

Research Article

Environmental Characteristics and Plankton Diversity of Major Freshwater Lake (L7) at Bharti Island, Larsemann Hills over East Antarctica

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***Corresponding author:** Pawan Kumar Bharti, R&D Division, Antarctica Laboratory, Shriram Institute for Industrial Research, 19, University Road, Delhi-110 007, India; E-mail: gurupawanbharti@rediffmail.com**Received:** June 10, 2016; **Accepted:** August 26, 2016;**Published:** August 29, 2016**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 50km², 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 freshwater 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 analysed for the physico-chemical parameters, major elements, trace metals & major plankton diversity in surface lake water by following standard methodology. The concentrations of metals Cu, Pb, Cd, Zn and Cr were measured using (ICP-OES) Inductively Coupled Plasma Optical Emission Spectroscopy. Phytoplankton and zooplankton were also assessed in the aquatic ecosystem of Lake L7 at Bharti Island, Antarctica.

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

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 [1]. The different problems of the lake include excessive influx of sediments from the lake catchment, discharge of untreated or partially treated sewage and industrial waste waters, dumping of solid waste, entry of diffused nutrients source from agricultural and forestry, improper management of storm water, over abstraction, over-exploitation of lake for activities like recreation, fishing, encroachments, land reclamation etc causing lake water shrinkage, shoreline erosion and impacting the lake hydrology, deteriorating water quality, impacting biodiversity, bringing climate changes etc. There is, therefore, an immediate need to know the pollution status of a lake at given time so that necessary conservation activities may be undertaken to regain/improve the health of water body [2].

Lakes of Antarctica 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 [3]. Nevertheless, Antarctic lakes are sensitive reference

systems of global climatic change and other human impacts [4]. 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 [5], organic pollutants and heavy metals [6].

These lake ecosystems have a relatively simple food web due to the extreme environmental conditions and react more rapidly and more sensitively to environmental changes than other lakes [7]. Even minor impacts are able to significantly affect the physical and chemical properties of soft water high altitude lakes, to induce changes in species composition and abundance of the biota and to cause accumulation of trace substances in higher trophic organisms [8]. 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 [9].

The Larsemann Hills area 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

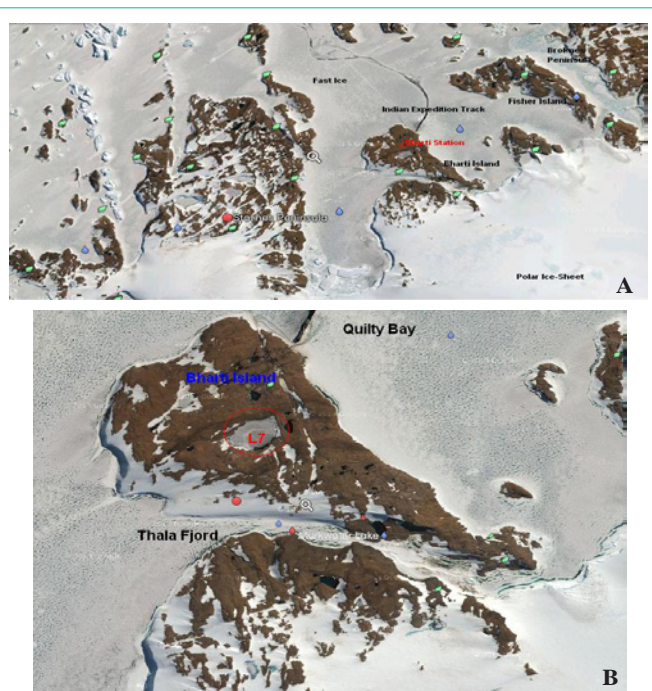


Figure 1 (A-B): Location map of the area and sampling sites.

Peninsula, Stornes Peninsula, and several other islands, promontories, and nunataks (Figure 1). The deglaciated terrain constitutes a transitional zone between marine and glacial ecosystems and includes gently rolling hills, glacially polished and striated bedrock hummocks (roches moutonnees), 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 [10].

