Distribution of a Few Trace Metals in a Section in the South-Western Indian Ocean.

Sujata Sanzgiry[1], Analia Mesquita[1] and R. Sen Gupta[1]

ABSTRACT

Determination of Cu, Cd, Fe, Mn, Zn, Pb, Co and Ni has been carried out at different depths at 8 stations- one station being in an Antarctic polynya and 7 in the Southern Ocean. The depthwise and surface-wise variations have been discussed in different parts of the sampling region - Antarctic polynya, Antarctic divergence, Antarctic convergence and subtropical convergence regions. Average dissolved Cu and Cd in the 100-500 m depth layer in the Antarctic region is nearly the same as the average concentrations of the two metals in the sub-tropical surface water. In general, dissolved Fe shows enrichment towards the bottom except in the Antarctic divergence region. Particulate Fe is high in the Antarctic region. Mn concentration is almost similar in the 100-500 m layer throughout the sampling region. Dissolved as well as particulate Zn is higher at surface and lower in the bottom layer. Pb, Co and Ni have no definite trend of variation in both dissolved as well as particulate forms.

INTRODUCTION

Man's impact on the oceanic environment has always been the cause for a great deal of concern. Inspite of several investigations on trace metals in different waters, the information from the world oceans is never complete either due to small number of samplings over a vast area or due to lack of reliable data because of varying techniques of sampling and analysis. The fact that the study of trace metals in different natural environments is essential, needs no emphasis. Several workers have reported data on the distribution of trace metals in different oceanic environments. Chester and Stoner (1974) have studied the distribution of some trace metals in different regions of the world ocean and have discussed their data in comparison with the earlier ones. Harris and Fabris (1979) have reported data on particulate Cd, Cu, Pb and Zn in the Indian Ocean sector of the Antarctic Ocean and Danielsson (1980) reported values of some trace metals in the Western Indian Ocean.

Earlier studies carried out by us were mostly in regions close to the coast in the Arabian Sea and the Bay of Bengal where man's impact has an influence (Sea Gupta et al 1978, Sanzgiry and Moraes 1979, Braganca and Sanzgiry 1980 and Sanzgiry and Braganca 1981). Comparison of the coastal or nearshore data with open ocean data is very necessary to understand the magnitude of human influence on the oceanic environment. Utilizing the opportunity to collect data from the unpolluted Southern Ocean, water samples were collected for trace metal analysis during the First Indian Expedition to Antarctica on board M. V. *Polar Circle* from December 1981 to February 1982. This study deals with the distribution of dissolved and particulate forms of a few trace metals in the Southern Ocean and their comparison with earlier data.

METHODS OF COLLECTION AND ANALYSIS

Water samples were collected using Niskin GOFLO sampler using stainless steel wire. Sampling was done at different depths at 8 stations (G_2 to 16) between 69°58.14'S Lat., 11°54.65'E. Long, and 39°25.6'S Lat. and 45°0.3.8'E Long. To avoid contamination from the ship's hull the first sample was collected at 10 m and treated as a surface sample. Sampling could not be done at more frequent intervals as well as at the same depths at all the stations due to technical problems during the expedition. However, stations have been covered in such a way that waters having antarctic to subtropical characteristics have been sampled. Station G_2 is in an antarctic polynya, G_4, G_8 and G_9 are representative of antarctic divergence, G_{10} and G_{12} are in the antarctic convergence region and G_{14} and G_{16} are in the subtropical convergence waters.

The method of analysis was similar to that described earlier (Sen Gupta et al 1978, Sanzgiry and Moraes 1979, Braganca and Sanzgiry 1980 and Sanzgiry and Braganca 1981). The precision of the analysis reported as coefficients of variation is less than or equal to 10% for all the metals.

[1] National Institute of Oceanography, Dona Paula, Goa 403 004.

RESULTS AND DISCUSSION

Table 1 shows the location of the sampling stations and the trace metal concentrations (dissolved and particulate) at different depths. The average concentrations of all the trace metals in different regions, as discussed in the text, are given in Table 2. Due to difficulties encountered in sampling, data of very few stations could be discussed. However, an attempt has been made at comparison. The distribution of individual trace metals is discussed below.

