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PRELIMINARY SURVEY OF PHYTOPLANKTON LAKHAL LAKE DAM (SOUTHEAST OF ALGERIA) BY USING PALMER AND NYGAARD'S ALGAL INDEX

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Abstract

In present investigation, algal communities which are used as indicator of organic pollution were reported from three stations of Lakhal reservoir over a two-years period (April 2006-March 2008). Total of 258 taxa have been identified, among these 117 species belonged to Chlorophyceae, 67 species to Bacillariophyceae, 38 species to Cyanophyceae, 17 species to Euglenophyceae, 9 species to Pyrrophyta, 7 species to Xanthophyta and 3 species to Rhodophyta. Chlorophyceae members constituted the dominant phytoplankton group in terms of species number. In the same time, the physico-chemical water quality of Lake was monitored in order to bridge the information on its limnology. The mean values of temperature of water, electrical conductivity (EC), pH, dissolved oxygen percent saturation (DO), nitrates, nitrites, sulfates, ammonia, inorganic phosphorous, chloride, sodium, calcium, magnesium, organic matter (Org. m.) and chlorophyll a (Chl. a) were analyzed to assess the trophic status of Lakhal reservoir. A statistical analysis was done using the Principal Component Analysis (PCA). The most pollution tolerant species of *Euglena, Phacus, Phormidium, Oscillatoria, Microcystis, Scenedesmus, Eudorina, Pandorina, Pediastrum, Chlamydomonas, Closterium and Nitzschia* listed. These are pollution tolerant genera and species according to Palmer (1969). The algal communities indicate that the reservoir was highly organically polluted. The Nygaard's compound index value and composition of phytoplankton indicate that the trophic state of Lakhal Dam Lake was eutrophic.

Keywords: Lakhal Dam Lake, Algal biodiversity, water quality, Palmer index, Nygaard's index, Algeria

1. INTRODUCTION

Reservoirs are recognized an aquatic ecosystems that harbor high biological diversity, provide sustenance for millions of people and face ongoing threats as a result of human activities throughout the world (Gopal & Chauhan 2001). Many aquatic organisms show sensitivity to physical and chemical changes in aquatic environment which they live (Shiklomanov, 1999). Algae that form the source of food and oxygen for heterotrophic organisms in aquatic habitats, directly affect primary productivity by forming first circle of food chain. And also, it is reported that the algae have a role in determining water pollution and cleaning waste water (Colak & Kaya, 1988). Phytoplankton abundance in a water body reflects the average ecological condition and, therefore, it may be used as an indicator of water quality (Bhatt et al. 1999; Saha et al. 2000). Population pressure, urbanization, industrialization and increased agricultural activity have significantly contributed to the pollution and toxicity of aquatic ecosystems. Continuous monitoring of the quality of aquatic ecosystems is one of the best protection techniques and recently, "using biological organisms for environmental monitoring" is the most popular topic for the scientific community (Atici & Ahiska, 2005; Tokatli, 2013). Palmer (1969) also demonstrated that algal assemblages could be used as indicators of clean or polluted water. Similarly Myxophyceae and Chlorophycean forms have been reported to reflect specific state of aquatic habitats on the basis of Nygaard's indices.

To date any studies have been conducted to investigate the Lakhal Dam Lake, this is the first report on the phytoplankton composition of this Dam Lake, one of the drinking water resources of the Bouira area. The aim of the study is to determine the diversity of the phytoplanktonic algal flora of the Lakhal reservoir and the determination of water quality using algae as biomonitors.

2. MATERIALS AND METHODS

2.1. Study area

The Lakhal Lake Dam (altitude: 670 m, depth 45 m) is located at 36°15'44"N, 3°42'55"E and about 4 km southeast of Ain Bessem near Bouira (80 km southeast of Algiers). It is established at the confluence of the Lakhal and Fahem rivers. The water samples for physico-chemical and plankton analysis were collected near the surface on a monthly basis for the calendar year 2006-2008 from three monitoring stations.

2.2. Physico-chemical analysis

Fourteen water quality parameters were selected for analysis in this study: temperature, pH, oxygen saturation (O. Saturation); Nitrate (NO_3^-);

Nitrite ((NO_2^-); sulphate (SO_4^{2-}); ammoniac (NH_4^+); phosphates (PO_4^{3-}); sodium (Na^+); chloride (Cl^-); calcium (Ca^{2+}); magnesium (Mg^{2+}) and organic matter (Org. m.) with standard methods for the examination of water and wastewater (APHA, 1998; Rodier, 1984). Chlorophyll-a was determined spectrofluorimetrically.

