DISTRIBUTION AND DIVERSITY OF PHYTOPLANKTON IN TWO LAKES OF MANDYA

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ABSTRACT

Phytoplankton in Arakere and Thaggahalli lakes of Mandya was studied over a period of two years. The data obtained was subjected to past software to get the diversity indices. The diversity index values was found to be between 1.27 to 3.03 and were not uniform throughout the year. The lesser diversity may be due to competition for nutrients within an uniform environment. The increased diversity during some seasons may be due to increase in nutrients level of the water. The diversity indices have revealed that dominance of species were almost similar and the species distribution was not even in both the lakes. From this it is evident that the factors influencing the diversity of the phytoplankton are similar in both the lakes.

***Keywords*:** Phytoplankton diversity, Species abundance, PASTA, Equitability, moderate

INTRODUCTION

In aquatic ecosystems phytoplankton are the primary producers and they form the first trophic level of the food chain. Hence they play a vital role in the food webs as they provide food for zooplankton and other aquatic fauna (Millman *et al.,* 2005; Shubert, 1984). One of the significant characteristic of lake environment is the presence of a large number of species at any given time. This kind of species diversity appears as a paradox (Hutchinson,1967). Phytoplankton abundance and diversity are widely used as biological indicators of still-water quality in lakes and reservoirs. The density and species composition of phytoplankton in tropical lakes and reservoirs exhibit a particular annual biological characteristics (Palmer *et al.,*1977; Shubert, 1984; Washington,1984; Pongswat *et al.,* 2004).

Phytoplankton succession in open lakes depends on the availability of nutrients, temperature, light intensity and transparency. Phytoplankton communities usually undergo a fairly predictable annual cycle, but some species may grow exponentially forming the blooms (Toman, 1996; Hinder *et al.,* 1999). Light limitation by high turbidity is another factor that frequently controls phytoplankton growth either during the whole year or seasonally (Ariyadej *et al.,* 2004). When the single group of organisms like algae competing for nutrients within an uniform environment, the diversity may be lower due to competitive elimination. But explanation for high diversity of fresh water plankton on the fact that interactions in the planktonic environment are highly complex.

Diversity indices are applied in water pollution research to evaluate the effects of pollution on species composition (Archibald, 1972). The qualitative and quantitative studies of phytoplankton have been utilized to assess the quality of water (Adoni *et al.,* 1985;Chaturvedi et al., 1999; Ponmanickam *et al.,* 2007; Shekhar *et al.,*2008). Changes in any environmental factor will consequently change diversity (Washington, 1984), as long as adaptation is either rare or nonexistent. Although ecologists have designed a range of indices and models for the measurement of diversity, yet it is hard to define diversity convincingly(Magurran,1983).

Diversity comprises two components, the varieties and relative abundance. Diversity can be measured by recording the number of species, by describing their relative abundance or by using a measure which combines both the components. Investigation on ecological are often confined to species richness, which is the direct count of the number of species present(Pianka,1983). It is commonly observed that no community consists of species of equal abundance. A majority of species are rare, while some are moderately common and the remaining species are very abundant. The reduction in numbers of species and the increase in number of individuals that characterize polluted areas results in significant decreases in values of diversity (Whitton, 1975; Sommer,1993).

The study of diversity measures are more useful in the monitoring of lake ecosystems as the lake harbor a large variety of algal species and species diversity within the genera. Hence application of species richness indices and the models that describe the distribution of species abundance is also essential. Therefore a community may be described by referring to the model which provides the closest fit to the observed pattern of species abundance(Hosmani,2010).

The present study is based on the data collected over a period of two years on the distribution of phytoplankton in two lakes of Mandya district.

MATERIALS AND METHODS

Study Area

Two Large lakes located at a distance of 20 Kms apart , one situated at south west (Arakere lake) and another towards south east (Thaggahalli lake) of Mandya were selected for the present study.

Arakere Lake is mainly rainfed and receives canal water as surface flow from the adjacent crop fields during the cropping periods. The sewage of the village joins the lake at one point. The total water spread area of the tank is 140 ha and the irrigation area is about 49 ha.

Thaggahalli lake receives water from the surface flow of the crop fields and also from canals, apart from the rain. The total water spread area of the tank is 50ha & the irrigation area is about 68ha. The tank is perennial & productive.

Collection of Samples

Water samples were collected monthly in plastic carbouys of one litre from the surface waters randomly from the lakes for plankton analysis. For each sample 25ml of 4% formaldehyde and few drops of Lugol's iodine were added and the sample was allowed to sediment in glass columns as described by Welch(1948). The sediment was further reduced to 20 ml by centrifugation. These samples were preserved and stored for further analysis. Semi permanent mounts were prepared in 50 % glycerine for identification and enumeration of plankton. Identification was done by referring to monographs of Desikachary (1959), Scott and Prescott (1961), Philipose (1967), Prescott (1982), Sarode and Kamath (1984). Their enumeration was made as per the methods described by Welch(1948), Hosmani and Bharathi (1980). Plankton count was done by Lackey's Drop Method [1938], modified by Saxena (1987). The phytoplankton were identified and recorded.

The data were subjected to PAST programme (Hammer et al., 2001) to evaluate nine diversity indices such as Dominance index, Shannon and Weiner index, Simpson's index, pielou's evenness index, Menhinick's index, Margalef's index, Shannon equitability index, Fisher's aloh index and Berger-Parker dominance index.

RESULTS AND DISCUSSION

The phytoplankton communities during 2009-10 were represented by 55 species in Arakere lake and 49 species in Thaggahalli.During 2010-11, 63 species of phytoplankton were found in Arakere lake and 62 species were recorded in Thaggahalli lake. The number of phytoplankton species of different groups per litre of water are shown in the tables 1 to 4.