TABLE 1

Concentrations of trace metals (D—Dissolved in µ/1; P—Particulate in µg/gm dry weight)

Srn No	Lat S	Long E	Depth m	Cu D	Cu P	Cd D	Cd P	Fe D	Fe P	Mn D	Mn P	Zn D	Zn P	Pb D	Pb P	Co D	Co P	Ni D	Ni P
			10	3.1	107	1.5	21	2	2528	ND	133	46.8	350	2.6	52	1.4	ND	3.7	124
G_2	69°58.14'	11°54.65'	200	3.0	53	0.5	23	4	222	2.8	ND	12	92	1.7	ND	1.4	ND	3.5	ND
			200	2.5	103	ND	26	3.1	2002	2.8	ND	17	274	2.7	37	ND	ND	1.8	25
G_2	68°43.50'	11°06.70'	1000	1.7	70	0.7	18	2.7	575	1.6	23	8.9	137	2.2	160	ND	ND	2.1	16
			1500	1.4	59	0.2	ND	6.6	72	1.2	14	13.3	ND	2.4	ND	1.1	17	3.0	14
			100	1.9	23	0.8	28	8.2	175	4.1	ND	10.9	93	3.5	ND	ND	ND	6.6	24
G_8	63°30.20'	22°26.13'	500	1.3	48	0.8	ND	4.3	709	4.1	17	17.9	72	3.4	71	1.5	15	3.4	ND
G_9	61°28.21'	25°01.15'	10	4.7	37	0.7	19	6.5	965	1.3	ND	29.6	141	2.1	88	0.9	ND	3.0	ND
			10	1.2	104	0.2	ND	6	1076	1.6	ND	16.6	873	2.9	214	1.1	ND	3.2	ND
G_{10}	59°58.74'	26°49.81'	100	1.5	ND	0.3	39	11.1	632	2.1	14	28.5	147	2.9	172	1.0	ND	2.3	ND
			500	<1	117	0.24	27	7	1780	1.6	ND	16.8	99	<1	ND	ND	ND	1.2	25
			10	1.1	54	0.6	ND	7.1	2220	2.6	ND	21.9	189	2.1	ND	ND	17	ND	13
til!	52=48.14'	34=25.44'	100	<1	71	0.6	ND	7	ND	<1	ND	16.8	1445	1.7	ND	<1	ND	2.7	16
			500	1.0	71	0.3	ND	6.1	1146	1.4	ND	12.8	28	1.3	46	ND	ND	<1	ND
			to	1.2	100	0.9	ND	5.3	2417	2.5	10	25.1	2359	2.4	105	1.5	29	1.5	27
G_{14}	45°38.07'	40°24.62'	100	1.8	35	0.5	ND	13	ND	2.1	ND	11.6	ND	1.2	69	1.7	16	2.7	ND
			500	1.4	ND	1.1	ND	10	35	<1	ND	12.9	173	4.9	69	1.9	20	3.4	ND
			10	1.8	NA	0.8	NA	10.25	NA	1.1	NA	17	NA	4.6	NA	1.6	NA	1.7	NA
G_{16}	39°25.60'	45°03.80'	100	1.4	NA	0.8	NA	11.8	NA	<1	NA	13.5	NA	3.5	NA	<1	NA	2.5	NA
			500	5.5	NA	0.7	NA	40.7	NA	2.1	NA	43.6	NA	3.4	NA	1.8	NA	2.8	NA

ND– not detectable
NA– not analysed

TABLE 2

Concentrations of dissolved trace metals (in µg/l) (values are average ± SE)