2.3. Phytoplankton Analysis

The phytoplankton samples were collected using a 105 μm mesh size planktonic net from 0.5 m depth of the water column and were preserved in 4% formalin for further analysis. The water samples were allowed to sediment for microscopic identification of plankton. For quantitative analysis, one drop of sample was taken on a clean glass slide and phytoplankton were counted by Lackey's drop count method, in which the coverslip was placed over a drop of water on the slide and the whole of the coverslip was examined by parallel overlapping strips to count all the organisms in the drop. About 20 strips were examined in each drop. The number of subsamples to be taken depended on examining 2 to 3 successive subsamples without any addition of encountered species when compared to the already examined subsamples (Trivedy & Goel, 1984). The results obtained were expressed as number of organisms per ml. The phytoplankton analyzed was assigned to major groups, namely green algae (Chlorophyta), blue green algae (Cyanophyta), Diatoms (Bacillariophyta), Pyrrophyta, Rhodophyta and Euglenophyta.

The identification of phytoplankton was carried out with the help of standard books and monographs (Bourrelly, 1966; 1968; 1970; Anagnostidis & Komárek, 1988;1990; Komárek & Anagnostidis, 1986; 1989; 1999; 2005); Opute (1992 and 2000).

2.4. Data treatment and statistical analysis

Both the biological and physico-chemical parameters were subject to statistical analysis for the comparison of mean values for various parameters. The Pearson correlation coefficient was used to establish the relationship among various environmental variables with phytoplankton density. A principal component analysis (PCA) was established to highlight the links between species composition and environmental variables using Statistica 10, Statsoft Inc., Tulsa, USA.

From the basic biological data various pollution indices like Palmer's algal pollution species index (Palmer, 1969) and Nygaard's index

(Nygaard, 1949), were calculated to qualify the water quality of the water bodies.

3. RESULTS

3.1. Water Quality Parameters

The two years average hydrochemical properties of water are given in Table 1. The surface water temperature of Lakhal Dam ranged between 12.8±0.4°C in winter to 26.2±1.0°C in summer. The temperature showed a gradual increase from the month of March till the onset of the summer season and gradually decreased in the winter season. In general, samples from Lakhal reservoir shows slightly alkaline condition, with a pH range between 7.7±0.2 (in winter and spring) to 7.9±0.2 in summer. The pH of the Lakhal Dam Lake was observed near neutral to alkaline. The electrical conductivity (EC) measurement varies from 630±15 μScm^{-1} in autumn to 717±30 μScm^{-1} (in summer). Oxygen saturation ranges between 66.2±2.9 % (in autumn) to 92.3±7.8 % in spring. There was a slight increased in concentration of DO during spring and summer seasons. The most chemically stable form of nitrogen is nitrate. High nitrate concentration can result in excess algal blooms in water body. Fertilizers, decayed vegetables and animal matter are the principle sources of nitrates in a water body. In the present study, the maximum value of nitrate was recorded as 9.15±1.16 $mg.L^{-1}$ in the spring and minimum value observed in autumn (3.05±0.73 $mg.L^{-1}$) with a mean value on two years of 5.93±0.64 $mg.L^{-1}$ (Table 1). Present investigations displayed that phosphates varied from 0.082±0.047 to 0.229±0.100 $mg.L^{-1}$. The overall mean value obtained was 0.151±0.035 $mg.L^{-1}$. The value of phosphate was found maximum during spring and it falls down during the autumn season. In the present investigation, the minimum chloride was recorded during spring season and the maximum during the summer and autumn seasons. The overall mean value obtained was 62.2±2.0 $mg.L^{-1}$.

Throughout the study period, the predominant anions can be arranged in the following sequence in decreasing order of their average concentration: $SO_4^{2-} > Cl^-$. Among cations, values for Ca^{2+} were higher than for Mg^{2+} and Na^+. Maximum chlorophyll a concentration was recorded during spring, as 39.1±5.8 $\mu g.L^{-1}$.

