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Plankton diversity and aquatic ecology of a freshwater lake (L3) at Bharti Island, Larsemann Hills, east Antarctica

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ABSTRACT: The Larsemann Hills range is an ice-free oasis on the Ingrid Christensen Coast of Princess Elizabeth Land, East Antarctica, which includes Bharti Island, Fisher Island, McLeod Island, Broknes Peninsula, Stornes Peninsula, and several other islands, promontories, and nunataks. 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. The ice-free area consists of two major peninsulas (Stornes and Broknes), four minor peninsulas, and approximately 130 near shore islands. The Larsemann Hills area contains more than 150 lakes at different Islands and peninsulas. Bharti Island of Larsemann Hills in east Antarctica was selected as a sampling site for the present study. Water sample was collected from a freshwater lake during XXXth Indian Scientific Expedition to Antarctica (ISEA) and analyzed for the physico-chemical parameters, major elements, trace metals and major plankton diversity in surface lake water by following standard methodology. The concentrations of metals Cu, Pb, Cd, Zn and Cr were measured using Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES). Phytoplankton and zooplankton were also assessed in the aquatic ecosystem of Lake L3 at Bharti Island, Larsemann Hills over east Antarctica. Psychrophillic bacteria were found 71 cfu in lake water, while total bacterial count was found to be 5.4 × 10^{2}cfu.

Keywords: *Antarctic lake, Aquatic ecology, Bharti Island, Water pollution, Water quality monitoring*

INTRODUCTION

Lakes are important feature of the Earth's landscape which are not only the source of precious water, but provide valuable habitats to plants and animals, moderate hydrological cycles, influence microclimate, enhance the aesthetic beauty of the landscape and extend many recreational opportunities to humankind. The lakes are also used for drinking, irrigation, fishing, eco-tourism, etc. apart from the above advantages. High altitude lakes of Antarctica continent represent a relatively unique ecosystem in general; however, they remain less intensely studied than lowland lakes, mainly because of their remoteness and the short summer open-water period (Bhat *et al.*, 2011). Nevertheless, Antarctic lakes are sensitive reference systems of global climatic change and other human impacts (Bharti, 2012a). In fact, although remote high altitude lakes are in general protected from direct human impacts, in the last few decades they have been increasingly affected by airborne contaminants, such as acids and nutrients (Rogora*et al.*, 2006), organic pollutants and heavy metals (Carrera *et al.*, 2002).

Due to the extreme environmental conditions (low temperature, strong radiations, mostly low buffering capacity and low nutrient level) these ecosystems have a relatively simple food web and react more rapidly and more sensitively to environmental changes than other lakes (Bharti and Gajananda, 2013). Even minor impacts are able to significantly affect the physical and chemical properties of soft water high altitude lakes, to induce changes in species

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composition and abundance of the biota and to cause accumulation of trace substances in higher trophic organisms (Hofer *et al.*, 2001). In spite of the socio-economic and ecological importance of these lakes, better knowledge of several ecological aspects (especially regarding species distribution patterns and biogeography, diversity and functional interaction among the different components of the food web) is needed for better understanding of their relationships with the environmental variables. These lakes have received little attention so far in terms of their limnology, diversity, conservation and water management, but they are becoming increasingly important due to the possible consequences of the global climate change.

The Larsemann Hills area (69° 20'–69° 28' S, 76° 00'–76° 30' E) is an ice-free oasis on the Ingrid Christensen Coast of Princess Elizabeth Land, East Antarctica, that includes Bharti Island, Fisher Island, McLeod Island, Broknes Peninsula, Stornes Peninsula, and several other islands, promontories, and nunataks (Fig. 1). The deglaciated terrain constitutes a transitional zone between marine and glacial ecosystems and includes gently rolling hills, glacially polished and striated bedrock hummocks (rochesmoutonnees), scoured surfaces, and broad valleys interspersed with lakes of varying dimensions. Indian scientific studies in the Larsemann Hills started in 2003 and the present work was carried out from 2010 to 2011 during the construction of the third Indian research station Bharti. To investigate the aquatic ecology, lake water chemistry and characteristics in the area water sample was collected from a lake on Bharti Island.

