Desalination and Water Treatment
www.deswater.com

131 (2018) 107–113
November

doi:10.5004/dwt.2018.23011

Assesment of seasonal variation of phytoplankton and related water quality parameters of Sazlidere Dam Lake (Istanbul, Turkey)

Nese Yilmaz

Department of Freshwater Resources and Managment, Istanbul University Faculty of Aquatic Scienses, Ordu St. No:8, 34134, Laleli, Istanbul, Turkey, Tel. +90 (212) 455 57 00, Fax +90 (212) 514 03 79, email: nyilmaz@istanbul.edu.tr (N. Yilmaz)

Received 20 April 2018; Accepted 25 August 2018

ABSTRACT

The seasonal variation of phytoplankton community and affecting some physico chemical factors of Sazlidere Dam Lake were investigated monthly from December 2003 to November 2005. Phytoplankton was constituted of Bacillariophyta, Charophyta, Chlorophyta, Cryptophyta, Cyanobacteria, Euglenozoa, Miozoa and Ochrophyta members. According to the functional group aproach, the phytoplankton community of the dam lake was formed by 19 groups (B, D, N, P, T, S2, X1, Y, E, F, J, H1, L_O, L_M, M, MP, R, W1 and W2) which were most common in mesotrophic and eutrophic waters. The seasonal variations of phytoplankton were most affected by light, temperature and nutrients. A highly significant positive correlation (r = 0.667) existed between phytoplankton density and orthophosphate concentrations. The Shannon-Weaver diversity index ranged from 0.035 to 1.059, Simpson dominance index changed between 0.096 and 0.973. According to regulations for the water quality of potable waters in Turkey, Sazlidere Dam is of class I in terms of temperature, pH, dissolved oxygen, nitrate, nitrite and orthophosphate concentrations. Chlorophyll- *a* concentrations (5.47–57.0 mg/m^3) showed that the lake has eutrophic characteristics. When the physicochemical and biologic features of the lake were evaluated, it was determined that the Sazlidere Reservoir showed a change towards from oligotrophic to mesotrophic characteristics.

Keywords: Phytoplankton; Water quality; Physico-chemical parameters; Nutrients; Sazlidere Dam Lake

1. Introduction

In recent years, depending on extreme population growth, unplanned urbanization, unconscious industrialization and global warming, our available water resources are expeditiously consumed. For this reason, it is need to do more researches on water quality and pollution each passing day. It is necessary to study not only physical and chemical but also biological properties of waters and evaluate together to determine their trophic level. Phytoplankters are at the fore front of bioindicator organisms which are used in aquatic ecosystems. Because of they give a quick response to the changes occurring in the aquatic environments. The composition of phytoplankton gives information about the primary production, nutrient level and water pollution of aquatic systems [1–4]. Determination of the phytoplankton composition and monitoring of seasonal changes will allow for estimation of undesirable situations that may occur in the aquatic systems and timely precautions to be taken.

Sazlidere Dam was built for supply drinking water to Istanbul Metropolitan, which has an increasing population and industrial establishment day by day. It was stated that although the catchment area of the dam lake is out of frontier the city, quick population increases will develop danger in the area [5]. Also, Sazlidere Dam is located on the "Channel Istanbul Project" route planned to be realized soon. In earlier studies the geological, hydrological and modelling investigations have been carried out at the reservoir. The presented study of the dam lake has the first ecological research feature and the phytoplankton species list has been published before [6]. The aim of this study is to determine the trophic structure and water quality using the

*Corresponding author.

phytoplankton composition and affecting physico-chemical parameters in Sazlidere Dam.

2. Materials and methods

2.1. Study area and climate

Sazlidere Dam Lake is situated in the Marmara Region on the European peninsula of Istanbul, south-east of Lake Terkos (Durusu) and north-east of Lake Kucukcekmece (Fig. 1). The dam was built on the Sazlidere Stream in order to supply drinking water to Istanbul Metropolitan. The drainage are of the dam is 165 km^2 and the average depth is 22.4 m. Sazlıdere Dam provides 55 million m^3 of water per year to Istanbul. Also the lake is used as a sport fishing and recreational area [5,6].

Istanbul is a transition area among the Mediterranean climate and the oceanic climate. The annual mean temperature in summer season is 14.5°C for the last two decades. High temperature with less precipitation is characteristic for Istanbul. The total precipitation averages for Istanbul is 640 mm per year and the relative humidity is between 73–77% in the city [6].

2.2. Physico-chemical variables

Water samples were collected by using a Nansen bottle from 5 stations between December 2003 and November 2005 on a monthly basis. The water temperature was measured with a thermometer; the Secchi disc depth was measured with a Secchi disc; the pH was measured using a Knick make pH-meter; the conductivity and salinity were determined with an Oxı 330/set make oxygen meter in the study area. Analysis of dissolved oxygen (DO), nitrite (NO_2-N), nitrate (NO_3-N), orthophosphate (PO_4-P), Calcium hardness, Magnesium hardness and total hardness were done at the laboratory, according to standard methods [7].

