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REPUBLIC OF TURKEY

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PHYTOPLANKTON COMPOSITION AND ECOLOGICAL PROPERTIES IN BURÇ RESERVOIR

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Supervisor

Prof. Dr. Abuzer ÇELEKLİ

by

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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Gülümser ÖZPINAR

ABSTRACT

PHYTOPLANKTON COMPOSITION AND ECOLOGICAL PROPERTIES IN BURÇ RESERVOIR

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In this study, it was aimed to investigate the existence of phytoplankton composition and related physicochemical changes in Burç Reservoir. The samples were monthly taken from three stations in Burç Reservoir between September 2018 and August 2019. Annual water quality analysis helps to evaluate the impact of anthropogenic activities on the reservoir. The Reservoir water was slightly alkaline characteristics with an average pH of 8.55. A total of 136 algae taxa had been identified. Chlorophyta was the dominant group with 40 taxa. *Pediastrum duplex* and *Cladophora glomerata* in phylum Chlorophyta (29%) were the most dominant groups in terms of biovolume followed by *Ulnaria biceps* and *Ulnaria ulna* in phylum Bacillariophyta (19%) and *Microcystis aueroginosa* and *Oscillatoria tenuis* in phylum Cyanobacteria (18%) in the reservoir. The two axes of Canonical Correspondence Analysis (CCA) explained the relations between phytoplankton species and environmental factors of Burç Reservoir with 99.4% and 99.2% respectively. The cumulative variance percentage of the species data explained with 20.7. These interactions indicated that phytoplankton species were directly affected by environmental variables. The most effective explanatory factors such as electrical conductivity, salinity, N-NO_3, TN, temperature, N-NO_2, P-PO_4, TP, etc. played significant roles ($p=0.002$) in the seasonality of species. Results of Carlson’s Trophic State Index and OECD indicated that Burç Reservoir had eutrophic structure.

Key Words: Burç Reservoir, Phytoplankton, Seasonality, Water Quality

ÖZET

BURÇ GÖLETİ FİTOPLANKTON KOMPOZİSYONU VE EKOLOJİK ÖZELLİKLERİ

ÖZPINAR, Gülümser
Yüksek Lisans Tezi, Biyoloji
Danışman: Prof. Dr. Abuzer ÇELEKLİ
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Bu çalışmada Burç Göleti fitoplankton kompozisyonu ve buna bağlı fizikokimyasal değişikliklerin araştırılması amaçlanmıştır. Numuneler, Eylül 2018 ile Ağustos 2019 tarihleri arasında her ay Burç Göleti'ndeki üç istasyondan alınmıştır. Yıllık su kalitesi analizi, antropojenik aktivitelerin gölet üzerindeki etkisinin değerlendirilmesine yardımcı olur. Göletin suyu, ortalama 8.55 pH ile hafif alkali özelliğindedir. Toplam 136 fitoplankton taksonu tespit edilmiştir. 40 Taksonla Chlorophyta familyası baskın grubu oluşturmuştur. Biyohacim açısından göletteki en baskın türler Phylum Chlorophyta'da (%29) *Pediastrum duplex* ve *Cladophora glomerata*; bunu Phylum Bacillariophyta'da (%19) *Ulnaria biceps* and *Ulnaria ulna* ve Phylum Cyanobacteria'da (%18) ise *Microcystis aueroginosa* ve *Oscillatoria tenuis* izlemiştir. Canonical Correspondence Analysis (CCA)'in ilk iki ekseni, fitoplankton türleri ile çevresel faktörler arasındaki ilişkiyi sırasıyla % 99.4 and %99.2 olarak açıklamıştır. Tür verilerinin kümülatif varyans yüzdesi 20.7 ile açıklanmıştır. Bu etkileşimler, fitoplankton türlerinin çevresel değişkenlerden doğrudan etkilendiğini göstermiştir. Elektriksel iletkenlik, tuzluluk, $N-NO_3$, TN, sıcaklık, $N-NO_2$, $P-PO_4$, TP, vb. gibi en etkili faktörler, türlerin mevsimselliklerinde önemli rol oynamıştır ($p = 0.002$). Burç Göleti, Carlson Trofik Durum İndeksi ve OECD'nin sonuçlarına göre ötrofik bir yapıya sahiptir.

Anahtar Kelimeler: Burç Göleti, Fitoplankton, Mevsimsellik, Su Kalitesi

''Dedicated to Water''

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LIST OF ABBREVIATIONS

BOD_5	Biochemical Oxygen Demand
Ca	Calcium
Cd	Cadmium
COD	Chemical Oxygen Demand
Cr	Chromium
Cu	Copper
DO	Total Dissolved Oxygen
EC	Electrical Conductivity
GASKİ	Gaziantep Su ve Kanalizasyon İdaresi
MLSS	Mixed Liquor Suspended Solid
NH_4-N	Ammonium Nitrogen
Ni	Nickel
NO_2-N	Nitrite Nitrogen
NO_3-N	Nitrate Nitrogen
NTU	Neplometric Turbidity Unit
OECD	The Organisation for Economic Co-operation and Development
Pb	Lead
P_m	Monthly Precipitation
PO_4-P	Orthophosphate
RH	Relative Humidity
Sal	Salinity
SDD	Secchi Disc Depth
TDS	Total Dissolved Solid
Temp	Water Temperature
TN	Total Kjeldahl nitrogen
TP	Total Phosphor
YSKY	Yerüstü Su Kalitesi Yönetmeliği

CHAPTER I

INTRODUCTION

1.1 Importance of Water

Water is the most common substance found on earth. It is essential for all forms of life and it can exist as a gas, liquid or solid. Water is the most important and abundant compound of the world and makes up approximately 75% of its surface. However, only a very small quantity of water is freshwater and appropriate for human use (Smol, 2008). 70% of the human body consists of water. More than half of the world's species live in water (Smol, 2008). Except in polar ice-caps, glaciers, and snow; most of the world freshwater exists as groundwater. Water distribution of Earth is given Figure 1.1. Earth water is mostly salty and our planet's water supply is constantly moving from one form to another. Things would get pretty awful without the water cycle.

People and lots of life on earth need freshwater sources. Groundwater provides excellent quality drinking water in many regions. However, groundwater can not be supplied by the reasons of geological conditions. Thus, where groundwater of unsuitable quality or supplies is insufficient, surface water must be used depending upon the usage purposes. Surface water is susceptible to many pollutant exposures in recent years. Therefore, natural and unnatural changes in water quality can be observed According to the Ministry of Agriculture and Forestry sectoral water usage datas rate are stated as follows. Agriculture water usage rate is 74%, industry 13% and domestic water is 13% in Turkey (TOB, 2019).

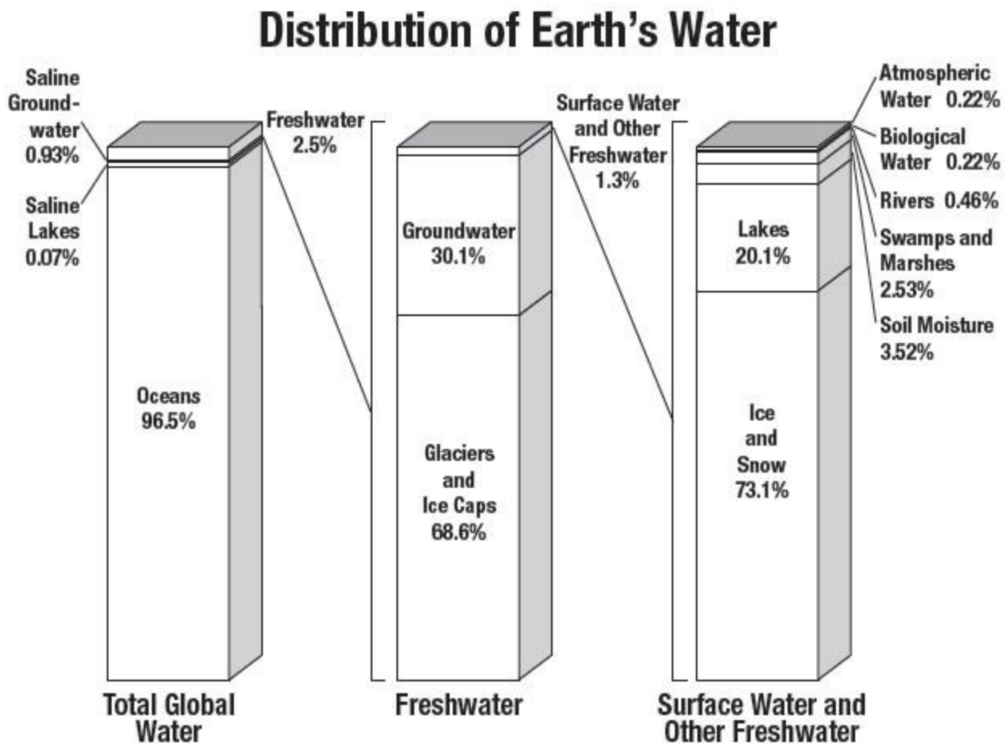

Figure 1.1 Earth's water source (Shiklomanov, 1993)

1.2 Water Pollution and Eutrophication

Freshwater's quality is determined depending on environmental factors, including topography, geology, biology, and climate. Those factors can change daily, seasonally or even over longer timespans. In defining the quality of water; in addition to natural factors, human impacts are also highly effective.

Providing clean drinking and potable water to the world's growing population is one of the greatest requirement of the century. Clean and high-quality water is a very important requirement for a sustainable healthy life. Increased environmental pollution impacts all freshwaters ecosystems and it threatens all global aquatic ecosystems. The quality of water has vital value before it's used, and is defined as its physical, chemical, biological parameters.

Naumann (1919) described the increase of nutrients in the aquatic ecosystems as eutrophication: on the other hand, Vollenweider (1968), described as degradation of water quality due to excessive plant growth and the effect of metabolisms in the water, especially as a result of enrichment of lake water in terms of nutrients.

Eutrophication of surface water is predicted to increase almost everywhere by 2030. The number of lakes with harmful algal blooms will increase by at least 20% until

2050 on earth. Nutrients discharge into receiving water bodies are increasing day by day. Thereafter; deterioration of surface waters will be seen more in developing countries. Likely; the situation might manage in developed countries (UN DESA, 2012).

The ecological status of accessible clean water resources is endangered by increased loads of nutrients and chemical pollution (Malve, 2007). But it is not appropriate to attribute the degree of eutrophication only key to the number of basic nutrients. It must be determined by many measurements such as hydrological, geographic, topographic, ecological, physical, chemical and biological parameters.

Amount of nutrients in the aquatic ecosystems is essential to support all the other trophic levels in the ecosystem and maintain a healthy structure and functioning. Generally, excess nutrients of anthropogenic origin cause an increase in the growth of plants; this leads to an increase in phytoplankton biomass in still waters, where harmful or toxic species can be dominant (European Communities, 2009).

Discharging of effluents and pollutants into watercourses may undesirable consequences on the ecosystems and their biodiversity (Gonzalo and Fernández, 2012). The presence of dyes in surface water ecosystems reduces light penetration and photosynthetic activity (Saratale et al., 2011).

Moreover, even at low concentrations of many dyes or metabolites in water bodies can cause various diseases and disorders in living organisms like skin irritation allergies and cancer (Çelekli et al., 2009; Salleh et al., 2011; Dotto et al., 2013).

The human population and industrial activities have been causing environmental pollution, especially water pollution in receiving water bodies such as rivers, sea, lakes, etc. Those industrial and anthropogenic activities have impacted water quality severely all worldwide.

Anthropogenic activities have caused many negative impacts to the biodiversity, on the management of water resources, and the assessment of the biological integrity in the great proportion of inland aquatic ecosystems (Allan and Castillo 2007, Cao et al., 2007; Delgado and Pardo, 2014).

According to The Ministry of Environment and Urban Planning (ÇŞB), a research carried out of 143 surface water resources in Turkey reported 34 of them (24%) were in the first class (high quality water), 26 (18%) were graded in the second class (less contaminated water), 33 (23%) graded the third class (contaminated water), 50 (35%) graded the fourth class (highly contaminated water) (ÇŞB, 2019). All those water quality classification were made according to the water pollution control regulation of Turkey.

On the other hand, the contamination causes of 389 surface water resources in Turkey were examined and reported as follows; 297 (76.3%) of contaminated resources were marked by domestic wastewater discharge, 294 (75.6%) of contaminated resources were marked by pesticide and fertilizer drain. 228 (58.6%) of contaminated resources were marked by domestic solid wastes. 165 (42.4%) of contaminated resources were marked by animal husbandry. 138 (35.5%) of them contaminated sources were marked by industrial wastewater as a possible cause of pollution (ÇŞB, 2019). From this point, the water must be protected and the protection of water is crucial for the future of humanity and the nature of our country.

Lakes have an essential role in preserving ecological health and required a resource to life forms in own region. Algal bloom indicates the phenomena eutrophication can cause a massive problem in all surface waters.

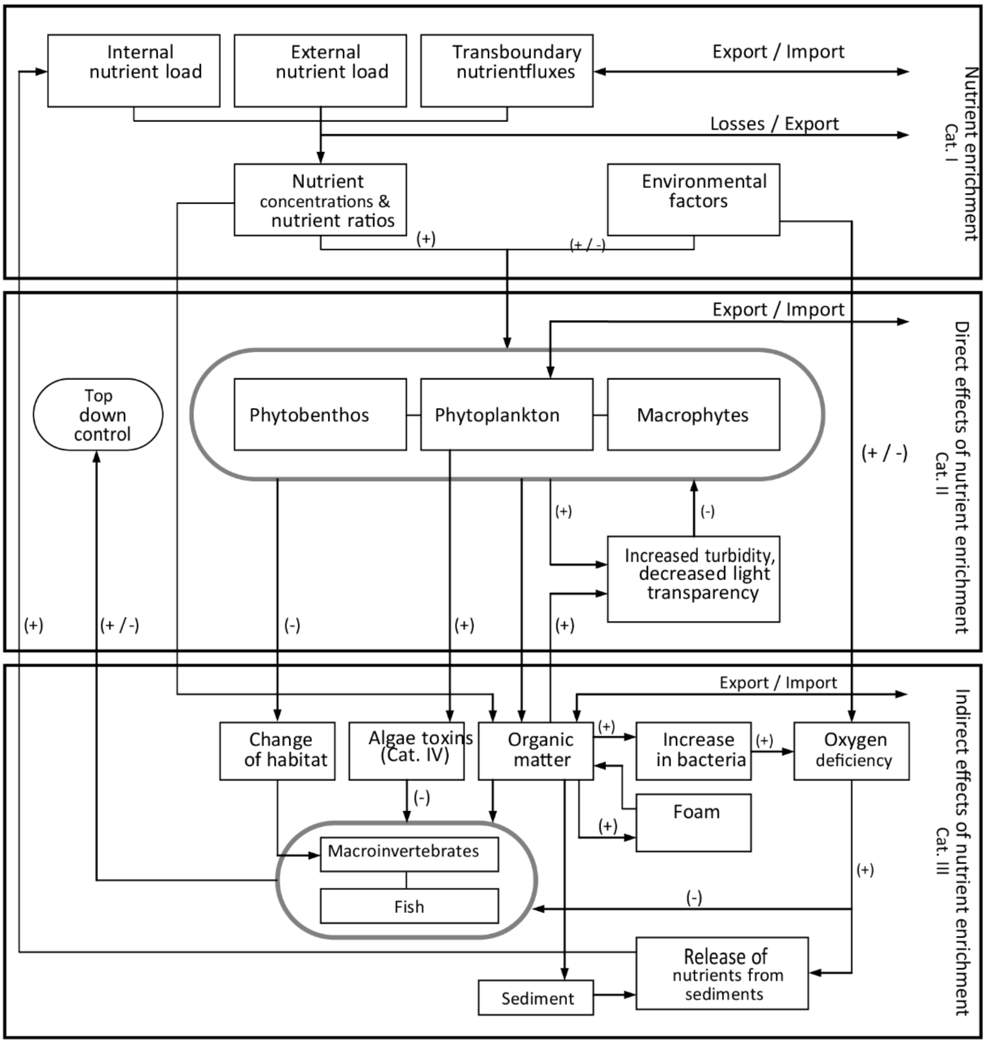

Figure 1.2. General conceptual framework for assessing eutrophication for all surface waters categories. (-) indicates a decrease, (+) indicates increase; round boxes indicate biological quality elements of WFD (WFD GD-23 European Communities, 2009).

1.3 European Union Water Framework Directive

The European Water Framework Directive (WFD) established that has goals to improve water quality framework to use, manage, resurrect and protect surface water, river, groundwater, transitional and coastal waters according to the environmental legislation of the directive (Directive, 2000). The EU WFD reported that water resource monitoring is quite important. Physiological and chemical variances in aquatic ecosystems cause differences in phytoplankton composition, density, and chemical content. Using the biochemical components and quantities in the algae as an early sign of risk potential in aquatic ecosystems.

In this sense, a great effort has been put forth worldwide to monitor freshwaters using not only chemical and physical but also biological variables. Biomonitoring provides a good measurement of extensive ecological and environmental integrity by using the lots kind of species in environmental variables or changes.

The WFD required member states to protect and assess all their water resources, with the target of good level surface water quality status and achieving good ecological potential by 2015 (European Communities, 2009).