MATERIALS AND METHODS

Study Area

Environmental monitoring and impact assessment studies were carried out in Antarctica during the austral summer seasons of various Indian Scientific Expeditions to Antarctica (SIIR, 2012).

Bharti Island of Larsemann Hills in east Antarctica was selected as a sampling site for the present study. Water sample was collected from L-3 Lake of Bharti Island during XXXth Indian Scientific Expedition to Antarctica (30-ISEA) and analysed for the physico-chemical parameters, major elements and trace metal in surface lake water (Bharti, 2012b). The location map

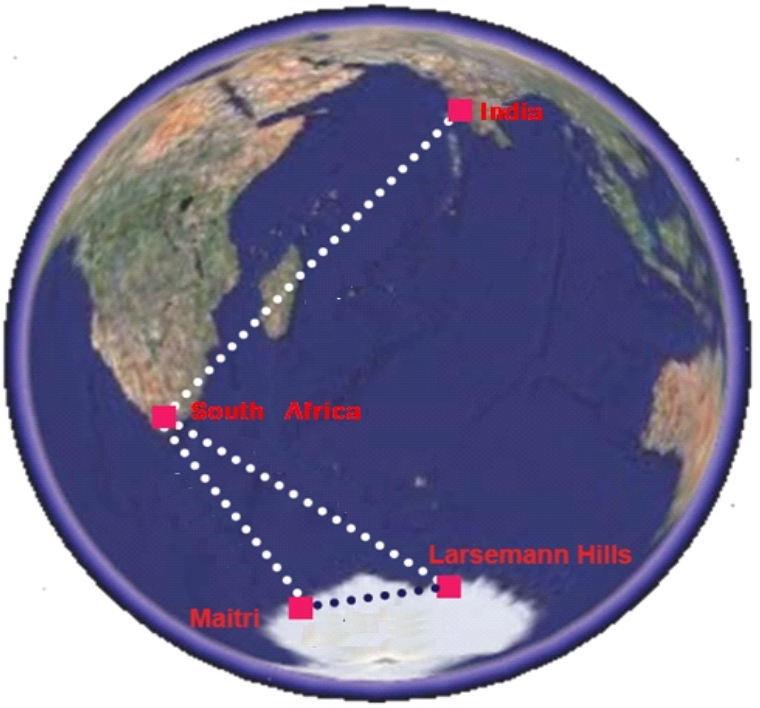

Fig. 1: Route map of Indian Antarctic Expedition

of study area is given in the Figs. 1, 2 and 3. One sampling point L-3 was selected at Bharti Island, Larsemann hills in east Antarctica. Geo-coordinates of sampling point are given in Table1.

Sampling

The sampling of lake water was carried out in the 1 L PET bottle and stored in a cold storage immediately after preservation by 1 ml 70 % HNO_3. The samples were transported to the laboratory after completion of expedition and analyzed for further analysis of the physico-chemical parameters, major elements, trace metals, plankton diversity and microbiological parameters.

Analytical Methods

Standards methods as described in APHA (2005) were followed for the dilution and analysis for various parameters. Laboratory analysis work for metal analysis was carried out with the help of Inductively Coupled Plasma Optical Emission spectroscopy (ICP-OES).

Water sample was collected from sampling station on 10 January 2011. Neatly cleaned and rinsed double Stoppard polyethylene bottles were used for collection of water samples. Bottles were kept in ice box and brought to the laboratory for further analysis. Some of the physico-chemical characteristics of water including water temperature, color, pH were determined onsite using mercury thermometer, visual, digital pH meter respectively. While dissolved oxygen, turbidity and total dissolved solids were analyzed using Orion onsite water quality monitoring kit at the sampling stations. Separate samples were collected in sterile bottles for microbiological studies. Lake water was concentrated using plankton net and collected in a tube for further laboratory studies. Collected plankton were preserved by adding 4% Formalin solution and Lugol's solution. Other parameters including plankton diversity and metals were analyzed in the laboratory following the methods of APHA, (2005) and Trivedi and Goel, (1984). Plankton counting was conducted with the help of Bogorov / Sedwick Rafter Plankton Counter chambers as described in APHA, (2005).

