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Biomarkers and their Application in Palaeoecological Study of Lake Ecosystem of Schirmacher Oasis, Antarctica

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ABSTRACT

Priyadarshini Lake of Schirmacher Oasis, Antarctica was studied on the basis of pigment, mineral matter and microfossils. Pigment profiles of lake cores at three different levels viz. top, central, and bottom are near similar. Microscope analysis showed that *Cosmarium* spp. predominated (~72%) in all three-core samples. The organic contents of the cores are mainly of algal cysts. The overall palynological assemblage seems to be a local micro-biota grown in a lake environment of isolated nature. The dominance of algal cysts suggests a bloom of algal planktons and warm phase of climate.

INTRODUCTION

Previously the investigations of the water bodies at Schirmacher Oasis, were carried out on the basis of its chemical characteristics (Bardin and Leflat, 1965) and freshwater algal composition (Komárek and Rùzicka, 1966). Schirmacher Oasis likely deglaciated at the Holocene-Pleistocene boundary as indicated by a grounding line retreat in the Lazareve Sea (Gingele et al, 1997). Relatively warm temperatures prevailed in Schirmacher Oasis between 8500 and 5500 cal. yr BP with a maximum between 6500 and 5500 cal. yr BP (Schwab, 1998). Later, it has been recognised that Antarctic lakes are useful repositories to understand past climate. This reference brought an interest in studying the lake ecosystem of Schirmacher Oasis in various palaeoecological studies (Sinha et al, 2000, Sharma et al. 2002 and Bera, 2004).

Wide spectrums of freshwater glacial bodies exist in Schirmacher Oasis. Depending upon their topographic setting, their occurrence was classified as inland lakes, ice margin lakes, and epishelf lakes (Ravindra et al, 2001). Lake Priyadarshini, located at about 255m away from Maitri station, has been described as a proglacial lake formed at the edge of the ice cap during the "Holocene" deglaciation phase. It covers an area of 0.297 km^2 (Ingole and Parulekar, 1990). The influx of water and sediment to the lake is through melting of glacier during spring and summer. The bathymetric contours show that the maximum water depth in central part of the lake is about 6.5 m; however the peripheral depth varies between 1 and 1.5 m (Ingole and Parulekar, 1990).

In this study an attempt has been made to understand the Biomarkers and their application in palaeoecological study of Lake Ecosystem of Schirmacher Oasis, East Antarctica. There is no previous photosynthetic pigment data from lake sediment core samples of Priyadarshini Lake of Schirmacher Oasis in context to the Indian Expedition since 1981.

The results are based on analysis of photosynthetic pigment, ash free dry weigh (AFDW), mineral matter (MM) and microfossil. The present study has a two-fold approach: firstly, to understand the past climatic changes, secondly to draw a comparison of pigment-inferred changes in algal populations during the immediate past. This approach permits an assessment of the response of lake algal communities to changing environmental conditions.

MATERIALS AND METHODS

The sediment cores (Fig. 2) were collected from three different sites of Priyadarshini lake. HYDRO-BIOS gravity corer sampler was used to collect the sediment cores. The length of the cores collected was different at different sites (Fig. 1). Core 1, which is 80 cm, was collected from site-1, located in Southwest part of lake close to the lake inflow with a water depth of 2.5 m. The core-2 was collected from site-2, from the deepest central part of lake (6 m), having 60 cm core. Core 3 was sampled from site-3, from Southeast part of lake where the second Lake Inflow is located. In this part of lake the water depth reaches 4 m and the length of core after collection was 55 cm. The cores show alternate layers of fine sediment and algal mats. After draining the water, the cores were sub-sampled, labelled and stored in clean polythene bags.

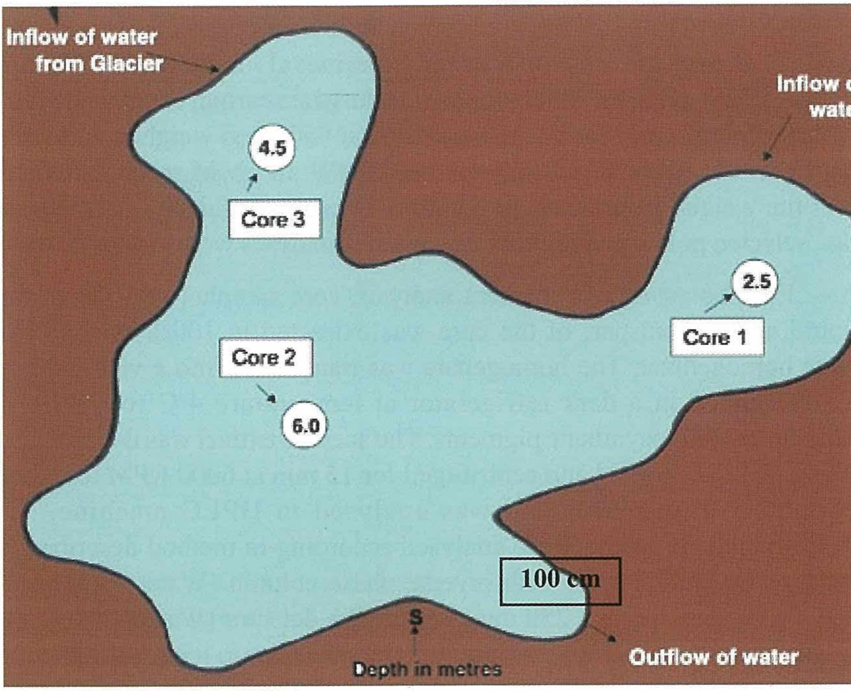

Fig. 1 : Priyadarshani Lake shows the site of collection and approximate depth.

