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Correlation of plankton diversity and density with physico-chemical parameters in Ghuma lake, rural area of Ahmedabad

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ABSTRACT

The present study was carried out on Ghuma lake of Ghuma village. Ghuma village is situated in Daskroi taluka of Ahmadabad district, Gujarat State. The plankton were collected, counted and were identified by using the method suggested by APHA (1995), Prescott (1970), Freshwater Zooplankton of India (Battish, 1992) and Fresh Water Biology (Edmondson, 1959). The plankton was counted by using Sedgwick Rafter Counting Cell method. Different classes such as cyanophyceae, chlorophyceae, bacillariophyceae, euglenophyceae, cilliata, cledocera, copepod and specimens from phylum rotifera were identified during the study. Among all these classes the listed phytoplankton such as Oscillatoria sp., Tetraedron sp., Navicula sp., Nitzschia sp, Euglena sp. and zooplankton such as Ceriodaphnia sp., Cyclops sp., Tropocyclops sp., Brachionus sp. and Platyias sp. were recorded as a dominant genera in Ghuma Lake. The study was carried out monthly but was tabulated seasonally by using statistical method. From the listed data the quality of water was concluded.

KEYWORDS: Ghuma Lake, Phytoplankton and Zooplankton, Correlation

INTRODUCTION:

Ahmedabad is the largest city of the Gujarat state and is the 7th largest city of India. Today the city becomes the commercial capital of the Gujarat state. It has its own indefinable charm, combining many traditional elements and the latest international blend. The present city is divided by the river Sabarmati into two parts, eastern and western Ahmedabad. The Ghuma Lake of Ghuma village is located in the outskirts of the western part of Ahmedabad city. The Ghuma Lake is a natural lake and is located on the western part of Ghuma village. The sewage waste of Ghuma village is directly discharge into this Lake. The People of village also use this Lake to wash their cloths, take bath, sanitation, etc. The cattle of the villagers also take bath in this Lake. The Lake covers an area of 84479 m^2. Peripheral area of the lake is 466.22 m. and depth is 21 feet. Its exact geographical location is **23⁰ 01′ 57.32″ N** Latitude and **72⁰ 26′ 56.15″ E** Longitude, and 140 feet above sea level.

MATERIALS AND METHODS:

The standard method suggested in APHA used for assessing water quality includes collection and Battish, (1992), Edmondson, (1959), Prescott (1970), Trivedy, (1993) and Subrahmanyam and Sambamurty (2004) for counting and identification of phytoplankton and zooplankton. Plankton were counted by using Sedgwick Rafter counting cell. Plankton net number 25 of mesh size 20 µm was used for collecting samples. 50 liters of water was measured in a graduated bucket and filtered through the net and concentrated in a 100 ml bottle. Samples were collected as close to the water surface as possible in the morning hours. The samples were labeled with the date, time, and study area i.e. name of Lake and the volume measured and pasted on the containers. Plankton is preserved by using 4% formalin. The sample was allowed to settle for 24-48 hours and was further concentrated to approximately 30 ml by decanting. Sedgwick Rafter counting cell is used to count the plankton. Sedgwick Rafter cell is approximately 50 mm long, 20 mm wide and 1 mm deep. The total volume of the cell is 1 ml. A trinocular compound microscope is used to count the plankton with different eyepieces such as 10X and 40X. The microscope is calibrated using an ocular micrometer. Formula to convert unit/ml of plankton into unit/liter is

$$n = \frac{(a \times 1000)\, c}{l}$$

Where,

n = Number of plankton / liter of water.
a = Average no. of plankton in one small counting chamber of S-R cell.
c = ml of plankton concentrate.
l = Volume of original water filtered in liter.

The graphic method indicates the existence of a correlation. But it is not possible to calculate the extent or degree of relationship using these graphs. To find out correlation between two variables is calculated by following formula of Karl Pearson's.

$$r = \frac{\sum (dx \,.\, dy)}{\sqrt{\sum (dx)^2 \,.\, \sum (dy)^2}}$$

Where,

r is the correlation coefficient,

x and y are the two variable

dx is the deviation from the x-mean of the x variable,

dy is the deviation from the y mean of the y variable,

Σ (dx . dy) is the sum of the products of the deviations,

Σ (dx)2 is the sum of the squares of the deviations of the x variable,

Σ (dy)2 is the sum of the squares of the deviations of the y variable,

The degree or the intensity of relationship between two variables was ascertained by computing the value of coefficient of correlation. Karl Pearson's has given a formula for measuring correlation. The result of this formula varies between +1 and –1. The following chart shows degrees of correlation according to Karl Pearson's formula, which is used time to time in different chapters.