RESULTS AND DISCUSSION

Physico-chemical characteristics and trace metals of lake water sample are given in Table 2. Lake water temperature was found in very low condition of 1.0 ºC. The lake water chemistry of the area is greatly influenced by chemistry of the host rock rather than precipitation and evaporation (Gibbs, 1970). Numerous examples have appeared in the literatures, which indeed support the idea that in an unpolluted environment, where anthropogenic activities are negligible, water quality can be correlated with minerals present in the bed rock (Asthana *et al.*, 2013).

General physico-chemical characteristics

Lake water was found to be free from any color, odor or turbidity. pH of selected freshwater lake sample was slightly acidic in nature and found to be 6.4 (Table 2). Total hardness of lake water sample was found to be 21 mg/L, while alkalinity was found to be 17 mg/L. Total dissolved solids were recorded 155 mg/L, whereas dissolved oxygen was measured to be 9.2 mg/L. Total organic carbon in lake water sample was found 0.557 mg/L.

Dominant elements

Chlorides and calcium were found to be the dominant constituents among the lake water contents. Maximum chloride and calcium were found to be 40 mg/L and 7.6 mg/L. Besides these, sulfate (13.0 mg/L), magnesium (3.8 mg/L) and phosphate (0.046 mg/L) were also detected in L-3 lake water sample at Bharti station, Larsemann Hills.

Trace metals and metalloids

Lead was found to be 0.03mg/L, while iron was found to be 0.014 mg/L in lake water collected from lake L-3 at Bharti Island. Zinc and Boron were also detected 0.222 mg/L and 0.005 mg/L respectively. Trace metals like cadmium, copper and aluminum were found below detection level in lake water sample.

Table 1: Location of lake's water sampling site at Bharti Island

S.N.	Sample ID	Date	Latitude (S)	Longitude (E)	Altitude (m)
1	L-3	10-01-2011	69º 24' 21.9" S	76º 11' 13.8" E	30

