

Lake Water quality of different Islands & Peninsulas at Larsemann Hills, east Antarctica

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Abstract

Water samples were collected from various Islands and peninsulas of Larsemann Hills Bharati Island, Mcleod Island, Fisher Island, Broknes, and Stornes Peninsula were selected to evaluate the water quality of the freshwater ecosystem. The assessment of the water quality would help in understanding the likely impacts of the proposed construction activities on the water environment and to ascertain the Self-assimilation capacity of the water environment. Water samples were analyzed for physico-chemical parameters and microbiological parameters. Lake water was found free from pollution and suitable for drinking purposes. *Pseudomonas* bacteria were found in seawater and in the lake water of Stornes peninsula. No pesticide and radiation contamination was observed during the study period.

Keywords: Water quality, physico-chemical parameter, microbiological characteristics, Antarctic lakes

Introduction

The Larsemann hills, named after Larsemann Christensen, is an ice-free coastal oasis with exposed rock and low promontory hills. These hills lie between 69°20'–69°30'S latitude & 75°55'–76°30'E longitude and spread over an area of approximately 50 sq. km, comprising four major ice-free oases found along the 5000 km coastline of east Antarctica. Here are hundreds of freshwater lakes of varying sizes and a depth ranging from small ponds less than 1 m deep to glacial lakes up to 10 ha and 38 m deep. The Broknes and the Stornes are the two main peninsulas on the two extremities and between these two peninsulas, there are a number of islands of varying dimensions and some unnamed Islands.

India has been carrying out scientific research programs for the last 6 years on the unnamed island that lies between Quilty Bay and Thala Fjord and named it "Bharati". Its area is separated to its west by Quilty Bay and Fisher Island and to its east by Thala Fjord and the Stornes peninsula. Cleod Island is situated about 6 km north of the Bharati Island.

The surface of Bharati Island, the Storne Peninsula, Fisher Island, and Mcleod Island is undulated; expressions on some points over these areas are very deep and vary in size uring the winter season; drifted ice covers all the points of depressions as well as of heights and when summer season onsets the covered ice starts melting and fills the depressions and forms large, small and medium size water bodies that have been marked as lakes over these areas here are more than 150 such lakes over Larsemann hill areas.

To assess the water quality of the study area, water samples from different freshwater lakes and two samples of seawater were collected and analyzed for various Physico-chemical parameters, Heavy metals, pesticides, radiation contamination and Biological parameters; his assessment is essential to study the effect of human activities on the environment of Larsemann Hills and to formulate mitigation measures to prevent the water bodies from further pollution.

The assessment of the water quality would help in understanding the likely impacts of the proposed construction activities on the water environment and to ascertain the Self-assimilation capacity of the water environment initially; a reconnaissance survey was undertaken to identify suitable water sampling locations 1. Major lake was identified for the study purpose in the vicinity of Bharati Island Water samples were also collected from Mcleod Island, Fisher Island, Broken and Stornes Peninsula.

Methodology

Primary data like temperature, pH, and conductivity were recorded onsite guidelines of standard protocols were followed for water analysis:

- IS 3025 (Relevant Parts) guidelines.
- APHA, AWWA, WEF; Ed. 21st, 2005.
- Indian Standard Specification for Drinking Water (IS: 10500-1991, Amendment 2-2003.).

Drinking water is drawn from varied sources that have the possibility of radioactive contamination from naturally occurring minerals or human activities. Lakewater samples from Bharati Island were also analyzed for the microbiological study. Radiation contamination T e standard protocols were followed in the evaluation of radioactivity content in water as per BIS specifications and methods instrument used in the testing of the Radiation Contamination area: Gross Alpha Counting system with Zn(Ag) detector, Gross Beta Counting System with Geiger Muller detector and Gamma Spectrometer with NaI(Tl) detector and 1k Multi-Channel Analyzer.

Results and Discussion

Water samples were collected from the lakes of Bharati Island, Fisher Island, McLeod Island, Broknes peninsula, and Stornes peninsula and analyzed for physico-chemical, microbiological parameters, pesticides, and radiation contamination.

Table-1: Site details of water monitoring sites at Larsemann Hills

S.N.	Location	Location Code	Source	Latitude (S)	Longitude (E)	Altitude
1	Bharati Island	L-1	Lake	69° 24' 18.5"	76° 11' 32.2"	13 m
2	Bharati Island	L-2	Lake	69° 24' 25.4"	76° 11' 27.4"	38 m
3	Bharati Island	L-3	Lake	69° 24' 21.9"	76° 11' 13.8"	30 m
4	Bharati Island	L-4	Lake	69° 24' 32.1"	76° 11' 46.7"	52 m
5	Bharati Island	L-5	Lake	69° 24' 26.0"	76° 10' 59.0"	52 m
6	Bharati Island	L-6	Lake	69° 24' 33.2"	76° 10' 32.8"	48 m
7	Bharati Island	L-7	Lake	69° 24' 31.9"	76° 11' 23.0"	54 m
8	Bharati Island	L-7A	Lake	69° 24' 29.4"	76° 11' 45.2"	54 m
9	Bharati Island	L-8	Lake	69° 24' 55.7"	76° 12' 43.7"	6 m
10	Bharati Island	L-10	Lake	69° 25' 16.2"	76° 11' 12.7"	28 m
11	Bharati Island	L-11	Lake	69° 25' 02.9"	76° 12' 13.7"	32 m
12	Bharati Island	L-12	Lake	69° 25' 03.1"	76° 11' 32.4"	33 m
13	Broknes Peninsula	BR	Lake	69° 23' 15.1"	76° 18' 45.7"	37 m
14	McLeod Island	ML	Lake	69° 21' 50.9"	76° 08' 03.6"	34 m
15	Fisher Island	F	Lake	69° 23' 37.7"	76° 14' 06.3"	40 m
16	Stornes Peninsula	ST-1	Lake	69° 26' 45.4"	76° 07' 02.6"	29 m
17	Stornes Peninsula	ST-2	Lake	69° 26' 18.8"	76° 07' 36.0"	31 m
18	Quilty Bay	Sea-1	Sea	69° 24' 19.0"	76° 11' 15.3"	-
19	Quilty Bay	Sea-2	Sea	69° 24' 10.5"	76° 12' 00.1"	-

Physical parameters:

Physical parameters like color, odor, and turbidity were analyzed to assess with respect to aesthetic aspects. T S has been estimated to know the presence of dissolved salts in water C lour of the water in collected samples is found less than 5 Hazen units (below the detection limit) in case of all the samples collected during 30th ISEA permissible limit of colour in water is 5 Hazen units W th respect to odour test, all the samples were found to have "Unobjectionable Odour" T rbidity has been observed less than 1 NTU in all lake water samples D sirable limit for turbidity is 5 NTU as per IS: 10500 T turbidity is found to be 2 NTU in seawater samples.

The dissolved solids in water indicate the amount of salts present in water T e desirable limit of dissolved solids in drinking water is 500 mg/l, whereas the maximum permissible limit for the same is 2000 mg/l Minimum value of total

dissolved solids was found to be 19 mg/l in Lake L-12, and the maximum was found to be 456 mg/l in the water of Lake L-7A at Bharati Island total dissolved solids were found as 126 mg/l in Lake-F, 140 mg/l in Lake-ML and 369 mg/l in Lake-BR at Fisher Island, Mcleod Island and Broken peninsula respectively the minimum value of total dissolved solids was found to be 64 mg/l in Lake ST-2, and the maximum was found to be 71 mg/l in the water of Lake ST-1 at Stornes peninsula A variation in the range of 37080 mg/l to 52320 mg/l has been observed in the TDS values in the seawater.

Chemical parameters:

The significant general chemical properties in water are pH, Chloride, Sulphate, Total Hardness, Calcium, Magnesium, Total Alkalinity, Fluoride, Nitrate, etc.