Bharti Island of Larsemann Hills in east Antarctica was selected as a sampling site for the present study. Water sample was collected from L-7 lake of Bharti Island during XXXth Indian Scientific Expedition to Antarctica (ISEA) and analysed for the physico-chemical parameters, major elements and trace metal in surface lake water [11]. The location map of study area is given in the (Figure 1A and Figure 1B). One sampling point L-7 was selected at Bharti Island, Larsemann hills in east Antarctica. Geo-coordinates of sampling point (Table 1).

Sampling

Sampling for general parameters: Water sample was collected

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-7	17-01-2011	69° 24' 31.9" S	76° 11' 23.0" E	54

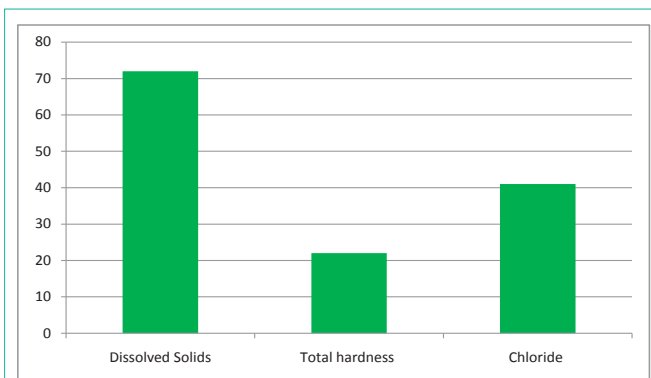


Figure 2: Showing total dissolved solids, hardness and chlorides in lake water (in mg l⁻¹).

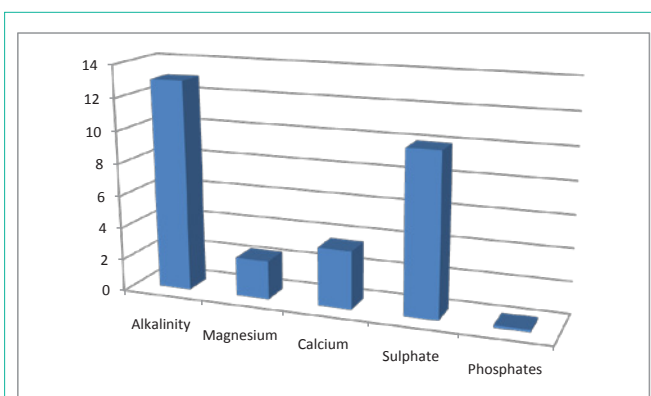


Figure 3: Showing major elements in lake water (in mg l⁻¹).

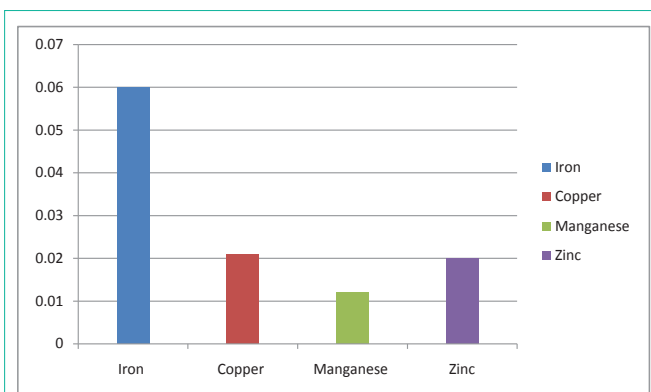


Figure 4: Showing major heavy metals in lake water (in mg l⁻¹).

from sampling station on 17 January 2011. Neatly cleaned and rinsed double Stoppard polyethylene bottle was used for collection of water sample. Bottle was 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 method, digital pH meter respectively. While dissolved oxygen, turbidity and total dissolved solids were analyzed using Orion onsite water quality monitoring kit at the sampling station. The sampling of lake water was carried out in the 1 L PET bottle and stored in a cold storage immediately after preservation by 1ml 70% HNO₃. The sample was transported to the

