

JANUARY 2020

M.Sc. in Biology

GÜLÜMSER ÖZPINAR

**REPUBLIC OF TURKEY
GAZİANTEP UNIVERSITY
GRADUATE SCHOOL OF NATURAL & APPLIED SCIENCES**

**PHYTOPLANKTON COMPOSITION AND ECOLOGICAL
PROPERTIES IN BURÇ RESERVOIR**

**M.Sc. THESIS
IN
BIOLOGY**

**BY
GÜLÜMSER ÖZPINAR
JANUARY 2020**

**PHYTOPLANKTON COMPOSITION AND ECOLOGICAL
PROPERTIES IN BURÇ RESERVOIR**

M.Sc. Thesis

in

Biology

Gaziantep University

Supervisor

Prof. Dr. Abuzer ÇELEKLİ

by

Gülümser ÖZPINAR

January 2020



©2020[Gülümser ÖZPINAR]

REPUBLIC OF TURKEY
GAZİANTEP UNIVERSITY
GRADUATE SCHOOL OF NATURAL & APPLIED SCIENCES
BIOLOGY

Name of the Thesis : Phytoplankton Composition and Ecological Properties in
Burç Reservoir

Name of the Student : Gülümser ÖZPINAR

Exam Date : 06.02.2020

Approval of the Graduate School of Natural and Applied Sciences

Prof. Dr. A. Necmeddin YAZICI
Director

I certify that this thesis satisfies all the requirements as a thesis for the degree of Master of Science.

Prof. Dr. Filiz ÖZBAŞ GERÇEKER
Head of Department

This is to certify that we have read this thesis and that in our consensus opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.

Prof. Dr. Abuzer ÇELEKLİ
Supervisor

Examining Committee Members:

Signature

Prof. Dr. Abuzer ÇELEKLİ

.....

Prof. Dr. Zafer ÇETİN

.....

Assoc. Prof. Dr. Muhittin DOĞAN

.....

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

ÖZPINAR, Gülümser

M.Sc. in Biology

Supervisor: Prof. Dr. Abuzer ÇELEKLİ

January 2020

65 pages

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 aueruginosa* 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-NO₃, TN, temperature, N-NO₂, P-PO₄, 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

Ocak 2020

65 sayfa

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 gruba 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 aeruginosa* ve *Oscillatoria tenuis* izlemiştir. Canonical Correspondence Analysis (CCA)'ın ilk iki eksenini, 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-NO₃, TN, sıcaklık, N-NO₂, P-PO₄, TP, vb. gibi 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”

ACKNOWLEDGEMENTS

I would like to thank my supervisor, Prof. Dr. Abuzer ÇELEKLİ for his support throughout the study. I am thankful for his guidance, encouragement, inspiration and supervision.

I would like to express my big thanks and gratitude to Gaziantep Metropolitan Municipality, Head of Housing and Urban Planning Department, Fitnat İrem ELBEYLİ. I am thankful for her support me to continue this scientific study.

I would like to express my love and gratitude to my dad Hamit ÖZPINAR and my mum Gülnaz ÖZPINAR for their support, always best wishes.

This work is supported by Gaziantep University Scientific Research Project Support.

TABLE OF CONTENTS

	Page
ABSTRACT.....	v
ÖZET	vi
ACKNOWLEDGEMENTS	viii
TABLE OF CONTENTS	ix
LIST OF TABLES	xi
LIST OF FIGURES	xii
LIST OF ABBREVIATIONS	xiii
CHAPTER I	1
INTRODUCTION.....	1
1.1 Importance of Water.....	1
1.2 Water Pollution and Eutrophication	2
1.3 European Union Water Framework Directive.....	5
1.4 Phytoplankton and Freshwater Quality	7
CHAPTER II.....	10
LITERATURE REVIEW	10
CHAPTER III	14
MATERIALS AND METHODS	14
3.1 Site Description	14
3.2 Sampling and Analyses	15
3.3 Measurement of Physicochemical Variables	16
3.4 Identification of Net-Plankton and Enumeration of Phytoplankton.....	17
3.5 Chlorophyll-a Analysis.....	18
3.6 Trophic State	19
3.7 Statistical Analyses.....	21
CHAPTER IV.....	22
RESULT AND DISCUSSION	22
4.1 Physicochemical Variables.....	22
4.2 Phytoplankton Composition	32

4.3 Phytoplankton-Environmental Relations in Burç Reservoir	44
4.4 Trophic State	49
CHAPTER V	52
CONCLUSION	52
REFERENCES.....	53
CURRICULUM VITAE (CV)	62



LIST OF TABLES

	Page
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)	7
Table 3.1 General Features of The Burç Reservoir.	15
Table 3.2 Trophic state ranges of lakes according to OECD index (Vollenweider and Kerekes, 1982).....	20
Table 3.3 Carlson trophic state index for lakes (Carlson, 1977)	20
Table 4.1 Atmospheric variables of Gaziantep	22
Table 4.2 Physicochemical variables of Burç Reservoir between September 2018 and August 2019	24
Table 4.3 Physico-chemical variables of Burç Reservoir as mean and standard deviation (mean $\pm$ SD).....	25
Table 4.4 Spearman's correlation test result among the environmental variables of Burç Reservoir	26
Table 4.5 Phytoplankton species list	33
Table 4.6 CCA results using Monte Carlo permutation test phytoplankton species list.....	45
Table 4.7 CCA results using Monte Carlo permutation test cyanobacteria species list.....	48
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	50

LIST OF FIGURES

	Page
Figure 1.1 Earth's water source (Shiklomanov, 1993)	2
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).....	5
Figure 3.1 Burç Reservoir and sampling stations	14
Figure 4.1 Burç Reservoir water temperature and dissolved oxygen distribution	27
Figure 4.2 Total Kjeldahl nitrogen, nitrite nitrogen and nitrate nitrogen distribution in Burç Reservoir	28
Figure 4.3 Burç Reservoir total phosphorus and orthophosphate distribution	29
Figure 4.4 Electrical conductivity, total dissolved solid and salinity variation in Burç Reservoir.....	30
Figure 4.5 Monthly chlorophyll-a variation in Burç Reservoir	31
Figure 4.6 Phytoplankton divisions of Burç Reservoir.....	38
Figure 4.7 Phytoplankton images of Burç Reservoir.....	39
Figure 4.8 Phytoplankton images of Burç Reservoir.....	40
Figure 4.9 Phytoplankton images of Burç Reservoir.....	41
Figure 4.10 Phytoplankton images of Burç Reservoir.....	42
Figure 4.11 Phytoplankton images of Burç Reservoir.....	43
Figure 4.12 Phytoplankton composition (green circle), environmental (red arrow) relations in Burç Reservoir during 12 months	44
Figure 4.13 Cynaobacteria composition (green circle), environmental (red arrow) relations in Burç Reservoir during 12 months	47

LIST OF ABBREVIATIONS

BOD₅	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
NH₄-N	Ammonium Nitrogen
Ni	Nickel
NO₂-N	Nitrite Nitrogen
NO₃-N	Nitrate Nitrogen
NTU	Neplometric Turbidity Unit
OECD	The Organisation for Economic Co-operation and Development
Pb	Lead
P_m	Monthly Precipitation
PO₄-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 data rates are stated as follows. Agriculture water usage rate is 74%, industry 13% and domestic water is 13% in Turkey (TOB, 2019).

Distribution of Earth's Water

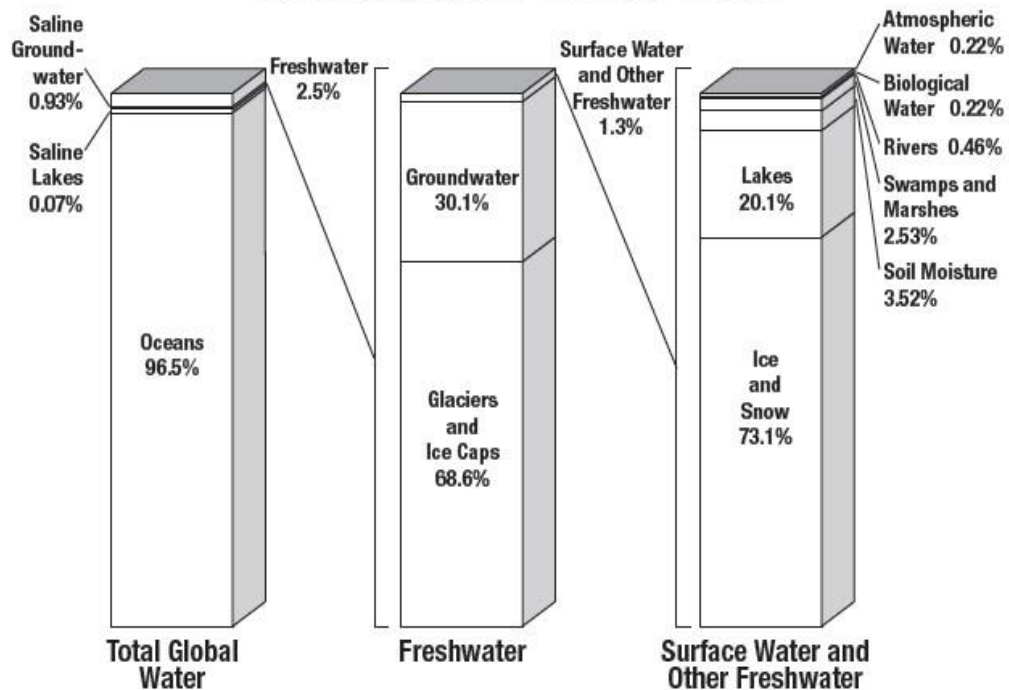


Figure 1.1 Earth's water source (Shiklomanov, 1993)

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.

