Available online at www.worldscientificnews.com

World Scientific News

WSN 54 (2016) 153-164 EISSN 2392-2192

Study of physico-chemical parameters and phytoplankton diversity of Ousteri lake in Puducherry

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ABSTRACT

The present study was carried out in the Ousteri lake (Puducherry State) from October 2013 to September 2014. The samples were collected during morning hours and were analysed monthly for physical, chemical and biological parameters. The various physico-chemical parameters like Water temperature, pH, Free CO_2, Dissolved Oxygen, Turbidity, Electrical conductivity, Total dissolved solids, Total alkalinity, Chloride, Phosphate, Nitrate, Biological oxygen demand and Chemical oxygen demand were analyzed. Results have shown an increased concentration in physico-chemical parameters is more in summer compared to other seasons. The plankton studies were noticed that a total of 34 species belonging to 26 genus under the 4 classes. Among these, Cyanophyceae comprised of 15 species (belonging to 11 genera) followed by Chlorophyceae 9 species (belonging to 7 genera), Bacillariophyceae 7 species (belonging to 6 genera) and Euglenophyceae 3 species (belonging to 2 genera) were recorded. During the study it was found that Cyanophyceae algal growth is dominated over Chlorophyceae, Bacillariophyceae and Euglenophyceae.

***Keywords*:** Ousteri lake; Physico-chemical analysis; Phytoplankton

1. INTRODUCTION

Water is important component of all living beings. It also performs unique and indispensible activities in earth ecosystem, biosphere and biogeochemical cycles. The freshwater resource is becoming day by day at the faster rate of deterioration of the water quality is now a global problem [1]. The threats to global freshwater biodiversity can be grouped under five interacting categories *viz*., over exploitation, water pollution, flow modification, destruction or degradation of habitat and invasion by exotic species [2]. The limnology is the study of inland waters i.e. lakes (both freshwater and saline), reservoirs, rivers, streams, wetlands and groundwater as ecological systems interacting with their drainage basins and the atmosphere. Declines in biodiversity are far greater in freshwaters than in the most affected terrestrial ecosystem [3].

These lakes therefore demand concerted attention towards a clear understanding of their ecosystem in order to take water being polluted is not used for drinking purpose. Local inhabitants use water for various purposes like bathing, washing clothes, swimming and cleaning cooking utensils. Inlets pouring water into lake also carrying chemical fertilizers and insecticides which further pollute the water. Biological assessment is a useful alternative for assessing the ecological quality of aquatic ecosystems since biological communities integrate the environmental effects of water chemistry of rivers and lakes [4].

Eutrophication is a global phenomenon associated with nutrient enrichment of aquatic ecosystem. In natural course it is slow process of lake aging ultimately lead to succession. Lakes have a more complex and fragile ecosystem as they do not have a self-cleaning ability and therefore readily accumulate pollutants. The increasing anthropogenic influence in recent years in and around aquatic systems and their catchment area have contributed to a large extent to deterioration of water quality and dwindling of water bodies leading to their accelerated eutrophication.

Physical properties such as temperature, light penetration and water movement play important role in plankton's distribution and lake stratification. These factors combine with each other to determine the water quality and consequently community of the lake. Physico-chemical characteristic of lake can be significantly altered by human activities such as various agricultural practices and irrigation as well as natural dynamics which consequently affect the water quality and quantity, species distribution and diversity, production capacity and even disruption in the balance of ecological system operating in the lake.

Phytoplankton is the primary producer community and consists mainly of algae such as diatoms, dinoflagellates and a variety of forms from other divisions of the plant kingdom. Phytoplankton constitutes the very basis of nutritional cycles of an aquatic ecosystem. They form a bulk of food for zooplankton, fishes and other aquatic organisms. The phytoplankton composition was influenced by so many factors and they change according to ecological changes. The phytoplankton biomass and community composition is important for the understanding the structure and dynamics of the ecosystem [5]. Phytoplankton as primary producers, form an important source of energy and basis for life in the aquatic environment. Hence, production at the higher tropic levels depends ultimately on photosynthetic primary production. The phytoplankton in a waste body is an important biological indicator of the water quality. Therefore certain groups of phytoplankton, especially blue green algae can degrade recreational value of surface water particularly thick surface scum, which reduces the use of amenities for contact sports (or) large concentrations.