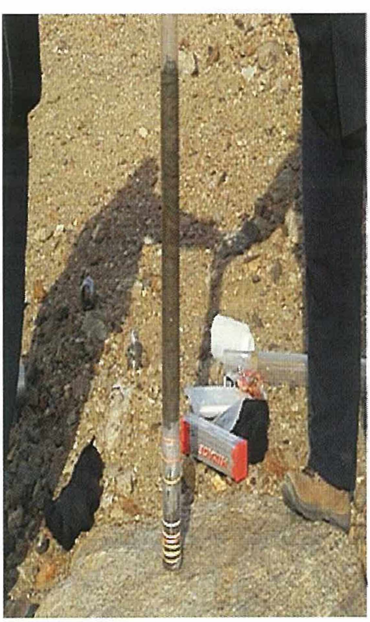

Fig. 2 : Sediment Core

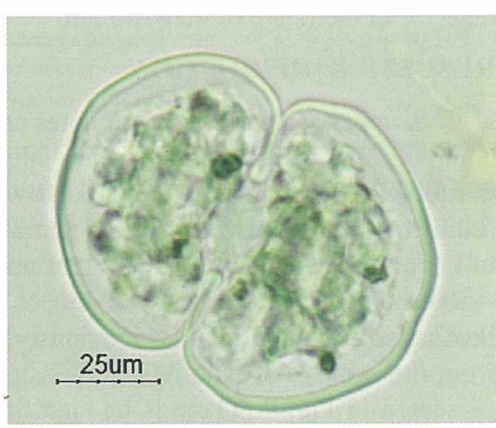

Fig. 3: Cosmarium spp.

Three replicate samples were taken for analysis of ash free dry weight (AFDW - organic carbon content), mineral material (MM) and photosynthetic pigment (PP) composition. Organic carbon content (AFDW) was also determined. Sediment were dried at 85°C and weighed and ash at 550°C in a crucible which allows the AFDW and MM to be calculated from the weight differences. In addition, microfossil (algae – *Cosmarium* spp., selected pollen and micro-fungi spores) analyses were also performed.

For photosynthetic pigment analysis, core sample (0.5 g) from top, central and bottom part of the core was extracted in 100% acetone in a tissue homogenizer. The homogenate was transferred into a vial and kept tightly capped in a dark refrigerator at temperature 4°C for night for extraction of photosynthetic pigments. The acetone extract was than adjusted to a set volume, pooled and centrifuged for 15 min at 6000 RPM to remote sediments. The supernatant was analysed in HPLC machine. The photosynthetic pigments were analysed according to method described by Sharma and Hall (1996), with reverse phase column (Waters Spherisorb ODS 25 mm x 4.6 mm x 250 mm) and a PDA detector (Waters 2996). The sample was filtered through nylon filter 0.2 mm prior to loading of 20 ml of supernatant into the HPLC. The gradient for separation was 0-100% ethyl acetate in acetonitrile/water (9:1) over 25 min with flow rate of 1.2 ml/min. The quantity of photosynthetic pigments was calculated from peak area using β-carotene as external standard. Identification of pigments was carried out using standards and spectral profile of individual peaks using PDA detector in the range of 400-700 nm.

RESULTS & DISCUSSION

In upper and lower parts of cores sandy layer is encountered. On the contrary in the central parts of cores silty or clayed material with organic matter was recorded. Upper and lower layers indicate most likely sedimentation of mineral material; central part has successive development of microbial mat. The central parts of core 1, the layer between depths 20 – 50 cm introduced the age of sediment of 7190 ± 300 years BP, as same level radiocarbon dating was previously performed by Sinha et al. (2000) from the same lake. The AFDW (%) in all three cores was studied and presented in Fig. 4. There is no significant correlation between mineral matter (MM) and ash free dry weight (AFDW).

