Soil and sediment quality of different Islands & Peninsulas at Larsemann Hills, East Antarctica

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Abstract

Soil represents the loose and unconsolidated materials through the disintegration of rocks. The soil comprises of mineral and organic constituents differentiated into horizons of variable depth, which differs, from the materials underneath in morphology, physical make up, chemical properties and composition and biological characteristics. Soil serves as a reservoir of nutrients. The impact of pollutants on soil quality may be a rather slow process but it may be of greater concern in the long run. The percolation of pollutants may get accumulated in the soil and ultimately affect its quality.

Soil and sediment samples were collected from various Islands and peninsulas of Larsemann Hills i.e. Bharti Island, McLeod Island, Fisher Island, Broknes and Stornes Peninsula. The assessment of the soil quality would help in understanding the likely impacts of the proposed construction activities on the land environment. The impacts on soil quality may be a rather slow process but it can sometimes cause concern in the long run. The fall out of heavy metals and other pollutants present in the smoke and dust emitted from construction site, local vehicular traffic and other sources may get accumulated in the soil and ultimately affect the trace metal concentration. Studies were carried out in Larsemann Hills area, for estimation of Physico – chemical quality characteristics of the soil and sediment. No radiation contamination was observed in any soil sample during the study period.

Keywords: Soil quality, physico-chemical parameter, sediment, Antarctic soil

Introduction

Antarctica has more than 98% ice cover and only about 2% rocky area. Rocky area was selected for the constructions of India's third scientific research station 'Bharti' in east Antarctica. As in other parts of the world, Antarctica may also experience land use changes due to a number of activities - both man-made as well as natural.

Soil represents the loose and unconsolidated materials derived through the breaking down of rocks. The soil is a natural constituent of plants, animal, mineral and organic materials differentiated into horizons of variable depth. It

also differs from the material below in morphology, physical make up, chemical properties, composition and biological characteristics. The comprehensive study of soil system in terms of its composition and contamination with a toxic chemical is of vital significance because it is an integral part of the bio-geographic system.

The soil comprises of mineral and organic constituents differentiated into horizons of variable depth, which differs, from the materials underneath in morphology, physical make up, chemical properties and composition and biological characteristics. The impact of pollutants and human activities on soil quality may be a rather slow process but it may be of greater concern in the long run. The percolation of pollutants may get accumulated in the soil and ultimately affect its quality.

Land environment study is an important study for prediction of various impacts due to construction and operational activities. The impacts on soil quality may be a rather slow process but it can sometimes cause concern in the long run. The fall out of heavy metals and other pollutants present in the smoke and dust emitted from construction site, local vehicular traffic and other sources may get accumulated in the soil and ultimately affect the trace metal concentration. Studies were carried out in Larsemann Hills area, for estimation of Physico – chemical quality characteristics of the soil and sediment.

Generally, the migration of pollutants released in an environment in the land occurs through the ground, and when it interacts with the water table, it can pollute the ground making it unsuitable for domestic use and growth of plants. As no major regular polluting activities or industries were present in the study area and no land is required for domestic and agricultural uses, so the chances of soil pollution are very less.

The Larsemann Hills is an ice-free area of approximately 50 km^2, located halfway between the Vestfold Hills and the Amery Ice Shelf on the south-eastern coast of Prydz Bay, Princess Elizabeth Land, East Antarctica (69°30'00" S,76°19'58" E). The ice-free area consists of two major peninsulas (Stornes and Broknes), four minor peninsulas, and approximately 130 near-shore islands. Nella Fjord further divides the eastern-most peninsula, Broknes, into western and eastern components. The closest significant ice-free areas are the Bolingen Islands (69°31'58" S, 75°42'E) 25 km to the south-west and the Rauer Islands (68°50'59" S, 77°49'58" E) 60 km to the north-east (Stüwe et al., 1989).

India is presently carrying out scientific research programs on the Bharati Island between Quilty bay and Thala Fjord. The nearest Islands/peninsulas are Stornes and Broknes Peninsula, Fisher Island and Mcleod Island. Loose Soil is found in the catchment area of these Islands/peninsulas. Larsemann Hill area was chosen to study existing soil characteristics.

Methodology

To investigate the existing Soil and sediment quality of the study area, samples of Soil from different locations were collected to cover important aspects of the physical and chemical properties of soil quality therein(Tables 1, 2A and 2B). Undisturbed soils and sediments samples representative of the area was collected by means of the auger. Soil and sediment samples collected from different locations in the study area have been assessed in the study area.

A preliminary reconnaissance survey was made to get a general picture of the area's land use. The activities around the sampling sites were also taken into consideration to learn the sources of pollution, if any or factors governing the Physico-chemical properties of the Soil. The study was carried out to analyse the soil quality of the area and to assess the impact of constructional and operational activities on land environment.

