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Euglenophycean Distribution in Relation to Water Quality of Selected Freshwater Bodies from Goa

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ABSTRACT

The algal communities occurring in fresh water bodies are important among other micro taxa where physico-chemical properties of water influence the algal population and its occurrence.These algal communities belonging to various classes are exclusive primary producers and often multiply rapidly resulting in increased turbidity. Euglenophyceae are one of the important group of motile fresh water flagellates often produce water bloom in ponds and lakes. Their occurrence in fresh water bodies point towards the possibility of eutrophication as they act as pollution indicator groups. Present study aimed in documenting the Euglenophycean diversity of four fresh water bodies in Goa by analyzing the water samples for understanding the seasonal dynamics of Euglenophyceae members and physico-chemical parameters by following standard protocols. In all 16 species of Euglenoids belonging to four genera were recovered. Genus *Euglena* is represented by 7 species; Whereas *Leponcinclis*, *Phacus* and *Trachalomonas* are represented by 3 species each. Seasonally three of the four water bodies investigated recorded maximum density of Euglenophyceae members during summer. Executed PCA results revealed that temperature, pH, BOD, nitrates (NO3) and phosphates (PO4 -) have a higher influence on abundance of Euglenophyceae members. Encountered Euglenoids proved to be the most powerful ecological indicators of degradation levels of water and are proper tools for biomonitoring of aquatic ecosystems.

Keywords Euglenophyceae, BOD, Nitrate, Phosphate.

INTRODUCTION

In aquatic ecosystems phytoplankton's have drawn much attention due to their role in primary productivity, biological assessment of water quality, pollution abatement capacity and as a source of metabolites. These are the most helpful indicators of water quality due to their rapid response to environmental changes related to larger animals and plants (Srivastava *et al*. 2014). The changes in phytoplankton biomass are related to eutrophication and the distribution of phytoplankton apparently is related to nutritional status and selective grazing by zooplanktons. Euglenoids

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often serve as indicators of organic pollution and are one of the important groups of plankton that occupy shallow aquatic ecosystem in large numbers due to high concentrations of organic materials to the environment (Hosmani 2012, Muralidhara and Murthy 2015). In present study an effort has been made with a principal objective of floristic survey of the class Euglenophyceae, its seasonal dynamics, and relationship with different physico-chemical parameters in four fresh water bodies of Goa.

MATERIALS AND METHODS

For present study two water bodies each from North Goa (Syngenta Lake and Khandola Pond) and South Goa (Lotus Lake and Curtorim Lake) were selected (Fig. 1). Water samples were collected on monthly basis for a period of two years during early hours, as daily vertical migrations of organisms occur in response to sunlight and nutrient concentrations from the surface near the landward margins. Enumeration of Euglenophyceae was carried out by collecting one liter of water sample from each water body with three replicates. To the collected water sample Lugol's solution was added immediately for sedimentation and retaining of color. The bottles were subsequently left undisturbed for 24 hrs. The phytoplankton's thus fixed and settled at the bottom of the containers, were filtered through net of mesh size 63 µm and 30 cm diameter, making final volume to 50ml and then preserved in 100 ml bottles containing 4% formaldehyde. Recovery of Euglenoids was done by modified Lackey's drop method Suxena (1987). Organisms were counted in each drop. This procedure was repeated three times for each samples and number of organism

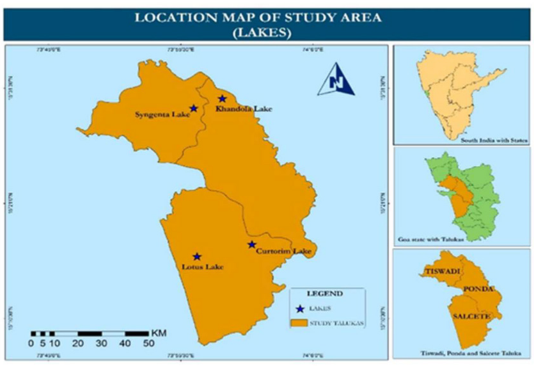


Fig. 1. Location map of study sites.

is measured as organism per liter. Formula used for the calculation of plankton as Org/L is

$$\text{Plankton Org/L} = \frac{n \times c \times 100}{V}$$

Where n = No. of plankton counted in 0.1ml of sample c = Total volume of concentrated in ml V = Total volume of water filtered through net.