It has been shown that in Priyadarshini Lake three different zones occur: a) peripheral, b) littoral, and c) deep water (Ingole and Parulekar,

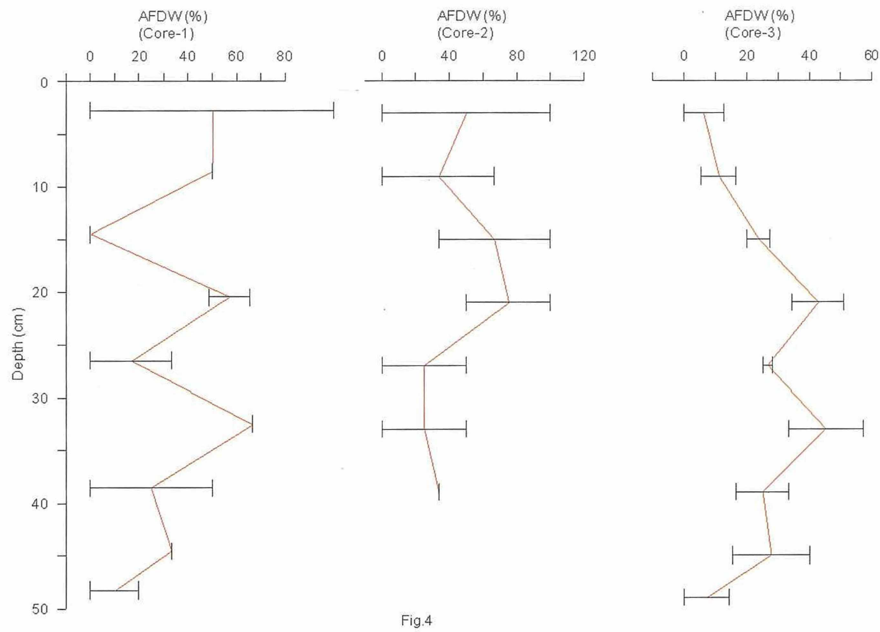

Fig. 4 : Figure shows the content of AFDW (%) in all three-studied core profiles. Core 1, content of AFDW in two upper layers was about 50%, which reduced to zero (depth 15 cm) and 60 to 70 % in central part of core (at depth 20 and 32 cm). In deepest part the values again dropped to 20 – 30%. Upper sediment layers collected from core-2 contained about 50% of AFDW. Statistical analysis of data shows high variability in standard error due to the same reason as in core 1. The values of AFDW dropped down to 40 % in core layer of about 8 cm. In central core part (15 to 22 cm) AFDW reaches 60 to 70%. At around 27 to 38 cm AFDW is low. Core 3 upper layers (4 to 6 cm) were poor (5 to 10%) in AFDW content. The content of AFDW peaked at core layer 20 to 35 cm, here AFDW content reaches 40%.

1990). Peripheral and littoral zones are rich in cyanobacteria and moss communities (Ingole and Parulekar, 1990), whereas in deep water zone sedimentation of mineral particles and organic matter occurs. It could be deduced that deep sedimentation zone of lake is free of phytobenthos biomass because there is lack of irradiance. Irradiance reaches only a particular depth band under these depths the growth of photosynthetic organisms is limited. It can be also deduced that silty or clayed material with organic matter content which has been found in central parts of cores 1 and 3 are residues of cyanobacteria and mosses biomass belt. This biomass rich belt has moved with changes of local climate into deeper horizon layer because of cooler and drier climate and also because the lake was probably much shallower in the past. It is suggested here that with the cooling of climate the Southwest and Southeast parts (sampling sites of core 1 and 3) of lake were much shallower and cyanobacteria and moss belt moved up to deepest parts of lake. Central part of lake (core 2) was probably still enough deep and sediment core is probably not influenced by biomass of cyanobacteria and mosses shore belt. This idea has been deduced from the

Table 1 : Quantification of Pigments Present in Core Samples of Priyadarshini Lake

Level of core	Core-1 Near Maitri pump house		Core-2 70° 45` 47.3`` 11 44` 22.8``		Core-3 70° 45 58.0 11° 44` 25.0``	
	HPLC Peak no.	*Pigment quantity 1µg*	*HPLC Peak no.*	*Pigment quantity 1µg*	*HPLC Peak no.*	*Pigment quantity 1µg*
Top of Core	1	70.27	1	25	1	6.65
	2	278	2	30	2	9.59
	3	46	3	17	3	9.44
	4	256	4	125	4	10.20
	5	112	5	16	5	5.47
	6	30	6	19	6	18
	7	58	7	134	7	7.15
			8	59	8	26
			9	8		
Central part of Core	1	64.19	1	7.59	1	6.48
	2	120	2	14.55	2	20
	3	194	3	64	3	16.51
	4	60	4	102	4	14
	5	24.64	5	9.85	5	7
	6	43.20	6	54.69	6	7
	7	6.47	7	12.70	7	7
			8	89.8	8	93
			9	2.28	9	19
					10	37
Bottom part of core	1	134	1	20	1	12
	2	7.32	2	18	2	1.60
	3	57.66	3	23	3	4.68
	4	23.22	4	19	4	21
	5	26.22	5	8		
			6	5		
			7	57		
			8	5		
			9	27		

fact that AFDW content in core 1 and 3 peaked at similar depth (about 20 to 35 cm). AFDW of the sediment of core 2 is probably formed predominantly by planktic species of *Cosmarium* spp. The sediment layers 15 to 22 cm and time when they were produced is probably period with high phytoplankton and phytobenthos productivity.