The environmental objectives of the WFD were to intercept deterioration, keep, protect, and enhance or restore water resources. Biological quality factors; including macrophytes, phytobenthos, benthic macroinvertebrates, phytoplankton, and fish are bioindicators of freshwaters. According to the WFD, physicochemical parameters, as well as the hydromorphological data were used to support the biological quality factors.

The use of phytoplankton, one of the five biological quality elements as an ecological indicator recommended by the WFD to evaluate surface waters is getting more and more important in lakes and reservoirs. Phytoplankton are used to be a good indicator for assessing water quality, due to its sensitivity and rapid responses to variations in its habitat (Padisák et al., 2006).

Table 1.1 Normative definitions of ecological status classifications. The general definition for rivers, lakes, transitional waters and coastal waters. From Annex V of the WFD (Directive, 2000/60/EC).

Status	**General condition**
High status	There are little or no anthropogenic alterations in physicochemical and hydromorphological quality element values. The values of the biological quality elements for the surface water body reflect those normally associated with that type under intact or uncontaminated conditions, and show no, or only very minor, evidence of distortion. These are the type of specific conditions and communities.
Good status	The values of biological quality elements for the type of surface water mass show low levels of degradation resulting from human activity, but under deviating conditions they only slightly deviate from those normally associated with the type of surface water mass.
Moderate status	The values of biological quality elements for the type of surface water mass deviate moderately from those normally associated with the type of surface water mass under undisturbed conditions. The values show moderate signs of distortion resulting from human activity and are significantly more disturbed than under conditions of good status.
Poor and bad	Waters achieving a status below moderate shall be classified as poor or bad.

1.4 Phytoplankton and Freshwater Quality

Phytoplankton are microscopic biotic and photosynthesizing organisms and it has a key role in determining water quality. High nutritive value features of phytoplankton are important primary producers. Phytoplankton are distributed on wide habitat on earth and important organisms for the biosphere. However; phytoplankton have an essential ecological mission being food sources as well as being primary producers in surface water

Phytoplankton or microalgae are free-living photosynthetic microorganisms in aquatic systems and are the primary producer of the limnetic zone. Phytoplankton communities dominate the surface water systems that cover 70% of the world's surface area (Reynolds, 2006). As prokaryotic or eukaryotic, unicellular, colonial or filamentous free-living photosynthetic microorganisms in aquatic systems, phytoplankton play a key role in the organization and functioning of aquatic ecosystems and are most relevant bioindicators for the monitoring of nutrient enrichment (Constanza et al., 2014).

Phytoplankton is one of the basic and key factors of a water ecosystem in the food web. Dynamic features of lakes such as clarity, trophic status, zooplankton and fish production depend on phytoplankton. Freshwater communities are highly sensitive to environmental variables (Darchambeau et al., 2014). Physicochemical factors strongly shape the all phytoplankton composition in the waters (Reynolds, 2006; Maileht et al., 2013).

To improve the quality of ecosystems in water, it is necessary to know which environmental factors are affected. In particular, physical or chemical pollution seen, frequently seen in surface water sources; plays a primary role in the destruction of ecosystems, but physicochemical analyzes alone may not be sufficient to identify the adverse effects of pollution.

The ecological status of surface water following Annex V" is defined as "an expression quality of the water ecosystems structure classified associated with surface waters, in WFD. This classification system of the water ecological status should reflect the structure of the biological factors changes and response to human activity pressure.

Phytoplankton are quite important bioindicators of the water ecology such as still waters, lakes, etc. Phytoplankton composition and dynamics act a key role in all lake ecosystem biodiversity. Phytoplanktons are considered good indicators of trophic conditions and water quality because they respond rapidly to environmental variables or water quality deterioration (Thakur et al., 2013) and the quantity and/or quality of phytoplankton dynamics should be considered water quality as well.

Appropriate environmental conditions and nutrients increment in the water causes the increase of phytoplankton biomass. It is very important to protect surface waters, which are very suitable for pollution.

The cyanobacteria also provide an extraordinarily wide-ranging contribution to human affairs in everyday life (Tiffany, 1958).

Some cyanobacteria produce cyanotoxin and there have been many poisoning cases around the world caused by cyanotoxins in waters. Therefore, the beneficial aspects, as well as the harmful features of phytoplankton, should be considered. Based on increased environmental pollution and global climate change can be caused increased cyanobacteria population in surface waters. Thereby, health problems caused by cyano-toxins may increase.

Burç Reservoir is one of the five reservoirs in the region and there is no detailed study about its annual phytoplankton phenology and water quality. It is extremely important to examine the water quality and ecological changes in the reservoir during the four seasons. From that point, physical, chemical and biological changes in the reservoir were monitored monthly between September 2018 and August 2019. Besides, limno-ecological characteristics of the reservoir were revealed in terms of seasonal change in phytoplankton composition and water quality.

CHAPTER II

LITERATURE REVIEW

Numerous studies have been carried out to determine the phytoplankton feature, compositions, impact or function of earth's water ecosystems and to investigate their ecological characteristics. Using phytoplankton as an indicator in water quality assessments is a new perspective in Turkey and it has become even more important after the 2000s.

Altuner (1982) examined the phytoplankton concentration’s changes in Lake Tortum seasonally. He has identified 35 phytoplankton species and 128 diatom species and stated that the lake has an oligotrophic structure.

Phytoplankton composition of Lake Seyfe which is a very salty lake was investigated by Baysal and Obalı (1995). In this study 49 species belonging to Bacillariophyta, Chlorophyta, Cyanophyta, Dinophyta and Euglenophyta divisions were identified. The most dominant division was Bacillariophyta with 24 species. Moreover; some physical and chemical properties of this lake were determined by this study.

Phytoplankton composition of Lake Akşehir was seasonally investigated (Elmacı, 1995). The chlorophyll-a, amount of phytoplankton, and some chemical and physical properties of this lake were determined. In total 120 species of algae have been identified.

Ibañez (1998) investigated the phytoplankton composition of Lake Camaleao (Brazil) in the Amazon region. A total of 262 algae taxa had been identified and 185 taxa belong to Euglenophyta was to be the dominant group.

Atıcı and Obalı (2006) phytoplankton compositions of Sarıyar Reservoir was determined and their distribution according to the chlorophyll-a amount, physical and chemical changes from March 1996 to June 1997. Chlorophyta and Bacillariophyta divisions were dominant. Maximum levels of Chlorophyll-a were analyzed in June and September 1996 and May 1997, corresponding to the maximum values of temperature calcium, sulphate, and orthophosphate in the lake.

Phytoplankton composition of Lake Gölköy and Lake Abant were determined (Çelekli, 2006a). A total of 285 phytoplankton taxa were determined in Lake Abant; 271 phytoplankton taxa were determined in Lake Gölköy. Lake Abant showed mesotrophic and dimictic structure, whereas Lake Gölköy had a monomictic structure in transition from mesotrophy to eutrophy (Çelekli and Külköylüoğlu, 2006) monthly investigated the diatom composition of Lake Abant for two years. A total of 123 diatom species were identified in Lake Abant. The number of diatom species was the highest in November with 83 taxa. The diatom composition of Lake Gölköy was monthly monitored for 26 months (Çelekli, 2006b). A total of 119 diatom species were identified in Lake Gölköy. The number of diatom species was the highest in November-December 2003 and September- October 2004 during study time.

Physico-chemical properties and phytoplankton composition of the Kemer Dam in Aydın were determined and seasonal changes were revealed (Özyalın, 2007). In autumn, a significant increase in phytoplankton density was observed. The reservoir had 77 species and showed an oligo-mesotrophic character.

Mustapha (2008) investigated the variations in physicochemical factors to determine the water quality of Oyun Reservoir in Offa, Kwara State, Nigeria. This study showed that the reservoir had high ecological status and excellent water quality.

Sömek and Balık (2009) investigated the algal flora and seasonal change of environmental conditions of Lake Karagöl which is a mountain lake between August 2002 and July 2003. In total 88 phytoplankton taxa have been identified and Lake Karagöl was reported as an eutrophic lake.

Phytoplankton compositions and water quality in Lake Hazar were examined during one year (Koçer, 2008). In total 69 phytoplankton taxa was identified and 54 species belong to Bacillariophyta as a dominant group. The result of this study indicated that Lake Hazar showed the mesotrophic class considering the nutrients' progress. On the other hand, Lake Hazar had oligotrophic structure due to its high dissolved ion concentration and pH values, lake property.

The physicochemical properties and phytoplanktonic organisms of Erfelek Reservoir were investigated from August 2010 to June 2011 (Ersanli, 2011). During the study period, 68 phytoplanktonic taxa were identified and Ochrophyta division was to be the dominant group with 28 taxa. In this study, Erfelek Reservoir; morphometric structure, water depth, chlorophyll-a and total phosphorus values were taken into consideration, it showed the feature of an oligotrophic lake. Also; it was determined mesotrophic lake according to phytoplankton structure, Secchi disc depth, and compound index value.

Phytoplankton composition and physico-chemical properties of the Alleben Reservoir were determined monthly between April 2012 and June 2013 (Çelekli and Öztürk, 2014). Thermal stratification was recorded between April - November 2012 and April 2013. Alleben Reservoir had 232 algae species and showed the eutrophic structure in transition from mesotrophy to eutrophy. However, it was reported that the reservoir waters may not be suitable for swimming because; the total number of coliform bacteria in the Alleben Reservoir was more than 100 cfu L^{-1}.

Bharat et al. (2012) researched the epipelic algae flora in Lake Samaguri, India between November 2009 and October 2010. As a result of the research, a total of 44 algae taxa was determined and Bacillariophyta was found to be the dominant group.

Jindal et al. (2014) monthly studied phytoplankton abundance and composition, chlorophyll-a of the Lake Prashar in India concerning to hydrography from March 2008 to February 2010. Annual chlorophyll-a mean concentration 4.87 mg L^{-1} in 2008-09 and 4.03 mg L^{-1} in 2009-10. High DO, low nutrient profile, presence of Dinophyceae, Chrysophyceae, and Bacillariophyceae abundance throughout the year were the main characteristics feature of Lake Prashar. It is stated that it is suitable for drinking and potable water as a clean drinking water source with permissible physicochemical features. Furthermore; they reported that the lake has a higher percentage of desmids and relatively less abundance of Cyanophyceae. Thus, Lake Prashar had an oligotrophic status and it was protected from human activities.

Bucak et al. (2018) investigated effects of climate change and land usage on the cyanobacteria of Lake Beyşehir ecosystem. The observations indicate that differences in land use directly affected the water ecosystem and fertilizer used in agricultural areas increased nutrients in the water and causes cyanobacteria increment. The results showed that the increase in abundance of cyanobacteria in the future can limit drinking and potable water and threaten Lake Beyşehir, which is the largest freshwater ecosystem in the Mediterranean basin.

Yilmaz (2019) investigated some physico-chemical properties, phytoplankton composition, and pollution status of Büyükcekmece Reservoir and its streams (Tahtaköprü, Eskice, Izzettin, Çekmece, Ahlat, Çakmaklı, Beylikçayı, and Karasu) which is the second-largest drinking water resources of Istanbul, Turkey. The study showed that the reservoir was close to eutrophic features, even if it indicated mesotrophic lake characteristics. The reservoir and its streams consisted of Ochrophyta (1), Miozoa (2), Cryptophyta (2), Charophyta (6), Euglenozoa (8), Cyanobacteria (8), Chlorophyta (14), and Bacillariophyta (22). It was reported that the reservoir and its creeks should be protected and observed to improve its quality by relevant authorities.

CHAPTER III

MATERIALS AND METHODS

3.1 Site Description

Burç Reservoir is located in Burç Village, Şahinbey district of Gaziantep province, the southeast Anatolia. The reservoir (37° 03' 46.64 N; 37° 10' 10.72 E) (Figure 3.1); is situated at about 830 m above the sea level and about 35 km away from the center of Gaziantep.

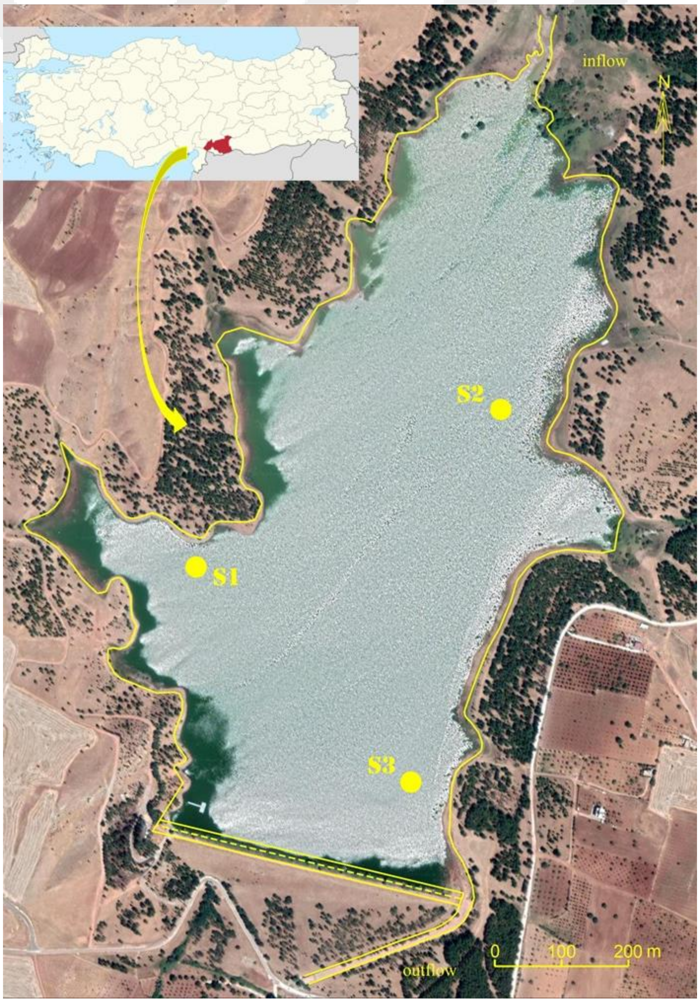

Figure 3.1 Burç Reservoir and sampling stations.

Gaziantep has "dry-summer subtropical" and cold and rainy in the winter climates which is often called "The Mediterranean". According to the Köppen Climate Classification.

Burç Reservoir is established to provide agricultural irrigation and water supply to villages in the region. General some information about the reservoir is given in Table 3.1.

Table 3.1 General features of Burç Reservoir

	Burç Reservoir
Reservoir Type	Artificial Pond
Purpose	Irrigation
Year of Built	1984
Drainage Basin Area	58 km^2
Storage Volume	5,500,000 m^3
Max Depth	21 m
Basin Water Yield	5535846 $m^3 year^{-1}$
Spilway Type	Ogee Spillway
Spilway Capacity	37,700 m^3 s^{-1}

The reservoir has 544394 m^2 (54 ha) surface area and it is surrounded by trees especially pines. As a matter of course, it was built on the lowest altitude location of the basin. The project implementation period is between 1984-1998. The storage volume of the reservoir is 5.5 km^3 and its irrigation site is 682 ha area. Due to the slope and geological characteristics of the basin, the flow of precipitation is 5-10 L s^{-1}. The highest altitude is 1320 m and the lowest altitude is 700 m of the basin.

3.2 Sampling and Analyses

All samples were monthly collected from three stations of Burç Reservoir between September 2018 and August 2019. Vertical samplings were made with a Zodiac boat when samples were collected with a 2.5 L of Van Dorn bottle from different depths. Several samples taking with Van Dorn bottle were concentrated by plankton net for net-phytoplankton identification. Water samples and phytoplankton samples were collected from the surface of Burç Reservoir.

Phytoplankton sampling was collected using a plankton net between September 2018 and August 2019. Phytoplankton sampling from the reservoir ecosystems was performed according to standard methods (CEN 9548, CEN 15204; CEN 16695; CEN 16698). To determine phytoplankton species composition, sampling was continued with the plankton net until phytoplankton density was sufficient. The concentrated water sample was placed in a 250 mL polyethylene water collection vessel and fixed with lugol-glycerol solution. For phytoplankton identification, hydrobios plankton net was used to collect phytoplankton, while 250 mL water samples were directly taken from just beneath of the surface water to the counting of phytoplankton taxa.

Water sampling was conducted (APHA, 2012) according to EN ISO/DIS 5667, EN ISO 5667. Water samples for physicochemical analyzes were taken directly from three sampling stations between September 2018 and August 2019. The samples were transferred to the laboratory of GASKİ-Gaziantep Water and Sewerage Administration as soon as possible after the collections.

3.3 Measurement of Physicochemical Variables

Sampling for physicochemical analyzes was taken directly from the reservoir described three stations. Physicochemical parameters such as water pH, temperature (Temp), conductivity (EC), specific conductance (SPC), total dissolved solid (TDS), salinity (Sal), oxidation reduction potential (ORP), dissolved oxygen (DO), percentage of dissolved oxygen (%DO), and atmosphere pressure were measured via YSI Professional Plus Multiparameter.

Secchi depth was measured using a Secchi disc (20 cm diameter limnological disc) to determine water transparency. The geographical data (elevation, latitude and longitude) were recorded with a geographical positioning system (Garmin 45 XL model). We obtained rainfall, humidity and atmospheric temperature values from Gaziantep Şahinbey Meteorological Observation Station.

