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Algal Diversity in a Group of Fifteen Small Lakes of T. Narasipur Taluk, Mysore District, Karnataka State

S. Umamaheshwari
Department of Microbiology, S. B. R. R. Mahajana First Grade College, Jayalakshmipuram, Mysore-570 012, Karnataka

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ABSTRACT

Phytoplankton distribution was investigated in 15 small lakes of T. Narasipur taluk in Mysore district of Karnataka. The data were subjected to PAST software program. Bray-Curtis Similarity Index was also calculated. Nine diversity indices were obtained that include Dominance index, Shannon and Weiner index, Simpson's index, Pielou's Evenness index, Menhinick and Margalef's index, Equitability index, Fisher α index and Berger-Parker dominance index. Sixty two species of algae were recorded of which Chlorococcales and Euglenophyceae members dominated. Species richness was observed in Harave Katte and Baw Kere, and species dominance in Holan Kere and Halgudu Kere. Diversity and Similarity indices are important in understanding the distribution and association of planktonic algae in freshwater lakes.

INTRODUCTION

Lakes are important resource of water for various purposes. However, escalating urbanization, development and agricultural activities have brought irreversible changes and caused loss of genetic biodiversity. The diversity in man-made ecosystems is often low compared with those of natural systems. Study of biodiversity is of immense importance since quality of an ecosystem is dependent on biological diversity. (Cairns & Dickson 1971). Phytoplankton forms a major vital link as primary producers in aquatic systems. Its type and density assess the quality of lakes. The diversity in a community is composed mainly of 2 components, i.e., species richness and evenness of suitability of a given species by their relative abundance, both denoting single term heterogenicity (Lloyd & Gheraldi 1964). These components are mainly dependent on the physico-chemical characteristics of the lakes (Kalff & Knoechel 1978).

In India algal diversity of freshwaters has been studied by Kartha & Rao (1992), Pandey (1993), Veereshkumar & Hosmani (2006), Tiwari & Shukla (2007), Senthilkumar & Das (2008). There are yet a large number of aquatic systems that have to be explored. An attempt has been made to study the diverse groups of algal species in 15 lakes of T. Narasipur taluk.

MATERIALS AND METHODS

T. Narasipur is a Panchayat town and second taluk headquarters in south-east of Mysore district at an elevation of 638 m at 12°12'36" N and 76°54' 22" E. Major rivers that pass through the taluk are Kaveri and Kapila. The lakes studied varied in size from 1 to 150 acres and depth from 5-40 ft. The lakes studied are Haravekatte-Kempayanahundi, Indvalukatte-Indvalu, Chikkalikere-Chowalli, Nilsogekere-Nilsoge, Hosakatte-Nilsoge, Holankere-Hiriyur, Mogekere-Hiriyur, Dodkere-Madapura, Dodnundikere-Dodnundi, Harankatte-Thotwadi, Bawkere-Muguru, Banhallihundikere-Banhallihundi, Halgudukere-Halgudu, Kattemane-SKP Agrahara, Kaggalipurakere-Kaggalipura. Of all Halgudukere is the biggest while Kattemane, Hosakatte measured least in area.

Surface water samples were collected from 15 different lakes during summer months. The samples were collected in air tight plastic containers. Around 20mL of 4% formaldehyde was added (Welch 1948) and allowed to sediment. The sediments were finally reduced to 25mL and preserved. From each sample one mL was mounted and algal diversity was estimated using standard method (Rao 1955). Plankton count was done by Lackey's drop method (1938), modified by Suxena (1987). The average counts of algae were expressed as organisms per mL for the purpose of calculating diversity indices. The monographs consulted for identification of algae were of Desikachary (1959), Prescott (1982), and Scott & Prescott (1961).

A total of 62 algal species belonging to Chlorococcales, Desmidaceae, Bacillariophyceae, Euglenophyceae and Cyanophyceae were recorded. The data were subjected to a software program PAST (Hammer et al. 2001) which generates nine diversity indices. The Bray-Curtis similarity index was also developed to understand similar and dissimilar lakes.

The formula designed for various indices are described below.

