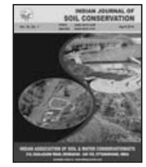
Vol. 42, No. 2, pp 174-177, 2014
Indian Journal of Soil Conservation
Online URL:http://indianjournals.com/ijor.aspx?target=ijor:ijsc&type=home



Heavy metal and microbiological analysis of sediments of Lake Priyadarshini, Indian Antarctic station 'Maitri'

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ARTICLE INFO

Article history :
Received : January, 2013
Revised : February, 2014
Accepted : April, 2014

Key words :
Lake Priyadarshani,
Microbiological analysis,
Physico-chemical analysis,
Sediments

ABSTRACT

The paper presents physico-chemical, heavy metal and microbiological analysis of sediment samples of Lake Priyadarshani, Indian Antarctic station 'Maitri'. All sediment samples showed neutral pH and conductivity in the range of 0.015-0.069 dS m^{-1}. Total hardness of the samples was found to be in the range of 300-800 μgml^{-1}. High levels of iron (3506-20222 μgg^{-1}) and manganese (92-280 μgg^{-1}) were detected in the samples. Other heavy metals such as zinc, cadmium, chromium, copper, nickel and lead were also detected in sediment samples. Anaerobic bacterial population representing both psychrophiles and psychrotrophs were determined in sediment samples. The total count of psychrophiles was 88-930x$10^2 g^{-1}$ sediment whereas psychrotrophs were detected less in numbers (3-120x$10^2 g^{-1}$sediment). The study revealed that psychrophiles were predominant microflora in sediments of Lake Priyadarshini.

1. INTRODUCTION

Antarctic continent have distinctive habitats such as lakes, ponds, rivers, streams, rocks and soil. These habitats differ from one another with respect to nutrients, temperature range, water activity and other physico-chemical parameters resulting in a relatively simplified system sensitive to perturbations (Yergeau and Kowalchuk, 2008). The insensitive conditions of the Antarctic environment sustain only moderately simple ecosystems with very low multifaceted food-web structures in the most extreme Antarctic habitats (Wall and Virginia, 1999). Microorganisms are the foremost biomass constituents of Antarctic ecosystems (Ramteke *et al.,* 2000; Shivaji *et al.,* 2011) and regardless of the harsh climatic conditions they have been detected in all the continent's distinctive habitats.

Lake Priyadarshini is one of the largest lakes in Schirmacher range of eastern Antarctica and main source of water supply to Indian Antarctic station 'Maitri'. Lake Priyadarshini has been described as a proglacial lake formed at the edge of the ice cap. The water and sediment input to the lake is through melt water during warmer periods of spring and summer. Earlier research on sediments of this lake has been focused on mineralogy (Sinha and Chatterjee, 2000), elemental and radioisotopic analysis (Sinha *et al.*, 2003). Few research reports are available on aerobic bacterial population from other fresh water lakes of Antarctica (Shivaji *et al.,* 2011; Sjoling and Cowan, 2003; Wand *et al.,* 2006; Stingl *et al.,* 2008). However, information on physic-chemical and heavy metal parameters and anaerobic bacteria thriving in the sediments of the Lake Priyadarshini is limited; thus, the present investigation was undertaken.

2. MATERIALS AND METHODS

Site Description and Sample Collection

Indian station 'Maitri' of the Schirmacher Oasis (Queen Maud Land/Dakshin Gangotri hill ranges) is situated 70 km away from the Princess Astrid coast of Antartica between the inland and shelf ice, occupying an area of 35 km. This region is situated between the geographical coordinates 70°45′12″ to 70°46′30″ S latitude and 11°22′44″ to 11°54′00″E longitude. Lake Priyadarshini is located 255 m away from "Maitri" with a total area of 0.75 sq km (Fig. 1 and Fig. 2).

Sediment samples of Lake Priyadarshini were collected from ten random sites with the aid of sediment core sampler and stored in polyethelene bags and pre-sterilized glass bottles for physico-chemical and microbiological analysis, respectively.

