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Study on Anthropogenic Pressure on Water Bodies Situated in Schirmacher Oasis and Larsemann Hills, Antarctica

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ABSTRACT

With the opening up of the route to the Antarctica, anthropogenic activities of various types are being experienced which are getting reflected in the freshwater bodies. The variation in chemical composition of different water bodies in Schirmacher Oasis and in Larsemann Hills of Indian base signifies the role of the respective catchment areas. The inflow from glaciers and accumulated snow are also responsible for governing the metabolic activity of the Antarctic water bodies. Besides, the hydrological detention governing the nutrient accumulation in water bodies has been found to be the main parameter responsible for the chemical and biological status of these water bodies.

Though temperature and light intensity are the chief factors in Antarctica yet the enhancement in nutrient levels has been found to give a shift in the primary productivity and nutrient levels towards higher side in the Antarctic water bodies.

INTRODUCTION

Present paper sums up the limnological status of water bodies located within the geographical coordinates, 77° 45' 51.5" to 70° 48'S and 11° 44' 2.7" to 11° 55'W (Schirmacher Oasis) and 69° 24.428'S and 76° 12.339'E (Larsemann Hills). These water bodies are accessible only during summer period. Water bodies situated at the higher elevations of the Schirmacher Oasis remain frozen during austral summer also, depicting their true amictic nature because the higher latitudes experience rapid fall in atmospheric temperature compared to the lower latitudes.

In contrast to the Himalayan water bodies situated at an elevation of more than 3000 m a.s.l. (open up at a maximum atmospheric temperature of 15°C), the Antarctic water bodies open up at low maximum atmospheric temperature of 6-7 °C. These water bodies reveal cold monomictic thermal

behaviour. The biological population found in these water bodies has revealed the highest adaptability to the cold climatic conditions as they start growing rapidly with the first melt of glaciers. Most of the biological specimens have been found to complete their life cycle within a short duration of time span as the water bodies remain open for just two months. The hydrological regime governing the metabolic activity has been found to vary with respect to the different morphological characteristics of the water bodies present both in Schirmacher Oasis and Larsemann Hills. The main source of freshwater to the water bodies situated in Schirmacher Oasis is from melting glaciers during austral summer while such type of feeding glaciers are lacking in Larsemann Hills. The source of water in the Larsemann Hills is from the accumulated snow in their respective catchments. The nearness of sea is responsible for increasing the salinity of some water bodies in the Larsemann Hills which is lacking in Schirmacher Oasis water bodies. As such, all water bodies in Schirmacher Oasis are of freshwater type.

Owing to the fact that these freshwater resources are the chief source of potable water, the present study gains much more importance keeping in view the mounting anthropogenic pressure.

MATERIALS AND METHODS

Analysis of some physico-chemical parameters like atmospheric temperature, water temperature, transparency, pH, conductivity and total dissolved solids (TDS) were made during sampling. The rest were analyzed at the base station. All physico-chemical characteristics have been determined after APHA (1995). For qualitative and quantitative analysis of plankton, known (100 l.) volume of freshwater was filtered through plankton net (64µm mesh size) followed by their immediate preservation in Lugol's solution for phytoplankton and in formalin solution (4%) for zooplankton. Identification and enumeration were done in India under an inverted microscope (Wanganeo and Wanganeo 1991 and 2006). Primary productivity measurements were made after Gaarder and Gran (1927) using light and dark bottle method.

RESULTS AND DISCUSSION

Ice bound Schirmacher Oasis with low lying hills of about 50-200 m high is studded with numerous shallow water bodies, with very few relatively deep water bodies to be recognized as lakes. The water bodies range from 0.02-0.75 km^2 in surface area. Vertical freezing of the water bodies depends upon its morphometric features especially the depth and latitudinal and altitudinal placement.

The present study revealed significant oscillating changes, towards higher trophic status of the water bodies experiencing mounted anthropogenic pressure.