Degree of correlation	Positive	Negative
Perfect correlation	+1	-1
Very high degree of correlation	+0.9 or more	-0.9 or more
Fairly high degree of Correlation	From +0.75 to +0.9	From -0.75 to -0.9
Moderate degree of correlation	From +0.50 to +0.75	From -0.50 to -0.75
Low degree of correlation	From +0.25 to +0.50	From -0.25 to -0.50
Very low degree of correlation	Less than +0.25	Less than -0.25
Absence of correlation	0	0

Ref.: D. C. Sancheti and V. K. Kapoor, (1998): Statistic (Theory, methods and Applications), Sultan Chand & Sons.

RESULTS AND DISCUSSION:

Plankton has long been used as indicator of water quality. Because of their short life spans, plankton responds quickly to environmental changes. They flourish both in highly eutrophic waters while a few others are very sensitive to organic and/or chemical wastes. Some species have also been associated with noxious blooms sometimes creating offensive tastes and odours or toxic conditions. Because of their short life cycles plankton responds quickly to environmental changes, and hence the standing crop and species composition indicate the quality of the water mass in which they are found.

In the present study 4 different genera of cyanophyceae class were recorded from the Lake. The blue green algae recorded in Ghuma lake are *Merismopedia* sp., *Nostoc* sp., *Oscillatoria* sp., and *Spirulina* sp. the minimum algal units were recorded during summer season where as maximu was recorded during winter season.

In Ghuma Lake 7 different genera of chlorophyceae class were recorded. In Ghuma Lake the algae recorded are *Closterium* sp., *Closteriopsis* sp., *Coelastrum* sp., *Mugeotia* sp., *Spirogyra* sp., *Tetraedron* sp., *Scendesmus* sp., the minimum value was recorded during summer season whereas maximum was recorded during monsoon season.

From the Ghuma Lake 7 different genera of bacillariophycea were recorded. In Ghuma Lake the diatom for bacillariophycea class recorded are *Cyclotella* sp., *Cymbella* sp., *Gomphonema* sp., *Gyrosigma* sp., *Navicula* sp., *and Nitzschia* sp.. The minimum units of diatom were recorded during winter season whereas maximum unit of diatoms were recorded during summer season.

In the Lake 2 genera of euglenoids were recorded. The euglenoid recorded in the lake are *Euglena* sp. and *Phacus* sp. In Ghuma Lake the minimum units of euglenoids were recorded during summer season and maximum unit of euglenoids were recorded during summer season.

In Ghuma lake 2 genera of class ciliata were recorded. The ciliate recorded in the lake are *Pleuronema* sp. and *Strombidium* sp. and 2 genera of cladocera are Alona sp. and Ceriodaphnia sp. In Ghuma lake 5 genera of copepod, *Cyclops* sp., *Diacyclops* sp., *Diaptomus* sp., *Eucyclops* sp., and *Tropocyclops* sp. were recorded. The minimum numbers of copepods were recorded during summer season whereas maximum unit of copepods were recorded during winter season.

In the lake 2 genera of phylum rotifer *Brachionus* sp. and *Platyas* sp. were recorded. The minimum numbers of rotifer were recorded during summer season whereas maximum unit of rotifer were recorded during monsoon season. (Table No. 1 and 2. Fig. 1 and 2)

