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RESEARCH ARTICLE

SURVEY AND STUDY OF PHYTOPLANKTON ECOLOGY IN ANCHAR LAKE, KASHMIR, (INDIA)

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ABSTRACT

Phytoplankton biodiversity and water quality of famous lake, Anchar Lake, Srinagar (Lat 34° 20´- 34° 36´N. 74° 82´ - 74° 85´E Long.), Kashmir were examined in the study. During the study period (June 2010 to May, 2011), phytoplankton composition and physico-chemical characteristics of water are indicative of eutrophic condition in three different collection zones (Z_A, Z_B and Z_C) of the lake. The species richness displayed fair variety of algal species (86 taxa). The community was dominated by the members of *Bacillariophycea*, *Chlorophyceae* and *Cyanophyceae*. Highest phytoplankton density (2082 individual/ L) and species diversity (0.928-2.628) was found during the summer season in the area (Z_A) where there was anthropogenic activity. The area with maximum disturbance in water column (Z_C) showed a minimum phytoplankton density of (164/L) and species diversity (0.991-2.319). Phytoplankton densities have significantly positive correlation with chloride (r= 0.707, significant at 0.05 level) and significantly negative correlation with DO (r= -0.449, significant at 0.05) in Z_A and significantly positive correlation with Total alkalinity (r=0.728, significant at 0.01 level) and calcium hardness (r= 0.672, significant at 0.05 level) in Z_B.

INTRODUCTION

Lentic ecosystem is one of the most productive ecosystems in the biosphere and plays a significant role in the ecological sustainability of the region. It serves many vital functions such as recycling of nutrients, restoration of ground water, purification of water, augmentation and maintenance of stream flow and habitat provision for wide variety of flora and fauna along with their recreational values. However, continuous inputs of various forms of pollution from a variety of human activities have seriously deteriorated the health status of Lake ecosystem. If this trend continues, it may lead to the collapse of Lake Ecosystem (Goldman and Horne, 1983;Constanza *et al.,*1997; Westman, 1977; Rapport *et al.*, 1998). Failure to restore this ecosystem results in extinction of species and cause permanent ecological damage. Thus, studies on physico-chemical factors and phytoplankton standing crop of the habitat are essential for the proper management of water resources and for the prediction of the potential changes in the aquatic ecosystem (Kobbia, 1982; Descy, 1987) and protection and remediation of ecosystems (Varshney, 1989). So, the objective of the present work was to study various physicochemical characteristics in relation to phytoplankton diversity which would help in assessing the current trophic status of this lake. The data obtained would also help in arriving at appropriate conservation strategies or restoration methods towards the conservation, management and sustainable use of natural resource in addition to formulating the diversity of this lake which is on the verge of extinction.

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Description of Study Area

Anchar Lake is a famous lake located in the Srinagar city. It has a fascinating range of flora and fauna. The water flowing into the lake is heavily loaded with silt. Due to higher run off, there is accelerated pace of erosion in the catchment areas, resulting in the higher rate of sedimentation in the Anchar Lake. The silt deposited year after year in the lake bed reduces the water storage capacity, depth, water spread area and submergence area at lake level. Keeping in mind the above mentioned problem and other anthropogenic activities therein, the lake was divided into three zones for study: Zone A (Z_A) with human activity, affected severely due to siltation); Zone B (Z_B) which supports angling activity; Zone C (Z_C) with maximum human activity (Figure 1).

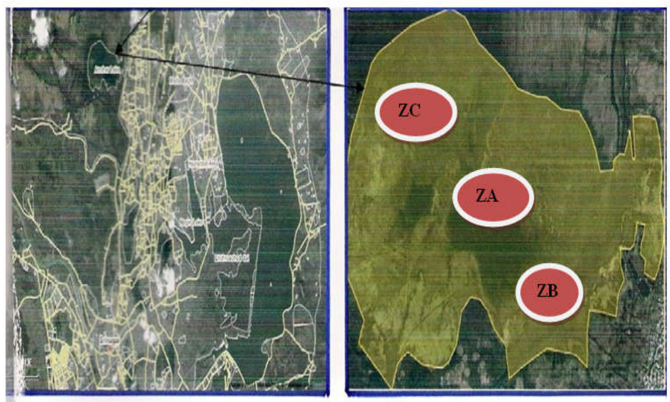

Fig. 1: Outline map of anchar lake showing location of sampling zones

METHODOLOGY

For the study of biotic and abiotic parameters, samples were collected from three substations (Z_A, Z_B and Z_C) of Anchar Lake between late morning and early evening fortnightly from June 2010 to May 2011.

