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Environmental Conditions of Psychrophilic *Pseudomonas spp.* in Antarctic Lake at Stornes Peninsula, Larsemann Hills, East Antarctica

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Abstract

Environmental monitoring and assessment was carried out during the 30th Indian Scientific Expedition to Antarctica (ISEA) at Larsemann Hills area in Ingrid Christenson coast. Surface water samples were collected from two lakes on Stornes Peninsula in mid-January 2011 and analysed for the physico-chemical parameters, major elements and trace metals. Lake waters were slightly acid, free from any colour, odour and turbidity, with dissolved oxygen close to saturation. Total dissolved solids were rather similar in both lakes, up to 71 mg/l and the dominant elements were Cl and Ca. Several minor and trace elements were very low or under detection limits. Total organic carbon was ca 0.7 mg C/l in both lakes and PO_4 was at 0.002 mg/level in one lake. Total bacterial count was 1.6×10^3 cfu/ml in lake ST-2 and lower in other lake while psychrophilic bacterial count was 1.6×10^2 cfu in the former lake. Also a Pseudomonas spp. was detected in the ST-2 lake sample. Ecological studies of aquatic ecosystem of freshwater lakes indicated the suitable condition for the growth and survival of Pseudomonas species in a lake at Stornes Peninsula, Larsemann Hills over east Antarctica. The present study shows that the selected site may be an ideal habitat for the discovery of new species of Pseudomonas bacteria.

Keywords

Antarctic Lake, Pseudomonas, Psychrophillic Bacteria, Stornes Peninsula, Aquatic Ecology

1. Introduction

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 (Schimidt and Psenner, 1992). 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 (Psenner, 2002). 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 (Hofer et al, 2001; Bharti and Gajananda, 2013). In spite of the socio-economic and ecological importance of these lakes, better knowledge of several ecological aspects 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.

Many scholars are in the process of exploring the different scientific aspects of freshwater lakes of Antarctica. Pollution load of a lake on Fisher Island (Bharti and Niyogi, 2015a), plankton diversity and aquatic ecology of lake ecosystems at Bharti Island (Bharti and Niyogi, 2015b) were also studied during Austral summer season of 30th Expedition under Indian Antarctic Programme.

2. Material and Methods

2.1. Study Area

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'S, 76°19'58"E). The ice-free area consists of two major peninsulas (Stornes and Broknes), four minor peninsulas, and approximately 130 islands. The Larsemann Hills area contains more than 150 lakes at different Islands and peninsulas.

Environmental monitoring and impact assessment studies were carried out during the austral summers of various Indian Scientific Expeditions to Antarctica since 2003. We analyzed the physicochemical parameters and the ionic constituents of water samples from two lakes on Stornes during 2010-11 during the construction of the third Indian Antarctic research station Bharti.

2.2. Sampling

Stornes Peninsula of Larsemann Hills in east Antarctica was selected as a sampling site for the present study. Water samples were collected from two selected lakes of Stornes Peninsula during 30th Indian Scientific Expedition to Antarctica (ISEA) and analysed for the physico-chemical parameters, microbiological parameters, major elements and trace metal in surface lake water. Water samples were collected from two selected small lakes and analysed for the physico-chemical parameters, major and trace elements in surface lake water. The location map of study area is given in the Fig.1. Two sampling points were selected at various locations, namely ST-1 and ST-2. Geo-coordinates and basic details of both sampling points are given in Table 1.

2.3. Analytical Methods

Some of the physico-chemical characteristics of water including temperature, color, pH were determined *in situ* by mercury thermometer, visual observation and digital pH meter respectively, while dissolved oxygen, turbidity and total dissolved solids were analyzed using Orion onsite water quality monitoring kit. Physico-chemical parameters were analysed using standard methodology (APHA, 2005; Trivedi and Goel, 1984). The concentrations of metals were measured using Inductively Coupled Plasma Optical Emission spectroscopy (ICP-OES).

Figure 1. *Location map of Stornes peninsula in Larsemann Hills, east Antarctica*

3. Results and Discussion

Lake water was found to be free from any colour, odour or turbidity. pH of both samples were close to neutral, 6.7 and 6.8. Total hardness of water samples was found to be 14 mg/l and 13 mg/l respectively for ST-1 and ST-2 and alkalinity was 4 mg/l and 5 mg/l respectively for ST-1 and ST-2. Total dissolved solids of ST-1 and ST-2 lakes were recorded as 71 mg/l and 64 mg/l respectively, whereas dissolved oxygen was recorded 10.8 mg/l and 13.2 mg/l for ST-1 and ST-2 respectively. Total organic carbon of both samples was found to be 0.7 mg/l.

Chlorides and calcium were found to be the dominant constituents among the lake water contents. Chloride was found to be 32 mg/l and 31 mg/l, while calcium was 3.6 mg/l and 1.3 mg/l at in ST-1 lake and ST-2 lake, respectively. Magnesium was found to be 1.3 mg/l at ST-1 lake and was nil in ST-2 lake. Boron was 0.007 mg/l at ST-2 lake site and nil in ST-1 lake. Iron was found to be 0.02 mg/l in ST-1 lake water, while it was found below detection limit in ST-2 lake water.