During study period *Cymbella* sp. shows moderately positive correlation while *Alona* sp. (r = -0.648), *Ceriodaphnia* sp., *Tropocyclops* sp. and *Platyias* sp. shows negative correlation with teperature. *Euglena* sp. (r = +0.671), *Scenedesmus* sp., and *Nitzschia* sp. shows positive correlation while *Coelastrum* sp., *Pandorina* sp., *Spirulina* sp. and *Strombidium* sp. shows fairly negative correlation with pH. *Tetraedron* sp. and *Navicula* sp. shows fairly positive correlation with turbidity. *Navicula* sp. (r = +0.763), *Nitzschia* sp. (r = +0.755) shows highly positive correlation, *Scenedesmus* sp., *Gyrosigma* sp. shows moderately positive correlation, while *Oscillatoria* sp. (r = -0.678), *Cyclops* sp. (r = -0.611), *Eucyclops* sp., *Phacus* sp. and *Platyias* sp. shows negative correlation with EC. *Scenedesmus* sp. (r = +0.622), *Nitzschia* sp. (r = +0.617), *Alona* sp. and *Ceriodaphnia* sp. shows positive correlation, while *Coelastrum* sp., *Phacus* sp., *Cyclops* sp. and *Brachionus* sp. shows negative correlation with TDS. *Mugeotia* sp., *Gomphonema* sp., *Nitzschia* sp., *Alona* sp. (r = +0.679) and *Ceriodaphnia* sp. shows positive correlation, while *Coelastrum* sp., (r = -0.617), *Brachionus* sp. (r = -0.626), *Pandorina* sp., *Spirulina* sp. and *Strombidium* sp. shows negative correlation with alkalinity. *Gomphonema* sp. (r = +0.609), *Alona* sp. (r = +0.687), *Mugeotia* sp., *Nitzschia* sp., and *Cyclops* sp. shows positive correlation, while *Coelastrum* sp., *Pandorina* sp., *Spirulina* sp., *Strombidium* sp. and *Brachionus* sp. shows negative correlation with TH. *Navicula* sp. shows positive correlation, while *Tropocyclops* sp. and *Platyias* sp. shows negative correlation with Mg. *Mugeotia* sp., *Alona* sp., *Ceriodaphnia* sp., *Eucyclops* sp. and *Platyias* sp. shows positive correlation with Ca. *Cyclops* sp., *Alona* sp. and *Ceriodaphnia* sp. shows positive correlation with phosphate. *Gomphonema* sp.and *Diaptomus* sp. shows negative correlation with DO. *Tetraedron* sp. (r = +0.692), *Navicula* sp., *Nitzschia* sp. shows positive correlation while *Spirogyra* sp., *Pandorina* sp., *Nostoc* sp., *Oscillatoria* sp., *Spirulina* sp., *Strombidium* sp. and *Diaptomus* sp. shows negative correlation with BOD. *Nitzschia* sp. (r = +0.627), *Scenedesmus* sp., *Navicula* sp. and *Alona* sp. shows positive correlation while *Coelastrum* sp. (r = -0.658), *Pandorina* sp., (r = -0.600), *Spirulina* sp. (r = -0.600), *Strombidium* sp. (r = -0.600), *Brachionus* sp., (r = -0.668), and *Oscillatoria* sp. shows negative correlation with chloride. (Table No. 3 and 4). Seasonal variation of diatoms recorded maximum in summer and minimum during winter and monsoon season. Pahwa and Mehrotra, (1966) also observed similar trends in the water body, which has been further supported by Rao, (1979) and Sengar and Sharma, (1982).

A number of factors prejudiced the distribution of diatoms in water body, such as change in water temperature, Aykulu, (1978), Saad and Abbas, (1985) and Descy *et. al*., (1987), immigration and fast reproducing capacity, Oemke and Burten, (1986). Aykulu, (1978) observed that the temperature and current discharge resulted in phytoplankton distribution and the maximum of water current associated with reduced water retention time and rainfall. In the water body temperature regulated the plankton development and water current formed the most important controlling factor.

Dhembare, (2011) stated that to monitor the aquatic ecosystems and integrity of water the zooplankton has been used recently as bioindicators. This study showed that community size of zooplankton was the highest in rainy while the lowest density in winter. Among the zooplankton rotifer forming dominant group followed by cladocera and copepoda. Sukumaran and Das, (2002) studied plankton abundance in relation to physico-chemical features of Manchribele reservoir in Bangalore, India and reported high chloride content and optimal temperature was favor for zooplankton in different seasons. In the studied groups of zooplankton rotifer was largest group and cladocera was second larger group followed by copepoda. Similar ranking was noticed in the present study.

Singh *et al.* (2002) reported that higher rotifer population occur during summer and winter might be dominant due to hypertropical condition of the pond at high temperature and low level of water. The dominance of rotifers was reported in winter Kulshreshtra and Joshi, (1999). Chandraseker, (1996) showed that the water temperature, turbidity and transparency and dissolved oxygen were favor for rotifer population. In rainy rotifers were lower might be due to neutral pH. At the alkalinity, pH and temperature above 29^0 C the rotifers disappears Dhanapathi, (1995). The differences in seasonal density might be the nutrition and biotic interactions Pawar and Pulle, (2005). Similar result was noticed in the present study. Presence of phytoplankton can adversely affect water quality. Most of them are also indicative of the potential problems likely to be affected on the water supply system. The diversity in the physico- chemical factors was responsible for the diversity in the phytoplankton production, Marykensa, (2011). The diversity and density of zooplankton depends upon the nutrient condition of water body, abiotic factors, DO, food chain, soil-water chemistry and web with life cycle Dhembare, (2011).

