

Glaciochemical Studies in Antarctica

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Abstract

The concentration of some major ions (Na, K, Cl) and heavy metals (Fe, Co, Ni, Ca, Mg, Zn, Cu, Pb and Cd) of ten snow, ice and lake water samples collected near Dakshin Gangotri (D.G.) Station (70°S, 12°E) have been measured.

The concentrations of major ions are normalised to Na. These ratios are similar to that of seawater indicating that snow/ice/lake-water samples are influenced by the marine salts. However, the reason for high Cl/Na ratios in Maitree glacier ice and Wohlthat lake are somewhat puzzling,

The concentrations of heavy metals Zn, Cu, Pb, Cd, Co, Ni are below the detection limit indicating no significant anthropogenic contribution in the region under investigation.

Introduction

The Antarctic ice sheet is considered to be one of the important driving forces behind global atmospheric circulation. Antarctica is very well known to be the reference point for all environmental and pollution studies because of its remoteness and the climatic conditions, restricting human activities to minimal in this region. An examination of potential pollutants, therefore, should give a base value for comparing with time their increase in the marine environment. The comparison of glacial ice of Antarctica with the Himalayan glaciers can indicate the concentrations of pollutants at the southern and northern extremities of the Indian Ocean.

Recent glaciochemical studies provide better understanding of the chemical composition of Antarctic precipitation. (De Angeles *et al.*, 1984; Delmas *et al.*, 1982; Palais and Legrand, 1985; Sengupta and Qasim, 1983).

It has been established that the ionic budget of recently deposited Antarctic snow has marine influence. At the present time, great efforts are being made to determine the concentrations of alkali metals (Na, K, etc.) and heavy metals as pollutants like Fe, Co, Ni, Zn, Pb, Hg, Cd etc. to obtain historical records of

the concentrations of these elements in polar regions of both hemispheres. Concentrations to be measured are unfortunately of very low values in the range from fraction of a ppb to ppm levels (10^{14} to 10^6 g/g). So it becomes extremely difficult to collect the samples in the field and to analyse them in the laboratories without introducing an artifact contamination. Many published data are then erroneous upto several orders of magnitude (Wolf and Peel, 1985). Special care has to be taken in developing the procedures for sample collections and their analysis to obtain reliable data.

In the present preliminary work, a few selected samples of different nature like snow, ice, fast ice and lake water from Antarctica were collected near the Indian station Dakshin Gangotri (DG) (70°S, 12°E) in Antarctica to study the ionic concentrations of trace elements and heavy metals as pollutants which are expected to have very low concentration levels.

Materials and Method

Ten samples of snow, surface and glacier ice, iceberg, lake waters of Maitree and Wohlthat mountains, and fast ice were collected near the DG station in Antarctica. Special care was taken to clean the plastic bottles with 2% HNO₃ and then rinsing them with de-ionised water for several times. The bottles were finally rinsed with the sample water itself before the collection of samples. Wherever necessary, the samples were melted in specially cleaned plastic mugs and then transferred to the laboratories of BARC, Bombay and National Chemical Laboratory, Pune for analysis using Ion chromatograph, polarised Zeeman Atomic Absorption Spectrometer and Plasma Emission Spectrography. Na, K and Cl were analysed using Ion chromatography and other heavy metals on AAS and Plasma emission spectrography according to standard procedures.

Results and Discussion

The major ions (Na, K, Ca, Mg, Cl) and heavy metals (Fe, Co, Ni, Zn, Cu, Pb and Cd) concentrations of the ten representative samples of Antarctic snow/ice/lake water are given in Table I.

Major ion concentrations

(a) *Na and K*: Concentrations of Na and K in samples A, C, P, Q, R and W (Table I) range from 180-525 ppb and 40-680 ppb respectively. The samples, D, E and T have higher values by an order of magnitude indicating that these three samples which range from 4 to 82 ppm and 0.6 to 10 ppm respectively are of marine origin.

(b) *Ca and Mg*: Concentrations of Ca and Mg for the samples listed in Table I vary from 75 ppb to 13.6 ppm. The high concentrations of Ca and Mg (13.6 and 10.2 ppm) observed in the fresh snow sample 'A' indicate marine influence on the fresh snowfall that occurred near the Indian Bay on 1-1-1986

Table I. Concentration of few major elements and a few heavy metals in snow, ice and lakewater samples, Antarctica

