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SEASONAL VARIATION OF PHYTOPLANKTON COMMUNITY IN RELATION TO CERTAIN PHYSICO-CHEMICAL PARAMETERS OF VEERANAM LAKE IN CUDDALORE DISTRICT, TAMIL NADU

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ABSTRACT

The objective of this work is to evaluate the quality of Phytoplankton biodiversity and water quality of Veeranam Lake, Cuddalore district in the State of Northern Tamil Nadu in South India (Coordinates 11° 20' 10"N and 79°32'40" E). During the present study (April 2010 to September 2010), during the study period, samples were collected monthly at five different locations and analysed for various physico-chemical parameters of the lake. The species richness displayed fair variety of algal species (89 taxa). The community was dominated by the members of chlorophyceae and cyanophyceae. The distinct peak of phytoplankton was observed during post-monsoon (252) and gradually decline during summer (202), pre-monsoon (200) and monsoon (130). This period is due to the effect of ecological and abiotic factors in the lake. The summer, pre-monsoon, monsoon and post-monsoon values were taken for statistical analysis. There were significant variations observed in water quality and zooplankton abundance during different seasons.

Keywords: Lake Veeranam; Ecology; Physicochemical parameters; Phytoplankton; species diversity.

1.INTRODUCTION

Water is a valued natural resource for the existence of all living organisms. Management of the quality of this precious resource is, therefore, of special importance. According to Linton and Warner (2003) stress is generally through to induce both quantitative and qualitative changes in structure and functioning of communities. Structural changes are usually assessed by analyzing species diversity or composition. It is an established fact that maintenance of healthy aquatic ecosystem is dependent on the physico-chemical properties of water and biological diversity. Water is vital to the existence of all living organisms, but this valued resource is increasingly being threatened as human populations grow and demand more water of high quality for domestic purposes and economic activities (UNEPGEMS, 2000). The quality of any body of surface or ground water is a function of either or both natural influences and human activities (Stark *et al.*, 2001, Kolawole *et al.*, 2008). It is now generally accepted that aquatic environments cannot be perceived simply as holding tanks that supply water for human activities. Rather, these environments are complex matrices that require careful use to ensure sustainable ecosystem functioning well into the future.

The deterioration of quality, loss of biodiversity and fast depletion of water resources are the main challenges, which need urgent attention. The limnological study gives the proper direction in decision-making processes for problems like pollution control, fish and other aquatic lives. This represents the organic material available in particulate form on which the animal population of aquatic ecosystem depends directly or indirectly. The studies of physico-chemical parameters are used to detect the effects of pollution on the water quality.

Water quality degradation by various sources becomes an important issue around the world. Usage of more land for agricultural purposes, soil salinization, increase in the use of agricultural fertilizers, common pesticide use, and erosion have become problems threatening natural water source (Zalidis *et al.*, 2002). Aquatic ecosystems are affected by several health stressors that significantly deplete biodiversity. In the future, the loss of biodiversity and its effects are predicted to be greater for aquatic ecosystems than for terrestrial ecosystems (Sala *et al.*, 2000). 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 a.l*, 1997; Westman, 1977; Rapport *et al.*, 1998). Failure to restore this ecosystem results in extinction of species or an

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ecosystem type 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 is to study various physicochemical characteristics in relation to phytoplankton diversity which would help in assessing the trophic status of this lake.

The present study primarily aims to document the physico-chemical parameters and phytoplankton species composition of Veeranam lake during the month of April 2010 to September 2010.

2.MATERIALS AND METHODS

Study area

The Veeranam lake is located 14 km SSW of Chidambaram in Cuddalore District, in the State of Northern Tamil Nadu in South India (Coordinates 11° 20' 10"N and 79°32'40" E). The lake type is reservoir, intermittent, the total catchment area of the reservoir is 25 km2 (9.7 sq.mile) and it is about 16 km (10 mile) long and 4 km (2.5 mile) width. The source to supply water to Veeranam lake is the surplus water from Keelanai (Lower Anaicut) and water coming from surrounding area. From where water is planned to be supplied to Chennai for drinking purpose, Ayacut area of 48,000 acres irrigation in Chidambaram Town. For the present study five stations (S1-Sethiyathoppu (Kuttu road); S2- Orathoor; S3 – Babunayakkan Madhagu; S4 – Kumarachi Madhagu and S5 – Lalpettai) selected for sample collection.