Water samples were monthly transferred taken to the accredited laboratory of GASKI. The chemical variables of the reservoir such as mixed liquor suspended solid (MLSS), biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), total Kjeldahl-nitrogen (TN), ammonium-nitrogen ($N\text{-}NH_4$), nitrite-nitrogen ($N\text{-}NO_2$), nitrate-nitrogen ($N\text{-}NO_3$), total phosphorus (TP), orthophosphate ($P\text{-}PO_4$), total organic carbon (TOC), calcium (Ca), copper (Cu), nickel (Ni), cadmium (Cd), chromium (Cr), lead (Pb), and cyanide (CN) were analyzed according to standard methods (APHA, 2012).

The determination of total hardness in the water was analyzed according to ISO 6059:1984 Water Quality Determination EDTA titrimetric method. Total Kjeldahl nitrogen and total phosphor analyses were performed according to Spectrophotometric measurements. Copper, nickel, cadmium, chromium, and lead were analyzed ICP – OES device (ICP-OES, Perkin Elmer, Optima 2100 DV) (APHA, 2012). Spectrophotometric measurements of Cyanide were performed the device which is called Merck Spectroquant Prove 600. The determination of ammonium and calcium analyses was done according to EN ISO 14911:1998 Water quality determination of dissolved Li^+, Na^+, $NH4^+$, K^+, Mn^{2+}, Ca^{2+}, Mg^{2+}, Sr^{2+} and Ba^{2+} using ion chromatography method. The determination of nitrite and nitrate were performed using the standard of ISO 10304-1:2007 Water quality determination of dissolved anions by liquid chromatography of ions Part 1: Determination of bromide, chloride, fluoride, nitrate, nitrite, phosphate and sulfate.

3.4 Identification of Net-Plankton and Enumeration of Phytoplankton

Net-plankton samples as 250 mL were collected with a 20 cm diameter plankton net to obtain net-phytoplankton. After the concentrated samples were brought to the laboratory, temporary and permanent slides of phytoplankton were made for the identification of species under the light microscope at 200X, 400X, and 600X magnification. The shapes of some phytoplankton were photographed with the BX 53 Olympus microscope with an attachment of DP73 camera.

Permanent slide was prepared to help for identification of the diatom taxa. Organic constituents of diatoms were removed from the debris to observe the details and ornamentations of valves of diatoms. These samples were boiled in a mixture of concentrated hydrochloric acid and potassium permanganate. The diatomaceous remains were then washed in distilled water until the valves were acid-free (Simonsen, 1974). The shapes of some diatoms were photographed with the attachment of the BX53 Olympus microscope with the attachment of DP73 camera. The cell size, shape, and ornamentation on cell wall (spin, raphe, number of striae per 10 μm) were generally used during the identification of taxa.

Taxonomic keys (Prescott 1982; Huber-Pestalozzi, 1983; Popovsky and Pfiester, 1990; Round et al., 1990; Krammer and Lange-Bertalot, 1991a,b; Komarek and Anagnostidis, 1998; Krammer and Lange-Bertalot, 1999a,b; Graham and Wilcox, 2000; John et al., 2002; Wehr and Sheath, 2003) were used to identify phytoplankton species. Besides, algaebase (2019) was used to check taxonomy of algal species. Cell-volume for each taxon was calculated using the geometric formula proposed by Rott (1981), Hillebrand et al. (1999) and Sun and Liu (2003). Besides, algaebase (2019) was used to check the taxonomy of algal species.

Samples for counting phytoplankton were placed in a graduated cylinder with different volumes of 30, 50, 75, and 100 mL. After waiting for 48 hours for the sedimentation of phytoplankton, the sample was siphoned from the top until a 10 mL sample at the bottom of the graduated cylinder. Hydrobios brand phytoplankton counting circles including a 10 mL sample was placed in the inverted microscope (Olympus CKX41 model). The enumeration of phytoplankton was carried out at 200X, 400X and 600X magnification. Obtained the number of organisms was calculated with the following formula.

$$\text{counted phytoplankton/mL} = \frac{\mathrm{C} * \mathrm{TA}}{\mathrm{F} * \mathrm{A} * \mathrm{V}} \tag{3.1}$$

C	: Counted individual
TA	: Total area
F	: Number of an area of view
A	: Area of view counted
V	: Settled water volume (mL)

3.5 Chlorophyll-a Analysis

Chlorophyll-a concentrations were determined by spectrophotometer after extraction in 99.7 % methanol according to the method described by Youngman (1978). To analyze chlorophyll-a concentration, water samples were filtered through a cellulose acetate membrane filter (0.45 µm). The pressure of filtration should not exceed 0.3 atm, to minimize damage to delicate organisms (Wetzel and Likens, 1991). The amount of sample required will vary according to the concentration of phytoplankton. Sample about 0.4 L was filtered through the membrane filter. The filtration was done as rapidly as possible, avoiding exposure to bright light or high temperature. After the filtration was completed, the acetate filter is placed the dark brown glass bottle containing 10 mL 99.7 % methanol. The parafilm was used to prevent the evaporation of methanol. These glass bottles containing acetate filter and methanol were put in a hot water bath adjusting 70 ^{o}C for 10 minutes. Thereafter, bottles waited in the darkness for 5 minutes. Thereafter the acetate filter in the bottle was mashed with a glass baget. Methanol contained chlorophyll pigment was taken centrifuge tube and make centrifuge at 5000 rpm for 5 minutes to separate pigment from other solid particles. The blank tube was prepared with methanol. These solutions, which were extracted with 99.7 % methanol, were measured using a spectrophotometer at 665 nm wavelength (Youngman, 1978).

Youngman formula (1978) is:

$$Chla \cdot (\mu g / l) = \frac{[(13.6) \cdot (A) \cdot (v)]}{[(d) \cdot (V)]} \tag{3.2}$$

where;

$Chla$ = chlorophyll-a

A = the absorption value.

v = extract volume in ml.

V = filtered water volume in liters.

d = length of the light path through cuvette or cell in cm.

k = 13.6 is absorption coefficient of chlorophyll-a

3.6 Trophic State

Trophic state index was used to determine trophic levels of Burç Reservoir. The trophic state of the reservoir with obtained Secchi disc depth, total phosphorus, and chlorophyll-a values during the study was determined, using the OECD criteria (Vollenweider and Kerekes, 1982). OECD criteria is given in Table 3.3. The trophic state of ecosystem was revealed using Carlson trophic state index (Carlson, 1977).

Table 3.2 Trophic state ranges of lakes according to the OECD criteria (Vollenweider and Kerekes, 1982)

Efficiency Level	TP (µg/L)	Chlo-a (µg/L)	Max.Chlo-a (µg/L)	SDD (m)	Min. SDD (m)
Oligotrophic	<10	<2.5	<8	<6	<3
Mesotrophic	10–35	2.5–8.0	8–25	3–6	1.5–3
Eutrophic	35–100	8–25	25–75	1.5–3	0.7–1.5
Hypereutrophic	100	25	75	1.5	0.7

The trophic state of ecosystem was revealed using Carlson trophic state index (Carlson 1977). Secchi disc depth (SDD), chlorophyll-a (Chla) and total phosphorus (TP) were put to the following equations (Eq.1)of Carlson trophic state index (TDI).

$$TD\dot{I}_{(SDD)} = 10\left(6 - \frac{\ln SDD}{\ln 2}\right) \tag{3.3}$$

$$TD\dot{I}_{(Chla)} = 10\left(6 - \frac{2{,}04 - 0{,}68 \ln Chla}{\ln 2}\right) \tag{3.4}$$

$$TD\dot{I}_{(TP)} = 10\left(6 - \frac{\ln(\frac{48}{TP})}{\ln 2}\right) \tag{3.5}$$

Table 3.3 Carlson trophic state index for lakes (Carlson, 1977)

Class	TDI
Oligotrophic	0–40
Mesotrophic	40–50
Eutrophic	50-70
Hypereutrophic	>70

3.7 Statistical Analyses

The relationship between the environmental variables and phytoplankton taxa were evaluated by means of stepwise multiple regression analysis. Physico-chemical variables among the sampling stations and among sampling months were compared using Analysis of Variance (one-way ANOVA was employed at 95% confidence interval using the program SPSS (IBM statistics version 23). Spearman correlation was used to test correlation among environmental variables. Detrended correspondence analysis (DCA) was used to determine the gradient length of phytoplankton composition, which is unimodal response before performing CCA (Leps and Smilauer, 2003). Canonical Correspondence Analysis (CCA) was used to determine the relationships between phytoplankton composition and physico-chemical environmental variables. All environmental variables were log-transformed (log (x+1)), except for pH; in order to reduce the skewness during CCA application (ter Braak and Smilauer, 1998). In the CCA, taxa encountered two or more times were used to reduce multicolinearity (ter Braak, 1995). Only species weight range with a percentage of 2% was selected in the CCA diagram together of the taxa were prevented in the CCA ordination. Environmental data was performed using the Monte Carlo permutation with forward selection. The program CANOCO was used for all the ordination analyses (ter Braak and Smilauer, 1998; Leps and Smilauer, 2003).

CHAPTER IV

RESULT AND DISCUSSION

4.1 Physicochemical Variables

Water temperature is a very important parameter for aquatic life in that it changes the viscosity and density of water, affects the speed of biochemical reactions occurring in the water environment and the dissolved gas concentration (Taş, 2011). Atmospheric data of Burç Reservoir are given in Table 4.1. Average the reservoir water temperature is 16.21 °C and the average atmospheric temperature is 16.59 °C. The water temperature was affected by the regional atmospheric temperature. The mean water temperature ranged between 3.83 °C and 25.63 °C, while atmospheric mean temperature ranged between 3.90 °C and 29.30 °C. The surface of the reservoir was frozen in December 2018 and January 2019.

Table 4.1 Atmospheric variables of Gaziantep.

Month	Temperature (°C)	Precipitation (kg m^{-2})	Humidity (%)
September 2018	25.8	8.4	33.5
October 2018	18.3	67.8	51.2
November 2018	10.8	38.3	71.3
December 2018	7	245.5	82.8
January 2019	3.9	164.2	78.3
February 2019	6	116.2	76.8
March 2019	9.2	155.4	63.6
April 20119	12.2	63	64.6
May 2019	21.8	6.2	38
June 2019	26.7	14.2	36.2
July 2019	28.1	0	33
Augst 2019	29.3	0.2	33.5
Mean	16.6	73.3	55.2

Annual precipitation as 879.20 mm was recorded during the study period, while 554.94 mm annual precipitation occurred in 1984. It can be stated that annual precipitation rate is increased in the present study time compared to 1984. The four seasonal limnological and physicochemical variables are given in Table 4.2.

The water of Burç Reservoir is slightly alkaline characteristics with an average pH of 8.55. In terms of pH values, the water of the reservoir indicated water quality class 1 according to Turkish water pollution control legislation. The water transparency has changed between 0.90 m and 3.00 m. The mean total Kjeldahl nitrogen of the reservoir was 2.97 mg L^{-1}. The maximum value of total Kjeldahl nitrogen of the reservoir reached 5.85 mg L^{-1} in January 2019. Ammonium nitrogen was mostly measured under 0.05 mg L^{-1}. The mean total phosphate of the reservoir 0.25 mg L^{-1}, and orthophosphate 0.13 mg L^{-1}.

Results indicated that some physicochemical parameters values were given as that; the reservoir mean dissolved oxygen value is 7.97 mg L^{-1} (81.26%), electrical conductivity 477.56 µS cm^{-1} The water quality of Burç Reservoir is between class 2 and class 3 depending on oxygen and nutrient concentrations, according to the water quality of Turkish regulation on surface water quality (YSKY, 2015).

The physicochemical average and standard deviation (mean ±SD) variables of Burç Reservoir are given in Table 4.3. The highest copper concentration was measured as 0.003 mg L^{-1} in December 2018, January 2019, and April 2019. Nickel concentration ranged between 0.001 mg L^{-1} and 0.003 mg L^{-1}. The highest cyanide concentration was found to be 0.003 mg L^{-1} in July 2019. Chromium and cadmium concentrations in the water were found to be 0.001 mg L^{-1} and 0.002 mg L^{-1} respectively. Lead concentration in the water was observed under 0.001 mg L^{-1} during the four seasons. Considering the total heavy metal concentrations, the water quality was evaluated as class 2 (YSKY, 2015). The correlation between the physicochemical variables of the Burç Reservoir lentic ecosystem is given in Table 4.4. Temperature negatively correlated with DO ($r = -0.792$ and $p < 0.01$) and TDS ($r = -0.589$ and $p < 0.01$). Electrical conductivity negatively correlated with salinity ($r = -0.795$ and $p < 0.01$) and N-NO_3 ($r = -0.721$ and $p < 0.01$). BOD positively correlated with COD ($r=0.945$ and $p<0.01$). BOD of the lentic ecosystems in Ceyhan basin also positively correlated with COD ($r=0.974$ and $p<0.01$) (Gümüş, 2018).

Table 4.2 Physicochemical variables of Burç Reservoir between September 2018 and August 2019

Variables	**Unit**	**S18**	**O18**	**N18**	**D18**	**J19**	**F19**	**M19**	**A19**	**Ma19**	**Ju19**	**Jl19**	**Ag19**
pH	-log H	8.17	8.44	8.50	8.37	8.33	8.58	8.71	8.66	8.55	8.62	8.80	8.89
Temp	˚C	23.77	19.30	11.10	8.27	3.83	6.83	10.83	12.97	22.60	24.13	25.23	25.63
EC	µS/cm	431.80	411.33	336.80	318.90	297.00	323.33	708.33	686.33	845.67	486.37	448.03	436.87
SPC	µS/cm	451.57	467.8	467.37	465.87	499.20	485.77	969.00	890.33	885.33	495.90	445.73	431.83
TDS	mg/L	293.77	304.2	303.58	301.82	324.47	588.69	630.50	578.33	574.00	322.40	289.68	280.48
Sal	mg/L	0.22	0.23	0.23	0.23	0.24	0.45	0.48	0.44	0.44	0.24	0.21	0.21
ORP	mV	-75	-79	-70	-73	-69	-85	-76	-80	-78	-77	-77	-78
DO	mg/L	7.50	5.52	7.78	8.35	7.21	12.06	12.37	11.49	7.26	6.28	3.40	6.36
% DO	% lt	95.37	67.2	73.9	78.2	61.2	102.6	113.6	108.2	84.7	70.8	41.4	78
SDD	M	2.50	1.80	3.00	0.70	1.63	1.17	0.90	1.70	1.23	1.80	1.80	2.00
MLSS	mg/L	17	23	11	43	11	8	12	19	21	11.0	11.0	8
BOD_5	mg/L	12.67	2.67	4.00	2.67	0.67	1.00	1.33	0.00	6.00	2.00	4.33	4.00
COD	mg/L	43	35	42	37	30	30	30	30	30	30	30	30
TKN	mg/L	0.70	0.63	2.20	2.13	5.85	5.53	4.57	3.97	3.56	2.93	2.50	1.12
NH_4-N	mg/L	0.05	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.1	0.05	0.05
NO_2-N	mg/L	0.05	0.05	0.05	0.07	0.10	0.10	0.10	0.20	0.20	0.20	0.20	0.10
NO_3-N	mg/L	0.05	0.05	0.05	4.03	20.6	20.2	15.9	11.6	10.7	8.5	5.6	1.9
TP	mg/L	0.17	0.26	0.24	0.30	0.35	0.28	0.26	0.16	0.28	0.25	0.21	0.17
PO_4-P	mg/L	0.081	0.153	0.117	0.220	0.287	0.123	0.053	0.057	0.187	0.203	0.047	0
NTU	NTU	10.81	12.73	4.66	51.17	11.73	4.75	7.34	4.82	13.60	4.88	5.75	1.34
TOC	mg/L	2.62	2.63	4.36	10.13	3.09	2.38	2.39	5.70	1.59	2.24	3.18	3.46
Ca	mg/L	45.75	44.48	45.16	50.29	76.13	74.65	73.66	75.13	58.51	60.45	46.83	32.01
T-Hard	mmol/L	2.09	2.08	2.10	2.14	2.25	2.69	1.99	2.27	1.58	2.28	2.00	1.83
Cu	mg/L	0.001	0.001	0.002	0.003	0.003	0.001	0.002	0.003	0.001	0.001	0.001	0.001
Ni	mg/L	0.001	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Cd	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.001	0.001	0.001	0.001
Cr	mg/L	0.001	0.001	0.001	0.001	0.002	0.001	0.002	0.002	0.002	0.001	0.001	0.001
Pb	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
CN^-	mg/L	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.001
Chlo-a	µg/L	28.11	48.7	59.8	27.2	31.1	27.7	26.5	22.9	19.7	8.0	19.9	21.53
A-Temp	˚C	25.8	18.3	10.8	7.0	3.9	6.00	9.2	12.2	21.8	26.7	28.1	29.3
RH	%	33.5	51.2	71.3	82.8	78.3	76.8	63.6	64.6	38.0	36.2	33.0	33.5
P_m	kg/m^2	8.4	67.8	38.3	245.5	164.2	116.20	155.4	63.0	6.2	14.2	0.0	0.2

Table 4.3 Physico-chemical variables of Burç Reservoir as mean and standard deviation (mean ±SD)