Some of these lakes are already on the verge of disappearance due to eutrophication. These lakes therefore demand concerted attention towards a clear understanding of their ecosystem in order to mitigate further deterioration. The main objectives of the study were to determine the present status of phytoplankton diversity and water quality in Ousteri lake and to study the effect of physico-chemical parameters on phytoplankton population, species composition and community organization.

2. MATERIALS AND METHODS

2. 1. STUDY AREA

Ousteri Lake, located around 11°56′ - 11°58′ North and 79°44′ - 79°45′ East, is a large shallow wetland situated along the eastern boundary of Puducherry (Figure 1). It is an inter-state lake with the water-spread area almost equally shared between the states of Puducherry and Tamil Nadu. The lake covers an area of about 800 ha of which 390 ha is in Puducherry and the rest in Tamil Nadu. Ousteri is the largest lake in Puducherry and is also one of the important wetlands of Asia.

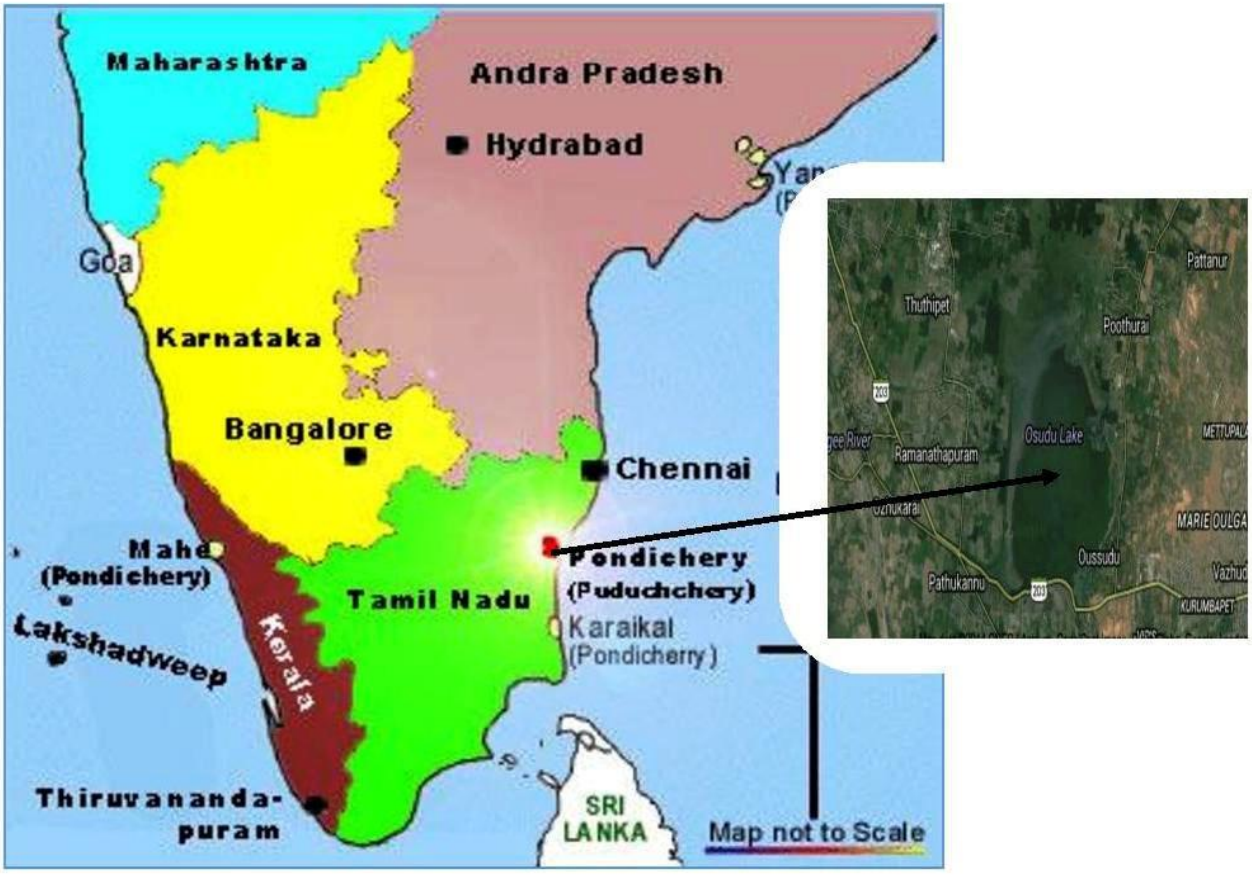


Figure 1. Geographical location of Ousteri lake in Puducherry.

2. 2. COLLECTION OF WATER SAMPLES

The surface water sample has been collected in the morning between 8.00 am to 10.00 am regularly at an interval of a month during October 2013 to September 2014.

2. 3. PHYSICO-CHEMICAL PARAMETERS ANALYSIS