The team comprising of SIIR scientist and associate members visited the site and identified the exact locations for soil and sediment sampling. At each location, the sample was collected with the help of hand-driven sampling augers from sub-surface region. Topsoil samples from all locations at a depth of 15 cm. (sub surface) of the soil profile in the region were collected for Physico-chemical analysis. Sediment samples were collected from the bottom of various lakes.

Samples were collected from several locations of Bharati Island, Fisher Island, Mcleod Island, Broknes and Stornes peninsula by adopting established sampling procedures given in the IS: 2720 specifications. Undisturbed soil samples which are representatives of the area, were collected by using an auger. Detailed analysis of collected soil samples was conducted using the methodologies given in various relevant protocols as specified in IS: 2720. Chemical, titrimetric, gravimetric and instrumental methods were used for various analysis. HPLC grade water was used for reagent preparation, samples dilution and blank corrections. Analytical Reagents (AR) were used in the analysis. Attention was paid to collecting an adequate amount of composite samples for analysis with the standard methods. Samples were homogenized before testing. The samples were packed in dependable, waterproof containers. They were marked accurately and distinctly, brought to the SIIR laboratory for testing, and analyzed as per ASTM, USEPA.

Sediment samples from all locations were collected from Lake Bottom for Physico-chemical analysis. The other thing related to handling, storing, packing, transporting, and analytical procedures were followed, like the soil samples. Sediment samples from the Lake were collected from the bank area of the Lake because the entire Lake was in frozen condition.

Table- 2: Zooplankton diversity of Lakes at Bharti Island, Larsemann Hills

S.N.	Parameter	Protocol/Test Method
1	pH	IS: 2720 (pt-26)
2	Conductivity, µs/cm	Conductivity Meter/APHA 21st Edition
3	Sodium (as Na_2O), % by mass	AAS/ICP/APHA 21st Edition
4	Potassium(as K_2O), % by mass	AAS/ICP/APHA 21st Edition
5	Calcium (as CaO), % by mass	AAS/ICP/APHA 21st Edition
6	Magnesium (as MgO), % by mass	AAS/ICP/APHA 21st Edition
7	Iron (as Fe_2O_3), % by mass	AAS/ICP/APHA 21st Edition
8	Aluminum (as Al_2O_3), % by mass	AAS/ICP/APHA 21st Edition
9	*Phosphorus (as P_2O_5), mg/kg*	AAS/ICP/APHA 21st Edition
10	Cadmium (as Cd), mg/kg	AAS/ICP/APHA 21st Edition
11	Chromium (as Cr), mg/kg	AAS/ICP/APHA 21st Edition
12	Zinc (as Zn), mg/kg	AAS/ICP/APHA 21st Edition
13	Manganese (as Mn), mg/kg	AAS/ICP/APHA 21st Edition
14	Copper (as Cu), mg/kg	AAS/ICP/APHA 21st Edition
15	Chloride (as Cl), % by mass	Volhard's Method
16	Sulphate(as SO_4), % by mass	IS: 2720 (pt-27)
17	*Radiation Contamination, (as Cs-137) Bq/kg*	AERB Guideline

Table-2A: Details of the Soil sampling locations

S.N.	Sampling Point	Point Code	Location	Latitude	Longitude
1	Near Lake L1	SQ – 1	Bharati Island	69° 24' 18.5"	76° 11' 32.2"
2	Near Lake L2	SQ – 2	Bharati Island	69° 24' 25.4"	76° 11' 27.4"
3	Near Lake L3	SQ – 3	Bharati Island	69° 24' 21.9"	76° 11' 13.8"
4	Near Lake L4	SQ – 4	Bharati Island	69° 24' 32.1"	76° 11' 46.7"
5	Near Lake L5	SQ – 5	Bharati Island	69° 24' 26.0"	76° 10' 59.0"
6	Near Lake L6	SQ – 6	Bharati Island	69° 24' 33.2"	76° 10' 32.8"
7	Near Lake L7	SQ – 7	Bharati Island	69° 24' 31.9"	76° 11' 23.0"
8	Near Lake L7A	SQ – 7A	Bharati Island	69° 24' 29.4"	76° 11' 45.2"
9	Near Lake L8	SQ – 8	Bharati Island	69° 24' 55.7"	76° 12' 43.7"
10	Near Lake L12	SQ – 12	Bharati Island	69° 25' 03.1"	76° 11' 32.4"
11	Near apple Hut	SQ – A	Bharati Island	69º 24' 21.2"	76º 11' 25.3"