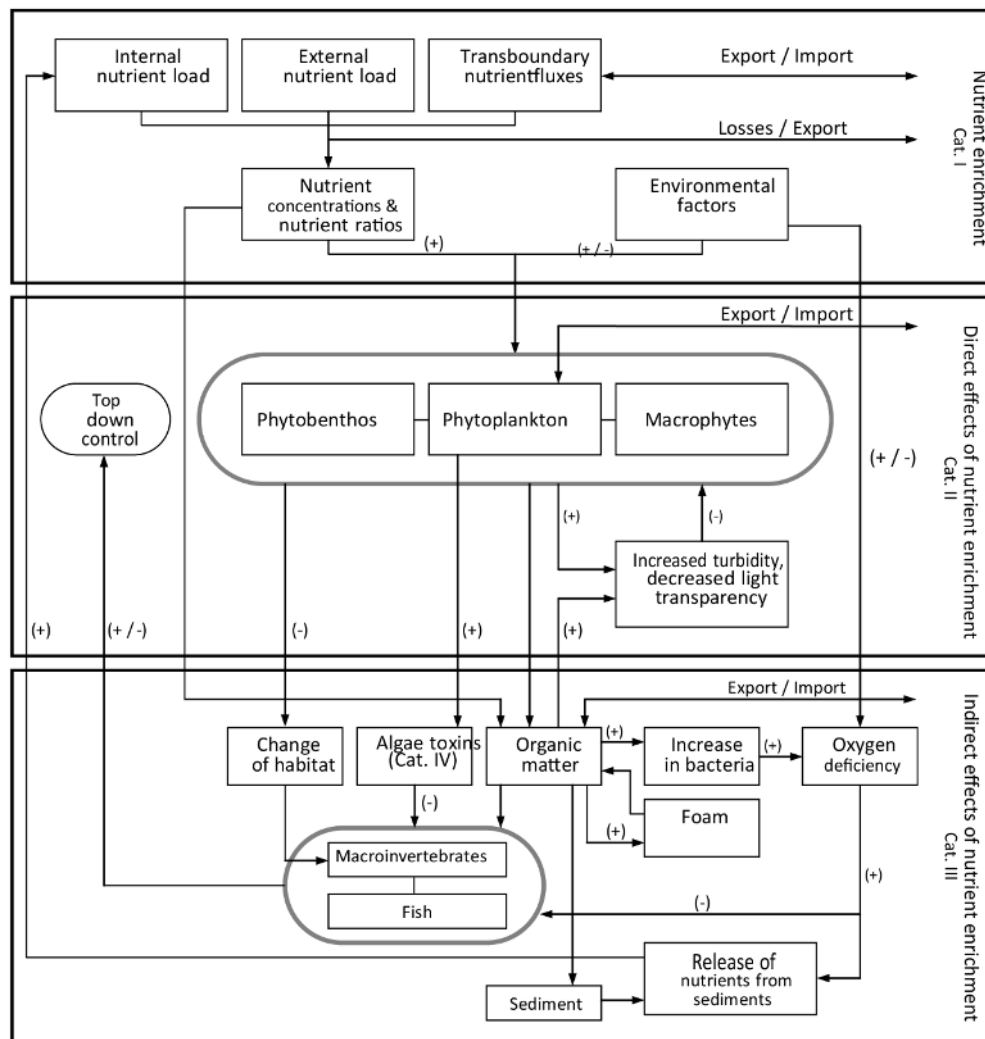


Figure 1.2. General conceptual framework for assessing eutrophication for all surface waters categories. (-) indicates a decrease, (+) indicates increase; round boxes indicate biological quality elements of WFD (WFD GD-23 European Communities, 2009).

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 Gök  y and Lake Abant were determined (  elekli, 2006a). A total of 285 phytoplankton taxa were determined in Lake Abant; 271 phytoplankton taxa were determined in Lake G  lk  y. Lake Abant showed mesotrophic and dimictic structure, whereas Lake G  lk  y had a monomictic structure in transition from mesotrophy to eutrophy (  elekli and K  lk  yl  o  lu, 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 G  lk  y was monthly monitored for 26 months (  elekli, 2006b). A total of 119 diatom species were identified in Lake G  lk  y. 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 (  zyalın, 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.

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

Phytoplankton compositions and water quality in Lake Hazar were examined during one year (Ko  er, 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 epipelagic 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 Büyükçekmece 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 ($37^{\circ} 03' 46.64$ N; $37^{\circ} 10' 10.72$ E) (Figure 3.1); is situated at about 830 m above the sea level and about 35 km away from the center of Gaziantep.

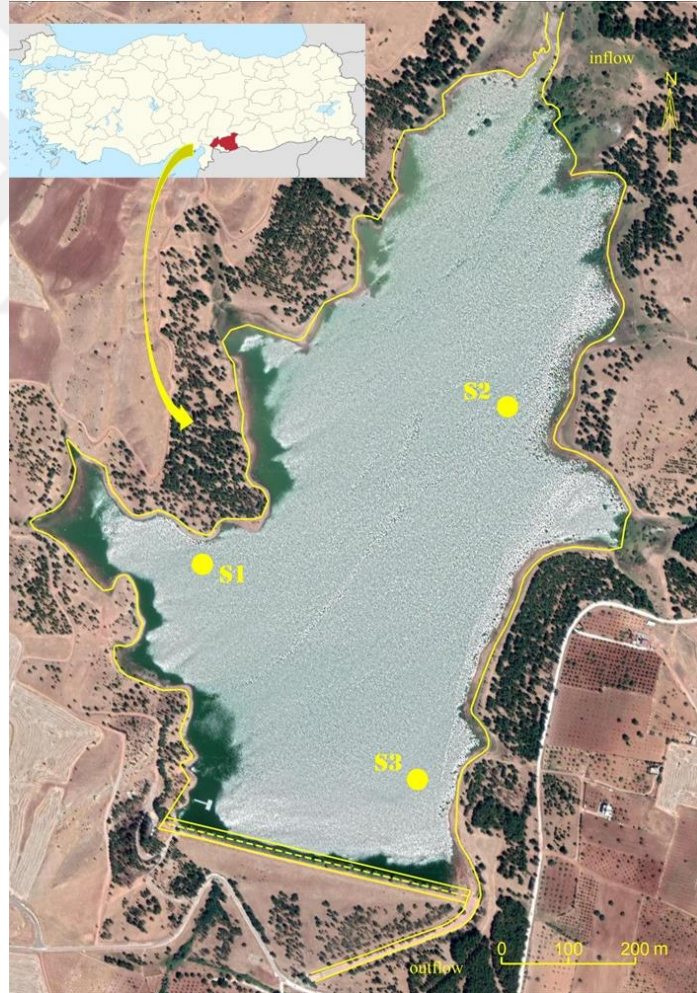


Figure 3.1 Burç Reservoir and sampling stations.

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 m² (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 km³ 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 GASKİ. 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 ($N-NH_4$), nitrite-nitrogen ($N-NO_2$), nitrate-nitrogen ($N-NO_3$), total phosphorus (TP), orthophosphate ($P-PO_4$), 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^+ , NH_4^+ , 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.

$$\text{counted phytoplankton/mL} = \frac{C * TA}{F * A * V} \quad (3.1)$$

- 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 °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:

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

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).

$$TDI_{(SDD)} = 10 \left(6 - \frac{\ln SDD}{\ln 2} \right) \quad (3.3)$$

$$TDI_{(Chla)} = 10 \left(6 - \frac{2,04 - 0,68 \ln Chla}{\ln 2} \right) \quad (3.4)$$

$$TDI_{(TP)} = 10 \left(6 - \frac{\ln \left(\frac{48}{TP} \right)}{\ln 2} \right) \quad (3.5)$$

