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Baseline Data on Natural Radioactivity and Trace Metal Concentration in Natural Antarctic Samples

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Abstract

The Antarctic environment can be expected to provide a reference level for environmental and pollution studies due to its remoteness and restricted human activities. BARC participated in the Ninth Expedition mainly to collect background baseline data on natural radioactivity and trace heavy metal concentrations in air, water and rock samples and also to measure background gamma dose rate in air and tritium levels in the ocean as well as in Antarctic fresh waters. The observations made during this expedition and the results of the analyses on the samples collected are presented in this report.

Introduction

Man's impact on the oceanic environment has always been the cause of great concern. In order to obtain a background level concentration in a less habitated region like Antarctica, an extensive survey was carried out by collecting air, water and environmental samples during the Ninth Expedition from 30 Nov., 1989 to 27 Mar., 1990.

Natural Radioactivity Levels in the Atmosphere

Measurement of natural radioactivity levels in the atmosphere due to Radon and Thoron daughter radionuclides have been carried out enroute to and at Antarctica. Radon (Rn^{222}, 3.825 days half life) is a radioactive gas emanated in the decay chain of U^{238} It is radioactive tracer for studying the global air mass movements.

The solid decay products arising from Radon disintegration are present along with atmospheric aerosols. These were collected on high efficiency filter paper using an air flow rate of 450 litres per minute for about 2 hours. The filter paper samples were counted on a ZnS gross alpha counting system having overall efficiency of 35% and background of 2-3 counts per minute.

The Radon values over the ocean during the initial stages of cruise were of the order of 0.8 pCi/m^3. This was due to the presence of small amount of continental air along with maritime air. According to the meteorological data this continental air was from African continent. As the ship approached 20º South latitude, the Radon activity increased to 2.3 pCi/m^3 due to fresh input of continental air from Mauritius island. Between 20° and 40° South latitudes the Radon values reduced to 0.4 to 1.1 pCi/m^3 (see Table. 1).

Table 1: Measured Radon Levels over the Ocean and at Antarctica

Sr.No.	Location	Date of sample	Rn levels in pCi/m^3
1	15°N(Goa)	30.11.89	25.00
2	10°-5N	2.12.89	1.1
3	5°N-Equator	3.12.89	0.8
4	Equator-5°S	4&5.12.89	0.4
5	5°S-10°S	6.12.89	0.2
6	10°S-15°S	7.12.89	0.5
7	15°S-20°S	8.12.89	0.5
8	Mauritius	9.12.89	2.3
9	20°S-25°S	10&11.12.89	0.7
10"	25°S-30°S	12.12.89	0.5
11	30°S-35°S	13.12.89	0.4
12	35°S-40°S	14&15.12.89	1.1
13	40°S-70°S	16-24.12.89	0.5
14	Maitri	4.1.90	0.8*

*Average of 21 values.

Table 2: Distribution of Gamma Dose Rate at Schirmacher Oasis

Name of the rock type	Ambient gamma dose rate, uR/hr
Tourmaline Pegmatite	12.5
Quartz garnet boitite gneiss	12.7
Sheard metabasalt	11.4
Banded quartz biotite gneiss	10.7
Quartz biotite gneiss	12.7
Charmockite	11.7
Matabasalt	11.6
Sheard porphyritic granite	11.6
Biotite gneiss	11.6
Pegmatite	11.2

At Maitri, the average level of Radon activity was observed to be 0.8 pCi/m^3 which is less than the level generally observed on any land. This shows that emanation rate of Radon at Antarctica is low. Generally on Schirmacher, rate of Radon emanation will be poor as the earth crust is exposed only over small area of 55 sq kms.

The results found in the Ninth Expedition match very well with the Radon levels observed during eighth expedition (Eapen *et al.,* 1992).

Measurement of Gamma Dose Rate at Schirmacher Area

The survey of natural background gamma dose rate was carried out using NaI scintillation dose meter. This gives the ambient air dose rate in a given area. The locations for these measurements were selected depending on the predominant rock formation observed at Antarctica. It was found that there were no significant changes in the gamma dose rate over these locations. The gamma dose rate in general varied between 10.7 to 12.7 uR/hr.

Table 3: Levels of Tritium in Fresh Water Lakes near Maitri
(Location-70° 45.8' S Lat. and 11° 45.5' E Long.)

Sample no.	Date of collection	Tritium level in TU
LW1 2 kms E of Maitri	6.1.90	3.1±0.02
LW2 2 kms W Snout	7.1.90	14.8±2.2
LW3 4 kms E Russian Camp	8.1.90	45.3±1.0*
LW4 Main lake	7.2.90	<5.0

*Value is rather high and needs to be confirmed from future expedition.
1TU = 0.12 Bq of Tritium in 1 litre of water.

Table 4: Tritium Level in Sea Water Samples Collected enroute to Goa

Sr no.		Date of collection	Lat.	Long,	Tritium level TU
1	SW1	12.2.90	69°47'	12°04'	<5
2	SW2	4.3.90	65°03'	18° 07'	25±1.3
3	SW3	7.3.90	55°00'	36°23'	17.7±1.3
4	SW4	9.3.90	50°22'	41°21'	5.7±0.9
5	SW5	10.3.90	45°00'	45°09'	26.4±1.3
6	SW6	13.3.90	32°30'	53°40'	16.941.1
7	SW7	15.3.90	25°00'	55°58'	<5
8	SW8	20.3.90	10°00'	63°16'	16.241.1

Tritium Measurement in Antarctic as well as Marine Water

For Tritium level studies, water samples were collected in one litre capacity air tight PVC bottles. Four fresh water samples were collected from the lakes near Maitri station and eight sea water samples were collected enroute Goa. After returning to BARC, the samples were distilled and enriched for their Tritium content using electrolysis which was carried out in standardised glass cells at about 4°C. The enriched samples were distilled to the last drop and analysed in a scintillation spectrometer using 100 minutes counting.