The majority of the analysis was conducted within three days of collection of the samples. Temperature and pH are conducted in the field. Free Carbon-dioxide (FCO_2), Dissolved Oxygen (DO), Total alkalinity, Turbidity, Electric conductivity (EC), Total dissolved solids (TDS), Chloride, Phosphate, Nitrate, Biological oxygen demand (BOD) and Chemical oxygen demand (COD) are conducted in the laboratory following Trivedy and Goel [6] and APHA [7].

2. 4. PHYTOPLANKTON ANALYSIS AND IDENTIFICATION

Phytoplankton material at different sampling point was collected by filtering 200 ml of water through the nylon bolting cloth (mesh 25nm). Plankton samples (200 ml) were kept for about 24h to settle samples were stored in small vials and diluted to 50 ml with distilled water. The diluted samples were used for further investigation. For microscopic investigation one ml sample was taken on "Sedgewick Rafter Cell". The averages of 5 to 10 counts were made for each sample and the results are expressed as numbers of organism per litre of sample. The identification of phytoplankton was done with the help of standard books and monographs [8,9]. Phytoplankton count was done by APHA [7].

Formula used for the calculation of phytoplankton as units /1 is

$$\text{Phytoplankton unit /L} = \frac{n \times v}{V} \times 1000$$

where,

N = Number of Phytoplankton counted in 0.1 ml concentrate.

C = Total volume of concentrate in ml

V = Total volume of water filtered through net.