12	Near melon Hut	SQ – M	Bharati Island	69º 24’ 28.7”	76º 11’ 05.3”
13	Near Lake ST1	SQ –ST1	Stornes Peninsula	69° 26' 45.4”	76° 07' 02.6”
14	Near Lake ST2	SQ –ST2	Stornes Peninsula	69° 26' 18.8”	76° 07' 36.0”
15	Near Lake ML1	SQ-ML1	Mcleod Island	69° 21' 50.9”	76° 08' 03.6”
16	Near Lake ML2	SQ–ML2	Mcleod Island	69° 22' 10.2”	76° 08' 35.1”
17	Near Lake BR	SQ –BR	Broknes Peninsula	69° 23' 15.1”	76° 18' 45.7”
18	Near Lake F	SQ – F	Fisher Island	69° 23' 37.7”	76° 14' 06.3”

Table-2B: Details of the Sediment sampling locations

S.N.	Sampling Point	Location Code	Location	Latitude (S)	Longitude (E)	Altitude
1	Lake L1	SD – 1	Bharati Island	69° 24' 18.5”	76° 11' 32.2”	13 m
2	Lake L2	SD– 2	Bharati Island	69° 24' 25.4”	76° 11' 27.4”	38 m
3	Lake L3	SD– 3	Bharati Island	69° 24' 21.9”	76° 11' 13.8”	30 m
4	Lake L5	SD– 5	Bharati Island	69° 24' 26.0”	76° 10' 59.0”	52 m
5	Lake L7	SD – 7	Bharati Island	69° 24' 31.9”	76° 11' 23.0”	54 m
6	Lake L8	SD – 8	Bharati Island	69° 24' 55.7”	76° 12' 43.7”	06 m
7	Lake L12	SD-12	Bharati Island	69° 25' 03.1”	76° 11' 32.4”	33 m
8	Lake ST1	SD-ST1	Stornes Peninsula	69° 26' 45.4”	76° 07' 02.6”	29 m
9	Lake ML1	SD-ML1	Mcleod Island	69° 21' 50.9”	76° 08' 03.6”	34 m
10	Lake BR	SD-BR	Broknes Peninsula	69° 23' 15.1”	76° 18' 45.7”	37 m
11	Lake F	SD-F	Fisher Island	69° 23' 37.7”	76° 14' 06.3”	40 m

Results and Discussion

Soil quality is simply defined as the capacity of a specific kind of Soil to function, i.e. mainly to provide nutrition to plants and absorb the drain water. The different properties of Soil are - texture, moisture, fertility (level of nitrogen, phosphorus, potassium) and pH level. The pH is the measure of a soil's acidity or alkalinity.

Each of these properties depends on different factors. For example, soil moisture depends on climate, topography and other soil characteristics. The temperatures of soils vary depending on their water holding capacity. Soils with low water holding capacity are warm.

Analytical results of all soil and sediment samples collected from Bharati Island, Fisher Island, Mcleod Island, Broken peninsula and Stornes Peninsula are as follows:

Soil quality:

pH value of all the samples was found to be in the range 6.8 to 8.5, which shows the suitability of the Soil for general fertility. Electrical conductivity (EC) is the indicator of soluble salts in the sample of Soil. EC of collected soil samples varied in the range of 120-311 µS/cm, when determined in the ratio of 1:5. The primary nutrient Phosphorous (as P_2O_5) was ranging between 57.37 – 1058.45 mg/kg. Secondary nutrients of the Soil are mainly Calcium and Magnesium. Magnesium as (MgO) was found between 0.70 – 21.48 % by mass, while Calcium as (CaO) was found varying between 0.5 – 15.40 % by mass. Chloride (as Cl) was found to vary between 0.05 – 1.01 % by mass. Sulphate (as SO_4) was found between 0.01 – 0.06 % in all soil samples. Cadmium was observed between 0.32 – 2.65 mg/kg in all samples. Iron (as Fe2O3) was found in the range of 3.0 – 16.11 % by mass. Copper (as Cu) was found to vary between 5.87 – 29.62 mg/kg. Chromium (as Cr) was found to vary between 8.63 – 63.03 mg/kg. Zinc (as Zn) was found to vary between 24.36 – 85.96 mg/kg. Manganese (as Mn) was found to vary between 41.42 – 668.98 mg/kg. Sodium (as Na_2O) was found in the range of 1.32 – 9.61 % by mass. Potassium (as K_2O) was found in the range of 1.12 – 13.41 % by mass. Aluminum (as Al_2O_3) was found in the range of 2.79 – 22.70 % by mass. Gasparon and Matschullat **(10)** gave similar trend of metals in soils at Larsemann Hills. Goldsworthy *et al.* **(7)** also investigated Soil and water contamination in Larsemann Hill area. Radiation contamination as (Cs-137) was found below the Minimum Detection Limit (MDL) in all the samples.

pH value of the sample was found to be 7.3. EC of collected soil sample was 196 µS/cm, when determined in the ratio of 1:5. The primary nutrient Phosphorous (as P_2O_5) was found 100.65 mg/kg. Sodium (as Na_2O), Potassium (as K_2O), Calcium (as CaO), Magnesium (as MgO) Chloride (as Cl), Sulphate (as SO_4), Iron (as Fe_2O_3) & Aluminum (as Al_2O_3) were found to be 2.44 %, 6.21 %, 4.6 %, 6.48 %, 0.22 %, 0.06 %, 4.56 % & 11.35 % by mass respectively.