Fig. 1. Lake Priyadarshini, "Maitri"

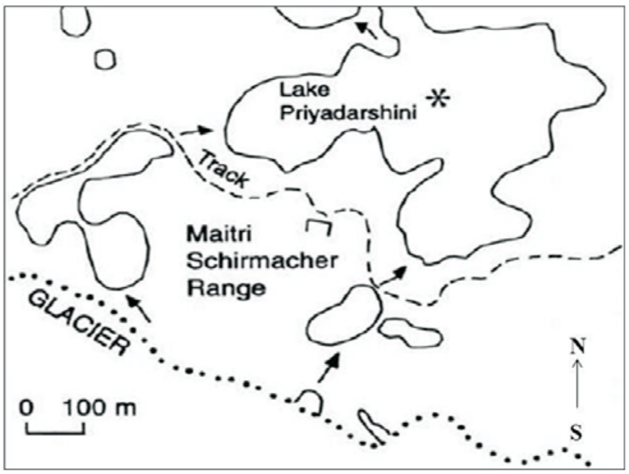

Fig. 2. Geographical location of Lake Priyadarshini (70˚45'12" to 70˚46'30" S latitude and 11˚22'44" to 11˚54'00" E longitude)

Physico-Chemical and Heavy Metal Analysis

After air drying and fine powdering of the sediment samples, they were subjected to the physico-chemical parameters using the standard procedures prescribed by APHA (1995). Physic-chemical parameters analysed were pH, conductivity, chloride and total hardness. For heavy metal analysis, dried samples were treated with perchloric acid and nitric acid (10 ml each) and was digested at 200^{o}C till a smoky white solution was obtained. Solution was later on transferred to a 100 ml calibrated volumetric flask and final volume of 100 ml was made using a stock 4% (v/v) HNO_3. Metal analyses were performed using Atomic Absorption Spectrophotometer (Perkin-Elmer, Model 3100).

Microbiological Analysis

The quantitative enumeration of viable population of anaerobicmicroorganisms was carried out following standard microbiological methods (APHA, 1995) using anaerobic media. Serial dilution of the sediment samples was carried out after which appropriate dilutions of the samples were inoculated on pre-prepared anaerobic media using the spread plate technique. The plates were incubated in anaerobic jars (E. Merck) both at freezing (4˚C) and 10±2˚C temperatures. Microorganisms grow at 4˚C and 10±2˚C are considered as psychrophiles and psychrotrophs, respectively. The data obtained was analyzed by completely randomized block design (Table 1 and 2).

3. RESULTS AND DISCUSSION

The results of physico-chemical and heavy metal analysis of sediments from lake Priyadarshini are given in Table 1 and Table 2, respectively. All sediment samples showed neutral pH and were found in the range of 7.0 to 7.9. Conductivity of the sediment samples was in the range of 0.015 to 0.069 ds m^{-1}. Chloride contents were detected in the

Table: 1
Physico-chemical analysis of sediment samples of Lake Priyadarshini, Indian Antarticstation "Maitri"

Sample*	pH	Conductivity (dS m^{-1})	Chloride (µgml^{-1})	Total Hardness (µgml^{-1})
1	7.1	0.027	200	700
2	7.3	0.044	250	800
3	7.9	0.045	100	300
4	7.2	0.065	150	400
5	7.3	0.051	NA	600
6	7.1	0.068	200	500
7	7.3	0.039	150	700
8	7.5	0.015	250	500
9	7.4	0.035	150	500
10	7.0	0.069	250	600

*Samples were taken from ten random sites

C.D.: pH: 23.77; P>0.05; Conductivity (dS$m^{-1)}$: 87.21;P>0.05; Chloride (µgml^{-1}): 73.91; P>0.05; Total Hardness (µgml^{-1}): 87.66.
C.V.: pH: 3.49; Conductivity (ds$m^{-1)}$: 38.16; Chloride (µgml^{-1}): 28.92; Total Hardness (µgml^{-1}): 26.8.

Table: 2
Heavy metals in sediments of Lake Priyadarshini, Indian Antartic station "Maitri"

Sample*	Heavy metals (μgg^{-1})							
	Cadmium	Chromium	Copper	Iron	Manganese	Nickel	Lead	Zinc
1	1.3	11.6	13.0	8782.4	108.6	13.5	30.2	47.0
2	1.6	17.1	15.0	11262.4	140.2	20.4	41.7	47.0
3	3.3	36.0	21.6	9302.4	129.0	38.3	93.0	57.0
4	11.6	12.7	10.8	7102.4	68.2	11.7	22.0	42.5
5	0.7	7.7	11.2	8502.4	116.6	15.4	24.6	53.0
6	0.8	16.6	9.2	3506.4	35.7	6.4	19.4	27.7
7	1.2	16.0	12.2	9622.4	92.2	16.1	33.0	77.0
8	1.1	8.8	40.2	7262.4	95.0	11.2	22.0	37.0
9	1.0	36.5	9.3	7222.4	83.4	23.0	29.0	98.1
10	3.7	46.6	41.8	20222.4	280.6	57.4	144.1	110.1