In the present study maximum atmospheric temperature recorded was 7°C while Ingole (1987) recorded an atmospheric temperature of -1.6°C **(Table 1)**. From **Tables 2 and 3** also enhancement in atmospheric temperature could be seen which is an outcome of mounting anthropogenic pressure. Water temperature which followed the trend in atmospheric variation also showed enhancement from the previous records as depicted in **Tables 1 and 3**.

Table 1—Comparison of physico-chemical characteristics of Schirmacher Oasis water bodies

Parameter	Unit	Present study; 2005	Ingole et al. (1987)
A. temp.	^{0}C	07	-1.6
W. temp.	^{0}C	5	2.38
pH		6	8.1
DO	mg/l	6.4 (Sur.) to 7 (Bot.)	8
NO_3-N	mg/l	0.2 - 0.2	0.0003
PO_4-P	mg/l	0.74 - 0.79	0.00011
Salinity	%		0.09
Cl	mg/l	0.78 - 4	
T. iron	mg/l	0.10 - 0.11	
Silica	mg/l		0.0159

Table 2—Comparison of Atmospheric temperature in Schirmacher Oasis

	Hosalikar, 1995		Present study; 2005	
Month	Max.	Min.	Max.	Min.
Jan.	5	-6	8.5	-7.0
Feb.	5	-12	4.2	-7.8

Table 3—A two decade variation in physico-chemical characteristics of Schirmacher Oasis water bodies

Parameter	Unit	Annon	Verlecar et al., 1996		Present study Priyadarshini water body	
		1982-1992	1994		2005	
			Sur.	Bot.	Sur.	Bot.
A. temp.	^{0}C	-3.2	-	-	7	-2
W. temp.	^{0}C	1 - 7.9	3.70	4.10	6.3	5.4
Secchi	m	-	-	-	1m 57cm	
pH		7.4 – 8.3	5.64	5.51	6	6
DO	mg/l	5.1 – 8.45	8.20	8.00	6.4	7.0
NH_4-N	mg/l	ND - 0.41	-	-	-	-
NO_2-N	mg/l	0.00006 – 0.00117	-	-	-	-
NO_3-N	mg/l	0.0003 – 0.0024	-	-	0.1	0.3
PO_4-P	mg/l	0.10	-	-	0.73	0.74
Cl	mg/l	ND – 0.048	-	-	0.8	1.6
Ca	mg/l	10 - 107	-	-	-	-
Mg	mg/l	12 – 67.1	-	-	-	-
SiO_3	mg/l	0.95 – 26.97	-	-	-	-

Present investigation revealed near neutral pH values **(Tables 1 and 3)**. However, the inconsistency in measurement of pH values needs further investigation as the temperature variation plays a very vital role in governing the pH. Lot of variation has been recorded in pH values measured by different workers. It has been found that temperature has an influence on the pH because it affects the dissociation co-efficients of acids, and solubility of CO_2. When pH of a water sample is measured at a different temperature from that at which it was collected, variation in its measurement is bound to take place.

Dissolved oxygen in ambient waters revealed higher values in bottom layers in comparison to surface layers (**Tables 1 and 3**). When the present values were compared with the previous records, a declining trend was observed which may be due to addition of organic material. Though an increase in water temperature was seen, this may not be sufficient enough to create thermal barriers responsible for decline in DO values.

Nitrate-Nitrogen and Phosphate-Phosphorus during the present study recorded an increasing trend from surface towards the bottom waters in Schirmacher Oasis water bodies (**Tables 1 and 3**). Comparison of the present values with the previous records also indicate a significant enhancement in concentration of these biologically important nutrients in the Oasis water bodies, which is a clear indication of anthropogenic impact.

A marked increase has been noticed with respect to the Chloride content of Water bodies of Schirmacher Oasis for more than a period of two decades (**Table 3**), depicting enhancement in organic pollution.

On comparing the Priyadarshini water body with the Nova station water body in the month of March when the surface waters of these water bodies are totally frozen, revealed similar chemical characteristics except chloride values which were relatively high in Priyadarshini water body, confirming the ingression of organic material **(Table 4)**.