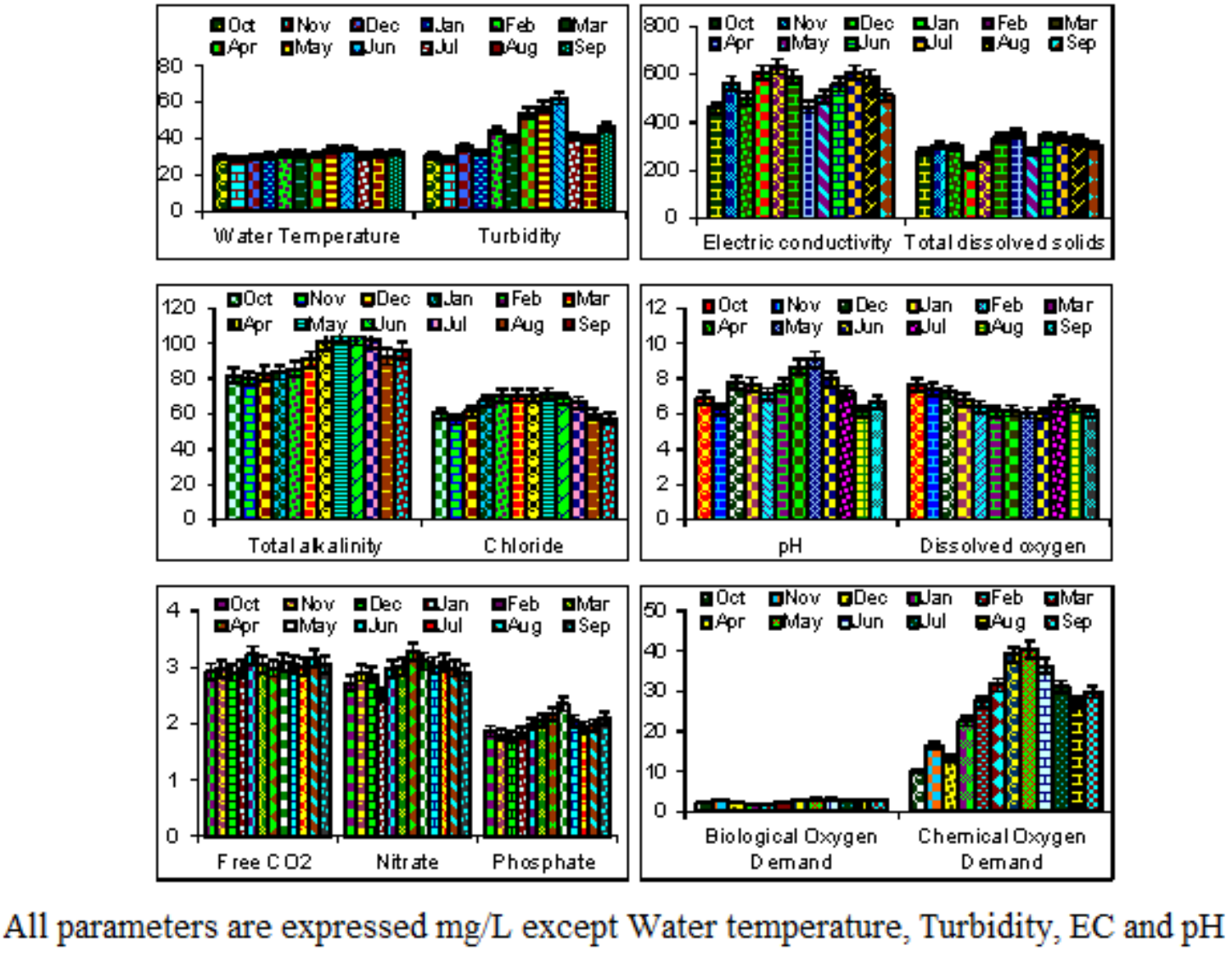
3. RESULTS AND DISCUSSION

3. 1. PHYSICO-CHEMICAL PARAMETERS

The physico-chemical parameters of Ousteri lake is shown in Graph 1. The water temperature of Ousteri lake ranges from 29.2 °C to 34.5 °C. The highest temperature was noted during the summer season and the lowest was recorded during the monsoon season. All metabolic and physiological activity and life process such as feeding, reproduction, movements and distribution of aquatic organisms are greatly influenced by water temperature. Surface temperature closely reflected to ambient air temperature. This is particularly true for lakes and ponds like in present study [10]. The variation in the water temperature in present investigation may be due to the difference in sampling time and the effect of season [11,12] and presence of more domestic sewage.

The pH value recorded ranges from 6.27 to 9.1. The highest value of pH was recorded during summer season and the lowest was recorded during monsoon season. The low value during monsoon may be due to dilution of rain water. High pH values promote the growth of algae and results in heavy bloom of phytoplankton [13]. The pH values above 8 in natural water are produced by photosynthetic rate that demand more CO_2 than quantities furnished by respiration and decomposition.

Suspension of particles in water interfering with passage of light is called turbidity. Turbidity value ranges from 29.1 NTU to 61.9 NTU. The high value was recorded during summer season and low value was recorded during monsoon season. The findings are in conformity with Jain [14] and Verma *et al*. [15]. The maximum values of turbidity in summer may be due to rainfall and surface runoff of water bringing a lot of sediments from the surrounding area.



Graph 1. Physico-chemical analyses of Ousteri lake (October 2013 to September 2014)

The EC ranges from 459.1 µS/cm to 606.6 µS/cm. The high value of conductivity was recorded during the pre monsoon season where as low value was recorded during monsoon season. EC in the water is due to salt present in water and current produced by them. Conductivity of water depends upon the concentration of ions and its nutrient status and variation in dissolve solid content. Similar results were observed by various workers [16,17]. The water during summer decreases as a result of death and decay of plants and animals.