2.3. Phytoplankton and chlorophyll-a

Samples which were taken in Nansen bottles were fixed with Lugol's iodine solution. First, samples were placed in glass tubes of 50 cc and were added Lugol's iodine to prepare for phytoplankton counting. Samples were left for 24 h to provide the phytoplankters sink to the bottom. The remaining bottom parts of 5 cm^3 of samples were transferred to the counting chambers. After waiting for 4 h, counting was done with a Nikon TMS inverted microscope at a magnification of 400 according to Lund et al. [8]. For phytoplankton identification water samples were filtered from Whatman GF/A glass fiber filter and stored in petri dishes. The identifications of algae, except diatoms, were done by examining these filter papers from temporary preparations with a light microscope. The identifications of diatoms were done from permanent preparation which were prepared by boiled 10–15 min in a heat-resistant glass beaker by adding a mixture of nitric and sulfuric acids. Phytoplankton species were identified by reference to the literature, including several comprehensive reviews on the subject [9–18]. All the recorded species were checked in algabase cite [19]. Chlorophyll- *a* concentrations were measured with respect to Parsons and Strickland [20].

2.4. Statistical analysis

Shannon-Weaver diversity index (H′) [21] and Simpson's dominance index [22] were estimated between December 2003 and November 2005 at all stations using Biodiversity 2.0 analysis program. Spearman's rank correlation analysis [23] was applied as seasonal between temperature, dissolved oxygen, nitrite, nitrate, orthophosphate and phytoplankton density using SPSS 11.0 computer program [24]. In addition Bray-Curtis similarity index were applied and obtained data were used in hierarchial Cluster analysis [25].

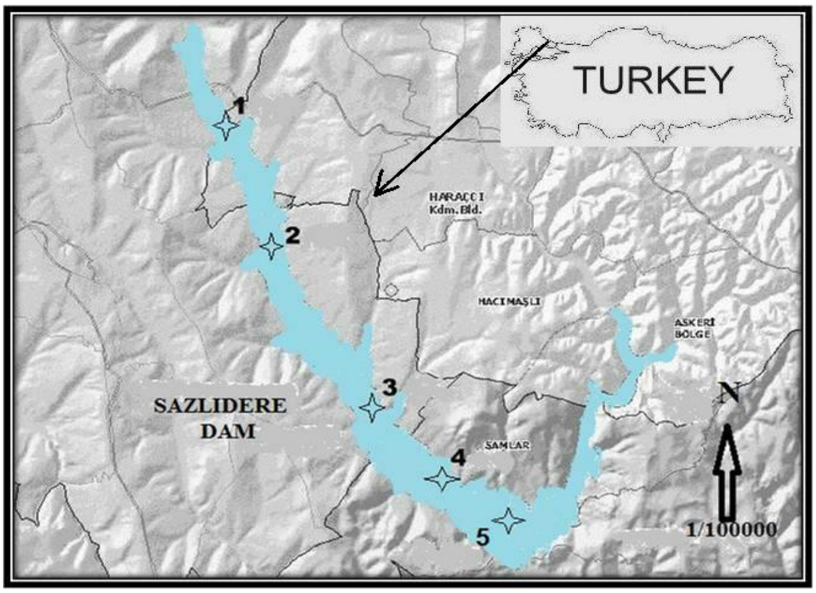

Fig. 1. The map of Sazlıdere Dam and sampling stations [6].

3. Results and discussion

3.1. Physico-chemical variables

During the study period, water temperature varied from 5.6 to 29.0°C and salinity ranged from 0.1‰ to 0.4‰. The highest salinity was recorded in October and December 2004 when the dam drained. Electrical conductivity was found in recommended values for drinking waters (290–740 µS/cm). The dissolved oxygen concentrations ranged from 4.58 to 14.97 mg/L, pH values ranged between 6.60 and 8.52; the average was 7.59 ± 0.04. The obtained data indicated that the water of the lake has light alkaline characteristics. The nitrite, nitrate and orthophosphate concentrations were between 0.52 and 15.24 µg/L; 0.09 and 58.48 µg/L and 0.02 and 31.7 µg/L respectively. Average concentrations of nitrite was measured 2.58 ± 0.17 µg/L, nitrate 23.60 ± 2.35 µg/L and orthophosphate 1.38 ± 0.51 µg/L. Sazlıdere Dam was found poor according to nutrient concentrations. In terms of temperature, pH levels, dissolved oxygen, nitrate and orthophosphate concentrations the dam is of class I water quality [26]. Total hardness ranged between 11.04–28.8°FS and average was 15.94 ± 0.63°FS. According to hardness classification the dam has light hard water characteristic. Calcium hardness varied from 0.15 to 1.09 mg/L and Magnesium hardness changed between 0.04 and 0.14 mg/L (Table 1).