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 multicollinearity (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 $477.56 \mu\text{S cm}^{-1}$. 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 $\pm$ 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 $\pm$ 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		μ S/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 $\pm$ 0.7	8.3 $\pm$ 0.1	432 $\pm$ 6	294 $\pm$ 2	0.22 $\pm$ 0.01	7.17 $\pm$ 0.15	12 $\pm$ 3	0.70 $\pm$ 0.34	0.04 $\pm$ 0.01	0.04 $\pm$ 0.01	0.04 $\pm$ 0.01	0.17 $\pm$ 0.01	0.08 $\pm$ 0.04	2.6 $\pm$ 0.1	45.7 $\pm$ 0.4
O18	19.3 $\pm$ 0.8	8.4 $\pm$ 0.1	411 $\pm$ 6	304 $\pm$ 1	0.23 $\pm$ 0.01	6.18 $\pm$ 0.53	4 $\pm$ 1	0.63 $\pm$ 0.13	0.06 $\pm$ 0.02	0.04 $\pm$ 0.01	0.04 $\pm$ 0.01	0.26 $\pm$ 0.02	0.12 $\pm$ 0.02	2.6 $\pm$ 1.6	44.5 $\pm$ 0.5
N18	11.1 $\pm$ 0.5	8.6 $\pm$ 0.3	397 $\pm$ 1	304 $\pm$ 1	0.23 $\pm$ 0.01	7.78 $\pm$ 0.31	5 $\pm$ 1	2.20 $\pm$ 1.34	0.04 $\pm$ 0.01	0.09 $\pm$ 0.08	0.04 $\pm$ 0.01	0.24 $\pm$ 0.02	0.12 $\pm$ 0.02	4.4 $\pm$ 0.2	45.2 $\pm$ 0.4
D18	8.3 $\pm$ 0.3	8.4 $\pm$ 0.1	389 $\pm$ 5	302 $\pm$ 8	0.23 $\pm$ 0.01	8.54 $\pm$ 0.64	3 $\pm$ 1	2.13 $\pm$ 0.03	0.04 $\pm$ 0.01	4.03 $\pm$ 0.26	0.07 $\pm$ 0.01	0.30 $\pm$ 0.02	0.22 $\pm$ 0.01	10.1 $\pm$ 2.1	50.3 $\pm$ 0.7
J19	4.0 $\pm$ 0.7	8.3 $\pm$ 0.1	460 $\pm$ 13	325 $\pm$ 1	0.24 $\pm$ 0.01	8.14 $\pm$ 0.05	2 $\pm$ 1	5.85 $\pm$ 0.20	0.04 $\pm$ 0.01	20.63 $\pm$ 2.24	0.14 $\pm$ 0.01	0.35 $\pm$ 0.03	0.29 $\pm$ 0.02	3.1 $\pm$ 0.1	76.1 $\pm$ 1.1
F19	6.8 $\pm$ 0.2	8.6 $\pm$ 0.2	690 $\pm$ 62	589 $\pm$ 85	0.45 $\pm$ 0.07	10.73 $\pm$ 0.19	2 $\pm$ 1	5.53 $\pm$ 0.53	0.04 $\pm$ 0.01	20.18 $\pm$ 0.34	0.10 $\pm$ 0.05	0.28 $\pm$ 0.02	0.12 $\pm$ 0.01	2.4 $\pm$ 0.3	74.7 $\pm$ 0.6
M19	10.8 $\pm$ 0.5	8.7 $\pm$ 0.1	708 $\pm$ 12	631 $\pm$ 1	0.48 $\pm$ 0.01	10.37 $\pm$ 0.38	2 $\pm$ 1	4.57 $\pm$ 1.11	0.04 $\pm$ 0.01	15.87 $\pm$ 0.22	0.14 $\pm$ 0.01	0.26 $\pm$ 0.01	0.06 $\pm$ 0.03	2.4 $\pm$ 0.2	73.7 $\pm$ 0.2
A19	13.0 $\pm$ 0.5	8.7 $\pm$ 0.1	686 $\pm$ 9	578 $\pm$ 7	0.44 $\pm$ 0.01	10.16 $\pm$ 0.40	4 $\pm$ 1	3.97 $\pm$ 0.67	0.04 $\pm$ 0.01	11.62 $\pm$ 0.67	0.15 $\pm$ 0.01	0.16 $\pm$ 0.01	0.06 $\pm$ 0.03	5.7 $\pm$ 2.2	75.1 $\pm$ 6.7
Ma19	22.6 $\pm$ 0.2	8.6 $\pm$ 0.1	746 $\pm$ 4	574 $\pm$ 4	0.44 $\pm$ 0.01	6.93 $\pm$ 0.26	6 $\pm$ 1	3.55 $\pm$ 0.77	0.04 $\pm$ 0.01	10.71 $\pm$ 0.15	0.20 $\pm$ 0.01	0.28 $\pm$ 0.02	0.19 $\pm$ 0.02	1.6 $\pm$ 0.1	58.5 $\pm$ 1.4
Ju19	24.1 $\pm$ 0.6	8.7 $\pm$ 0.1	486 $\pm$ 3	322 $\pm$ 1	0.24 $\pm$ 0.01	6.04 $\pm$ 0.22	3 $\pm$ 1	2.93 $\pm$ 0.68	0.10 $\pm$ 0.02	8.46 $\pm$ 0.07	0.19 $\pm$ 0.01	0.25 $\pm$ 0.01	0.20 $\pm$ 0.02	2.3 $\pm$ 0.1	60.4 $\pm$ 1.3
Jl19	25.2 $\pm$ 0.7	8.8 $\pm$ 0.1	425 $\pm$ 15	290 $\pm$ 1	0.21 $\pm$ 0.01	5.40 $\pm$ 0.41	4 $\pm$ 1	2.50 $\pm$ 0.41	0.04 $\pm$ 0.01	5.60 $\pm$ 0.05	0.17 $\pm$ 0.01	0.21 $\pm$ 0.02	0.05 $\pm$ 0.02	3.2 $\pm$ 0.1	46.8 $\pm$ 0.4
Au19	25.6 $\pm$ 0.1	8.9 $\pm$ 0.1	407 $\pm$ 1	281 $\pm$ 1	0.21 $\pm$ 0.01	6.02 $\pm$ 0.76	2 $\pm$ 1	1.12 $\pm$ 0.42	0.04 $\pm$ 0.01	1.90 $\pm$ 0.02	0.10 $\pm$ 0.01	0.17 $\pm$ 0.05	0.04 $\pm$ 0.01	3.5 $\pm$ 0.1	32.0 $\pm$ 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 Büyükçekmece Reservoir (Yılmaz, 2019).

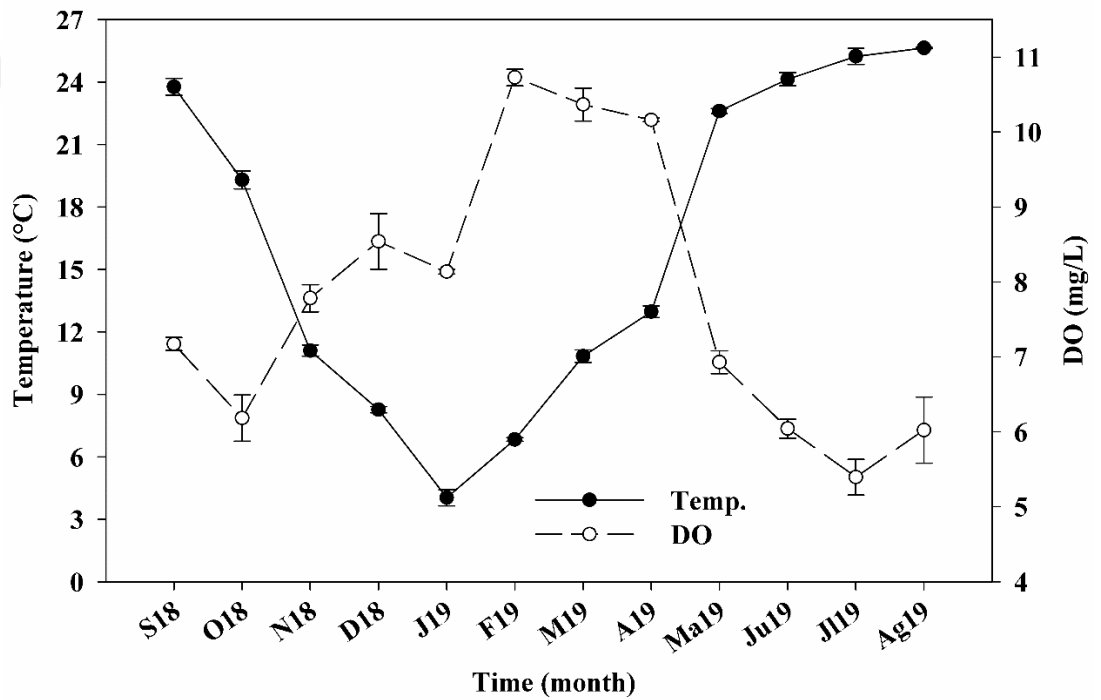


Figure 4.1 Burç Reservoir water temperature and dissolved oxygen distribution

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).

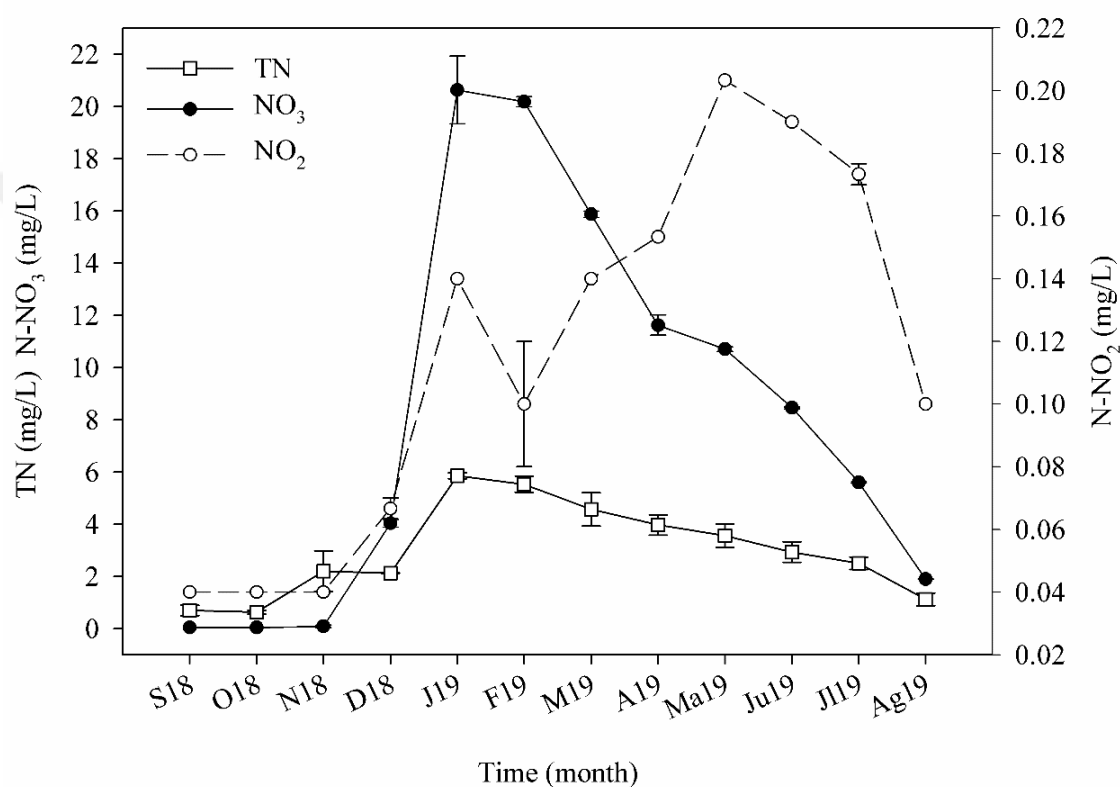


Figure 4.2 Total Kjeldahl nitrogen, nitrite-nitrogen and nitrate-nitrogen distribution in Burç Reservoir

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 (Gümüő, 2018).