TDS are the solids present in water in the dissolved state. TDS ranges from 215.9 mg/l to 354.7 mg/l. The high amount of TDS was recorded during summer season where as low amount of TDS was recorded during post monsoon season. In natural water dissolved solids are composed mainly of carbonates, bicarbonates of calcium, magnesium, sodium, potassium, iron and manganese *etc*. TDS denote mainly the various kinds of minerals present in the water. The high value of TDS during summer may be due to addition of domestic waste water, garbage and sewage etc. in the natural surface water body [18]. Increased high concentration of TDS increases the nutrient status of water body which was resulted into eutrophication of aquatic bodies [19]. The water containing more than 500 mg l^{-1} of TDS does not qualify for drinking purposes.

The total alkalinity recorded for different seasons in the lake ranges from 80.2 mg/l to 105.8 mg/l. The peak value of alkalinity was recorded during monsoon season and the least value of alkalinity was recorded during summer season. Alkalinity in most natural water is the function of bicarbonate and carbonates. Their salts get hydrolyzed in solution and produced hydroxyl ion. The degradation of plants and other organism and organic waste might also be one of the reason for the increase in carbonate and bicarbonate thereby the alkalinity [20]. A lake water alkalinity may result due to waste discharge, microbial decomposition of organic matter in the water body.

The value of FCO_2 recorded in Ousteri lake ranges from 2.91 mg/l to 3.22 mg/l. The high value of FCO_2 was recorded during the post monsoon season where as low value was recorded during monsoon season. FCO_2 is one of the essential constituents of an aquatic ecosystem. The abundance of carbon dioxide exerts certain specific effects of aquatic biota. Telkhade *et al*. [21] reported the maximum CO_2 value in month of March. The present study clearly indicated the fluctuations in free carbon dioxide values corresponded directly with changes in the productivity values.

The amount of DO is higher in those places where there is a good aquatic life. DO ranges from 6.01 mg/l to 7.66 mg/l. The maximum value of dissolved oxygen was recorded during monsoon season and the minimum value was recorded during summer season. The oxygen in water can be dissolved from air or is produced from the photosynthetic organism like algae and aquatic plants. Oxygen is poorly soluble gas in water and it solubility depend on the temperature of water and its partial pressure has established a direct relationship between photosynthesis and DO. DO is affected by the photosynthetic activity and aeration rate. Results of the present study are similar to those reported by [16,17].

The chloride concentration was used as an important parameter for detection of contamination by sewage. The value of chloride ranges between 56.8 mg/l and 70.8 mg/l. Chloride concentration in the form of chloride ions is one of the major inorganic anions in water [22]. In general, it occurs in the discharges of effluent from industries, sewages, irrigation wastes etc. [23]. The chloride content showed marked seasonal variation being maximum during summer and minimum during monsoon season, which is in agreement with the observation made by [16,17].

The amount of nitrate ranges from 2.52 mg/l to 3.28 mg/l. The high amount of nitrate was recorded during monsoon season and the low amount was recorded during post monsoon season. Nitrates are contributed to fresh water through discharge of sewage, industrial wastes and runoff from agricultural fields. Higher concentration may be due to influx nitrogen rich flood water and bring about large amount of sewage. The monsoon season was period with the highest nitrate-nitrogen concentration which is known to support the formation of blooms [24].

Phosphate is the key nutrient also causing eutrophication leading to extensive algal growth. Phosphate content in a lake may be due to release of phosphate from bottom sediment and organic load of the water, this helps in growth of the phytoplankton and weeds in the lake. The amount of phosphate recorded in the lake ranges between 1.77 mg/l to 2.35 mg/l. The highest seasonal values were reported during post monsoon season and lowest during monsoon season, is in the conformity with the findings of various workers [16,18].