Physico-Chemical Assessment

Samples were collected from each substation randomly over a length of 100 mts.The physicochemical parameters of water quality were analyzed using standard methods given in APHA (American Public Health Association), 1998.

Assessment of Biotic Population

Plankton samples were collected by filtering 50L of water through plankton net (50 µm size) and then preserved in 4% buffered formalin solution. Quantification and identification of the plankton was done according to standard references (Prescott, 1954; Ward and Whipple, 1959; Needham and Needham, 1962; Anantani and Marathe, 1972; Gupta, 1972; Pandey *et al.,* 1993; Kumar and Singh 1995; APHA, 1998; Garg *et al.*, 2002).Species diversity index was calculated using Shannon and weaver diversity index (Shannon and Weaver, 1963) and Simpson diversity index (Simpson, 1949). Monthly mean and standard error was calculated for each physical, chemical and biological variable. Karl Pearson correlation coefficient was calculated by SPSS computer software version 11.5 for windows to see any correlation between various recorded parameters.

RESULTS

Physico-chemical parameters

The water temperature in Anchar Lake during the study period was found to have minor variations in all the zones. Surface water temperature, averaged over the entire study period was around 25.6˚C. The lowest and highest surface water temperature recorded during the study period were 3.4˚C (Z_A) in January, 2011 and 25.6˚C (Z_C) in August, 2010 respectively. pH in all the three zones ranged from 7.96-8.39. A definite pattern of increase or decrease of conductivity was observed at the collection zones. Average dissolved oxygen concentration at all the zones ranged from 2.0 to 4.9 mg/L in Z_A to 3.20 to 6.64 mg/L in Z_B and 3.0 to 6.9 mg/L in Z_C. Free CO_2 ranged between 4.0-34.00 mg/L being, maximum at Z_C (34 mg/L). Orthophosphate varied from 51.4 – 179.6 µg/L. Highest peak was observed in the month of May and June at all collection zones.

Phytoplankton

Plankton samples from Anchar Lake show the existence of diverse phytoplankton, some of them occur sporadically. A total of included 86 taxa were reported in the lake (Table 1) and thus, reflect the overall environmental heterogeneity and habitat diversity of this lake. Taxonomic determination was done to genus level, and where possible also to species level. The assemblage was dominated, in descending order by chlorophyceae (36 taxa), cyanophyceae (21 taxa), bacillariophyceae (24 taxa), dinophyceae (2 taxa), euglenophyceae (2 taxa) and cryptophyceae (1 taxon). Z_A had maximum species richness (64 taxa) of which 40 per cent was constituted by chlorophyceae. *Closterium* spp. And *Spirogyra* spp. dominated over other chlorophyceae members. Bacillariophyceae and Cyanophyceae respectively constituted 32 and 28 per cent. *Cyclotella* sp. and *Cymbella* spp. predominantly represented Bacillariophycea whereas *Nodularia* spp. was found to be predominant group of cyanophyceae. Species richness was maximum in August and minimum in December (Table 2). Population density decreased from June to July, thereafter a sharp increase was recorded till August. After August, again phytoplankton density decreased sharply in October (Fig.2).