Dimensions of the cells were measured using micrometry technique and photomicrographs were taken using Nikon DS Fi 2 camera. Identification was done using relevant literature (Smith 1950, Prescott 1962, Adoni *et al*. 1985). Water samples were also collected simultaneously for the analysis of environmental variables such as pH, BOD, nitrates and phosphates. These were estimated using standard procedures (APHA 2012) and expressed in terms of mg/l except pH.

RESULTS AND DISCUSSION

During present investigation total 16 species of Euglenophyceae belonging to four genera were recovered which are depicted in Table 1. Genus *Euglena* is represented by 7 species; Whereas *Leponcinclis*, *Phacus* and *Trachalomonas* are represented by 3 species each. Out of 4 waterbodies studied, Khandola Pond showed lowest population of Euglenophytes. Seasonal variations in physico-chemical parameters recorded during study is shown in Table 2. Water temperature at the study sites varied from 25°C to 31°C. Maximum temperature was recorded in May (late summer and early rainy season) and minimum in January (winter season). Water temperature plays an important role in controlling the occurrence and abundance of phytoplanktons (Nazneen 1980). It was noticed that algal photosynthesis increased with temperature and resulted in blooms. Similar observations are recorded by (Spencer and King 1989). The pH of water in the selected water bodies ranged from 5.9 to 7.8. Variations in pH were recorded in all the water bodies studied. The pH in Syngenta Lake varied from 5.9 to 6.8, Khandola Pond varied from 6.0 to 7.1, Lotus Lake ranged from 5.9 to 7.8 while at Curtorim Lake it ranged from 5.5 to 7.2. The variations recorded in Euglenophycean diversity may be

Table 1. Phytoplanktons (Euglenophyceae members) isolated from the study sites.

Sl. No.	Species	SL	KP	LL	CL
1	*Euglena acus* (O.Muller) Ehrenberg	+	-	+	+
2	*Euglena elongata* Schewiakoff	+	-	+	+
3	*Euglena gracilis* Klebs	+	-	+	+
4	*Euglena minuta* Prescott	+	+	+	+
5	*Euglena oxyuriss* Schmarda	+	+	+	+
6	*Euglena polymorpha* P.A. Dangeard	+	-	+	+
7	*Euglena proxima* Dangeard	+	-	+	+
8	*Leponcinclis fusiformis* var. major	+	-	+	+
9	*Leponcinclis ovum* Ehrenberg	+	-	+	+
10	*Leponcinclis fusiformis* (H. J. Carter) Lemmerman	+	-	+	+
11	*Phacus asymmetrica* Prescott	+	-	+	+
12	*Phacus chloroplastus*	+	-	+	+
13	*Phacus curvicauda* Swirenko	+	-	+	+
14	*Trachalomonas charcoviences* Swirenko	+	-	+	+
15	*Trachalomonas rotunda* Swirenko	+	-	+	+
16	*Trachalomonas volvocina* Ehrenberg	+	-	+	+

Legend: SL = Syngenta Lake, KP = Khandola Pond, LL = Lotus Lake, CL = Curtorim Lake.