It was stated by Akça [5], most of water quality parameters of Sazlıdere Dam provide scarcely class of I and II, which were determined for inland waters. Additionally water quality of inflowing streams of Sazlidere Dam head towards to class of III and class of VI. It was determined that, the biggest factor of pollution of Sazlidere Dam and its inflowing streams were domestic waste waters which came from settlements. It was designated that, although the nutrient concentrations wasn't found high in the present study, domestic inputs raise the concentrations at station 2 which is located in residential area. It was noted by Akça [5] as a result of trophic state estimation, danger of eutrophication was determined. Chlorophyll- *a* concentrations are one of the important criteria for determine the productivity of lakes. Measured chlorophyll-*a* concentrations varied between 5.47 mg/m^3 and 57.0 mg/m^3 on the surface water which indicated that the lake is in the beginning of eutrophic characteristic.

3.2. Phytoplankton density and seasonal variation

In the present study, a total of 67 taxa were identified. The phytoplankton community of the dam lake consists of Bacillariophyta (46%), Charophyta (7%), Chlorophyta (19%), Cryptophyta (2%), Cyanobacteria (13%), Eugleno-

Table 1
Some physico chemical parameters with stand art errors according to sampling stations in Sazlidere Dam

Parameters	St	Min.–Max.	Average and stand art error	Parameters	St	Min.–Max.	Average and stand art error
Temp.(°C)	St.1	6.5–27.0	18.86 ± 1.45	Nitrate (µg/L)	St.1	0.49–32.14	14.43 ± 2.29
	St.2	6.8–29.0	18.77 ± 1.67		St.2	5.27–58.48	27.1 ± 4.01
	St.3	5.8–27.0	18.36 ± 1.70		St.3	2.61–52.04	26.52 ± 3.98
	St.4	5.6–28.0	18.64 ± 1.74		St.4	0.71–52.04	24.56 ± 3.70
	St.5	5.8–27.0	18.40 ± 1.72		St.5	0.09–53.60	25.80 ± 4.34
pH	St.1	6.78–8.30	7.46 ± 0.13	PO_4 (µg/L)	St.1	0.06–31.7	3.26 ± 1.63
	St.2	6.80–8.49	7.61 ± 0.14		St.2	0.06–3.65	0.85 ± 0.23
	St.3	6.69–8.39	7.54 ± 0.15		St.3	0.02–2.01	0.50 ± 0.10
	St.4	6.72–8.52	7.66 ± 0.14		St.4	0.02–24.68	1.70 ± 1.21
	St.5	6.60–8.48	7.68 ± 0.16		St.5	0.06–3.14	0.62 ± 0.15
Salinity (‰)	St.1	0.1–0.4	0.24 ± 0.01	Calcium (mg/L)	St.1	0.18–1.09	0.49 ± 0.04
	St.2	0.1–0.3	0.20 ± 0.01		St.2	0.25–0.65	0.45 ± 0.02
	St.3	0.1–0.3	0.19 ± 0.008		St.3	0.35–0.68	0.54 ± 0.01
	St.4	0.1–0.2	0.18 ± 0.006		St.4	0.43–0.71	0.51 ± 0.01
	St.5	0.1–0.3	0.20 ± 0.01		St.5	0.15–0.70	0.41 ± 0.03
Dissolved oxygen (mg/L)	St.1	4.66–14.97	9.08 ± 0.81	Magnesium (mg/L)	St.1	0.04–0.13	0.071± 0.006
	St.2	9.22–12.72	10.79 ± 0.25		St.2	0.05–0.11	0.081 ± 0.004
	St.3	6.46–12.39	10.76± 0.41		St.3	0.05–0.12	0.092 ± 0.003
	St.4	4.58–13.42	10.96 ± 0.55		St.4	0.04–0.11	0.085 ± 0.003
	St.5	9.00–13.44	11.38 ± 0.37		St.5	0.05–0.14	0.084 ± 0.006
Nitrit (µg/L)	St.1	0.52–15.24	3.23 ± 0.81	Total Hardness (°FS)	St.1	11.90–28.80	18.35 ± 1.194
	St.2	0.62–13.28	2.54 ± 0.61		St.2	11.04–20.38	15.08 ± 0.51
	St.3	0.95–13.67	2.24± 0.62		St.3	14.22–20.68	15.76 ± 0.51
	St.4	0.82–13.61	2.33 ± 0.62		St.4	14.10–19.54	15.76 ± 0.40
	St.5	0.80–13.79	2.58 ± 0.68		St.5	12.50–20.64	14.70 ± 0.54

zoa (6%), Miozoa (5%) and Ochrophyta (2%) members. In terms of species diversity and phytoplankton density the Bacillariophyta division was found to be dominant. It was determined that *Cyclotella atomus* Hustedt, *C. ocellata* Pantocsek and *Ulnaria ulna* (Nitzsch) Compere of Bacillariophyta, *Anabaena flos-aquae* Brebisson ex Bornet & Flauhault and *Planktothrix rubescens* (De Candolle ex Gomont) Anagnostidis & Komarek of Cyanobacteria were increased in spring and summer; *Sphaerocystis planctonica* (Korshikov) Bourrelly, *Scenedesmus* spp., and *Mougeotia* sp. species of Chlorophyta were increased in autumn and winter. While numbers of Chlorophyta members were decreased, numbers of Cryptophyta and Miozoa members were increased, in case of the vertical distribution of phytoplankton examined in Sazlidere Dam. Light can not penetrate too more deep in dams because of water movements and turbidity. Therefore photosynthetic algae were on surface and near to surface; on the contrary active members showed increase in deeper waters.