Atomic tests mostly conducted in the northern hemisphere are the major source of Tritium in water in northern region. It is no surprise that quite low levels of Tritium have been observed in southern oceans as given above.

Trace Heavy Metals in Air

Heavy metals in air: For these studies the air borne particulate matter was collected on EPM 2000 filter papers. The samples collected were analysed for trace heavy metals like lead and copper. The concentrations of metals in air particulate at different locations enroute Antarctica as well as at Maitri were determined (Table 5). In general the levels of metals were found to decrease downwards to Maitri where these were the lowest. The levels of atmospheric Lead enroute was found to vary between 15.9 to 26.2 ng/m^2 while at Maitri it ranged from 0.23 to 0.74 ng/m^3 . The concentration of copper enroute was found to very from 5.93 to 49.7 ng/m^3 while at Maitri it was 0.33 to 1.7 ng/m^3.

Table 5: Atmospheric Lead and Copper Concentration in ng/m^3

Sr no.	Date of collection	Location	Concentration	
			Pb	Cu
1	1.12.89	12°1'N 72°2'E	15.91	49.7
2	3-5.12.89	5° 9'S 70° 4'E	26.2	14.5
3	6-8.12.89	13°8'S 58°32'E	23.3	5.98
4	10-12.12.89	26° 4' S 52° 6' E	16.0	6.4
5	12-14.12.89	35°6'S 46°51'E	8.0	4.3
6	5-8.1.90	Maitri	0.74	4.03
7	9-12.1.90	Maitri	0.27	1.17
8	19-22.1.90	Maitri	0.23	0.96
9	22-25.1.90	Maitri	0.29	0.44
10	28-31.1.90	Maitri	0.41	0.51
11	1-4.2.90	Maitri	0.33	0.4

Table 6: Lead, Cadmium and Copper Content in Water

Sr. no.	Location	Concentration in µg/L		
		Pb	Cd	Cu
	Lake Water			
1	Russian Camp	0.046	ND	0.41
2	2 Kms E. Maitri	0.039	ND	0.31
3	2 Kms W. Maitri	0.2S	0.015	0.98
4	Main Lake	0.43	0.17	1.87
	Sea Water			
5	60° S	0.34	0.05	Not analysed
6	55° S	0.3	0.09	"
7	32° S	0.49	0.13	"
8	25° S	0.76	0.22	"
9	10°S	0.23	0.04	"
10	Equator	0.49	0.15	"
Typical Bombay and Madras values in fresh water				
	Bombay	0.21-2.7	0.01-0.5	
	Madras	0.28-2.0	0.01-0.4	

Table 7: Lead, Cadmium, Copper and Zinc Concentration in Rock

Sr.no.	Type of rock	Concentration in µg/g			
		Pb	Cd	Cu	Zn
1	Sheared meta basalt	8.03	ND	2.5	17.8
2	Metabasalt	2.68	0.25	—	8.52
3	Pegmatite	0.29	ND	2.7	7.06
4	Granite	4.24	ND	1.13	4.49
5	Biotite gneiss	0.69	ND	8.00	—
6	Granite	1.16	0.04	0.27	1.48
7	Quartz biotite gneiss	2.0	ND	10.5	1.1
8	Leucogranite	0.2	ND	0.76	2.81

Heavy Metals in Water

Water samples were analysed for Lead, Copper and Cadmium. Sea water could not be analysed for zinc because of interference from chloride. These samples were directly measured for metals after acidification. The levels of metals in sea water enroute to Goa were found to be higher than in lake water at Maitri. The Lead concentration in sea water was found to vary from 0.3 to 0.76 µg/L while in lake water at Maitri it ranged from 0.05 to 0.43 µg/L. The Copper concentration in lake water at Maitri was found to vary from 0.31 to 1.87 µg/L. The Cadmium levels in lake and sea water was found to vary from 0.02 to 0.17 µg/L and 0.04 to 0.22µg/L, respectively.

Heavy Metals in Rock Samples near Maitri Site

There was a wide range in Lead levels in rock samples. The levels vary from 0.29 to 8.1 µg/g while copper ranged from 1.13 to 10.5 µg/g. The maximum and minimum levels for zinc were 1.1 and 17.8 µg/g respectively. The maximum level of cadmium in rock samples observed was 0.25 µg/g while minimum level was 0.04 u,g/g of rock.

Only a few studies have been carried out for finding the trace metals contents in rock samples at Antarctica. Kaul *et al,* (1988) have reported the Lead levels in basaltic rock at Antarctica to be < 5 µg/g.

Conclusions

Results of the measurements carried out on the samples collected by the participant from Bhabha Atomic Research Centre during Ninth Antarctica Expedition from 30.11.89 to 27.3.90 are reported. These results will provide a reliable data base regarding the natural radioactivity levels present in air water and other environmental samples as well the as heavy metal concentrations present over South Indian Ocean and at a remote location like Antarctica.

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