelatinous groups (12.82 ppm) are higher than that in mysids (8.88 ppm) and decapods (8.3 ppm).

Concentration of Mn was relatively high at sts 3 and 4. Highest value of 180 ppm was obtained from st 3 and the minimum of 5 ppm from st 2. Mean values of Mn concentration in gelatinous organisms, copepods, decapods and mysids were respectively 86.25, 70.63, 48.75 and 33.29 ppm. The reported[2] value of Mn in zooplankton from Arabian Sea (22-129 ppm) is lower than the present record.

Ni concentration ranged from 27.27 (st 2) to 90.91 (st 1) ppm being invariably high in samples from st 1. Mean values of Ni in gelatinous groups, copepods, decapods and mysids were respectively 69.32, 59.41, 43.18 and 31.25 ppm. The reported[2] values in the concentration of Ni from Arabian Sea is lower (0-17 ppm) than the present.

Fluctuations in Cd concentration in zooplankton was at a relatively narrow range of 6.85 (st 2) to 15 (st 3) ppm. Average concentration of Cd in different groups of zooplankton did not show much variation, the values being 9.53, 11.14, 10.07 and 10.28 ppm respectively in mysids, decapods, copepods and gelatinous groups.

Bioassay test—Toxicity of $CuSO_4$ and $NiSO_4$ are shown in Fig. 2. The selected groups are Medusae, ctenophores, chaetognaths, mysids, copepods, *Lucifer*, *Acetes* and brachyuran larvae. During the experiments salinity, DO and *p*H were monitored

Table 1—Concentration of Metals in Zooplankton from Nearshore Waters of Bombay

[Values are in ppm dry weight]

Group	Cu	Co	Mn	Ni	Cd
	St 1 (Thana Creek)				
Copepods	16.25	18.13	44.38	79.55	8.57
Copepods	17.5	17.5	33.75	70.45	9
Chaetognaths, Medusae & ctenophores	16.25	15.63	50	90.91	10.28
	St 2 (Versova Creek)				
Mysids	51.25	8.75	71.25	27.27	6.85
Mysids	23.75	5	5	29.55	11.57
Mysids	86.25	7.5	41.25	29.55	10.28
Decapods	40	7.5	21.25	34.09	11.14
Decapods	75	7.5	35.63	50	12
Copepods & mysids	60	12.5	98.13	45.45	11.14
	St 3 (off Versova)				
Mysids	33.75	6.25	15.63	38.64	9.42
Copepods	63.74	8.75	98.13	37.64	12.42
Copepods	65	11.25	106.25	50	10.28
Decapods	50	10	89.38	45.45	10.28
Mysids & gastropods	100	20.63	180	68.18	15
Copepods & mysids	135	10	225	47.73	10
	St 4 (off Mahim)				
Copepods & decapods	305	13.13	101.88	59.09	14.57
Copepods & decapods	43.75	8.75	100	50	9.85
Chaetognaths	53.75	10	125.5	47.73	10.28

which were 35.5 to 36 $\times 10^{-3}$, 6.5 to 7 $mg.l^{-1}$ and 8 to 8.2 respectively.

The selected range of concentrations for $CuSO_4$ toxicity was from 0.1 to 3 $mg.l^{-1}$. For Medusae, ctenophores, chaetognaths and lucifers 100% mortality was obtained at 0.25 $mg.l^{-1}$ of $CuSO_4$ while the same for copepods and mysids was respectively at 0.32 and 0.64 $mg.l^{-1}$ concentration of $CuSO_4$. The calculated 24 h LC_{50} for chaetognaths, ctenophores, medusae, *Lucifer*, copepods, *Acetes*, mysids and zoea was 0.38, 0.41, 0.44, 0.44, 0.5, 1.02, 1.12 and 1.75 $mg.l^{-1}$ respectively.

The toxicity of $NiSO_4$ was tested in the range 1 to 6 $mg.l^{-1}$. Experiments were conducted only for copepods and lucifers and 100% mortality for both the groups was not observed within the tested range. The calculated 24 h LC_{50} for copepods and lucifers was respectively 6 and 3.4 $mg.l^{-1}$ of $NiSO_4$.