3.2.1. Seasonal variation of phytoplankton groups at station 1

The first station was selected from the stream input of the lake (N 41°11 31.4″, E 028° 38′ 37.9″). Bacillariophyta was recorded the dominant group in March 2004, April 2004, May 2004, December 2004, January 2005, April 2005, May 2005, July 2005 and August 2005 at station 1. In May 2004, when the maximum density of phytoplankton were recorded as 13134 ind./cm^3, Bacillariophyta members were determined as 12281 individual/cm^3. The dominant algal group was Chlorophyta (58.6%) in June 2004 while the phytoplakton was formed from Euglenozoa in August 2004. Cyanobacteria were found as the dominant group both in November 2004 (69.5%) and November 2005 (98.4%).

3.2.2. Seasonal variation of phytoplankton groups at station 2

The second station was located in the littoral region of Sazlibosna settlement area (N 41° 09′ 02.0″, E 028° 40″ 16.2″). Bacillariophyta members were recorded as the dominant group in March 2004, April 2004, May 2004, June 2004, July 2004, October 2004, June 2005 and July 2005 at station 2. When the maximum algae density was recorded in July 2004, the Bacillariophyta was identified as 2228 individual/cm^3 and in June 2004 by 1047 individual/cm^3. Chlorophyta was constituted the dominant group in August 2004 (48.7%), November 2004 (57.1%), December 2004 (74.1%), May 2005 (58.5%) and August 2005 (66.6%). Cyanophyta members were the dominant group in September 2004 (100%) and April 2005 (73%).

3.2.3. Seasonal variation of phytoplankton groups at station 3

The third station was choosen from the shore of the stone quarries (N 41° 07′ 57.9″, E 028° 41′ 10.02″). The dominant algae group was formed by Bacillariophyta in March 2004, July 2004, October 2004, December 2004, January 2005, April 2005, May 2005, June 2005, July 2005, August 2005 and November 2005. In July 2005, when maximum algal density was recorded, Bacillariophyta members were determined as 3484 individual/cm^3. In June 2005, only Bacillariophyta members were recorded.

3.2.4. Seasonal variation of phytoplankton groups at station 4

The forth station was situated in front of a road channel (N 41° 07′ 22.7″, E 028° 42′ 08.2″). Bacillariophyta members were recorded as the dominant algae group in March 2004, May 2004, June 2004, July 2004, October 2004, November 2004, April 2005, May 2005, June 2005, July 2005 and November 2005. In July 2005, the Bacillariophyta members were represented by 3003 individual/cm^3 in which the maximum algal density was recorded (3800 ind./cm^3).

3.2.5. Seasonal variation of phytoplankton groups at station 5

The fifth station was on the deepest region of the lake, and close to the dam embankment (N 41° 07, 08.09″, E 028° 42′ 34.5″). Bacillariophyta members were constituted the dominant algae group in March 2004, May 2004, June 2004, July 2004, October 2004, November 2004, January 2005, April 2005, June 2005 and July 2005 at station 5. In March 2004, the Bacillariophyta members were recorded as by 3393 individual/cm^3, at which the maximum algal density was recorded (3650 ind./cm^3). Crytophyta became the dominant group in April 2004 (71 ind./cm^3) and December 2004(18 ind./cm^3). Cyanobacteria was recorded the dominant group in Agust 2004 (23 ind./cm^3), September 2004 (3154 ind./cm^3), Agust 2005 (517 ind./cm^3) and November 2005 (69 ind./cm^3). Phytoplankton was consituted of 5 species of green algae in May 2005 at station 5.

3.3. Functional groups of phytoplankton

The phytoplankton functional groups approach comprises more than 45 assemblages that are identified by alphanumerical codes according to their sensitivities and tolerances [27,28]. The functional groups represented by the phytoplankton in Sazlıdere Dam were B, D, N, P, T, S2, X1, Y, E, F, J, H1, L_O, L_M, M, MP, R, W1 and W2 (Table 2). The phytoplankton composition of Yedikır Dam Lake, which was described as an eutrophic water body, was classified into B, C, D, N, N_A, P, MP, T_B, X1, Y, E, F, J, H1, Lo, L_M, W1 and W2 groups [29]. It was reported that in eutrophic Kucukcekmece Lake, the phytoplankton consist of B, C, D, N, X1, Y, F, J, Lo, M, M_P, W1 and W2 functional phytoplankton groups [30]. The phytoplankton community of Elmalı Dam Lake, which is reported to be close to eutrophy, consists of B, D, N, P, X1, Y, F, J, H1, L_O, M, MP, T_B, W1 and W2 functional groups [31].