Fluoride (0.1 mg/l in ST-1 lake), aluminum (0.006 mg/l in ST-1 & 0.007 mg/l in ST-2 lake) and manganese (0.003 mg/l at ST-2) were found in minor quantities Sulphate (1.0 mg/l) and phosphate (0.002 mg/l) were detected in sample ST-1 only.

Of trace metals cadmium was below detection level in both samples. Similar trend was observed for copper, mercury, selenium, arsenic, lead, zinc & chromium metals. 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 (Campbell et al., 1988).

Results of studies on microbiological parameters of lake water samples are given in Table-4. Total bacterial count was found to be less than 1 cfu and 1.6×10^3 cfu in ST-1 and ST-2 lake water samples, while psychrophillic counts were found to be 66 cfu and 1.6×10^2 cfu in ST-1 and ST-2 respectively. No growth was observed for MPN coliform in any of the samples. Salmonnela and Staphylococcus were also found to be absent in both of the lake water sample, while Pseudomonas spp. was found in ST-2 lake water sample. The above given physico-chemical parameters, metal content and other variables provide favorable conditions to microbial community especially to Pseudomonas spp.

High dissolved oxygen content in lake water always support to aquatic organisms. This is indeed very good and healthy condition for any aquatic ecosystem. Selected lake water sample are almost pesticide free and radiation contamination free. Lake water samples were found free from harmful pathogens and have an abundant psychrophillic bacterial population in both lake water. Due to bacterial community in both of the lakes, water may be harmful for drinking purposes. Total dissolved solids are also very low, so the raw lake water can be considered as drinking water, but in case of emergency only. The presence of Pseudomonas spp. in ST-2 lake indicates the survival of new bacterium and its new strain in Antarctic lake water under subzero conditions. However, many strains were isolated by Reddy *et al.* (2004) from cyanobacterial mat from Antarctica, but the selected location of Stornes peninsula has a potential to have some new strains of Pseudomonas in freshwater lake of Antarctica.

Table 1. *Location of lake water sampling points at Stornes Peninsula*

SN	Sample ID	Date	Latitude (S)	Longitude (E)	Altitude (m)	Temperature (ºC)
1	ST1	15.01.2011	69º 26' 45.4"S	76º 07' 02.6"E	29	1.0
2	ST2	15.01.2011	69º 21' 18.8"S	76º 07' 36.0"E	31	1.8

Table 2. *Physico-chemical parameters of lake water at Stornes Peninsula*

SN	Parameter	IS: 10500-1991 Desirable (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	Dissolved Solids, mg/l	500, Max. (2000)	71	64
7	Chloride (as Cl), mg/l	250, Max. (1000)	32	31
8	Alkalinity (as $CaCO_3$), mg/l	200 Max.(600)	4	5
9	Sulphate (as SO_4), mg/l	200, Max.	1	<1
10	Total Organic Carbon (TOC), mg/l	-	0.735	0.711
11	Dissolved Oxygen (DO), mg/l	-	10.8	13.2

Table 3. *Metal content of lake water samples at Stornes peninsula*

S.N.	Parameter	IS: 10500-1991 Desirable (Permissible)	ST1	ST2
1	Iron (as Fe), mg/l	0.3, Max. (1.0)	0.02	<0.01
2	Fluoride (as F), mg/l	1.0, Max. (1.5)	0.1	<0.1
3	Magnesium (as Mg), mg/l	30, Max. (100)	1.3	Nil
4	Calcium (as Ca), mg/l	75, Max. (200)	3.6	1.3
5	Manganese (as Mn), mg/l	0.1, Max. (0.3)	<0.01	0.003
6	Aluminum (as Al), mg/l	0.2, Max	0.006	0.007
7	Boron (as B), mg/l	1, Max (5)	<0.001	0.007

Table 4. *Microbial community in lake water samples at Stornes Peninsula*

S.N.	Sample ID.	ST-1	ST-2
1	Total Bacterial Count/ml(As per guidelines of IS : 5402-2002, Reaff 2007)	Less than 1 cfu	1.6×10^3
2	Psychrophillic Count/ml (As per guidelines of IS: 1479 p-3, 1977, Reaff: 2003)	66 cfu	1.6×10^2
3	MPN Coliform /100ml (As per guidelines of IS:1622-1981, Reaff : 2003) Ed 2.4 (2003-05)	No growth observed	No growth observed
4	Salmonella/ 25ml (As per guidelines of IS: 5887 (p-3) 1999 Reaff: 2005)	Absent	Absent
5	Staphylococcus aureus/25ml (As per guidelines of IS : 5887 P-2 1976 Reaff : 2005)	Absent	Absent
6	Pseudomonas spp./10ml (As per guidelines of IS:13428, Amn.D, 2005)	Absent	Present

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