Sl.No	Group, Genus and Species	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
1	*Eunotia minor (Kutzing) Gronow*	0	0	0	0	560	0	0	0	0	0	1120	0
2	*Gomphonema gracile.Ehr*	0	0	0	1120	0	0	0	2240	0	0	0	0
3	*Gomphonema parvulum* Kützing	0	0	0	0	560	0	0	0	0	0	1120	0
4	*Gyrosigma accuminatum (Kuetz)Rabh*	0	0	0	0	0	0	1120	0	0	0	0	0
5	*Gyrosigma hippocampus (Ehrenberg)*	0	0	0	1120	0	0	0	1120	0	0	0	0
6	*Navicula germainii Wallace*	0	2240	0	0	0	1120	0	0	0	0	0	0
7	*Navicula rhomboides Ehrenberg*	1120	1120	0	560	0	0	0	1120	0	560	0	0

8	*Navicula rhyncocephala Kutz*	6720	0	0	0	0	0	0	0	0	0	0	5600
9	*Navicula viridis (Nitzsch) Ehrenb*	0	0	0	0	2240	0	0	1120	0	0	0	0
10	*Navicula viridula (Kützing) Ehrenberg*	0	0	1120	0	1120	0	0	0	0	0	0	0
11	*Nitzschia gracilis Hantzsch*	0	0	1120	0	0	0	0	0	0	0	0	0
12	*Pinnularia acrosphaeria Rabenhorst*	0	0	0	1120	0	0	0	0	560	0	0	0
13	*Pinnularia gibba .Ehr*	0	1680	2240	0	0	0	1120	560	1120	1680	1680	1120
14	*Stauroneis phoenicenteron.Ehr*	0	0	2240	0	0	0	0	0	0	0	0	0
15	*Surirella angusta Kützing*	0	0	0	0	0	1120	0	0	560	0	0	0
16	*Synedra ulna Kutzing*	0	1120	2240	560	560	1120	5600	12320	11200	11200	3360	0
17	*Actinastrum hantyschi Lagerh*	2240	1120	0	0	0	1120	0	0	0	0	0	0
18	*Ankistrodesmus falcatus*	0	0	1120	0	1120	0	0	0	1120	0	0	0
19	*Coelastrum cambricum Archer*	0	1120	0	0	0	1120	0	0	1120	0	0	0
20	*Coleosphaerium dubium.Grunow*	1120	1680	0	0	0	0	0	0	0	0	0	0
21	*Pediastrum duplex Meyen*	0	1120	0	0	0	0	0	0	1120	0	0	0
22	*Scenedesmus armatus (Chodat) G. M. Smith*	0	0	1120	0	0	0	0	0	0	1120	0	0
23	*Scenedesmus bijuga (turp)Laqerhium*	0	0	0	0	0	0	0	0	0	0	0	1120
24	*Scenedesmus dimorphus (Turpin) Kützing*	0	0	1120	0	0	0	0	0	0	1120	0	0
25	*Scenedesmus obliquus (Turpin) Kützing*	0	0	1120	0	0		1120	0	0	1120	0	0
26	*Scenedesmus quadricauda Turpin*	2240	0	0	0	0	0	0	0	0	2240	0	0
27	*Tetradron limnitium*	0	0	0	0	0	1120	0	0	0	0	0	0

28	Euglena oxyuris Presctt	1120	0	0	0	1120	0	0	0	1120	0	0	0
29	Euglena polymorpha Dangeard	0	0	0	0	0	0	0	1120	0	0	1120	0
30	Lepocinclis ovum.Ehr	1120	2240	1120	1120	1120	0	560	0	0	1120	0	0
31	Phacus caudatus Huebner	0	0	0	0	0	1120	0	0	0	0	0	0
32	Trachelomonas volvocine Her	1120	0	0	0	1120	0	0	0	0	0	0	0
33	*Anabaena spiroides Klebahn*	0	1120	0	0	1120	0	0	560	0	0	0	0
34	*Arthrospira femmeri*	0	0	0	0	1120	0	0	0	1120	0	0	0
35	*Arthrospira platensis (Nordst) Gom*	0	1120	0	0	0	0	0	0	0	0	0	0
36	*Chroococcus limneticus Lemn*	0	0	0	0	0	0	1120	0	1120	0	0	0
37	*Merismopedia tenuissima Lemn*	560	2800	0	0	560	0	0	0	0	0	0	0
38	*Microcystis aeruginosa Kurtz*	0	4480	0	0	0	0	0	0	0	0	0	0
39	*Nostoc muscorum Ag*	0	0	0	0	0	0	0	0	0	0	0	3360
40	*Oscillatoria subbrevis Schmidle*	1120	0	0	0	0	0	1120	0	1120	0	0	0
41	*Phormidium fragile Gomont*	0	0	0	2240	0	0	1120	0	0	0	0	0
42	*Raphidiopsis mediterranea Skuja*	4480	1120	0	0	0	0	0	0	0	0	0	1120
43	*Spirulina compacta*	1120	0	0	1120	0	0	0	1120	0	0	0	0
44	*Spirulina meneghiniana Zanard*	0	0	0	0	1120	0	0	0	0	0	0	0
45	*Spirulina platensis (Gomont) Geitler*	2240	1120	0	2240	1120	0	0	0	2240	0	0	0
46	*Closterium porrectum Nordst*	0	560	0	0	0	0	0	0	0	0	0	0

47	*Cosmarium margaritatum(Lund)*	0	0	0	0	0	0	1120	0	0	0	0	560
48	*Cosmarium setaceum Her*	1120	0	0	0	0	0	0	0	0	0	0	1120
49	*Cosmarium subspeciosum(Nordst)*	1120	0	0	0	0	0	0	0	0	0	1120	0
50	*Sorastrum dentatum*	1120	0	0	0	0	0	0	0	0	1120	0	0
51	*Triceratium*	0	0	0	0	0	0	0	0	560	0	0	0
52	*Oedogonium anomalum Hir*	0	0	0	0	0	2240	1120	0	0	0	0	1120
53	*Spirogyra crassa Kuetz*	0	0	0	0	0	11200	0	0	0	1120	1120	0
54	*Ulothrix aequalis Quetzing*	0	0	0	0	0	0	0	0	0	1120	0	0
55	*Zygnema micropunctatumTranseau*	0	0	0	0	0	0	1120	0	0	0	0	0

Table 2. Phytoplankton in Thaggahalli lake. Org/lit (2009-10)