Region	Depth range (m)	Cu	Cd	Fe	Mn	Zn	Pb	Co	Ni
Antarctic Polynya	10	3.1 ± 0.2	1.5 ± 0.1	2 ± 0.2	ND	46.8 ± 4.6	2.6±0.2	1.4±0.1	3.7 ± 0.3
	100-500	3 ±0.2	0.5 ± 0.03	4 ± 0.4	2.8±0.2-	12 ± 1.2	1.7 ± 0.1	1.4±0.1	3.5 ± 0.2
Antarctic Divergence	10	4.7 ± 0.2	0.7 ±0.04	6.5 ± 0.6	1.3 ± 0.1	29.6±3	2.1 ±0.2	0.9 ±0.07	3 ± 0.2
	100—500	1.9±0.1	0.8 ± 0.05	5.2±0.5	3.7 ±0.3	15.3±1.5	3.2±0.3	0.5 ±0.04	3.9± 0.3
	below 500	1.5 ±0.1	0.4 ± 0.02	4.7±0.5	1.4 ±0.1	11.1±1.1	2.3±0.2	0.6 ±0.04	2.6± 0.2
Antarctic Convergence	10	1.1±0.1	0.4 ± 0.02	6.9 ± 0.7	2.1 ±0.2	19.3±1.9	2.5±0.2	0.6±0.04	1.6±0.1
	100-500	1.1±0.1	0.8 ±0.02	7.8±0.7	15± 0.1	18.7±1.9	1.7 ± 0.1	0.5 ± 0.04	1.8 ± 0.1
Subtropical convergence	10	1.5 + 0.1	0.9 + 0.05	7.8 + 0.8	1.8 + 0.2	21+2	3.5 + 0.3	1.6+0.1	1.6±0.1
	100-500	2.5 ±0.1	0.5 ±0.04	18.9±1.9	1.6±0.1	20.4 ±2	3.3+0.3	1.6±0.1	2.9 ±0.2

ND-non detectable

Copper and Cadmium

Dissolved Cu concentration hardly shows depthwise variation in waters of the polynya as expected from the mixed nature of the water. In the antarctic region, average dissolved Cu decreases from surface to bottom while it is the reverse in the subtropical convergence region. Average Cu concentration in the antarctic waters in the depth range 100-500 m shows a similarity to that of the subtropical surface waters. The range of surface Cu observed in the present study-is 1-4.7µg/1 which agrees fairly well with the observations of Chester and Stoner (1974). However, average surface Cu in this study is higher than that in their study. This could be due to very few surface samples analysed by us.

In the antarctic polynya dissolved Cd decreases deeper down while the surface average is always lower than the average between 100-500 m for all the remaining 3 regions considered. As in the case of Cu, antarctic waters between 100-500 m have on an average almost the same Cd concentration as the subtropical surface waters. The overall range of surface Cd is 0.18-1.5µg/1 with an average of 0.8µg/1 which is much higher than that reported by Chester and Stoner (1974) for the world ocean waters (0.02-0.18 µg/l; avg 0.07µg/1). Concentrations as high as 4.2µg/1 of Cd have been reported in surface waters of the English Channel by Abdullah et al(l972). Stations in the present study reflect intermediate characteristics between oceanic and shelf waters.

Particulate Cu shows a scatter and indicates no trend of variation for drawing any definite conclusion while particulate Cd is almost negligible.

Iron and Manganese

Dissolved Fe shows a steady increase from the antarctic surface towards the subtropical surface while particulate Fe is fairly high in the antarctic region, reflecting the possibility of presence of high organic matter in the region resulting, probably, from ice melting. This can be seen from the very high value at the surface of the polynya (Stn. G_2, Table 1). Average dissolved Fe shows an enrichment in the 100-500 m depth in all the regions except in the antarctic divergence where the surface average is higher. At station G_{16}, a typical station of the subtropical region, dissolved Fe is higher at all depths than at other stations, the highest being at 500 m. Observation of concentrations of dissolved Fe between 100-500 m shows that, average dissolved Fe in the antarctic polynya is the lowest, intermediate in the antarctic region and the highest in the subtropical region.

Compared to Fe, Mn concentrations are low in the 100-500 m layer. In the polynya and antarctic divergence regions, Mn is higher in the 100-500 m layer than at surface while it is the reverse in the antarctic convergence region (Table 2). Particulate Mn is low throughout.

Zinc

Surface dissolved Zn is the highest in the antarctic polynya, the concentration being twice the surface average in the antarctic as well as the subtropical surface waters. At all the stations average Zn concentration at surface is higher than that at the 100-500 m layer. Average surface Zn in the antarctic and subtropical regions is about 23.3 µg/1. This compares well with the range 6.5-22 µg/1 from the North Eastern Atlantic (Riley and Taylor, 1972).

Particulate Zn at all the stations is higher at surface and intermediate layers while it decreases at depths thus adding to soluble Zn pool (Table 1).