	Temp	pH	EC	TDS	Sal	DO	BOD_5	TKN	NH_4-N	NO_3-N	NO_2-N	TP	PO_4-P	TOC	Ca
	˚C		µS/cm	mg/L	ppt	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
S18	23.8±0.7	8.3±0.1	432±6	294±2	0.22±0.01	7.17±0.15	12±3	0.70±0.34	0.04±0.01	0.04±0.01	0.04±0.01	0.17±0.01	0.08±0.04	2.6±0.1	45.7±0.4
O18	19.3±0.8	8.4±0.1	411±6	304±1	0.23±0.01	6.18±0.53	4±1	0.63±0.13	0.06±0.02	0.04±0.01	0.04±0.01	0.26±0.02	0.12±0.02	2.6±1.6	44.5±0.5
N18	11.1±0.5	8.6±0.3	397±1	304±1	0.23±0.01	7.78±0.31	5±1	2.20±1.34	0.04±0.01	0.09±0.08	0.04±0.01	0.24±0.02	0.12±0.02	4.4±0.2	45.2±0.4
D18	8.3±0.3	8.4±0.1	389±5	302±8	0.23±0.01	8.54±0.64	3±1	2.13±0.03	0.04±0.01	4.03±0.26	0.07±0.01	0.30±0.02	0.22±0.01	10.1±2.1	50.3±0.7
J19	4.0±0.7	8.3±0.1	460±13	325±1	0.24±0.01	8.14±0.05	2±1	5.85±0.20	0.04±0.01	20.63±2.24	0.14±0.01	0.35±0.03	0.29±0.02	3.1±0.1	76.1±1.1
F19	6.8±0.2	8.6±0.2	690±62	589±85	0.45±0.07	10.73±0.19	2±1	5.53±0.53	0.04±0.01	20.18±0.34	0.10±0.05	0.28±0.02	0.12±0.01	2.4±0.3	74.7±0.6
M19	10.8±0.5	8.7±0.1	708±12	631±1	0.48±0.01	10.37±0.38	2±1	4.57±1.11	0.04±0.01	15.87±0.22	0.14±0.01	0.26±0.01	0.06±0.03	2.4±0.2	73.7±0.2
A19	13.0±0.5	8.7±0.1	686±9	578±7	0.44±0.01	10.16±0.40	4±1	3.97±0.67	0.04±0.01	11.62±0.67	0.15±0.01	0.16±0.01	0.06±0.03	5.7±2.2	75.1±6.7
Ma19	22.6±0.2	8.6±0.1	746±4	574±4	0.44±0.01	6.93±0.26	6±1	3.55±0.77	0.04±0.01	10.71±0.15	0.20±0.01	0.28±0.02	0.19±0.02	1.6±0.1	58.5±1.4
Ju19	24.1±0.6	8.7±0.1	486±3	322±1	0.24±0.01	6.04±0.22	3±1	2.93±0.68	0.10±0.02	8.46±0.07	0.19±0.01	0.25±0.01	0.20±0.02	2.3±0.1	60.4±1.3
Jl19	25.2±0.7	8.8±0.1	425±15	290±1	0.21±0.01	5.40±0.41	4±1	2.50±0.41	0.04±0.01	5.60±0.05	0.17±0.01	0.21±0.02	0.05±0.02	3.2±0.1	46.8±0.4
Au19	25.6±0.1	8.9±0.1	407±1	281±1	0.21±0.01	6.02±0.76	2±1	1.12±0.42	0.04±0.01	1.90±0.02	0.10±0.01	0.17±0.05	0.04±0.01	3.5±0.1	32.0±13.7

Table 4.4 Spearman's correlation test result among the environmental variables of Burç Reservoir

	Temp	pH	EC	TDS	SAL	DO	COD	BOD	TN	NH4	NO3	NO2	TP	PO4	TOC	Ca	Hard	Cu	Ni	Cd	Cr	CN	Chloa	A-temp
Temp																								
pH	.434**																							
EC	-0.114	0.065																						
TDS	-.589**	-0.119	.789**																					
SAL	-.564**	-0.110	.795**	.987**																				
DO	-.792**	-0.185	.335*	.677**	.667**																			
COD	0.321	-0.141	-0.107	-0.249	-0.250	-0.265																		
BOD	.393*	-0.193	-0.130	-0.318	-0.314	-.337*	.945**																	
TKN	-.554**	0.062	.646**	.728**	.712**	.553**	-.402*	-.453**																
NH4	.355*	-0.013	-0.069	-0.109	-0.077	-.406*	-0.194	-0.150	-0.244															
NO3	-.512**	0.062	.721**	.760**	.733**	.556**	-.534**	-.579**	.915**	-0.200														
NO2	0.232	0.281	.603**	.354*	.337*	-0.171	-0.043	-0.069	.493**	0.130	.576**													
TP	-.683**	-.445**	0.139	.421*	.390*	0.297	-0.283	-.360*	.429**	-0.119	.458**	0.102												
PO4	-.492**	-.492**	-0.006	0.245	0.217	0.073	-0.130	-0.159	0.256	0.184	0.238	0.113	.733**											
TOC	-0.132	0.004	-.667**	-.368*	-.397*	0.145	0.015	0.044	-0.265	-0.123	-0.311	-.375*	-0.262	-0.127										
Ca	-.586**	-0.124	.694**	.812**	.778**	.642**	-.346*	-.399*	.846**	-0.179	.904**	.502**	.395*	0.311	-0.210									
Hard	-.493**	-0.079	0.222	.520**	.496**	.499**	-.338*	-.393*	.473**	0.165	.455**	0.060	0.131	0.272	0.059	.634**								
Cu	-.610**	-0.321	-0.012	.363*	0.327	.559**	-0.189	-0.183	.377*	-0.327	.365*	0.028	0.277	0.152	.459**	.499**	0.270							
Ni	-0.221	-0.290	-.687**	-0.305	-0.314	-0.030	.338*	0.291	-.549**	0.037	-.642**	.670**	0.120	0.209	.448**	-.496**	-0.084	0.070						
Cd	-0.172	0.244	.431**	.564**	.556**	.524**	-0.109	-0.149	.341*	-0.199	.390*	0.219	-0.245	-.442**	0.093	.474**	0.298	.531**	-0.277					
Cr	-.334*	-0.025	.567**	.654**	.636**	.392*	-0.182	-0.172	.569**	-0.140	.630**	.499**	0.161	0.080	-0.158	.657**	0.292	.536**	-.436**	.655**				
CN	.596**	.446**	-0.068	-.370*	-.368*	-.650**	0.018	0.001	-0.066	.355*	-0.060	.480**	-0.285	-0.132	-0.121	-0.124	-0.037	-.360*	-0.303	-0.219	-0.208			
Chloa	-,447**	-0.327	-.374*	-0.082	-0.061	0.229	0.076	0.081	-0.141	-0.270	-0.278	-.708**	0.146	-0.003	0.288	-0.233	-0.035	0.160	.546**	-0.072	-0.131	-.427**		
A-temp	.990**	.424*	-0.130	-.603**	-.572**	-.805**	0.321	.386*	-.567**	.366*	-.523**	0.225	-.685**	-.475**	-0.124	-.599**	-.487**	-.609**	-0.198	-0.194	-0.327	.599**	-.433**	

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Burç Reservoir water temperature and dissolved oxygen changes are shown in Figure 4.1. The graph shows the correlation between water temperature and dissolved oxygen in the water. The dissolved oxygen ratio increases while the water temperature decreases. The lowest average dissolved oxygen ratio was measured in July 2019 by 3.40 mg L^{-1} and the highest average dissolved oxygen ratio was measured in March 2019 by 12.37 mg L^{-1}. The dissolved oxygen average concentration was calculated as 7.97 mg L^{-1} and it shows between the class of I and II water quality according to Turkish water pollution control legislation. Burç Reservoir mostly contained more dissolved oxygen compared to Büyükcekmece Reservoir (Yılmaz, 2019).

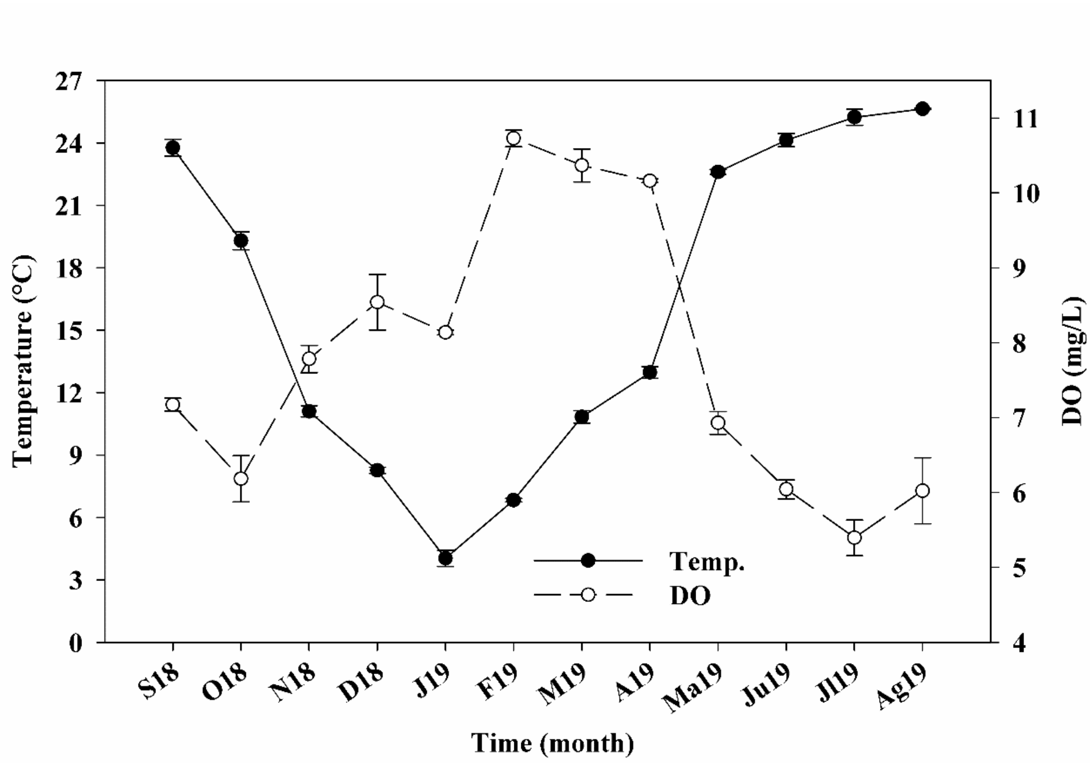

Figure 4.1 Burç Reservoir water temperature and dissolved oxygen distribution

The changes in total Kjeldahl nitrogen, nitrite, and nitrate concentrations are given in Figure 4.2. The most common nitrogenous compounds found in natural waters are nitrite, nitrate, ammonium and organic nitrogen (Horne and Goldman, 1994). The mean TKN value of the reservoir was 2.97 mg L^{-1}. The highest nitrate nitrogen value was measured 20.60 mg L^{-1} in January 2019 and the highest average nitrite nitrogen 0.20 mg L^{-1} in May 2019. Total nitrogen values in Burç Reservoir are usually exceeded the limit value (YSKY, 2015).

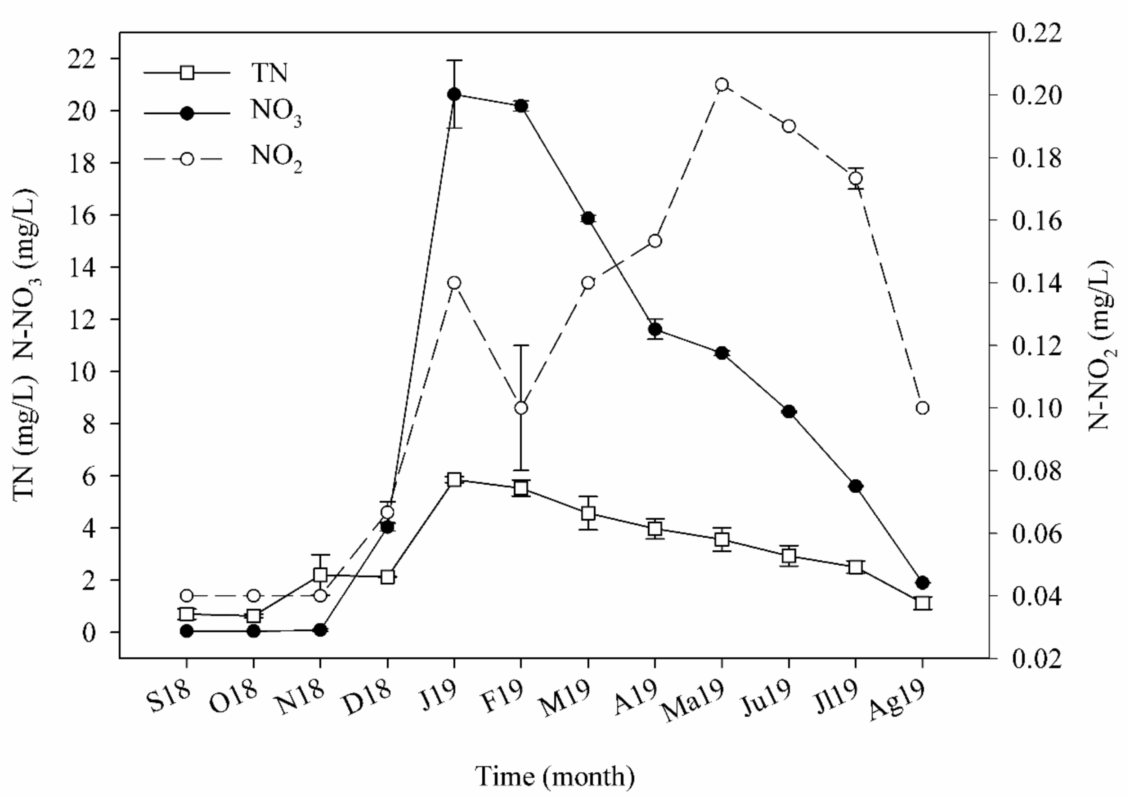

Figure 4.2 Total Kjeldahl nitrogen, nitrite-nitrogen and nitrate-nitrogen distribution in Burç Reservoir

Total phosphorus and orthophosphate variations in Burç Reservoir are given in Figure 4.2. Phosphorus is one of the basic elements of the eutrophication in aquatic ecosystems (Horne and Goldman, 1994). The mean total phosphorus value of the reservoir was determined as 0.25 mg L^{-1} and orthophosphate (PO_4) value of the reservoir was determined as 0.13 mg L^{-1}. Amount of phytoplankton is observed a rapid increase with the accumulation of aquatic ecosystems phosphorus. Total phosphorus value in Kartalkaya Dam was analyzed as 0.313 mg L^{-1} and TP values in Azaplı Lake and Ayvalı Dam was measured similar (Gümüş, 2018).

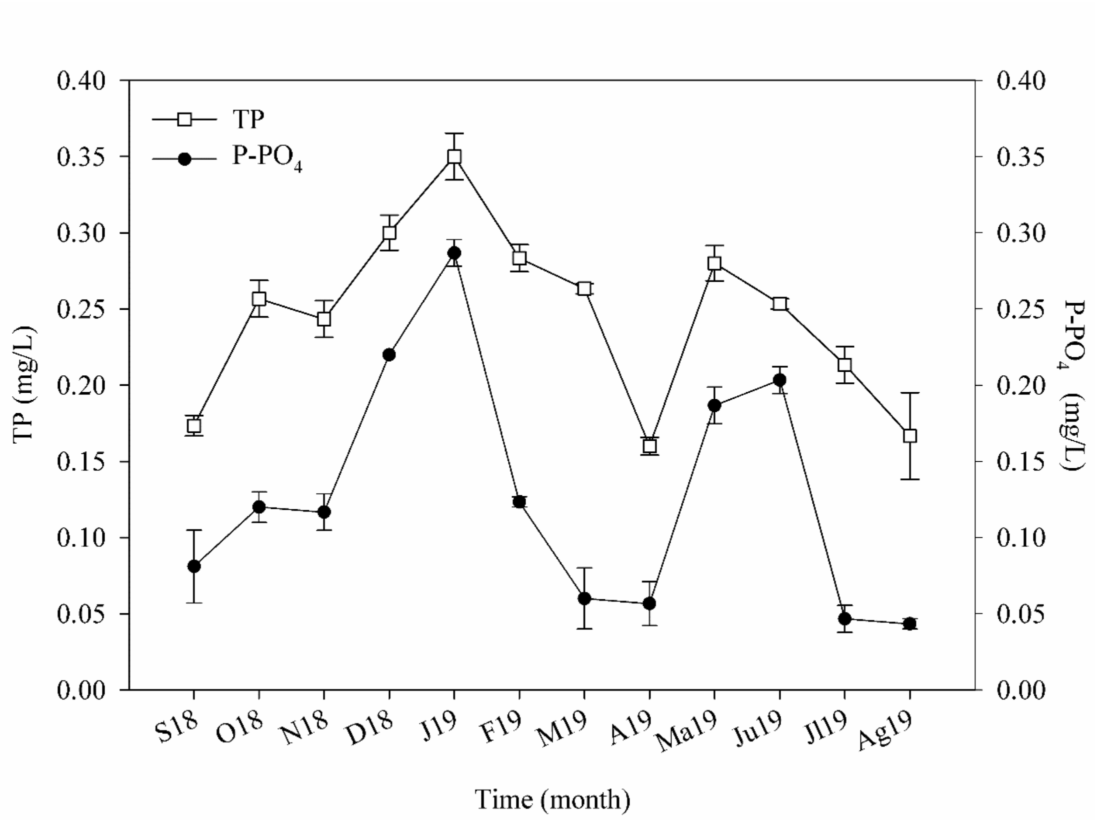

Figure 4.3 Burç Reservoir total phosphorus and orthophosphate distribution

Seasonal variations of electrical conductivity (EC), total dissolved solid and salinity in Burç Reservoir are given in Figure 4.3. Water EC gives information about the amount of ions in the aquatic ecosystems (Ünlü et al., 2008). Electrical conductivity and total dissolved solids concentrations were observed in close interaction with salinity in the reservoir. Salinity value of the reservoir ranged from 0.21 to 0.48 ppt. Electrical conductivity and salinity rapidly increased at the end of winter and in the spring. Alleben Reservoir minimum and maximum conductivities (EC) of 278.0 and 414.0l µS cm^{-1} were noted in September 2012 and May 2013, respectively (Çelekli and

Öztürk, 2014). It can be said that the conductivity of the Burç Reservoir was higher than that of Alleben Reservoir.