The BOD refers to the amount of oxygen used by microorganism in the aerobic oxidation of organic matter. The BOD recorded in the lake ranges between 1.82 mg/l to 3.17 mg/l. The maximum values was recorded during summer season where as the minimum value was recorded during post monsoon season. BOD is dissolved oxygen required by micro organism for aerobic decomposition of organic matter present in water. Jain and Dhanija [25] have considered BOD as an important parameter in aquatic ecosystem to establish the status of pollution. High BOD during summer / pre monsoon season may be due to the presence of several microbes in water bodies which accelerate their metabolic activities with the increase in concentration of organic matter.

Prasanna Kumari *et al*. [26] also stated that the higher values of BOD during summer was also due to input of organic wastes and enhanced bacterial activity. High temperatures do play an important role by increasing rate of oxidation. The BOD of unpolluted water is less than 1.00 mg l^{-1}, moderately polluted water 2.00-9.00 mg l^{-1} while heavily polluted water have BOD more than 10.00 mg l^{-1} [27].

The COD recorded in the lake ranges between 10.2 mg/l to 40.5 mg/l. The maximum values was recorded during summer season were as the minimum value was recorded during monsoon season. The high COD values indicate that some degree of non-biodegradable oxygen demanding pollutants were present in the water [28].

3. 2. PHYTOPLANKTON DIVERSITY

Phytoplankton the major producer of all aquatic ecosystems shows a great diversity. The most important advantage of biological methods is that they directly measure the results of pollution. The plankton studies were noticed that a total of 34 species of plankton belonging to 26 genus under the 4 classes (Table 1).

Among these, cyanophyceae comprised of 15 species (belonging to 11 genera) followed by chlorophyceae 9 species (belonging to 7 genera), bacillariophyceae 7 species (belonging to 6 genera) and euglenophyceae 3 species (belonging to 2 genera) were recorded. Maximum density of phytoplankton was recorded in summer and minimum in monsoon season. Similarly Laskar and Gupta [29] reported minimum density of phytoplankton during monsoon and maximum during summer in Chatla Lake, Assam. High density of phytoplankton in summer was observed by [30,31].

3. 3. CYANOPHYCEAE

Table 1. List of Micro algae at Osuteri lake in Pondicherry (October 2013 - September 2014)

