Thirteenth Indian Expedition to Antarctica, Scientific Report, 1997
Department of Ocean Development, Technical Publication No. 11, pp. 313-321

Characterisation of Selective Soil and Sediment Samples around Indian Station Maitri in Schirmacher Oasis, East Antarctica

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Abstract

In view of scientific activities round the year in Indian Antarctic station Maitri since 1988, critical assessment of soil and sediment, which play key role in ecosystem functioning, were carried out under the programme of detailed EI A studies. Altogether 16 samples were collected from different points of the Zub lake, seepage water channel and open land. The parameters studied were particle size, texture, water holding capacity, pH, nutrient load, CEC, organic content, hydrocarbon and oil & grease contamination. In general, soil is coarse, sandy, having water holding capacity 28 to 52% and poor in nutrient and organic contents. Hydrocarbon and oil & grease were observed to be comparatively more in seepage channel.

Introduction

Antarctica is an isolated glacial continent covering an area of 14 million km^2 of which only *2%* constituting of rocks and soil is free from ice during austral summer. Earlier studies revealed limited growth of plant because of extreme cold and non availability of nutrients in Antarctic soil and water (Lars 1988, Joshi and Banerjee 1988). Biotic and abiotic components are especially intimate in soil and sediment which consist of the weathered layer of the earth's crust with living organisms and products of their intermingled. The role of soil type, plays in ecosystem function, depends on the stage in geological and ecological development (Kellogg 1975, Richards 1974).

Scientific expeditions by Indians at Schirmacher region of Antarctica is a regular feature since 1981. While the station Dakshin Gangotri was installed on shelf ice in 1983-84, the permanent station Maitri was build on rocky terrain during 1988- 89. Considering the major activities of earlier expeditions around the station, viz. emissions from fuel generations, oil spillage (Plate 1), waste-water seepage and solid waste dumping, the deterioration of soil characteristics

Plate I: Spillage of fuel causing soil pollution on the bank of Zub lake

has been taken into account, and accordingly during 13th expedition (Jan-Feb. 1994) the locations were identified and soil samples were collected around the Maitri Station for detailed characterisation.

The wastewater generated from the Maitri station is passed through the biodises B1 and B3 for treatment from where the treated wastewater is collected in two ponds and subsequently discharged on land. In view of steeper slope, a seepage channel has been originated and found its way to meet the Zub lake. This warrants assessment and monitoring of sediment qualities of the Zub lake, associated seepage channel and waste collecting ponds.

Materials and Methods

Study site

The Schirmacher Oasis, forming a part of Dronning Maud Land, is about 90 km south of Princess Astrid coast of East Antarctica. It is an E-W tending low lying range with the maximum width of 3.5 km in the central part. It has a length of about 20 km and total area of about 35 sq km. The Schirmacher range comprises of a group of low lying hills about 50 to 200 m interspersed with a few glacial lakes ranging in size for 0.02 to 0.70 km^2. The present study covers the surrounding areas of Maitri station including the areas having activities and no activity zone.

Soil and Sediment Collection and Analysis

Around the station nine sampling locations were selected and surface coring soil samples were collected using auger. The collected samples Were stored in polyethylene bags. Additionally one sample from 1 m depth coring near Laser heterodyne hut was also collected. The sampling locations are depicted in Fig.l. Specific physico-chemical parameters, viz. particle size distribution, texture, water holding capacity, pH, nutrient load, cation exchange capacity, exchangeable cations and percent organic content were analysed as per the standard methods (1992). Hydrocarbons and oil & grease in soils were also estimated to signify the impact of oil spillages if any, leading to the deterioration of soils.

Seven sediment samples were also collected from different locations by using an acrylic/metallic hand coring device, wrapped in aluminium foil and refrigerated at 4°C. The sampling locations are depicted in Fig. 1. The samples were analysed for total carbon, nitrogen, sulphur, oil & grease and hydrocarbon.