Methodology

For the study of biotic and abiotic parameters, samples were collected from five substations (S1, S2, S3, S4 and S5) of Veeranam Lake between late morning and early evening fortnightly from April 2010 to September 2010.

Physico-Chemical Assessment

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

Sample analysis

During the study period, the surface analysis from five sampling stations at the lake samples were taken once every month from April 2010 to September 2010. Water samples were collected in 2 lr clean well dried bottles with necessary precautions and labelled for collecting points. The collection was usually completed during morning hours between 8.00 am to 10.00 am. Temperature was recorded on the spot, the remaining parameters were analysed by standard methodology APHA (2005).

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; 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. 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.

Phytoplankton

Plankton samples from Veeranam Lake show the existence of a speciose and diverse phytoplankton biocoenosis some of them occur sporadically included 89 taxa (Table 2) and thus, reflect the overall environmental heterogeneity and habitat diversity of this national wetland. Taxonomic determination was done to genus level, and where possible also to species level.

3.RESULTS AND DISCUSSION

The average seasonal variation in the physico-chemical characteristics of the Veeranam lake water samples are given in Table 1. All the physico-chemical parameter values are higher during summer except BOD, COD, phosphate, sulphate and iron. The minimum values observed during monsoon except phosphate, BOD and COD. The BOD, COD and iron values higher during pre-monsoon and lower during post-monsoon. The phosphate values higher during monsoon and lower during post-monsoon. A similar instance was early reported by Devaraj *et al*., (1988) in Hemavathy reservoir and Pazhanisamy (2005) in lower Anaicut. The high value of dissolved phosphate during monsoon may be due to the rain washings from the catchment through river discharges and flood water as well as seepage from paddy fields.

The assemblage was dominated, in descending order by chlorophyceae (37 taxa), cyanophyceae (26 taxa), bacillariophyceae (19 taxa), dinophyceae (2 taxa), euglenophyceae (2 taxa) and cryptophyceae (1 taxon). S1 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 is June and minimum in September. Population density decreased from April to May, thereafter a sharp increase was recorded till July. After July again phytoplankton density decreased sharply in August (Figure 2).

At S2, 45 taxa were identified of which chlorophyceae (16), cyanophyceae (14), bacillariophyceae (10), dinophyceae (3) eugeinophyceaea (1) and cryptophycea (1) represented respectively 36 %, 31%, 22%, 7%, 2% and 2% of the total species richness. Nodularia spp. was found to be abundant. S3 showed minimum species richness with 31 taxa, predominantly represented by chlorophyceae (17) which constituted 48 per cent. The other groups belonged to bacillariophyceae (8) and cyanophyceae (7) respectively constituted 25 and 24 percent. Only one species of Euglenophyceae was represented by one species only. Sirocladium sp. was found to be predominant. Population density at S2 and S3 was comparatively much less than S1. However, in July significant increase in population density was observed at S1 and S4 but S5 showed decrease up to July and thereafter no significant variation was reported till September. Numerically maximum populations of 2082 individuals/ L were observed during July at S1 and minimum 164 individuals/ L during May at S3. A decrease in phytoplankton population was observed from S3 to S4, in order of increase in anthropogenic activities therein. Seasonal variations showed an increase in phytoplankton population during summer (May to July). The population was maximum during July and declined in August. During the study year the monsoon was quite late during August. This might be the reason for significant decrease in phytoplankton population during August.

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 TDS (r= 0.592, significant at 0.05 level), chloride (r = 0.127, significant at 0.05 level) and significantly negative correlation with BOD (r = -0.942, significant at 0.05) in S1and S3 and significantly positive correlation with bicarbonate alkalinity (r= 0.943, significant at 0.01 level) and calcium hardness (r= 0.419, significant at 0.05 level) in S1, S2 and S5.

Ecological factors estimated and characterised by this study reflect a typical tropical 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 water at all stations appeared well oxygenated. Low values of DO in the month of June was observed at S1&S2 could be attributed to the reduction of the collection zone to isolated pools and thus decrease in water level (Iqbal *et al.*, 2003). However in S3, 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 monsoon month (August) may be attributed to the presence of carbonates and absence of free CO2 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 Sukhna Lake are productive in nature. Low value of chloride reflects that there was minimum amount of organic waste of animal origin (Pathak *et al.*, 2001; Shastri and Pendse, 2001; Pandey and Verma, 2004). Rise in orthophosphate concentration in May and June 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 ; Kumar et al., 2005. Minimum concentration in the month of August and September was may be due to enhanced consumption as well as dilution due to rainfall (Joshi et al., 1993). According to Lee et al., 1981 classification based on orthophosphate concentration, it was found that lake is mesotrophic in nature.