Sl. No	Name of the Micro algae	Month											
		Monsoon			Post Monsoon			Summer			Pre Monsoon		
		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
	Class: Cyanophyceae												
01	*Chroococcus minor* (Kutz.) Nageli	-	-	-	-	-	-	+	+	+	+	-	-
02	*Marssoniella elegans* Lemm.	-	-	-	-	+	+	+	+	+	+	-	-
03	*Microcystis aeruginosa* (Kutz.) Kirchner	-	-	-	+	+	+	+	+	+	+	+	+
04	*Lyngbya shackletoli* West	+	+	+	-	-	-	-	-	-	+	+	-
05	*Oscillatoria curviceps* Ag. ex Gomont	+	+	+	+	+	+	+	+	+	+	+	+
06	*Oscillatoria subbrevis* Schmidle F. Crassa	-	-	-	+	+	+	+	+	-	-	-	+
07	*Spirulina major* (Kütz.) Gomont	-	-	+	-	+	-	+	+	-	+	+	+
08	*Spirulina princeps* Voucher ex. Gomont	-	+	-	+	+	-	-	-	-	-	-	+
09	*Anabaena spiroides* Klebahn	+	+	+	+	+	+	+	+	+	+	+	+
10	*Nostoc pruniforme* Ag.	+	+	+	+	+	+	+	+	+	+	+	+
11	*Oscilltoria tenuis* Ag. Ex Gomont	+	+	+	+	+	+	+	+	+	+	-	+
12	*Phormidium uncinatum* Beck	+	+	+	+	+	-	+	+	-	-	-	+
13	*Chroococcus minor* (Kutz.) Nageli	-	-	+	-	+	-	+	-	-	+	+	-
14	*Arthrospira plantensis* Nordst	-	-	+	+	+	+	+	+	+	-	-	+
15	*Aphanocapsa grevillei* (Hass.) Rabenh	-	-	-	-	+	+	+	+	+	+	+	+
	Class: Chlorophyceae												
16	*Pediastrum* sp	+	+	+	+	+	+	+	+	+	+	+	-
17	*Chloroccum humicola* Lieb.	+	+	+	+	+	+	+	+	+	+	+	+
18	*Chlorella pyrenoidosa* Chick	-	-	-	-	-	+	+	+	-	+	-	-
19	*Chlorella vulgaris* Beyernick	+	+	+	+	+	+	+	+	+	+	+	+
20	*Scenedesmus acc uminatus* Kutz.	-	-	-	-	-	-	+	-	-	+	-	-
21	*Scenedesmus obliquus* (Turp.) Breb.	-	-	+	+	+	+	+	+	-	-	-	-
22	*Cladophora crispate* (Roth) Kutz.	-	-	-	-	-	+	+	+	-	+	+	+
23	*Spirogyra* sps.	+	+	+	+	+	+	+	+	+	+	+	+
24	*Closterium purvulum* Nageli	-	-	-	-	-	-	+	+	+	+	+	+
	Class: Bacillariophyceae												
25	*Cyclotella striata* Kutz.	+	+	+	+	+	+	+	+	+	+	+	+
26	*Gyrosigma spencerii* Kutz.	-	-	-	+	+	+	+	+	-	+	+	+
27	*Actinella punctata* lewis.	-	-	-	-	-	-	-	+	+	+	+	-
28	*Navic ula cincta* Kutz.	+	+	+	-	-	-	+	-	+	+	-	-
29	*Cymbella aspera* Kutz.	-	-	+	+	+	+	+	+	+	-	-	-
30	*Pinnularia cymbiformis* Ehr.	-	-	-	-	-	+	+	+	+	-	-	-
31	*Pinnularia gibba* Ehr.	-	-	-	-	-	-	+	+	+	-	-	-
	Class: Euglenophyceae												
32	*Euglena viridis* Ehr.	-	-	+	+	+	+	+	+	+	+	+	+
33	*Euglena convolute* Korsch	-	-	-	+	+	+	-	+	-	+	+	-
34	*Phacus tortus* Her.	-	-	+	+	+	+	-	-	-	+	+	-

(+) = Present, (-) = Absent.

This is distinctive group of algae in which the pigment are localized in the peripheral portion of protoplast and include chlorophyll a, Carotene, distinctive Xanthophyll, blue pigments (C - Phycocyanin) and a red pigment (C-Phycoerythrin). Another unique feature of cyanophyceae is the primitive type of nucleus, which lack nucleolus and nuclear membrane. These algae can tolerate very high range of temperature and form the dominant group. In the present study in Ousteri lake, 15 genera of cyanophycean algae were recorded (Table 1) as dominant species such as *Anabaena spiroides*, *Nostoc pruniforme*, *Microcystis aeruginosa*, *Phormidium unicinatum*, *Oscillatoria* sp., and *Arthrospira platensis*.

In Ousteri lake it was found that cyanophyceae algal growth is dominated over chlorophyceae, bacillariophyceae, and euglenophyceae. In the present investigation, the density of cyanophyceace in Ousteri lake was found to be maximum during summer season. It may be due to higher water temperature.

Nirmal Kumar and Cini Oommen [32] were of the opinion that high temperature favours the luxuriant growth of blue-greens. This is clear from the result that Cyanophyceae were lowest during monsoon months, when the water column was remarkably stratified to a large extent because of heavy rainfall, high turbidity caused by run-off, reduced salinity, decreased temperature and pH, overcast sky and cool conditions. Physico-chemical parameters like pH, dissolved oxygen, phosphate, nitrate, total alkalinity, BOD and COD may have influenced the growth of cyanophyceae [28]. Rajagopal *et al*. [33] and Kensa [34] have also demonstrated the similar dominance among cyanophycean phytoplankton in their respective lentic water bodies.