Table 4—Comparative study of potable water source water bodies of Indian and Russian base stations

Parameter	Unit	Priyadarshini water body	Novo station lake
		1/3/2005	2/3/2005
At. Temp.	^{0}C	-5	-7
pH		5.2	6.8
Cond.	µS/cm	10	10
DO	mg/l	7.6	7.9
Cl	mg/l	1.17	0.87
NO_3-N	mg/l	0.1	0.3
T. Iron	mg/l	0.16	0.21

Table 5—Comparison of trace elements concentration in different water bodies of (Schirmacher Oasis)

Heavy metal	Unit	Sathe, 1994 (Work conducted during 9th IEA)			Present study, 2005
		Priyadarshini lake	2 km East Maitri	2 km West Maitri	Schirmacher Oasis
Pb	µg / l	0.43	0.039 – 0.046*	0.28	ND-10 (only in one water body)
Cd	µg / l	0.17	ND	0.15	ND-3.0
Cu	µg / l	1.87	0.31 – 0.41*	0.98	5-14
Zn	µg / l	-	-	-	ND-804
Fe	µg / l	-	-	-	168

* Russian Camp

Table 5 documents the presence of heavy metals in different water bodies of Schirmacher Oasis. The perusal of data revealed a conspicuous enhancement in heavy metal concentrations in Schirmacher Oasis water bodies from the previous records.

On the other hand, high Secchi disc transparency value in Priyadarshini water body coupled with low conductivity values do not put the water body under alarming category of nutrient rich water bodies supporting diverse flora and fauna besides low primary productivity values (**Table 6**). The high flushing rate during austral summer has been found to be responsible for diluting the nutrient level in Priyadarshini water body besides other receiving water bodies.

Table 6—Comparison of primary productivity values in Priyadarshani waterbody

	Verlecar et al. (1996)						Present study
Primary	1982	1985	1987	1989	1992	1994	2005
Productivity (mg $cm^{-3}hr^{-1}$)	0.68	206	0.65	-	7.0	-	GPP : 0.03 NPP : 0.025 RR : 0.004

Water samples collected from various water bodies in the vicinity of the proposed site in Larsemann Hills during summer 2004 after analyzing for dissolved salts revealed their fresh water nature except for the L-7 which was saline in nature. The high salinity in the water body may be on account of its high hydraulic residence time besides ingression from the nearby sea. Some of the important physico-chemical parameters of these water bodies are provided in **Table 7**. No marked variation with respect to their physico-chemical characteristics was noticed in the Larsemann Hill water bodies except for L-7 which documented significantly high values of Conductivity and Chloride. The water bodies besides being shallow revealed low hydraulic detention period/ high flushing rate except for L-7 which on account of its close morphometric basin structure and deeper nature showed relatively high hydraulic detention period resulting in accumulation of dissolved salts responsible for enhancement in its conductivity values.

Ecological investigations in Antarctica assume utmost significance because of its repository nature. Most of the pollutants get transported from other parts of the globe in the form of gaseous and particulate matter. This problem is further compounded by way of exposing the continent to increasing anthropogenic pressure.

Table 7—Physico-chemical properties of water bodies at Larseman Hills

Parameter	**Unit**	**Lake-L1**	**Lake-L3**	**Lake-L7**	**Lake-L8**	**Lake-L9**
Atm. temperature	< -1.0 (fluctuating due to high wind velocity)					
Water temperature	°C	-0.1	-0.1	-0.1	0.1	0.1
pH		6.1	6.1	6.1	6.4	6.0
Conductivity	µS/cm	80	80	930	120	20
NO_3-N	mg/l	0.3	0.4	0.2	0.2	0.2
PO_4-P	mg/l	0.73	0.71	0.72	0.72	-
Alkalinity	mg/l	4.0	4.0	16	6.0	4.0
Chloride	mg/l	5.95	5.26	70.73	8.0	2.04
Total iron	mg/l	0.12	0.03	0.08	0.15	0.13

The water bodies present in Schirmacher Oasis in general are small and mostly shallow, surrounded by moraines. During austral summer the water bodies in Schirmacher Oasis swell with snowmelt which gets considerably reduced with lowering of atmospheric temperature as the flow of melt water from glaciers stops leading to high hydrolic detention and sedimentation, which in turn increases transparency of water thus leading to the enhancement in euphotic zone up to bottom layers, which support relatively high algal biomass in comparison to surface waters. As in surface waters photo inhibition phenomenon has been observed.