It was seen that generally in algological studies of Turkish freshwaters the Bacillariophyta was the dominant divison [32,33,34]. Bacillariophyta was represented by 31 species. Codon B was represented by *Aulocoseira italica* (Ehr.) Simonsen, *Cyclotella atomus* and *Cyclotella ocellata* of centrik diatoms. This group found generally in mesotrophic lakes with tolerances for light deficiencies. *C. atomus* and *C. ocellata* were recorded in all seasons. *Cyclotella* species were accepted by many investigators as one of the typical components of both oligotrophic lakes and reservoirs [35,36]. Codon D, one of the phyto-

Table 2
Functional groups of recorded phytoplankton species

Codon	Habitat	Typical representatives	Tolerance	Sensitivities
B	Vertically mixed, mesothrophic, small to medium lakes	*Aulocoseira italica, Cyclotella atomus, Cyclotella ocellata*	Light deficiency	pH rise, Si depletion stratification
D	Shallow, enriched turbid waters including rivers	*Ulnaria acus, Ulnaria ulna Nitzschia acicularis, Nitzschia spp. Stephanodiscus astrea*	Flushing	Nutrient depletion
N	Mesotrophic epilimnia	*Cosmarium depressum, Cosmarium formosulum, Tabellaria sp.*	Nutrient deficiency	Stratification, pH rise
P	Eutrophic epilimnia	*Fragilaria crotonensis, Fragilaris spp. Closterium acutum, Staurastrum crenulatum*	Low light and nutrient deficiency	Si decline, stratification
MP	Frequently-stirred-up, inorganically turbid shallow lakes	*Cymbella affinis, Navicula cuspidata Nitzschia sigmoidea, Oscillatoria tenuis*	–	–
T	Deep, well mixed epiimnion	*Mougeotia sp.*	Light inadequacy	Food insufficiency
S2	Shallow, warm and often highly alkaline waters	*Spirulina major*	Light inadequacy	Overflowing
X1	Shallow, eu-hypertrophic environments	*Ankistrodesmus falcatus*	Stratification	Nutrient depletion
Y	Usually small, enriched lakes	*Cryptomonas ovata*	Low light	Phagothrophs
E	Small, oligotrophic, poor based lakes and heterotrophic pools	*Dinobryon sertularia*	Low nutrients	CO_2 insufficiency
F	Clear deeply mixed meso-eutrophic lakes	*Kirchneriella sp., Oocystis borgei*	Low nutrients high turbidity	CO_2 insufficiency
J	Shallow, highly enriched lakes, ponds and rivers	*Coelastrum microporum, Pediastrum duplex, Pediastrum simplex Scenedesmus communis, Scenedesmus dimorphus, Scenedesmus quadricauda*	–	Settling into low light
H1	Eutrophic, both stratified and shallow lakes with low nitrogen content	*Anabaena flos-aquae, Aphanizomenon ovalisporum*	Low nitrogen, low carbon	Mixture, poor light, low phosphorus
L_O	Deep and shallow, olig to eutrophic, medium to large lakes	*Peridinium bipes, Merismopedia glauca*	Segregated nutrients	Prolonged or deep mixing
L_M	Eutrophic to hypertrophic, small to medium sized lakes	*Ceratium furca, Ceratium hirundinella*	Very low carbon	Mixture, low stratification, low light
M	Eutrophic to hypertrophic, small to medium water bodies	*Microcystis aeruginosa*	High insolation	Mixing, poor light stratification
R	Under stratification, in the metalimnion or upper hypolimnion of deep oligo-mesotrophic lakes	*Planktothrix rubescens*	Low light, strong distinction	Instability
W1	Ponds, even temporary, rich in organic matter from husbandary or sewages	*Euglena gracilis Phacus sp.*	High BOD	Grazing
W2	Meso-eutrophic ponds, even temporary, shallow lakes	*Trachelomonas hispida, Trachelomonas volvocina*	–	–