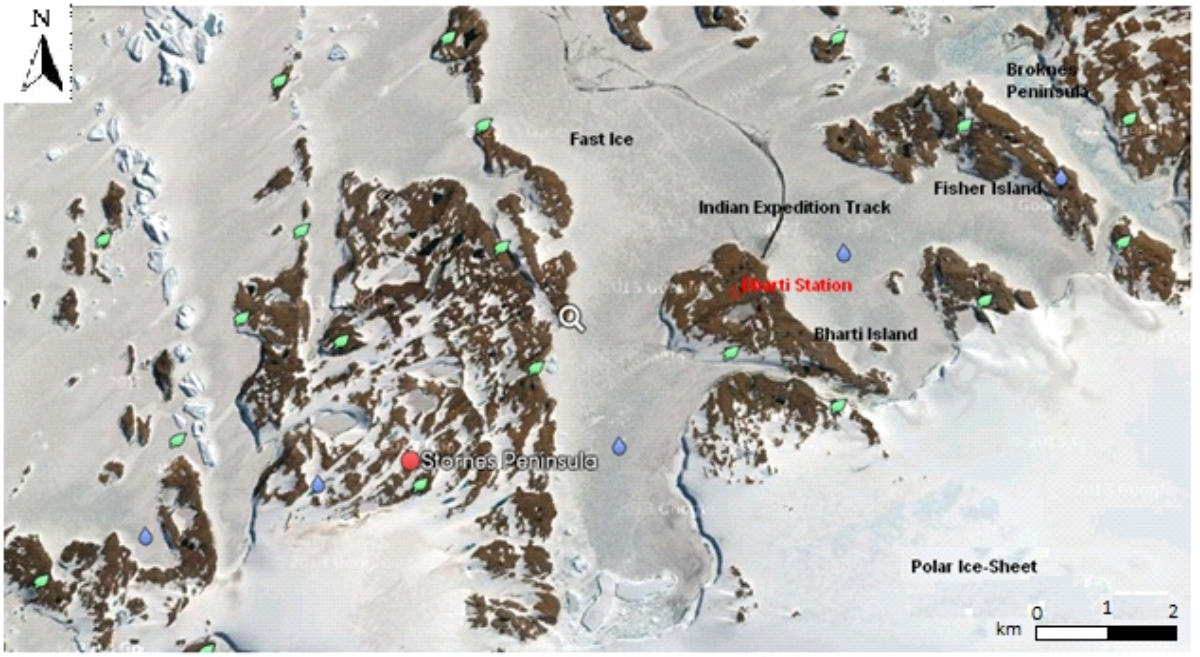

Fig. 2: Map of Bharti Island in Larsemann Hills

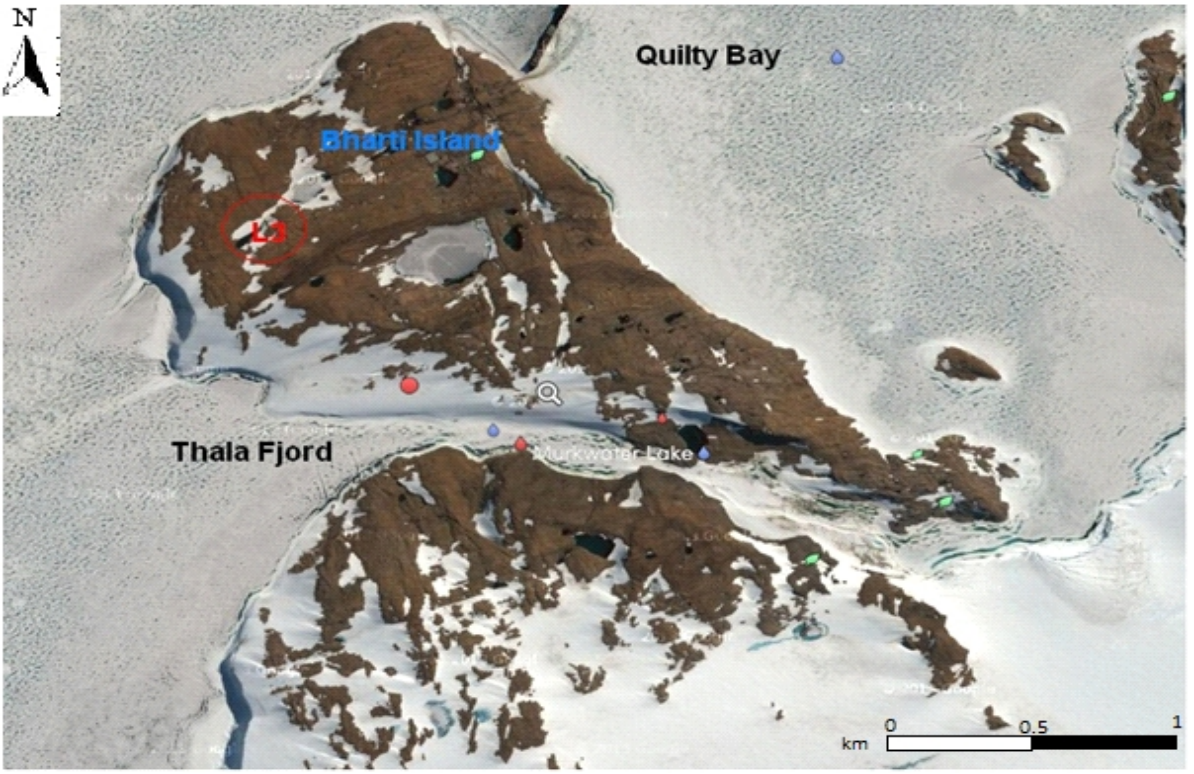

Fig. 3: Location map of Lake L3 at Bharti Island

Similar trend was observed for mercury, aluminum, manganese, selenium, arsenic and chromium metals in lake water sample collected from Bharti Island (Table 2). Fluoride was detected to be 0.1 mg/L in the water of lake L-3. Few metals like Cu and Zn are biologically essential to living organisms in trace quantities in aquatic ecosystems. These trace metals may re-circulate from sediment and became available