Dominance Index = 1-J, J is evenness of relative diversity (H'/Hmax) where absolute evenness = 1.00. Shannon Weiner Index (H') assumes all species are represented, sample randomized = $-\Sigma$pi ln pi, where pi = proportion of the i[th] species and ln is natural logarithm. The Simpson's Diversity Index (D) (1949) is calculated as Ds = Σ(ni (ni-1/N (n-1) where Ds = Bias corrected from Simpson index, n1 is number of individuals of species 1, N = total number of species in community. As diversity increases index value gets smaller. Pielou's evenness index (1975) measures equitability and compares the observed Shannon-Weiner Index against the distribution of individuals between the observed species that would maximize diversity. The index is expressed as J = H'/log (S). If H is the observed Shannon-Weiner Index, the maximum value this would take is log(S), where S is the total number of species in the habitat. Menhinick's index (Dmm) (Whittaker, 1977) is expressed as Dmm = S/N, where N is the number of individuals in the sample and S the species number. Margalef's Index (1968) is expressed as D = (S-1)/In N. It is calculated as the species number (S) minus 1 divided by the logarithm of the total number of individuals (N). The Shannon's equitability Index (EH) = H/Hmax = H/In S (Lloyd & Ghelard 1964). Equitability assumes a value between 0 and 1 with the value of 1 being complete evenness. The Fisher α index is a parametric index of diversity, which assumes that the abundance of species follows the log distribution, and is expressed as ax, ax2/2, ax3/3....axn/n. The Berger-Parker Dominance Index is a simple measure of the numerical importance of the most abundant species and is expressed as d = N max/N, N max is the number of individuals in the most abundant species and N is the total number of individuals in the sample. A reciprocal of the Index 1/d is often used so that increase in the value of the index accompanies an increase in diversity and a reduction in dominance (Hosmani 2010).

The Bray Curtis similarity index lies between 0 and 1, where 0 specifies two sites have same composition, i.e. they share all the species, and 1 specifies two sites do not share any of the species. It is equivalent to total number of species that are unique to any one of two sites divided by total number of species over the two sites (Bray Curtis 1957). In analysis, high similarity clusters become more distinct, low similarity approach 0 and intermediate become obscure. The data are expressed in Dendrogram, and 'fixed stopping rule' is employed to read Dendrogram, i.e., 85%. If cluster linkage is greater than the level it is important or else it is ignored.

RESULTS AND DISCUSSION

A variety of objective measures have been created in order to empirically measure phytoplankton diversity. Each measure of diversity relates to a particular use of the data. The observations of distribution of algal species in 15 lakes are presented in Table 1, the calculated diversity indices in Table 2 and Bray Curtis similarity index as dendrogram is represented in Fig. 1. Of the total 62 algal species recorded, 18 were Chlorococcales, 15 Euglenaceae, 13 Bacillariophyceae, 11 Cyanophyceae, and 5 Desmidaceae. Filamentous forms were omitted.

The highest numbers of taxa were observed in Harave Katte (19) followed by Baw Kere (17), and least in Holan Kere and Dodnundi Kere (3). Species richness, i.e., the maximum number was found in Harave Katte (46), Baw Kere (38), and minimum in Dodnundi Kere (6).

The dominance index in the present study indicates that Holan Kere (0.44), followed by Banallihundi Kere (0.34), Dodnundi Kere (0.33) and Moge Kere (0.30) have highest dominance index of planktonic species, and Harave Katte (0.06) showed the least.

Shannon and Weiner diversity index (1949) represents diversity index, i.e., number of individuals and number of taxa varying theoretically from 0 to infinity. The index also determines the pollution status of water body. Wilham & Dorris (1968) after examining diversity in the range of polluted and nonpolluted ecosystems concluded that the values of H (number of species present and evenness into a single index) greater than 3 indicated clean water, values in the range of 1-3 characterized moderate pollution and values less than 1 characterized heavily polluted condition. Applying this index in the present study, it was found that all the 15 lakes range from 1-3 showing moderate pollution. The highest being Harave Katte and Baw Kere, and least being Holan Kere.

The Simpson's Index (1949) quantifies the biodiversity of habitat taking into account number of species present as well as abundance of species. Greater the value greater is the diversity. The index represents the probability that two individuals randomly selected from a sample will belong to different species. As per this index in the study, the greatest diversity was observed in Harave Katte and Baw Kere, and least in Holan Kere, Dodnundi Kere and Bannalihundi Kere.

Pielou's Evenness index (1975) states that species evenness is diversity index, a measure of diversity, which quantifies how equal the community is numerically. The index E is contradict between 0 and 1. Lesser the variation in community between the species higher is E. Higher value is recorded in Dodnundi Kere (Table 2). Menhinick's (1977) and Margalef's (1968) indices indicate species richness. Equitability index is a measure of the evenness with which individuals are divided among the taxa. The value lies between 0 and 1, 1 representing complete evenness. For a given richness (total number of species in a community, S), Simpson's diversity index increases as richness increases. The data show Dodnundi Kere has maximum evenness of 1 and others were near to the evenness, i.e., species evenness is not well marked in the lakes.

