Biological Studies on the Iceshelf and in Fresh Water Lakes at Princess Astrid Coast, Dronning Maud Land, Antarctica

S. G. Prabhu Matondkar[1] and Helga R. Gomes[1]

ABSTRACT

Biotic and environmental characteristics of four fresh-water lakes in the mountainous *Dakshin Gangotri* (Lat. 70°45'12"S; long. 11°38'12"E) region of the Antarctica are reported. Lakes were truly limnetic with little or no floating ice. Waters were highly turbid (750 to 1530 1^{-1}) thus impeding the passage of sunlight in the subsurface region. Water temperature varied within a narrow range of 0 to +2°C as against the wide fluctuations in the air temperature. While the essential nutrient salts of nitrogen and phosphorous were low, the silicates were considerably high.

Chl *a* estimates ranged from 0.11-0.38 µg 1^{-1}, whereas ATP estimates indicated the presence of viable seston. Rate of photosynthesis, varying from 0.14 to 0.68 mg Cm^{-3} hr^{-1} largely depend on the subsurface illumination. Bacterial counts were very high (12×10^4 - $5.9 \times 10^6 ml^{-1}$ and the bacterial flora was dominated by *Bacillus, Micrococcus* and *Corynebacterium.*

A comparison of data on inorganic salts, POC, ATP, and bacterial counts from the lakes and iceshelves clearly indicated that the Antarctic lakes represent an entirely different and self-contained ecosystem from the iceshelves.

INTRODUCTION

Fresh water lakes are closed ecosystems and simple in trophic structure. Antarctica contains numerous lakes within less that 5% of its area which is ice free. It is generally considered that these lakes are evolved from epipelagic ponds which do not freeze to the bottom during the harsh Antarctic winter. Scott had noticed the 'water plants' in Antarctic lakes (Holdgate, 1970). Ice covered lakes are studied for their biological productivity for quite a long time (Wright, 1964). Hand and Burton (1981) have studied the microbial ecology of an Antarctic lake. They found that the bacterial population was very important in cycling of materials in the lake. Recently, Parker, Simons, Seaburg, Gathey and Allnuff (1982) have reported the ecology of plankton community in seven Antarctic lakes. Masuda, Nishimura and Torii (1982) have reported the glacier as the major source of water and elements in Antarctic lakes.

The present report is the preliminary presentation of biological and environmental characteristic features of the four fresh water lakes in Antarctica, based on the data collected during the First Indian Expedition to Antarctica (1981-1982).

MATERIALS AND METHODS

Four freshwater lakes in the vicinity of *Dakshin Gangotri* (Lat. 70°45' 12"S; Long. 11°38' 13 "E), were studied. These lakes are surrounded by rocks and glaciers. Observations were undertaken in January 1982, when very few ice blocks were found floating in lake 3 and 4, whereas lake 1 and 2 were devoid of any ice and surface samples could be taken easily by acid-cleaned, plastic bucket. The rate of photosynthesis was determined by ^{14}C method, of *in situ* incubation for 6 hours. Water samples for chlorophyll, particulate organic carbon, total suspended load and ATP concentrations, were analysed on board following the same procedures, as reported earlier (Matondkar and Qasim, 1983).

Bacterial population was studied by taking viable counts. Counts were taken by spreading 1 ml of water sample including melted ice or 0.2 ml of sediment dilution in ship's laboratory on dried plates of nutrient agar, and other media like Marine agar, Sabouraud agar, Glucose peptone agar, Yeast and Mold agar, Kuster s agar for bacteria, fungi, yeast and actinomycetes population.

National Institute of Oceanography, Dona Paula Goa 403 004, India

RESULTS AND DISCUSSION

Environment

Lakes were mostly free from ice and temperature ranged from 0.0 to + 2°C in different lakes (Table 1). Air temperature at the beginning of the study was +6°C near lake area and after 6 hours it was +1 to 0°C. Because of such lowering of temperature, process of ice formation in surface water was initiated, resulting in substantial reduction of light in deeper water layers. Thus short-termvariations in temperature may be due to sudden changes in wind velocity, play an important role in Antarctic lake ecosystems. In lakes 3 and 4, the water temperature at the surface was stabilised by melting ice and was maintained near 0°C. Antarctic fresh water lakes are known for high photosynthetic activity and short turnover time for phytoplankton (Baross and Morita, 1978), during the period of Antarctic summer where temperatures are relatively high as recorded here also (Table 1). Thus, this period is ideal for the study of organic input by plankton in lake ecosystem.