attributed to the changing pH levels. Physico-chemical and biological characteristics of water bodies are known to influence each other (Verma and Mohanty 1995). The pH range of 5.0 to 8.5 is reported to be ideal for phytoplankton growth (Robert *et al*. 1974). The results of BOD showed significant monthly variations during the study period. The BOD values were maximum in summer followed by monsoon and winter seasons. Levels of BOD varied from 6.07 to 18.34 mg L^{-1} at Syngenta Lake, 18.79 to 47.83 mg L^{-1} at Lotus Lake and 21.89 to 59.9 mg L^{-1} at Curtorim Lake. BOD was below detectable level at Khandola Pond. Increase in BOD levels caused rapid depletion of DO. According to Sankar *et al*. (2002) and Ahipathi and Puttaiah (2006) high BOD in summer may be due to the increased oxygen demand for the degradation of the organic wastes dumped into the water body. The decrease in BOD levels in late monsoon and post- monsoon, may be due to low temperature (Bhatt *et al*. 1999). Run off from residential areas carry excess organic waste contributing to increase in oxygen demand. The nitrate levels in the water bodies varied from 0.20 to 0.54 mg L^{-1} in Syngenta Lake, 0.23 to 0.58 mg L^{-1} in Khandola Pond, 1.43 to 4.55 mg L^{-1} in Lotus Lake and 0.80 to 2.76 mg L^{-1} in Curtorim Lake. High nitrate levels were recorded

Table 2. Seasonal variations in physico-chemical parameters recorded during study.

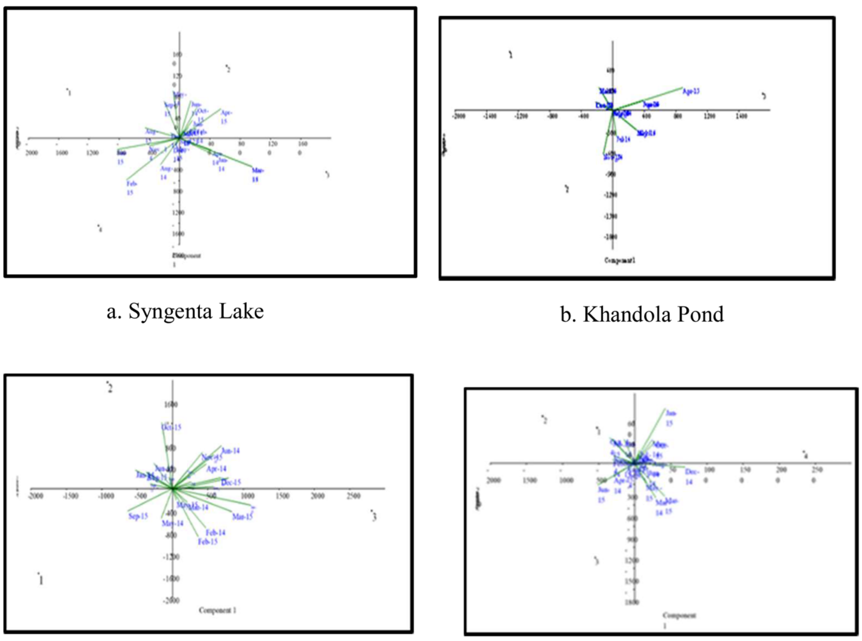
Months	Syngenta Lake					Khandola Pond					Lotus Lake					Curtorim Lake				
	Temp	pH	BOD	Nitr	Phos	Temp	pH	BOD	Nitr	Phos	Temp	pH	BOD	Nitr	Phos	Temp	pH	BOD	Nitr	Phos
1	25	6.1	10.5	0.20	0.10	25	7.1	BDL	0.27	0.01	25	7.8	36.8	1.43	0.01	25	6.8	36.8	0.80	0.01
2	28	5.9	10.1	0.72	0.12	28	6.1	BDL	0.23	0.02	29	6.6	32.3	1.58	0.03	29	6.9	32.4	1.27	0.02
3	28	6.2	12.5	0.82	0.23	28	6.0	BDL	0.56	0.01	29	6.4	32.4	1.66	0.10	29	6.7	32.7	1.50	0.01
4	30	6.2	14.0	0.31	0.10	30	6.1	BDL	0.47	0.04	30	6.0	36.8	1.76	0.25	30	6.9	36.9	1.78	0.04
5	31	6.3	13.2	0.54	0.24	31	6.0	BDL	0.36	0.02	31	5.9	37.7	1.81	0.25	31	6.7	38.2	2.57	0.12
6	30	6.4	11.3	0.33	0.27	30	6.8	BDL	0.50	0.02	30	6.0	21.8	2.16	0.30	30	7.6	37.7	1.32	0.15
7	28	6.8	8.5	0.41	0.25	30	6.4	BDL	0.58	0.30	30	6.7	18.7	4.55	2.41	30	7.6	32.4	2.27	1.72
8	27	6.4	6.0	0.50	0.19	28	6.2	BDL	0.34	0.25	26	6.0	25.9	3.16	1.92	26	7.6	26.3	2.76	0.49
9	28	6.2	8.1	0.53	0.20	27	6.4	BDL	0.38	0.15	28	6.5	27.9	3.38	0.78	28	7.5	21.8	1.43	0.55
10	29	6.0	12.8	0.48	0.15	28	6.4	BDL	0.31	0.15	29	6.0	27.5	4.45	0.60	29	7.6	29.9	1.27	0.30
11	29	6.5	11.3	0.31	0.19	29	6.4	BDL	0.30	0.10	29	6.6	33.7	3.06	0.19	29	6.4	25.9	1.19	0.19
12	28	6.7	10.5	0.29	0.10	28	6.4	BDL	0.29	0.02	28	6.0	37.7	2.38	0.10	28	6.9	29.6	1.27	0.10
13	23	6.1	11.5	0.21	0.11	23	7.1	BDL	0.21	0.01	25	6.8	39.8	1.76	0.27	25	6.6	37.8	0.93	0.19
14	25	6.0	11.7	0.34	0.07	25	6.1	BDL	0.23	0.02	29	6.6	42.3	1.65	0.20	29	6.7	42.4	1.43	0.30