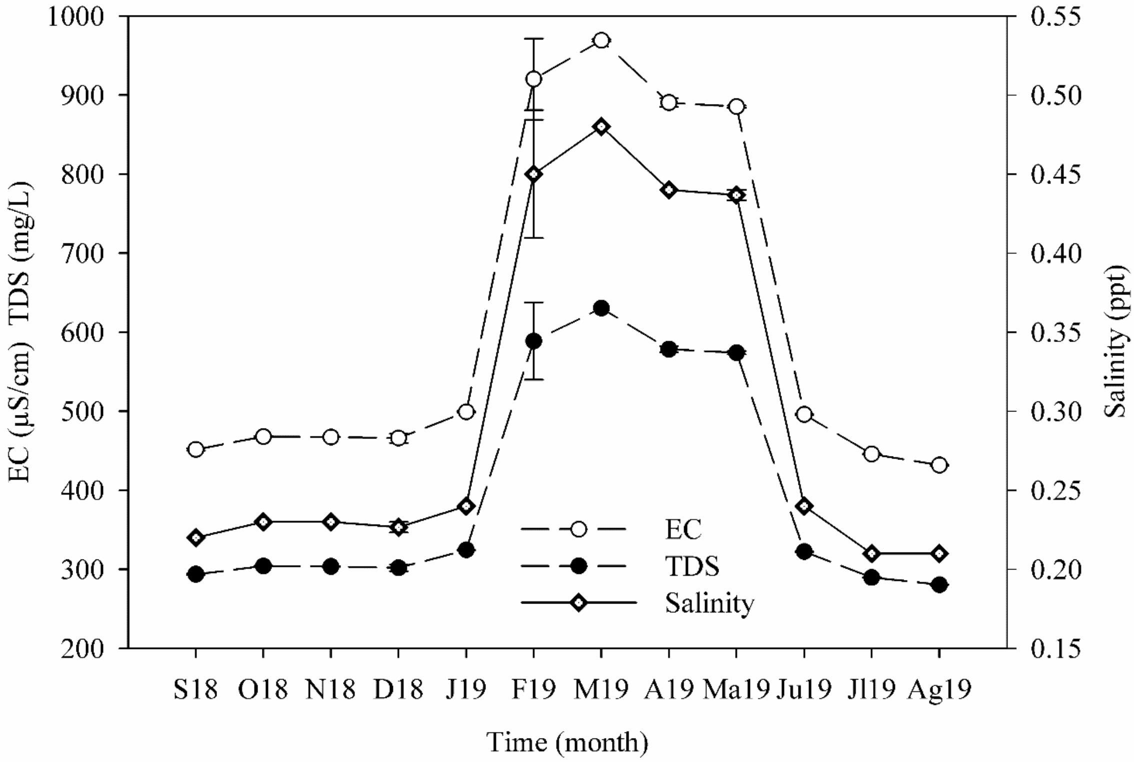

Figure 4.4 Electrical conductivity (EC), total dissolved solid (TDS), and salinity variation in Burç Reservoir

The changes of chlorophyll-a values in Burç Reservoir for one-year are given in Figure 4.4. The chlorophyll-a values of the reservoir were measured between 8.0 µg L^{-1} and 59.8.8 µg L^{-1}. Chlorophyll-a value was generally higher in the autumn season than that other seasons. The mean chlorophyll-a value was ascertained to be 28.43 µg L^{-1}. The highest chlorophyll-a 59.80 µg L^{-1} was found in November 2018; the lowest amount 8.0 µg L^{-1} in June 2019. The chlorophyll-a values of Burç Reservoir mostly were higher compared to Alleben Reservoir in the same region (Çelekli and Öztürk, 2014).

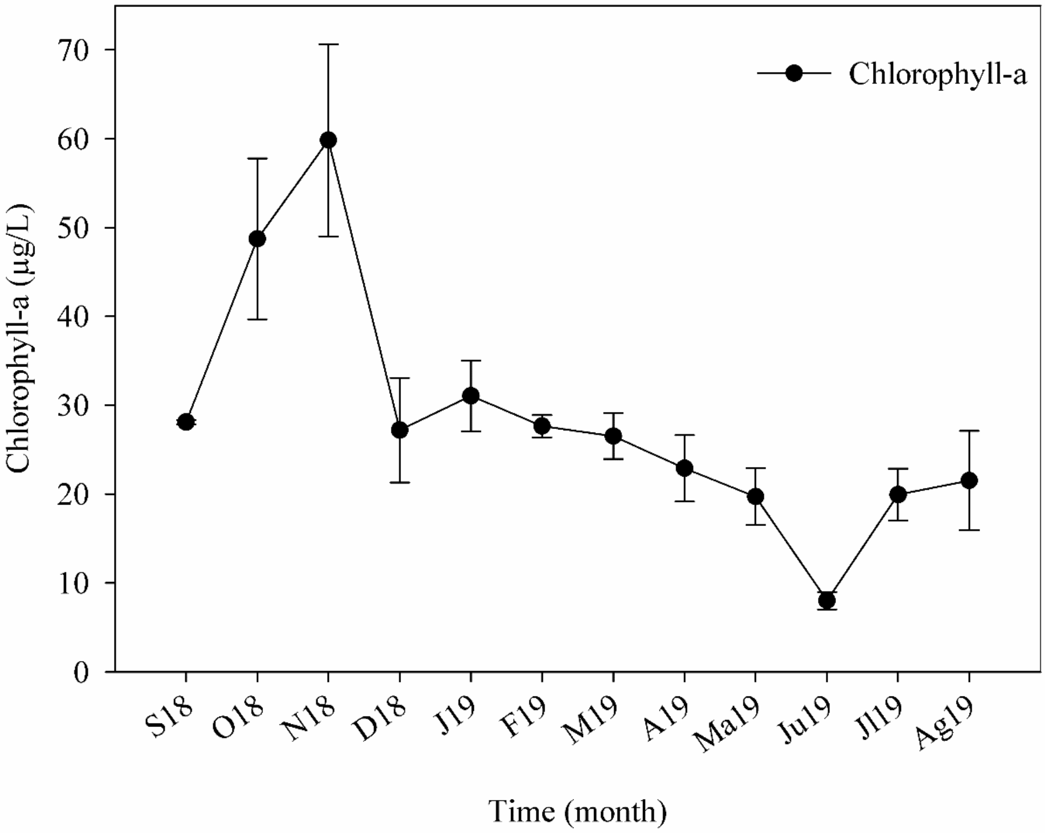

Figure 4.5 Monthly chlorophyll-a variation in Burç Reservoir

4.2 Phytoplankton Composition

This study revealed that 136 phytoplankton species belonging to 8 phyla were identified in Burç Reservoir (Table 4.5.). During the study, *Aulacoseira granulata, Ulnaria biceps, Ulnaria ulna, Cryptomonas marssonii, Cryptomonas ovata, Crucigenia tetrapedia, Pediastrum duplex, Scenedesmus brevispina, Microcystis aueroginosa* and *Dinobryon sociale* were commonly found in Burç Reservoir. The most intense phytoplankton composition was observed in autumn. However, the phytoplankton population decreased at the beginning of the 2019 spring. These could be due to an increase in zooplankton abundance. On the other hand, phytoplankton species were identified and reported in previous studies as well. 28 Phytoplankton species were identified in Azaplı Lake, 22 in the Ayvalık Dam, 28 in the Gölbaşı Lake, 30 in Kartalkaya Dam, 31 in Aslantaş Dam, 27 in the Klavuzlu Dam and 38 in Hakkıbeyli Pond. *Scenedesmus communis, Ceratium hirundinella, Cyclotella iris, Fragilaria ulna*, *Cocconeis placentula*, *Aulacoseira granulata, Amphora ovalis* and *Gomphonema parvulum* determined as the dominant species (Gümüş, 2018). However, it was observed that *Dinobryon divergens* species were commonly found in Lake Abant (Atıcı and Obalı, 2002; Çelekli, 2006a). *Cyclotella planctonica*, *Cyclotella iris, Peridinium cinctum, Fragilaria biceps, Tetraedron sp*., *Dinobryon divergens* species were determined as the dominant species of Alleben Reservoir and 232 algal taxa were identified (Çelekli and Öztürk, 2014).

Table 4.5 Phytoplankton species list

Phylum: Bacillariophyta

Acmi	*Achnanthidium minutissimum* (Kützing) Czarnecki 1994
Amsp	*Amphora* sp.
Augr	*Aulacoseira granulata* (Ehrenberg) Simonsen 1979
Augran	*Aulacoseira granulata var. angustissima* (O.Müller) Simonsen 1979
Chmu	*Chaetoceros* sp.
Cyme	*Cyclotella meneghiniana* Kützing 1844
Cyaf	*Cymbella affinis* Kützing 1844
Cyas	*Cymbella aspera* (Ehrenberg) Cleve 1894
Cyne	*Cymbella neolanceolata* W.Silva in Silva, Machado de Souza & Barnes Proena 2013
Epgi	*Epithemia gibba* (Ehrenberg) Kützing 1844s
Frca	*Fragilaria capucina* Desmazières 1830
Frcr	*Fragilaria crotonensis* Kitton 1869
Gosp	*Gomphonema* sp.
Gysp	*Gyrosigma* sp.
Icca	*Iconella capronii* (Brébisson & Kitton) Ruck & Nakov in Ruck et al. 2016
Meci	*Meridion circulare* (Greville) C.Agardh 1831
Nano	*Navicula notha* J.H.Wallace 1960
Nasp	*Navicula* sp.
Natr	*Navicula trivialis* Lange-Bertalot 1980
Nipa	*Nitzschia palea* (Kützing) W.Smith 1856
Nisi	*Nitzschia sigma* (Kützing) W.Smith 1853
Nisig	*Nitzschia sigmoidea* (Nitzsch) W.Smith 1853
Nisp	*Nitzschia* sp.
Suli	*Surirella librile* (Ehrenberg) Ehrenberg 1845
Ulbi	*Ulnaria biceps* (Kützing) Compère 2001
Ulul	*Ulnaria ulna* (Nitzsch) Compère 2001

Phylum: Charophyta

Clac	*Closterium aciculare* T.West 1860
Clco	*Closterium cornu* Ehrenberg ex Ralfs 1848
Clgr	*Closterium gracile* Brébisson ex Ralfs 1848
Cotu	*Cosmarium turpinii* Brébisson 1856
Elac	*Elakatothrix acuta* Pascher 1915
Elge	*Elakatothrix gelatinosa* Wille 1898
Klkl	*Klebsormidium klebsii* (G.M.Smith) P.C.Silva, K.R.Mattox & W.H.Blackwell 1972
Klri	*Klebsormidium rivulare* (Kützing) M.O.Morison & Sheath 1985
Mobo	*Mougeotia boodlei* (West & G.S West) Collins 1912
Moel	*Mougeotia elegantula* Wittrock 1872

Table 4.5 continued

Monu	*Mougeotia nummuloides* (Hassall) De Toni 1889
Mopa	*Mougeotia parvula* Hassall 1843
Moqu	*Mougeotia quadrangulata* Hassall 1843
Mosc	*Mougeotia scalaris* Hassall 1842
Splo	*Spirogyra longata* (Vaucher) Kützing 1843
Spsp	*Spirogyra* sp.
Stch	*Staurastrum chaetoceras* (Schröder) G.M.Smith 1924
Stdi	*Staurastrum dilatatum* Ehrenberg ex Ralfs 1848

Phylum: Chlorophyta

Bobr	*Botryococcus braunii* Kützing 1849
Chac	*Chlamydomonas acidophila* Negoro 1944
Chgl	*Chlamydomonas globosa* J.W.Snow 1903
Chglo	*Chlamydomonas gloeopara* Rodhe & Skuja in Skuja 1948
Chsn	*Chlamydomonas snowiae* Printz 1914
Clgl	*Cladophora glomerata* (Linnaeus) Kützing 1843
Clacs	*Closteriopsis acicularis* (Chodat) J.H.Belcher & Swale 1962
Cllo	*Closteriopsis longissima* (Lemmermann) Lemmermann 1899
Coas	*Coelastrum astroideum* De Notaris 1867
Comi	*Coelastrum microporum* Nägeli in A.Braun 1855
Copy	*Coenochloris pyrenoidosa* Korshikov 1953
Crte	*Crucigenia tetrapedia* (Kirchner) Kuntze 1898
Deco	*Desmodesmus communis* (E.Hegewald) E.Hegewald 2000
Deop	*Desmodesmus opoliensis* (P.G.Richter) E.Hegewald 2000
Fust	*Furcilla stigmatophora* (Skuja) Korshikov 1939
Gein	*Geminella interrupta* Turpin 1828
Gora	*Golenkinia radiata* Chodat 1894
Hare	*Hariotina reticulata* P.A.Dangeard 1889
Mipu	*Micractinium pusillum* Fresenius 1858
Misp	*Microspora* sp.
Mosi	*Monactinus simplex* (Meyen) Corda 1839
Moco	*Monoraphidium contortum* (Thuret) Komárková-Legnerová in Fott 1969
Mocon	*Monoraphidium convolutum* (Corda) Komárková-Legnerová 1969
Ooma	*Oocystis marssonii* Lemmermann 1898
Pamo	*Pandorina morum* (O.F.Müller) Bory in J.V.Lamouroux, Bory & Deslongschamps 1827
Pedu	*Pediastrum duplex* Meyen 1829
Psbo	*Pseudopediastrum boryanum*(Turpin) E.Hegewald in Buchheim *et al. 2005*
Rada	*Raphidocelis danubiana* (Hindák) Marvan, Komárek & Comas 1984
Scbr	*Scenedesmus brevispina* (G.M.Smith) Chodat 1926

Table 4.5 continued

Scel	*Scenedesmus ellipticus* Corda 1835
Scse	*Schroederia setigera* (Schröder) Lemmermann 1898
Stte	*Stauridium tetras* (Ehrenberg) E.Hegewald in Buchheim et al. 2005
Stpe	*Stichococcus pelagicus* (Nygaard) Hindák 1996
Stpr	*Stigeoclonium protensum* (Dillwyn) Kützing 1845
Tedi	*Tetradesmus dimorphus* (Turpin) M.J.Wynne 2016
Tela	*Tetradesmus lagerheimii* M.J.Wynne & Guiry 2016
Teob	*Tetradesmus obliquus* (Turpin) M.J.Wynne 2016
Temi	*Tetraëdron minimum* (A.Braun) Hansgirg 1888
Ulae	*Ulothrix aequalis* Kützing 1845
Ulsp	*Ulothrix* sp.