The minimum value of pH was found to be 5.9 in Lake L-5. The maximum was found to be 7.4 in the water of Lake L-1 at Bharati Island p was found to be 6.6 in Lake-F, 6.9 in Lake-ML and 6.8 in Lake-BR at Fisher Island, Mcleod Island and Broknes peninsula respectively the minimum value of pH was found to be 6.7 in Lake ST-2 and maximum was found to be 6.8 in the water of Lake ST-1 at Stornes peninsula A variation in the range of 6.3 to 6.8 has been observed in the pH values in the seawater.

The desirable limit of chloride in the drinking water is 250 mg/l, whereas the maximum permissible limit is 1000 mg/l Minimum value of chlorides was found to be 10 mg/l in Lake L-12 and the maximum was found to be 213 mg/l in the water of Lake L-7A, at Bharati Island Chlorides were found as 57 mg/l in Lake-F, 65 mg/l in Lake-ML and 172 mg/l in Lake-BR at Fisher Island, Mcleod Island and Broknes peninsula respectively Chlorides were found around 31-32 mg/l in Lake water samples collected from Stornes peninsula A variation in the range of 19495 mg/l to 24195 mg/l has been observed in the chloride values in the seawater.

The desirable limit of total hardness (as CaCO_3) in the drinking water is 300 mg/l, whereas the maximum permissible limit is 600 mg/l Minimum value of total hardness was found nil in Lake L-12, and the maximum was found to be 175 mg/l in the water of Lake L-7A at Bharati Island T tal hardness was found as 26 mg/l in Lake-F, 30 mg/l in Lake-ML and 88 mg/l in Lake-BR at Fisher Island, Mcleod Island and Broknes peninsula respectively total hardness was found around 13-14 mg/l in Lake water samples collected from Stornes peninsula A variation in the range of 7020 mg/l to 8430 mg/l has been observed in the total hardness values in the seawater.

The desirable limit of alkalinity (as CaCO_3) in the drinking water is 200 mg/l, whereas the maximum permissible limit is 600 mg/l Minimum value of alkalinity was found 3 mg/l in Lake L-12, and the maximum was found to be 47

mg/l in the water of Lake L-2 at Bharati Island A salinity was found as 11 mg/l in Lake-F, 14 mg/l in Lake-ML and 37 mg/l in Lake-BR at Fisher Island, Mcleod Island and Broknes peninsula respectively A salinity was found around 4-5 mg/l in Lake water samples collected from Stornes peninsula A variation in the range of 178 mg/l to 212 mg/l has been observed in the alkalinity values in the seawater.

The desirable limit of Sulfates (as SO_4) in drinking water is 200 mg/l, whereas the maximum permissible limit is 400 mg/l (Provided Magnesium as Mg does not exceed 30 mg/l) Minimum value of sulfates was found to be less than 1 mg/l in Lake L-10, L-11 & L-12 and maximum was found to be 21 mg/l in the water of Lake L-7A at Bharati Island fates was found as 3 mg/l in Lake-F, 9 mg/l in Lake-ML and 17 mg/l in Lake-BR at Fisher Island, Mcleod Island and Broknes peninsula respectively S fates value was found around 1 mg/l in Lake water samples collected from Stornes peninsula A variation in the range of 3480 mg/l to 4120 mg/l has been observed in the sulfates values in the seawater.

The desirable limit of Nitrate (as NO_3) in the drinking water is 45 mg/l. The value of nitrates was found to be less than 1 mg/l in Lake L-1, L-2, L-6, L-10, L-11 & L-12, and the maximum was found to be 2.2 mg/l in the water of Lake L-3 & L-7A at Bharati Island Ni rates was found less than 1 mg/l in Lake-F, 2.2 mg/l in Lake-ML and 3.3 mg/l in Lake-BR at Fisher Island, Mcleod Island and Broknes peninsula respectively Ni ates was not found in Lake L-ST1 and L-ST2 water samples collected from Stornes peninsula A variation in the range of 112 mg/l to 138 mg/l has been observed in the nitrates values in the seawater.

The desirable limit of fluoride (as F) in the drinking water is 1.0 mg/l, whereas the maximum permissible limit is 1.5 mg/l Minimum value of fluoride was found to be less than 0.1 mg/l in Lake L-1, L-7, L-10, & L-12 and the maximum was found to be 0.2 mg/l in the water of Lake L-2 & L-8 at Bharati Island Flu ride was found as 0.1 mg/l in L-F, L-ML, and L-BR at Fisher Island, Mcleod Island and Broknes peninsula respectively.

Fluoride value was found around or less than 0.1 mg/l in Lake water samples collected from Stornes peninsula. A variation in the range of 0.5 mg/l to 0.7 mg/l has been observed in the fluoride values in the seawater.

Inorganic Metallic constituents:

Toxic metals like Mercury (as Hg), Cadmium (as Cd), Selenium (Se), Arsenic (as As), and Hexavalent Chromium (Cr^{+6}) were Not Detected in any of the samples drawn from Bharati Island, Mcleod Island, Fisher Island, Stornes peninsula and Broknes peninsula and Sea Water.

The maximum permissible limit of lead in drinking water is 0.05 mg/l. The value of lead was found to be less than 0.01 mg/l in Lake L-1, L-2, L-5, L-6, L-

&, L-7A, L-8, L-10, L-11 & L-12 and maximum was found to be 0.03 mg/l in the water of Lake L-3 at Bharati Island. Lead was found less than 0.01 mg/l in Lake-F, Lake-ML and Lake-BR at Fisher Island, Mcleod Island and Broknes peninsula respectively. Lead was not found in Lake L-ST1 and L-ST2 water samples collected from Stornes peninsula. A variation in the range of 0.3 mg/l to 0.5 mg/l has been observed in the lead values in the seawater.

The desirable Limit is 5 mg/l, and the Maximum Permissible Limit is 15 mg/l for drinking water. The value of Zinc was found to be less than 0.01 mg/l in Lake L-1, L-10, L-11 & L-12, and the maximum was found to be 0.222 mg/l in the water of Lake L-3 at Bharati Island. Zinc was found less than 0.01 mg/l in Lake-F, 0.01 mg/l in Lake-ML and 0.15 mg/l in Lake-BR at Fisher Island, Mcleod Island and Broknes peninsula respectively. Zinc was not found in Lake L-ST1 and L-ST2 water samples collected from Stornes peninsula. A variation in the range of 0.13 mg/l to 0.35 mg/l has been observed in the Zinc values in the seawater.

The desirable Limit is 0.3 mg/l, and the Maximum Permissible Limit is 1.0 mg/l for drinking water. Minimum value of Iron was found to be less than 0.01 mg/l in Lake L-11, and the maximum was found to be 0.22 mg/l in the water of Lake L-10 at Bharati Island. Iron was found as 0.04 mg/l in Lake-F, 0.05 mg/l in Lake-ML and 0.06 mg/l in Lake-BR at Fisher Island, Mcleod Island and Broknes peninsula respectively. Iron was not found in Lake L-ST1 and was found 0.02 mg/l in L-ST2 water samples collected from Stornes peninsula. A variation in the range of 0.03 mg/l to 0.5 mg/l has been observed in the Iron values in the seawater.

The desirable Limit is 0.1 mg/l, and the Maximum Permissible Limit is 0.3 mg/l for drinking water. The value of Manganese was found to be less than 0.001 mg/l in all Lakes at Bharati Island except L-5 (0.003 mg/l) and L-7 (0.012 mg/l). Manganese was found to be less than 0.001 mg/l in Lake-F, 0.01 mg/l in Lake-ML and 0.02 mg/l in Lake-BR at Fisher Island, Mcleod Island, and Broknes peninsula, respectively. Manganese was found to be less than 0.001 mg/l in L-ST1 and was found 0.003 mg/l in L-ST2 water samples collected from Stornes peninsula. A variation in the range of 0.05 mg/l to 0.1 mg/l has been observed in the Manganese values in the seawater.