Cadmium (as Cd), Chromium (as Cr), Zinc (as Zn), Manganese (as Mn) and Copper (as Cu) were observed to be 0.89, 12.97, 44.89, 302.31 and 4.18 mg/kg respectively in soil sample.

pH value of the samples was found to be in the range of 7.7 to 7.9. EC of collected soil samples varied in the range of 186 - 210 µS/cm, when determined in the ratio of 1:5. The primary nutrient Phosphorous (as P_2O_5) was ranging between 78.81 – 141.76 mg/kg. Magnesium as (MgO) was found between 4.67 – 9.31 % by mass, while Calcium as (CaO) was found varying between 5.26 – 6.29 % by mass. Chloride (as Cl) was found to vary between 0.12 – 0.42 % by mass. Sulphate (as SO_4) was found between 0.03 – 0.06 % in all soil samples. Cadmium was observed between 0.07 – 0.49 mg/kg in soil samples. Iron (as

Fe2O3) was found in the range of 6.32 – 7.79 % by mass. Copper (as Cu) was found to vary between 6.20 – 9.23 mg/kg. Chromium (as Cr) was found to vary between 11.35 – 41.60 mg/kg. Zinc (as Zn) was found to vary between 42.01 – 68.08 mg/kg. Manganese (as Mn) was found to vary between 214.96 - 386.37 mg/kg. Sodium (as Na_2O) was found in the range of 5.26 – 6.57 % by mass. Potassium (as K_2O) was found in the range of 8.66 – 10.94 % by mass. Aluminum (as Al_2O_3) was found in the range of 11.66 – 15.29 % by mass.

pH value of the sample was found to be 6.9, while Electric Conductivity was found 241 µS/cm. Phosphorous (as P_2O_5) was found 378.07 mg/kg. Sodium (as Na_2O), Potassium (as K_2O), Calcium (as CaO), Magnesium (as MgO), Chloride (as Cl), Sulphate (as SO_4), Iron (as Fe_2O_3) & Aluminum (as Al_2O_3) were found to be 1.39 %, 2.01 %, 2.38 %, 1.47 %, 0.35 %, 0.08 %, 4.77 % & 11.86 % by mass respectively.

Cadmium (as Cd), Chromium (as Cr), Zinc (as Zn), Manganese (as Mn) and Copper (as Cu) were observed to be 0.99, 65.13, 78.83, 599.19 and 34.31 mg/kg respectively in the soil sample.

pH value of the samples was found to be in the range of 6.8 to 7.2. EC of collected soil samples varied in the range of 385 - 582 µS/cm, when determined in the ratio of 1:5. The primary nutrient Phosphorous (as P_2O_5) ranged between 112.62 – 142.94 mg/kg. Magnesium as (MgO) was found between 1.50 – 2.16 % by mass, while Calcium as (CaO) was found varying between 1.41 – 1.91 % by mass. Chloride (as Cl) was found to vary between 0.35 – 0.76 % by mass. Sulphate (as SO_4) was found between 0.02 – 0.04 % in all soil samples. Cadmium was observed between 0.21 – 0.24 mg/kg in soil samples. Iron (as Fe_2O_3) was found in the range of 2.49 – 3.49 % by mass. Copper (as Cu) was found to vary between 13.28 – 21.55 mg/kg. Chromium (as Cr) was found to vary between 13.97 – 36.16 mg/kg. Zinc (as Zn) was found to vary between 52.96 – 73.13 mg/kg. Manganese (as Mn) was found to vary between 136.03 – 539.33 mg/kg. Sodium (as Na_2O) was found in the range of 2.36 – 3.17 % by mass. Potassium (as K_2O) was found in the range of 1.66 – 2.43 % by mass. Aluminum (as Al_2O_3) was found in the range of 1.27 – 5.27 % by mass of Soil.

Table-3A: Texture of Soil samples of Bharati Island

S.N.	Parameter	SQ-1	SQ-2	SQ-3	SQ-4	SQ-5	SQ-6
Soil Texture							
1	Sand* (%)	70	75	85	78	90	82
2	Silt (%)	22	15	10	14	7	10
3	Clay (%)	8	10	5	8	3	8