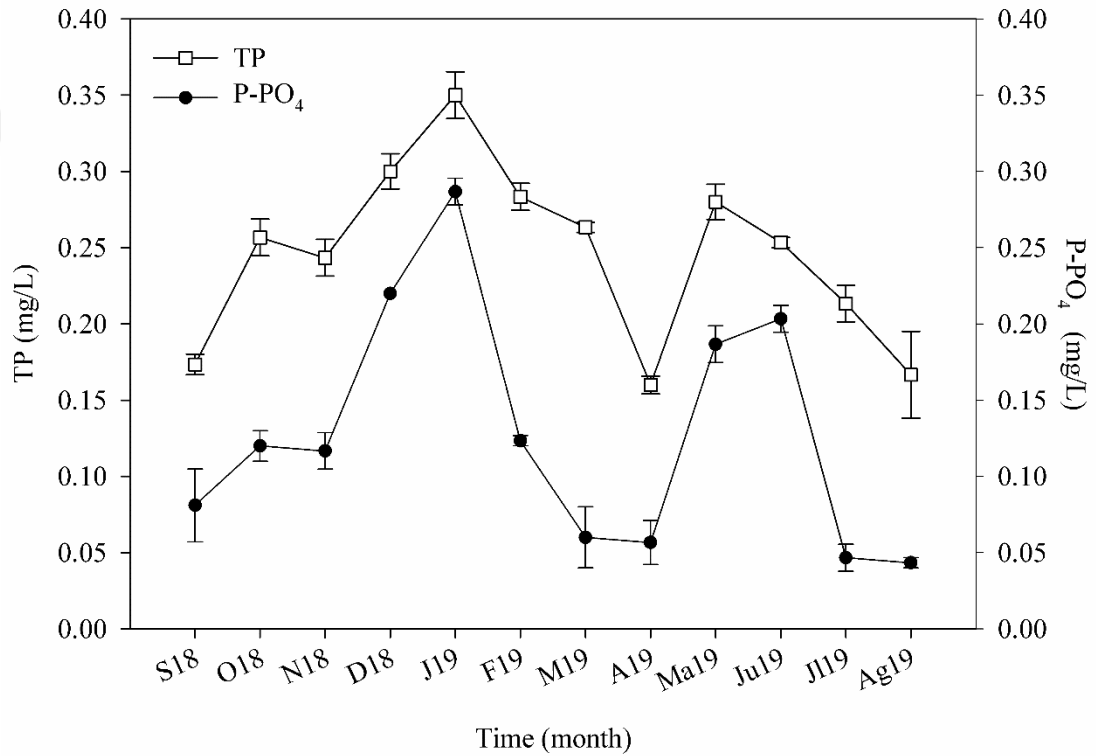


Figure 4.3 Burç Reservoir total phosphorus and orthophosphate distribution

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 $414.01 \text{ } \mu\text{S cm}^{-1}$ 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.

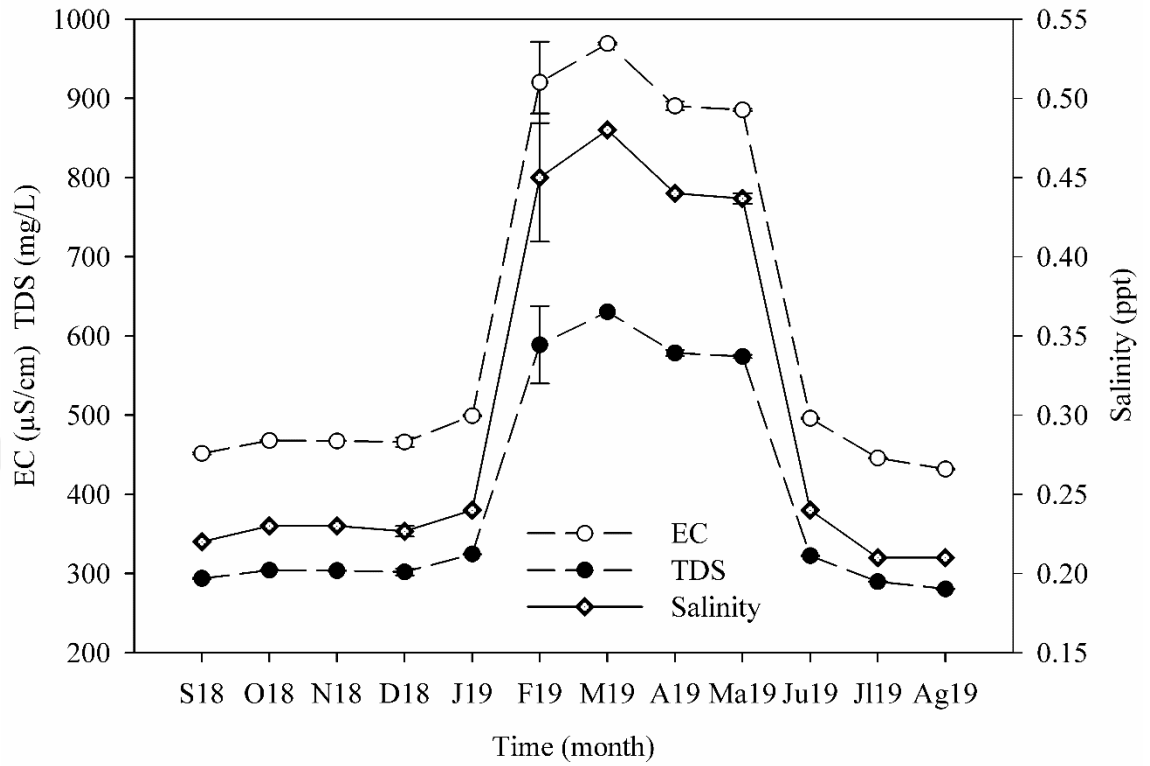


Figure 4.4 Electrical conductivity (EC), total dissolved solid (TDS), and salinity variation in Burç Reservoir

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 $8.0 \mu\text{g L}^{-1}$ and $59.8 \mu\text{g L}^{-1}$. Chlorophyll-a value was generally higher in the autumn season than that other seasons. The mean chlorophyll-a value was ascertained to be $28.43 \mu\text{g L}^{-1}$. The highest chlorophyll-a $59.80 \mu\text{g L}^{-1}$ was found in November 2018; the lowest amount $8.0 \mu\text{g L}^{-1}$ 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).

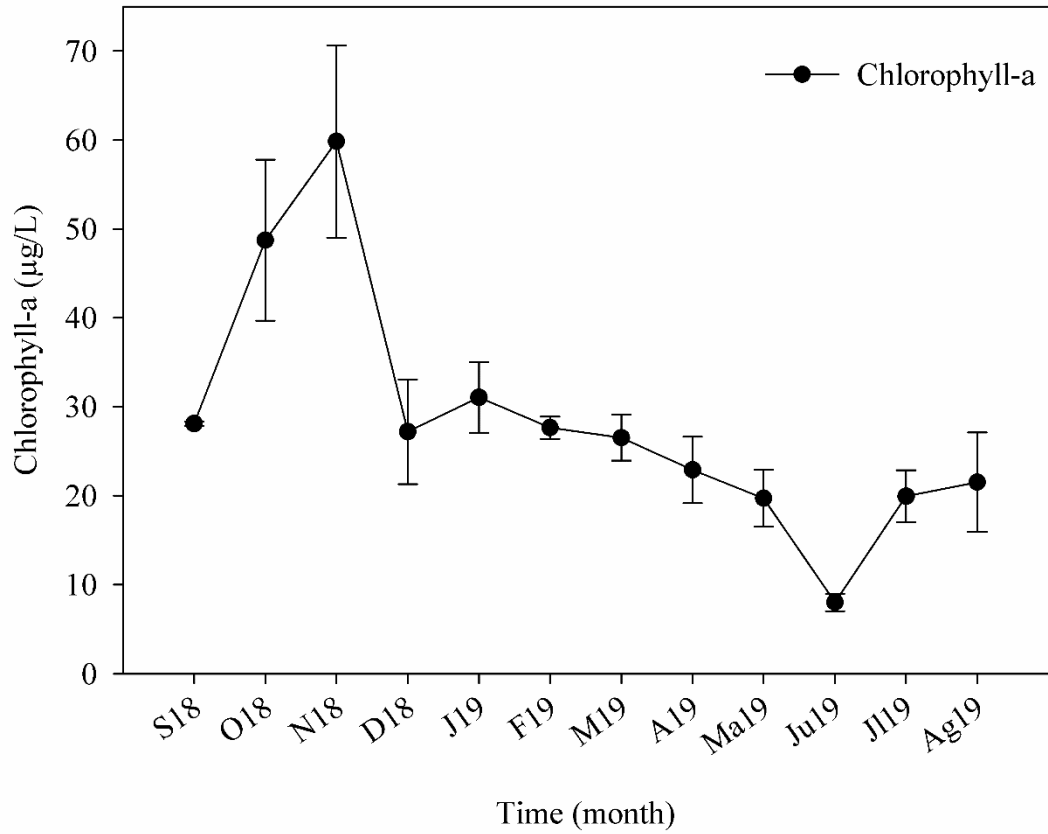


Figure 4.5 Monthly chlorophyll-a variation in Burç Reservoir

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 aeruginosa* 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**

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

Phylum: Charophyta

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

Table 4.5 continued

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

Phylum: Chlorophyta

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

Table 4.5 continued

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

Phylum: Cryptophyta

<i>Crma</i>	<i>Cryptomonas marssonii</i> Skuja 1948
<i>Crov</i>	<i>Cryptomonas ovata</i> Ehrenberg 1832
<i>Plla</i>	<i>Plagioselmis lacustris</i> (Pascher & Ruttner) Javornický 2001
<i>Plna</i>	<i>Plagioselmis nannoplantica</i> (Skuja) G.Novarino, I.A.N.Lucas & Morrall 1994

Phylum: Cyanobacteria

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

Table 4.5 continued

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

Phylum: Euglenozoa

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

Phylum: Miozoa

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

Phylum: Ochrophyta

<i>Didi</i>	<i>Dinobryon divergens</i> O.E.Imhof 1887
-------------	---

Table 4.5 continued

<i>Diso</i>	<i>Dinobryon sociale</i> (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).