Fisher's index (1943), a mathematical calculation determines the diversity within a population. The index here mathematically relates number of species and number of individuals. The data indicate Holan Kere (1.4) is very low and Harave Katte (12.12) shows abundance of species.

The Berger-Parker index (1970) is number of individuals in the dominant taxon divided by number of individuals (n). The index is influenced by evenness of the indices (Shannon & Weiner 1949). As per the study Harave Katte (0.08) has least and Holan Kere (0.6) has highest index.

As per Bray-Curtis similarity distribution of phytoplankton, the fixed stopping rule was determined at 85%. Close association was observed between *Spirulina platensis* and *Scenedesmus quadricauda* at 85%. Higher association of about 90% was observed between *Microcystis aeruginosa* and *Navicula rhynchocephala* var. *tenua*. Very close association was that of *Pinnularia acroshaeria*, *Surirella angusta*, *Coeloshaerium dubium, Euglena playfairiana, Euglena polymorpha, Phacus pseudoswirenkoi*, *Trachelomonas armata* and *Trachelomonas hexangulata*. Next, there were four forms, which coexisted, *Closterium porrectum, Ankistrodesmus falcatus, Scenedesmus indicus* and *Scenedesmus opoliensis.* Other forms in association were *Spirulina compact, Staurastrum dentatum, Kircheneriella lunaris* and *Pediastrum duplex*; *Tetradron limneticum, Arthrospira jenneri* and *Scenedesmus armatus,* and *Pinnularia gibba, Coelastrum cambricum* and *Trachelomonas bolconi* are the other 3 that coexisted together. Rest occurred in pairs as per similarity data; they were *Selenastrum westii* and *Euglena minuta; Closterium setaceum* and *Pediastrum tetras;* and *Cosmarium crassanguatum* and *Cosmarium margariratum.* Similar association were reported by Hosmani (2010).

Diversity measures are more useful in lake ecosystems, which harbour large variety of algal species in general, and species diversity within genera. The diversity and composition of plankton in aquatic ecosystems serve as a reliable index for biomonitoring of pollution load (Venkateshwarlu 1981). Species diversity indices when correlated with physico-chemical properties provide one of the best ways to detect and evaluate the impact of pollution on aquatic communities (Margalef 1968). Certain groups of phytoplankton, especially blue green alga can degrade recreational value of surface waters and in higher densities can cause deoxygenation of water (Whitton & Patts 2000). The analysis showed that some sites are rich in Euglenaceae only indicating high

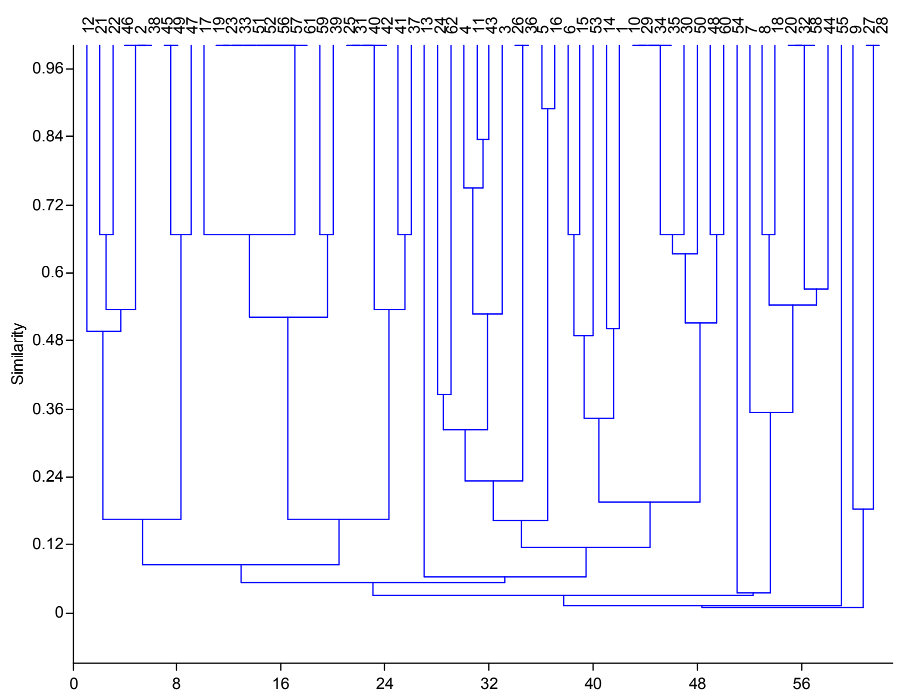

Fig. 1: Bray Curtis Similarity Index for lakes of T. Narasipur taluk.
No. 1-62 indicate planktonic species as in Table 1. Fixed stopping rule applied at 85% and above.