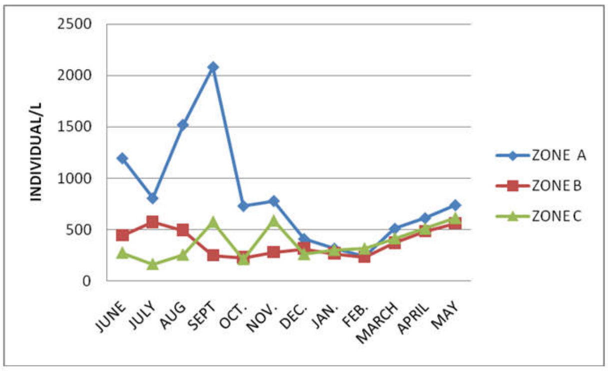

Fig 2: Monthly variation population density of phytoplankton at three zones

At ZB, 45 taxa were identified of which chlorophyceae (16), cyanophyceae (14), bacillariophyceae (10), dinophyceae (2) euglenophyceaea (1) and cryptophycea (1) represented respectively 36%, 31%, 22%, 7%, 2% and 2% respectively of the total species richness. *Nodularia* spp. was found to be abundant. Z_C showed minimum species richness with 31 taxa, predominantly represented. by chlorophyceae (15) which constituted 48 per cent. The other groups belonged to bacillariophyceae (8) and cyanophyceae (7) respectively constituted 26 and 23 percent. Only one species of Euglenophyceae was represented. *Sirocladium* sp. was found to be predominant. Population density at Z_B and Z_C was comparatively much less than Z_A. However, in September and July, significant increase in population density was observed at Z_A and Z_C respectively but Z_B showed decrease during October. Numerically maximum population of 2082 individuals/ L were observed during September at Z_A and minimum 164 individuals/ L during July at Z_C.

Table 1: List of Phytoplankton found in the preserved samples from Lake Anchar

Species marked as ** were reported only once during the study period

CHLOROPHYCEAE

Pedistrum boryanum
Pediastrum duplex
Pediastrum simplex
Closterium acerosum
Closterium tumidum
Cosmarium bengalense
Cosmarium granatum
Cosmarium subtumidum
Cosmarium venustum
Cosmarium poritanium
*Oocystis sp.***
Microspora sp.
*Steioclonium sp.***

Apanochaeta sp.
Dicanthos sp.
Chlorella sp.
Crucigenia sp.
Rhizoclonium sp.
Tetrasporidium sp.
Senedesmus bijugatus
Euastrum sp.
*Hormidium flaccidium***
Ulothrix zonata
Oedogonium nodulosum
Mougeotia sp. **
Sirocladium sp.
Zygnema fanicum
Spirogyra spp.
Pleurotaenium sp. **
Mesotaenium sp.
*Netrium digitus***
Penium sp. **
*Actinotaenium sp.***
Sphaerozosma sp.
*Leptosira sp.***
*Spirulina sp***

BACILLARIOPHYCEAE

Stephanodiscus neoastraea
Meridion sp. **
Fragilaria sp.
Cymbella tumida
Epithemia sorex
Cymbella cymbiformes
Mastogloia sp.
Frustulia sp. **
Cycotella sp.
Amphipleura sp.
Cocconeis cistula
Phacus longicanda **
Melosira sp. **
Synedra ulna
Tabellaria flocculosa
Nitzschia sp.
Surirella brebissonii
Anomoneis sp. **
Neidium sp.
Pinnularia abaujensis
Navicula cryptocephala
Navicula sp.
Gopmhonema sp.
Stauronesis kriegeri

CYANOPHYCEA

Chrococcus turgidus
Synechocystis sp.
Gloeocaspa sp.
Phormidium sp.
Lyngbya sp. **
Synechococcus sp.
Microcystis sp.
Aphanocaspa sp.
Merismopedia elegans
Gomphosphaeria sp.
Oscillatoria principles
Cylindrospermium majus
Nodularia muscorum
Nodularia spermigenia
Stichosiphon sp.
Gloetricha echinulata **
Rivularia sp.
Coelosphaerium sp. **
Entophysalia sp. **
Gloeochaeta sp.
Anabaena sp.

EUGLENOPHYCEA

Euglena sp.
Gymnozyga sp. **

DINOPHYCEA

Cystodinium sp.
Kentosphaera sp

CRYPTOPHYCEA

Cryptomonas sp. **

A decrease in phytoplankton population was observed from Z_A to Z_C, in order of increase in anthropogenic activities therein. Seasonal variations showed an increase in phytoplankton population during summer (April to May,2011).