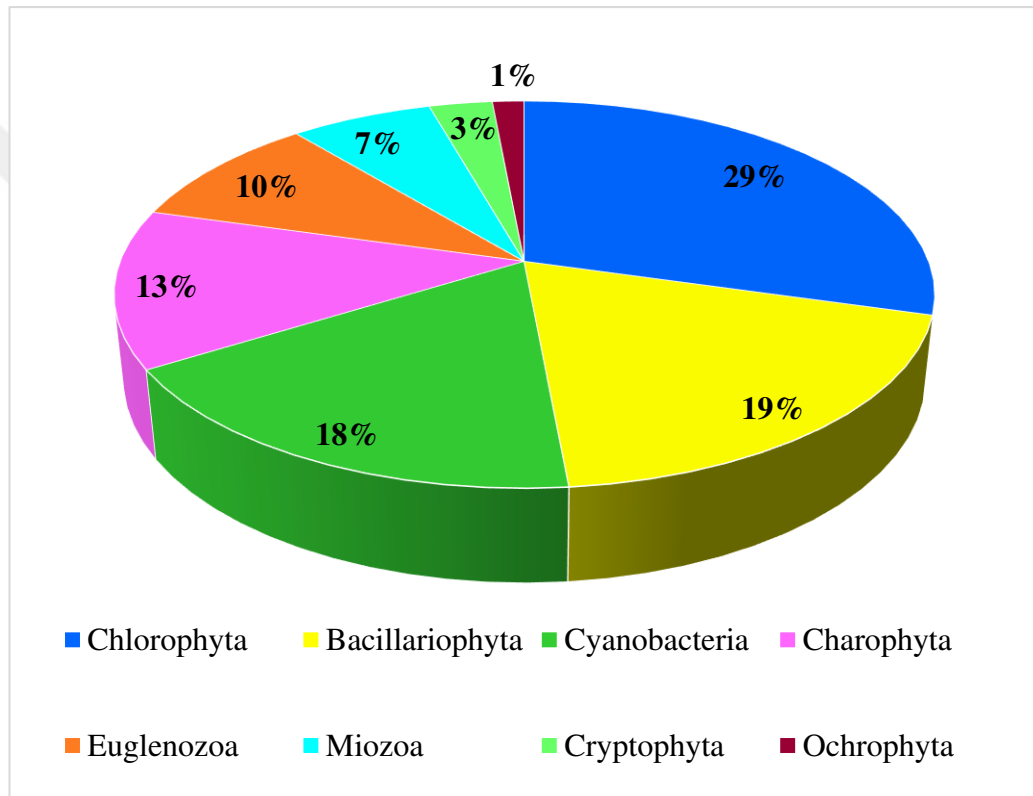
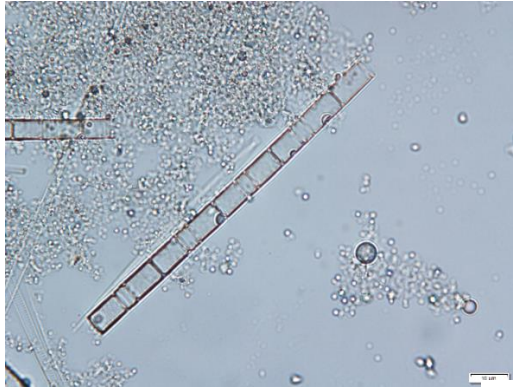


Figure 4.6 Phytoplankton divisions of Burç Reservoir

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



a



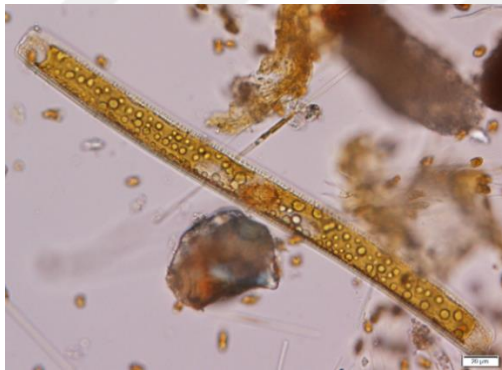
b



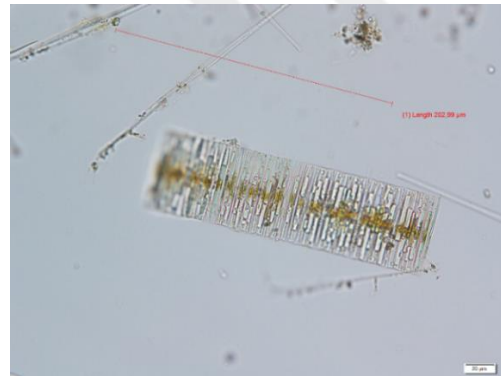
c



d

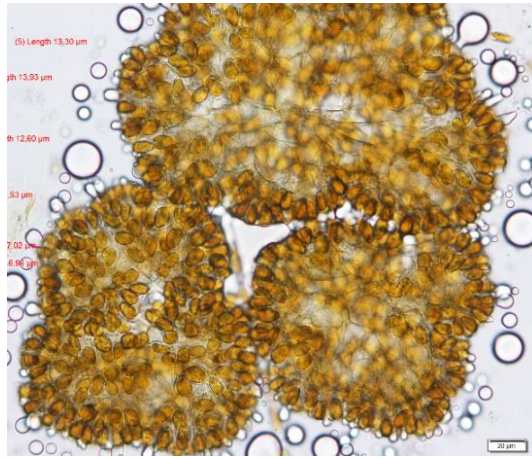


e



f

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).



a



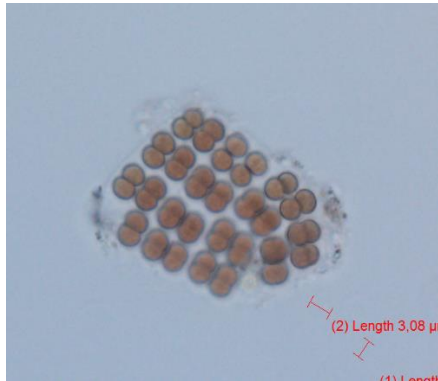
b



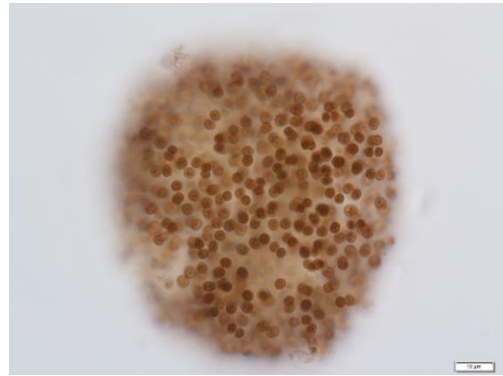
c



d



e

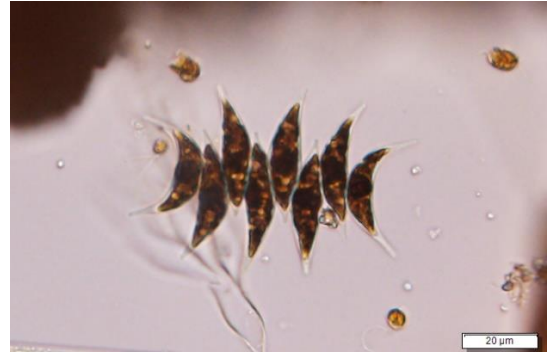


f

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).



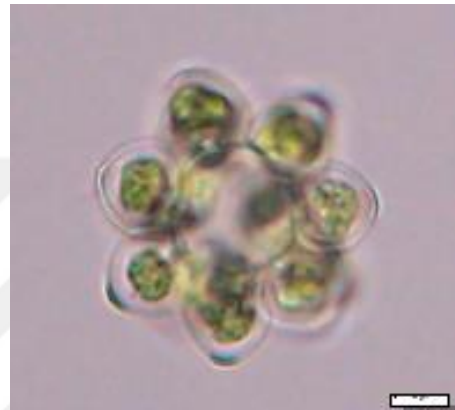
a



b



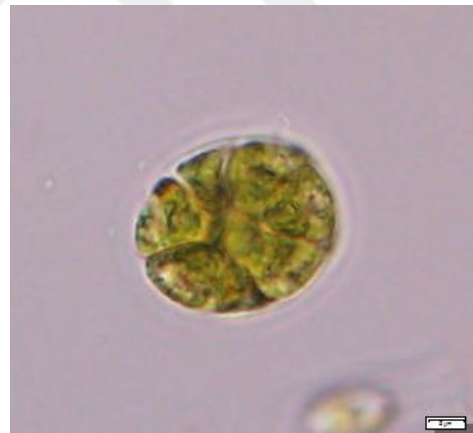
c



d



e

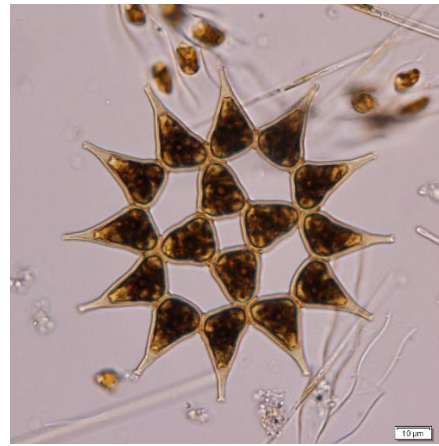


f

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)



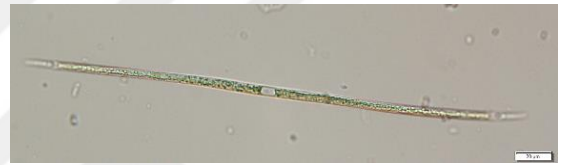
a



b



c



d



e



f

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)