Sample Code	Nature of Sample	Major Ion "Concentration							Heavy Metal" Concentration						
		Na	K	Ca	Mg	cl	Fe	Co	Ni	Zn	Cu	Pb	Cd		
A	Fresh Snow	185b	100b	13.6m	10.2m	510b	770b	BDL	BDL	615b	BDL	BDL	0.2b		
C	Shelf Ice (D.G.)	260b	40b	75b	BDL	710b	BDL	do	do	BDL	do	do	do		
D	Shelf Ice (Indian Bay)	4.5m	560b	209b	377b	8m	BDL	do	do	do	do	do	do		
E	Ice berg	19.5m	2.1m	1.06m	2.7m	35m	BDL	do	do	do	do	do	do		
P	Maitree lake	355b	200b	370b	154.5b	640b	BDL	do	do	do	do	do	do		
Q+	Snout Ice	370b	200b	1.3m	261b	1140b	277b	do	do	do	do	do	do		
R	Snout Water	525b	68Qb	811b	282b	540b	434b	do	do	do	do	do	do		
W	Wohlthatlake	340b	80b	445b	BDL	6000b	1.6m	do	do	do	do	do	do		
T	Fast Ice	82m	10m	4.5m	10m	V.H.	BDL	do	do	do	do	do	do		

*P.S. b = PP^b

m = ppm

+Maitree glacier snout ice at 10m depth.

Others are surface samples.

The samples E and T which show relatively higher values than other samples are of marine origin.

(c) *Cl* The concentrations of Cl for the samples D, E and T are observed to be 8, 35 and > 35 ppm respectively. The high values in these samples are expected due to their seawater influence. The other samples range from 500 to 6000 ppb.

Heavy metal concentrations

As can be seen from the Table I the concentrations of Co, Ni, Zn, Cu and Pb are below the detection limit of 1 ppb and 0.2 ppb for Cd. The high value of Fe Zn and Cd observed for fresh snow sample 'A' may be due to some contamination by the human activity as the sample was collected near DG station.

The concentrations of 'Fe' in the samples C, D, E are below the detection limit whereas the other samples vary from 277 ppb to 1.6 ppm.

With the limited data available, it may not be possible to explain the absolute concentration of individual samples for the trace metals discussed above,

Ratios of major ions

The concentration of major ions in these samples are normalised to Na (Table II) in order to delineate the effect of marine salts.

Table II. Ratios of few major ions normalised to Na in snow, ice and lakewater samples in Antarctica

Sample Code	Cl/Na	K/Na	Mg/Na	Ca/Na
Seawater	1.8	0.04	0.12	0.04
A	2.7	0.54	0.06	0.73
C	2.7	0.15	0.003	0.29
D	1.8	0.12	0.09	0.05
E	1.8	0.11	0.14	0.05
P	1.8	0.56	0.43	1.04
Q	3	0.54	0.44	3.50
R	1.02	1.25	0.12	1.54
W	17.6	0.23	0.003	1.30
T	1.8	0.12	0.12	0.05

Cl/Na ratios: Comparison of Cl/Na ratios of different samples with seawater ratio shows that samples, except Q and W, are comparable with that of seawater

which has the ratio of 1.8, The higher ratios of 3 and 17.6 in the samples Q and W which are located 100 and 200 km away from the coast, respectively, can be connected to the important depletion of Na or enrichment of Cl with the distance from the coast. The high ratios of 3 and 17.6 in the samples Q and W cannot be explained due to sodium depletion alone compared to coastal samples. The enrichment of Cl is also observed in both the samples (a factor of about 10 in case of sample W).

A tentative explanation is an input gaseous chlorine (Cl_2 , HCl) whose presence has been detected in various locations (Junge, 1957; Duce *et al.*/1965; Chesselet *et al.* 1972). Not much data is available on gaseous chloride but gaseous bromine and iodine have been detected in Antarctic environment. Higher Cl/Na ratios have been measured in precipitations (Rosby and Hegner, 1955; Tsunogai *et al.*, 1972) and explained by input of gaseous chlorine. However, we cannot discard the possibility of part of this chlorine originating from volcanic or manmade sources and human activity. Before any conclusions can be drawn, systematic sampling and analysis should be carried out in this region from coastal to polar ice inland upto hundreds of kilometres.

K/Na and Ca/Na ratios: The K/Na and Ca/Na ratios show a marked enrichment of K and Ca by a factor of 3 to 30 in case of K and 8 to 100 in case of Ca. The sample W shows enrichment of K by a factor 30 whereas the samples Q, R and W from Maitree and Wohlthat mountains show an enrichment of 30 to 100 for Ca. The higher ratios indicate that K and Ca are enriched due to weathering processes. The ratios of K/Na and Ca/Na for the samples D, E and T are the same or comparable with that of seawater as expected due to their seawater origin.

Mg/Na ratios: As expected Mg/Na ratios in the samples D, E and T (Table I) are comparable with that of seawater (0.12). In case of samples A, C and D, ratios are lower than that of seawater suggesting no leaching of Mg from any other sources, whereas the samples P and Q (Table I) from Maitree are enriched by a factor of three indicating contribution by weathering processes.

Suggestions

Glaciochemical studies on snow/ice/lake water samples from Antarctica should be continued by providing better sampling and laboratory facilities under ultra clean conditions.

Sampling of snow/ice should be carried out as a function of distance from the coast upto 1000 km towards the south pole to have better understanding of the marine influence on the chemical composition of ice. The present day levels of chemical constituents and pollutants can be compared with that of past by studying ice cores from shelf ice as well as from polar ice.

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