The desirable Limit is 0.05 mg/l, and the Maximum Permissible Limit is 1.5 mg/l for drinking water. The value of Copper was found to be less than 0.001 mg/l in all Lakes at Bharati Island except L-7 (0.021 mg/l) and L-8 (0.03 mg/l). Copper was found less than 0.001 mg/l in Lake-F & Lake-ML and 0.01 mg/l in Lake-BR at Fisher Island, Mcleod Island and Broknes peninsula respectively. Copper was found less than 0.001 mg/l in L-ST1 and L-ST2 water samples collected from Stornes peninsula. A variation in the range of 0.08 mg/l to 0.1 mg/l has been observed in the Copper values in the seawater.

The desirable limit in drinking water is 1 mg/l & maximum permissible limit is 5 mg/l Minimum value of Boron was found to be less than 0.01 mg/l in Lake L-4, L-5, L-6, L-7, L-8, L-10, L-11 & L-12 and maximum was found to be 0.075 mg/l in the water of Lake L-7A at Bharati Island Boron was found less than 0.001 mg/l in Lake-F, Lake-ML and Lake-BR at Fisher Island, Mcleod Island and Broknes peninsula respectively Boron as not found in Lake L-ST1 and was found 0.007 mg/l in L-ST2 water samples collected from Stornes peninsula A variation in the range of 0.236 mg/l to 0.319 mg/l has been observed in the Boron values in the seawater.

The maximum permissible limit of Aluminum (as Al) in drinking water is 0.2 mg/l Minimum value of Aluminum was found to be less than 0.02 mg/l in Lake L-3, L-5, L-6 & L-7, and the maximum was found to be 0.088 mg/l in the water of Lake L-10 at Bharati Island Alumin m was found less than 0.02 mg/l in Lake-F, Lake-ML and Lake-BR at Fisher Island, Mcleod Island and Broknes peninsula respectively Alumin was found 0.006 mg/l in Lake L-ST1 and was found 0.007 mg/l in L-ST2 water samples collected from Stornes peninsula Aluminu values have been observed less than 0.2 mg/l in the seawater.

The maximum permissible limit of Phosphate in drinking water is 0.05 mg/l Minimum value of Phosphate was found 0.002 mg/l in Lake L-12, and maximum was found to be 0.046 mg/l in the water of Lake L-3 at Bharati Island Phospho e was found 0.014 mg/l in Lake-F, 0.011 mg/l in Lake-ML and 0.06 mg/l in Lake-BR at Fisher Island, Mcleod Island and Broknes peninsula respectively Phospho was found less than 0.001 mg/l in Lake L-ST1 and was found 0.002 mg/l in L-ST2 water samples collected from Stornes peninsula A variant on in the range of 0.065 mg/l to 0.087 mg/l has been observed in the Phosphate values in the seawater.

Other significant chemical constituents:

Phenolic compounds estimated as C₆H₅OH was not detected in any of the sample for which the maximum permissible limit in the drinking water is 0.002 mg/l. Mineral was not detected in any of the samples. Its maximum permissible limit in the drinking water is 0.01 mg/l Cyanide as CN) was not detected in any of the samples Its maxi um permissible limit in drinking water is 0.05 mg/l Anionic detergents (MBAS) were not detected in any of the samples for which maximum permissible limit in drinking water is 0.2 mg/l.

Total Organic Carbon:

At Bharati Island, TOC in lake water was found in range of 0.085 to 1.862 mg/l with maximum at L-4 location & minimum at L-5 location TOC was ound 1.263 mg/l in Lake-F, 1.652 mg/l in Lake-ML and 1.915 mg/l in Lake-BR at Fisher

Island, Mcleod Island and Broknes peninsula respectively TOC was und 0.735 mg/l in Lake L-ST1 and 0.711 mg/l in L-ST2 water samples collected from Stornes peninsula A variati n in the range of 1.349 mg/l to 1.418 mg/l has been observed in the TOC values in the seawater.

Dissolved Oxygen:

At Bharati Island, Dissolved Oxygen in lake water was found in range of 9.2 to 13.4 mg/l with the maximum at L-10 location & minimum at L-3 location. Dissolved Oxygen was found 11.4 mg/l in Lake-F, 12.2 mg/l in Lake-ML and 9.6 mg/l in Lake-BR at Fisher Island, Mcleod Island and Broknes peninsula respectively Dissolved xygen was found 10.8 mg/l in Lake L-ST1 and 13.2 mg/l in L-ST2 water samples collected from Stornes peninsula A variatio in the range of 6.3 mg/l to 6.8 mg/l has been observed in the Dissolved Oxygen values in the seawater.

Pesticides:

This study has been carried out in freshwater lakes to ascertain the contamination of lake water with respect to listed pesticides Samples we e collected from Bharati Island, Fisher Island, Mcleod Island, Stornes Peninsula and Broknes Peninsula No pestici e was detected in lake water samples analysed so far.

Radiation Contamination:

This additional study has been carried out in freshwater lakes to ascertain the radiation contamination of lake water Samples we e collected from Bharati Island, Fisher Island, Mcleod Island, Stornes Peninsula and Broknes Peninsula.

All the listed radioactive contaminants were found below the Minimum Detection Level in all the collected samples.

Microbiological parameters:

A microbiological examination of Lake and Seawater samples was carried out.

At Bharati Island, the Colony count at 300C was less than 1 cfu in all lake water except L-1 (5.4×10^2 cfu). Colony count was found to be less than 1 cfu in lake water collected from Fisher Island, Mcleod Island, and Broknes peninsula. At Stornes peninsula, the Colony count was observed to be 1.6×10^3 cfu in the ST-2 sample, while it was less than 1 cfu in ST-1 sample In Sea water , the Total colony count was found 1.3×10^3 cfu in the Sea-1 sample and 1.2×10^2 cfu in Sea-2 sample.

At Bharati Island, the Psychrophillic count was less than 1 cfu in all lake water except L-1 (71 cfu) Psychrophilic count was found to be less than 1 cfu in lake water collected from Fisher Island and Broknes peninsula. However, it was found 47 cfu in lake water collected from Mcleod Island At Stornes peninsula. Psychrophillic count was observed to be 1.6×10^2 cfu in ST-2 sample. In comparison, it was 66 cfu in ST-1 sample. In Sea water, the Psychrophilic count was found 1.4×10^2 cfu in the Sea-1 sample and 74 cfu in the Sea-2 sample.

No growth was observed in any water sample collected from Bharati Island, Fisher Island, Mcleod Island, Broknes peninsula, Stornes peninsula, and Quilty Bay Sea. During the microbiological examination, Yeast and Mould were absent in all water samples collected from Bharati Island, Fisher Island, Mcleod Island, Broknes peninsula, Stornes peninsula and Quilty Bay Sea. *Salmonella* s found absent in all water samples collected from Bharati Island Fisher Island, Mcleod Island, Broknes peninsula, Stornes peninsula and Quilty Bay Sea. *Staphylococcus* was also absent in all water samples collected from Bharati Island, Fisher Island, Mcleod Island, Broknes peninsula, Stornes peninsula and Quilty Bay Sea.

Pseudomonas was found present in 3 water samples (2 Seawater and 1 freshwater Lake) *Pseudomonas* as found to be present in L-ST2 lake water collected from Stornes peninsula *Pseudomonas* as also found to be present in Sea-1 & Sea-2 samples collected from Quilty Bay Sea *Pseudomonas* as found absent in all remaining water samples collected from Bharati Island, Fisher Island, Mcleod Island, Broknes and Stornes peninsula.

Lakes water sampling was carried out from Larsemann Hills during XXXth Indian Scientific Expedition to Antarctica. The aim of studies was to know the water characteristics of the area, which are likely to get influenced by ongoing human activities and scientific research programs by various nations. Water sample were collected from freshwater lakes & nearest Sea and analyzed for Physico-chemical parameters, metals, pesticides, microbiological, and radiation contamination. Physico-chemical parameters like total dissolved solids and other basic characteristics were found within the permissible limits for drinking water. Physico-chemical parameters indicated the status of water quality of lake ecosystem (Gasparon and Burgess, 2000). Loose soil particles of surrounding areas might lead to increase the total dissolved solids in water bodies (Goldsworthy *et al.*, 2003).