Sl.No	Genus and Species	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
1	*Eunotia minor (Kutzing) Gronow)*	0	0	0	0	0	0	0	0	1120	1120	0	0
2	*Gomphonema gracile.Ehr*	0	560	0	0	0	0	0	0	1680	1120	1120	1120
3	*Gomphonema parvulum Kützing*	0	0	0	0	0	1120	0	1120	0	0	0	1120
4	*Gyrosigma accuminatum (Kuetz)Rabh*	0	560	0	0	0	0	0	0	0	0	1120	0
5	*Gyrosigma hippocampus Her*	0	0	0	1120	0	0	0	0	0	0	0	0
6	Navicula germainii Wallace	0	1120	1120	0	0	0	0	0	0	0	0	0
7	*Navicula rhyncocephala Kutz*	0	0	0	0	0	0	0	5600	0	1120	0	0
8	*Navicula viridis (Nitzsch) Ehrenb*	0	0	560	0	0	2240	0	0	0	0	0	0
9	*Navicula viridula (Kützing) Ehrenberg*	0	0	0	0	0	0	2240	0	0	0	0	0
10	*Nitzschia gracilis Hantzsch*	1120	1120	1120	4480	0	0	0	0	0	2240	1680	0
11	*Pinnularia acrosphaeria Rabenhorst*	0	0	0	0	0	0	0	1120	0	0	0	0
12	*Pinnularia gibba .Ehr*	560	1120	2240	2240	0	0	0	0	0	3360	2240	0
13	*Stauroneis phoenicenteron.Ehr*	0	0	1120	0	0	0	0	0	0	0	1120	0
14	*Surirella angusta Kützing*	0	0	0	0	0	0	0	1120	0	0	0	0
15	*Surirella splendida .Ehr*	0	0	0	0	0	0	0	0	560	0	0	0
16	*Synedra ulna Kutzing*	1120	4480	2240	2240	0	0	1120	1120	4480	3920	5600	5600

17	*Actinastrum hantyschi Lagerh*	0	0	0	0	0	0	0	0	0	2240	2240	0
18	*Ankistrodesmus falcatus*	0	0	1120	0	0	0	0	0	0	0	0	0
19	*Coelastrum cambricum Archer*	0	0	0	0	0	0	0	0	1120	1120	0	0
20	*Coleosphaerium dubium Grunow*	0	0	0	0	0	0	0	1120	0	0	0	0
21	*Kirchneriella lunaris (Kirchner) K.Möbius*	1120	0	1120	0	0	0	0	0	0	0	0	0
22	*Pediastrum duplex Meyn*	0	0	0	0	0	0	0	0	1120	0	0	0
23	*Pediastrum tetras (Ehrenberg) Ralfs*	0	0	0	0	0	0	0	0	0	0	0	1120
24	*Scenedesmus armatus (Chodat) G. M. Smith*	0	0	0	0	0	0	0	1120	0	0	0	0
25	*Scenedesmus bijuga (turp)Laqerhium*	0	0	1120	0	0	0	0	1120	0	0	0	0
26	*Scenedesmus obliquus (Turpin) Kützing*	0	0	1120	0	0	1120	0	0	1120	0	0	0
27	*Scenedesmus quadricauda Turpin*	0	0	0	0	0	0	0	0	1120	0	0	0
28	*Tetradron limnitium*	0	0	0	0	0	0	1120	0	0	0	0	0
29	*Tetraedron trilobatum (REINSCH) HANSG*	0	0	0	0	1120	0	0	0	0	0	0	0
30	*Chroococcus limneticus Lemn*	1120	0	0	0	0	0	0	0	2240	2240	0	0
31	*Merismopedia tenuissima Lemn*	1120	0	1120	0	0	0	1120	0	0	0	1120	0
32	*Oscillatoria subbrevis Schmidle*	0	0	0	0	1120	0	0	0	1120	0	0	0
33	*Phormidium fragile Gomont*	0	0	0	0	2240	0	0	0	2240	0	0	0
34	*Raphidiopsis mediterranea Skuja*	0	0	0	0	0	0	0	0	0	1120	4480	0
35	*Spirulina compacta*	1120	0	0	0	1120	0	0	0	0	0	0	0
36	*Spirulina platensis (Gomont) Geitler*	2240	0	1120	0	0	0	0	0	2240	0	1120	1120
37	*Closterium porrectum Nordst*	0	0	0	0	0	0	0	0	1120	0	0	0
38	*Cosmarium crassangulatum Borge*	0	0	0	0	0	0	0	560	0	0	0	0
39	*Cosmarium margaritatum(Lund)*	560	0	0	0	0	560	0	0	0	0	0	0
40	*Desmidium baileyi(Ralfs) Nordst*	0	0	0	0	0	0	0	0	0	1120	1120	0
41	*Euglena oxyuris Presctt*	0	0	0	0	0	0	0	0	1120	0	0	0
42	*Lepocinclis sphagnophila Lem*	560	0	0	0	0	0	0	0	0	0	0	0

43	*Phacus caudatus Huebner*	0	0	0	0	0	0	0	0	0	0	1120	0
44	*Phacus orbicularis Skbortzow*	0	1120	0	0	0	0	0	0	0	0	0	0
45	*Trachelomonos charkowiensis Swirenko*	0	1120	0	0	0	0	1120	1120	1120	0	0	0
46	*Oedogonium anomalum Hir*	0	0	0	0	0	0	0	0	1120	1120	1120	0
47	*Spirogyra crassa Kuetz*	0	0	0	560	0	0	0	0	560	0	0	0
48	*Ulothrix aequalis Quetzing*	0	0	0	0	0	0	0	0	1120	0	0	0

Table 3. Phytoplankton in Arakere lake. Org/lit (2010-11)

Sl.No	Group, Genus and Species	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
1	Achnanthes affinis Grunow	0	0	0	0	0	0	0	0	2240	2240	1120	0
2	Caloneis permagna (J.W.Bailey) Cleve	0	0	0	0	0	0	0	0	1120	0	0	0
3	Cymbella cymbiformis C.A. Agardh	0	0	1120	2800	0	3360	3360	3360	4480	2240	3360	4480
4	Eunotia arcus Ehrenberg	0	0	0	0	0	0	0	0	0	0	2240	0
5	Fragilaria intermedia Grunow	0	0	0	0	0	0	2240	2240	0	0	0	4480
6	Fragilaria pinnata. Ehrenb	0	0	0	0	0	0	0	0	2240	1120	0	0
7	Gomphonema gracile.Ehr	2240	0	0	0	0	0	0	0	0	0	2240	3360
8	Gomphonema martini F.Fricke	0	0	0	0	0	1120	0	0	0	0	0	0
9	Gyrosigma accuminatum(Kuetz)Rabh	0	0	0	0	0	1120	0	0	0	0	0	0
10	Mastogloia recta Hustedt	0	0	1120	0	0	1120	1120	3360	0	1120	2240	1120
11	*Navicula disjuncta*	0	0	0	1120	1120	0	0	0	0	0	0	0

