

METAL CONCENTRATIONS IN WATER BODIES OF SCHIRMACHER OASIS, ANTARCTICA : AN ASSESSMENT

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Introduction

Antarctic Treaty Consultative Meeting (ATCM) held in Gorizia, Italy in 1993 emphasized the necessity of long term monitoring programmes to verify the impacts of human activities such as tourism and scientific research on the physico-chemical attributes of antarctic ecosystems. The SCAR/COMNAP document on the environmental monitoring (1992) also referred close monitoring of the chemical compounds (eg. Heavy metals and/or selected anions in waste water, soil, snow etc.) alongwith the biological indices of the Antarctic ecosystems (SCAR report, No. 12, October, 1996). Monitoring of the concentrations of metal ions (including heavy metals) is an important prerequisite for the assessment of the aesthetic value of the lake water of Antarctica. The toxic impacts of heavy metals on plants and human beings are well established therefore, a sufficient bulk of baseline data regarding the concentrations of heavy metals in lake water as well as timebound variations in the concentrations of these metals is essential for the timely implementation of remediation processes.

Present communication describes the results obtained by the analysis of the samples collected during the austral summer (1997-98) of the 17th Indian Antarctic Expedition. Concentrations of twelve metals were determined in the water samples collected from different sites around the permanent Indian station 'Maitri' situated in Schirmacher Oasis.

Material and Methods

The objective of the water quality monitoring of the lakes around 'Maitri' (70°, 45' 52" S : 11°, 44' 03" E) in the Schirmacher Oasis, Antarctica was to (i) determine the quality of water in its natural state which might be available for the future needs and to assess (ii) the impact of activities by human and scientific operations upon the quality of water in its suitability for required uses.

Study Sites : Water samples were collected from 40 different locations (Fig.1) at a particular time and represents only the composition of the source at that time.

Control : This comprises of lakes where no human activity was found in the vicinity eg. DG lake and Epsilon or Long lake in the Central Schirmacher, west of 'Maitri' and CL1, CL2 and CL3 lakes as shown in Fig.1. The observations of these lakes have been pooled to represent the undisturbed control sites (Table -1).

Priyadarshini : Sampling from M1 to M6 and M11 to M19 has been presented in the Fig.1.

Waste Disposal Pond (WDP) : The waste water is collected from the kitchen, urinal and wash room in the waste discharge pond. Periodically it is pumped out and discharged few hundred meters away as shown in Fig.1. From the discharge point of the pumped waste water, the water trickles down to the waste disposal pond (GL/L). Water renewal is a constant feature in this pond due to the snow melts of the Glacier in the South. This causes rapid dilution of the metals in the summers (see sampling points WDP1 to WDP4 and Li1 to Li2 in Fig.1).

Behind Aditya Generator Complex (BAG) : Sampling was done in the small stagnant pool of water behind the generator complex expressed as BAG1 to BAG4 and GL/R (Fig.1 and Table. 1).

Pipeline Sites : This comprises of water samples just beside the drinking water pipeline in the Priyadarshini-lake (P2 to P6) upto the

container complex and P1 from the pump house (Fig.1 and Table.1).

Sampling procedure : Samples were collected in 1 litre bottles for the study of Acid-Extractable Metals. At the time of collection the entire sample was acidified with 5 ml conc HNO₃/L sample. Before analysis, the sample was well mixed and transferred to 100 ml flask and added 5 ml 1+1 high purity HCl. The same was heated for 15 min on a steam bath and filtered through membrane filter and the filtrate volume was adjusted to 100 ml for further analysis. Metal analysis was carried out by Atomic Absorption Spectrophotometer were as the analysis of Sodium and Potassium were estimated by flame photometer (Greenberg et al., 1992).

Results and Discussions

Cadmium is regarded as one of the most toxic elements in the environment. Its persistence in the environment, rapid uptake and accumulation in the food-chain contributes to its potential hazards. Recommended level of cadmium in drinking water is 0.01 µg/ml (US and Indian Standards) and 0.005 µg/ml according to WHO guideline values. Maximum concentration of 0.05 µg/ml Cd was recorded in waste disposal pond which was slightly lowered in Priyadarshini (0.047 µg/ml). Taking into account the concentration of Cd adjacent to the pipeline sites (0.03 µg/ml), it is assumed that per day intake of 2 liters of water and only 6% absorption in the gut, the daily intakes of cadmium is 3.6 µg which is very high. (WHO 1984, Murti CRK and Vishwanathan P. 1991). Most of the Cd absorbed is deposited in the liver, binding to a low molecular weight protein-metallothionin which has a high binding capacity for Cd, Zn and Cu (Table.2). Later on Cd is transferred from the liver to the kidney and eventually accumulates in the kidney cortex. In long term, low level exposure, the kidney is regarded as the critical organ and it has been estimated that renal dysfunction may appear when the Cd concentration in the renal cortex is around 200 mg/kg wet weight (Friberg et al, 1974 and Roels et al, 1983). Toxicity of Cd to plants and microorganisms has been assumed in the presence of divalent cations (eg. Zn, Mg, Mn, Ca and Fe).