CONCLUSIONS:

Therefore from the above study it is concluded that the total phytoplankton count/ml. is more in summer season and basillariophyceae is dominant while total zooplankton count/ml. is more in winter season. Rotifer is dominant in Ghuma Lake. The total plankton count/ml. is minimum in monsoon season (256/ml) and maximum in summer season (360/ml). This was proved by the above result as the amounts of cyanophyceae algae and rotifera were found in Ghuma Lake, which are indicator of pollution.

During study period it is observed that Ghuma lake is natural lake, in which the cattle used to drink and bath, rain water enter from the surroundings into the lake. One portion of the lake is covered by local people who are engaged in washing clothes and discharge soap water into the lake, local people immerse worship material in lake water. People from the surrounding area discharge their waste and domestic sewage directly into its water. These are some reasons of water pollution.

Result Table 1: Seasonal variation of phytoplankton in Ghuma Lake

PHYOTOPLANKTON		SAMPLING SEASON		
CLASS	GENERA	MONSOON MEAN	WINTER MEAN	SUMMER MEAN
CHLOROPHYCEAE	Closteriopsis Sp.	10	0	0
	Coelastrum Sp.	8	0	0
	Mugeotia sp.	0	14	8
	Pandorina Sp.	4	0	0
	Scenedesmus Sp.	0	0	2
	Spirogyra sp.	0	12	0
	Tetraedron Sp.	6	0	8
Total		28	26	18
CYANOPHYCEAE	Merismopedia Sp.	4	0	0
	Nostoc Sp.	0	4	0
	Oscillatoria Sp.	14	24	0
	Spirulina Sp.	6	0	0
Total		24	28	00
BACILLARIOPHYCEAE	Amphiplrura sp.	2	0	0
	Cyclotella sp.	2	0	2
	Cymbella Sp.	4	0	4
	Gomphonema Sp.	0	8	4
	Gyrosigma sp.	0	0	24
	Navicula Sp.	58	16	96
	Nitzschia sp.	22	20	78
Total		88	44	208
EUGLENOPHYCEAE	Euglena Sp.	16	54	70
	Phacus sp.	2	2	00
Total		18	56	70
TOTAL PHYTOPLANKTON COUNT/ ML		158	154	296
TOTAL PHYTOPLANKTON COUNT/ L		94800	92400	177600

Result Table 2: Seasonal variation of zooplankton in Ghuma lake

ZOOPLANKTON		SAMPLING SEASON		
GROUP	GENERA	MONSOON MEAN	WINTER MEAN	SUMMER MEAN
CILIATA	Pleuronema sp.	2	6	0
	Strombidium Sp.	2	0	0
Total		04	06	00
CLADOCERA	Alona sp.	0	0	6
	Ceriodaphnia sp.	16	28	32
Total		16	28	38
COPEPODA	Cyclops sp.	10	10	2
	Dicyclops sp.	0	10	0
	Diaptomus sp.	2	12	0
	Eucyclops sp.	4	8	0
	Tropocyclops sp.	4	12	6
Total		20	52	08
ROTIFERA	Brachionus sp.	56	4	14
	Platyias sp.	2	18	4
Total		58	22	18
TOTAL ZOOPLANKTON COUNT / ML		98	108	64
TOTAL ZOOPLANKTON COUNT / L		58800	648000	38400
TOTAL PLANKTON COUNT / ML		256	262	360
TOTAL PLANKTON COUNT / L		153600	157200	216000

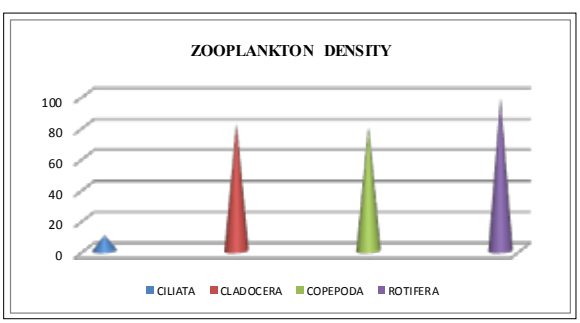

TABLE NO. 3: Correlation of plankton with physico-chemical parameters of Ghuma lake