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12	*Navicula hustedtii* Krasske	0	0	0	0	0	0	0	0	0	0	0	1120
13	*Navicula reinhardtii* (Grunow)	0	0	0	1120	0	0	0	0	0	0	0	0
14	*Navicula rhyncocephala Kutz*	0	0	0	0	0	0	1120	0	0	0	0	0
15	*Navicula vulpina* Kutz.	0	0	0	3360	1120	0	0	0	0	0	0	0
16	*Pinnularia gibba .Ehr*	0	0	1120	0	0	0	0	2240	0	0	1120	0
17	*Pinnularia neglecta Mayer (Berg)*	1680	0	0	0	0	0	0	0	0	0	0	0
18	*Rapolodia gibba,Ehr*	0	0	0	0	0	0	0	0	0	0	0	1120
19	*Surirella subsola*	0	0	0	0	0	0	0	0	2240	0	0	0
20	*Synedra acus* Kützing	0	1680	0	0	0	0	2240	2240	4480	2240	0	4480
21	*Synedra tabulata* (C. Agardh) Kütz	0	0	0	0	0	0	0	0	0	1120	0	0
22	*Synedra ulna Kutzing*	2240	0	0	560	3360	2240	2240	0	0	0	0	0
23	*Actinastrum hantyschi Lagerh*	0	0	0	0	0	3360	0	0	0	0	0	3360
24	*Ankistrodesmus falcatus (Corda) Ralfs*	0	0	0	560	0	0	0	0	0	0	0	0
25	*Coelastrum cambricum Archer*	0	0	0	0	0	0	0	0	0	0	0	1120
26	*Coleosphaerium dubium.Grunow*	560	0	0	0	0	0	0	0	0	0	0	0
27	*Dactylococcus infusionum Naegeli*	560	0	0	1120	0	0	0	0	0	0	0	0
28	*Franceia ovalis (Francé) Lemmermann*	0	0	0	0	0	3360	0	0	2240	0	0	0
29	*Pediastrum tetras (Ehrenberg) Ralfs*	0	0	0	560	0	0	0	0	0	0	0	0
30	*Scenedesmus bijuga (turp)Laqerhium*	1120	0	2800	1680	0	0	0	0	0	0	0	0
31	*Scenedesmus bijugatus Kützing*	0	0	0	0	0	0	0	0	0	0	0	1120
32	*Scenedesmus dimorphus (Turpin) Kützing*	0	0	0	2240	0	0	0	0	0	0	2240	0

33	*Scenedesmus quadricauda. (Turp.) de Breb*	0	0	0	0	0	0	0	0	0	0	0	1120
34	*Tetraedron tumidulum (Reinsch) Hansgirg*	0	0	2800	0	0	0	0	0	0	0	1120	0
35	*Tetraedron verrucosum G.M.Smith*	560	0	0	0	0	0	0	0	0	0	0	0
36	*Cocconeis placentula Ehrenb*	0	0	0	0	0	0	0	0	1120	0	2240	2240
37	*Euglena minuta Prescott*	0	0	0	1120	0	0	0	0	1120	0	0	0
38	*Euglena polymorpha Dangeard*	0	0	1120	1120	0	0	0	0	0	0	0	0
39	*Lepocinclis ovum (Ehrenberg)*	0	0	0	0	0	0	0	0	1120	0	1680	0
40	*Phacus caudatus Huebner*	0	0	0	560	0	0	0	0	0	0	0	0
41	*Phacus longicauda (Ehrenberg)*	0	0	0	560	0	0	0	0	0	0	0	0
42	*Trachelomonas armata (EHR.)*	0	0	0	0	0	0	0	2240	0	0	0	0
43	*Trachelomonas volvocina EHR*	0	0	0	0	0	0	0	0	0	0	0	560
44	*Aphanothece microspora (Meneghini) Rabenhorst*	0	0	560	0	0	0	0	0	0	0	0	0
45	*Chroococcus dispersus (Keissler) Lemmermann*	2240	2240	0	1120	0	0	1120	0	2240	3360	0	1120
46	*Chroococcus limneticus Lemn*	0	0	0	0	0	0	0	0	0	1120	0	1120
47	*Gloeocapsa punctata Nägeli*	1120	0	0	0	0	0	0	0	0	0	0	0
48	*Gloeothece rupestris (Lyngbye) Bornet*	560	2240	1680	0	0	0	0	0	0	0	0	0
49	*Merismopedia elegans A.Braun ex Kützing*	1120	0	0	0	0	0	0	0	0	3360	2240	0
50	*Merismopedia glauca (Ehrenberg) Kützing*	1120	0	0	0	0	0	0	0	0	0	0	0

51	*Merismopedia tenuissima Lemn*	0	0	0	2800	0	4480	0	0	0	0	0	3360
52	*Oscillatoria subbrevis Schmidle*	560	0	2240	0	2240	0	0	1120	2240	0	0	0
53	*Spirulina nordstedtii Gomont*	0	1680	0	1120	0	0	0	0	0	0	0	0
54	*Closterium lunula Ehrenberg & Hemprich*	0	0	0	0	0	0	1120	0	0	0	0	0
55	*Cosmarium margaritatum(Lund)*	1120	0	0	0	0	0	0	0	0	0	0	0
56	*Staurastrum sps*	0	0	0	0	0	0	0	0	0	1120	0	0
57	*Triceratium sps*	0	0	0	560	0	0	0	0	0	0	0	0
58	*Botryococcus braunii Kützing*	0	0	0	0	0	0	0	0	0	0	0	1120
59	*Gloeocystis gigas (Kützing) Lagerheim*	0	0	0	560	0	0	0	0	0	0	0	0
60	*Kirchneriella lunaris (Kirchner) K. Möbius*	0	0	560	0	0	0	0	0	0	0	0	0
61	*Kirchneriella obesa (G.S. West) Schmidle*	0	0	0	0	0	0	1120	0	0	1120	0	0
62	*Oedogonium anomalum Hir*	560	0	0	0	0	560	0	0	0	0	0	0
63	*Ulothrix aequalis Quetzing*	0	0	0	0	0	0	0	0	0	1120	0	0
64	*Ulothrix zonata (F. Weber & D. Mohr) Kützing*	0	0	0	0	0	0	560	0	1120	0	0	0

Table 4. Phytoplankton in Thaggahalli lake. Org/lit (2010-11)

Sl.No	Genus and Species	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
1	*Achnanthes lanceolata* (Bréb.)	0	0	1120	0	0	0	1120	0	0	0	0	0
2	*Anomoeoneis brachysira (Breb.) Grun*	0	0	0	0	0	0	0	0	0	0	1120	0
3	*Caloneis permagna* (J.W.Bailey) Cleve	0	2240	0	0	0	0	0	0	0	0	0	0