The study of microbes in Lake Water gives the knowledge of life in icy environments and allows drawing meaningful hypotheses for the human impacts and future exploration of Lake (Ellis-Evan *et al.* 1998). Few bacteria colonies were encountered in a few samples. Psychrophillic bacteria were found in a few lakes. *Pseudomonas* as also observed in 1 lake and 2 Seawater samples.

MPN, Yeast & Mould, Salmonella and Staphylococcus were not found in any water sample. Li *et al.* (1997) explained the similar physico-chemical and biological characteristics of lakes at Larsemann Hills.

The values of inorganic non-metallic and metallic constituents: sulphate, fluoride, Copper, Manganese, Mercury, Cadmium, Selenium, Arsenic, Lead, Zinc, & Phosphate in all samples were below the prescribed limit of drinking water standards. High content actions of a few metals in drinking water may be harmful to human beings (Gasparon & Matschullat, 2006). No pesticide and radiation contamination was observed in any lake water from any Island or peninsula. A similar trend of findings was also observed at Larsemann Hills; during the XXVII, XXVIII, and XXIX ISEA by SIIR (2010).

Table- 2: Results of Lakes at Larsemann Hills

S.N.	Parameter	IS: 10500-1991 Desirable (Max. Permissible)	L-1	L-2	L-3
1.	Colour, Hazen unit	5, Max.	<5	<5	<5
2.	Odour	Unobjectionable (UO)	UO	UO	UO
3.	Turbidity, NTU	5, Max. (10)	<1	<1	<1
4.	pH	6.5-8.5	7.4	6.4	6.4
5.	Total hardness (as CaCO ₃), mg/l	300, Max. (600)	24	37	21
6.	Iron (as Fe), mg/l	0.3, Max. (1.0)	0.024	0.023	0.014
7.	Chloride (as Cl), mg/l	250, Max. (1000)	44	152	40
8.	Fluoride (as F), mg/l	1.0, Max. (1.5)	<0.1	0.2	0.1
9.	Dissolved Solids, mg/l	500, Max. (2000)	110	332	155
10.	Magnesium (as Mg), mg/l	30, Max. (100)	3.6	7.6	3.8
11.	Calcium (as Ca), mg/l	75, Max. (200)	5.8	3.8	7.6
12.	Copper (as Cu), mg/l	0.05, Max. (1.5)	<0.001	<0.001	<0.001
13.	Manganese (as Mn), mg/l	0.1, Max. (0.3)	<0.001	<0.001	<0.001
14.	Sulphate (as SO ₄), mg/l	200, Max.	3	19	13
15.	Nitrates (as NO ₃), mg/l	45, Max	<1	<1	2.2
16.	Phenolic Compounds (as C ₆ H ₅ OH), mg/l	0.002, Max	ND	ND	ND
17.	Mercury (as Hg), mg/l	0.001, Max.	<0.001	<0.001	<0.001
18.	Cadmium (as Cd), mg/l	0.01, Max.	<0.01	<0.01	<0.01
19.	Selenium (as Se), mg/l	0.01, Max.	<0.005	<0.005	<0.005
20.	Arsenic as As,mg/l	0.01, Max	<0.005	<0.005	<0.005
21.	Cyanide (as CN), mg/l	0.05, Max	<0.01	<0.01	<0.01

22.	Lead (as Pb), mg/l	0.05, Max	<0.01	<0.01	0.03
23.	Zinc (as Zn), mg/l	5 Max. (15)	<0.01	0.1	0.222
24.	Anionic Detergents (MBAS) mg/l	0.2, Max	ND	ND	ND
25.	Chromium (as Cr ⁺⁶), mg/l	0.05, Max	<0.01	<0.01	<0.01
26.	Mineral Oil, mg/l	0.01, Max	ND	ND	ND
27.	Alkalinity (as CaCO ₃), mg/l	200 Max.(600)	18	47	17
28.	Aluminum (as Al), mg/l	0.2, Max	0.02	0.006	<0.02
29.	Phosphate (as PO ₄), mg/l	0.05, Max.	0.026	0.011	0.046
30.	Boron (as B), mg/l	1, Max (5)	0.005	0.001	0.005
31.	Total Organic Carbon (TOC), mg/l	-	1.205	1.785	0.557
32.	Dissolved Oxygen (DO), mg/l	-	10.2	9.8	9.2

Table- 3: Results of Lakes at Larsemann Hills

S.N.	Parameter	IS: 10500-1991 Desirable (Max. Permissible)	L-4	L-5	L-6
1.	Colour, Hazen unit	5, Max.	<5	<5	<5
2.	Odour	Unobjectionable (UO)	UO	UO	UO
3.	Turbidity, NTU	5, Max. (10)	<1	<1	<1
4.	pH	6.5-8.5	6.2	5.9	7.1
5.	Total hardness (as CaCO ₃), mg/l	300, Max. (600)	19	25	96
6.	Iron (as Fe), mg/l	0.3, Max. (1.0)	0.019	0.06	0.05
7.	Chloride (as Cl), mg/l	250, Max. (1000)	41	48	152
8.	Fluoride (as F), mg/l	1.0, Max. (1.5)	0.1	0.08	0.1
9.	Dissolved Solids, mg/l	500, Max. (2000)	85	97	384
10.	Magnesium (as Mg), mg/l	30, Max. (100)	2.2	3.8	8.7
11.	Calcium (as Ca), mg/l	75, Max. (200)	5.8	6.7	14.3
12.	Copper (as Cu), mg/l	0.05, Max. (1.5)	<0.001	<0.001	<0.001
13.	Manganese (as Mn), mg/l	0.1, Max. (0.3)	<0.001	0.003	<0.001
14.	Sulphate (as SO ₄), mg/l	200, Max.	4	7	18
15.	Nitrates (as NO ₃), mg/l	45, Max	1.1	1.1	<1
16.	Phenolic Compounds (as C ₆ H ₅ OH), mg/l	0.002, Max	ND	ND	ND
17.	Mercury (as Hg), mg/l	0.001, Max.	<0.001	<0.001	<0.001
18.	Cadmium (as Cd), mg/l	0.01, Max.	<0.01	<0.01	<0.01
19.	Selenium (as Se), mg/l	0.01, Max.	<0.005	<0.005	<0.005
20.	Arsenic as As,mg/l	0.01, Max	<0.005	<0.005	<0.005

21.	Cyanide (as CN), mg/l	0.05, Max	<0.01	<0.01	<0.01
22.	Lead (as Pb), mg/l	0.05, Max	0.01	<0.01	<0.01
23.	Zinc (as Zn), mg/l	5 Max. (15)	0.02	0.01	0.01
24.	Anionic Detergents (MBAS) mg/l	0.2, Max	ND	ND	ND
25.	Chromium (as Cr ⁶⁺), mg/l	0.05, Max	<0.01	<0.01	<0.01
26.	Mineral Oil, mg/l	0.01, Max	ND	ND	ND
27.	Alkalinity (as CaCO ₃), mg/l	200 Max.(600)	11	10	31
28.	Aluminum (as Al), mg/l	0.2, Max	0.023	<0.02	<0.02
29.	Phosphate (as PO ₄), mg/l	0.05, Max.	0.022	0.025	0.012
30.	Boron (as B), mg/l	1, Max (5)	<0.001	<0.001	<0.001
31.	Total Organic Carbon (TOC), mg/l	-	1.862	0.085	1.621
32.	Dissolved Oxygen (DO), mg/l	-	11.6	10.9	12.2