*Samples were taken from ten random sites

C.D.: Cadmium: 77.9; P>0.05;Chromium: 48.11;P>0.05;Copper: 54.11; P>0.05; Iron: 32.26; Manganese: 22.77; P>0.05; Nickel: 47.31;P>0.05; Lead: 66.61; P>0.05; Zinc: 65.82P>0.05.
C.V.: Cadmium: 27.8; P>0.05; Chromium: 34.33;P>0.05; Copper: 39.47; P>0.05; Iron: 53.23; P>0.05; Manganese: 42.60; P>0.05; Nickel: 97.72;P>0.05; Lead: 87.61; P>0.05; Zinc: 45.12;P>0.05.

range of 100- 250 μgml^{-1}. Total hardness of the sample was in the range of 300-800 μgml^{-1}.

As expected, high levels of iron were detected in all sediment samples (Table 2). From the results, it is also evident that sediment samples showed high levels of chromium, manganese, nickel, lead and zinc. Except for cadmium and chromium in one sample, all other heavy metals were detected at higher levels as compared to other samples.

Anaerobic bacterial population in sediments of lake Priyadarshini is given in Table 3. Isolation of psychrophiles ranged from 110 to 930 x 10^2 g^{-1} sediment. On the other hand, psychrotrophs were isolated in lower numbers as compared to topsychrophiles. From the results, it is clear that psychrophiles which grow on lower temperature of 4^0C or less are predominant than psychrotrophs that grows in the range of 4-10^0C. Psychrophiles are extremophiles which are cold-loving and have an optimal temperature at 10˚C or lower with a maximum temperature at about 20˚C and a minimal temperature at 0˚C for growth, respectively (Moyer and Morita, 2007). However, other report suggests presence of true psychrophiles is rare in the Antarctic lake sediments as psychrotrophs and mesophilic psychotolerant organisms inhabit these areas more commonly (Cowan *et al.,* 2011).

The varied adaptability of the bacteria obtained from the sediment samples can be correlated with the fact that the organisms surviving in the icy environments are enriched with dynamic mechanisms in order to shield themselves from life-threatening environmental conditions that would otherwise damage their cellular structure. Adaptation to varied levels of fluctuating conductivity, high chloride content and higher total hardness can help these microorganisms to overcome the stresses associated with water loss, namely escalated intracellular solute concentrations, decreased cell size, a weakened cell membrane and physical cell rupture caused by freezing and thawing. Similar findings have been found in the microbes from other two Anatarctic sites the Pony Lake (Foght *et al.,* 2004) and supraglacial fluvial system on Cotton Glacier (Zhang *et al.,* 2008).

In freshwater sediments, prokaryotes play a major role in the transformation of complex organic compounds and minerals (Jurgens *et al.,* 2000). Consequently, investigating microbial structure and function in freshwater sediments is of immense importance so as to understand the role of microorganisms in aquatic ecosystems. Approaches to investigating microbial ecosystems in freshwater sediments on the basis of conventional culture methods are important since, via this approach, the ecological role of the cultivated and characterized prokaryotes can be estimated.

Thus, the long-term impact of subzero temperatures and adaptability to varied extreme environmental conditions should be regarded not as the extreme and limiting but rather as a stabilizing factor supporting the viability of microorganisms adapted to these conditions. The environmental factors orient change in the ecology, physiology and metabolism processes of psychrophiles and

Table: 3
Anaerobic bacterial population in sediments of Lake Priyadarshini, Indian Antartic station "Maitri"

Sample*	CFUx10^2 g^{-1} sediment	
	Psychrophiles	Psychrotrophs
1	200	22
2	230	13
3	270	3
4	88	14
5	16	6
6	220	4
7	110	43
8	430	120
9	930	14
10	220	71

psychrotrophs and they play a significant role in mineralization processes especially in cold environments (Ramteke *et al.,* 2005; Shivaji *et al.,* 2012).

4. CONCLUSIONS

Sediment samples of lake Priyadarshani located at Indian Antarctic station 'Maitri' were analysed for physico-chemical and anaerobic microbial population. All sediment samples showed neutral pH and conductivity which signify a normal range of chloride and total hardness. However, high levels of iron and manganese were detected in the samples. The study revealed that among anaerobic microbial population psychrophiles were predominant microflora in sediments of Lake Priyadarshini.

ACKNOWLEDGEMENTS

The authors wish to thank the Director, National Centre for Antarctic and Ocean Research (Department of Ocean Development), Headland Sada, Vasco da Gama, Goa, for providing an opportunity to be a summer member of 18th Indian Scientific Expedition to Antarctica. Financial support by Council of Scientific and Industrial Research (CSIR) is gratefully acknowledged.

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