Plankton Genus	Temp.	pH	Tur	EC	TDS	Alk	TH	Mg ++	Ca ++	Nit	Phos	DO	BOD	Chl
Closteriopsis Sp.	0.283	0.064	-0.158	-0.38	-0.363	-0.256	-0.242	-0.174	-0.01	0.349	0.345	-0.077	0.039	-0.303
Coelastrum Sp.	0.400	-0.633	0.178	-0.098	-0.505	-0.618	-0.532	0.038	-0.388	-0.139	-0.161	0.356	-0.348	-0.659
Mugeotia sp.	-0.36	-0.116	-0.235	-0.089	0.238	0.579	0.537	-0.208	0.543	0.048	-0.426	-0.301	-0.355	0.197
Pandorina Sp.	0.168	-0.498	-0.257	-0.203	-0.259	-0.442	-0.474	-0.262	-0.086	0.239	0.127	0.015	-0.432	-0.6
Scenedesmus Sp.	-0.005	0.416	0.138	0.485	0.622	0.116	0.106	0.261	-0.162	0.051	-0.091	-0.171	0.51	0.526
Spirogyra sp.	0.11	0.205	0.088	-0.027	0.025	0.116	-0.126	0.087	-0.162	-0.347	0.345	-0.309	-0.432	-0.069
Tetraedron Sp.	-0.103	-0.058	0.507	0.279	0.204	-0.097	-0.171	0.083	-0.192	-0.396	-0.204	0.301	0.692	0.349
Merismopedia Sp.	0.283	0.064	-0.158	-0.38	-0.363	-0.256	-0.242	-0.174	-0.01	0.349	0.345	-0.077	0.039	-0.303
Nostoc sp.	0.11	0.205	0.088	-0.027	0.025	0.116	-0.126	0.087	-0.162	-0.347	0.345	-0.309	-0.432	-0.069
Oscillatoria Sp.	0.159	-0.059	-0.31	-0.612	-0.354	-0.129	-0.358	-0.299	0.07	0.126	0.329	-0.378	-0.523	-0.412
Spirulina Sp.	0.168	-0.498	-0.257	-0.203	-0.259	-0.442	-0.474	-0.262	-0.086	0.239	0.127	0.015	-0.432	-0.6

TABLE NO. 4: Correlation of plankton with physico-chemical parameters of Ghuma lake

Plankton Genus	Temp.	pH	Tur	EC	TDS	Alk	TH	Mg^{++}	Ca^{++}	Nit	Phos	DO	BOD	Chl
Amphiplrura sp.	0.283	0.064	-0.158	-0.38	-0.363	-0.256	-0.242	-0.174	-0.01	0.349	0.345	-0.077	0.039	-0.303
Cyclotella sp.	-0.093	0.2	-0.07	-0.142	0.037	0.31	0.416	0	0.268	0.37	0.512	-0.114	0.058	0.071
Cymbella Sp.	0.42	0.304	-0.143	0.07	-0.207	-0.241	-0.1	0.064	-0.184	0.296	0.189	-0.114	0.058	-0.181
Gomphonema Sp.	-0.198	0.216	-0.067	-0.11	0.151	0.454	0.609	0.252	0.172	0.074	0.118	-0.402	-0.256	0.127
Gyrosigma sp.	0.201	0.386	-0.022	0.512	0.167	0.065	0.267	0.295	-0.163	0.08	-0.022	-0.092	0.047	0.138
Navicula Sp.	0.107	0.349	0.434	0.764	0.389	0.068	0.264	0.464	-0.304	-0.151	-0.005	0.217	0.567	0.426
Nitzschia sp.	-0.355	0.542	-0.036	0.755	0.617	0.474	0.56	0.146	0.204	0.149	0.336	0.317	0.442	0.628
Euglena Sp.	0.186	0.672	-0.178	0.314	0.247	-0.017	0.232	0.369	-0.223	0.323	0.054	-0.34	0.333	0.259
Phacus sp.	0.335	0.148	-0.198	-0.426	-0.439	-0.379	-0.187	0.064	-0.184	0.37	0.189	-0.184	0.058	-0.339
Pleuronema	0.256	0.175	-0.102	-0.05	-0.288	-0.333	-0.013	0.34	-0.31	0.163	-0.118	0.11	0.051	-0.187
Strombidium Sp.	0.168	-0.498	-0.257	-0.203	-0.259	-0.442	-0.474	-0.262	-0.086	0.239	0.127	0.015	-0.432	-0.6
Alona sp.	-0.649	0.188	-0.06	0.165	0.485	0.68	0.688	-0.122	0.553	0.209	0.481	0.064	0.273	0.486
Ceriodaphnia sp.	-0.424	0.108	-0.212	0.02	0.522	0.547	0.449	-0.106	0.406	0.292	0.463	-0.361	-0.175	0.244
Cyclops sp.	0.187	-0.242	0.088	-0.678	-0.569	-0.351	-0.285	-0.065	-0.111	-0.01	-0.14	-0.199	0.107	-0.32
Diacyclops sp.	0.029	0.193	-0.016	-0.165	-0.022	0.097	-0.127	0.056	-0.101	-0.269	0.274	-0.317	-0.39	-0.036
Diaptomus sp.	0.118	-0.126	-0.213	-0.377	-0.198	-0.037	-0.096	-0.028	-0.046	-0.081	-0.134	-0.5	-0.667	-0.38
Eucyclops sp.	-0.141	-0.051	-0.302	-0.485	-0.203	-0.04	-0.151	-0.325	0.28	0.288	0.094	0.001	0.068	-0.003
Tropocyclops sp.	-0.48	-0.022	-0.27	-0.26	0.173	0.275	0.04	-0.434	0.516	0.225	0.124	0.091	0.229	0.345
Brachionus Sp.	0.506	-0.228	-0.221	-0.281	-0.474	-0.626	-0.543	-0.141	-0.263	0.399	0.25	-0.07	-0.221	-0.668
Platyias sp.	-0.5177	-0.0961	-0.3951	-0.452	0.01751	0.18167	-0.0908	-0.5426	0.52097	0.15728	0.04264	0.0185	0.09206	0.19509