* *including gravels and stones*

Table-3B: Quality characteristics of Soil samples of Bharati Island

S.N.	Parameter	SQ-1	SQ-2	SQ-3	SQ-4	SQ-5	SQ-6
1	pH	7.8	7.6	8.0	7.3	7.5	7.1
2	Electrical Conductivity µs/cm	172.0	256.0	211.0	151.0	197.0	148.0
3	Sodium (as Na_2O) % by mass	4.35	2.33	3.84	5.46	2.63	1.53
4	Potassium(as K_2O) % by mass	7.96	6.35	13.41	2.82	3.02	3.01
5	Calcium (as CaO) % by mass	11.34	7.59	15.40	5.16	7.32	5.57
6	Magnesium (as MgO) % by mass	11.39	3.53	10.39	3.23	21.48	5.14
7	Iron (as Fe_2O_3) % by mass	16.11	9.35	11.06	11.30	9.87	6.98
8	Aluminum (as Al_2O_3) % by mass	15.95	9.24	12.27	12.34	21.46	8.68
9	Phosphorus (as P_2O_5) mg/kg	130.08	57.37	110.96	187.64	90.91	69.67
10	Cadmium (as Cd) mg/kg	1.53	0.49	1.84	0.95	0.83	0.32
11	Chromium (as Cr) mg/kg	21.23	31.82	19.31	63.03	9.13	11.35
12	Zinc (as Zn) mg/kg	85.96	69.14	24.86	57.04	24.36	36.17
13	Manganese (as Mn) mg/kg	186.55	92.16	102.04	142.58	50.54	41.42
14	Copper (as Cu) mg/kg	9.33	14.27	20.32	10.20	8.69	5.87
15	Chloride (as Cl) % by mass	0.45	0.77	0.05	0.86	0.21	0.46
16	Sulphate(as SO_4) % by mass	0.06	0.06	0.01	0.03	0.02	0.02
17	Radiation Contamination* (as Cs-137) Bq/kg	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL

* *MDL : < 1.9 bq / kg*

Table-4A: Texture of Soil samples of Bharati Island

S.N.	Parameter	SQ-7	SQ-7A	SQ-8	SQ-12	SQ-A	SQ-m
Soil Texture							
1	Sand* (%)	94	80	68	85	78	70
2	Silt (%)	4	14	22	12	12	2
3	Clay (%)	2	6	10	3	10	8

* *including gravels and stones*

Table-4B: Quality characteristics of Soil samples of Bharati Island

S.N.	Parameter	SQ-7	SQ-7A	SQ-8	SQ-12	SQ-A	SQ-m
1	pH	6.9	7.2	7.5	6.8	8.2	8.5
2	Electrical Conductivity µs/cm	130.0	162.0	290.0	120.0	311.0	174.0
3	Sodium (as Na_2O) % by mass	1.32	5.99	1.52	1.54	9.61	5.17
4	Potassium(as K_2O) % by mass	1.12	3.74	1.41	1.35	6.40	3.57
5	Calcium (as CaO) % by mass	2.29	2.20	1.21	0.50	11.59	6.49
6	Magnesium (as MgO) % by mass	1.31	1.21	0.70	0.49	12.14	14.17
7	Iron (as Fe_2O_3) % by mass	3.00	3.24	4.40	4.72	12.27	6.62
8	Aluminum (as Al_2O_3) % by mass	2.79	3.26	3.92	2.58	18.70	22.70
9	Phosphorus (as P_2O_5) mg/kg	317.65	124.12	508.64	1058.45	70.35	57.45
10	Cadmium (as Cd) mg/kg	0.88	0.42	1.07	0.62	2.65	1.17
11	Chromium (as Cr) mg/kg	36.94	45.47	45.60	58.58	16.82	8.63
12	Zinc (as Zn) mg/kg	46.35	65.71	71.77	83.39	54.00	35.45
13	Manganese (as Mn) mg/kg	152.05	139.25	600.90	668.98	114.43	82.02
14	Copper (as Cu) mg/kg	25.95	19.98	29.62	27.65	13.98	8.26
15	Chloride (as Cl) % by mass	0.45	0.78	0.50	0.30	1.01	0.62
16	Sulphate(as SO_4) % by mass	0.02	0.04	0.04	0.02	0.03	0.06
17	Radiation Contamination* (as Cs-137) Bq/kg	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL

* *MDL : < 1.9 bq / kg*

Table-5A: Texture of Soil samples of various Islands/peninsula at Larsemann Hills

S.N.	Parameter	SQ-ST1	SQ-ST2	SQ-ML1	SQ-ML2	SQ-BR	SQ-F
Soil Texture							
1	Sand* (%)	83	80	90	85	90	85
2	Silt (%)	15	17	8	11	8	11
3	Clay (%)	2	3	2	4	2	4