Table- 4: Results of Lakes at Larsemann Hills

S.N.	Parameter	IS: 10500-1991 Desirable (Max. Permissible)	L-7	L-7A	L-8
1.	Colour, Hazen unit	5, Max.	<5	<5	<5
2.	Odour	Unobjectionable (UO)	UO	UO	UO
3.	Turbidity, NTU	5, Max. (10)	<1	<1	<1
4.	pH	6.5-8.5	7.1	6.5	6.9
5.	Total hardness (as CaCO ₃), mg/l	300, Max. (600)	22	175	44
6.	Iron (as Fe), mg/l	0.3, Max. (1.0)	0.06	0.14	0.19
7.	Chloride (as Cl), mg/l	250, Max. (1000)	41	213	118
8.	Fluoride (as F), mg/l	1.0, Max. (1.5)	<0.1	0.1	0.2
9.	Dissolved Solids, mg/l	500, Max. (2000)	72	456	269
10.	Magnesium (as Mg), mg/l	30, Max. (100)	2.4	9.1	5.6
11.	Calcium (as Ca), mg/l	75, Max. (200)	3.6	16.9	12.4
12.	Copper (as Cu), mg/l	0.05, Max. (1.5)	0.021	<0.001	0.03
13.	Manganese (as Mn), mg/l	0.1, Max. (0.3)	0.012	<0.001	<0.001
14.	Sulphate (as SO ₄), mg/l	200, Max.	10	21	15
15.	Nitrates (as NO ₃), mg/l	45, Max	1.1	2.2	1.1
16.	Phenolic Compounds (as C ₆ H ₅ OH), mg/l	0.002, Max	ND	ND	ND
17.	Mercury (as Hg), mg/l	0.001, Max.	<0.001	<0.001	<0.001
18.	Cadmium (as Cd), mg/l	0.01, Max.	<0.01	<0.01	<0.01

19.	Selenium (as Se), mg/l	0.01, Max.	<0.005	<0.005	<0.005
20.	Arsenic as As,mg/l	0.01, Max	<0.005	<0.005	<0.005
21.	Cyanide (as CN), mg/l	0.05, Max	<0.01	<0.01	<0.01
22.	Lead (as Pb), mg/l	0.05, Max	<0.01	<0.01	<0.01
23.	Zinc (as Zn), mg/l	5 Max. (15)	0.02	0.025	0.03
24.	Anionic Detergents (MBAS) mg/l	0.2, Max	ND	ND	ND
25.	Chromium (as Cr ⁺⁶), mg/l	0.05, Max	<0.01	<0.01	<0.01
26.	Mineral Oil, mg/l	0.01, Max	ND	ND	ND
27.	Alkalinity (as CaCO ₃), mg/l	200 Max.(600)	13	43	30
28.	Aluminum (as Al), mg/l	0.2, Max	<0.02	0.071	0.065
29.	Phosphate (as PO ₄), mg/l	0.05, Max.	0.15	0.041	0.02
30.	Boron (as B), mg/l	1, Max (5)	<0.001	0.075	<0.001
31.	Total Organic Carbon (TOC), mg/l	-	1.1	1.069	0.721
32.	Dissolved Oxygen (DO), mg/l	-	12.6	10.4	11.8

Table- 5: Results of Lakes at Larsemann Hills

S.N.	Parameter	IS: 10500-1991 Desirable (Max. Permissible)	L-10	L-11	L-12
1.	Colour, Hazen unit	5, Max.	<5	<5	<5
2.	Odour	Unobjectionable (UO)	UO	UO	UO
3.	Turbidity, NTU	5, Max. (10)	<1	<1	<1
4.	pH	6.5-8.5	6.2	7.1	6.0
5.	Total hardness (as CaCO ₃), mg/l	300, Max. (600)	7	15	Nil
6.	Iron (as Fe), mg/l	0.3, Max. (1.0)	0.22	<0.01	0.02
7.	Chloride (as Cl), mg/l	250, Max. (1000)	12	26	10
8.	Fluoride (as F), mg/l	1.0, Max. (1.5)	<0.1	0.1	<0.1
9.	Dissolved Solids, mg/l	500, Max. (2000)	20	49	19
10.	Magnesium (as Mg), mg/l	30, Max. (100)	0.7	1.2	Nil
11.	Calcium (as Ca), mg/l	75, Max. (200)	1.2	2.4	Nil
12.	Copper (as Cu), mg/l	0.05, Max. (1.5)	<0.001	<0.001	<0.001
13.	Manganese (as Mn), mg/l	0.1, Max. (0.3)	<0.001	<0.001	<0.001
14.	Sulphate (as SO ₄), mg/l	200, Max.	<1	<1	<1
15.	Nitrates (as NO ₃), mg/l	45, Max	<1	<1	<1
16.	Phenolic Compounds (as C ₆ H ₅ OH), mg/l	0.002, Max	ND	ND	ND

17.	Mercury (as Hg), mg/l	0.001, Max.	<0.001	<0.001	<0.001.
18.	Cadmium (as Cd), mg/l	0.01, Max.	<0.01	<0.01	<0.01
19.	Selenium (as Se), mg/l	0.01, Max.	<0.005	<0.005	<0.005
20.	Arsenic as As,mg/l	0.01, Max	<0.005	<0.005	<0.005
21.	Cyanide (as CN), mg/l	0.05, Max	<0.01	<0.01	<0.01
22.	Lead (as Pb), mg/l	0.05, Max	<0.01	<0.01	<0.01
23.	Zinc (as Zn), mg/l	5 Max. (15)	<0.01	<0.01	<0.01
24.	Anionic Detergents (MBAS) mg/l	0.2, Max	ND	ND	ND
25.	Chromium (as Cr ⁺⁶), mg/l	0.05, Max	<0.01	<0.01	<0.01
26.	Mineral Oil, mg/l	0.01, Max	ND	ND	ND
27.	Alkalinity (as CaCO ₃), mg/l	200 Max.(600)	3	7	3
28.	Aluminum (as Al), mg/l	0.2, Max	0.088	0.006	0.022
29.	Phosphate (as PO ₄), mg/l	0.05, Max.	0.013	0.003	0.002
30.	Boron (as B), mg/l	1, Max (5)	<0.001	<0.001	<0.001
31.	Total Organic Carbon (TOC), mg/l	-	0.475	0.212	0.172
32.	Dissolved Oxygen (DO), mg/l	-	13.4	12.4	10.8

Table- 6: Results of Lakes at Larsemann Hills

S.N.	Parameter	IS: 10500-1991 Desirable (Max. Permissible)	BR	ML	F
1.	Colour, Hazen unit	5, Max.	<5	<5	<5
2.	Odour	Unobjectionable (UO)	UO	UO	UO
3.	Turbidity, NTU	5, Max. (10)	<1	<1	<1
4.	pH	6.5-8.5	6.8	6.9	6.6
5.	Total hardness (as CaCO ₃), mg/l	300, Max. (600)	88	30	26
6.	Iron (as Fe), mg/l	0.3, Max. (1.0)	0.06	0.05	0.04
7.	Chloride (as Cl), mg/l	250, Max. (1000)	172	65	57
8.	Fluoride (as F), mg/l	1.0, Max. (1.5)	0.1	0.1	0.1
9.	Dissolved Solids, mg/l	500, Max. (2000)	369	140	126
10.	Magnesium (as Mg), mg/l	30, Max. (100)	10.2	3.8	3.8
11.	Calcium (as Ca), mg/l	75, Max. (200)	9.8	5.7	5.7
12.	Copper (as Cu), mg/l	0.05, Max. (1.5)	0.01	<0.001	<0.001
13.	Manganese (as Mn), mg/l	0.1, Max. (0.3)	0.02	0.01	<0.001
14.	Sulphate (as SO ₄), mg/l	200, Max.	17	9	3
15.	Nitrates (as NO ₃), mg/l	45, Max	3.3	2.2	<1