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

SN	Parameter	IS: 10500-1991 Desirable (permissible)	L-7
1	Colour, Hazen unit	5, Max.	<5
2	Odour	Unobjectionable (UO)	UO
3	Turbidity, NTU	5, Max. (10)	<1
4	pH	6.5-8.5	7.1
5	Total hardness (as CaCO ₃), mg/l	300, Max. (600)	22
6	Iron (as Fe), mg/l	0.3, Max. (1.0)	0.06
7	Chloride (as Cl), mg/l	250, Max. (1000)	41
8	Fluoride (as F), mg/l	1.0, Max. (1.5)	<0.1
9	Dissolved Solids, mg/l	500, Max. (2000)	72
10	Magnesium (as Mg), mg/l	30, Max. (100)	2.4
11	Calcium (as Ca), mg/l	75, Max. (200)	3.6
12	Copper (as Cu), mg/l	0.05, Max. (1.5)	0.021
13	Manganese (as Mn), mg/l	0.1, Max. (0.3)	0.012
14	Sulphate (as SO ₄), mg/l	200, Max.	10
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	BDL
17	Mercury (as Hg), mg/l	0.001, Max.	<0.001
18	Cadmium (as Cd), mg/l	0.01, Max.	<0.01
19	Selenium (as Se), mg/l	0.01, Max.	<0.005
20	Arsenic as As, mg/l	0.01, Max	<0.005
21	Cyanide (as CN), mg/l	0.05, Max	<0.01
22	Lead (as Pb), mg/l	0.05, Max	<0.01
23	Zinc (as Zn), mg/l	5 Max. (15)	0.02
24	Anionic Detergents (MBAS) mg/l	0.2, Max	BDL
25	Chromium (as Cr ⁶⁺), mg/l	0.05, Max	<0.01
26	Mineral Oil, mg/l	0.01, Max	BDL
27	Alkalinity (as CaCO ₃), mg/l	200 Max. (600)	13
28	Aluminum (as Al), mg/l	0.2, Max	<0.02
29	Phosphate (as PO ₄), mg/l	0.05, Max.	0.15
30	Boron (as B), mg/l	1, Max (5)	<0.001
31	Total Organic Carbon (TOC), mg/l	-	1.1
32	Dissolved Oxygen (DO), mg/l	-	12.6

BDL: Below Detection Limit

laboratory after completion of expedition and analyzed for further analysis of the physico-chemical parameters, major elements and metal constituents (Figure 2, Figure 3).

Sampling for biological parameters: Separate sample was collected in sterile bottle for microbiological studies. Lake water was concentrated using plankton net and collected in a collection tube for further laboratory studies. Collected plankton sample was preserved by adding 4% Formalin solution and Lugol's solution.

Gamma irradiated, clean and sterilized bottles (200ml capacity) were used for the collection of lake water sample from Antarctica. For dechlorination sodium thiosulphate was added to the clean, dry sampling bottles before gamma sterilization in an amount to provide an approximate concentration of 100mg/lit in the sample [12].

Aseptic conditions were maintained during the collection of samples. The samples were kept in an ice pack to prevent any changes in the microbial flora of the samples during the transportation. The water samples were transported to the lab in vertical position maintaining the temperature 1-4°C with ice pack enveloped conditions (Figure 4).

All the media were procured from Hi-Media Laboratory, Mumbai, India. Procured dehydrated media were used as per the instructions written on the box and growth promotion test of each media carried out before evaluation of samples. Sodium Chloride, Sodium thiosulphate and other chemicals were of analytical grade. Gram-Stain kit and other reagent procured from Difco Laboratories.

Analytical methods: Temperature and pH of lake water sample were recorded onsite using thermometer and digital pH meter. Standards methods as described in [13] were followed for the dilution and analysis for various parameters. Laboratory analysis work for metal analysis was carried out with the help of ICP-OES (Inductively Coupled Plasma Optical Emission spectroscopy).

Other biological parameters including plankton diversity and microbiological variables were analyzed in the laboratory following the methods of [13,14]. Plankton counting was conducted with the help of Bogorov/Sedwick Rafter Plankton Counter chambers as described in [13].