Discussion

Concentration of Cu, Co, Mn and Ni in zooplankton from st 2 is relatively lower than that observed for the offshore station (st 3). Cd content in zooplankton was relatively low. An increase in the concentration of some metals towards the offshore

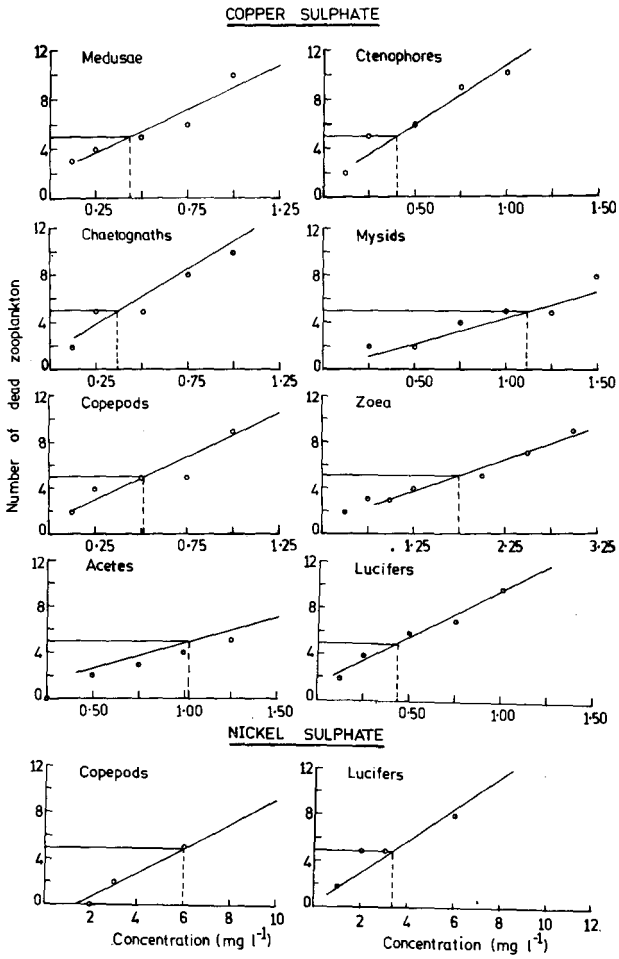

Fig. 2—Mortality rate of different groups of zooplankton at various concentrations of $CuSO_4$ and $NiSO_4$

area had been reported[2] while Cd content was observed to be quite uniform within the 100 km stretch[13]. Concentrations of metals in different groups of zooplankton indicated that Co, Mn and Ni were higher in copepods and gelatinous groups while they were relatively low in mysids and decapods. Cd concentration in mixed zooplankton was generally below 5 ppm dry wt and the range of 10-13 ppm dry wt in selected species was considered to be usually high[1].

Among the different groups of zooplankton gelatinous organisms, copepods and lucifer were found to be more sensitive to Cu. Brachyuran larvae, *Acetes* and mysids were the most tolerant groups of zooplankton. Studies conducted by Reeve *et al.*[14] on 2 species of ctenophores indicated that they were more sensitive to metal than copepods and chaetognaths. The reported range in LC_{50} values for copepod from Goa regions[7] was lower (0.01 to 0.04 mg.l^{-1}) than the present observation (0.13 to 0.19 mg.l^{-1}).

Both phytoplankton and zooplankton play a major role in the biogeochemical cycles of trace elements either by bioaccumulation and later transfer to higher levels or by redistribution[15]. Zooplankton accumulate metals by direct absorption from water and also by assimilation through food substances. The instantaneous metal content of any group or species of zooplankton is dependant on the degree of imbalance between the ingoing and outgoing fluxes of the metal[15]. The available data on the concentration of metals in zooplankton indicate variation probably due to a combination of factors affecting the uptake and loss of metals by animals[1]. Even data for zooplankton from restricated area may give wide range but this is usually associated with gradient in metal concentration due to pollution[1]. In industrialised cities like Bombay, urban run off leads to heavy metal enrichment of the aquatic environment. Substantial increase in Hg of Thana Creek resulting in bioaccumulation in animal tissues has already been reported[5,6]. In the present study relatively high concentrations of Ni and Co were observed in zooplankton from Thana Creek which receives considerable amount of industrial effluent.

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