TABLE 1

Productivity and related aspects of 4 fresh water lakes at Dakshin Gangotri

Characteristics	Lake 1	Lake 2	Lake 3	Lake 4
Temperature (°C)	+2	+ 1.5	0.0	0.0
Primary productivity				
($mgCm^{-3}hr^{-1}$) Phyto	0.68	0.68	0.28	0.14
Nanno	0.38	0.51	0.22	0.12
Chloropyll a ($\mu g\ l^{-1}$)	0.3738	0.2136	0.1068	0.1068
Total suspended matter ($\mu g\ l^{-1}$)	840	750	1120	1430
Particulate organic carbon ($\mu g\ l^{-1}$)	81.48	303.072	475.2	280.896
A.TP($\mu g\ l^{-1}$)	0.170	0.498	0.378	0.469
Bacterial counts (ml^{-1})	24 X 10^4	12 X 10^4	59 x 10^5	1.8 X 10^6
Nitrite(µg -at l^{-1})	0.56			
Nitrite(µg -at l^{-1})	2.04			
Phosphate (µg -at l^{-1})	0.64			
Silicate (µg -at l^{-1})	26.97			

Measurement of seston indicated the presence of high particulate matter content in water body ranged rom 750 - 1430 $\mu g\ l^{-1}$ in all the 4 lakes studied. Nutrients, such as, nitrate and phosphate were moderately low as compared to silicate (26.97 μg at l^{-1}) in the first lake studied in present investigation (Table 1).

Chl *a* estimates of lake water ranged from 0.11 - 0.30 $\mu g\ l^{-1}$. ATP estimates indicated that, a considerable fraction of seston is viable in this environment. Wright. (1964) has reported very high Chl *a* content (1.0-17.0 $\mu g\ l^{-1}$) in similar lake systems. Further, he has reported that plankton were abundant and adapted to low light with varying rate of photosynthesis from 0.15 - 9.09 mg C m^{-3} hr^{-1}. Parker, Simmons, Seaburg, Cathey and Allnuff (1982) have reported same range of Chl *a* but low rate of photosynthesis.

The rate of photosynthesis observed in the present study varied from 0.14 to 0.68 mg C m^{-3} hr^{-1} and it depends upon the period of sampling in this area. Goldman, Mason, Hobbie (1967) have studied the lake

Bonney and Vanda, where rate of ^{14}C fixation was as low as 1.2 - 1 3 mg C m^{-2} day $^{-1}$. In comparison to lake Bonney and Vanda, *Dakshin Gangotri* lakes are productive with respect to phytoplankton. Wright (1964) has found the higher productivity at sub-surface layers in such lakes studied earlier. Thus, further depthwise study of these lakes will give better measurement of productivity and better understanding of the role of various organisms in this ecosystem. Next to photosynthetic activity, microbiological activity is also equally important for recycling nutrients in these polar lakes.

Bacterial counts taken from these lakes water were high ranging from 12 X 10^4 -5.9 X 10^6 ml^{-1}. Twenty bacterial cultures isolated from nutrient agar plates of lakes indicated predominance of *Bacillus* and *Micrococcus* associated with lake water. *Corynebacterium* sp. was also found. In a similar study of Antarctic lakes, bacterial counts were in the range of 1 X10^3 - 1.2 x$1O^5$ ml^{-1} (Hand and Burton, 1981). Benoit, Hatcher and Green (1971) have reported the presence of groups of microorganisms like yeast *Candida* and *Cryptococcus* from lake Bonney in Antarctica. Microflora such as *Bacillus, Micrococcus, Corynebacterium* and yeast have been reported in Don Juan — an oligotrophy Antarctic lake (Meyer, Morrow, Wyss, Berg and Littlepage, 1962) and have found 0°C as the favourable temperature for microbial growth.

Lake sediment samples were plated on different media and incubated for longer periods (one month) indicated that at 8 ± 4°C, 15 days incubation period is sufficient to grow fast and slow growing bacteria. For comparison purpose marine sediment collected during this expedition was also studied using the same techniques (Table 3). From data it is seen that bacteria, fungi and yeast are equally important groups of organisms in Antarctic marine as well as fresh water ecosystem.

TABLE 2

Microbial Counts (g^{-1}) on different media from sediment of a *Dakshin Gangotri* lake

(Laboratory Study)

Media	Incubation 8 ± 4°C	
	15 days	30 days
Nutrient Agar	1.1 x 10^3	2 x 10^4
Marine Agar	—	5 x 10^3
Soyabean Agar		—
Sabouraud Agar	700	750
Glucose Peptone Agar	5 x 10^3	1.5 X 10^4
Yeast and Mold Agar	2.5 x 10^4	5,6 x 10^4
Kuster's Agar	—	—

In order to study the factors responsible for enrichment of these lakes, the ice shelf was simultaneously studied, by adopting similar methods. Although, plant pigment concentration in ice was very poor, however rate of ^{14}C fixation was moderately high. Bacterial plate counts were less than 10 - 63 g^{-1} of ice. Whereas, ice was poor in POC and ATP content (Table 4). Indicated that lake ecosystems are entirely different from that of connecting ice shelves in Antarctic region. Masuda, Nishimura and Torri (1982) have reported the transport of trace elements from Glacier-Glacial melt water lake in Antarctic region.