The unsettled and disturbed conditions of the water column resulting from the rains and the heavy inflow and outflow retard the phytoplankton production. According to Welch (1952) the incoming water due to is poor plankton content dilutes the plankton counts of the standing water. The lowest phytoplankton recorded during monsoon may be related to low temperature Marshall and Orr (1972) also observed minimum phytoplankton population at low temperature. The nearly neutral and marginally hard waters of this manmade lake show moderate values for BOD and low concentration of sulphate.

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 the monsoon seasons. The species richness displayed a fair variety of algal species (89 taxa). The community was predominantly constituted by the members of chlorophyceae, bacillariophyceae, and cyanophyceae. Three 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 May and June when days are longer and the water level is at its minimal. The five stations studied in Lake Veeranam differ in the physical structure as well as in utilization for human activities. As expected, the phytoplankton samples taken from S2 and S3 were less dense and less diverse than those taken from S1. The result supports the hypothesis that recreational boating and removal of riparian area has negative effect on the density and diversity of the planktons. 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 wild area (S1) where there was no anthropogenic activity. The area with maximum disturbance in water column (S3) showed minimum plankton density and species diversity. Less phytoplankton density and diversity at S4 could be because the boating activity does not allow phytoplankton especially the filamentous algae to colonize. The results goes in confirmation to Stople and Moore, 1997;. According to them the turbulence created by propellers disrupts phytoplankton communities living just beneath the surface of the water, which results in a redistribution of the organisms (Harris, 1983, 1986; Pearl, 1995). This turbulence also decreases light penetration, which can reduce the photosynthetic rates of submerged aquatic vegetation,

Table 1: List of Phytoplankton found in the preserved samples from Lake Veeranam
Species marked as ‘r’ were reported only once during the study period

CHLOROPHYCEAE
Pediastrum boryanum
Pediastrum duplex
Pediastrum simplex
Closterium acerosum
Closterium tumidum
Cosmarium bengalense
Cosmarium granatum
Cosmarium subtumidum
Cosmarium venustum
Cosmarium poritanium
Oocystis sp. r
Microspora sp.
Steioclonium sp. r
Closteriopsis sp.
Dicanthos sp
Apanochaeta sp
Chlorella sp.
Crucigenia sp. r
Rhizoclonium sp. r
Senedesmus bijugatus
Tetrasporidium sp. r
Euastrum sp.
Hormidium flaccidium r
Ulothrix zonata
Oedogonium nodulosum
Mougeotia sp. r
Sirocladium sp.
Zygnema fanicum r
Spirogyra spp
Pleurotaenium sp. r
Mesotaenium sp.
Netrium digitus r
Penium sp. r
Actinotaenium sp. r
Sphaerozosma sp.
Leptosira sp. r

BACILLARIOPHYCEAE
Stephanodiscus neoastraea
Meridion sp. r
Fragilaria sp.
Cymbella tumida
Cymbella cymbiformes
Epithemia sorex
Mastogloia sp.
Frustulia sp. r
Cyclotella sp.
Amphipleura sp.
Cocconeis cistula. r
Phacus longicauda. r
Melosira sp. r
Synedra ulna
Tabellaria flocculosa. r
Nitzschia sp.
Surirella brebissonii
Anomoneis sp. r
Neidium sp.
Pinnularia abaujensis
Navicula cryptocephala
Navicula sp.
Gomphonema sp
Stauroneis kriegeri

CYANOPHYCEAE
Chrococcus turgidus
Synechocystis sp.
Gloeocaspa sp.
Phormidium sp.
Lyngbya sp. r
Synechococcus sp.
Microcystis aeroginosa
Microcystis sp1
Aphanocaspa sp.
Merismopedia elegans
Gomphosphaeria sp.
Spirulina sp. r
Oscillatoria principles
Cylindrospermium majus
Nodularia muscorum
Nodularia spermigenia
Stichosiphon sp.
Rivularia sp.
Gloeotricha echinulata r
Coelosphaerium sp. r
Entophysalia sp. r
Gloeochaeta sp.
Anabaena sp.

EUGLENOPHYCEAE
Euglena sp.
Gymnozyga sp. r

DINOPHYCEAE
Cystodinium sp.
Kentosphaera sp

CRYPTOPHYCEAE
Cryptomonas sp. r

Table.2 Average seasonal variations of Physico-chemical parameters of Veeranam lake from April 2010 to September 2010.