Table 2: Results of lake's water sample from Bharti Island

SN	Parameter	IS: 10500-1991 Desirable (permissible)	L-3
1	Color, Hazen unit	5, Max.	<5
2	Odor	Unobjectionable (UO)	UO
3	Turbidity, NTU	5, Max. (10)	<1
4	pH	6.5-8.5	6.4
5	Total hardness (as $CaCO_3$), mg/L	300, Max. (600)	21
6	Fe, mg/L	0.3, Max. (1.0)	0.014
7	Cl_2, mg/L	250, Max. (1000)	40
8	F, mg/L	1.0, Max. (1.5)	0.1
9	Dissolved Solids, mg/L	500, Max. (2000)	155
10	Mg, mg/L	30, Max. (100)	3.8
11	Ca, mg/L	75, Max. (200)	7.6
12	Cu, mg/L	0.05, Max. (1.5)	<0.001
13	Mn, mg/L	0.1, Max. (0.3)	<0.001
14	SO_4, mg/L	200, Max.	13
15	NO_3, mg/L	45, Max	2.2
16	C_6H_5OH, mg/L	0.002, Max	ND
17	Hg, mg/L	0.001, Max.	<0.001
18	Cd, mg/L	0.01, Max.	<0.01
19	Se, mg/L	0.01, Max.	<0.005
20	As, mg/L	0.01, Max	<0.005
21	CN, mg/L	0.05, Max	<0.01
22	Pb, mg/L	0.05, Max	0.03
23	Zn, mg/L	5 Max. (15)	0.222
24	MBAS, mg/L	0.2, Max	ND
25	Cr^{+6}, mg/L	0.05, Max	<0.01
26	Mineral Oil, mg/L	0.01, Max	ND
27	Alkalinity (as $CaCO_3$), mg/L	200 Max.(600)	17
28	Al, mg/L	0.2, Max	<0.02
29	PO4, mg/L	0.05, Max.	0.046
30	B, mg/L	1, Max (5)	0.005
31	Total Organic Carbon (TOC), mg/L	-	0.557
32	Dissolved Oxygen (DO), mg/L	-	9.2

(BDL- Below Detection Limit)

for biota (Campbell *et al.*, 1988). Fluoride (<0.1 mg/L) was found below detection limit in lake water sample.

Complex organic compounds

Phenolic compounds (as C_6H_5OH), Anionic detergents (MBAS) and mineral oil were not detected in lake water sample at Bharti Island in east Antarctica.

Microbiology of lake water

Results for microbiological parameters of lake water samples are given in Table 3. Total bacterial count and psychrophilic counts were found to be 5.4×10^2 and 71 cfu respectively. No growth was observed for MPN coliform in the sample. Yeast and Moulds, Salmonella, Staphylococcus and Pseudomonas spp. were also found to be absent in freshwater lake water sample.

Plankton

Plankton community consists of two major groups namely phytoplankton and zooplankton in an aquatic ecosystem. Both groups have further various subgroups (families or phylum) having different characteristics, body structure and life cycles.

Under phytoplankton group, Chlorophyceae members (400 individuals/m^3), Basillariophyceae members (1200 individuals/m^3) and Cyanophyceae members (100 individuals/m^3) were observed, while Rhodophyceae members were not found at the time of sampling. Some unidentified or phytoplankton of other groups (800 individuals/m^3) were also found in the water of L-3 freshwater lake at Bharti Island. Among the Phytoplankton community, Basillariophyaceae and Chlorophyaceae groups were found dominant in the lake water at Bharti Island. Diatoms were found as a major constituent of Phytoplankton. Pinnularia, Nitzschia and Achnanthes were the major diatoms. Frazilaria, Navicula and Hantzchia might be present in Antarctic fresh waters as per Gupta, (2002). Besides this, evidences of the presence of Nostoc, Osillotoria, in Antarctic water were also observed by Palanisamy, (2010). Few unidentified Phytoplankton genera were also encountered in lake waters.