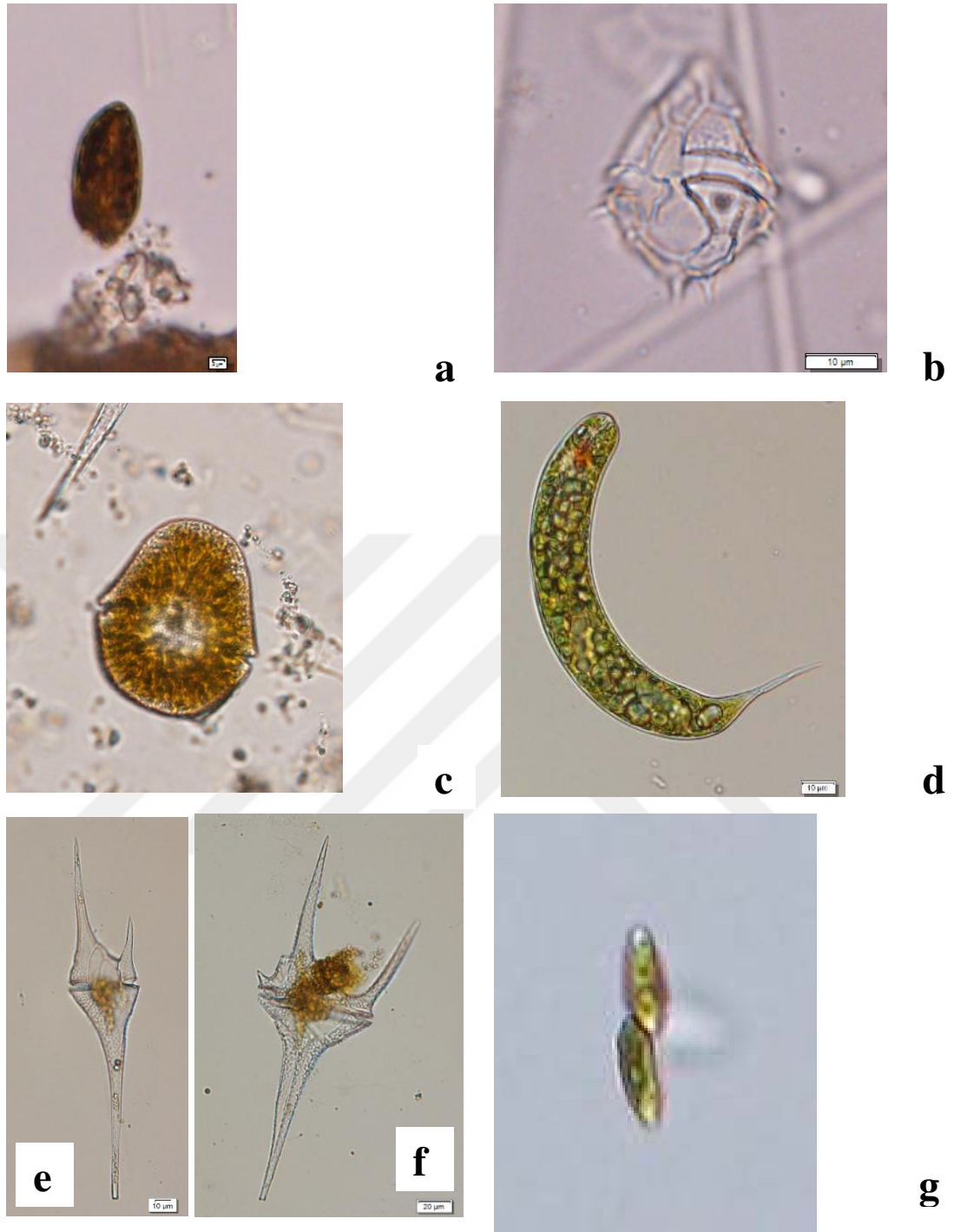


Figure 4.11 Phytoplankton images of Burç Reservoir a) *Cryptomonas ovata* (Scale 5 μm), b) *Peridiniopsis cunningtonii* (Scale 10 μm), c) *Gymnodinium uberrimum*, d) *Euglena oxyuris*, (Scale 10 μm), e) *Ceratium furcoides* (Scale 10 μm), f) *Ceratium hirundinella* (Scale 20 μm), g) *Elakatothrix acuta*

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.

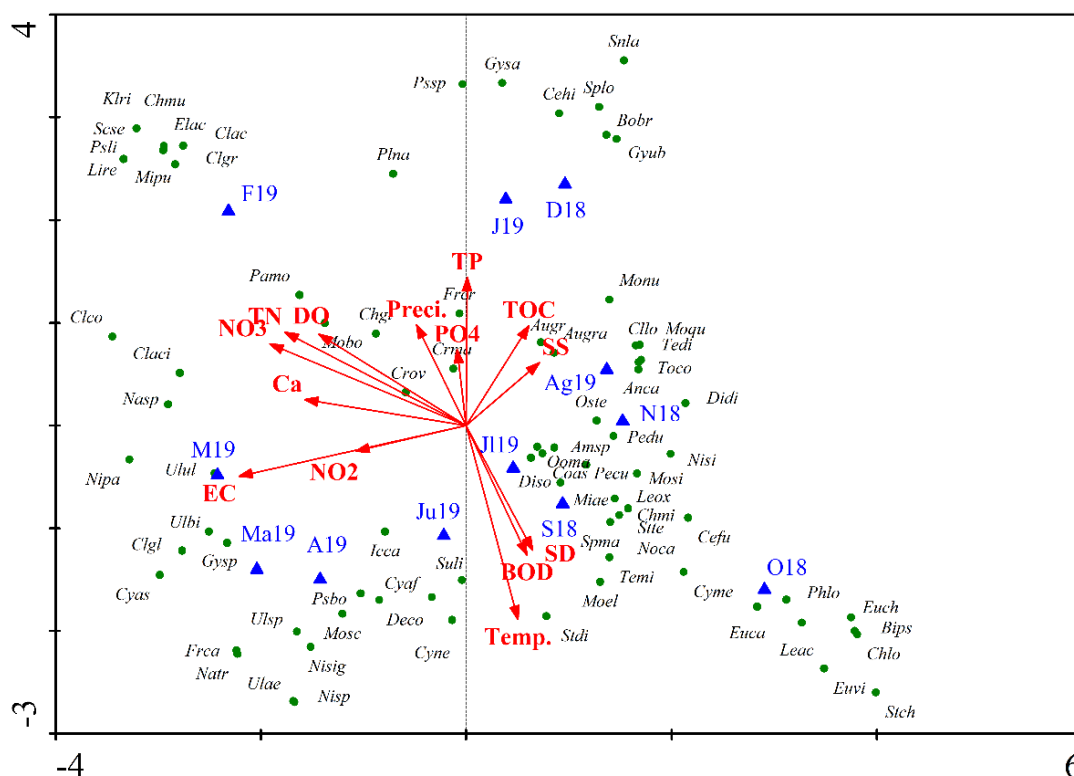


Figure 4.12 Phytoplankton composition (green circle), environmental (red arrow) relations in Burç Reservoir during 12 months. Code and full names of phytoplankton species are given on Tablo 4.5. Sampling months (up triangle) are abbreviated as S18-September 2018, O18-October 2018, N18-November 2018, D18-December 2018, J19-January 2019, F19-February 2019, M19-March2019, A19-April 2019, Ma19-May 2019, Ju19-June 2019, J119-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 (Abrantes et al., 2006), 90.5% for Lake Abant (Çelekli, 2006), 95% for Uluabat Lake (Dalkiran 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	λ_1	λ_2	λ_3	λ_4	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-NO₃ ($F=3.136$ $p=0.002$), 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 ($F=2.246$ $p=0.002$), $N-NO_2$ ($F=2.172$ $p=0.006$), $P-PO_4$ ($F=1.998$ $p=0.004$), 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 $N-NO_3$.

In the third group, the spring months are located on the negative side of the x and y axes and associated with EC and $N-NO_2$. 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, J19-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.

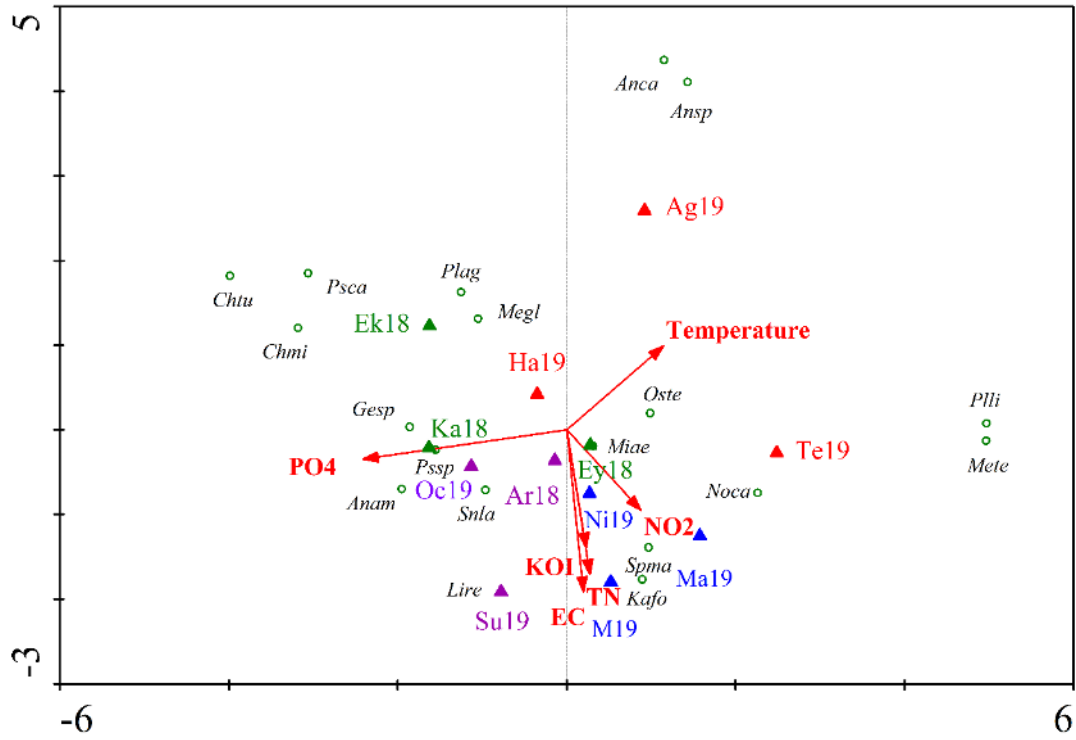


Figure 4.13 Cyanobacteria composition (green circle), environmental (red arrow) relations in Burç Reservoir for 12 months. Code and full names of phytoplankton species are given on Tablo 4.5. Sampling months (up triangle) are abbreviated as S18-September 2018, O18-October 2018, N18-November 2018, D18-December 2018, J19-January 2019, F19-February 2019, M19-March2019, A19-April 2019, Ma19-May 2019, Ju19-June 2019, J119-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	λ_1	λ_2	λ_3	λ_4	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-NO₂ ($F=1.566$ $p=0.020$), and P-PO₄ ($F=1.530$ $p=0.014$).

CCA divided the sampling months into four groups (Figure 4.13). The summer months (Ju19-June 2019, J119-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 *Kamptomonas formosum* and *Spirulina major*.

The September 2018 was related to N-NO₂ and *Microcystis aeruginosa* *Microcystis aeruginosa*, while the November 2018 was related to P-PO₄ 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 aeruginosa* and *Oscillatoria tenuis* were found to be closer to the ordination center and therefore as a wide tolerant species. *Microcystis aeruginosa* 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	TDI _{SD}	TDI _{TP}	TDI _{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; Bur Reservoir TDI_{TP} scores were higher than 77. According to TDI_{TP} scores, Bur Reservoir is eutrophic. Bur 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 (elekli, 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 aeruginosa* 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 aeruginosa* 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.