To compare quantitively the pigment content from three sites (Table-1, and fig.i, ii, iii, iv, v, vi), it is observed that core-1 contained for greater amount of photosynthetic pigments than core 2 and core-3. This is probably due to habitation of more biota at lower level of depth due to more light availability during polar summer and also even during polar winter, when lakes fridge the ice sheet act as lens and light passes for photosynthesis and their survival. Also in areas of lower depth the lake bottom has more geothermal impact so that even in polar winter life is comparatively more comfortable. Pigment content from core-2 was the least due to maximum depth where light availability is comparatively lesser in both polar summer & polar winter.

Pigment profiles of Core-1, 2, and 3 at three different levels viz. top, central, and bottom is the same, which could indicate: a) same population of

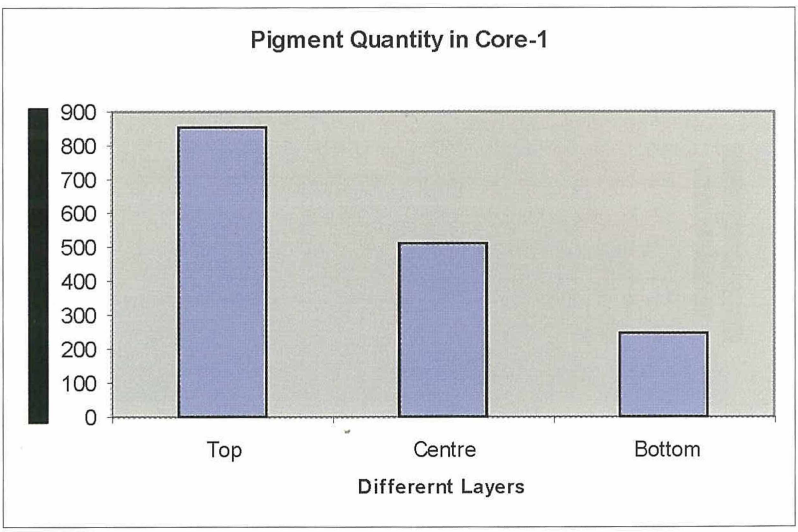

Fig. i

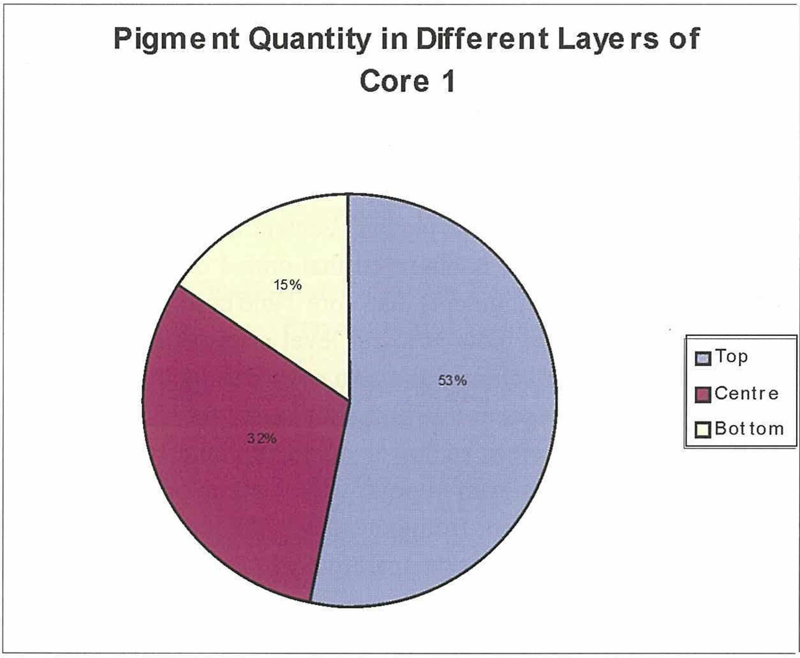

Fig. ii

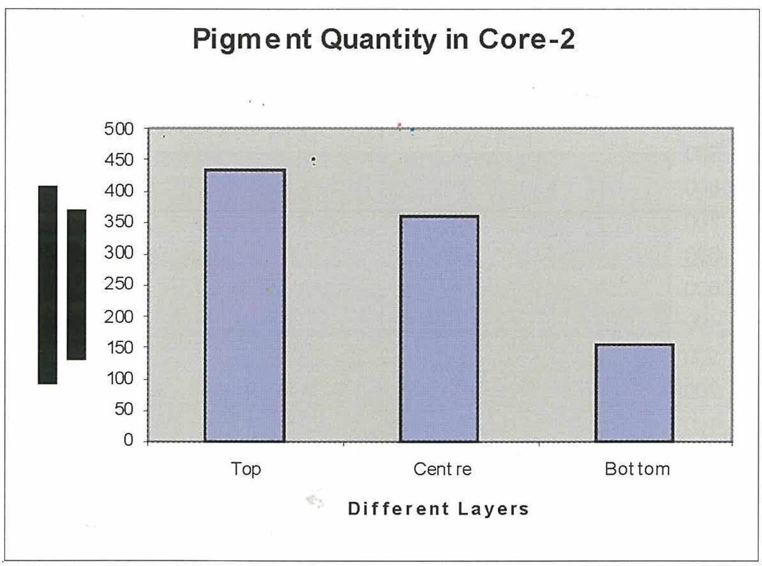

Fig. iii

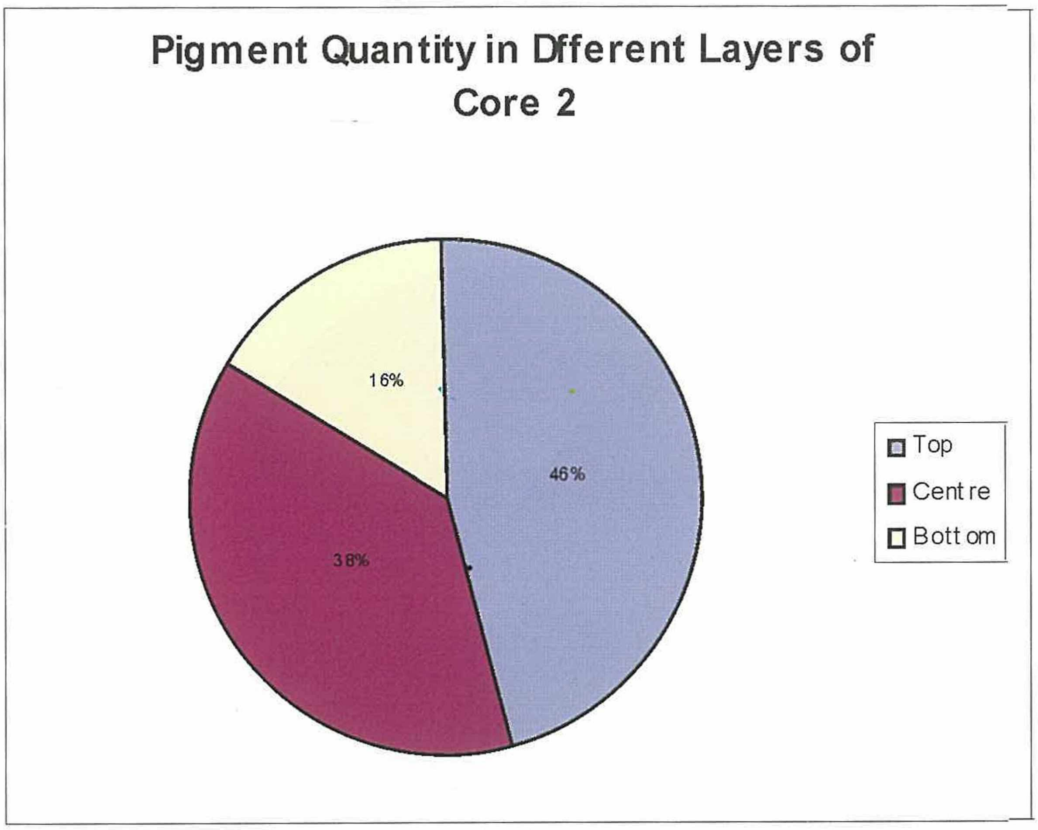
Pigment Quantity in Dfferent Layers of Core 2
16%
46%
38%
Top
Centre
Bottom

Fig. iv

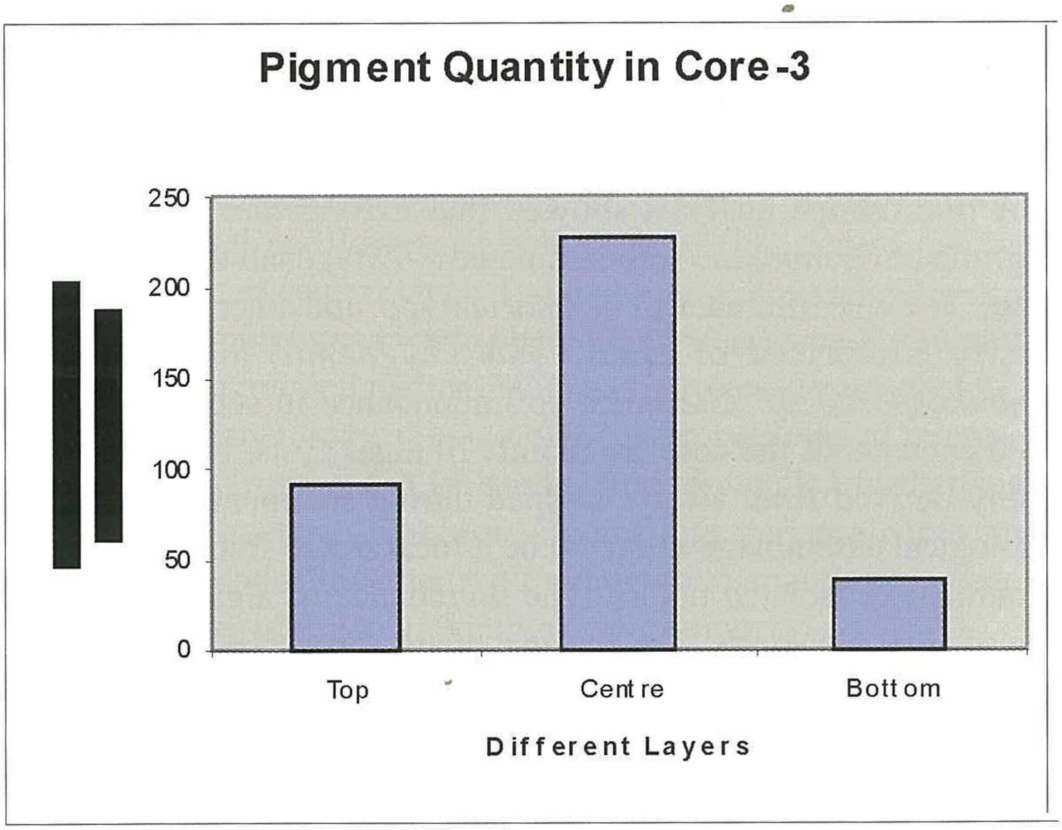
Pigment Quantity in Core-3
250
200
150
100
50
0
Top
Centre
Bottom
Different Layers