plankton functional goups, was formed by the diatoms, *Ulnaria acus* (Kütz.) Aboal, *Ulnaria ulna*, *Nitzschia* spp. and *Stephanodisus astrea* (Kütz.) Grunow which usually occur in shallow, nutrient-enriched turbid waters including rivers. This group have a tolerance for flushing and they are sensitive to nutrient depletion [27,28]. *U. ulna* of pennat diatoms, constituted extreme increases in July 2004 and July 2005. This species is known to be characteristic of eutrophic lakes [35,37]. But also it was recorded as dominant in Lake Hafik and Derbent Dam Lake which are oligotrophic lakes [38,39]. Chlorophyta was represented by 13 species and green algae members were usually found widely and abundantly in mesotrophic and eutrophic lakes [36]. *Sphaerocystis planctonica, Scenedesmus communis* E. Hegewald, *Scenedesmus dimorphus* (Turp.) Kütz., *Scenedesmus quadricauda* (Turp.) Brebisson, *Pediastrum simplex* Meyen and *Pediastrum duplex* Meyen were recorded in important numbers. Codon J was formed by *Coelastrum microporum* Nägeli, *Pediastrum* spp. and *Scenedesmus* spp. which were presented in shallow, mixed highly enriched systems including many low-gradient rivers. It was stated that species which belongs to group J have sensitivitiy to light [27,28]. Ochrophyta was represented by *Dinobryon sertularia* Ehrenberg which is one of the characteristic species of mesotrophic lakes [27]. It was determined that this species was shown increases in July 2004 and July 2005. Codon E was formed by *Dinobryon* and members of this group were presented usually in small, oligotrophic, base poor lakes or heterotrophic ponds with low nutrient tolerances [27]. Cryptophyta was represented by *Cryptomonas ovata* Ehrenberg which takes place in codon Y. This species was usually found in small enriched lakes with tolerance to low light. *C. ovata* was recorded as subdominant at station 2 in March 2004 and dominant in May 2004. Also it was found subdominant species in June 2004 at station 4 and 5. Because of its low light tolerance, it was determined as dominant at vertical sampling stations [27]. It was recorded 9 taxon belonging to Cyanobacteria. *Oscillatoria* sp. was became dominat in June 2004 at station 5 which was located in the deeper part of the dam. The species *Anabaena flos-aquae* and *Oscillatoria* sp., which usually inhabit eutrophic waters, were observed to become in high numbers in September 2004 in all stations. Codon H1 was formed by *Anabaena flos-aquae* and *Aphanizomenon ovalisporum* Forti which have tolerance to low nitrogen and sensivities for mixing and poor light. *Planktothrix rubescens* De Candelle ex Gomont Anagnostidis & Komarek which is recognized in the group R was presented in the metalimnion of mesotrophic stratified lakes [27]. According to Padisak et al. [28] this group was existed under stratification, in the metalimnion or upper hypolimnion of deeper oligotrophic lakes. Miozoa was represented by 3 taxon. *Peridinium bipes* Stein and *Ceratium* species were recorded scarcely on the phytoplankton. Bourelly [40] stated that, *Ceratium hirundinella* (O.F. Müller) Dujardin which was found on the phytoplankton of eutrophic and oligotrophic waters, shows common distribution all over the world. *Ceratium* species are taking place in L_M assembladge which are found in eutrophic to hypertrophic, small-to medium- sized lakes [28] and summer epilimnion in eutrophic lakes [27]. *Peridinium bipes* is in L_O assembladge, which are present in summer epilimnion of mesotrophic lakes [27]. According to Padisak et al. [28] the habitat of codon L_O is deep and shallow, oligo to eutrophic, medium to large lakes. Euglenozoa was represented by 4 taxon. Members of Euglenozoa are reported to be more abundant in contaminated waters and to develop well in environments with high organic matter input [41]. *Euglena gracilis* G.A. Klebs was increased in June 2004 and June 2005 while it was recorded in low numbers during the study period. Euglenoids were included in group W1 which are abundant in small organic ponds and rich in organic matter from husbandry or sewage. W2 assembladge was formed by *Trachelomonas hispida* (Perty) F. Stein and *Trachelomonas volvocina* Ehrenberg which were presented in shallow mesotrophic lakes [27,28].

3.4. Statistical analysis

The Shannon- Weaver diversity index which applied on Sazlıdere Dam phytoplankton ranged between 0.035 and 1.059, Simpson's dominance index changed between 0.096 and 0.973. While high diversity indice values show generally rich, good balanced communities; low values shows stress and negative impact. When estimating all stations, lowest Shannon-Weaver diversity indice values and highest Simpson's dominance indice values were found at station 3; for the reason that extreme increases of *Anabaena flos-aquae* on September 2004. According to Spearman's rank correlation analysis, a highly significant positive correlation ($r = 0.667$) existed between phytoplankton density and orthophosphate concentrations. There was very low positive correlation ($r = 0.167$) between phytoplankton density and nitrate concentrations. Because of phosphorus is a limiting nutrient in aquatic ecosystems. Furthermore there was a negative correlation between temperature and dissolved oxygen and was found important ($p < 0.05$). It was described a linear correlation depending on temperature increases, dissolved oxygen amounts decreases.