In the present investigation 57 species of phytoplankton were recorded from the water bodies present in Schrimacher Oasis. Bacillariophyceae contributed 28 species while Cyanophyceae contributed 18 species followed by Chlorophyceae (9 species). Euglenophyceae was represented only by 2 species (**Table 8**). Species of *Oscillatoria*, *Nostoc*, *Phormidium*, *Lyngbya*, *Gloeocapsa*, *Aphanocapsa*, *Aphanothece*, and *Chroococcus* were also reported by Gupta and Kashyap (1998). Among zooplankton, only two classes, Rotifera and Protozoa were recorded in the present investigation.

In West Schirmacher water bodies Cyanophyceae was followed by Chlorophyceae, Euglenophyceae and Bacillariophyceae (**Fig.1 A**). Moving from West towards East the dominance of Chlorophyceae was recorded more over Cyanophyceae. Bacillariophyceae and Euglenophyceae followed Cyanophyceae in order of dominance at this geographical location (**Fig. 1 B**). Eastern Schirmacher water bodies recorded higher density of Cyanophyceae followed by Bacillariophyceae and Chlorophyceae (**Fig. 1 C and D**).

Abundance of Cyanophyceae in the water bodies towards the Eastern side of Schrimacher Oasis may be on account of enhancement in the anthropogenic activities as, mostly filamentous blue-green forms (*Oscillatoria* sp. in general was followed by *Nostoc*, *Phormidium* and *Anabaena* sp.) were often recorded in relatively high numbers in the samples collected from various water bodies. Besides the dominance of Cyanophyceae, Bacillariophyceae was mainly represented in order of density dominance by *Nitzschia* sp., *Gomphonema* sp. and *Navicula* sp. The abundance of these species signifies the organic enrichment of the said water bodies. However, the dominant presence of *Cosmarium* and *Gloeotrichia* sp. among Chlorophyceae reveal Oligotrophic nature of the water bodies.The periodical variations in the abundance of various species among Cyanophyceae and Chlorophyceae reveal that the water bodies in

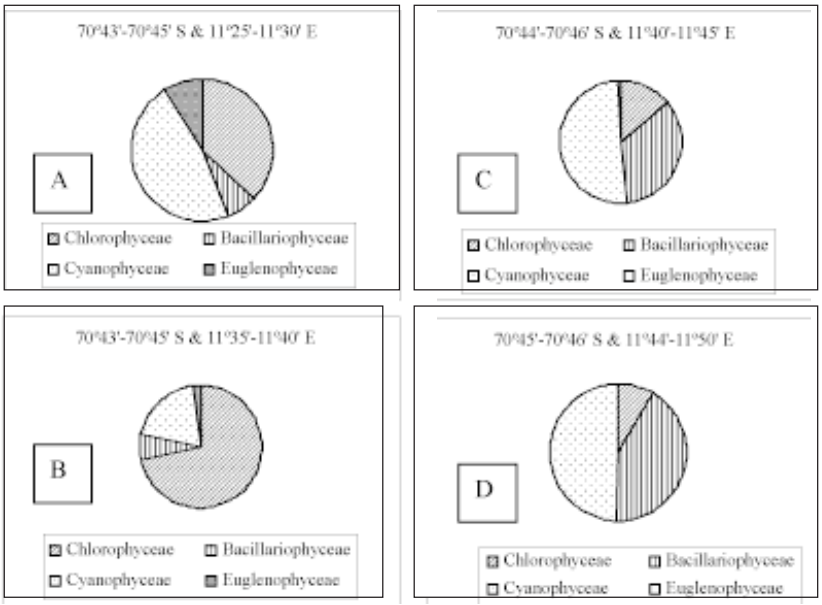

Fig. 1 : Variation in Phytoplankton classes in water bodies placed at different geographical co-ordinates in Schirmacher Oasis