Table 1: Seasonal variations of physico-chemical parameters in Lakhal Lake Dam (T: Temperature; EC: Electrical conductivity; D.O.: Dissolved oxygen percent saturation; NO_3^-: Nitrate; NO_2^-: Nitrite; SO_4^{2-}: Sulfate; NH_4^+: Ammoniac; PO_4^{3-}: Phosphate; Na^+: Sodium; Cl^-: Chloride; Ca^{2+}: Calcium; Mg^{2+}: Magnesium; Org. m.: Organic matter; Chl.a: Chlorophyll a). Data are given as mean±SE

	T (°C)	pH	EC ($\mu S.cm^{-1}$)	DO (%)	Nitrates ($mg.L^{-1}$)	Nitrites ($mg.L^{-1}$)	Sulfates ($mg.L^{-1}$)	Ammonia ($mg.L^{-1}$)
2-years average	18.8±1.3	7.8±0.1	670±14	81.7±3.7	5.93±0.64	0.25±0.04	159±4	0.127±0.046

	Phosphates ($mg.L^{-1}$)	Sodium ($mg.L^{-1}$)	Chloride ($mg.L^{-1}$)	Calcium ($mg.L^{-1}$)	Magnesium ($mg.L^{-1}$)	Org. m. ($mg.L^{-1}$)	Chl.a ($\mu g.L^{-1}$)
2-years average	0.151±0.035	45.0±2.2	62.2±2.0	64.4±3.1	27.9±1.4	6.89±0.25	31.7±1.9

3.2. Phytoplankton

In the present study, the phytoplankton comprised 258 species, among which 117 species belong to Chlorophyceae, 67 species to Bacillariophyceae, 38 species to Cyanophyceae, 17 species to Euglenophyceae, 9 species belong to Pyrrophyta, 7 species to Xanthophyta and 3 species to Rodophyta. The Chlorophyta was observed to be the most dominant division of phytoplankton and its contributed in three sites about 3836±2062 $cells.mL^{-1}$ in overall two years followed by Cyanobacteria with mean 1644±723 $cells.mL^{-1}$, Bacillariophyta (919±331 $cells.mL^{-1}$) and Euglenophyceae (517±257 $cells.mL^{-1}$) (Table 2).

Table 2. Descriptive statistics Data

Taxa	Minimum	Maximum	Mean	Standard Error	Median
Chlorophyta	171	17666	3836	2062	1536
Cyanobacteria	35	6097	1644	723	607
Bacillariophyceae	77	2835	919	331	660
Euglenophyceae	35	2231	517	257	517
Pyrrophyta	4	1536	348	184	348
Xanthophyceae	4	20	13	3	13

The density of phytoplankton is depicted in Figure 1

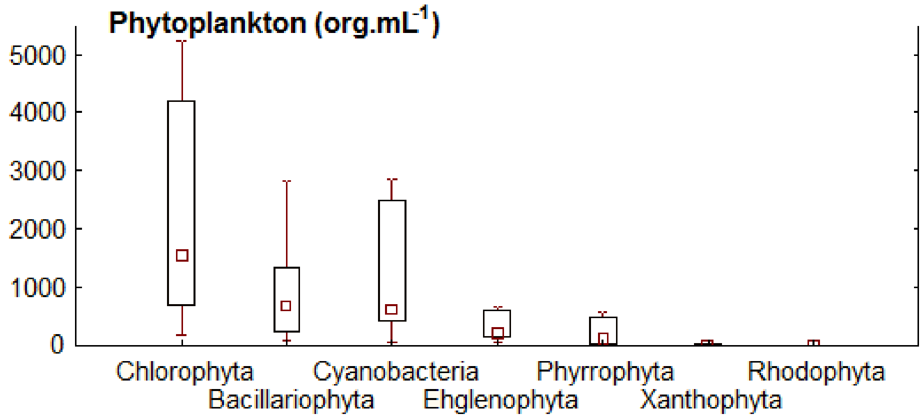

Figure 1. Distribution of phytoplankton density in the Lakhal Dam Lake. The graph show the box-plot with the median, the 25%-75% limits totalizing fifty percent of the values and the non-outlier range

The correlation coefficients of physico-chemical parameters and phytoplankton revealed that the most important parameters with the phytoplankton density showed a positive correlation of temperature with Cyanophyceae (r =0.815), Bacillariophyceae (r = 0.871), Pyrrophyta (0.782); electrical conductivity with Cyanophyceae (r=0.857), Bacillariophyceae (r=0.794), Pyrrophyta (r=0.850); nitrites with Euglenophyceae (r=0.743) and sulfates with Xanthophyceae (r= 0.928). However, electrical conductivity, DO and nitrates showed negative correlation with Xanthophyceae (r = -0.924, -0.939 and -0.962 respectively). Furthermore, the correlation was negative with calcium (r =-0.942) and positive with sodium (r= 0.943).

3.3. Species–environment relationships

The scree plot shows that the extracted components which contributed about 73.84 % are on the steep slope, while the components on the shallow slope contributed little to the solution. The last big drop occurred between the second and third components (Figure 2).