4	*Caloneis silicula (Ehrenberg) Cleve*	0	0	0	0	0	0	0	0	0	1120	0	0
5	*Cymbella cymbiformis C.A. Agardh*	0	3360	0	2240	0	0	2240	2240	0	2240	2240	1680
6	*Eunotia arcus Ehrenberg*	0	0	0	0	0	0	2240	0	0	0	0	0
7	*Eunotia monodon Ehrenberg*	0	0	0	1120	0	0	0	0	0	0	0	0
8	*Fragilaria brevistriata Grunow*	0	0	0	2240	0	0	0	2240	0	1120	0	1120
9	*Fragilaria capucina Desm.*	0	0	0	2240	0	0	0	1120	0	1120	0	0
10	*Fragilaria construens f. venter (Ehr) Hustedt*	0	0	0	0	0	0	1120	0	1120	0	0	0
11	*Gomphonema gracile.Ehr*	0	2240	1120	0	0	0	0	1680	1120	2240	2240	1680
12	*Gomphonema parvulum Kützing*	3360	0	0	0	0	0	0	0	0	0	0	0
13	*Gyrosigma kuetnigii ?*	0	0	0	0	0	0	0	0	0	1120	0	0
14	*Mastogloia dolosa Venkataraman*	0	0	1120	0	0	0	0	0	0	0	0	0
15	*Mastogloia recta Hustedt*	0	0	0	0	0	0	1120	0	0	0	0	0
16	*Melosira granulata (Ehrenberg) Ralfs*	0	0	560	0	0	0	0	0	0	0	0	0
17	*Melosira juergenswii*	0	0	0	0	1120	0	0	0	0	0	0	0
18	*Navicula germainii Wallace*	1120	0	1120	0	0	0	0	0	0	0	0	0
19	*Navicula radiosa Kütz*	0	0	0	0	0	0	0	0	0	1120	0	0
20	*Navicula rhyncocephala Kutz*	1120	0	0	0	0	0	0	0	0	0	0	0

21	*Navicula sphaerophora Ehrenberg*	2240	0	1120	0	0	0	0	0	0	1120	1120	0
22	*Navicula vulpina Kutz.*	0	0	0	0	0	0	0	0	0	0	0	2240
23	*Nitzschia intermedia Hantzsch*	0	0	1120	0	0	1120	1120	0	0	0	0	0
24	*Nitzschia sublineris*	0	1120	0	0	0	0	0	0	0	0	0	0
25	*Pinnularia acrosphaeria Rabenhorst*	0	1680	0	0	0	0	0	0	0	0	0	1120
26	*Pinnularia gibba .Ehr*	2240	2240	2240	0	0	2240	2240	0	0	1120	1120	1120
27	*Rapolodia gibba,Ehr*	2240	0	1120	0	0	0	0	0	0	0	0	0
28	*Stauroneis phoenicenteron.Ehr*	0	2240	0	0	0	0	0	0	0	0	0	0
29	*Synedra acus Kützing*	0	0	0	0	0	0	2240	0	0	2240	2240	0
30	*Synedra ulna Kutzing*	0	0	0	0	0	4480	0	2240	2240	0	0	0
31	*Actinastrum hantyschi Lagerh*	0	0	3360	0	0	0	4480	0	0	0	0	2800
32	*Coelastrum cambricum Archer*	1120	0	0	0	0	0	0	0	0	0	0	0
33	*Franceia ovalis (Francé) Lemmermann*	4480	4480	0	0	0	0	0	0	0	0	0	1120
34	*Kirchneriella lunaris (Kirchner) K.Möbius*	1120	0	0	0	0	0	0	0	0	0	0	0
35	*Pediastrum obtusum Lucks*	0	1120	0	0	0	0	0	0	0	0	0	0
36	*Pediastrum simplex Meyen*	0	0	1680	0	0	0	0	0	0	0	0	0
37	*Pediastrum tetras (Ehrenberg) Ralfs*	0	0	0	0	0	0	0	1120	0	0	0	1120

38	*Scenedesmus bijugatus Kützing*	0	2240	0	0	0	0	0	0	0	0	0	0
39	*Scenedesmus dimorphus (Turpin) Kützing*	0	0	2240	0	0	0	0	0	0	0	0	0
40	*Scenedesmus incrassatus Bohlin*	2240	0	0	0	0	0	0	0	0	0	0	0
41	*Scenedesmus obliquus (Turpin) Kützing*	2240	0	2240	0	0	0	0	0	0	0	0	1120
42	*Scenedesmus orbicularis*	0	0	1120	0	0	0	0	0	0	0	0	0
43	*Scenedesmus quadricauda Turpin*	1120	2240	2800	2240	1120	0	0	2240	0	1120	0	1680
44	*Tetraedron trilobatum (Reinsch.) Hansg*	1120	0	0	0	0	0	0	0	0	0	0	0
45	*Peridynium sps*	0	0	0	0	0	0	0	0	1120	560	0	0
46	*Anabaena azollae Strasburger*	2240	2240	0	0	0	0	0	0	0	0	1120	1680
47	*Anabaena circinalis Rabenhorst*	1120	0	0	0	0	0	0	0	0	0	0	0
48	*Chroococcus limneticus Lemn*	0	1120	1120	0	0	0	0	0	0	0	0	0
49	*Gloeothece rupestris (Lyngbye) Bornet*	0	0	0	0	1120	0	0	0	0	0	0	0
50	*Gomphosphaeria oponima. Lyngbya*	1120	0	0	0	0	0	0	0	0	0	0	0
51	*Oscillatoria formosa Bory*	1120	0	0	0	0	0	0	0	0	0	0	0
52	*Oscillatoria subbrevis Schmidle*	1120	2240	0	0	0	0	0	1120	0	0	0	0
53	*Oscillatoria tenuis C.Agardh*	2240	0	0	0	0	0	0	1680	0	0	0	0
54	*Oscillatoria terebriformis C.Agardh*	1120	0	0	0	0	0	0	0	0	0	0	0