* *including gravels and stones*

Table-4B: Quality characteristics of Soil samples of Bharati Island

S.N.	Parameter	SQ-ST1	SQ-ST2	SQ-ML1	SQ-ML2	SQ-BR	SQ-F
1	pH	6.8	7.2	7.9	7.7	6.9	7.3
2	Electrical Conductivity µs/cm	385.0	582.0	210.0	186.0	241.0	196.0
3	Sodium (as Na_2O) % by mass	2.36	3.17	6.57	5.26	1.39	2.44.
4	Potassium(as K_2O) % by mass	1.66	2.43	8.66	10.94	2.01	6.21
5	Calcium (as CaO) % by mass	1.41	1.91	5.26	6.29	2.38	4.60
6	Magnesium (as MgO) % by mass	1.50	2.16	9.31	4.67	1.47	6.48
7	Iron (as Fe_2O_3) % by mass	3.49	2.49	6.32	7.79	4.77	4.56
8	Aluminum (as Al_2O_3) % by mass	1.27	5.27	11.66	15.29	11.86	11.35
9	Phosphorus (as P_2O_5) mg/kg	142.94	112.62	141.76	78.71	378.07	100.65
10	Cadmium (as Cd) mg/kg	0.21	0.24	0.49	0.07	0.99	0.89
11	Chromium (as Cr) mg/kg	36.16	13.97	11.35	41.60	65.13	12.97
12	Zinc (as Zn) mg/kg	73.13	52.96	42.01	68.08	78.83	44.89
13	Manganese (as Mn) mg/kg	539.33	136.03	214.96	386.37	599.19	302.31
14	Copper (as Cu) mg/kg	21.55	13.28	9.23	6.20	34.31	4.18
15	Chloride (as Cl) % by mass	0.35	0.76	0.42	0.12	0.35	0.22
16	Sulphate(as SO_4) % by mass	0.02	0.04	0.03	0.06	0.08	0.06
17	Radiation Contamination* (as Cs-137) Bq/kg	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL

* *MDL : < 1.9 bq / kg*

Sediment quality:

pH value of all the samples was found to be in the range 6.6 to 7.6. Electrical conductivity (EC) of collected sediments samples varied in the range of 113 – 278 µS/cm. Sodium (as Na_2O) was found in the range of 1.32 – 3.60 % by mass. Potassium (as K_2O) was found in the range of 2.02 – 4.35 % by mass. Calcium as (CaO) was found between 0.45 – 2.43 % by mass, while Magnesium as (MgO) was found varying between 1.28 – 7.29 % by mass. Iron (as Fe_2O_3) was found in the range of 5.02 – 9.81 % by mass. Aluminum (as Al_2O_3) was found in the range of 4.18 – 8.83 % by mass. Phosphorous (as P_2O_5) was ranging between 243.08 – 727.57 mg/kg. Chloride (as Cl) was found to vary between 0.34 – 1.25 % by mass. Sulphate (as SO_4) was found between 0.09 – 0.38 % in all samples.

Cadmium was observed between 0.63 – 1.72 mg/kg in all samples. Chromium (as Cr) was found to vary between 63.04 – 167.67 mg/kg. Zinc (as Zn) was found to vary between 56.65 – 212.99 mg/kg. Manganese (as Mn) was found to vary between 125.03 – 353.20 mg/kg. Copper (as Cu) was found varying between 7.57 – 112.33 mg/kg.

pH value of the sample was found to be 6.9. EC of collected sample was 179.0 µS/cm, when determined in the ratio of 1:5. Phosphorous (as P_2O_5) was found 385.28 mg/kg. Sodium (as Na_2O), Potassium (as K_2O), Calcium (as CaO), Magnesium (as MgO), Chloride (as Cl), Sulphate (as SO_4), Iron (as Fe_2O_3) & Aluminum (as Al_2O_3) were found to be 2.17 %, 2.03 %, 1.04 %, 2.87 %, 0.63 %, 0.24 %, 5.83 % & 5.40 % by mass respectively. Cadmium (as Cd), Chromium (as Cr), Zinc (as Zn), Manganese (as Mn) and Copper (as Cu) were observed to be 0.87, 36.55, 112.22, 421.49 and 9.20 mg/kg respectively in sediment sample.

pH value of the sample was found to be 7.3. EC of collected sample was 189.0 µS/cm, when determined in the ratio of 1:5. Phosphorous (as P_2O_5) was found 265.98 mg/kg. Sodium (as Na_2O), Potassium (as K_2O), Calcium (as CaO), Magnesium (as MgO), Chloride (as Cl), Sulphate (as SO_4), Iron (as Fe_2O_3) & Aluminum (as Al_2O_3) were found to be 2.37 %, 3.45 %, 1.27 %, 4.77 %, 0.42 %, 0.29 %, 6.01 % & 3.90 % by mass respectively. Cadmium (as Cd), Chromium (as Cr), Zinc (as Zn), Manganese (as Mn) and Copper (as Cu) were observed to be 0.73, 81.92, 71.86, 214.21 and 8.21 mg/kg respectively in sediment sample.