The data for different physico-chemical and phytoplankton variables were analyzed using Principal Component Analysis (PCA) (Fig. 3). The first factor (horizontal) explained 56.45% of the total variance of the environmental and phytoplankton data, whereas the second factor (vertical) accounted for a further 17.39 % variability for a total of 73.84% of the total variance (Table 3). The percentage of the latter group (Rhodophyta) did not exceed 1% of the total density recorded, thus was neglected in graph representation.

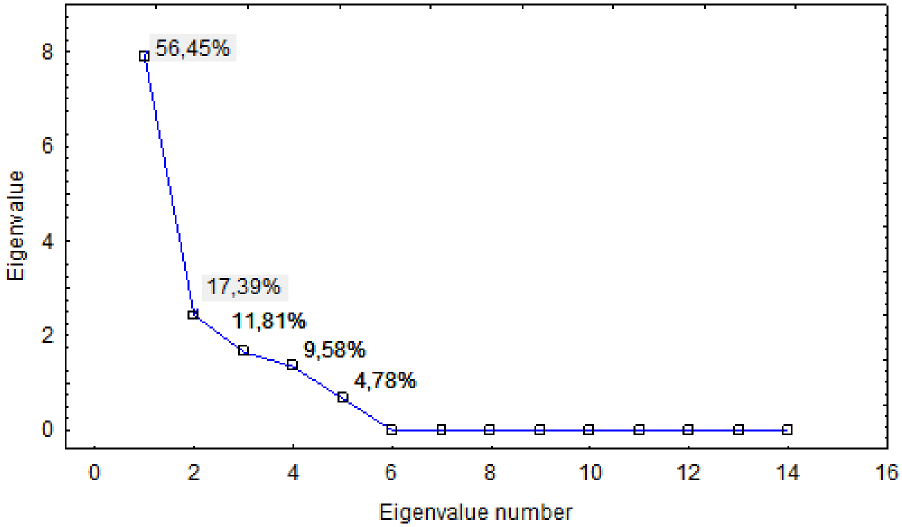

Figure 2. Scree plot of eigenvalues of initial component

Table 3. Eigenvalues and cumulative percent variance of environmental data for the first four PCA axes obtained for Lakhal Dam Lake (see Figure 3)

PCA axis	Eigenvalues	Cumulative percentage variance of environmental and phytoplankton data
1	7.90	56.45%
2	2.43	73.84%
3	1.63	85.64%
4	1.34	95.22%

PCA biplot clearly indicates the correlation between different variables as also the relative importance of each variable in explaining the overall variability in the environmental and phytoplankton data (Figure 3). PCA analysis results also revealed that the first component was associated with DO, nitrites, nitrates, calcium, Chl. a and electrical conductivity. The second component comprised pH and temperature. In general, similar variables clustered together e.g., (i) phytoplankton as Bacillariophyceae, Pyrrophyta and Cyanobacteria associated with temperature, electrical conductivity and chl. a (ii) Chlorophyceae and Euglenophyceae with electrical conductivity and Chl. a; (iii) Xanthophyceae with Na^+ and SO_4^{2-} but inverse association with nitrites, nitrates, DO and calcium.