Seasons & Stations / Parameters	Pre-monsoon					Monsoon					Post-monsoon					Summer				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
Air temperature (°C)	33	33	31.5	40.5	31.5	38	28.7	29.3	29.3	29	29.7	30	30.7	31	32	33.7	35	35	34.7	35
Water temperature (°C)	24.5	26.5	27	28	26.5	24.7	23.7	23.7	24	23.7	24	24.3	24.67	24.3	24.3	29.3	29.3	29.3	29	29.3
Turbidity (NTU)	2.25	1.82	2.2	1.85	2.25	1.5	1.53	1.53	1.5	1.5	1.5	1.4	1.6	1.5	1.5	2.3	2.27	2.23	2.3	2.3
TDS (mg/l)	540	505	540	520	522.5	452	440	445	445	437	425	429.3	478.3	430	426.7	567.7	576	573.7	578.3	566
EC (µmol/cm)	760	730	755	755	737.5	670	666.7	641.7	687.7	682	721.7	303.3	690	726.7	723.3	863.3	917.3	903.3	913.3	882
pH	7.9	7.9	8	7.95	7.85	8.5	7.47	7.47	7.57	7.27	7.9	7.9	8.1	8.1	8	8.5	8.4	8.46	8.5	8.46
Total alkalinity (mg/l)	187.5	177.5	193	177.5	167.5	145	133.7	132.3	146.3	137	141.7	140.7	145.7	143.7	146.7	210	195.7	208.7	208.3	203
Total hardness (mg/l)	155	144	145	146	145.5	160	153.3	145	150.7	160	138.7	136.7	140.7	140	146.7	211	196.7	209.3	201.7	200
Calcium (mg/l)	57.5	54	56.5	52	56.5	45	46.7	45.7	44	46.7	54.3	56	60	57.3	54.3	57.3	60	58.7	58.3	58
Magnesium (mg/l)	25.1	23.45	25.7	23.25	22.25	23.7	27.3	26.3	25	27	25.3	26.3	27.7	25.7	27	27.3	28.7	27.7	29.3	28.3
Iron (mg/l)	0.365	0.415	0.36	0.38	0.38	0.28	0.3	0.29	0.3	0.31	0.23	0.25	0.25	0.26	0.28	0.31	0.33	0.3	0.31	0.31
Ammonia (mg/l)	0.805	0.785	0.79	0.82	0.81	0.46	0.48	0.45	0.47	0.48	0.72	0.72	0.75	0.75	0.72	0.71	0.81	0.73	0.77	0.71
Nitrate (mg/l)	2.01	1.94	2.03	1.91	1.89	1.29	1.38	1.25	1.32	1.29	1.3	1.2	1.4	1.2	1.3	1.47	1.25	1.3	1.42	1.41
Nitrite (mg/l)	0.405	0.42	0.42	0.38	0.43	0.1	0.08	0.08	0.11	0.09	0.21	0.17	0.21	0.23	0.3	0.07	0.31	0.07	0.06	0.34
Chloride (mg/l)	77.5	72.5	77	77.5	77	66.7	65	66	66.7	66.3	67.3	66	71	71	68.3	74	83.3	90.7	83.7	74.3
Fluoride (mg/l)	0.285	0.255	0.31	0.305	0.24	0.19	0.19	0.19	0.17	0.18	0.25	0.27	0.27	0.28	0.3	0.31	0.33	0.37	0.33	0.34
Sulphate (mg/l)	33.5	32.5	34	34	33	23.7	24	24.7	24.7	24	34.7	32.3	31.3	30.3	33.8	29	31	31.7	32.7	30
Phosphate (mg/l)	0.24	0.255	0.26	0.26	0.235	0.28	0.5	0.31	0.29	0.3	0.19	0.25	0.18	0.23	0.2	0.23	0.28	0.25	0.26	0.246
BOD (mg/l)	19.35	19.1	18.6	19.45	18.35	14.1	14.8	15.4	14.8	14.8	9.2	8.7	8.10	9.5	10	8.7	9.5	9.2	8.7	9.1
COD (mg/l)	26.5	26	26	26	26	25.3	25.7	26.3	26.3	26.7	23.3	22.7	25.3	23.7	24	24.6	25.7	25.7	24	25