Table 1: Diversity of plankton in lakes of T. Narasipur taluk (orgs./mL).

No.	Phytoplankton	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
	Total species	19	6	10	7	9	3	4	10	3	9	17	6	4	7	9
	Total individuals	46	16	22	12	23	10	11	26	6	31	38	32	8	22	19
	Cyanophyceae															
1	*Anabaena spiroides*	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
2	*Arthrospira jenneri*	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
3	*Chrococcus limneticus*	2	0	0	0	0	0	0	2	0	0	0	4	4	0	4
4	*Merismopedia tenuissma*	4	0	0	0	0	0	0	0	0	0	0	2	0	4	2
5	*Microcystis aeruginosa*	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0
6	*Nostoc muscorum*	2	2	0	2	0	0	0	2	0	0	0	0	0	0	0
7	*Oscillatoria subbrevis*	0	0	0	0	0	0	2	0	0	10	0	0	0	0	0
8	*Phormidium fragile*	0	0	0	0	4	0	0	0	0	4	0	0	0	0	0
9	*Raphidopsis meditariana*	0	0	0	0	0	0	0	0	0	0	0	0	2	8	0
10	*Spirulina compact*	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	*Spirulina platensis*	4	0	2	0	0	0	0	0	0	0	0	4	0	2	2
	Bacillariophceae															
12	*Gomphonema parvulum*	0	0	0	0	0	2	0	2	0	0	2	0	0	0	0
13	*Gyrosigma hippocampus*	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
14	*Navicula germainii*	0	4	0	0	0	0	0	0	0	2	0	0	0	0	0
15	*Navicula rhomboides*	2	2	0	1	0	0	0	0	2	0	0	0	0	0	0
16	*Navicula rhynchocephala* Var. *tenua*	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0
17	*Navicula viridula*	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0
18	*Navicula viridis*	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0
19	*Pinnularia acrosphaeria*	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
20	*Pinnularia gibba*	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
21	*Scellaphora pupula*	0	0	0	0	3	0	0	2	0	0	2	0	0	0	1
22	*Stauroneis phoenicenteron*	0	0	0	0	2	0	0	2	0	0	0	0	0	0	0
23	*Surirella angusta*	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
24	*Synedra ulna*	4	2	2	2	4	6	4	0	0	0	4	0	0	2	2
	Desmidaceae															
25	*Closterium porrectum*	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
26	*Closterium setaceum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
27	*Cosmarium crassangulatum*	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
28	*Cosmarium margariratum*	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
29	*Staurastrum dentatum*	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Chlorococcales															
30	*Actinastrum hantzshi*	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	*Ankistrodesmus falcatus*	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
32	*Coelastrum cambricum*	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
33	*Coeloshaerium dubium*	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
34	*Kircheneriella lunaris*	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35	*Pediastrum duplex*	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36	*Pediastrum tetras*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
37	*Scenedesmus arcuatus*	0	0	2	0	0	0	0	0	0	0	2	0	0	0	0
38	*Scenedesmus armatus*	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
39	*Scenedesmus dimorphus*	2	0	0	0	0	0	0	0	0	0	2	0	0	0	0
40	*Scenedesmus indicus*	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
41	*Scenedesmus oblicus*	0	0	2	0	0	0	0	2	0	0	2	0	0	2	0
42	*Scenedesmus opoliensis*	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
43	*Scenedesmus quadricauda*	4	0	0	0	0	0	0	0	0	0	0	4	0	0	2
44	*Scenedsmus bijuga*	0	0	2	0	0	0	0	0	0	3	0	0	0	0	0
45	*Selenastrum westii*	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
46	*Tetradron limneticum Borge*	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
47	*Tetradron tribolatum*	0	0	0	0	2	0	0	0	0	0	0	0	0	2	0
	Euglenaceae															
48	*Euglena elastica*	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
49	*Euglena minuta*	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0

Table cont...