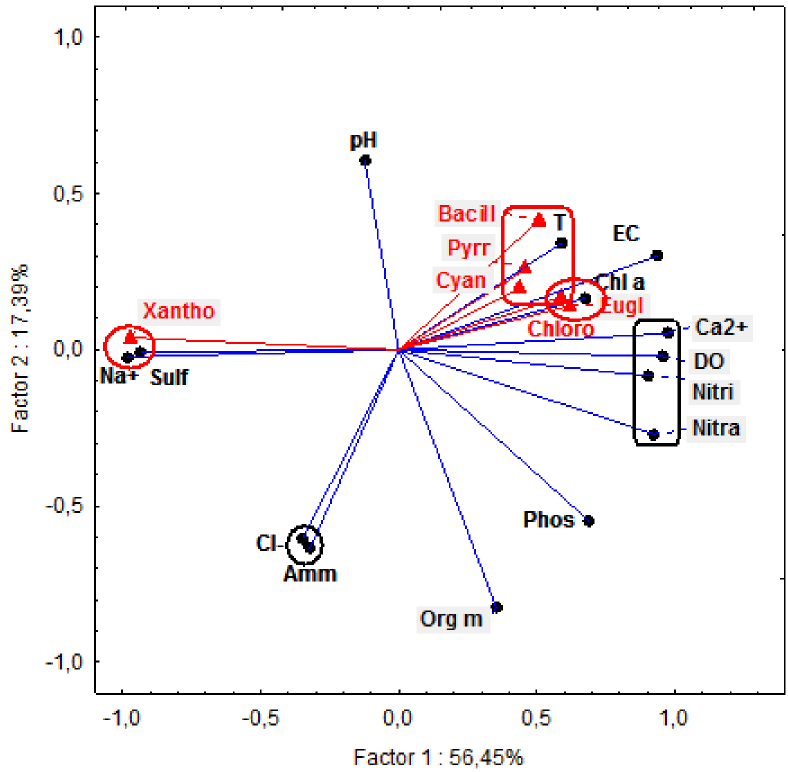

Figure 3. PCA ordination diagram for the Lakhal Lake with phytoplankton and environmental factors. The abbreviations used for environmental variables are given in Table 1.

3.4. Palmer Pollution Index

Algal pollution indices of Palmer (1969) based on genus were used in rating water samples for high organic pollution. Twenty most frequent genera were taken into account (Table 4). A pollution index factor was assigned to each genus by determining the relative number of Total Point Scored by each alga, for rating of water samples as high or low organically polluted.

A pollution index factor of 1 through 5 has been assigned to each of the 20 types of algae that are most tolerant to organic pollution. Types of algae most tolerant of organic pollution were assigned a factor of 5. Less tolerant types were assigned a lower number. If the pollution index score is 20 or more, the score is evidence of high organic pollution. A score of 15-19 indicates probable organic pollution. Lower scores usually indicate less organic pollution. In present study, Palmer index was calculated for Lakhal

Lake and it is found that out of 20 Genus, 16 Genus were found with total index value of 36 that indicate high organic pollution in Lakhal Lake and clearly indicated that the water body was eutrophic nature. Detailed results of the Palmer Index are summarized in Table 4.

Table 4. Palmer Pollution Index for Lakhal Lake

Genus	Pollution Index	Lakhal Lake
Microcystis	1	1
Ankistrodesmus	2	-
Chlamydomonas	4	4
Chlorella	3	-
Closterium	1	1
Cyclotella	1	1
Euglena	5	5
Gomphonema	1	1
Lepocinclis	1	1
Micractinium	1	-
Navicula	3	3
Nitzschia	3	3
Oscillatoria	5	5
Pandorina	1	1
Phacus	2	2
Phormidium	1	1
Scenedesmus	4	4
Stigeoclonium	2	-
Synedra	2	2
Anacystis sp.	1	1
Palmer Index value		36

3.5. Nygaard's (1949) indices

Nygaard's indices of different groups of algae Myxophycean, Chlorophycean, Diatoms, Euglenophycean and Compound Quotient (CQ) are used to get a meaningful evaluation of the extent of pollution in the water. The trophic state indice of Myxophycean in this site is indicating Eutrophic nature of fresh water. The trophic state indice of Chlorophycean group indicates Eutrophic nature of water bodies. The trophic state indices of Diatoms indicate oligotrophic nature of water. The trophic state indice of Euglenophycean was shown oligotrophic nature. The compound index indicates the trophic level of a lake (Nygaard, 1949). If the ratio is less than

1, the lake is accepted as being oligotrophic, whereas if it is greater than 3, the lake is accepted as being eutrophic. Compound index value (Cyanophyceae +Chlorococcales + Centrales + Euglenales / Desmidiales) has been found to be 7.64 for Lakhal Lake, indicating that it is eutrophic (Table 5).

Table 5. Nygaard's Trophic Status Indices of Lakhal Lake

Indices Nygaard's index	Calculation	Trophic Status Indices Eutrophic Oligotrophic	Lakhal Lake
Myxophyceae	Myxophyceae / Desmideae	0.1-3.0 00-0.4	2.23
Chlorococcales	Chlorococcales / Desmideae	0.2-9.0 00-0.7	3.41
Diatoms	Centric Diatoms / Pennates Diatoms	0.0-1.75 0.0-0.3	0.33
Euglenophycean	Euglenophyceae / Myxophyceae+chlorococcales	0.0-1.0 0.0-0.7	0.17
Compound Quotient (CQ)	Myxophyceae + Centric Diatoms + Chlorococcales + Euglenophyceae / Desmideae	CQ < 2 oligotrophic 2>CQ< 6 mesotrophic CQ> 6 eutrophic	7.64