Phylum: Cryptophyta

Crma	*Cryptomonas marssonii* Skuja 1948
Crov	*Cryptomonas ovata* Ehrenberg 1832
Plla	*Plagioselmis lacustris* (Pascher & Ruttner) Javornicky 2001
Plna	*Plagioselmis nannoplanctica* (Skuja) G.Novarino, I.A.N.Lucas & Morrall 1994

Phylum: Cyanobacteria

Anca	*Anabaena catenula* Kützing ex Bornet & Flahault 1886
Ancy	*Anabaena cylindrica* Lemmermann 1896
Ansp	*Anabaena* sp.
Anam	*Anagnostidinema amphibium* (C.Agardh ex Gomont) Strunecký, Bohunická, J.R.Johansen & J.Komárek 2017
Arpl	*Arthrospira platensis* Gomont 1892
Chmi	*Chroococcus minutus* (Kützing) Nägeli 1849
Chtu	*Chroococcus turgidus* (Kützing) Nägeli 1849
Gesp	*Geitlerinema splendidum* (Greville ex Gomont) Anagnostidis 1989
Kafo	*Kamptonema formosum* (Bory ex Gomont) Strunecký, Komárek & J.Smarda 2014
Lire	*Limnothrix redekei* (Goor) Meffert 1988
Megl	*Merismopedia glauca* (Ehrenberg) Kützing 1845
Mete	*Merismopedia tenuissima* Lemmermann 1898
Miae	*Microcystis aeruginosa* (Kützing) Kützing 1846
Mism	*Microcystis smithii* Komárek & Anagnostidis 1995
Noca	*Nostoc caeruleum var. planctonicum* (V.S.Poretsky & V.K.Tschernow) B.A.Whitton 2011
Oste	*Oscillatoria tenuis* C.Agardh ex Gomont 1892
Plli	*Planktolyngbya limnetica* (Lemmermann) Komárková-Legnerová & Cronberg 1992
Plag	*Planktothrix agardhii* (Gomont) Anagnostidis & Komárek 1988

Table 4.5 continued

Psba	*Pseudanabaena batrachospermorum* (Skuja) Anagnostidis & Komárek 1988
Psca	*Pseudanabaena catenata* Lauterborn 1915
Psli	*Pseudanabaena limnetica* (Lemmermann) Komárek 1974
Pssp	*Pseudanabaena* sp.
Snla	*Snowella lacustris* (Chodat) Komárek & Hindák 1988
Spma	*Spirulina major* Kützing ex Gomont 1892

Phylum: Euglenozoa

Euch	*Euglena chlamydophora* Mainx 1928
Euvi	*Euglena viridis* (O.F.Müller) Ehrenberg 1830
Eupr	*Euglenaformis proxima* (P.A.Dangeard) M.S.Bennett & Triemer in Bennett et al. 2014
Euca	*Euglenaria caudata* (E.F.W.Hübner) Karnowska-Ishikawa, Linton & Kwiatowski in Linton et al. 2010
Leac	*Lepocinclis acus* (O.F.Müller) B.Marin & Melkonian in Marin et al. 2003
Lefu	*Lepocinclis fusiformis* (H.J.Carter) Lemmermann 1901
Leox	*Lepocinclis oxyuris* (Schmarda) B.Marin & Melkonian in B.Marin et al. 2003
Leoxm	*Lepocinclis oxyuris f. Major* (Woronichin) Wolowski 2011
Mopy	*Monomorphina pyrum* (Ehrenberg) Mereschkowsky 1877
Phac	*Phacus acutus* Pochmann 1942
Phal	*Phacus alatus* G.A.Klebs 1883
Phli	*Phacus limnophilus* (Lemmermann) E.W.Linton & A.Karnkowska-Ishikawa in Linton et al. 2010
Phlo	*Phacus longicauda* (Ehrenberg) Dujardin 1841

Phylum: Miozoa

Bips	*Biecheleria pseudopalustris* (J.Schiller) Moestrup, K.Lindberg & Daugbjerg 2009
Cefu	*Ceratium furcoides* (Levander) Langhans 1925
Cehi	*Ceratium hirundinella* (O.F.Müller) Dujardin 1841
Chlo	*Chimonodinium lomnickii* (Woloszynska) Craveiro, Calado, Daugbjerg, Gert Hansen & Moestrup 2011
Gysa	*Gymnodinium saginatum* T.M.Harris 1940
Gyub	*Gymnodinium uberrimum* (G.J.Allman) Kofoid & Swezy 1921
Pecu	*Peridiniopsis cunningtonii* Lemmermann 1907
Pewi	*Peridinium willei* Huitfeldt-Kaas 1900
Toco	*Tovellia coronata* (Woloszynska) Moestrup, K.Lindberg & Daugbjerg in K.Lindberg, Moestrup & Daugbjerg 2005

Phylum: Ochrophyta

Didi	*Dinobryon divergens* O.E.Imhof 1887

Table 4.5 continued

Diso	*Dinobryon sociale* (Ehrenberg) Ehrenberg 1834

The phytoplankton taxa belong to different algal groups is summarized in Figure 4.6. Burç Reservoir phytoplankton species composition were identified as 29% Chlorophyta, 19% Bacillariophyta, 18% Cyanobacteria, 13% Charophyta, 10 % Euglenozoa, 7% Miozoa, 3% Cryptophyta and 1% Ochrophyta.

The phytoplankton species composition of the lakes studied in Aras Basin was 49% Bacillariophyta, 23% Chlorophyta, 13% Cyanobacteria, 10% Charophyta, 3% Miozoa, 1% Ochrophyta and 1% Cryptophyta. Bacillariophyta was the most dominant group among divisions followed by Chlorophyta divisions (Gümüş, 2018).

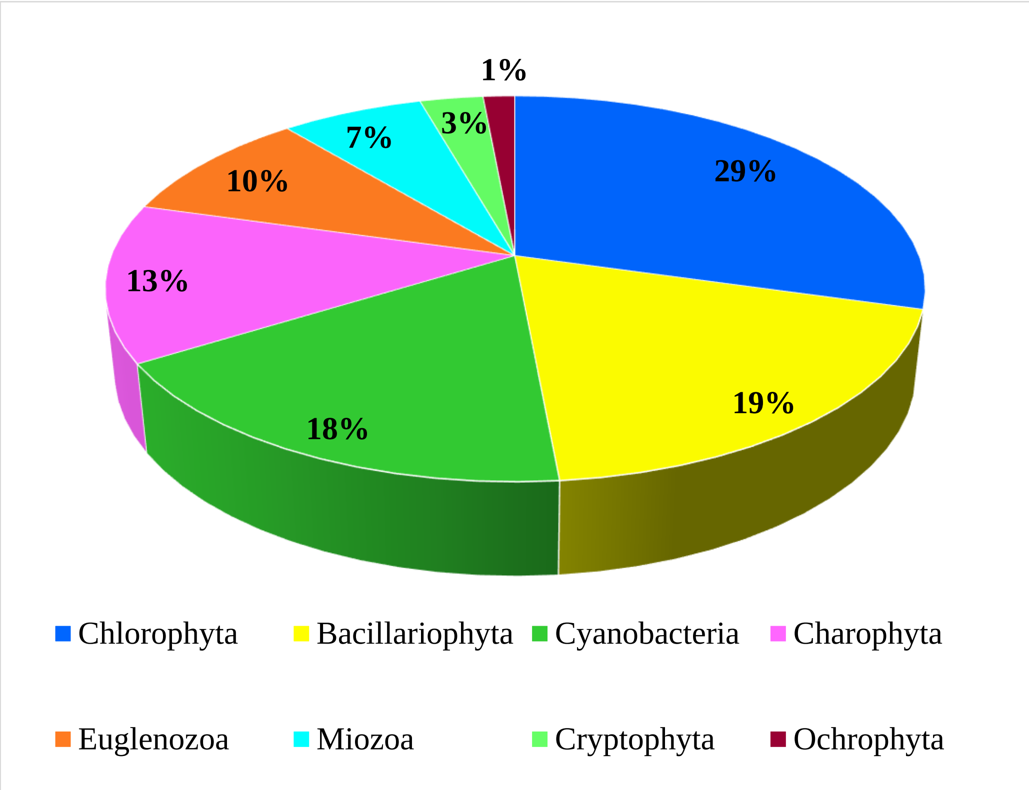

Figure 4.6 Phytoplankton divisions of Burç Reservoir

The photographes of several phytoplankton taxa in Burç Reservoir are given in Figures 4.7- 4.11.

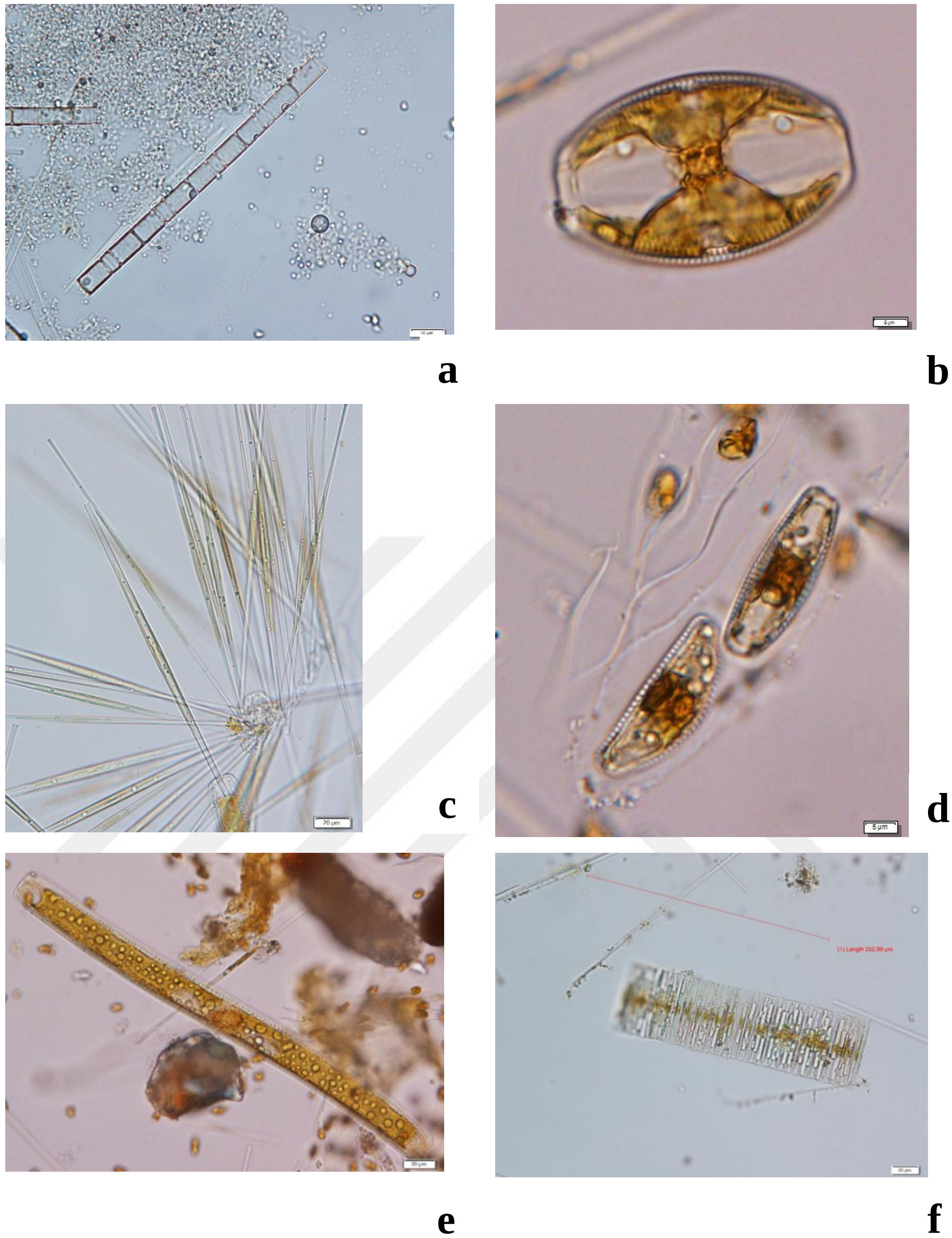

Figure 4.7 Phytoplankton images of Burç Reservoir a) *Aulacoseira granulata* (Scale 10 µm), b) *Amphora* sp. (Scale 5 µm), c) *Ulnaria ulna* (Scale 20 µm), d) *Cymbella affinis* (Scale 5 µm), e) *Nitzschia sigmoidea* (Scale 20 µm), f) *Fragilaria capucina* (Scale 20 µm).

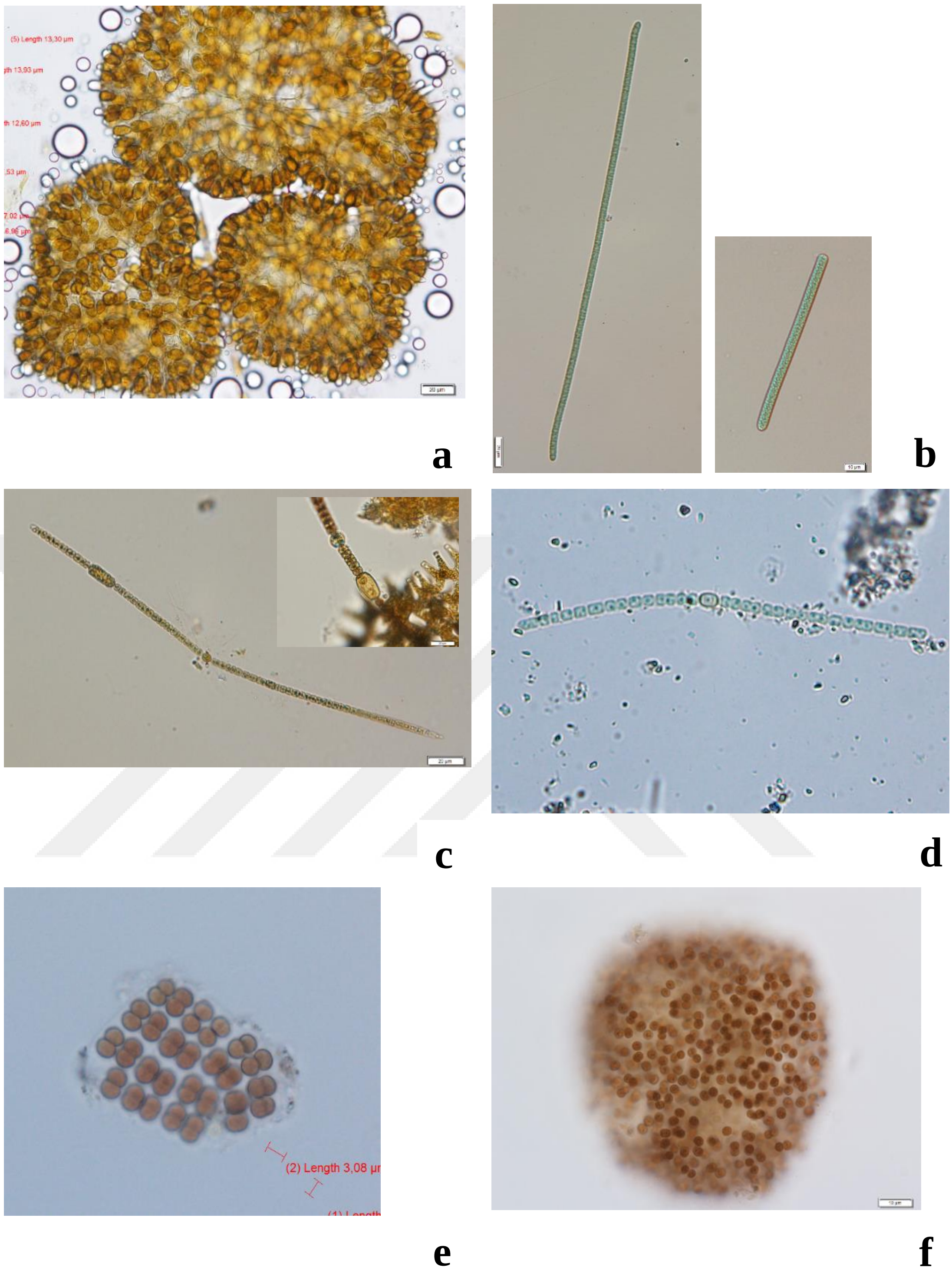

Figure 4.8 Phytoplankton images of Burç Reservoir a) *Snowella lacustris* (Scale 20 µm), b) *Oscillatoria tenuis* (Scale 20 µm and Scale 10 µm), c) *Anabaena catenula* (Scale 20 µm), d) *Anabaena cylindrica* (Scale 20 µm), e) *Merismopedia tenuissima* (Scale 10 µm), f) *Microcystis smithii* (Scale 10 µm).