55	*Cocconeis placentula Ehrenb*	0	0	0	0	0	0	2240	0	0	2240	0	0
56	*Euglena minuta Prescott*	0	2240	2240	0	0	0	0	0	0	0	0	0
57	*Euglena oxyuris Presctt*	0	0	0	0	0	0	0	1120	0	0	0	0
58	*Lepocinclis ovum.Ehr*	1120	2240	0	0	0	1120	1120	0	0	0	0	0
59	*Phacus curvicauda Svirenko*	1120	1680	0	0	0	0	0	0	0	1120	0	1120
60	*Phacus tortuosa Roll*	0	1120	1120	0	0	0	0	0	0	0	0	0
61	*Trachelomonas volvocine Her*	0	0	1120	3360	0	0	0	0	0	0	0	0
62	*Pandorina morum (O. Muller)*	0	2240	0	0	0	0	0	0	0	0	0	0
63	*Ulothrix aequalis Quetzing*	0	0	0	0	0	0	1120	0	560	0	0	0

The highest number of species distribution was found in Arakere lake compared to Thaggahalli lake. In both the lakes phytoplankton of Bacillariophyceae was found to be high in number. *Synedra ulna, Pinnularia gibba, Navicula rhyncocephala* and *Gomphonema gracile* were recorded in both the lakes during the study period. *Gomphonema parvulum* and *Navicula viridula* were found in Thaggahalli lake during the study period, while they are found only during 2010-11 in Arakere lake, indicating organic pollution is more in Thaggahalli lake as compared to Arakere lake. The presence of more individuals of *Nitzschia gracilis, Stauroneis phoenicenteron, Navicula rhynchocephale, Synedra ulna* and *Surirella angusta* in Arakere lake reveals the fact that Anthropogenic activities are more in Arakere lake as these species are indicators of Anthropogenic pollution.

Nine species of Desmids were recorded in these lakes. They were more in number in Arakere lake than Thaggahalli lake. Storm(1929) is of the opinion that the hindrance in the growth of Desmids is due to organic contamination of water. According to Munnawar(1970) the paucity of Desmids is due to eutrophic nature of water. Seenayya(1971) has showed that highly polluted waters are deficient in Desmid population. As Desmids were altogether absent in Thaggahalli lake during 2010-11, indicating that the pollution stress is more in Thaggahalli lake. Rao(1968) has established that the Desmids with multivariate projections thrive well compared to those lacking such morphological modifications. Our studies have shown that the Desmids in the lakes of Mandya do not show any such morphological peculiarities and were lesser in number.

Scenedesmus quadricauda, Actinastrum hantyschi, Ankistrodesmus falcatus, Coelastrum cambricum were widely distributed among the chlorococcales. Cyanophycean members showed the highest density all through the winter until mid summer. Although Euglenaceae members were found in both the lakes, they were higher in number in Arakere lake and Thaggahalli during 2009-10 and 2010-11 respectively.

The chlorophycean members were abundant in both the lakes during summer. According to Kagalou *et al.* (2001) the population of chlorophyceae increase under high temperatures. Richardson et al. (2000) also showed that temperature is a major driving force for the seasonal succession of species in Lake Baikal. However during our studies we found that Chlorophycean members were abundant in winter season also. This may be due to the inflow of nutrient rich agricultural runoff from the neighbouring farmland. Similar observations were reported by Nowrouzi *et al.* (2011). The various diversity indices of two lakes over the period of two years are presented in tables 5 to 8 and radar diagrams of the diversity indices in figures 1 to 9.

Table 5. Diversity indices of Arakere Lake Apr 2009-Mar 2010

Sl No	Index	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
1	Taxa S	16	16	10	9	14	9	11	9	13	11	7	8
2	Individuals	29680	25760	14560	11200	14560	21280	16240	21280	24080	23520	10640	15120
3	Dominance	0.11	0.08	0.11	0.14	0.08	0.31	0.16	0.36	0.24	0.26	0.18	0.22
4	Shannon	2.52	2.64	2.25	2.10	2.57	1.66	2.14	1.52	1.98	1.87	1.84	1.79
5	Simpson	0.89	0.92	0.89	0.87	0.92	0.69	0.84	0.64	0.76	0.74	0.82	0.78
6	Evenness	0.78	0.87	0.94	0.90	0.93	0.58	0.78	0.51	0.56	0.59	0.90	0.75
7	Menhinick	0.09	0.10	0.08	0.09	0.12	0.06	0.09	0.06	0.08	0.07	0.07	0.07
8	Margalef	1.46	1.48	0.94	0.86	1.36	0.80	1.03	0.80	1.19	0.99	0.65	0.73
9	Equitability	0.91	0.95	0.98	0.95	0.97	0.76	0.89	0.69	0.77	0.78	0.95	0.86
10	Fisher ά	1.63	1.66	1.05	0.96	1.53	0.89	1.15	0.89	1.33	1.10	0.73	0.81
11	Berger-Park	0.23	0.17	0.15	0.20	0.15	0.53	0.34	0.58	0.47	0.48	0.32	0.37

Table 6. Diversity indices of Thaggahalli Lake Apr 2009-Mar 2010

Sl. No	Index	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
1	Taxa S	10	8	12	5	4	4	5	10	18	12	13	5
2	Individuals	10640	11200	15120	10640	5600	5040	6720	15120	26320	21840	25200	10080
3	Dominance	0.12	0.22	0.09	0.28	0.28	0.31	0.22	0.18	0.08	0.11	0.12	0.36
4	Shannon	2.22	1.82	2.42	1.41	1.33	1.27	1.56	2.03	2.75	2.36	2.36	1.30
5	Simpson	0.88	0.79	0.91	0.72	0.72	0.69	0.78	0.82	0.92	0.89	0.88	0.64
6	Evenness	0.92	0.77	0.94	0.82	0.95	0.89	0.95	0.76	0.87	0.89	0.81	0.74
7	Menhinick	0.10	0.08	0.10	0.05	0.05	0.06	0.06	0.08	0.11	0.08	0.08	0.05
8	Margalef	0.97	0.75	1.14	0.43	0.35	0.35	0.45	0.94	1.67	1.10	1.18	0.43
9	Equitability	0.96	0.87	0.98	0.88	0.96	0.92	0.97	0.88	0.95	0.95	0.92	0.81
10	Fisher ά	1.09	0.84	1.28	0.50	0.42	0.43	0.53	1.04	1.89	1.23	1.32	0.51
11	Berger-Park	0.21	0.40	0.15	0.42	0.40	0.44	0.33	0.37	0.17	0.18	0.22	0.56

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Table 7. Diversity indices of Arakere Lake Apr 2010-Mar 2011