4. DISCUSSION

Temperature has a direct effect on certain chemical and biological activities of the organisms in aquatic ecosystem (Singh et al.1980). Water temperature in the study lake was closely followed by air temperature, with maximum in summer and minimum in winter. Values of pH between 7.0 and 8.0 are optimal for supporting a diverse aquatic ecosystem. Garg et al. (2010) opines that pH range between 6.0 and 8.5 indicates the productive nature of any water body. Considering these limits, the average pH of Lakhal Lake was suitable for aquatic life forms and indicating various favorable conditions for phytoplankton production. Dissolved oxygen (DO) is crucial for the survival of aquatic organisms and is also used to evaluate the degree of freshness of a river (Agbaire & OBI, 2009). The percentage oxygen saturation for all the sites over two years in Lakhal lake were found to be high than 50%, which also suggests good water quality status. Oxygen saturation above 90% is considered a healthy lake status (Rewati, 2012). Electrical conductivity of water is a direct function of its total dissolved salts (Harilal et al. 2004) and is used as an index to represent the total concentration of soluble salts in water (Purandara et al. 2003; Gupta et al. 2008). The variation in calcium and magnesium concentrations may be related to the geology of the area, climate and seasonal variations, different biogeochemical activities in the water ecosystem, human activities, water uses and due to the addition of surface run-off from agricultural and other catchment area (Kumar et al. 2006). Similar conclusions are made by (Toma, 2000; Raoof, 2002). In this study, the predominant cation trend was in the order of $Ca^{2+} > Na^{+} > Mg^{2+}$ and the predominant anion trend was in the order of $SO_4^{2-} > Cl^{-} > NO_3^{-}$ with sulphates being the dominant anion. Nitrate concentration in groundwater and surface water is normally low but can reach high levels as a result of agricultural runoff or contamination with human or animal wastes (Nas & Berktay 2006). The phosphates enters the lakes through domestic wastewater, accounting for the accelerated eutrophication (Vyas et al. 2006) and the augmented concentration of PO_4^{3-} and NO_3^{-} N in lakes resulted in enhanced phytoplankton productivity (Pandit & Yousuf 2002).

The major inorganic nutrients required by phytoplankton for growth and reproduction are nitrite, nitrate, ammoniac and phosphorus. In the present study, the phytoplankton community in fresh water was represented by members of Chlorophyceae, Cyanophyceae, Bacillariophyceae, Euglenophyceae, Pyrrophyta and Xanthophyceae. Chlorophyceae was the dominant group. Ven Den Hoeck (1995) reported that higher Chlorophyceae are a large and important group of freshwater algae. Dominance of class Chlorophyceae in Lakhal was due to high DO (81.7±3.7%). Similar findings were reported by Kensa (2011). In the group of Chlorophyceae, the Chlorococcales were most represented. In literature, members of Chlorococcales are widespread in eutrophic lakes (Reynolds, 1984). There is a close relationship between conductivity and Chl a then the abundance of this group.

Cyanobacteria dominance and sometimes bloom are among the most visible symptoms of accelerated eutrophication of a water body (Moschini-Carlos et al. 2009). However, Cyanobacteria were represented by *Anabaena, Aphanizomenon, Chroococcus, Oscillatoria, Lyngbya, Microcystis etc..* The results of PCA analysis show that Cyanobacteria were affected by some environmental variables. Jewel et al. (2006) reported that Cyanobacteria especially *Microcystis sp.* was found to be controlled by relatively high temperature (>25°C) and nutrient enrichment, especially high NO_3^-N concentration (3.8 mg.L^{-1}). May (1981) report that bloom of *Microcystis aeruginosa* and *Anabaena circinalis* were increasing due to increasing pollution of the water.

Euglenophyta members are known to be abundant in eutrophic waters and on sediments polluted with organic matter (Round, 1984). In this study, Euglenophyta were represented by *Phacus, Euglena, Trachelomonas, Lepocinclis* and *Strombomonas*. In present study, presence of diatoms like *Cyclotella, Cymbella, Fragilaria, Navicula and Nitzschia* were observed in lake.

The association between Cyanobacteria, Pyrrophyta and Bacillariophyta with temperature, electrical conductivity and Chl. a are an indication that it's growth was affected by these parameters. Electrical conductivity measures of dissolved substances in water and most of which are nutrients. While Chlorophyll a measures a phytoplankton density.

In order to apply biological means of determining the trophic status, Palmer's pollution indices of phytoplankton and Nygaard's phytoplankton quotient values were calculated. The values of these two indices clearly indicated a high degree of pollution.