pH value of the sample was found to be 6.7. EC of collected sample was 132.0 µS/cm, when determined in the ratio of 1:5. Phosphorous (as P_2O_5) was found 428.62 mg/kg. Sodium (as Na_2O), Potassium (as K_2O), Calcium (as CaO), Magnesium (as MgO), Chloride (as Cl), Sulphate (as SO_4), Iron (as Fe_2O_3) & Aluminum (as Al_2O_3) were found to be 1.84 %, 2.17 %, 1.06 %, 1.43 %, 0.85 %, 0.38 %, 3.25 % & 3.98 % by mass respectively. Cadmium (as Cd), Chromium (as Cr), Zinc (as Zn), Manganese (as Mn) and Copper (as Cu) were observed to be 1.09, 86.29, 65.76, 157.21 and 20.12 mg/kg respectively in the sediment sample.

pH value of the sample was found to be 6.7. EC of the collected sample was 125.0 µS/cm, when determined in the ratio of 1:5. Phosphorous (as P_2O_5) was found 385.76 mg/kg. Sodium (as Na_2O), Potassium (as K_2O), Calcium (as CaO), Magnesium (as MgO), Chloride (as Cl), Sulphate (as SO_4), Iron (as Fe_2O_3) & Aluminum (as Al_2O_3) were found to be 1.50 %, 1.77 %, 0.36 %, 0.42 %, 0.31 %, 0.11 %, 2.85 % & 3.57 % by mass respectively. Cadmium (as Cd), Chromium (as Cr), Zinc (as Zn), Manganese (as Mn) and Copper (as Cu) were observed to be 2.00, 54.0, 46.90, 187.45 and 12.10 mg/kg respectively in sediment sample. Wang et al. (1997) highlighted the weather processes and characteristics of Soil at Stornes peninsula.

Radiation contamination as (Cs-137) was found below Minimum Detection Limit (MDL) in all soil and sediment samples collected from Bharati Island,

Fisher Island, Mcleod Island, Broknes and Stornes peninsula at Larsemann Hills.

Sediment provides a substratum and breeding ground for aquatic organisms, especially to benthic communities. Sediment is also a source of nutrients and accumulated organic matter, and it may help phytoplankton to uptake these in dissolved form from water. Sediment of a freshwater ecosystem plays a very important role in regulating ecological balance.

Due to the less anthropogenic activities in the Larsemann Hill area, any unwanted, foreign, or toxic substance was not detected in any sediment sample. This condition is suitable for aquatic life. Most lakes have an oligotrophic status in Larsemann Hills, east Antarctica, so sediment has less organic load compared to eutrophic lakes. All the sediment samples have basic constituents in a different ratio. The chemical characteristic was also not found to be objectionable, outstanding, or abnormal. Few heavy metals may arise in Geo-genic activities, and Soil is probably one of the natural sources of heavy metals (Wang et al., 1997.

Soil represents the loose and unconsolidated materials through the disintegration of rocks. The Soil comprises mineral and organic constituents differentiated into horizons of variable depth, which differ, from the materials underneath in morphology, physically makeup, chemical properties and composition, and biological characteristics. Soil serves as a reservoir of nutrients. The impact of pollutants on soil quality may be a relatively slow process, but it may be of more significant concern in the long run. The percolation of pollutants may accumulate in the Soil, ultimately affecting its quality. Goldsworthy *et al.* (2003) also investigated Soil and water contamination in the Larsemann Hill area. Tarnocai and Campbell (2002) described the Physicochemical characteristics of polar soils.

Larsemann Hill area is rocky, and due to the weathering, loose particles from the rock reach the bank of the low-lying area of lakes. Hall and Walton (1992) described the rock weathering and soil formation process over a period of time. The soil samples have been collected from where loose particles in the form of Soil have gathered. Oil spillage may influence the major quality characteristics of polar soils (Everett, 1978). The result shows that the existing soil quality in this area is least affected by the activities of the surrounding research stations.

Table-6A: Texture of Sediment samples of Bharati Island

S.N.	Parameter	SD-1	SD-2	SD-3	SD-5	SD-7	SD-8
Soil Texture							
1	Sand* (%)	92	90	96	93	95	88
2	Silt (%)	6	9	3	5	4	8
3	Clay (%)	2	1	1	2	1	4