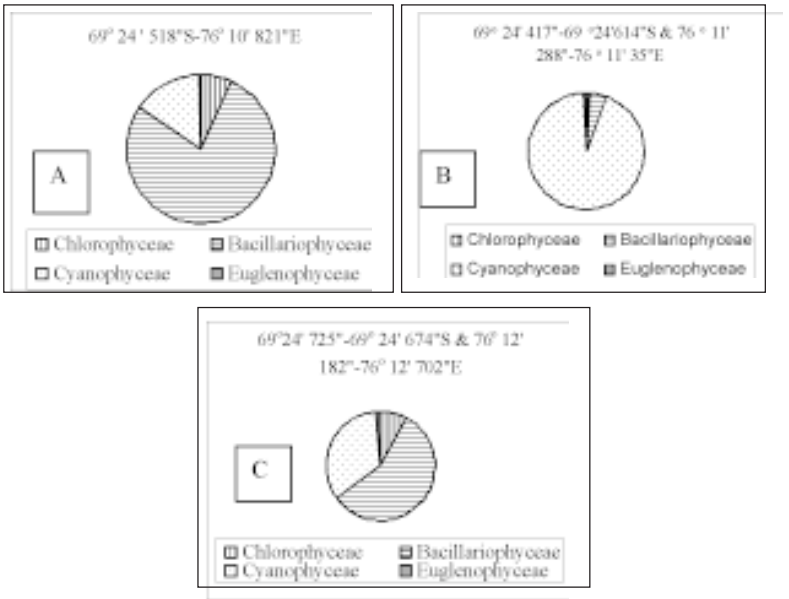

Fig. 2 : Variation in Phytoplankton classes in water bodies placed at different geographical co-ordinates in Larsemann Hills

Table 8—Phytoplankton Taxa of Freshwater bodies of Schirmacher Oasis

Bacillariophyceae	**Cyanophyceae**	**Chlorophyceae**	**Euglenophyceae**
Achnanthes minutissima	*Anabaena* sp.	*Chlorella* sp.	*Euglenomorpha* sp.
Amphora microcephala	*Aphanocapsa* sp.	*Cosmarium* sp.	*Euglena* sp.
Cyclotella sp.	*Aphanothece nidulans*	*Elkatothrix* sp.	
Cymbella sp.	*A. microscopic*	*Gloeotrichia* sp.	
Diatoma sp.	*Chroococcus* sp.	*Mougeotia* sp.	
Fragillaria sp.	*Gloeocapsa* sp.	*Selenastrum* sp.	
Gomphonema sp.	*Lyngbya* sp.	*Westella* sp.	
G.parvulum	*L. versicolor*	*Tetradesmus* sp.	
G. lucas rankala	*Nostoc* sp.		
G. intricatum	*Oscillatoria* sp.		
G. sphaerophorum	*O. tenuis*		
G. lanceolatum	*O. rubescence*		
G. olivaceum	*O. subbrevis*		
Mastogloia sp.	*Phormidium* sp.		
Melosira sp.	*P. tenue*		
Navicula sp.	*Synechocystis* sp.		
N. halophila	*Synechococcus aeruginosus*		
N. subrhyncocephala	*Spirulina* sp.		
Nitzschia sp.			
N. cummutata			
N. palea			
Pinnularia sp.			
Synedra sp.			
S. ulna			
S. rumpens			
Penium sp.			
Opephora sp.			

Schirmacher Oasis have entered into a transition phase, oscillating between Oligotrophic and near mesotrophic condition. Present work signifies the sensitive nature of fresh water bodies of Schirmacher Oasis towards the anthropogenic pressure.

Based on the average population density values, most of the water bodies in Larsemann Hills recorded the maximum dominance of Bacillariophyceae followed by Cyanophyceae, Chlorophyceae and Euglenophyceae. On the other hand water bodies situated between geographical coordinates of 69° 24' 417"-69° 24' 614"S & 76° 11' 288"-76° 11' 35"E however, documented the maximum abundance of Cyanophyceae followed by Bacillariophyceae, Chlorophyceae and Euglenophyceae **(Fig. 2)**.

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