...Cont. Table

50	*Euglena oxyuris*	2	0	0	0	2	0	0	0	0	0	0	0	0	0	0
51	*Euglena playfairiana*	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
52	*Euglena polymorpha*	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
53	*Lepocinclis ovum*	2	4	4	2	0	0	1	0	0	0	2	0	0	0	0
54	*Phacus anacoelus Stockes*	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0
55	*Phacus caudatus*	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
56	*Phacus pacudoswirenkoi*	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
57	*Trachelomonas armata*	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
58	*Trachelomonas bolconi*	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
59	*Trachelomonas charkowensis*	2	0	0	2	0	0	0	0	0	2	2	0	0	0	0
60	*Trachelomonas giradina*	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
61	*Trachelomonas hexangulata*	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
62	*Trachelomonas volvocin*	2	0	0	0	2	2	0	8	2	0	0	0	0	2	2

A-Haravekatte; B-Indvalukatte; C-Chikkalikere; D-Nilsogekere; E-Hosakatte; F-Holankere; G-Mogekere; H-Dodkere; I-Dodnundikere; J-Harankatte; K-Bawkere; L-Banhallihundikere; M-Halgudukere; N-Kattemane; O-Kaggalipurakere.

Table 2: Diversity indices of planktonic algae in lakes of T. Narasipur taluk. Data generated by PAST Programme (Hammer et al. 2001).

N	Lakes	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
	Total species	19	6	10	7	9	3	4	10	3	9	17	6	4	7	9
	Total individuals	46	16	22	12	23	10	11	26	6	31	38	32	8	22	19
1	Dominanceindex (Bellan Santini) (1969)	0.06	0.19	0.11	0.15	0.12	0.44	0.31	0.15	0.33	0.17	0.064	0.21	0.34	0.21	0.12
2	Shannon index(1949)	2.86	1.73	2.27	1.9	2.15	0.95	1.26	2.14	1.1	2	2.8	1.66	1.21	1.77	2.14
3	Simpson's Index (1949)	0.94	0.81	0.89	0.85	0.88	0.56	0.69	0.85	0.67	0.83	0.94	0.79	0.66	0.79	0.88
4	Pielou's Index (1975)	0.92	0.94	0.97	0.96	0.95	0.86	0.88	0.85	1	0.82	0.97	0.88	0.84	0.84	0.95
5	Menhinick's Index (1977)	2.8	1.5	2.13	2.02	1.88	0.95	1.21	1.96	1.23	1.62	2.76	1.06	1.41	1.49	2.07
6	Margalef's Index (1968)	4.7	1.8	2.91	2.42	2.55	0.87	1.25	2.76	1.12	2.33	4.4	1.44	1.44	1.94	2.72
7	Shannon's Equitability Index (1949)	0.97	0.97	0.99	0.98	0.98	0.87	0.91	0.93	1	0.91	0.99	0.93	0.88	0.91	0.97
8	Fisher's alpha Index (1943)	12.12	3.49	7.08	7.03	5.44	1.45	2.26	5.95	2.39	4.26	11.81	2.18	3.18	3.54	6.69
9	Berger-Parker Index (1970)	0.09	0.25	0.18	0.17	0.17	0.6	0.36	0.31	0.33	0.32	0.11	0.31	0.5	0.36	0.21

A-Haravekatte; B-Indvalukatte; C-Chikkalikere; D-Nilsogekere; E-Hosakatte; F- Holankere; G-Mogekere; H-Dodkere; I-Dodnundikere; J-Harankatte; K-Bawkere; L-Banhallihundikere; M-Halgudukere; N-Kattemane; O-Kaggalipurakere.

organic pollution; while many sites showed dominance of Chlorococcales and Bacillariophyceae. Diversity indices are important in understanding the distribution of planktonic algae in developing conservation strategies for polluted lakes.

CONCLUSION

Lakes are affected by several sources and misused as public toilets leading to unhygienic environment there by increasing organic load. Apart from dumping garbage, entry of sewage has affected water quality. The study here indicates diversity and density richness in Harave Katte and at the same Holan Kere having been highly polluted. Baw Kere shows bloom of *Microcystis aeruginosa* and Kattemane with presence of *Raphidiopsis meditariana* causing fish kill in lakes (Hosmani & Lingannaiah 2002). Baw Kere representing maximum Euglenaceae members indicates organic pollution.

Even today in the area, people rely on lakes for most of their activities. In an unscientific carelessness towards the environment scarcity as well as quality of potable water is affecting human health. The diversity of phytoplankton in freshwaters lakes provides us with information of the status of the water bodies and, therefore, helps in developing conservation strategies.

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