Sl. No	Index	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
1	Taxa S	16	4	10	19	4	11	10	8	13	12	11	18
2	Individuals	18480	7840	15120	24640	7840	24640	16240	19040	28000	21280	21840	37520
3	Dominance	0.08	0.26	0.13	0.08	0.31	0.12	0.12	0.13	0.10	0.10	0.10	0.08
4	Shannon	2.64	1.38	2.17	2.75	1.28	2.21	2.18	2.04	2.44	2.38	2.34	2.69
5	Simpson	0.92	0.74	0.87	0.92	0.69	0.88	0.88	0.87	0.90	0.90	0.90	0.92
6	Evenness	0.88	0.99	0.87	0.83	0.90	0.83	0.89	0.96	0.88	0.90	0.95	0.82
7	Menhinick	0.12	0.05	0.08	0.12	0.05	0.07	0.08	0.06	0.08	0.08	0.07	0.09
8	Margalef	1.53	0.33	0.94	1.78	0.33	0.99	0.93	0.71	1.17	1.10	1.00	1.61
9	Equitability	0.95	0.99	0.94	0.93	0.92	0.92	0.95	0.98	0.95	0.96	0.98	0.93
10	Fisher ά	1.72	0.41	1.04	2.02	0.41	1.10	1.04	0.79	1.30	1.23	1.11	1.81
11	Berger-Park	0.12	0.29	0.19	0.14	0.43	0.18	0.21	0.18	0.16	0.16	0.15	0.12

Table 8. Diversity indices of Thaggahalli Lake Apr 2010-Mar 2011

Sl. No	Index	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
1	Taxa S	23	19	21	6	3	5	13	11	7	16	7	13
2	Individuals	40320	40320	31920	13440	3360	10080	23520	19040	8400	21840	11200	19600
3	Dominance	0.05	0.06	0.06	0.18	0.33	0.28	0.10	0.10	0.16	0.07	0.16	0.09
4	Shannon	3.03	2.88	2.95	1.75	1.10	1.43	2.45	2.35	1.88	2.70	1.89	2.51
5	Simpson	0.95	0.94	0.94	0.82	0.67	0.72	0.90	0.90	0.84	0.93	0.84	0.91
6	Evenness	0.90	0.94	0.91	0.96	1.00	0.83	0.89	0.10	0.93	0.93	0.94	0.95
7	Menhinick	0.11	0.09	0.12	0.05	0.05	0.05	0.08	0.08	0.08	0.11	0.07	0.09
8	Margalef	2.08	1.70	1.93	0.53	0.25	0.43	1.19	1.02	0.66	1.50	0.64	1.21
9	Equitability	0.97	0.98	0.97	0.98	1.00	0.89	0.96	0.98	0.96	0.98	0.97	0.98
10	Fisher ά	2.36	1.91	2.19	0.60	0.32	0.51	1.33	1.13	0.75	1.69	0.73	1.36
11	Berger-Park	0.11	0.11	0.11	0.25	0.33	0.44	0.19	0.12	0.27	0.10	0.20	0.14