4. Conclusion

Phytoplankton of Sazlidere Dam mainly consists of diatoms, green and blue-green algae. Especially *Anabaena flos-aquae* and *Planktothrix rubescens* of cyanobacteria showed increases in spring and summer. When *P. rubescens* presents in large numbers it can clog the filters used in water treatment processes and can lead to unwanted situations in waters [3]. *Anabaena flos-aquae* is one of the species of cyanobacteria that has been reported to produce toxins in waters [42]. Therefore, according to recorded excessive blooms of this harmful algae indicates danger of eutrophication in the study area. Also, the high levels of chlorophyll- *a* concentrations showed the lake water has eutrophic characteristics. But low nutrient amounts, existence of oligotrophic, mesotrophic and eutrophic species indicated that the characteristic of Sazlidere Dam changes from oligotrophic character to mesotrophic character.

The "Canal Istanbul" project, which is a channel connecting the Black Sea and the Sea of Marmara parallel to the Bosphorus, also includes the Sazlidere Dam Basin. Due to this project, a massive effect on the environment in Turkey and beyond is expected. If the "Channel Istanbul" project is carried out not only in Turkey; a large ecosystem covering many countries, including the Black Sea, Mediterranean, Bulgaria, Romania, Ukraine, Russia, Georgia and Greece, will be affected at the same time. Therefore, obtained data from this research have important value.

In conclusion, continuing detailed ecological studies of Sazlidere Dam which supplies potable water to Istanbul Metropolitan will prove effective in re-evaluation of the uses of the lake, and preservation, improvement and control of the water quality. The data gathered will be useful in determining the trophic status of Sazlidere Dam will provide input for future researches.

Acknowledgments

I'm grateful to the late Dr. Mustafa Temel for his help in the identification of the species and the late Dr. Hacer Canan Okgerman for her help in statistical analysis. I also wish to thank Dr. Sinem Göktürk for rechecking the English language in the article. I thank the Istanbul University Scientific Research Project Fund for financial support (Project No:T-336/03112003 and UDP Project No:6366).

References

[1] C.S. Reynolds, What factors influence the species composition of phytoplankton in lakes of different trophic status?, Hydrobiologia, 369/370 (1998) 11–26.

[2] M. Katsiapi, M. Moustaka-Gouni, U. Sommer, Assessing ecological water quality of freshwaters: PhyCoI—a new phytoplankton community ındex, Ecol. Inform., 31 (2016) 22–29.

[3] E.G. Bellinger, D.C. Sigee, Freshwater Algae Identification, Enumeration and Use as Bioindicators 2nd ed., John Wiley&Sons, West Sussex, UK, 2015.

[4] N. Yilmaz, I.I. Ozyigit, G. Demir, I.E. Yalcin, Determination of phytoplankton density, and study of the variation of nutrients and heavy metals in the surface water of Riva Stream; one of the water sources of Istanbul, Turkey, Desal. Water Treat., 55 (2015) 810–820.

[5] A. Akça, Sazlıdere Havzası Su Kalitesi Atıksu Uzaklaştırma Optimizasyonu ve Sulak Alan Maliyetlerinin Değerlendirilmesi [Sazlıdere Basin Water Quality Wastewater Removal Optimization and Evaluation of Wetland Costs (in Turkish)] Master's Thesis, Yıldız Technical University, Institute of Science and Technology, Department of Environmental Engineering, 2005.

[6] N. Yilmaz, Phytoplankton Composition of Sazlidere Dam Lake, Istanbul, Turkey, Maejo Int. J. Sci. Technol., 7 (2013) 203–211.

[7] Apha, Standart Methods for the Examination of Water and Waste water, 16th Ed., Washington, 1992.

[8] J.W.G. Lund, C. Kipling, E.D. Le Cren, The inverted microscope method of estimating algal numbers and the statiscal basis of estimations by counting, Hydrobiologia., 11 (1958) 143–170.

[9] F. Hustedt, Bacillariophyta (Diatomeae) heft 10, in Die Süsswasser-flora Mitteleuropas (Ed. A. Pascher), Gustav Fischer Pub., Jena, Germany, 1930.

[10] F. Hustedt, The Pennate Diatoms, Koeltz Scientific Books, Koeningstein, Germany, 1985.

[11] T.V. Desikachary, Cyanophyta, Monograph on Algae, Botany Department, University of Madras, New Delhi, 1959.

[12] G.W. Prescott, Algae of western great lake area, W.M.C. Brown Co. Publishers, Dubuque, USA, 1961.

[13] G.W. Prescott, Fresh Water Algae, W.M.C. Brown Co. Publishers, Dubuque, USA, 1964.

[14] R. Patrick, C.W. Reimer, The diatoms of the united states: exclusive of alaska and hawaii, Vol. 1, The Academy of Natural Sciences, Philadelphia, USA, 1966.

[15] R. Patrick, C.W. Reimer, The diatoms of the united states: exclusive of alaska and hawaii, Vol 2, Academy of Natural Sciences, Philadelphia, USA, 1975.