16.	Phenolic Compounds (as C ₆ H ₅ OH), mg/l	0.002, Max	ND	ND	ND
17.	Mercury (as Hg), mg/l	0.001, Max.	<0.001	<0.001	<0.001
18.	Cadmium (as Cd), mg/l	0.01, Max.	<0.01	<0.01	<0.01
19.	Selenium (as Se), mg/l	0.01, Max.	<0.005	<0.005	<0.005
20.	Arsenic as As,mg/l	0.01, Max	<0.005	<0.005	<0.005
21.	Cyanide (as CN), mg/l	0.05, Max	<0.01	<0.01	<0.01
22.	Lead (as Pb), mg/l	0.05, Max	<0.01	<0.01	<0.01
23.	Zinc (as Zn), mg/l	5 Max. (15)	0.15	0.01	<0.01
24.	Anionic Detergents (MBAS) mg/l	0.2, Max	ND	ND	ND
25.	Chromium (as Cr ⁺⁶), mg/l	0.05, Max	<0.01	<0.01	<0.01
26.	Mineral Oil, mg/l	0.01, Max	ND	ND	ND
27.	Alkalinity (as CaCO ₃), mg/l	200 Max.(600)	37	14	11
28.	Aluminum (as Al), mg/l	0.2, Max	<0.02	<0.02	<0.02
29.	Phosphate (as PO ₄), mg/l	0.05, Max.	0.06	0.011	0.014
30.	Boron (as B), mg/l	1, Max (5)	<0.001	<0.001	<0.001
31.	Total Organic Carbon (TOC), mg/l	-	1.915	1.652	1.263
32.	Dissolved Oxygen (DO), mg/l	-	9.6	12.2	11.4

Table- 7: Results of Lakes at Larsemann Hills

S.N.	Parameter	IS: 10500-1991 Desirable (Max. Permissible)	ST1	ST2
1.	Colour, Hazen unit	5, Max.	<5	<5
2.	Odour	Unobjectionable (UO)	UO	UO
3.	Turbidity, NTU	5, Max. (10)	<1	<1
4.	pH	6.5-8.5	6.8	6.7
5.	Total hardness (as CaCO ₃), mg/l	300, Max. (600)	14	13
6.	Iron (as Fe), mg/l	0.3, Max. (1.0)	0.02	<0.01
7.	Chloride (as Cl), mg/l	250, Max. (1000)	32	31
8.	Fluoride (as F), mg/l	1.0, Max. (1.5)	0.1	<0.1
9.	Dissolved Solids, mg/l	500, Max. (2000)	71	64
10.	Magnesium (as Mg), mg/l	30, Max. (100)	1.3	Nil
11.	Calcium (as Ca), mg/l	75, Max. (200)	3.6	1.3
12.	Copper (as Cu), mg/l	0.05, Max. (1.5)	<0.001	<0.001
13.	Manganese (as Mn), mg/l	0.1, Max. (0.3)	<0.001	0.003

14.	Sulphate (as SO ₄), mg/l	200, Max.	1	<1
15.	Nitrates (as NO ₃), mg/l	45, Max	<1	<1
16.	Phenolic Compounds (as C ₆ H ₅ OH), mg/l	0.002, Max	ND	ND
17.	Mercury (as Hg), mg/l	0.001, Max.	<0.001	<0.001
18.	Cadmium (as Cd), mg/l	0.01, Max.	<0.01	<0.01
19.	Selenium (as Se), mg/l	0.01, Max.	<0.005	<0.005
20.	Arsenic as As,mg/l	0.01, Max	<0.005	<0.005
21.	Cyanide (as CN), mg/l	0.05, Max	<0.01	<0.01
22.	Lead (as Pb), mg/l	0.05, Max	<0.01	<0.01
23.	Zinc (as Zn), mg/l	5 Max. (15)	<0.01	<0.01
24.	Anionic Detergents (MBAS) mg/l	0.2, Max	ND	ND
25.	Chromium (as Cr ⁺⁶), mg/l	0.05, Max	<0.01	<0.01
26.	Mineral Oil, mg/l	0.01, Max	ND	ND
27.	Alkalinity (as CaCO ₃), mg/l	200 Max.(600)	4	5
28.	Aluminum (as Al), mg/l	0.2, Max	0.006	0.007
29.	Phosphate (as PO ₄), mg/l	0.05, Max.	0.002	<0.001
30.	Boron (as B), mg/l	1, Max (5)	<0.001	0.007
31.	Total Organic Carbon (TOC), mg/l	-	0.735	0.711
32.	Dissolved Oxygen (DO), mg/l	-	10.8	13.2

Table- 8: Results of Sea Water at Larsemann Hills

S.N.	Parameter	Sea-1	Sea-2
1.	Colour, Hazen unit	<5	<5
2.	Odour	UO	UO
3.	Turbidity, NTU	2	2
4.	pH	6.3	6.8
5.	Total hardness (as CaCO ₃), mg/l	7020	8430
6.	Iron (as Fe), mg/l	0.03	0.1
7.	Chloride (as Cl), mg/l	19495	24195
8.	Fluoride (as F), mg/l	0.7	0.5
9.	Dissolved Solids, mg/l	37080	52320
10.	Magnesium (as Mg), mg/l	1298	1456
11.	Calcium (as Ca), mg/l	377	534
12.	Copper (as Cu), mg/l	0.1	0.08
13.	Manganese (as Mn), mg/l	0.1	0.05

14.	Sulphate (as SO ₄), mg/l	3480	4120
15.	Nitrates (as NO ₃), mg/l	112	138
16.	Phenolic Compounds (as C ₆ H ₅ OH), mg/l	ND	ND
17.	Mercury (as Hg), mg/l	<0.001	<0.001
18.	Cadmium (as Cd), mg/l	<0.01	<0.01
19.	Selenium (as Se), mg/l	<0.005	<0.005
20.	Arsenic as As,mg/l	<0.005	<0.005
21.	Cyanide (as CN), mg/l	<0.01	<0.01
22.	Lead (as Pb), mg/l	0.5	0.3
23.	Zinc (as Zn), mg/l	0.35	0.13
24.	Anionic Detergents (MBAS) mg/l	ND	ND
25.	Chromium (as Cr ⁺⁶), mg/l	<0.01	<0.01
26.	Mineral Oil, mg/l	ND	ND
27.	Alkalinity (as CaCO ₃), mg/l	178	212
28.	Aluminum (as Al), mg/l	<0.2	<0.2
29.	Phosphate (as PO ₄), mg/l	0.087	0.065
30.	Boron (as B), mg/l	0.236	0.319
31.	Total Organic Carbon (TOC), mg/l	1.349	1.418
32.	Dissolved Oxygen (DO), mg/l	6.3	6.8

Table- 9 (a): Analysis of Pesticides in water at Bharati Island, Larsemann Hills

S.N.	Tests Pesticides	Detection Limit Mg/l	Protocol adopted	L-1	L-2	L-3	L-4	L-5	L-6
1	Dichlorvos	0.0002	GC-MS	ND	ND	ND	ND	ND	ND
2	Propoxur	0.0002	GC-MS	ND	ND	ND	ND	ND	ND
3	Dimethoate	0.0002	GC-MS	ND	ND	ND	ND	ND	ND
4	Carbofuran	0.0002	GC-MS	ND	ND	ND	ND	ND	ND
5	BHC (Benzene Hexa Chloride)	0.0002	GC-MS	ND	ND	ND	ND	ND	ND
6	Atrazine	0.0002	GC-MS	ND	ND	ND	ND	ND	ND
7	Diazinon	0.0002	GC-MS	ND	ND	ND	ND	ND	ND
8	Lindane	0.0002	GC-MS	ND	ND	ND	ND	ND	ND
9	Phosphamidon	0.0002	GC-MS	ND	ND	ND	ND	ND	ND
10	Methyl – Parathion	0.0002	GC-MS	ND	ND	ND	ND	ND	ND
11	Fenitrothion	0.0002	GC-MS	ND	ND	ND	ND	ND	ND
12	Aldrin	0.0002	GC-MS	ND	ND	ND	ND	ND	ND
13	Malathion	0.0002	GC-MS	ND	ND	ND	ND	ND	ND
14	Fenthion	0.0002	GC-MS	ND	ND	ND	ND	ND	ND
15	Parathion	0.0002	GC-MS	ND	ND	ND	ND	ND	ND