Species diversity

Shannon Weaver diversity index and Simpson's index of dominance was calculated to know the species diversity during different months (Table 2). The species diversity was comparatively more in summer months than during the rainy season. Z_A had highest species diversity which ranged between 0.928 to 2.628 being, minimum in October and maximum in July. Simpson index showed maximum (0.506) value in October and minimum (0.079) in January. At both Z_B and Z_C, diversity was maximum in August and Simpson index was minimum in August at Z_B whereas minimum index at Z_C was observed in August and maximum value of Simpson index was found in November.

The relationships between phytoplankton and some physico-chemical parameters

Statistical relationships between the composition of phytoplankton and the physico-chemical environment variables in the surface water at the sampling stations were explored. It indicated that several abiotic factors exert a considerable influence on phytoplankton abundance and diversity (Das *et al.*, 1996). Phytoplankton densities had significantly positive correlation with chloride (r= 0.707, significant at 0.05 level) in Z_A and significantly positive correlation with total alkalinity (r= 0.728, significant at 0.01 level) and calcium hardness (r= 0.672, significant at 0.05 level) in Z_B (Table 3).

DISCUSSION

Physico-chemical

Ecological factors estimated and characterized by this study reflect a typical water quality characteristics which concurrent with lake's geographical location. Alkaline pH values recorded throughout the study were a reflection that lake is bicarbonate type (Wetzel, 1983; Joshi *et al.*, 1993). Surface

Table 2: Comparison of phytoplankton richness, diversity and density at three sampling zones

MONTHS	RICHNESS			DENSITY (IND/L)			SHANNON-WEINER INDEX			SIMPSON'S DOMINANCE INDEX		
JUNE-MAY	**ZA**	**ZB**	**ZC**	**ZA**	**ZB**	**ZC**	**ZA**	**ZB**	**ZC**	**ZA**	**ZB**	**ZC**
JUNE	23	14	12	1196	445	274	2.480	1.719	1.345	0.115	0.242	0.257
JULY	31	21	07	808	575	164	2.628	2.359	1.294	0.087	0.111	0.269
AUG	44	30	14	1521	493	254	2.453	2.627	2.319	0.147	0.008	0.067
SEPT	32	14	12	2082	247	575	2.084	1.954	1.092	0.108	0.106	0.388
OCT.	13	10	07	733	226	212	0.928	0.827	0.991	0.506	0.225	0.316
NOV.	16	03	05	781	280	587	2.213	0.466	0.595	0.096	0.949	0.965
DEC.	12	16	14	412	314	261	1.142	1.612	1.411	0.124	0.312	0.314
JAN.	21	12	11	318	266	301	2.181	2.142	0.921	0.079	0.121	0.212
FEB.	14	16	09	241	231	315	2.121	0.912	0.312	0.412	0.212	0.161
MARCH	16	15	13	512	371	414	2.181	2.411	1.411	0.091	0.018	0.128
APRIL	27	14	14	614	482	509	2.421	1.314	2.121	0.104	0.128	0.212

Table 3: Karl-Pearson coefficient of correlation between different abiotic parameters and phytoplankton density

S. NO.	PARAMETER	ZONE "A"	ZONE "B"	ZONE "C"
1	DEPTH	0.116	0.014	0.361
2	TEMPERATURE	0.113	0.025	0.422*
3	TRANSPARENCY	0.142	0.121	0.136
4	pH	-0.196	-0.016	-0.192
5	DISSOLVED OXYGEN	-0.449	-0.039	0.029
6	FREE CARBON DIOXIDE	0.059	0.397	0.039
7	TOTAL ALAKALINITY	-0.018	0.728**	0.322
8	CONDUCTIVITY	-0.017	0.421*	0.312
9	SILICATES	0.121	0.212	0.014
10	TOTAL HARDNESS	0.145	0.537**	0.033
11	CHLORIDE	0.707*	0.275	0.585*
12	CALCIUM	0.121	0.627	0.161
13	MAGNESIUM	0.121	0.149	0.171
14	TOTAL PHOSPHATE PHOSPHOROUS	0.021	0.141	0.171
15	ORTHOPHOSPHATE PHOSPHOROUS	0.085	0.230	0.117
16	NITRATE- NITROGEN	0.128*	0.214	0.281
17	NITRITE-NITROGEN	0.107	0.121*	0.131
18	SODIUM	0.023	0.043	0.032
19	POTASSIUM	0.011	0.012	0.013