Results and Discussion

Geo-coordinates of sampling location (Table 1). Physico-chemical characteristics and trace metals of lake water sample (Table 2). Lake water temperature was found around subzero condition as was about 1.0°C at the time of sampling in Austral summer season. The lake water chemistry of the area is greatly influenced by chemistry of the host rock rather than precipitation and evaporation [15]. 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 [16].

General physico-chemical characteristics

Lake water was found to be free from any colour, odour or turbidity. pH of selected freshwater lake sample was almost neutral in nature and found to be 7.1. Total hardness of lake water sample was found to be 22mg/l, while alkalinity was found to be 13mg/l. Total dissolved solids were recorded 72mg/l, whereas dissolved oxygen was measured to be 12.6mg/l. Total organic carbon in lake water sample was found 1.1mg/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 41mg/l and 3.6mg/l. Besides these, sulfate (10.0mg/l) and phosphate (0.015mg/l) were also detected in L-7 lake water sample at Bharti station, Larsemann Hills.

Metals

Magnesium was found to be 2.4mg/l, while iron was found to be 0.06mg/l in lake water collected from biggest freshwater lake L-7 at Bharti Island. Zinc and copper were also detected 0.02mg/l and 0.021mg/l respectively. Trace metals like cadmium and aluminum were found below detection level in lake water sample. Similar trend

Table 3: Microbiological Studies of lake water sample from Bharti Island (30th ISEA).

S.N.	Parameters	L-7
1	Total Bacterial Count/ml (As per guidelines of IS : 5402-2002, Reaff 2007)	Less than 1
2	Psychrophillic Count/ml (As per guidelines of IS: 1479 p-3, 1977, Reaff: 2003)	Less than 1
3	MPN Coliform /100ml (As per guidelines of IS:1622-1981, Reaff : 2003) Ed 2.4 (2003-05)	No growth observed
4	Yeast & 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 aureus/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

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	Chlorophyceae	700
2	Basillariophyceae	1600
3	Cyanophyceae	100
4	Rhodophyceae	-
5	Others / Unidentified	1200
B. Zooplankton		
1	Protozoa	40
2	Rotifera	20
3	Copepoda	40
4	Cladocera	60
5	Decapoda	-
6	Others / Unidentified	80

was observed for mercury, selenium, arsenic, lead & chromium metals in lake water sample collected from Bharti Island. Few metals are biologically essential to living organisms in trace quantities in aquatic ecosystems. These trace metals may re-circulate from sediment and became available for biota [18]. Fluoride (<0.1mg/l) was found below detection limit in lake water sample.

Complex organic compounds

Phenolic compounds (as C₆H₅OH), 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 (Table 3). Total bacterial count and psychrophillic counts were found to be less than 1cfu. No growth was observed for MPN coliform in the sample. Yeast & Moulds, Salmonella, Staphylococcus and Pseudomonas spp. were also found to be absent in freshwater lake water sample. Antarctic environment provides a unique opportunity to discover few new species of microorganisms [19,20].

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 [9].

Under phytoplankton group, Chlorophyceae members (700

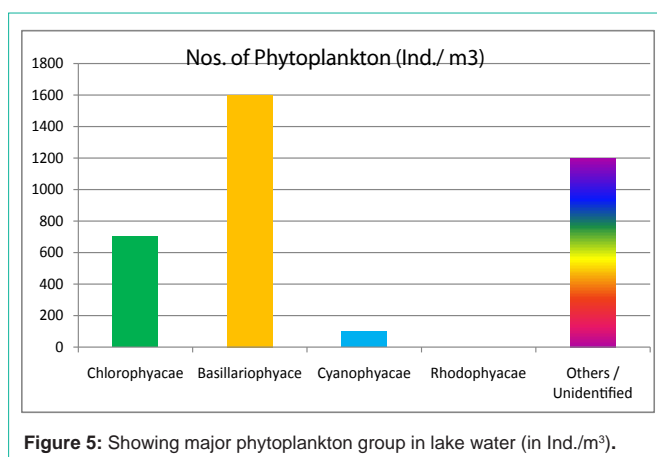


Figure 5: Showing major phytoplankton group in lake water (in Ind./m³).