Fig. v

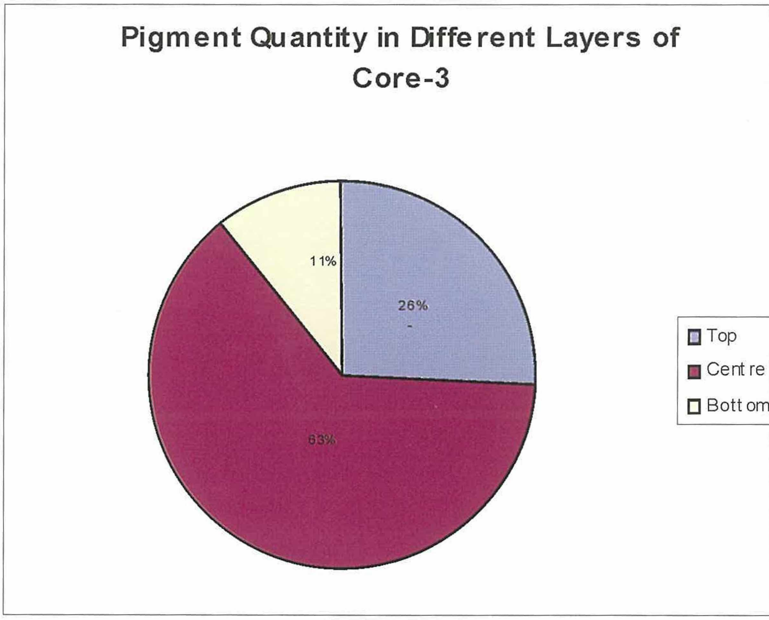

Fig. vi

algae (*Cosmarium* Fig.3) throughout the core b) similar environmental conditions of lake. Previously reported that the pH, temperature and sediment characteristics were remains same through out the lake, (Ingole & Dhargalkar, 1988).

A microscope analysis showed that *Cosmarium* spp. (green algae from group of *Desmidiales*) predominated (~72%) in all three-core sediment samples. There is difference in *Cosmarium* spp. and other microbial remnant diversity comprised of algal cysts (*Zygnema*) and fungal spores (*Helminthosporite* sp. *Alternaria* sp.) abundance in sediment layers. The organic contents of the core are mainly of algal cysts. Fungal spores were probably derived from air got trapped during sedimentation. The overall palynological assemblage seems to be a local micro- biota grown in a lake environment of isolated nature. The dominance of algal cysts suggests a bloom of algal planktons. The absence of any terrestrial source (pollen and spores) is best explained the environment was quiet far for the palynomorphs (Table-2, plate-1a-r) to be disseminated into the lake where these algal palynomorphs were grown and deposited.

Table 2 : Palynological Assemblage of Core Samples of Priyadarshini Lake

	Level of core	Sub-samples of core.	Assemblage
Core-2 70° 45` 47.3`` 11 44` 22.8``	Top	0-9cm	Algal cysts and few fungal spores – *Amphitrema flavum* (Ascospore) and Sordariaceous ascospores found to be present.
		9-18cm	There are few algal cysts. *Zygnema* algal cyst and fungal spores are also found to be present. One globose microfossil (? Poaceae) is also found to be present.
		18-27cm	Algal cysts and fungal spores dominate this level.
	Central	27-36cm	Only algal cysts observed.
		36-45cm	Algal cysts, tetraporate pollen and fungal spore – *Helminthosporite* sp. are found to be present.
		45-54cm	Algal cysts and fungal spores belonging to *Alternaria* and few ascospores are found at this level.
	Bottom	54-60cm	Algal cysts dominate.