Table 3. Correlation coefficient (r) of Phytoplankton with Physico-chemical parameters of water of Veeranam lake Parameters

arameters	Pre-monsoon	Monsoon	Post-monsoon	Summer
Air temperature (°C)	0.746	-0.618	0.512	0.183
Water temperature (°C)	0.884	0.247	0.440	0.138
Turbidity (NTU)	0.212	-0.326	0.947	-0.460
TDS(mg/l)	0.592	0.235	0.271	-0.269
EC (µmol/cm)	0.183	-0.029	0.860	-0.050
pH	0.555	-0.172	0.819	0.404
Total alkalinity (mg/l)	0.943	0.268	0.818	0.569
Total hardness (mg/l)	-0.962	-0.245	0.573	0.626
Calcium (mg/l)	0.419	-0.276	0.449	-0.908
Magnesium (mg/l)	-0.247	-0.186	0.418	-0.463
Iron (mg/l)	-0.502	0.155	0.265	-0.938
Ammonia (mg/l)	-0.588	-0.581	0.662	-0.709
Nitrate (mg/l)	0.541	-0.834	0.651	0.144
Nitrite (mg/l)	0.457	0.217	0.558	-0.397
Chloride (mg/l)	0.127	0.628	0.875	-0.294
Fluoride (mg/l)	0.200	-0.237	0.265	0.609
Sulphate (mg/l)	0.246	0.560	-0.259	0.088
Phosphate (mg/l)	0.379	0.279	-0.582	-0.344
BOD (mg/l)	-0.942	0.438	0.454	-0.179
COD (mg/l)	-0.355	0.539	0.147	0.113

thereby slowing down primary production rates (Stolpe and Moore, 1997). On the contrary comparatively high phytoplankton density and diversity at S1, S2&S5 can be attributed to release of nutrients in the water through riparian vegetation and thus promoting algal growth (Backhurst and Cole, 2000).

The assemblages of phytoplankton in Veeranam 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 analyses provide a better understanding of the lake's present condition and their information can be used to mitigate negative effects.

4.REFERENCES

APHA 2005. Standard methods for examination of water and waste water. 21st edition, Washington D.C., U.S.A. bacterial analysis of drinking borewell and sewage water in three different places of Sivakasi. J. Environ. Biol., **28:** 105-108.

Chowdhury, M. M. R., Mondol, M. R. K. and Sarker, C. (2007). Seasonal variation in plankton population of Borobila beel in Rangpur district. Univ. J. Zool. Rajshahi Univ., **26:** 49 -54.

Costanza, R., d'Arge, R., Groot, Rde., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R.V., Paruelo, J., Raskin, R.G., Sutton, P. and Vandenbelt, M. (1997). The value of the world's ecosystem services and natural capital. Nature, **387:**253-260.

Descy, J. P. (1987). Phytoplankton composition and dynamics in river Meuse (Belgium). Arch. Hydrobiol., **2:** 225-247.

Devaraj, K.V., Mahadeva, H.S. and Pazal, A.A. 1988. Hydrobiology of the hemavathy reservoir. In: M. Mohan Joseph (ed.). The first Indian Fisheries Forum. Proceedings. Asian Fisheries Society. Indian Branch. Mangalore. Pp. 323-327.

Flood, D. (1996). Irrigation water quality for BC Greenhouses. A report of Floriculture Fact Sheet, Ministry of Agriculture, Fisheries and Food. British Columbia.

Garg, S. K., Kalla, A. and Bhatnagar, A.(2002). Experimental Ichthyology. CBS Publishers, New Delhi, pp: 172.

Goldman, R. C. and Horne, A. J. (1983). Limnology. Mc Graw-Hill Book Company, New York.

Harris, G. P. (1980). Spatial and temporal scales in phytoplankton ecology. Mechanisms, methods, models and management. Can. J. Fish. Aquat. Sci., **37:** 877–900.

Iqbal, F., Ali, M., Abdus, S., Khan, B.A., Ahmad, S., Qamar, M. and Umer, K. (2003). Seasonal variation of physico-chemical characteristics of River Soan water at Pathan Bridge (Chakwal), Pakistan. Int. J. Agri. Biol., 1560-8530.

Izaguirre, I., OOFarrell, I. and Tell, G. (2001). Variation in phytoplankton composition and limnological features in a water-water ecotone of Lower Parana Basin (Argentina). Freshwater Biol., 46: 63-74.

Joshi, B. D., Pathak J. K., Singh, Y. N., Bisht, R. C. S., Joshi, P. C. and Joshi, N. (1993). Assessment of water quality of river Bhagirathi at Uttarkashi. Him. J. Environ. Zool., 7: 118-123.