16	Endosulfan	0.0002	GC-MS	ND	ND	ND	ND	ND	ND
17	Dieldrin	0.0002	GC-MS	ND	ND	ND	ND	ND	ND
18	o,p DDT (di-chloro, di-phenyl, tri-chloroethane)	0.0002	GC-MS	ND	ND	ND	ND	ND	ND
19	Ethion	0.0002	GC-MS	ND	ND	ND	ND	ND	ND
20	p,p DDT	0.0002	GC-MS	ND	ND	ND	ND	ND	ND
21	Captafol	0.0002	GC-MS	ND	ND	ND	ND	ND	ND
22	Phosalone	0.0002	GC-MS	ND	ND	ND	ND	ND	ND
23	Permethrin	0.0002	GC-MS	ND	ND	ND	ND	ND	ND
24	Cypermethrin	0.0002	GC-MS	ND	ND	ND	ND	ND	ND
25	Fenvalerate	0.0002	GC-MS	ND	ND	ND	ND	ND	ND
26	Deltamethrin	0.0002	GC-MS	ND	ND	ND	ND	ND	ND
27	2,4-D (Dichlorophenyle acetic acid)	0.0001	LC-MS	ND	ND	ND	ND	ND	ND
28	Isoproturon	0.0001	LC-MS	ND	ND	ND	ND	ND	ND
29	Monocrotophos	0.0001	LC-MS	ND	ND	ND	ND	ND	ND

ND-Not Detected

Table- 9 (b): Analysis of Pesticides in water at Bharati Island,
Larsemann Hills

S.N.	Tests Pesticides	Detection Limit Mg/l	Protocol adopted	L-7	L-7A	L-8	L-10	L-11	L-12
1	Dichlorvos	0.0002	GC-MS	ND	ND	ND	ND	ND	ND
2	Propoxur	0.0002	GC-MS	ND	ND	ND	ND	ND	ND
3	Dimethoate	0.0002	GC-MS	ND	ND	ND	ND	ND	ND
4	Carbofuran	0.0002	GC-MS	ND	ND	ND	ND	ND	ND
5	BHC (Benzene Hexa Chloride)	0.0002	GC-MS	ND	ND	ND	ND	ND	ND
6	Atrazine	0.0002	GC-MS	ND	ND	ND	ND	ND	ND
7	Diazinon	0.0002	GC-MS	ND	ND	ND	ND	ND	ND
8	Lindane	0.0002	GC-MS	ND	ND	ND	ND	ND	ND
9	Phosphamidon	0.0002	GC-MS	ND	ND	ND	ND	ND	ND
10	Methyl – Parathion	0.0002	GC-MS	ND	ND	ND	ND	ND	ND
11	Fenitrothion	0.0002	GC-MS	ND	ND	ND	ND	ND	ND
12	Aldrin	0.0002	GC-MS	ND	ND	ND	ND	ND	ND
13	Malathion	0.0002	GC-MS	ND	ND	ND	ND	ND	ND
14	Fenthion	0.0002	GC-MS	ND	ND	ND	ND	ND	ND
15	Parathion	0.0002	GC-MS	ND	ND	ND	ND	ND	ND
16	Endosulfan	0.0002	GC-MS	ND	ND	ND	ND	ND	ND
17	Dieldrin	0.0002	GC-MS	ND	ND	ND	ND	ND	ND

18	o,p DDT (di-chloro, di- phenyl, tri- chloroethane)	0.0002	GC-MS	ND	ND	ND	ND	ND	ND
19	Ethion	0.0002	GC-MS	ND	ND	ND	ND	ND	ND
20	p,p DDT	0.0002	GC-MS	ND	ND	ND	ND	ND	ND
21	Captafol	0.0002	GC-MS	ND	ND	ND	ND	ND	ND
22	Phosalone	0.0002	GC-MS	ND	ND	ND	ND	ND	ND
23	Permethrin	0.0002	GC-MS	ND	ND	ND	ND	ND	ND
24	Cypermethrin	0.0002	GC-MS	ND	ND	ND	ND	ND	ND
25	Fenvalerate	0.0002	GC-MS	ND	ND	ND	ND	ND	ND
26	Deltamethrin	0.0002	GC-MS	ND	ND	ND	ND	ND	ND
27	2,4-D (Dichlorophenyle acetic acid)	0.0001	LC-MS	ND	ND	ND	ND	ND	ND
28	Isoproturon	0.0001	LC-MS	ND	ND	ND	ND	ND	ND
29	Monocrotophos	0.0001	LC-MS	ND	ND	ND	ND	ND	ND

ND-Not Detected

Table- 9 (c): Analysis of Pesticides in water at Larsemann Hills

S.N.	Tests Pesticides	Detection Limit Mg/l	Protocol adopted	BR	ML	F	ST1	ST2
1	Dichlorvos	0.0002	GC-MS	ND	ND	ND	ND	ND
2	Propoxur	0.0002	GC-MS	ND	ND	ND	ND	ND
3	Dimethoate	0.0002	GC-MS	ND	ND	ND	ND	ND
4	Carbofuran	0.0002	GC-MS	ND	ND	ND	ND	ND
5	BHC (Benzene Hexa Chloride)	0.0002	GC-MS	ND	ND	ND	ND	ND
6	Atrazine	0.0002	GC-MS	ND	ND	ND	ND	ND
7	Diazinon	0.0002	GC-MS	ND	ND	ND	ND	ND
8	Lindane	0.0002	GC-MS	ND	ND	ND	ND	ND
9	Phosphamidon	0.0002	GC-MS	ND	ND	ND	ND	ND
10	Methyl – Parathion	0.0002	GC-MS	ND	ND	ND	ND	ND
11	Fenitrothion	0.0002	GC-MS	ND	ND	ND	ND	ND
12	Aldrin	0.0002	GC-MS	ND	ND	ND	ND	ND
13	Malathion	0.0002	GC-MS	ND	ND	ND	ND	ND
14	Fenthion	0.0002	GC-MS	ND	ND	ND	ND	ND
15	Parathion	0.0002	GC-MS	ND	ND	ND	ND	ND
16	Endosulfan	0.0002	GC-MS	ND	ND	ND	ND	ND
17	Dieldrin	0.0002	GC-MS	ND	ND	ND	ND	ND
18	o,p DDT (di-chloro, di- phenyl, tri- chloroethane)	0.0002	GC-MS	ND	ND	ND	ND	ND
19	Ethion	0.0002	GC-MS	ND	ND	ND	ND	ND
20	p,p DDT	0.0002	GC-MS	ND	ND	ND	ND	ND

21	Captafol	0.0002	GC-MS	ND	ND	ND	ND	ND
22	Phosalone	0.0002	GC-MS	ND	ND	ND	ND	ND
23	Permethrin	0.0002	GC-MS	ND	ND	ND	ND	ND
24	Cypermethrin	0.0002	GC-MS	ND	ND	ND	ND	ND
25	Fenvalerate	0.0002	GC-MS	ND	ND	ND	ND	ND
26	Deltamethrin	0.0002	GC-MS	ND	ND	ND	ND	ND
27	2,4-D (Dichlorophenyle acetic acid)	0.0001	LC-MS	ND	ND	ND	ND	ND
28	Isoproturon	0.0001	LC-MS	ND	ND	ND	ND	ND
29	Monocrotophos	0.0001	LC-MS	ND	ND	ND	ND	ND

ND-Not Detected

(BR – Broknes, ML – Mcleod, ST – Stornes, L- Bharati Island)

Table- 10 (a): Results of Radiation Contamination in water at Bharati Island, Larsemann Hills

TEST RESULT

Test Parameters and Protocol	Requirement	L-1	L-2	L-3	L-4	L-5	L-6
Radioactivity analysis: Gross alpha (including Radium – 226) As per IS:14194 (Part 2)	< 0.5 bq / l	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
2) Gross beta Particle activity As per IS: 14194(Part 1)	< 1.9 bq / l	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
3) Radioactive contamination analysis: Cesium 137 content As per AERB Guidelines	< 1.9 bq / l	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL

Table- 10 (b): Results of Radiation Contamination in water at Bharati Island, Larsemann Hills