* *including gravels and stones*

Table-6B: Quality characteristics of Sediment samples of Bharati Island

S.N.	Parameter	SD-1	SD-2	SD-3	SD-5	SD-7	SD-8
1	pH	7.3	7.2	7.6	7.1	6.8	6.9
2	Electrical Conductivity µs/cm	165.0	136.0	197.0	181.0	116.0	278.0
3	Sodium (as Na_2O) % by mass	1.32	1.88	2.15	2.23	1.66	3.60
4	Potassium(as K_2O) % by mass	3.13	4.35	2.83	2.43	2.02	4.32
5	Calcium (as CaO) % by mass	0.74	0.86	1.15	1.34	0.45	2.43
6	Magnesium (as MgO) % by mass	3.93	5.17	6.35	3.27	1.28	7.29
7	Iron (as Fe_2O_3) % by mass	5.02	9.81	7.54	6.53	7.08	9.34
8	Aluminum (as Al_2O_3) % by mass	6.31	5.21	7.73	5.71	4.18	8.83
9	Phosphorus (as P_2O_5) mg/kg	317.20	727.57	586.27	424.68	387.28	340.90
10	Cadmium (as Cd) mg/kg	0.74	1.17	0.93	0.66	1.72	0.63
11	Chromium (as Cr) mg/kg	167.67	115.30	87.03	97.05	130.64	98.95
12	Zinc (as Zn) mg/kg	97.93	74.11	128.19	71.94	56.65	212.99
13	Manganese (as Mn) mg/kg	353.20	255.31	154.35	282.44	213.34	125.03
14	Copper (as Cu) mg/kg	53.92	25.03	34.56	21.09	12.81	112.33
15	Chloride (as Cl) % by mass	1.25	0.92	0.85	0.55	0.62	1.13
16	Sulphate(as SO_4) % by mass	0.22	0.12	0.09	0.35	0.15	0.38
17	Radiation Contamination* (as Cs-137) Bq/kg	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL

** MDL : < 1.9 bq / kg*

Table-7A: Texture of Sediment samples of various Islands/peninsula at Larsemann Hills

S.N.	Parameter	SD-12	SD-ST1	SD-ML1	SD-BR	SD-F
	Soil Texture					
1	Sand* (%)	94	97	96	95	92
2	Silt (%)	5	2	3	4	6
3	Clay (%)	1	1	1	1	2

** including gravels and stones*

Table-7B: Sediment Quality characteristics of various Islands/peninsula at Larsemann Hills

S.N.	Parameter	SD-12	SD-ST1	SD-ML1	SD-BR	SD-F
1	pH	6.6	6.7	7.3	6.7	6.9
2	Electrical Conductivity µs/cm	113.0	125.0	189.0	132.0	179.0
3	Sodium (as Na_2O) % by mass	1.94	1.50	2.37	1.84	2.17
4	Potassium(as K_2O) % by mass	2.16	1.77	3.45	2.17	2.03
5	Calcium (as CaO) % by mass	0.66	0.36	1.27	1.06	1.04
6	Magnesium (as MgO) % by mass	1.63	0.42	4.77	1.43	2.87
7	Iron (as Fe_2O_3) % by mass	7.37	2.85	6.01	3.25	5.83
8	Aluminum (as Al_2O_3) % by mass	5.50	3.57	3.90	3.98	5.40
9	Phosphorus (as P_2O_5) mg/kg	243.04	385.76	265.98	428.62	385.28
10	Cadmium (as Cd) mg/kg	0.66	2.00	0.73	1.09	0.87
11	Chromium (as Cr) mg/kg	63.04	54.00	81.92	86.29	36.55
12	Zinc (as Zn) mg/kg	89.26	46.90	71.86	65.76	112.22
13	Manganese (as Mn) mg/kg	166.56	187.45	214.21	157.21	421.49
14	Copper (as Cu) mg/kg	7.57	12.10	8.21	20.12	9.20
15	Chloride (as Cl) % by mass	0.34	0.31	0.42	0.85	0.63
16	Sulphate (as SO_4) % by mass	0.18	0.11	0.29	0.38	0.24
17	Radiation Contamination* (as Cs-137) Bq/kg	<MDL	<MDL	<MDL	<MDL	<MDL

* *MDL : < 1.9 bq / kg*

Conclusion

Primary study reveals that Larsemann Hills soil is almost uncontaminated. Still it is not altered by the presence of activities at various Islands/ peninsulas of Larsemann Hills during XXX ISEA. However, detail environmental monitoring is also required in future course of time to know the human activities impacts in Larsemann Hills.

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Glossary

This section provides the list some of the published papers from 30th ISEA. The results in the published papers are included in the technical reports of this volume.

Behera, J. K., A. K. Sinha, A. K. Singh, R. Rawat, G. Vichare, A. Dhar, B. M. Pathan, K. U. Nair, C. Selvaraj and P Elango (2014), J. Earth Syst. Sci. 123. No. 3, pp. 593-602.

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S. Manu , R. Rawat , A. K. Sinha , S. Gurubaran* and K. Jeeva, Schumann resonances observed at Maitri, Antarctica: diurnal variation and its interpretation in terms of global thunderstorm activity, Current Science, Vol. 109, No4, 25, 2015

Madhumita, P., S. Tarulata, d. Dhanwal, and R. Dewan, Circad, Circadian levels of Serumm Melatonin and Cortisol in relation to Changes in mood, sleep, and Neurocongnitive performance, spanning a year of residence in Antarctica. Neuroscience Journal Volume 2013, ArticlID 254090, 10 pages http://dx.doi.org/10.1155/2013/254090

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