Cd has been shown to inhibit enzyme activity, oxidative phosphorylation and photosynthetic rates, to alter cell membrane permeability and integrity, to interfere with RNA and protein synthesis and to complex with DNA. By this multipronged influence on the cell, it is not surprising that Cd may affect several aspects of microbial growth (Babich and Stotzky, 1978).

Chromium is ubiquitous in nature most commonly found in the divalent state, but hexavalent compounds are also in small quantities (Langard and Norseth, 1978). Chromium is an essential micronutrient in some mammalian diet including humans (Mertz, 1969; Schroeder et al, 1962) but not essential to plants. After uptakes Cr accumulates in the roots and only a small amount reaches the leaves (Wallace et al 1976) which produced Chlorosis in tomato and potato (Hewitt, 1953) and a number of deleterious effects viz. Chromosome aberrations and mutations in *Allium cepa* (Sahi et al, 1998). Similar results are expected in the mosses growing in close contact of the water having high chromium content eg. Priyadarshini lake (0.078 µg/ml) where chromium content was considerably high above the prescribed limit of 0.05 µg/ml by the WHO, US and Indian standards.

Copper is frequently found in surface water and is an essential micronutrient for plants and animals. Copper deficiency as an outcome of the disturbance of trace metal metabolism in the human body may occur eg. Genu Valgum syndrome, a new manifestation of classical flurosis. Copper concentration in the water samples around 'Maitri' was found to be appreciably higher than the prescribed limit of 0.05 µg/ml in drinking water except the undisturbed sites designated as control.

There is evidence that Manganese occurs in surface water, both in suspension in the quadrivalent state and in the trivalent state in a relatively stable, soluble complex. It is rarely present beyond 1 mg/L. But at few sites e.g., BAG and Pipeline sites the level of Mn was appreciably higher than the prescribed limit of 0.01 mg/L. Similarly the concentration of Iron also exceeded the limit of 0.03 mg/L (WHO, 1971) in drinking water at almost every site and ranged between 0.38 µg/ml to 1.03 µg/ml in Priyadarshini Lake and

control, respectively.

The present study will serve as the baseline data for future environment impact assessment programme and in predicting a better environment management strategy.

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Table 1: Metal concentrations ($\mu\text{g/ml}$) in water bodies around Indian station "Maitri".

Metal	Control	Priyadarshini	WDP	BAG	Pipeline sites	LSD
Cadmium	0.0	0.047 ± 0.03	0.050 ± 0.003	0.020 ± 0.005	0.029 ± 0.018	0.046
Copper	0.0	0.055 ± 0.035	0.073 ± 0.024	0.313 ± 0.156	0.130 ± 0.045	0.297
Chromium	0.017 ± 0.002	0.078 ± 0.032	0.010 ± 0.004	0.020 ± 0.005	0.005 ± 0.002	0.427
Nickel	0.008 ± 0.005	0.200 ± 0.009	0.029 ± 0.013	0.015 ± 0.007	0.022 ± 0.011	0.028
Lead	0.016 ± 0.002	0.055 ± 0.009	0.042 ± 0.006	0.048 ± 0.015	0.030 ± 0.015	0.034
Calcium	0.040 ± 0.022	2.483 ± 0.688	3.380 ± 0.675	4.980 ± 0.529	4.271 ± 1.036	1.932
Iron	1.036 ± 0.792	0.382 ± 0.031	0.657 ± 0.163	2.902 ± 0.226	0.690 ± 0.189	1.23
Potassium	1.250 ± 0.250	1.250 ± 0.250	2.830 ± 0.210	7.833 ± 0.0641	3.333 ± 1.062	1.711
Magnesium	0.320 ± 0.020	0.885 ± 0.217	1.202 ± 0.184	3.073 ± 0.079	1.520 ± 0.367	0.614
Manganese	0.012 ± 0.003	0.050 ± 0.011	0.050 ± 0.04	0.147 ± 0.07	0.175 ± 0.082	0.109
Sodium	3.500 ± 0.000	10.167 ± 2.076	16.333 ± 2.905	36.166 ± 0.601	16.833 ± 4.233	7.239
Zinc	0.075 ± 0.054	0.051 ± 0.005	0.064 ± 0.078	0.056 ± 0.02	0.056 ± 0.073	0.039

Table 2: Consequences of metal concentrations above the permissible limits in drinking water.

Metal	Permissible limit in drinking water	Consequences of above permissible limit concentrations
Cadmium	0.01	Renal dysfunction, Respiratory diseases
Copper	0.05	Eye inflammation, hepatic and renal damage
Chromium	0.05	Liver necrosis, nephritis, irritation, gastrointestinal mucosa
Nickel	0.05	Embryo toxic and nephrotoxic effects, contact dermatitis
Lead.	0.10	Reduced hemoglobin,
Iron	0.03	Peripheral nerve dysfunction
Manganese	0.10	Decrease in systolic BP, disturbed excretion of 17 ketosteroid