TEST RESULT

Test Parameters and Protocol	Requirement	L-7	L-7A	L-8	L-10	L-11	L-12
Radioactivity analysis: Gross alpha (including Radium – 226) As per IS:14194 (Part 2)	< 0.5 bq / l	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
2) Gross beta Particle activity As per IS: 14194(Part 1)	< 1.9 bq / l	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
3) Radioactive contamination analysis: Cesium 137 content As per AERB Guidelines	< 1.9 bq / l	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL

Table- 10 (c): Results of Radiation Contamination in water at Bharati Island, Larsemann Hills**TEST RESULT**

Test Parameters and Protocol	Requirement	BR	ML	F	ST1	ST2
Radioactivity analysis: Gross alpha (including Radium – 226) As per IS:14194 (Part 2)	< 0.5 bq / l	<MDL	<MDL	<MDL	<MDL	<MDL
2) Gross beta Particle activity As per IS: 14194(Part 1)	< 1.9 bq / l	<MDL	<MDL	<MDL	<MDL	<MDL
3) Radioactive contamination analysis: Cesium 137 content As per AERB Guidelines	< 1.9 bq / l	<MDL	<MDL	<MDL	<MDL	<MDL

Table- 10 (d): Results of Radiation Contamination in water at Bharati Island, Larsemann Hills**TEST RESULT**

Test Parameters and Protocol	Requirement	Sea-1	Sea-2
Radioactivity analysis: Gross alpha (including Radium – 226) As per IS:14194 (Part 2)	< 0.5 bq / l	<MDL	<MDL
2) Gross beta Particle activity As per IS: 14194 (Part 1)	< 1.9 bq / l	<MDL	<MDL
3) Radioactive contamination analysis: Cesium 137 content As per AERB Guidelines	< 1.9 bq / l	<MDL	<MDL

Minimum detection limit (MDL) of the instrument used:

Alpha counting system: 0.04 bq / liter

Beta counting system: 0.6 bq / liter

Minimum detection limit of the instrument used:

Gamma spectrometer with 1 k multi channel analyzer: 1.7 bq / l

(BR – Broknes, F – Fisher, ML – Mcleod, ST – Stornes, L- Bharati Island)

Table- 11 (a): Results of Microbiological Studies of Bharati Island, Larsemann Hill lake water samples

S.N.		L-1	L-2	L-3	L-4	L-5	L-6
1	Colony Count at 30 °C cfu/ml (As per guidelines of IS : 5402-2002, Reaff 2007)	5.4×10^2	< 1	< 1	< 1	< 1	< 1
2	Psychrophillic Count cfu/ml (As per guidelines of IS : 1479 p-3, 1977, Reaff 2003)	71	< 1	< 1	< 1	< 1	< 1
3	MPN Coliform/100ml (As per guidelines of IS : 1622-1981, Reaff : 2003) Ed 2.4 (2003-05)	NGO	NGO	NGO	NGO	NGO	NGO
4	Yeast & Mould Count/ml (As per guidelines of IS: 5403-1999, Reaff. : 2005)	Ab	Ab	Ab	Ab	Ab	Ab
5	Salmonella/ 25ml (As per guidelines of IS: 5887 (p-3) 1999 Reaff. : 2005)	Ab	Ab	Ab	Ab	Ab	Ab
6	Staphylococcus aureus /25ml (As per guidelines of IS : 5887 P-2 1976 Reaff : 2005)	Ab	Ab	Ab	Ab	Ab	Ab
7	Pseudomonas/10ml (As per guidelines of IS:13428, Annex.D, 2005)	Ab	Ab	Ab	Ab	Ab	Ab

No Growth Observed: NGO; Absent: Ab

Table- 11 (b): Results of Microbiological Studies of Bharati Island, Larsemann Hill lake water samples

S.N.		L-7	L-7A	L-8	L-10	L-11	L-12
1	Colony Count at 30 °C cfu/ml (As per guidelines of IS : 5402-2002, Reaff 2007)	< 1	< 1	< 1	< 1	< 1	< 1
2	Psychrophillic Count cfu/ml (As per guidelines of IS : 1479 p-3, 1977, Reaff 2003)	< 1	< 1	< 1	< 1	< 1	< 1
3	MPN Coliform/100ml (As per guidelines of IS : 1622-1981, Reaff : 2003) Ed 2.4 (2003-05)	NGO	NGO	NGO	NGO	NGO	NGO
4	Yeast & Mould Count/ml (As per guidelines of IS: 5403-1999, Reaff. : 2005)	Ab	Ab	Ab	Ab	Ab	Ab
5	Salmonella/ 25ml (As per guidelines of IS: 5887 (p-3) 1999 Reaff. : 2005)	Ab	Ab	Ab	Ab	Ab	Ab
6	Staphylococcus aureus /25ml (As per guidelines of IS : 5887 P-2 1976 Reaff : 2005)	Ab	Ab	Ab	Ab	Ab	Ab
7	Pseudomonas/10ml (As per guidelines of IS:13428, Annex.D, 2005)	Ab	Ab	Ab	Ab	Ab	Ab

No Growth Observed: NGO; Absent: Ab

Table- 11 (c): Results of Microbiological Studies of Larsemann Hill lake water samples

S.N.		BR	ML	F	ST1	ST2
1	Colony Count at 30 °C cfu/ml (As per guidelines of IS : 5402-2002, Reaff 2007)	< 1	< 1	< 1	< 1	1.6×10^3
2	Psychrophillic Count cfu/ml (As per guidelines of IS : 1479 p-3, 1977, Reaff 2003)	< 1	47	< 1	66	1.6×10^2
3	MPN Coliform/100ml (As per guidelines of IS : 1622-1981, Reaff : 2003) Ed 2.4 (2003-05)	NGO	NGO	NGO	NGO	NGO
4	Yeast & Mould Count/ml (As per guidelines of IS: 5403-1999, Reaff. : 2005)	Absent	Absent	Absent	Absent	Absent
5	Salmonella/ 25ml (As per guidelines of IS: 5887 (p-3) 1999 Reaff. : 2005)	Absent	Absent	Absent	Absent	Absent
6	Staphylococcus aureus /25ml (As per guidelines of IS : 5887 P-2 1976 Reaff : 2005)	Absent	Absent	Absent	Absent	Absent
7	Pseudomonas/10ml (As per guidelines of IS:13428, Annex.D, 2005)	Absent	Absent	Absent	Absent	Present

(BR – Broknes F – Fisher ML – Mcleod ST – Stornes, L- Bharati Island)

Table- 8: Results of Sea Water at Larsemann Hills

S.N.		Sea-1	Sea-2
1.	Colony Count at 30 °C cfu/ml (As per guidelines of IS : 5402-2002, Reaff 2007)	1.3×10^3	1.2×10^2
2.	Psychrophillic Count cfu/ml (As per guideline-s of IS : 1479 p-3, 1977, Reaff 2003)	1.4×10^2	74
3.	MPN Coliform/100ml (As per guideline-s of IS : 1622-1981, Reaff : 2003) Ed 2.4 (2003-05)	No growth observed	No growth observed
4.	Yeast & Mould Count/ml (As per guidelines of IS: 5403-1999, Reaff. : 2005)	Absent	Absent
5.	Salmonella/ 25ml (As per guidelines of IS: 5887 (p-3) 1999 Reaff. : 2005)	Absent	Absent
6.	Staphylococcus aureus /25ml (As per guidelines of IS : 5887 P-2 1976 Reaff : 2005)	Absent	Absent
7.	Pseudomonas/10ml (As per guidelines of IS:13428, Annex.D, 2005)	Present	Present

Conclusions

Antarctica has many simple and fragile lake ecosystems. Lakes are the only source of drinking water for expedition members in Antarctica. Preliminary assessment is a prime concern to evaluate the basic characteristics and pollution

level of freshwater ecosystems. Primary study reveals that Larsemann Hills Lake water is purest and 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 of lake ecosystem is also required in future course of time to know the human activities impacts in Larsemann Hills.

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