REFERENCES

1. Amabsht, R. S., (1971). Ecosystem study of tropical pond in relation to primary production of different vegetation zones Bocharesi. Hydrobiologia, 12: 57-61. | 2. APHA (1995). Standard methods for the examination of water and waste water. 19th Edition, American Public Health Association, American Water Work Association and Water Pollut. Contl. Federation, Washington, D.C., NewYork. | 3. Aykulu G., (1978). A comparative study of the phytoplankton of the river Avon, Bristol. Phycol, J. 13: 91-102. | 4. Battish S. K. (1992). Fresh water zooplankton of India. Oxford and IBH Pub. Co. New Delhi. | 5. Chandrasekar, S. A., (1996).Ecological studies on Sarrornagar lake Hyderabad with special reference to zooplankton communities. Ph.D. Thesis, Osmania Univ. Hyderabad AP. | 6. Dhembare, Anant J. (2011). Statistical approaches for computing diversity and density of zooplankton with water factors in Mula Dam, Rahuri, MS, India. European Journal of Experimental Biology, 2011, 1 (2):68-76 | 7. Edmondson, W. T. 1959. Fresh Water Biology. 2nd ed.Jhon wiley and sons. New York. New York 1248pp. | 8. Kulshreshtra, S. K. and Joshi, M., (1999). Periphyton community of lower lake of Bhopal in relation to sewage pollution. In: Aquatic Science in India (Ed. Gapal B and Asthana V) Indian Asso. Limno. and Oceano. | 9. Mary Kensa, V., (2011). Inter–relationship between physico-chemical parameters and phytoplankton diversity of two perennial ponds of kulasekharam area, kanyakumari district, tamil nadu. Plant Sciences Feed, 1 (8): 147-154 | 10. Oemke, D.V. and Burtan T. M., (1986). Diatom colonization dynamics in a lotic system. Hydrobiologia.139: 153-166. | 11. Pahwa D. V. and Mehrotra S. N., (1966). Observation of fluctuation in the abundance of plankton in relation to certain hydrological condition of river Ganga. Proc. Nat., Acad. Sci. India.B, 36(2): 157-189. | 12. Prescott G.W. 1970. Algae of the western great Lakes areas. Pub Cranbrook Institute of science Bulletin. 33: 1-496. | 13. Subrahmanyam N. S. and A. V. S. Sambamurty. (2004): Ecology. Narosa Publication. | 14. Trivedy, R.K. 1993. Biomonitoring of water pollution in R.k. Trivedy edited, Encyclopedia of Envronmental Pollution and Control. Vol 1 and 2. Environ Media, Karad, India.