In zooplankton group, members of phylum Protozoa (20 individuals/m^3), phylum Rotifera (20 individuals/m^3), phylum Copepoda (20 individuals/m^3), phylum Cladocera (40 individuals/m^3) were observed, while Decapoda members were not found during the sampling period. Some unidentified or zooplankton of other groups (160 individuals/m^3) were also found in the water of L-3 freshwater lake at Bharti Island. Few Daphnia and others unidentified Ciliates were also found in Lake L-3, which indicates presence of new species of Plankton. During the study period in 30th ISEA, the lakes were found in frozen condition so the sample could not be collected for benthic diversity assessment from the deep regions of lake.

Results for phytoplankton and zooplankton community in freshwater lake ecosystem are given in Table4.

CONCLUSION

After a brief evaluation of general physico-chemical parameters, metals and quantities of complex organic compounds in lake water, it has been observed that the lake water has no pollution load and no impact of any anthropogenic activity is reflecting. A very low organic load in lake water indicates the oligotrophic stage of lake ecosystems. In oligotrophic lakes that are low in primary productivity as a result of low nutrient

Table 3: Microbiological Studies of lake water samplefrom Bharti Island (30th ISEA)

S.N.	Sample ID.	L-3
1	Total Bacterial Count/ml(As per guidelines of IS : 5402-2002, Reaff 2007)	5.4×10^2 cfu
2	Psychrophilic Count/ml (As per guidelines of IS: 1479 p-3, 1977, Reaff: 2003)	71 cfu
3	MPN Coliform /100ml (As per guidelines of IS:1622-1981, Reaff : 2003) Ed 2.4 (2003-05)	No growth observed
4	Yeast and Mould Count/ml (As per guidelines of IS: 5403 1999, Reaff: 2005)	Absent
5	Salmonella/ 25ml (As per guidelines of IS: 5887 (p-3) 1999 Reaff: 2005)	Absent
6	Staphylococcus sp./25ml (As per guidelines of IS : 5887 P-2 1976 Reaff : 2005)	Absent
7	Pseudomonas spp./10ml (As per guidelines of IS:13428, Amn.D, 2005)	Absent

(cfu- Colony Forming Unit)

Table 4: Plankton diversity in lake water at Bharti Island (30th ISEA)

S.N.	Plankton group	Nos. of Plankton (Ind./ m^3)
	A. Phytoplankton	
1	Chlorophyacae	400
2	Basillariophyace	1200
3	Cyanophyacae	100
4	Rhodophyacae	-
5	Others/Unidentified	800
	B. Zooplankton	
1	Protozoa	20
2	Rotifera	20
3	Copepoda	20
4	Cladocera	40
5	Decapoda	-
6	Others/Unidentified	160

content, the chemistry depends mainly on lithology, precipitation, evaporation and period of sojourn of water in the basin (Shrivastava *et al.*, 2011).

High dissolved oxygen content in lake water will support to aquatic organisms. This is indeed very good and healthy condition for any aquatic ecosystem. Lake water sample was found free from harmful pathogens and having few psychrophilic bacterial counts in lake water. Total dissolved solids were also not so high. Presence of plankton community indicated the establishment of a healthy ecosystem in freshwater lake L-3 at Bharti Island. Abundance of major phytoplankton group members showed the favorable circumstances for photosynthesis in aquatic ecosystem. Phytoplankton and zooplankton observed in the aquatic ecosystem of freshwater lakes of Bharti Island can also serve as indicator for further pollution studies and to know the status of Lake Ecosystem.

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