Lead

Surface average Pb concentrations in the polynya and antarctic region are comparable while the

subtropical surface average is higher (Table 2). Pb is an element quite prone to contamination and as sucn no definite conclusion about any region can be arrived at, unless there is a close frequency of sampling. Particulate Pb does not show any specific trend of variation however the range ND-214µg/gm (dry weight) agrees well with the observation of Harris and Fabris (1979) for the Indian Ocean sector of the Antarctic Ocean.

Cobalt and Nickel

Concentrations of dissolved Co lie between non-detectable values to 1.9µg/1 while the particulate fraction is negligible. Average concentration from the polynya compares well with the subtropical average while in the antarctic region Co concentration is appreciably low (Table 2). In the subtropical region, average surface Ni concentration is 1.6µg/1 which is very similar to that in the antarctic convergence region while in the Antarctic divergence region it is almost twice as much. Our range of surface Ni is well within that quoted by Chester and Stoner (1974) for open ocean (<1-23.5 µg/1; avg 1.2 µg/1). However, our average is higher than theirs. This is due to very few samplings done by us. Particulate Ni is in general, negligible.

Only a few zooplankton samples could be collected during this Expedition.The results of the analysis have been given in Table 3. However, no comments can be made due to lack of sufficient data.

TABLE 3

Concentrations of trace metals in zooplankton (ppm, dry weight)

Stn. No.	Cu	Cd	Fe	Mn	Zn	Pb	Co	Ni
G10	14.5	NA	765	7.6	96.3	43.3	3.3	ND
G11	10.2	NA	441.8	9.1	70.2	26.8	3.8	2.9
G12	59.9	NA	2573	25.7	621.2	527.2	—	6.7
G13	40.3	NA	2474	26.4	770.2	179.5	8.5	16.6

NA—not analysed
ND—not detectable

Before drawing any conclusion, regarding the intercomparison of trace metal concentrations between the antarctic and subtropical regions, we require to collect many more samples at stations closely spaced over a wide area.

ACKNOWLEDGEMENT

We have great pleasure in acknowledging the help, advice and leadership of Dr. S. Z. Qasim during the on board work and Dr. V. V. R. Varadachari for his valued support during the shore job. We thank all the members of the Expedition team particularly Mr. M. C Pathak, for their help during the samplings. Thanks are also due to our colleague, Mr. Tariq Kureishy for helpine in the analysis of zooplankton samples.

REFERENCES

Abdullah, M. I., L. G. Royle and A. W. Morris 1972

Heavy metal concentration in coastal waters. *Nature, 235,*158-160,

Braganca A. and S. Sanzgiry 1980

Concentrations of a few trace metals in coastal and offshore regions of the Bay of Bengal.Ind. *J. Mar.* Sci., 9, 283-286.

Chester R. and J. H, Stoner 1974

The distributionof zinc , nickle, manganese,cadmimum,copper and iron in some surface water from the world ocean.*Mar. Chem,2,17-32.*

Danielsson. L.G. 1980
Cadmium, cobalt, copper, iron, lead, nickel and zinc in Indian Ocean water. ***Mar. Chem,, 8,*** **199-215**

Harris J. E. and G. J. Fabris 1979
Concentrations of suspended matter and particulate cadmium, copper, lead and zinc in the Indian Ocean Sector of the Antarctic region. ***Mar. Chem., 8,*** **163-179.**

Riley, J. P. and D. Taylor 1972
The concentrations of cadmium, copper, iron, manganese, molybdenum, nickel, vanadium and zinc in part of the tropical north-east Atlantic ocean. ***Deep-Sea Res., 19,*** **307-319.**

Sanzgiry S. and C. Moraes 1979
Trace metals in the Laccadive Sea. ***Ind. J. mar. Sci., 8,*** **254-257.**

Sanzgiry S. and A. Braganca 1981
Trace metals in the Andaman Sea. ***Ind. J. mar. Sci., 10,*** **238-240.**

Sen Gupta R., S. Y.S.Singbal and S. Sanzgiry 1978
Atomic absorption analyses of a few trace metals in Arabian Sea waters. ***Ind. J. mar Sci.,*** **7,295-299.**