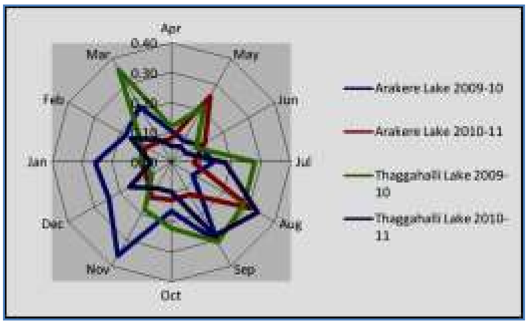

Fig.1: Dominance Index

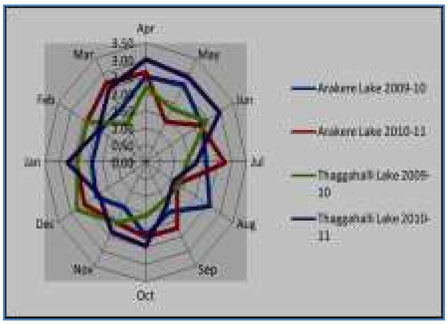

Fig.2: Shannon Weiner Index

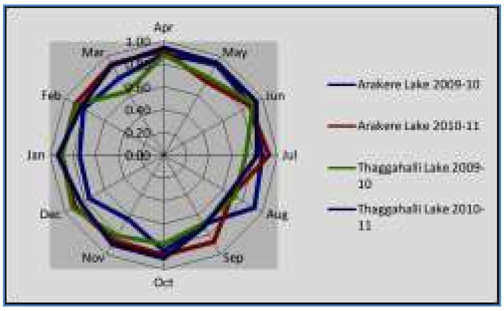

Fig.3: Simpson's Index

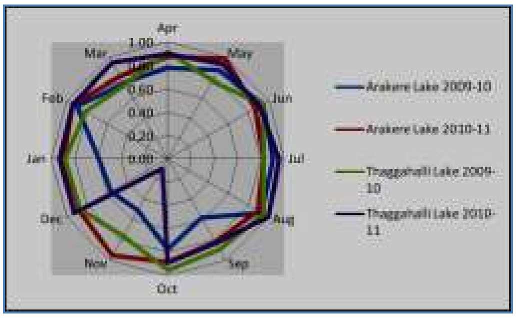

Fig.4: Pielou's Index

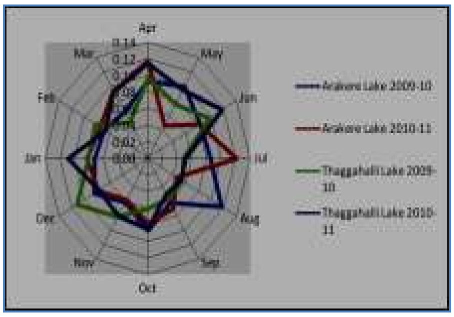

Fig.5: Menhinick's Index

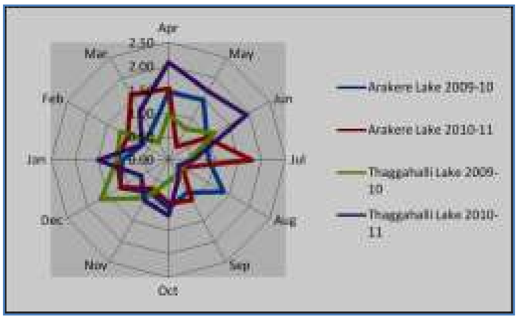

Fig.6: Margalef's Index

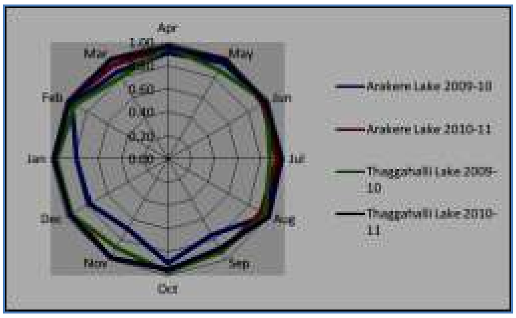

Fig.7: Shannon Equitability Index

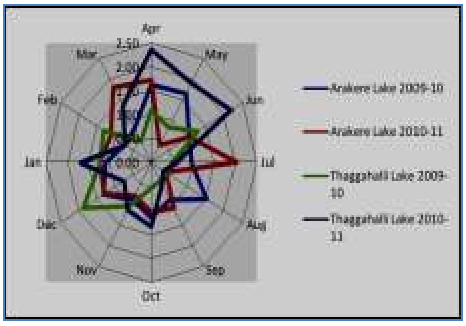

Fig.8: Fisher's ά-Index

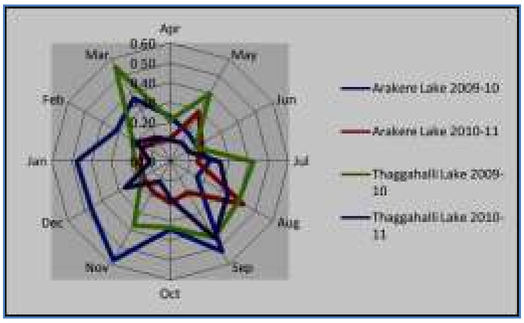

Fig.9: Parker Dominance Index

The Dominance index in the present study indicates that both Arakere and Thaggahalli lakes showed highest dominance of species in winter and rainy season during 2009-10.The Dominance index ranged between 0.08 to 0.36. During 2010-11, the dominance index was high in summer and rainy season in Arakere lake (0.26 to 0.31). In Thaggahalli lake it was high during winter and rainy season (0.16 to 0.33). Thaggahalli lake showed highest dominance as compared to Arakere lake during the study period.

Simpson's index is used to quantify the biodiversity of habitats. It takes in to account the number of species present as well as the abundance of species. The greater the value, greater is the sample diversity. The index represents the probability that two individuals randomly selected from the sample belong to different species. According to the Simpson's index, species are not evenly distributed. The index ranged between 0.64 to 0.92 during 2009-10 and 0.67 to 0.95 during 2010-11. Simpson's index showed highest value in Arakere and Thaggahalli lakes during 2009-10 and 2010-11 respectively. This may probably due to disturbances such as inflow of canal water etc.

Pielou's evenness index(E) (1975) states that species evenness is a diversity index, a measure of diversity that quantifies how equal the community is numerically. The index E is a constraint between 0 and 1. Frequent variation in communities between the species, the higher the value of E. This value is however, incorporated in the Shannon and Weaver index and needs no separate discussion.

Shannon and Weiner index(1949) represents entropy. It is a diversity index that take in to account the number of individuals as well as the number of taxa. It varies from zero for communities with only a single taxon to high values for community with many taxa, each with few individuals. This index can also determine the polluted status of a water body. Normal values range from 0 to 4. This index is a combination of species present and the evenness of species. Examining the diversity in the range of polluted and un polluted ecosystems, Wilham and Dorri's(1968) concluded that the values of the index greater than 3 indicate clean water, values in the range of 1 to 3 are characterized by moderate pollution and values less than 1 are characterized as heavily polluted. According to this index the water of both the lakes are grouped as moderately polluted.

Both Menhinick's and Margalef's indices measure species richness in an ecosystem. Menhinick's index values are found to be almost similar in both the lakes while Margalef's index showed higher values in Thaggahalli lake during 2010-11 indicating its species richness.

Shannon equitability index is a measure of evenness with which individuals are divided among the taxa present. Equitability takes a value between 0 and 1, with one being complete evenness. The index when applied to the present study indicates that individuals of the community in both the lakes are not evenly distributed with values ranging from 0.69 to 1. The evenness was attained in Thaggahalli lake during August 2010 only.

Fisher's ά- index(1943) is a mathematical calculation for determining diversity within a population. It represented the first attempt to describe mathematically the relationship between the number of species and the number of individuals of those species used extensively in entomological studies. The index ranged between 0.32 to 2.36. The lowest as well as highest values were recorded in Thaggahalli lake during the year 2010.

Berger-Parker dominance index (1970) is the number of individuals in the dominant taxon divided by number of individuals(n). it is the largest species proportion of all species in a community. This index is most strongly influenced by evenness of the indices (Shannon and Weiner, 1949). Its reciprocal value is an index of diversity. In the present study it indicates that individuals of the community in both lakes are not evenly distributed. The values ranged between 0.10 to 0.58 during the study period.

Various diversity measures have potential applications in aquatic ecosystems, mainly in conservation. It is often understood that species rich communities are better than species poor communities. Secondly in environmental monitoring it is assumed that the adverse effects of pollution will be reflected in the reduction of diversity or change in the composition of species abundance. Both these factors involve diversity as an index of good ecosystem. Rosenberg (1976) and Patrick(1973) are of the opinion that enriched or polluted ecosystems display a reduction in diversity. Shannon and Weiner index is widely accepted in pollution monitoring. Plat *et al.,* (1984) used the Simpson's index in bio monitoring. Stoermer (1984) discussed the role of phytoplankton species and assemblage as bioindicators. Simple species richness and and dominance measure are invariably informative. There is considerable evidence that conservation strategies may be improved if information on species abundance patterns is taken in to account. Maguran(1983) comments that ecologists should be able to ask the question and formulate the hypothesis to help them understand and sensitively manage the natural ecosystem. According to diversity indices both the lakes were moderate regarding the quality of water.

CONCLUSION

Shannon and Weiner diversity index has showed that both Arakere and Thaggahalli lakes as moderately polluted. The index values recorded between 1.27 to 3.03 were not uniform throughout the year. The lower in diversity may be due to competition for nutrients within an uniform environment. The increased diversity during some seasons may be due to richness of nutrients of the water. This study also revealed that the species were not evenly distributed in both lakes. This has indicated that though the the two lakes are geographically separated, the influencing factors on planktonic dynamics are similar in nature in both the lakes. However the presence of more desmids in Arakere lake and their absence in Thaggahalli lake indicated that organic contamination is more in Thaggahalli lake as compared to Arakere lake.

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