Table 2. Continued.

Months	Syngenta Lake					Khandola Pond					Lotus Lake					Curtorim Lake				
	Temp	pH	BOD	Nitr	Phos	Temp	pH	BOD	Nitr	Phos	Temp	pH	BOD	Nitr	Phos	Temp	pH	BOD	Nitr	Phos
15	29	6.2	12.5	0.73	0.09	29	6.1	BDL	0.50	0.01	29	6.4	37.4	1.75	0.21	29	7.1	42.7	1.67	0.48
16	30	6.2	15.0	0.24	0.10	30	6.1	BDL	0.49	0.04	30	6.0	46.8	1.70	0.18	30	6.7	46.9	1.51	0.40
17	32	5.9	15.6	0.32	0.20	32	6.0	BDL	0.32	0.02	32	5.8	48.9	1.81	0.25	32	6.8	50.2	1.55	0.47
18	31	6.2	18.3	0.37	0.25	31	6.1	BDL	0.35	0.02	31	6.0	47.8	2.24	0.39	31	6.7	57.4	2.30	1.15
19	28	6.2	13.5	0.43	0.29	28	6.3	BDL	0.28	0.01	30	6.7	41.8	2.95	1.01	30	6.6	42.0	2.45	1.22
20	27	6.4	10.6	0.59	0.31	27	6.2	BDL	0.33	0.02	26	6.7	39.7	3.19	1.62	26	6.6	40.3	2.64	1.54
21	28	6.4	12.4	0.57	0.28	28	6.4	BDL	0.38	0.04	28	6.0	37.9	3.38	1.70	28	6.5	41.8	2.40	0.95
22	29	6.3	17.9	0.53	0.22	29	6.3	BDL	0.32	0.03	29	5.4	44.5	2.55	1.03	29	6.1	59.9	1.73	0.40
23	29	6.1	14.3	0.45	0.17	29	6.4	BDL	0.29	0.02	29	6.2	39.7	2.17	0.17	29	5.4	51.0	1.65	0.20
24	28	6.3	10.5	0.37	0.12	28	6.4	BDL	0.27	0.01	28	6.5	35.0	2.02	0.11	31	6.3	38.2	2.57	0.12

Legend: Values are average of three readings, BDL- Below detectable level.