3. 4. CHLOROPHYCEAE

The chlorophyceae is a group of algae having their photosynthetic pigments localized in chromatophores which are grass-green because of the predominance of chlorophyll '*a*' and 'b' over the carotene and xanthophylls. Photosynthetic reserves usually stored as starch. In the present study 9 genera of chlorophyceae class were recorded throughout the period (Table 1) such as *Spirogyra* sp., *Scenedesmus obliquus*, *Pediastrum simplex*, *Pediastrum tetras*, *Chlorella* sp. and *Chlorococcum humicola*. The minimum units of algae of chlorophyceae class were recorded during monsoon season and maximum units were recorded during pre monsoon season. Chlorophyceace are free living and planktonic, mostly confined to lake water and are attached to the submerged plants or found on moist soil [35]. Chlorophyceae was widespread and second dominant group among the plankton. The presence of chlorophyceae might be due to high dissolved contents. High turbidity has adverse effect on phytoplankton abundance by absorbing solar energy in the surface layer on water and thus impairing photosynthesis which cause a sharp fall in phytoplankton density. High rain fall dilution and over flooding in the water bodies, water are also playing devastating role in the phytoplankton growth. This finding was also made by [36,37].

3.5. BACILLARIOPHYCEAE

This group includes a large number of unicellular and colonial genera which differ from other algae in the shape of their cells. The main characteristic feature of diatoms is the presence of highly silicified cell wall which is composed of two overlapping values. In the present study total 7 genera of bacillariophyceae (Table 1) such as *Cyclotella striata*, *Gyrosigma spencerii*, *Cymbella aspera* and *Cymbella cymbiformi* were recorded throughout the study. The minimum units were recorded during monsoon season and maximum unit were

recorded during summer season. A number of factors influenced the distribution of diatoms in water body, such as change in water temperature [38] light and irradiance of water. Harikrishnan *et al*. [39] stated that alkaline pH favours the abundance of diatomic population.

3. 6. EUGLENOPHYCEAE

Euglenophytes are free-swimming algal flagellates found in a variety of freshwater and marine environments. Englenoid algae (Euglenophyceae) are relatively large and diverse. Few species are truly planktonic. In the present study 3 genera of eugleophyceae class were recorded throughout the study (Table 1) as dominant species such as *Euglena viridis*, *Euglena convolute* and *Phacus tortus*. The minimum units of euglenoid were recorded during monsoon and maximum during post monsoon. Euglenoids grow luxuriantly and often develop in to water blooms in water, which are organically rich. Hassan *et al*. [40] reported minimum density of phytoplankton during monsoon and maximum during post monsoon followed by summer in Euphrates river, Iraq. Similarly [29] reported minimum density of phytoplankton during monsoon and maximum during post monsoon followed by summer in Chatla Lake, Assam. Milind and Hujare [41] have considered that free carbon dioxide, dissolved oxygen, phosphate are the chief factors that regulate the distribution of Euglenoids in the fresh water bodies and also reported phytoplankton density in different seasons in order of summer > monsoon > pre monsoon.

4. CONCLUSION

Results obtained suggest that Ousteri lake is moderately polluted and showed a trend of increasing eutrophication. Richness in nitrogen and orthophosphates were favourable for growth of phytoplanktons. Dominance of Cyanophyceae in summer and pre monsoon seasons, second dominance species (Chlorophyceae) in pre monsoon, Bacillariophyceae in summer season and euglenophyceae in post monsoon season showed distinct seasonal variation in the distribution of phytoplankton. During the study it was found that Cyanophyceae algal growth is dominated over Chlorophyceae, Bacillariophyceae and Euglenophyceae. Most of the dominant species of phytoplankton were not considered as harmful and dangerous for human health. However certain species like *Anabaena*, *Microcystis* and *Oscillatoria* are known to produce certain neurotoxin, hepatotoxin and skin damages. Cyanophycean members are highly tolerant organisms; they prefer to grow at higher temperatures and highly alkaline, BOD and COD waters. Hence they can withstand high levels of contaminated waters. It is recommended that the proper maintenance of the water bodies is necessary. Proper sanitation measures and environmental education to public care are essential to keep these water bodies clean and safe. A few efforts like diversion of sewage, presentation of leaching of nutrients from catchment area through plantations would definitely yield healthy hygienic and sustainable environment.

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(Received 14 August 2016; accepted 29 August 2016)