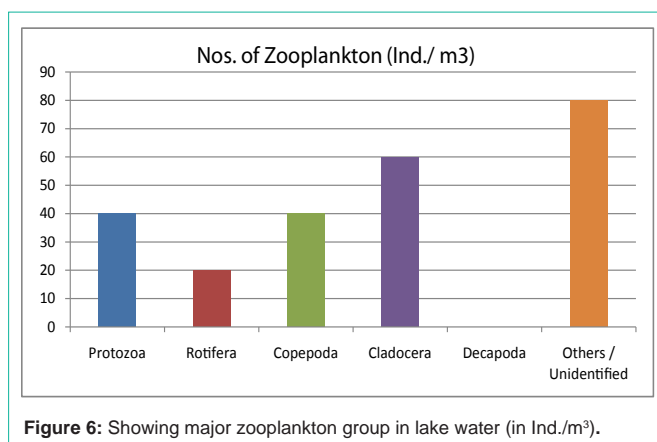


Figure 6: Showing major zooplankton group in lake water (in Ind./m³).

individuals/m³), Basillariophyceae members (1600 individuals/m³) and Cyanophyceae members (100 individuals/m³) were observed, while Rhodophyceae members were not found at the time of sampling. Some unidentified or phytoplankton of other groups (1200 individuals/m³) were also found in the water of L-7 freshwater lake at Bharti Island. Among the Phytoplankton community, Basillariophyceae and Chlorophyceae 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 some researchers [21]. Besides this, evidences of the presence of Nostoc, Osillotoria, in Antarctic water were also observed by [22] Few unidentified Phytoplankton genera were also encountered in lake waters.

In zooplankton group, members of phylum Protozoa (40

individuals/m³), phylum Rotifera (20 individuals/m³), phylum Copepoda (40 individuals/m³), phylum Cladocera (60 individuals/m³) were observed, while Decapoda members were not found during the sampling period. Some unidentified or zooplankton of other groups (80 individuals/m³) were also found in the water of L-7 freshwater lake at Bharti Island. Few Daphnia and others unidentified Ciliates were also found in Lake L-7, 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 (Table 4), (Figure 5 and Figure 6) respectively.

Aquatic ecology of a freshwater lake is often regulated by a number of physico-chemical characteristics and environmental variables of local setting. Extreme atmospheric conditions like very low ambient air temperature of Lake Surface always influenced on lake water characteristics. Due to subzero condition of Antarctic continents, freshwater lakes always remains in frozen condition except for few days in Austral summer season. The frozen condition of lake regulates the entire ecosystem ecology in a different ways. Many general characteristics of lake water get deviated accordingly. Plankton diversity may also alter due to introduction of foreign material and metal constituents into Lake Ecosystem [20]. Availability of sunlight in the water column of Lake Ecosystem is the main reason of the present status and composition of plankton diversity in Lake Ecosystem in east Antarctica. Although, some increasing anthropogenic activities in Antarctic premises may also be the reason of alteration in aquatic ecology of freshwater Antarctic lake, but the present lake is on very high altitude and almost negligible imprints of human activities can be noticed in the periphery of the lake studied [23].

Conclusion

After evaluating general physico-chemical parameters, heavy metals and organic compounds in lake water, it has been observed that the water of the selected lake has no pollution load and no significance impact of any anthropogenic activity. Low organic load in lake water indicate the oligotrophic stage of lake ecosystems. In oligotrophic lakes that are low in primary productivity as a result of low nutrient content, the chemistry depends mainly on lithology, precipitation, evaporation and period of sojourn of water in the basin [24].

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 has no psychrophilic bacterial population in lake water. Total dissolved solids are also very low, so the raw lake water can be considered as drinking water.

Presence of plankton community indicated the establishment of a healthy ecosystem in freshwater lake L-7 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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