REFERENCES

- Abrantes, N., Antunes, S. C., Pereira, M. J., Gonçalves, F. (2006). Seasonal Succession of Cladocerans and Phytoplankton and Their Interactions in a Shallow Eutrophic Lake (Lake Vela, Portugal). *Acta Oecologica* **29**, 54-64.
- Allan, J.D., Castillo, M.M., (2007). *Stream ecology: structure and function of running waters*. 2nd ed. Berlin: Springer, 436 p.
- Altuner, Z. (1982). Lake Tortum (Erzurum) A Research on Phytoplankton and Benthic Algae. Ataturk University. Ph.D. Thesis of Institute of Science. 83 p.
- APHA, American Public Health Association. (1995). Standard Methods for the Examination of Water and Wastewater. American Public Health Association. 19th Edition. Washington, D.C.
- APHA, American Public Health Association. (2012). American Water Works Association, Water Environment Federation, Standard Methods for the Examination of Water and Wastewater. 22nd Edition, 1496. p. Washington, D.C.
- Atıcı, T., Obalı, O. (2002). Comparison of Seasonal Variation of Phytoplankton and Chlorophyll-a Values of Lake Abant and Yedigöller (Bolu). *E. U. Journal of Fisheries and Aquatic Sciences* **19**, 381-389.
- Atıcı, T., Obalı, O. (2006). Seasonal Variation of Phytoplankton and Value of Chlorophyll a in the Sarıyar Dam Reservoir (Ankara) *Turkish Journal of Botany Turk J Bot*, **9**, 349-357
- Baysal, A., Obalı, O. (1995). Phytoplankton of Lake Seyfe (Kırşehir) İ.Ü. *Su ürünleri Fakültesi Su Ürünleri Dergisi*. **9**, 1-2.
- Bharat, B. B., Farishta, Y., Nilotpal, K. B. (2012). Epipellic Algal Flora of Samaguri Lake of India: A Systematic Approach on Algae, II. *Annals of Biological Research*. **3** (10), 4808-4819.

Bucak, T., Trolle, D., Tavşanoğlu, Ü.N., Çakıroğlu, A. İ., Özen, A., Jeppesen, E., Beklioğlu, M. (2018). Modeling the Effects of Climatic and Land Use Changes on Phytoplankton and Water Quality of the Largest Turkish Freshwater Lake: Lake Beyşehir, *Science of The Total Environment* Volume **621**, 802-816p.

Cao, Y., Hawkins, C. P., Olson, J. (2007). Modeling Natural Environmental Gradients Improves the Accuracy and Precision of Diatom Based Indicators, *Journal of the North American Benthological Society*, **26**, 566–585.

Carlson, R. E. (1977). A Trophic State Index for Lakes. *Limnology and Oceanography*, **22**, 361–369.

Carvalho, L., Poikane, S., Lyche Solheim, A., Phillips, G., Borics, G., Catalan, J., De Hoyos, D., Drakare, S., Dudley, B.J., Järvinen, M., Laplace-Tretyure, C., Maileht, K., McDonald, C., Mischke, U., Moe, J., Morabito, G., Nöges, P., Nöges, T., Ott, I., Pasztaleniec, A., Skjelbred, B., Thackeray, S. J. (2013). Strength and Uncertainty of Phytoplankton Metrics for Assessing Eutrophication Impacts in Lakes, *Hydrobiologia*, **704**, 127–140.

Çelekli, A. (2006). Comparative Analysis of Seasonal Water Quality Changes and Algae Potential Between Lake Abant and Lake Gököy. Turkey: Abant İzzet Baysal University, Department of Biology Graduate School of Arts and Sciences, Ph.D. Thesis, 395 p.

Çelekli, A., Öztürk, B. (2014). Determination of Ecological Status and Ecological Preferences of Phytoplankton Using Multivariate Approach in a Mediterranean Reservoir, *Hydrobiologia*, **740**, 115–135.

Çelekli, A., Yavuzatmaca, M., Beyazcicek, E., Bozkurt, H. (2009). Effect of Initial Reactive Red 120 Concentrations on the Biomass Production and Dye Uptake by *Spirulina Platensis*, *Fresenius Environmental Bulletin*, **18**, 994-998.

Çelekli, K., Ongun, T. (2008). Spatial and Temporal Dynamics of the Steady-State Phytoplankton Assemblages in a Temperate Shallow Hypertrophic Lake (Lake Manyas, Turkey), *Limnology*, **9**, 115–123.

CEN. Comité Européen de Normalisation. (2003) Water Quality - Guidance Standard for the Routine Sampling and Pretreatment of Benthic Diatoms from Rivers. European Standard EN, 13946, Brussels: European Committee for Standardization, 14 p.

CEN. Comité Européen de Normalisation (2006). Water Quality - Guidance Standard on the Enumeration of Phytoplankton Using Inverted Microscopy (Utermöhl technique). European Standard EN, 15204. Brussels: European Committee for Standardization, 16 p.

CEN. Comité Européen de Normalisation. (2014). Water Quality- Guidance for the Routine Sampling and Preparation of Benthic Diatoms from Rivers and Lakes. European Standard EN 13946. Brussels: European Committee for Standardization, 16 p.

CEN. Comité Européen de Normalisation. (2012). Water Quality - Sampling - Part 3: Preservation and Handling of Samples. - European Standard EN, 5667-3. Brussels: European Committee for Standardization, 12 p.

Çevre ve Şehircilik Bakanlığı (2019). Türkiye Çevre Sorunları ve Öncelikleri Değerlendirme Raporu 2019

Darchambeau, F., Sarmentob, H., Descy, J.P., (2014). Primary Production in a Tropical Large Lake: The Role of Phytoplankton Composition. *Sci. Total Environ.* 473–474, 178–188.

Delgado, C., Pardo, I. (2014). Comparison of Benthic Diatoms from Mediterranean and Atlantic Spanish Streams: Community Changes in Relation to Environmental Factors, *Aquatic Botany*, **120**, 304–314.

Directive. (2000). Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 Establishing a Framework for Community Action in the Field of Water Policy. *Official Journal of the European Committee*, **327**, 1–72.

do Socorro Ibañez, M. (1998). Phytoplankton Composition and Abundance of a Central Amazonian Floodplain Lake. *Hydrobiologia*, **362**, 79-83.

Dotto, G. L., M. Vieira, L. G., Esquerdo, V. M., Pinto, L. A. A. (2013). Equilibrium and Thermodynamics of Azo Dyes Biosorption onto *Spirulina Platensis*, *Brazilian Journal of Chemical Engineering*, **30**, 13 – 21.

EC, (2009) Technical Report - 2009 - 030 Common Implementation Strategy for the Water Framework Directive (2000/60/EC) Guidance Document No. 23 Guidance Document on Eutrophication Assessment in the Context of European Water Policies EC. European Communities. (2009). Water Framework Directive Intercalibration Technical Report. Part 2. In: Poikane S. editor. Lakes. Ispra (Italy): European Commission: Joint Research Centre.

Elmacı, A. (1995). A Research on Phytoplankton of Lake Akşehir (Konya), Ecological and Floristic of Coastal Zone (littoral zone) Algae of Akşehir Lake Ankara University. Ph.D. Thesis of Institute of Science 122.p.

Ersanlı, E. T. (2011). An Investigation Phytoplankton of Erfelek Dam Lake (Sinop) and Physicochemical Effects on its Phytoplankton. Tübitak Project no: 109Y409. 109 p

European Committee for Standardization. (2004b). Water Quality – Guidance Standard for the Surveying, Sampling and Laboratory Analyses of Phytobenthos in Shallow Running Water. European Standard EN, 15708. 22 p. Brussels. Graham L.E., Wilcox L.W. (2000). Algae. Prentice-Hall, Inc. *Upper Saddle River*. London. 640 p.

General Directorate of Meteorology, Gaziantep/Şahinbey Observation Station 17261 Datas.

Gonzalo, M, Fernández, MdR. (2012). Diatoms as Indicators of Water Quality and Ecological Status: Sampling, Analysis and Some Ecological Remarks. *In Ecological Water Quality - Water Treatment and Reuse*. Publisher: InTech,. 184-204 p.

Graham L.E., Wilcox, L.W. (2000). *Algae*. Prentice-Hall, Inc. Upper Saddle River. London. 640 pp.

Gümüş, E. (2018). Phytoplankton Composition and Ecological Characteristics of Some Lentic Ecosystems in the Ceyhan Basin Gaziantep University Institute of Sciences Biology Department Master Thesis. 67.s

- Hillebrand, H., Dürselen, C. D., Kirschtel, D., Polingher, D., Zohary, T. (1999). Biovolume Calculation for Pelagic and Benthic Microalgae, *Journal of Phycology*, **35**, 403–424.
- Huber-Pestalozzi, G. (1983). Das Phytoplankton des Süßwassers. Systematik und Biologie. Chlorophyceae (Grünalgen) Ordnug: Chlorococcales 7. Teil, 1. Hälfte. Stuttgart: E Schweizerbart'sche Verlagsbuchhandlung. 1043 p.
- Jindal, R., Thakur, R.K., Singh, U.B., Ahluwalia, A.S. (2014). Phytolankton Dynamics and Water Quality of Prashar Lake (Himachal Pradesh, India). *Sustainability of Water Quality and Ecology* 3-4,101-113
- John, D.M., Whitton, B.A., Brook J.A. (2002). *The Freshwater Algal Flora of the British Isles*. First edition. Cambridge University Press. Cambridge 702 p.
- Koçer, M. A. T. (2008). Water Quality and Phytoplankton Distribution of Lake Hazar. Fırat University, Institute of Sciences, Ph.D. Thesis, 395 p.
- Komarek, J., Anagnostidis, K. (1998). *Cyanoprokaryota Chroococcales* In: Süßwasserflora von Mitteleuropa. Gustav Fisher Jena, 548 p.
- Krammer, K., Lange–Bertalot, H. (1991a). *Bacillariophyceae*. 3. Teil: Centrales, Fragilariaceae, Eunotiaceae In: Ettl, H., Gerloff, J., Heynig, H., Mollenhauer, D. (Hrsgb.), Süßwasserflora von Mitteleuropa. Band. 2. Fischer Verlag, Stuttgart. 576 p.
- Krammer, K., Lange–Bertalot, H. (1991b). *Bacillariophyceae*. 4. Teil: Achnanthaceae. Kritische Ergänzungen zu Navicula (Lineolatae) und Gomphonema. In: Ettl, H., Gartner, G., Gerloff, J., Heynig, H., Mollenhauer, D. (Hrsgb.), Süßwasserflora von Mitteleuropa. Band. 2. Fischer Verlag, Stuttgart. 437 p.
- Krammer, K., Lange–Bertalot, H. (1999a). *Bacillariophyceae*. 1. Teil: Naviculaceae In: Ettl, H., Gerloff, J., Heynig, H., Mollenhauer, D. (Hrsgb.), Süßwasserflora von Mitteleuropa. Band. 2. Akademischer Verlag Heidelberg, Berlin. 876 p.
- Krammer, K., Lange–Bertalot, H. (1999b). *Bacillariophyceae*. 2. Teil: Bacillariaceae, Epithemiaceae, Surirellaceae In: Ettl, H., Gerloff, J., Heynig, H., Mollenhauer, D. Süßwasser–flora von Mitteleuropa. Band. 2. Akademischer Verlag Heidelberg, Berlin. 611 p.