during monsoon and low levels were recorded during post-monsoon season. Similar observations have been recorded earlier (Prabhakar *et al*. 2012). Nitrates are useful as nutrients but their entry into water resources increases the growth of nuisance algae, macrophytes and triggers eutrophication (Trivedy and Goel 1986),. Even though phosphate is essential for growth of organisms, the discharge of raw wastewater, agricultural drainage, or industrial waste to water body stimulates the growth of photosynthetic aquatic micro- and macro-organisms in large quantities (USEPA 1973). In the present study variations in phosphate concentrations in different water bodies were recorded and ranged from 0.07 to 0.31 mg L^{-1} in Syngenta Lake, 0.01 to 0.30 mg L^{-1} in Khandola Pond, 0.01 to 2.41 mg L^{-1} in Lotus Lake and 0.01 to 1.72 mg L^{-1} in Curtorim Lake. During monsoon season, levels of nitrates and phosphates elevate as they enter the water bodies from the surrounding area, especially farmlands and sewage (Sawaiker and Rodrigues 2016). Higher of



a. Syngenta Lake

b. Khandola Pond

c. Lotus Lake

d. Curtorim Lake

Fig 2. Principal component analysis of physico-chemical parameters and Euglenophyceae members.

concentration of phosphate may also be due to inflow of domestic waste, washing activities and bathing of cattle (Joseph *et al*. 1993). Levels of phosphates and nitrates are known to deplete DO resulting in the formation of algal blooms (Ansar and Khad 2005). According to Yanamadala (2005), high levels of phosphates and nitrates have an impact on the overall health of the water and its organisms.

Principal Component Analysis (PCA) was carried out using PAST software. PCA analysis helps to identify the patterns in the data and to direct the data by highlighting their similarities and differences. This technique primarily used to explore relationships between dependent variables. Correlations were observed between physico-chemical parameters and Euglenophyceae members. Population density of Euglenoids was maximum during premonsoon and minimum during monsoon. PCA was used, to find out the seasonal relationship between phytoplankton and physico-chemical parameters (Fig. 2). Executed PCA results revealed that temperature, pH, BOD, nitrates (NO3) and phosphates (PO4 -) have a higher influence on abundance of Euglenophyceae members. In Syngenta Lake, positive correlation was observed between *Trachalomonas volvocina*, *Euglena minuta*, *Liponcinclis fusiformis* and *Phaus asymmerica*. In Khandola Pond *Euglena minuta* and *E. oxyuriss* played the role of principal components and were positively correlated to *Phacus asymmetrica*. In Lotus Lake *T. volvocina*, *E. minuta* and *P. asymmetrica* were inversely proportional to each other and showed positive correlation with *Liponcinclis fusiformis*. While in Curtorim Lake *Trachalomonas volvocina* was principal component and was positively correlated to *Liponcinclis fusiformis* and *Euglena minuta*. pH, BOD, Nitrates and Phosphates played key role as principal components and were the drivers of euglenophycean communities. Seasonally three of the four lakes investigated recorded maximum density of euglenoids during summer. Euglenophyceae are generally abundant in waters rich in organic matters (Kalff 2000).

CONCLUSION

Euglenophyceae members encountered during study are most powerful ecological indicators of degradation levels and are proper tools for biomonitoring of aquatic ecosystems. Euglenophycean diversity is highly dynamic depending on the nutrient availability which is clearly explained by PCA analysis. From Figs. 2 (a – d) it is clear that analyzed physicos chemical parameters played a great role in growth and abundance of Euglenophyceae members. From present investigation it is concluded that there is deterioration of water quality in selected water bodies due to organic and anthropogenic pollution. Activities such as unrestricted entry of huge quantity of sewage and effluents, cattle washing and fishing, runoff from the surrounding residential areas and industries are responsible for eutrophic condition in Syngenta, Lotus and Curtorim Lsakes. Khandola Pond showed mesotrophic condition. Euglenoids as biological indicators and physico-chemical elements form the core of any monitoring program of fresh water aquatic ecosystems. The data attained during this study will also be helpful in deriving the conservational strategies of studied waterbodies.

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