Kobbia, I. A. (1982). The standing crop and primary production of phytoplankton in Lake Brollus, Egypt. J. Bot., **25** (1-3): 109-127.

Kolawole O.M., Ajibola T.B., Osuolale O.O. 2008; Bacteriological Investigation of a wastewater discharge run-off stream in Ilorin, Nigeria. J. Appl. Environ. Sci. **4:**33–37.

Kumar, S., Singh, A., Dajus, D. and Biswas, S.P. 2009. Physico-chemical parameters and fish enumeration of Maijan beel (Wetland) of upper Assam. Geobios. 36: 184-188.

Liddle, M. J. and Scorgie, H. R. A. (1980). The effects of recreation on freshwater plants and animals: a review. Biol. Conserv., **17:** 183-206.

Pandey, B. N., Misra, A. K. and Jha, A. K. (1993). Phytoplankton population of the river Mahanandi Kathihar (Bihar). Environ. Ecol., 11 **(4):** 936-940.

Pathak, V., Mahavar, L. R. and Sarkar, A. (2001). Ecological status and production dynamics of stretch of river Mahanadi. J. Inland Fish. Soc. India, 33(1): 25-31.

Pazhanisamy, S. 2005. Reservoir ecology of lower anaicut Thanjavur District, Tamil Nadu, Ph.D. Thesis, Bharathidasan University, p. 136.

Pearl, H. W. (1995). Ecology of blue-green seaweed in aquaculture ponds. J. W. Aquacul. Soc., **26:** 109–131.

Polli, B. and Simona, M. (1992). Qualitative and quantitative aspects of the evolution of the planktonic population in lake Lugano. Aquat. Sci., **54:**303-320.

Prescott, G. W. (1954). How to Know the Freshwater Algae Iowa: Wm. C. Brown Co. Dubuque.

Radha Krishnan, R., Dharmaraj, K. and Ranjitha, D. B. (2007). A comparartive study on physico-chemical and

Rapport, D. J., Costanza, R. and McMichael, A. J. (1998). Assessing ecosystem health. Trends Ecol. Evol., 13**(10):**397-402.

Richardson, T. L., Gibson, C. E. and Heaney, S. I. (2000). Temperature, growth and seasonal succession of Phytoplankton in Lake Baikal, Siberia. Freshwater Biol., 44: 431-440.

Sala O.E., Chapin III F.S., Armesto J.J., Berlow E., Bloomfield J., Dirzo R., Huber-Sanwald E., Huenneke L.F., Jackson R.B., Kinzig A., Leemans R., Lodge D.M., Mooney H.A., Oesterheld M., Poff N.L., Sykes M.T., Walker B.H., Walker M. and Wall D.H. (2000), Global biodiversity scenarios for the year 2100, *Science*, **287**, 1770–1774.

Shastri, Y. and Pendse, D. C. (2001). Hydrobiological study of Dahikuta reservoir. J. Environ. Biol. 22(1):67-70.

Stark J.R., Hanson P.E., Goldstein R.M., Fallon J.D., Fong A.L., Lee K.E., Kroening S.E., Andrews W.J. Water Quality in the Upper Mississippi River Basin, Minnesota, Wisconsin, South Dakota, Iowa, and North Dakota, 1995–98. United States Geological Survey; Reston, VA, USA: 2001.

Stolpe, N. E. and Moore, M. (1997). Boating workshop raises tough questions, [Online], Available: http://www.fishingnj.org/artobm2.htm [15/02/08].

United Nations Environment Programme Global Environment Monitoring System/Water Programme. Water Quality for Ecosystem and Human Health. National Water Research Institute; Burlington, ON, Canada: 2000.

Varshney, C. K. (1989). Water pollution and management. Wiley Eastern Ltd, New Delhi, 4-5.

Welch, T.S. 1952. Limnology (2nd Ed). McGraw Hill Book Co. New York, p. 538.

Westman, W. E. (1977). How much are nature's services worth? Science, **197:**960-964.

Wetzel, R. G. (1983). Limnology, 2nd Edition. Saunders, USA, 767.

Zalids, G., Stamatiadis, S., Takavakoglou, V., Eskridge, K. and Misopolinos, N. 2002. Impacts of Agricultural Practices on soil and Water Quality in the Mediterranean Region and Proposed Assessment Methodology. Agriculture, Ecosystems and Environment, **88:**137-146.

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