Results and Discussion

Physical Quality of Soil and Sediment

The physical nature of soil as presented in Table 1 is characterised by selecting specific parameters, viz. particle size distribution, water holding capacity and soil textural class. Knowledge of particle size distribution leads to important conclusion about the oxygen and parent materials of soils. The particle size distribution of soils collected from impact zone in terms of percentage of sand, silt and clay is shown in Table 1. Percent composition of different particles stand as, clay 3.92 to 6.48%, silt 3.48 to 12.86%, coarse sand 56.42% to 76.38% and fine sand 9.29 to 34.18%. The results indicate that the area is dominated by sandy and loamy sand type of soil. The water holding capacity of the soil in the study area varied between 28 and 52%.

The sediments collected were found to be rich in coarse particles size, moderate in crystalline particles and dominated by pebbles. The earlier study also indicated almost similar particles size distribution (Ingole and Parulekar 1990, 1993).

Chemical Properties of Soils and Sediments

The results obtained for chemical properties are summarized in Table 2. The pH of soil is an important factor which indicates the alkaline and acidic nature of soil, controlled by the high concentration of basic cations and excess

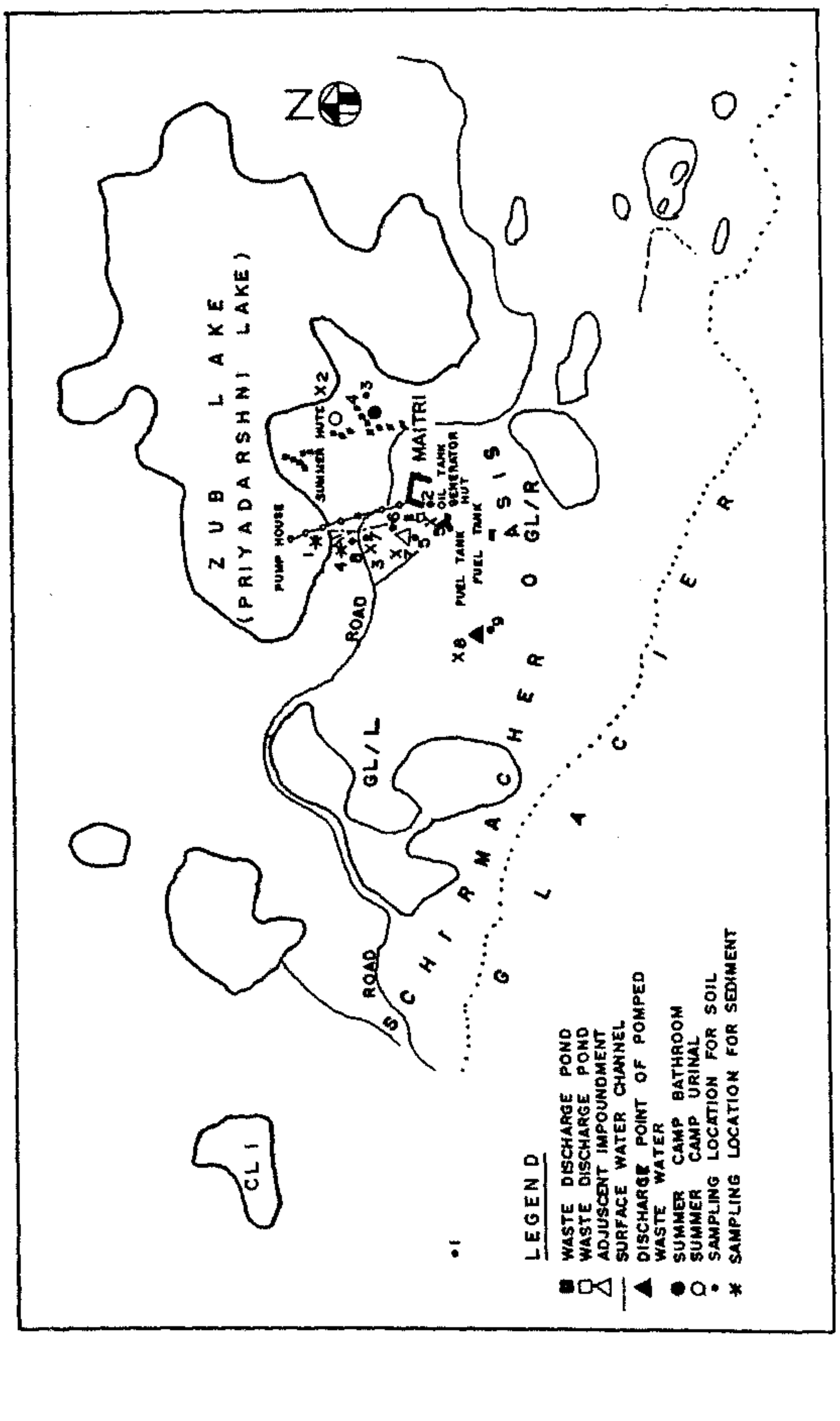

Fig. I: Locations selection for soil and sediment quality

Table 1: Physical Properties of Soil

Sr.No.	Sampling location	Particle size distribution (%)				Soil textural class	Water holding capacity (%)
		Coarse	Silt	Clay	Fine sand		
1.	Near German hut at Western side of Maitri station	56.42	3.48	3.92	34.18	Sandy	42
2.	50 m behind Aditya (Generator)	76.38	6.89	5.38	9.29	Loamy sand	28
3.	Surface coring sample closed to Laser heterodyne hut	74.38	4.82	4.36	13.32	Sandy	38
4.	1 meter deep coring sample closed to Laser heterodyne hut	68.42	4.72	6.42	18.48	Sandy	48
5.	100 m North-West of B_1B_3 pond	72.62	8.43	6.32	9.68	Loamy sand	52
6.	Near impoundment	74.68	4.38	4.32	14.36	Sandy	48
7.	16 m downstream of sampling point 6	73.48	4.22	4.80	16.32	Sandy	32
8.	25 m downstream of sampling point 6	68.32	5.96	5.16	18.46	Sandy	36