CONCLUSION

By using Palmer's pollution index number, the total score of Lakhal Lake was greater than 20 indicating the confirmed high organic pollution. Thus the pollution tolerant algal communities can be used as bioindicators of organic pollution. Nygaard's indices of different groups of algae myxophycean, chlorophycean, Diatoms, Euglenophyte and compounds were used to get meaningful evaluation of the extent of pollution of this lake. All the indices were showing eutrophic nature of the sites except diatoms and Euglenophyceae indices. The compound index which had the widest range and was very sensitive holds good index for assessing the eutrophication of the lake.

REFERENCES

Agbaire, P.O., & OBI, C.G, 2009, Seasonal Variations of Some Physico-Chemical Properties Of River Ethiope Water in Abraka, Nigeria. Journal *of Applied Sci. Environment and Management*, **13**(*1*), 55-57.

Anagnostidis, K. & Komárek, J., 1988, Modern approach to the classification system of Cyanophytes. 3 - Oscillatoriales. *Algological*

Studies, 50-53, 327-472. *Archiv. Fur Hydrobiologie,* Supplementband 80. Stuttgart.

Anagnostidis, K., Komárek, J., 1990, Modern approach to the classification system of Cyanophytes. 5 - Stigonematales. *Algological Studies*, 59, 1-73. *Archiv. Fur Hydrobiologie*, Supplementband 86. Stuttgart.

APHA, 1998, Standard Methods for the Examination of Water and Waste water, American Public Health Association, 18th edition, Washington DC, USA.

Atici, T. & Ahiska, S., 2005. Pollution and Algae of Ankara Stream. G.Ü. *Fen Bilimleri Dergisi,* **18**(*1*), 51-59.

Bhatt, L.R., Lacoul, P., Lekhal, H.D., Jha, P.K., 1999, Physico-chemical characteristics and phytoplanktons for Taudha Lake, Kathmandu. *Pollution Research*, **18**, 353-358.

Bourrelly, P., 1966, *Les algues d'eau douce. Initiation à la systématique*. Tome I : Les algues vertes. Eds. Boubée et Cie, Paris, 572 p.

Bourrelly, P., 1968, *Les algues d'eau douce. Initiation à la systématique*. Tome II : Les algues jaunes et brunes, Chrysophycées, Phéophycées, Xanthophycées et Diatomophycées. Eds. Boubée et Cie, Paris, 438 p.

Bourrelly, P., 1970, *Les algues d'eau douce. Initiation à la systématique*. Tome III: Les algues bleues et rouges. Les Eugléniens, Péridiniens et Cryptomonadines. Eds. Boubée et Cie, Paris, 512 p.

Çolak, Ö., & Kaya, Z., 1988, Alglerin atık suların biyolojik arıtılmasında. kullanılmaolanakları. *Doğa Bilim Dergisi*, **12** (*1*), 18-29.

Garg, R.K., Rao, R.J., Uchchariya, D, Shukla, G., Saksena, D.N., 2010, Seasonal variations in water quality and major threats to Ramsagar reservoir, India. *Afr. Environ. Sci. Technol.,* **4**(*2*), 061-076.

Gopal B. & Chauhan M., 2001, South Asian wetlands and their diversity: the role of monsoons. - In: Gopal, B., Junk, W.J., Davis, J.A. (eds) *Biodiversity in wetlands: assessment, function and conservation*, Backhuys Publishers, Leiden, 2, pp 257-276.

Gupta, S., Maheto, A., Roy, P., Datta, J.K., Saha, R.N., 2008, Geochemistryof groundwater Burdwan district, West Bengal India. *Environ. Geol.,* **53**, 1271-1282.

Harilal, C.C., Hashim, A., Arun, P.R., Baji, S., 2004, Hydrogeochemistry of two rivers of Kerala with special reference to drinking water quality, *Ecology, Environment and Conservation*, **10** (*2*), 187-192.

Jewel, M. A. S., Rahman, M. M., Sarker, M. A., 2006, Effects of environmental parameters on the cyanobacterial bloom in a lake of Bangladesh. *Bangladesh J. Prog. Sci. & Tech*., **4**(*2*), 159-164.

Kensa, M.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.

Komárek, J. & Anagnostidis , K., 1986, Modern approach to the classification system of Cyanophytes. 2 - Chroococcales. *Algological Studies*, **43**, 157-226. Archiv. Fur Hydrobiologie, Supplementband 73. Stuttgart.

Komárek, J.& Anagnostidis, K., 1989, Modern approach to the classification system of Cyanophytes. 4 - Nostocales. *Algological Studies*, **56**, 247-345. Archiv. Fur Hydrobiologie, Supplementband 82. Stuttgart.

Komarek, J. & Anagnostidis, K., 1999, Süsswasserflora von Mitteleuropa 19/1. Cyanoprokaryota 1.Teil: Chroococcales. Gustav Fischer Ed., Gustav Fischer, Stuttgart, 548 p.