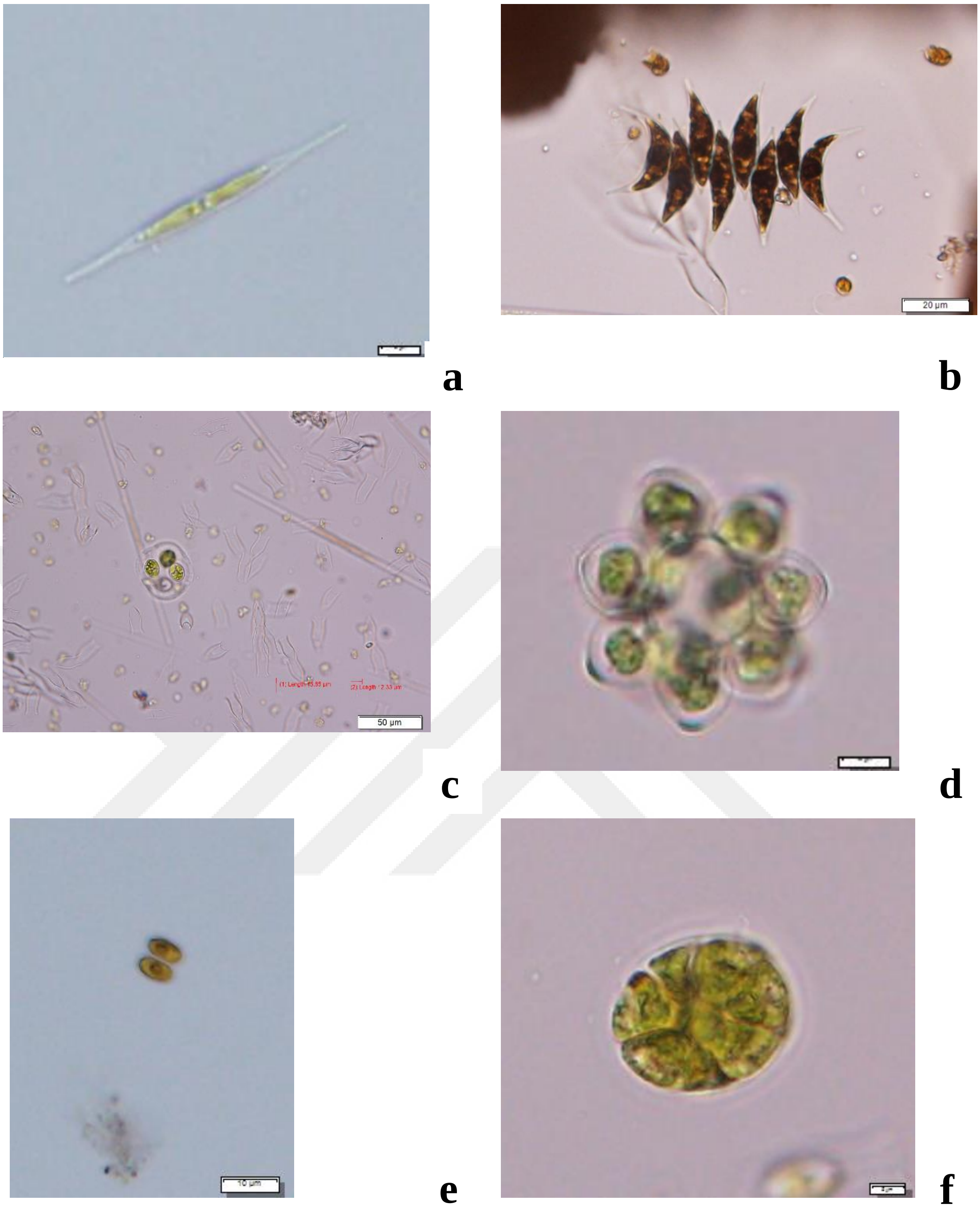

Figure 4.9 Phytoplankton images of Burç Reservoir a) *Schroederia setigera* (Scale 5 µm), b) *Scenedesmus dimorphus* (Scale 20 µm), c) *Oocystis marssonii* (Scale 50 µm), d) *Coelastrum astroideum* (Scale 5 µm), e) *Scenedesmus brevispina* (Scale 10 µm), f) *Pandorina morum* (Scale 5 µm)

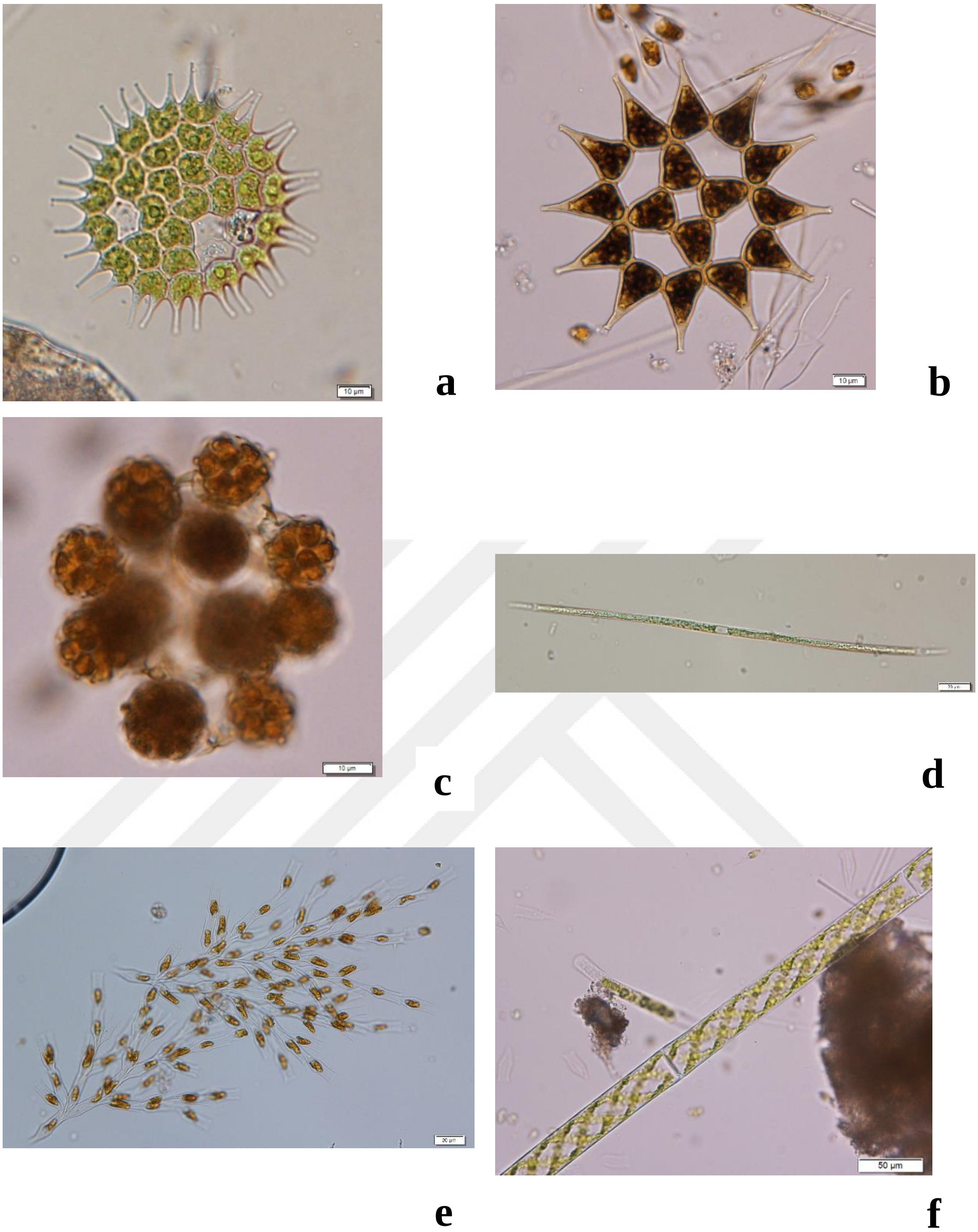

Figure 4.10 Phytoplankton images of Burç Reservoir a) *Pediastrum boryanum* (Scale 10 µm), b) *Pediastrum simplex* (Scale 10 µm), c) *Coelastrum reticulatum* (Scale 10 µm), d) *Closteriopsis longissima* (Scale 20 µm), e) *Dinobryon divergens* (Scale 20 µm), f) *Spirogyra* sp (Scale 50 µm)

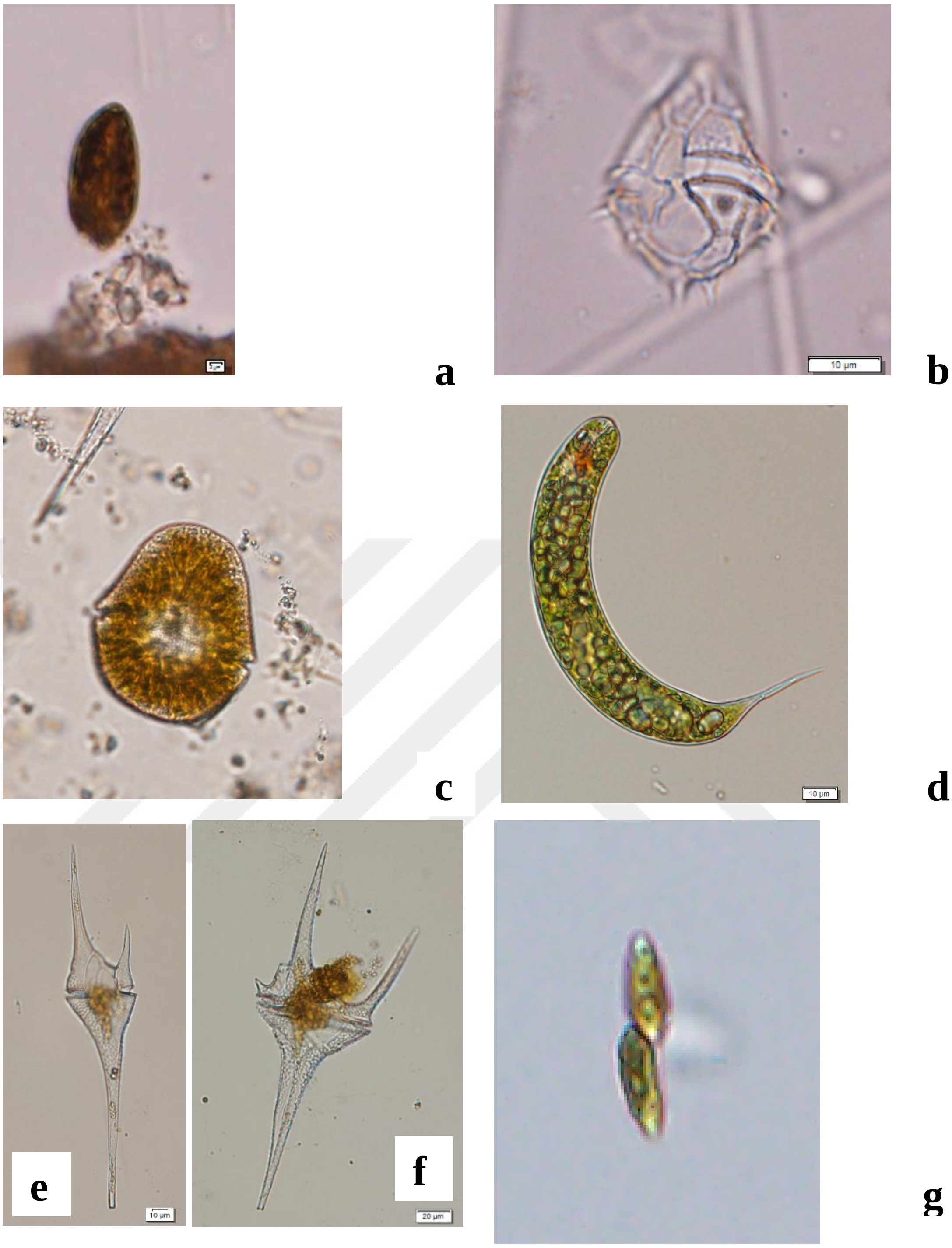

Figure 4.11 Phytoplankton images of Burç Reservoir a) *Cryptomonas ovata* (Scale 5 µm), b) *Peridiniopsis cunningtonii* (Scale 10 µm), c) *Gymnodinium uberrimum*, d) *Euglena oxyuris*, (Scale 10 µm), e) *Ceratium furcoides* (Scale 10 µm), f) *Ceratium hirundinella* (Scale 20 µm),), f) *Elakatothrix acuta*

4.3 Phytoplankton-Environmental Relations in Burç Reservoir

Canonical Correspondence Analysis (CCA) was used to explain the relations between phytochemical variables and identified phytoplankton assemblages in Burç Reservoir (ter Braak and Smilauer, 1998; Leps and Smilauer, 2003). These temporal relations for phytoplankton and cyanobacteria are given in Figure 4.12 and Figure 4.13 respectively.

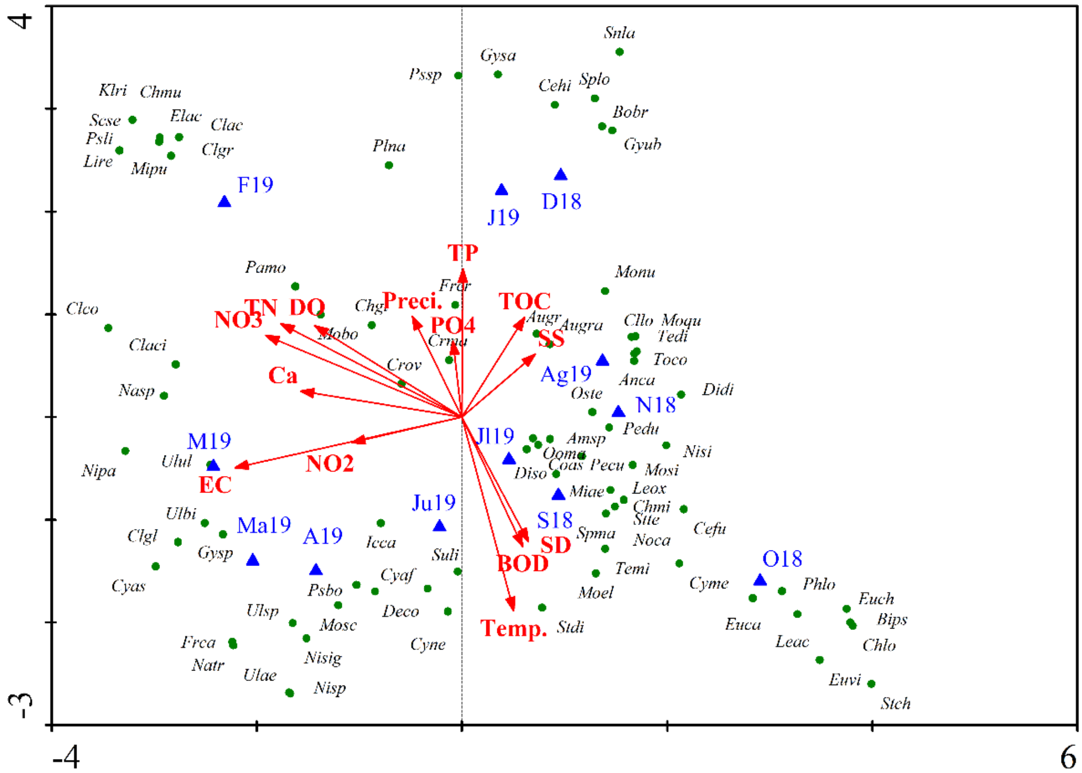

Figure 4.12 Phytoplankton composition (green circle), environmental (red arrow) relations in Burç Reservoir during 12 months. Code and full names of phytoplankton species are given on Tablo 4.5. Sampling months (up triangle) are abbreviated as S18-September 2018, O18-October 2018, N18-November 2018, D18-December 2018, J19-January 2019, F19-February 2019, M19-March2019, A19-April 2019, Ma19-May 2019, Ju19-June 2019, Jl19-July 2019, and Au19-August 2019.

The results of Monte Carlo permutation test and CCA analysis for species-environment relation in the ecosystem are given in Table 4.6. The two axes of CCA explained very well between phytoplankton species and environmental factors of Burç Reservoir with 99.4% and 99.2%, respectively. The cumulative variance percentage of the species data explained with 20.7 (Table 4.6). Strong interactions between environmental variables and phytoplankton species composition had been reported in previous studies as well. For instance; considering the first axis 96.7% for Alleben Reservoir (Çelekli and Ozturk, 2014), 95.4% for Lake Vela in Portugal (Abranthes et al., 2006), 90.5% for Lake Abant (Çelekli, 2006), 95% for Uluabat Lake (Dalkıran et al., 2016) and 97.0% for Akkaya spring in Bolu (Çelekli and Külköylüoğlu, 2007) are reported as. Those interactions indicate that phytoplankton species are directly affected by environmental variables Therefore, algae play an important role to understand, control and manage water quality in different aquatic habitats.

Table 4.6 CCA results using Monte Carlo permutation test

Axes	λ1	λ2	λ3	λ4	Total inertia
Eigen values	0.786	0.731	0.678	0.549	7.323
Species-environment correlations	0.994	0.992	0.982	0.975	
Cumulative percentage variance of species data	10.7	20.7	30.0	37.5	
of species-environment relation	12.9	25.0	36.2	45.2	
Sum of all eigen values					7.323
Monte Carlo permutation test		F = 1.443		p = 0.002	

The temporal distribution of phytoplankton species was significantly affected by the physico-chemical factors of Burç Reservoir ($p = 0.002$). The most important physico-chemical factors in the distribution of phytoplankton species in Burç Reservoir according to the partial CCA results, are given as EC ($F=3.529$ $p=0.002$), TDS ($F=3.443$ $p=0.002$), Sal ($F=3.255$ $p=0.002$), N-NO_3 ($F=3.136$ $p=0.002$), TN ($F=2.845$ $p=0.002$), Temp ($F=2.666$ $p=0.002$), DO ($F=2.588$ $p=0.002$), Ca ($F=2.377$ $p=0.002$),

P_m (F=2.246 p=0.002), $N\text{-}NO_2$ (F=2.172 p=0.006), $P\text{-}PO_4$ (F=1.998 p=0.004), and TP (F=1.924 p=0.008).

The CCA ordination divided the sampling months into four groups (Figure 4.12). In the first group, the fall months were collected and mostly in relation to BOD and Secchi disc depth. September 2018 (S18) sampling month is characterized by *Microcystis aeruginosa, Stauridium tetras, Lepocinclis oxyuris, Mougeotia elegantula* and *Nostoc caeruleum* var. *planctonicum*. At the beginning of autumn, an increase of Cyanobacteria biomass was observed (Horne and Goldman, 1994). October 2018 (O18) sampling month is characterized by *Euglenaria caudata*, *Euglena chlamydophora*, *Euglena viridis, Lepocinclis acus*, *Phacus longicauda, Staurastrum chaetoceras* and *Cyclotella meneghiniana*. In October 2018, Euglenozoa species were commonly identified and they are indicators of organic pollution (Horne and Goldman, 1994; Hutchinson, 1967). In this period, organic pollution may be discharged to the ecosystem.