9.	Near pumped wastewater	68.16	12.86	6.48	9.98	Loamy sand	32

organic matter. The pH of soil in the study area was found to be alkaline and in the range of 6.8 to 8.2. The nutrient load in terms of available nitrogen, total nitrogen and percent organic matter varied from 1.62 to 3.86 mg/100 gm, 2.42 to 4.62 mg/100 gm and 2.80 to 10.62% respectively. Among the exchangeable cations Ca^{++}, mg^{++}, Na^{+} and K^{+} were found in the range of 9.48-14.23,3.8-8.2, 0.8-2.7 and 2.8-10.62 meq/100 gm respectively. Cation exchange capacity (CEC) is the important property of soils generally used for characterising its ability to supply cation nutrients to plants. CEC is consequence of positive electric charges on clay and humus particles in soils and is balanced by adsorption of positively charged counter ions. It is the property that largely determines the storage capacity of the soil for plant nutrient ions. The CEC of the soils in the region was found in the range of 19.42 to 28.48 meq/100 gm of soil. The results obtained for oil & grease and hydrocarbon are summarized in Table 3. While the concentration of hydrocarbon was found to vary from 0.04

Table 2: Chemical Properties of Soil

Sr. No	Sampling location	*p*H	Available nitro gen (mg/100 gm)	Total nitrogen (mg/100 gm)	Cation exchange capacity (meq/100 gm)	Exchangeable cations (meq/100gm) Ca^{++}	Mg^{++}	Na^{++}	K^{++}	Per cent organic matter
1.	Near German hut at Western side of Maitri station	7.2	1.62	2.42	19.42	11.24	3.8	2.6	0.9	2.80
2.	50 m behind Aditya (Generator)	7.9	2.06	3.16	24.26	10.48	4.3	1.9	1.2	8.2
3.	Surface coring sample closed to laser heterodyne hut	6.8	2.48	2.98	26.32	11.3	6.8	4.2	1.1	3.26
4.	1 meter deep coring sample closed to laser heterodyne hut	7.2	2.19	3.06	28.48	14.23	7.8	4.3	1.1	6.8
5.	100 m North-west of B_1B_3 pond	8.1	3.82	4.62	26.32	48	8.2	2.8	0.8	10.62
6.	Near impoundment	7.9	2.42	3.72	28.36	14.16	7.2	4.8	1.3	9.2
7.	16 m down stream of sampling point 6	8.2	1.92	2.48	22.48	9.48	6.32	2.7	1.8	5.2
8.	25 m down stream of sampling point 6	8.1	1.96	2.04	28.36	13.96	7.20	3.8	2.7	4.02
9.	Near pumped wastewater	7.8	3.86	4.04	27.36	12.62	6.8	2.8	1.9	3.6