Recently, Cathy, Parker, Simons, Vongue and Van Brunt (1981) have reported algal mats in fresh water lakes. Role of microflora like bacteria recycling this material in lakes is not yet known. In addition to this, contribution by mosses, benthic diatoms and epiphytic algae should also be studied in future expeditions.

TABLE 3

(Microbial Counts g^{-1}) *on different media from marine sediments of the Antarctic region (Range of 7 stations)*

Media	Incubation 8 ± 4°C	
	15 days	30 days
Nutrient Agar	$3 \times 10^5 - 1.87 \times 10^7$	$8 \times 10^3 - 8.4 \times 10^6$
Marine Agar	$1.04 \times 10^4 - 7.5 \times 10^5$	$1.15 \times 10^4 - 1.35 \times 10^6$
Soyabean Agar	$50.0 - 2 \times 10^4$	$1.28 \times 10^4 - 1.56 \times 10^5$
Sabouraud Agar	$300 - 3.26 \times 10^4$	$500 - 3.37 \times 10^4$
Glucose Peptone Agar	$1.5 \times 10^3 - 1.4 \times 10^6$	$5 \times 10^4 - 3.75 \times 10^5$
Yeast & Mold Agar	$100 - 5 \times 10^4$	$200 - 4.25 \times 10^4$
Kuster's Agar	$6.5 \times 10^2 - 4.25 \times 10^5$	$6.5 \times 10^2 - 4.25 \times 10^5$

TABLE 4
Study of the ice shelf

Characteristic	St. 1	St. 2	St. 3
Temperature (°C)	0.0	0.0	-3.0
Primary productivity ($mgCm^{-3} hr^{-1}$)	0.48	0.3816	0.245
Chlorophyll a ($\mu g\ l^{-1}$)	0.067	0.054	0.027
Particulate organic carbon ($\mu g\ l^{-1}$)	128	103	142
ATP ($\mu g\ l^{-1}$)	0.07	0.12	0.025
Bacterial counts (ml^{-1})	63	110	20
Nitrite (μg-at l^{-1})	0.26		
Nitrate (μg-at l^{-1})	1.15		
Phosphate (μg-at l^{-1})	0.84		
Silicate (μg-at l^{-1})	0.33		

REFERENCES

Baross, J. A. and R. Y. Morita, (1978).
Microbial life at low temperatures: Ecological Aspects: In: *Microbial Life in Extreme Environments,* edited by Kushner, D. J. Academic Press, London: 9-71.

Benoit, R., R. Hatcher and W. Green, (1971).
Bacteriological profiles and some chemical characteristics of two permanently frozen Antarctic-lakes — In: *The structure and function of fresh water microbial communities,* edited by J. Cairns Jr., Virginia Polytechnique Institute and State University, Blacksburg, Virginia: 281-293.

Cathey, D. D., B. C. Parker, G.M. Simons, W. H. Yongue and M. R. Van Brunt, (1981).
Microfauna of algal mats and artificial substrates in Southern Victoria land lakes of Antarctica. *Hydrobiologia,* 85:3-15.

Goldman, C. R., D. T. Mason and J. E. Hobbie, (1967).
Two Antarctica desert lakes. *Limnology and Oceanography, 12:*295-310.

Hand R. M. and H. R. Burton, (1981).
Microbial ecology of an Antarctic saline moronictic lake. *Hydrobiologia, 84:*363-374.

HoIdgate,M.,(.l970)
In: Antarctic Ecology, edited by M. W. Hodgate, Academic Press, London and New York, 998 pp.

Masuda, N. M. Nishimura, T. Torii, (1982).
Pathway and Distribution of trace elements in Lake Vanda, Antarctica. *Nature 298:,* 154-156.

Matondkar, S. G. P. and S. Z. Qasim, (1983).
Some observations on the Biological Proaductivity of Antarctic waters:*In this report.*

Meyer, G. M., M. B. Morrow, O. Wyss, T. E. Berg and J. Q. Littlepage, (1962).
Antarctica: The microbiology of an unfrozen saline pond. *Science. 138:*1103-1104.

Parker, B. C., M. Simons, K. G. Seaburg, D. D. Cathey andF. C. T. Allnuff, (1982).
Comparative ecology of plankton communities in seven Antarctic Oasis *lakes.Journal of Plankton Research. 4:*271-286.

Wright, R.T., (1964).
Dynamics of phytoplankton community in an ice covered lake. *Limnology and Oceanography. 9:*163-178.