[16] G. Huber-Pestalozzi, Das Phytoplankton des Süsswassers: Systematik und Biologie: 2. Teil, 2. Halfte: Diatomeen, in Die Binnengewasser (Ed. A. Thienimann Teil 2 Diatomeen), E. Schweizerbartsche Verlagsbuchhandlung, Stuttgard, Germany.

[17] K. Krammer, H. Lange-Bertalot, Bacillariophyceae: Teil 3. Centrales, Fragilariaceae, Eunotiaceae, Gustav Fischer Verlag, Jena, Germany, 1986.

[18] D.M. John, B.A. Whitton, A.J. Brook, The freshwater algal flora of the british isles, Cambridge University Press, New York, USA.

[19] M.D. Guiry in Guiry, M.D. & Guiry, G.M. 2018. *AlgaeBase*. World-wide electronic publication, National University of Ireland, Galway. http://www.algaebase.org; searched on 12 April 2018.

[20] T.R Parsons, J.D.H. Strickland, Discussion of spectrophotometric determination of marine plant pigments, whit revised equations for ascertaining chlorophylls and carotenoids, J. Mar. Res., 21 (1963) 115–163.

[21] E.O. Wilson, W.H. Bossert, A primer of population biology, Mass, Sinaeuer, 1971.

[22] E.H. Simpson, Measurement of Diversity, Nature, 163: 688, 1949.

[23] S. Siegel, Nonparametric Statistics, McGraw-Hill, New York, 1956.

[24] M.J. Norusis, SPSS 11.0 Guide to Data Analysis, Prentice Hall; Pap/Cdr edition, 2002.

[25] P.G.N. Digby, J.C. Gower, Ordination and classification. Séminaire de mathématiques supérieures No. 98, Les presses de L'Université de Montreal, Canada, 1986.

[26] O. Uslu, A. Türkman, Su Kirliliği ve Kontrolü [Water Pollution and Its Control (in Turkish)], Ankara, T.C. Başbakanlık Çevre Genel Müdürlüğü Yayınları, Eğitim Dizisi I, 1987.

[27] C.S. Reynolds, V. Huszar, C. Kruk, L. Naselli-Flores, S. Melo, Towards a functional classification of the fresh water phytoplankton, J. Plankton Res., 24 (2002) 417–428.

[28] J. Padisak, L.O. Crossetti, L. Naselli-Flores, Use and misuse in the application of the phytoplankton functional classification: a critical review with updates, Hydrobiologia., 621 (2009) 1–19.

[29] F. Maraşlıoğlu, A. Gönülol, Phytoplankton community, functional classification and trophic state indices of Yedikır Dam Lake (Amasya), J. Biol. Environ.l Sci., 8 (2014) 133–141.

[30] N. Yilmaz, Diversity of phytoplankton in Kucukcekmece Lagoon channel, Turkey, Maejo Int. J. Sci. Technol., 9 (2015) 32–42.

[31] N. Yilmaz, The phytoplanktonic algal flora of Elmali Dam Lake (İstanbul, Turkey), Erzincan University Fen Bilimleri Enstitüsü Dergisi, J. Sci. Technol., 10 (2017) 78–89.

[32] A. Elmacı, O. Obalı, The algal flora of the littoral region in lake aksehir, Tr. J. Biology., 22 (1998) 81–98.

[33] H. Gürbüz, Z. Altuner, A quantitative and qualitative study on the phytoplankton of palandöken pond, Turk. J. Biol., 24 (2000) 13–30.

[34] N. Yılmaz, G. Aykulu, The seasonal variation of the phytoplankton density on the surface water of Sapanca Lake, Turkey, Pak. J. Bot., 42 (2010) 213–1224.

[35] G.E. Hutchinson, A treatise on limnology, Vol: II. Introduction to Lake Biyology and the Limnoplankton, John Wiley and Sons, 1967.

[36] I.S. Trifonova, Phytoplankton composition and biomass structure in relation to trophic gradient in some temperate and subarctic lakes of North-western Russia and the Prebaltic, Hydrobiologia, 369–370 (1998) 99–108.

[37] Ş. Cirik, Ş. Cirik, Limnoloji [Limnology (in Turkish)], Ege Üniversitesi Su Ürünleri Fakültesi Yayınları, No: 21, 1991.

[38] S. Kılınç, A study in the seasonal variation of phytoplankton in hafik lake (Sivas, Turkey), Tr. J. Botany., 22 (1998) 35–41.

[39] B. Taş, Gönülol, A. Planktonic Algae of Derbent Dam Lake (Samsun, Turkey) planktonik algleri, Journal of Fisheries-Sciences.com, 1 (2007) 111–123.

[40] P. Bourelly, Les algues d'eau douce, Tome III, Société Nouvelle des éditions Boubée, Paris, 1985.

[41] F.E. Round, The ecology of algae, Cambridge University Pres., Cambridge, 1984.

[42] M.F. Watanabe, K. Harada, W.W. Carmichael, H. Fujiki, Toxic Microcystis, CRC Press, Boca Raton, New York, London, Tokyo, 1995.