CONCLUSION

Qualitative analysis of pigment shows a similar composition in the three core samples but quantitative analysis of Pigment profiles of cores indicates that the core 1 and core 2 show a trend of highest quantity of pigment at top level and lowest at bottom level, but core 3 has highest quantity of pigment at central level. The dominance of algal cysts suggests a bloom of algal planktons and warm phase of climate. There is no significant correlation between mineral matter (MM) and ash free dry weight (AFDW) data. The overall palynological assemblage is probably local micro- biota grown in a lake environment of isolated nature. A detailed further study of bacterio-benthos, bacterio-plankton, microfungi and remnants mosses diversity and abundance together with radiocarbon analyses is needed for better understanding of Priyadarshini Lake evolution.

ACKNOWLEDGEMENTS

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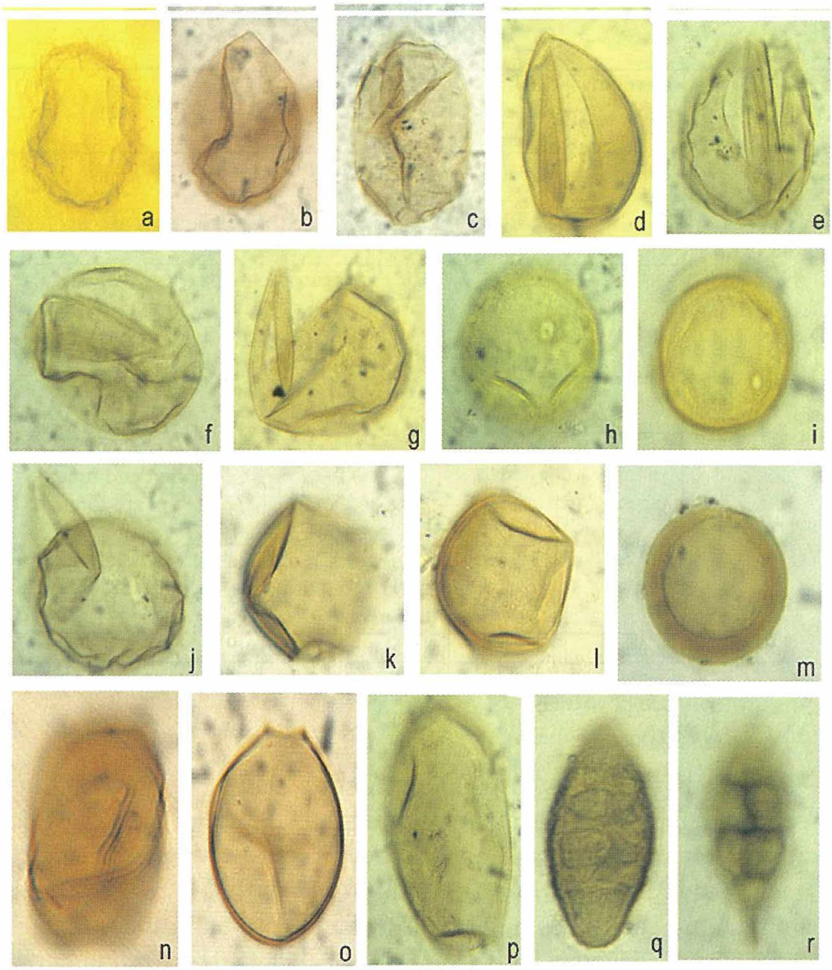

Explanation of Plate –1. Palynological assemblage of core -2 (All photomicrographs magnified ca x 500). a-c, e-g. Algal cysts, *d.* Zygnema cyst, h. Globose microfossil *(? Poaceae), i.* Tetraporate pollen grain, *j-l.* Algal cyst, *m.* Fungal spore, *n. Amphitrema flavum* (Ascospore), *o. Sordariaceous ascospore,* p. Ascospore, *q. Helminthosporites* sp, *r. Alternaria* sp

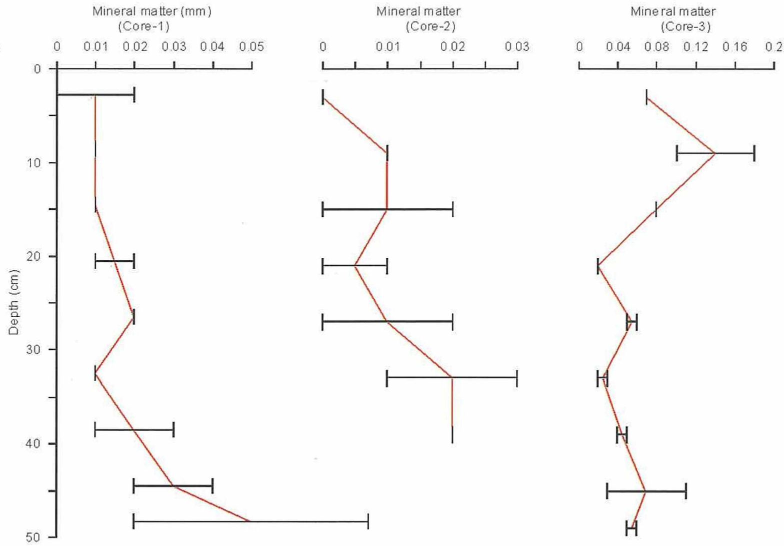

Figure 5 shows the content of MM (gram of mineral matter per gram of dry weight of sediment) in all three-studied core profiles. It is in contrary in AFDW, In core 1 and 2 it is growing slowly and reaching maximum in deeper part of cores (in core 1 about 0.04 to 0.05 g MM/g DWS and core 2 - 0.02g, respectively). The core 3 is very different. The highest mineral matter content was found in upper parts of sediment profile (4 to 8 cm). Here the values reach 0.08 to 0, 12 g MM/g DWS. After that the MM slowly decrease up to zero.