water at all zones appeared low in oxygen. Low values of DO in the month of June was observed at Z_A could be attributed to the low biological activity(Vass *et al*., 1977; Qadri *et al*., 1981) However in zone C, maximum value of DO was observed due to frequent turbulence caused by paddled boats which resulted in proper mixing of water. Alkalinity throughout the study period was mainly due to bicarbonates but high peak in the spring month (March) may be attributed to the presence of carbonates and absence of free CO_2 (Tucker,1958; Chakrabarty *et al.,* 1959; Bisop, 1973; Flood, 1996; Shashtri and Pendse, 2001; Radhakrishnan *et al.,*2007). Water bodies having total alkalinity above 50 mg/L can be considered productive (Moyle, 1946). Thus, the present findings showed that all the three zones of Anchar Lake are highly productive in nature. High value of chloride reflects that there was maximum amount of organic waste of animal origin (Ganpati,1960). Higher values of chlorides were recorded in summer and spring months while low values in winter months (Gonzalves and Sharma, 1964; Patil *et al*., 1985). Rise in orthophosphate concentration in summer period might be due to increased decomposition at higher temperature and low water level which was in accordance with the findings of Swaranlatha and Rao, 1998; Jha and Barat, 2003. According to Lee *et al.,* 1981 classification based on total phosphorous concentration, it was found that lake is eutrophic in nature.

Phytoplankton

The variations in phytoplankton are related to a variety of environmental factors in aquatic environments(Washington, 1984; Boney, 1989; Wu and Chou, 1999) the approach adopted in the present investigation, is tolerate temporal changes in diversity to temporal changes in environmental conditions. It is a well established fact that phytoplankton grow and multiply best during summer when temperature is high (Richardson *et al.*,2000; Izaguirre *et al*., 2001; Susanne *et al*., 2005; Farahani *et al*., 2006 ; Chowdhury *et al*., 2007) and longer photoperiod (Polli and Simon, 1992; Salmaso and Naselli, 1999 ; Brizzio *et al*., 2001). Therefore the present study was planned in summer and during moderate conditions. The species richness displayed a fair variety of algal species (86 taxa). The community was predominantly constituted by the members of chlorophyceae, bacillariophyceae, and cyanophyceae. Two members of dinophyceae, and one each of euglenophyceae and cryptophyceae also contributed to the community structure. The results of seasonal variation in phytoplankton population revealed highest species diversity during summer when days are longer and the water level is at its minimal. The three zone studied in Lake Anchar differ in the physical structure as well as in utilization for human activities. As expected, the phytoplankton samples taken from Z_B and Z_C were less dense and less diverse than those taken from Z_A. Phytoplankton abundance and taxonomic diversity depends on the supply of the nutrients in natural water. In the present study highest plankton density and species diversity was found during the summer season toward the area (Z_A) where there was anthropogenic activity. The area with maximum disturbance in water column (Z_C) showed minimum plankton density and species diversity. Less phytoplankton density and diversity at Z_C could be because the boating activity does not allow phytoplankton especially the filamentous algae to colonize. The results goes in confirmation to Stolpe and Moore, 1997; Asplund, 2000. According to them the turbulence created by oars of boaters and shikaras disrupts phytoplankton communities living just beneath the surface of the water, which results in re-distribution of the organisms (Harris, 1978, 1980, 1983, 1986; Reynold and Walsby, 1978; Pearl, 1995). This turbulence also decreases light penetration, which can reduce the photosynthetic rates of submerged aquatic vegetation, thereby slowing down primary production rates (Stolpe and Moore, 1997). On the contrary comparatively high phytoplankton density and diversity at Z_A can be attributed to release of nutrients in the water through vegetation and thus promoting algal growth (Liddle and Scorgie, 1980; Backhurst and Cole,2000).The assemblage of phytoplankton in Anchar Lake were indicative of the lake's richness based on species abundance and diversity. The analysis of physicochemical parameter of lake was an indicator of how healthy the lake was and the number of species found there was dependent on the physicochemical parameters of lake. These complementary analysis provide a better understanding of the lake's present condition (Arfi *et al.*, 2003) and their information can be used to mitigate negative effects.

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