Komarek, J. & Anagnostidis, K., 2005, Süsswasserflora von Mitteleuropa 19/2. Cyanoprokaryota 2.Teil: Oscillatoriales“. Elsevier SpeKtrum Akademischer Verlag éd., Elsevier, München, 759 p.

May, V., 1981, The occurrence of toxic cyanophyte blooms in Australia. In: *The Water Environment: Algal toxin and Health.* Carmichael, W. W. (eds.). Plenum Press. New York and London. pp. 127-141.

Kumar, A., Qureshi, T.A., Parashar, A., Patiyal, R.S., 2006, Seasonal variation in physico-chemical characteristics of Ranjit Sagar reservoir, Jammu & Kashmir. *Journal of Ecophysiology & Occupational Health*, **6**, 159-163.

Moschini-Carlos V., Bortoli, S., Pinto, E., Yuri Nishimura, P., Gomes de Freitas, L., Pompeo, M. L. M., Dorr, F. 2009, Cyanobacteria and Cyanotoxin in the Billings Reservoir (Sao Paulo, SP, Brazil). *Limnetica*, **28** (*2*): 273-282.

Nas, B., & Berktay, A., 2006, Groundwater contamination by nitrates in the city of Konya, (Turkey): A GIS perspective. *Journal of Environmental Management*, **79**, 30–37.

Nygaard, G., 1949, Hydrobiological studies on some Danish ponds and lakes II. The quotient hypothesis and some new or little known phytoplankton organisms. *Dat. Kurge. Danske. Vid. Sel.Biol.Skr.*, **7**, 1-293.

Opute, F.I., 1992, Contribution to the knowledge of algae of Nigeria. I. Desmids from the Warri/Forcados Estuaries“. Part II. The genera Euastrum and Micrasterias. *Algological Studies*, **65**, 73-92.

Opute , F.I., 2000, Contribution to the knowledge of algae of Nigeria. I. Desmids from the Warri/Forcados Estuaries. Part II. The elongate baculiform desmids. *J. Limnol.*, **59**(*2*), 131-155.

Palmer, C.M., 1969, Composite rating of algae tolerating organic pollution. *J. phycol.*, **5**, 78-82.
Pandit, A.K & Yousuf, A.R., (2002), Trophic status of Kashmir Himalayan lakes as depicted by water chemistry. *J. Res. Dev.*, **2**, 1-12.
Purandara, B.K., Varadarajan, N., Jayashree, K., 2003, Impact of sewage on ground water: a case study, *Poll Res.*, **22**(*2*), 189–197.
Raoof, I.Y., 2002, *A phycolimnological study on Duhok impoundment and its main Watershade*. Ph.D. Thesis, University of Dohuk, Dohuk.
Rewati, N. 2012, Evaluation of the Limnological Status of Beeshazar Lake, a Ramsar Site in Central Nepal. *Journal of Water Resource and Protection*, **4**, 256-263.
Reynolds, C.S., 1984, The ecology of freshwater phytoplankton. Cambridge Univ. Press, Cambridge, New York, 384 pp.
Rodier, J., 1984, *L'analyse de l'eau: eaux naturelles, eaux résiduaires, eau de Mmr*, ,7th Ed. Dunod: Paris.
Round, F.E., 1984, *The ecology of algae*. Cambridge University Press, Cambridge, 653 pp.
Saha, S.B, Bhattacharya, S.B, Chaudhary, A., 2000, Diversity of phytoplankton of sewage pollution brackish water Tidal ecosystems. *Environ. Biol*., **21**, 9-14.
Tokatli, C., 2013, Evaulation of Water Quality By Using Trophic Diatom Index: Example of Porsuk Dam Lake. *Journal Applied Biological Sciences*, **7** (*1*), 01-04.
Toma, J.J., 2000, *Limnological study of Dokan Lake, Kurdistan region of Iraq*. M. Sc. Thesis, University of Salahaddin, Arbil.
Trivedy, R.K., & Goel, P.K., 1984, Chemical and Biological Methods for Water Pollution Studies. *Environm. Pub, Karad,* India.
Ven Den Hoeck, C., Mann, D.G., Jahns, H. M., 1995, Algae: An introduction to phycology Cambridge University Press, Cambridge.
Vyas, A., Mishra, D.D., Bajapai, A., Dixit, S., Verma, N., 2006, Environment impact of idol immersion activity lakes of Bhopal, India. *Asian J. Exp. Sci.*, **20** (*2*), 289–296.