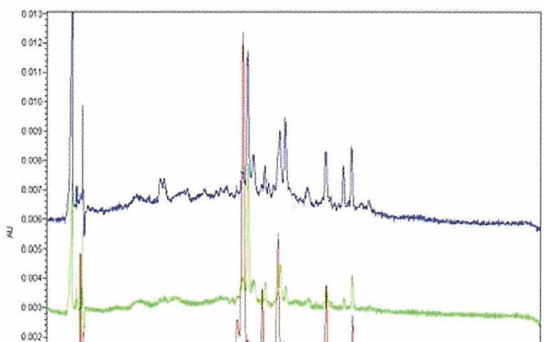

Figure 6 shows HPLC profile of core taken from site-1. The analysis show presence of wide range of photosynthetic pigments at all the depth with almost no qualitative differences, however quantitatively amount of pigment varies with reference to depth of the core. The pigment composition of core mainly represents β-carotene, Chlorophyll-a, leutin, phycobillins and xanthophylls.

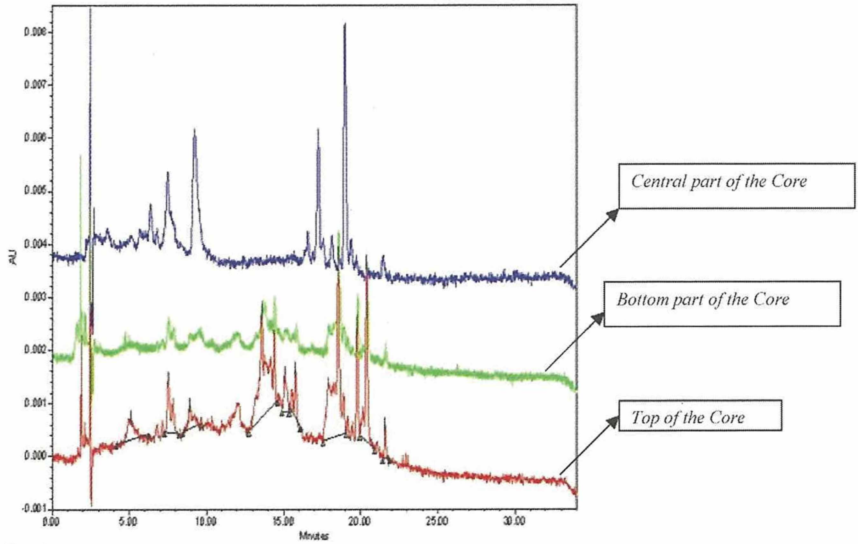

Fig. 7:

Figure 7 shows HPLC analysis of core taken from site-2, again almost no qualitative changes, however top layer show quantitively more pigments than the pigments from lower part of the core.

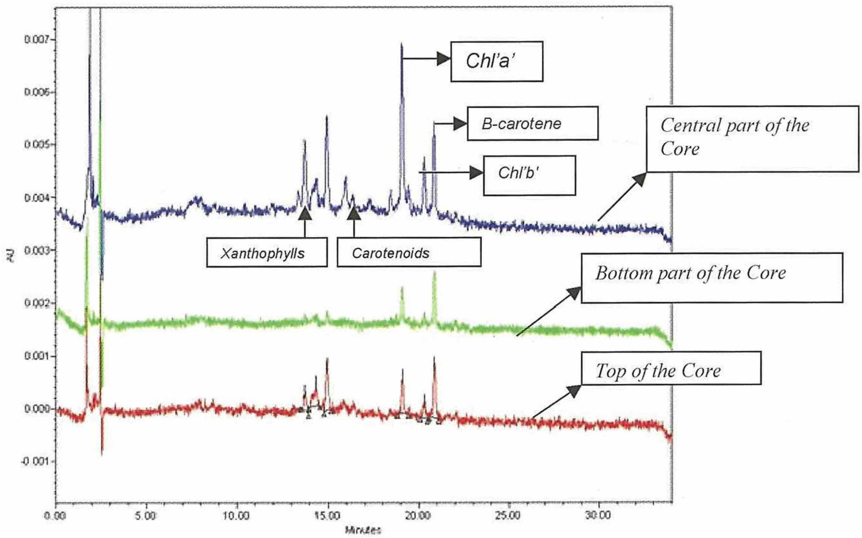

Figure 8 shows pigment profile of the core taken from site-3. Here also no qualitative changes in the profile of the photosynthetic pigments. The middle part of the core showed comparatively higher amount of photosynthetic pigments as compared to top and bottom part of the core. The bottom part of the core contains almost negligible xanthophylls contents.

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