to 2.04µg/gm, oil & grepe was found to be in the range of 0.24 to 8.42 mg/gm of soil. Higher levels were recorded in the areas prone to spillage.

The ultimate analysis of sediments in terms of percentage of carbon, nitrogen and sulphur is summarized in Table 4 and found to be in the range of 1.02 to 4.28, 1.84 to 2.80 and in non- detectable level respectively. The levels of oil & grease and hydrocarbon (Table 5) were observed to fluctuate within

Table 3: Oil & Grease and Hydrocarbon of Soil

Sr. NO	Sampling location	Oil & Grease (mg/g)	Hydrocarbon (µg/g)
1.	Near German hut at Western side of Maitri station	0.24	0.04
2.	50 m behind Aditya (Generator)	1.82	0.32
3.	Surface coring sample closed to Lasser heterodyne hut	1.76	0.56
4.	1 meter deep coring sample closed to Lasser heterodyne hut	2.42	0.48
5.	100 m North-west of B_1B_3 pond	8.42	1.32
6.	Near impoundment	7.12	2.04
7.	16 m down stream of sampling point 6	4.06	1.68
8.	25 m down stream of sampling point 6	3.28	0.66
9.	Near pumped wastewater	2.52	1.08

Table 4: Chemical Characteristics ofSediments from Selected Water Bodies (values are in percent of air dried samples)

Sr. No	Sampling location	Total carbon	Total nitrogen	Total Sulphur
	Zub lake			
1.	Near confluence point of seepage channel	4.28	2.80	ND
2.	Closed to summer camp urinal	1.02	1.84	ND
	Seepage channel			
3.	Before road	3.84	2.63	ND
4.	3 m before confluence	2.16	2.04	ND
5.	Wastewater pond B_1	1.98	2.76	ND
6.	Wastewater pond B_3	3.26	2.48	ND
7.	Impoundment, N-W side of B_1B_3 ponds	2.57	2.16	ND

Table 5: Oil & Grease and Hydrocarbons of Sediments around Indian Station Maitri

Sr. No.	Sampling location	Oil & Grease (mg/g)	Hydrocarbon (μg/g)
	Zub lake		
I.	Near confluence point of seepage channel	1.52	0.08
2.	Closed to Summer camp urinal	0.68	0.11
	Seepage channel		
3.	Before road	1.18	0.16
4.	3 m before confluence to Zub lake	1.32	0.42
5.	Wastewater pond B_1	1.13	0.38
6.	Wastewater pond B_3	1.24	0.23
7.	Impoundment, N-W side of B_1B_3 pond	1.36	0.14

the ranges 0.68 to 1.52 mg/g and 0.08 to 0.42 ug/g respectively. Identification of low levels of oil & grease and hydrocarbons in Zub lake sediments and comparatively higher levels in seepage water channel clearly indicates flow of these contaminants to lake water during austral summer. This seepage channel which crosses the road meant for vehicle movement may enhance the levels of pollutants carrying to Zub lake.

Acknowledgement

The authors wish to thank the Department of Ocean Development (DOD), Government of India, for providing the opportunity to participate for TK Ghosh in 13th Indian Scientific Expedition to Antarctica. They are also grateful to Prof.P.Khanna, Director, NEERI and Dr.R.Sarin, Scientist and Head, BRT Division, NEERI, for all sorts of co-operation and providing necessary facilities.

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