The second group included the winter sampling months. The months of December 2018 (D18) and January 2019 (J19) mostly related to TP and TOC. This sampling time is characterized by *Plagioselmis nannoplanctica*, *Pseudanabaena* sp., *Gymnodinium saginatum*, *Gymnodinium uberrimum* and *Botryococcus braunii* species. February 2019 (F19) was related to *Closterium gracile*, *Closteriopsis acicularis*, *Elakatothrix acuta* and *Micractinium pusillum* phytoplankton species, which associated with TN and $N\text{-}NO_3$.

In the third group, the spring months are located on the negative side of the x and y axes and associated with EC and $N\text{-}NO_2$. The spring sampling months are characterized by *Ulnaria ulna, Ulnaria biceps, Nitzschia palea, Gyrosigma* sp., *Fragilaria capucina* and *Navicula trivialis*.

The summer months (Ju19-June 2019, Jl19-July 2019, and Ag19-August 2019) in particular, the sampling month of July 2019 were localized at the CCA ordination center. July 2019 sampling month is characterized by *Dinobryon sociale, Coelastrum astroideum*, *Oocystis marssonii* and *Amphora* sp.

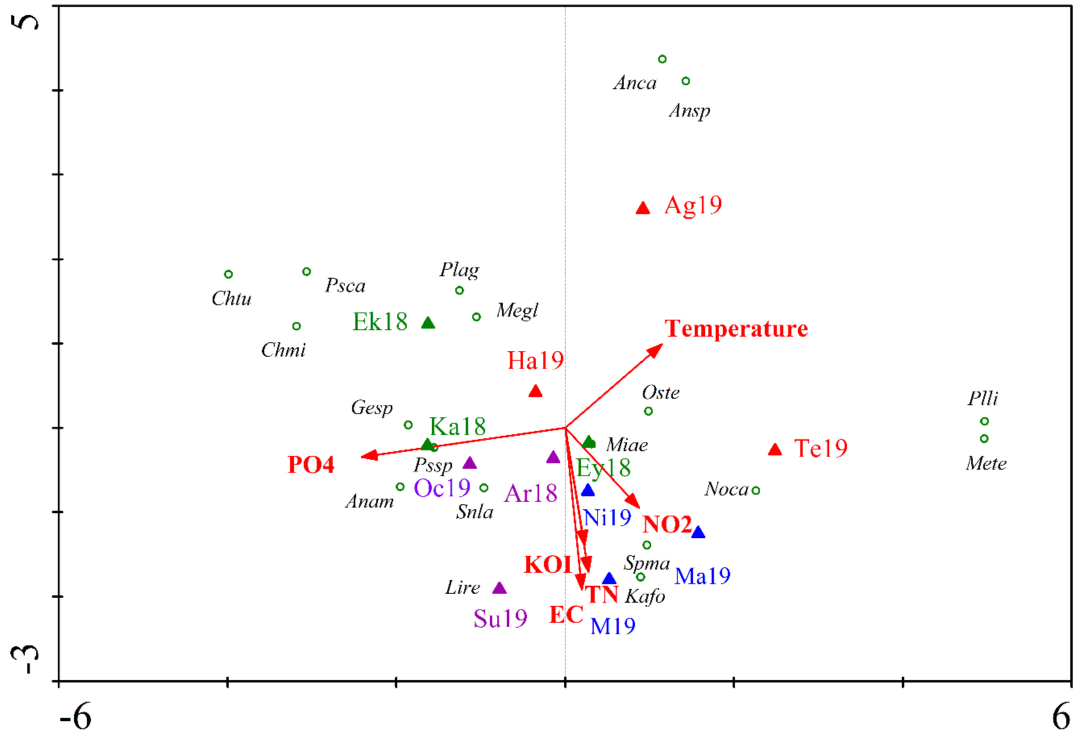

Figure 4.13 Cyanobacteria composition (green circle), environmental (red arrow) relations in Burç Reservoir for 12 months. Code and full names of phytoplankton species are given on Tablo 4.5. Sampling months (up triangle) are abbreviated as S18-September 2018, O18-October 2018, N18-November 2018, D18-December 2018, J19-January 2019, F19-February 2019, M19-March2019, A19-April 2019, Ma19-May 2019, Ju19-June 2019, Jl19-July 2019, and Au19-August 2019.

The results of Monte Carlo permutation test and CCA analysis for species-environment relation in the ecosystem are given on Table 4.7. The two axes of CCA explained very well between Cyanobacteria species and environmental factors in Burç Reservoir with 97.5% and 87.1%, respectively. The cumulative variance percentage of the species data explained with 15.5 (Table 4.7).

Those interactions indicated that Cyanobacteria species are directly affected by environmental variables. Therefore, algae play an important role to understand, control and manage water quality in different aquatic habitats.

Tablo 4.7 CCA results using Monte Carlo permutation test

Axes	λ1	λ2	λ3	λ4	T. inertia
Eigen values	0.868	0.647	0.577	0.533	9.794
Species-environment correlations	0.975	0.871	0.817	0.870	
Cumulative percentage variance of species data	8.9	15.5	21.4	26.8	
of species-environment relation	25.8	45.0	62.1	77.9	
Sum of all eigen values					9.794
Sum of all canonical eigen values					3.369
Monte Carlo permutation test		F = 2.140		p = 0.002	

The temporal distribution of cyanobacteria species were significantly affected by the physico-chemical factors of Burç Reservoir (p = 0.002). The most important physico-chemical factors in the distribution of Cyanobacteria species in Burç Reservoir according to the partial CCA results, are EC (F=2.150 p=0.002), TDS (F=1.939 p=0.002), Sal (F=1.894 p=0.002), water temp (F=1.729 p=0.004), COD (F=1.682 p=0.006), airTemp (F=1.657 p=0.004), TN (F=1.645 p=0.004), N-NO_2 (F=1.566 p=0.020), and P-PO_4 (F=1.530 p=0.014).

CCA divided the sampling months into four groups (Figure 4.13). The summer months (Ju19-June 2019, Jl19-July 2019, and Au19-August 2019) are symbolized by a red triangle and are closely related to water temperature. During the summer months, Ag19 was especially associated with the temperature variable. The summer sampling months are characterized by *Oscillatoria tenuis*, *Anabaena catenula*, *Anabaena* sp., *Planktolyngbya limnetica* and *Merismopedia tenuissima* species.

The winter sampling months are characterized by *Snowella lacustris* and *Limnothrix redekei* . The spring months (M19-March 2019, A19-April 2019, and Ma19 May 2019) were associated with COD, TN, and EC. The spring sampling months are characterized by *Kamptonema formosum* and *Spirulina major*.

The September 2018 was related to N-NO_2 and *Microcystis aeruginosa* Microcystis aeruginosa, while the November 2018 was related to P-PO_4 and *Pseudanabaena* sp., *Anagnostidinema amphibium* and *Geitlerinema splendidum*, and *Pseudanabaena* sp. Were associated with *Anagnostidinema amphibium* and *Geitlerinema splendidum* species.

According to the CCA, *Microcystis aueroginosa* and *Oscillatoria tenuis* were found to be closer to the ordination center and therefore as a wide tolerant species. *Microcystis aueroginosa* is a bioindicator eutrophic structure and *Euglena acus* has been recorded as a bioindicator of organic pollution (Horne and Goldman, 1994; Hutchinson, 1967).

4.4 Trophic State

During the study, the trophic state of Burç Reservoir was evaluated with the chlorophyll-a, total phosphorus, and Secchi disc depth values using Carlson (1977) trophic status index (TDI) and OECD scale (Vollenweider and Kerekes, 1982). The trophic states of the Burç Reservoir using selected variables is summarized in Table 4.8.

Table 4.8 Carlson (1977) trophic statu index and Secchi disc (SD) depth according to Vollenweider and Kerekes (1982). Temporal variation of TP and chlorophyll-a values. H symbolizes for hypertrophic, Ö for eutrophic, M for mesotrophic and M/Ö for meso-eutrophic.

	Carlson index			OECD		
Months	$TDİ_{SD}$	$TDİ_{TP}$	$TDİ_{Chlo-a}$	SD	TP	Chlo-a
S18	Ö	Ö	Ö	Ö	H	H
O18	Ö	Ö	Ö	Ö	H	H
N18	M/Ö	Ö	Ö	Ö	H	H
D18	Ö	Ö	Ö	H	H	H
J19	Ö	Ö	Ö	H	H	H
F19	Ö	Ö	Ö	H	H	H
M19	M	Ö	Ö	H	H	H
A19	Ö	Ö	Ö	Ö	H	Ö
Ma19	Ö	Ö	Ö	H	H	Ö
Ju19	Ö	Ö	M	Ö	H	Ö
Jl19	Ö	Ö	Ö	Ö	H	Ö
Au19	M/Ö	Ö	Ö	Ö	H	Ö

According to Carlson's index, the trophic state of lakes were considered as oligotrophic 0-40, mesotrophic 40–50 and eutrophic when it was greater than 50 (Table 3.3). According to TDI_{SD} values, Burç Reservoir is mostly eutrophic. It was mesotrophic in March 2019 sampling period and meso-eutrophic in November 2018 and August 2019. According to TDI_{TP} and TDI_{Chlo-a} values, Burç Reservoir was determined to be eutrophic. Only in June 2019 it was mesotrophic according to TDI_{Chlo-a} value. Burç Reservoir demonstrated eutrophic structure according to Carlson's trophic state index (Carlson, 1977).

Burç Reservoir water quality was also determined according to the OECD criteria based on Secchi disc depth, total phosphorus concentration, and chlorophyll-a values. Results indicated that Burç Reservoir demonstrates hypertrophic structure based on TP values. However, the reservoir had the form that is from eutrophic structure to hypertrophic structure by total phosphorus (TP) and chlorophyll-a values.

During the study; Burç Reservoir TDI_{TP} scores were higher than 77. According to TDI_{TP} scores, Burç Reservoir is eutrophic. Burç Reservoir is hypertrophic considering the OECD classification TP values. The amount of phosphorus is higher in eutrophic lakes than in oligotrophic lakes (Lepistö and Rosenström, 1998). According to Carlson’s trophic state index (Carlson, 1977) and the OECD (Vollenweider and Kerekes, 1982) trophic classifications using Secchi depth, and total phosphorous were indicated as mesotrophic and meso-eutrophic state at Lake Abant and Gölköy, respectively (Çelekli, 2006).

CHAPTER V

CONCLUSION

- This study revealed that phytoplankton brings complementary information, reflected and integrated unambiguously the ecological status of Burç Reservoir.
- Physicochemical variables in Burç Reservoir were monthly determined from September 2018 to August 2019.
- The water of Burç Reservoir is slightly alkaline characteristics with a mean pH of 8.55.
- Mean total phosphorus value was determined as 0.25 mg L^{-1} and orthophosphate 0.13 mg L^{-1}during the study.
- Some heavy metal concentrations of the water such as Cu, Ni, Cd, and Cr increased in the winter season.
- A total of 136 phytoplankton taxa have been identified. Chlorophyta was the dominant group with 40 taxa.
- During the study, *Aulacoseira granulata, Ulnaria biceps, Ulnaria ulna, Cryptomonas marssonii, Cryptomonas ovata, Crucigenia tetrapedia Pediastrum duplex, Microcystis aueroginosa* and *Dinobryon sociale* were commonly found in Burç Reservoir.
- The two axes of CCA explained very well between phytoplankton species and environmental factors of Burç Reservoir with 99.4% and 99.2%, respectively. The cumulative variance percentage of the species data explained with 20.7. These interactions indicated that phytoplankton species were directly affected by environmental variables. CCA divided the sampling months into four groups (Figure 4.12).
- According to the CCA, *Microcystis aueroginosa* and *Oscillatoria tenuis* were found to be closer to the ordination center and therefore as a wide tolerant Cyanobacteria species to the changes in ecological conditions in the reservoir.
- Burç Reservoir had an eutrophic structure according to Carlson's trophic state index. Burç Reservoir had hypertrophic structure considering the OECD classifications.

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CURRICULUM VITAE (CV)

GÜLÜMSER ÖZPINAR
ENVIRONMENTAL ENGINEER

Contact Information:
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Personal Information:
Total experience : 11 Years
Employment status : Working
Educational Status : University (Graduate)
Nationality : Republic of Turkey
Date of Birth : 25.12.1985
Place of birth : Turkey - Gaziantep
Driver's license : B (2012)

Job Experiences

Gaziantep Metropolitan Municipality
Housing and Urban Planning Department
Project Specialist / 06.2017- (still working) Gaziantep – Turkey / Full-Time

- conducting the Gaziantep Ecological City Project (Akıllı EkoKent);
- preparing and conducting innovative projects about sustainable environment and urbanization (Ekonteyner; Solar İstasyon, Solar Durak, Piezoelektrik caddesi, EkoKöy, Ekolojik ev etc.);
- giving seminars about climate change, water pollution, sustainable urban life, ecolife etc.

(GASKI) Nurdağı Advanced Biological Domestic Waste Water Treatment Facility
Facility Manager / 07.2015- 06.2017 Gaziantep – Turkey / Full-Time

- responsible for the managing of the facility;
- operating and controlling all processes of the facility;
- responsible for leading and oversee the works of the facility employees; (shifts, tasks, periodical control and maintenance etc.).

Ziylan Group
Health, Safety and Environment Expert / 03.2013-03.2015 / İstanbul(Avr.) - Turkey / Freelance

- responsible for the prevention of occupational-related diseases and accidents;
- carrying out corrective and preventative action(CAPA);
- devising and implementing emergency planning and national/international inspection-controls, respectively;
- training employees in Basic Occupational Health & Safety and carrying out risk assessments.

Porland Porland Porcelain industry & Trade Inc.
Environmental and Occupational Safety Cheif / 05.2011-01.2013 Bilecik – Turkey / Full-Time

whilst working for Porland Porselen,

- main tasks for the job were to take care of both the environmental and occupational safety department.
- the waste management system of the factory was implemented by me (14001 ISO environmental management system)
- performed to reduce waste at the source.
- also taken care of hazardous, non-hazardous waste reduction, separation, collection and disposal of such materials. I've designed and planned these projects in accordance with the local regulations.
- quality of waste water treatment systems and carbon emission were remediated by good operating. I've also managed to obtain necessary Environmental Permit for the factory.
- whilst performing these tasks I've also worked on occupational accident & professional diseases, corrective and preventative actions, emergency , international and national inspections as the occupational safety specialist of the factory.
- given occupational health&safety training to all the employees (1500 employees) annual, and also assessed the factory's performance when it comes accidents at work.
- risk assessment was being kept up to renew with regulations, process change, accidents etc. by the company. I've operated and supervised the corrective and preventive actions (CAPA) and emergency planning-drill.
- on the other hand ISO 9001, ISO 14001 and OHSAS 18001 management systems were conducted.

Ibrahim Halil Akpınar Recycling Facility
Responsible Environmental Engineer / 02.2010-05.2011 Gaziantep – Turkey / Full-Time

▪ operated all phases of the recycling facility as a responsible environmental engineer and obtained Environmental Permit and License of the recycling facility.
▪ areas included: Textile Waste, Packaging Waste, Non-hazardous Waste

Gaziantep Şahinbey Municipality
Environmental Engineer / 08.2009-12.2010 Gaziantep – Turkey/ Full-Time
▪ coordinated collection, removal, separation and disposal phases waste in accordance with environmental procedures and legislation.
▪ areas included: Municipal Solid Waste, Packaging Waste, Electrical and Electronical Waste, Construction Waste, Hazardous Waste, Non-hazardous Waste, Radioactive Waste

Education Informations

University (Master's Degree) : 01.2016 - still studying Gaziantep University, Institute of Science and Technology, Biology
University (Bachelor's Degree) : 09.2005-07.2009 Cumhuriyet University Engineering Faculty, Environmental Engineering (Turkish) 2.8/4
High School : 09.1999-06.2003 Islahiye Anatolian High School Science 70 /100
Computer Skills : Microsoft Office Programmes : Good

Engineering Project Reward

My Engineering Project is "**Anaerobic Decomposition and Biotechnology**" which has been approved as a new lecture at Cumhuriyet University (ÇEV4013-June of 2009).

Foreign Language

English: Reading ;Good Writing ;Good Speech ;Good Listening ; Good
English Language Certificate Information : IELTS (academic) - 09.2014
Cambridge (International English Language Testing System) : (**5.5/9) / Malta**

Certificates and Other Educations

1- Republic of Turkey / Ministry of Labour and Social Security - 07.2011
Occupational Health and Safety Specialist Certificate
2- Republic of Turkey / Ministry of Environment and Urbanisation - 01.2011 and visa training 12.2015
A necessary certificate of Environmental Engineering depending on environmental laws of Turkey
3- Dema Yönt. Sis. Limited Company - 07.2009

TS-EN-ISO 9001 Quality Management System Basic and Internal Auditor Training Course

4- Dema Yönt. Sis. Limited Company – 09.2009

TS-BS-OHSAS 18001 Occupational Health and Safety Management System Basic and Internal Auditor Training Course

5- Dema Yönt. Sis. Limited Company – 08.2009

TS-EN-ISO 14001 Environmental Management System Basic and Internal Auditor Training Course

6- Republic of Turkey / Ministry of Environment and Forestry - 04.2012

Attended Waste Management Symposium

7- Chamber of Environmental Engineers - 05.2011

Waste Management and Environmental Law Training

8- Chamber of Environmental Engineers - 06.2011

LPG Engagement Manager Course

Hobbies and Personal İnterests : Volleyball, jogging and travelling

Memberships : Union of Chambers of Turkish Engineers and Architects

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