Lepistö, L., Rosenström, U. (1998). The Most Typical Phytoplankton Taxa in Four Lakes in Finland. *Aquatic Ecology*, **42**, 227–236.

Leps, J., Smilauer, P. (2003). *Multivariate analysis of ecological data using CANOCO*. Cambridge: University Press.

Malve, O. (2007). Water Quality Prediction for River Basin Management. Finland: Helsinki University of Technology, Department of Civil and Environmental Engineering, Water Resources Laboratory, Ph.D. Thesis, 126 p.

Mustapha, M. K. (2008). Assessment of the Water Quality of Oyun Reservoir. Offa, Nigeria. Using Selected Physico-Chemical Parameters, *Turkish Journal of Fisheries and Aquatic Science*, **8**, 309-319.

Naumann, E. (1919). Några Synpunkter Angående Limnoplanktons Ökologi Med Särskild Hänsyn Till Fytoplankton. *Svensk Botanisk Tidskrift*, **13**, 129–163.

OECD, Organisation for Economic Cooperation and Development. (1982). Eutrophication of Waters, Monitoring, Assessment and Control. Paris: OECD Cooperative Programme on Monitoring of Inland Waters (Eutrophication Control).

Orman ve Su İşleri Bakanlığı Yerüstü Su Kalitesi Yönetmeliği Resmî Gazete Number 28483 (2012) , Rev. Number 29327 (2015) and Rev. Number 29797 (2016)

Öztürk, B. (2013). Algae Composition and Limno-Ecological Properties of Alleben Reservoir, Gaziantep University Institute of Sciences Biology Department Master Thesis. 111.s

Özyalın, S. (2007). Investigation of Kemer Dam Lake (Aydın) Phytoplankton Composition and its Physicochemical Properties. Ege University Institute of sciences Master Thesis. 111.s

Padisák, J., Borics, G., Grigorszky, I., Soróczki-Pintér, E. (2006). Use of Phytoplankton Assemblages for Monitoring Ecological Status of Lakes Within the Water Framework Directive: The Assemblage Index, *Hydrobiologia*, **553**, 1–14.

Paerl, H. W., Fulton, R. S., Moisander, P. H., Dyble, J. (2001). Harmful Freshwater Algal Blooms, with an Emphasis on Cyanobacteria, *The Scientific World*, **1**, 76-113.

Paerl, H. W., Huisman, J. (2009). Climate change: A Catalyst for Global Expansion of Harmful Cyanobacterial Blooms, *Environmental Microbiology Reports*, **1**, 27-37

Paerl, H. W., Paul, V. J. (2012). Climate Change: Links to Global Expansion of Harmful Cyanobacteria, *Water research*, **46**, 1349-1363.

Pipp, E. and Rott, E. (1995). A Phytoplankton Compartment Model for a Small Meromictic Lake with Special Reference to Species–Specific Niches and Long–Term Changes. *Ecology*. **78**, 129–148.

Popovsky, J., Pfiester L.A. (1990). *Dinophyceae (Dinoflagellida)* In: Süßwasserflora von Mitteleuropa. Band 6 Gustav Fischer Verlag Jena, 272 p.

Prescott, G.W. (1982). *Algae of the western great lakes area with an illustrated key to the genera of desmids and freshwater diatoms*. 1-977, Otto Koeltz Science Publishers, Koenigstein. 977 p.

Reynolds, C.S. (2006). *The ecology of phytoplankton*. Cambridge: Cambridge University Press, 535 p.

Rott, E. (1981). Some Results from Phytoplankton Counting Intercalibrations. Schweiz Zürich. *Hydrology*. **43**, 34–62.

Round, F.E., Crawford, R.M., Mann, D.G. (1990). The Diatoms. Cambridge University Press. *Biology and Morphology of the Genera*. 1-747.

Salleh, M.A., Mahmoud, M., Abdul Karim, D. K., Idris, W. A. W. (2011). Cationic and Anionic Dye Adsorption by Agricultural Solid Wastes: A comprehensive review. *Desalination*, **280**, 1-13.

Simonsen, R. (1974). The Diatom Plankton of Indian Ocean Expedition of RV ‘Meteor’ 1964-1965. ‘Meteor’ Forschungsergebnisse Reihe D No. **19** 1-61p. Gebrüder Borntraeger Berlin.

Singh, U.B., Ahluwalia, A.S. (2013). Microalgae: a promising tool for carbon sequestration. *Mitigation and Adaptation Strategies for Global Change* **18** (1), 73–95.

Singh, U.B., Sharma, C. (2014). Microalgal diversity of Sheer Khad (stream): a tributary of Sutlej River, Himachal Pradesh, India. *J. Res. Plant Sci.* **3** (1), 235– 241.

Shiklomanov, I.A. (1993). World Fresh Water Resources. in Gleick P, ed. Water in Crisis: a guide to the World's Fresh Water Resources. Oxford(UK):Oxford University Press. 13-24 p.

Smol, J.P. (2008). *Pollution of lakes and rivers: a paleoenvironmental perspective* / John P. Smol. – 2nd ed. Oxford: Blackwell Publishing, 383 p.

Sömek, H., Balık, S. (2009). Lake Karagöl (Mountain Lake, İzmir) Algal Flora and Seasonal Variation of the Environmental Conditions, Ege University, *Ege Journal of Fisheries and Aquatic Sciences* **26/2**, 121-128

Sun, J., Liu, D. (2003). Geometric Models for Calculating Cell Biovolume and Surface Area for Phytoplankton, *Journal of Plankton Research*, **25**, 1331–1346.

T.C. Tarım ve Orman Bakanlığı (2019). Ulusal Su Planı 2019-2023

ter Braak, C.J.F. (1995). Ordination. In Jongman. R.H.G., C.J.F. ter Braak and O. F. R. Van Tongeren (eds). Data Analysis in Community and Landscape Ecology. Cambridge: Cambridge University Press.

ter Braak, C.J.F., Šmilauer, P. (1998). CANOCO Reference Manual and User's Guide to CANOCO for Windows (Version 4). Wageningen: Center for Biometry.

ter Braak, C.J.F., Šmilauer, P. (2002). CANOCO Reference Manual and CanoDraw for Windows User's Guide: Software for Canonical Community Ordination (version 4.5). Ithaca: Microcomputer Power Press.

Thakur, R.K., Jindal, R., Singh, U.B., Ahluwalia, A.S., (2013). Plankton Diversity and Water Quality Assessment of Three Freshwater Lakes of Mandi (Himachal Pradesh, India) with Special Reference to Planktonic Indicators. *Environ. Monit. Assess.* 185 (10), 8355–8373.

Tiffany, L.H. (1958) *Algae*. The Grass of Many Waters. Charles C. Thomas Publisher, Springfield, 199 pp.

United Nations (2012) Back to Our Common Future Sustainable Development in the 21st century (SD21) project Summary for policymakers United Nation Conference on Sustainable Development (UNCSD or “Rio+20”)

(https://sustainabledevelopment.un.org/content/documents/UNDESA_Back_Common_Future_En.pdf). Accessed 25.10.2019.

Ünlü, A., Çoban, F. and Tunç, M.S. (2008). Investigation water quality in terms of physical and inorganic chemical parameters of Lake Hazar. *Journal of the Faculty of Engineering and Architecture of Gazi University* **1**, 119-127.

Verma, R., Singh, U.B., Singh, G.P., (2012). Seasonal Distribution of Phytoplankton in Laddia Dam in Sikar District of Rajasthan. *Vegetos* **25** (2), 165–173.

Vollenweider, RA. (1968). *Scientific fundamentals of the eutrophication of lakes and flowing waters, with particular reference to nitrogen and phosphorus as factors in eutrophication*. Paris: Organisation for Economic Co-operation and Development. Technical Report DAS/CS 1/68.27. 250 p.

Vollenweider, RA., Kerekes, J. (1982). *Eutrophication of waters. Monitoring, assessment and control*. OECD Cooperative programme on monitoring of inland waters (Eutrophication control). Environment Directorate, OECD, Paris. 154 p.

Wehr, J.D., Sheath, R.G. (2003). *Freshwater algae of North America. Ecology and Classification*. Academic Press, California. 918 p.

Wetzel R. G., Likens G. E. (2000). *Limnological analyses*. 3rd edition. Springer, Berlin, Germany, 429 pp

Yılmaz, N. (2019). Water Quality Assessment Based on the Phytoplankton Composition of Buyukcekmece Dam Lake and its Influent Streams (Istanbul), Turkey. *Desalination and Water Treatment* 159, 3-12.

Youngman, RE. (1978). *Measurement of chlorophyll*. Great Britain: Water Research Center, Medmenham Laboratory, 23 p.

CURRICULUM VITAE (CV)

GÜLÜMSER ÖZPINAR **ENVIRONMENTAL ENGINEER**



Contact Information:

E-mail : gulumserozpinar@gmail.com

Address : Turkey - Gaziantep - Şehitkamil

Cell Phone : 0090 (533) 922 59 24

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.

(GASKİ) 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 Interests : Volleyball, jogging and travelling

Memberships : Union of Chambers of Turkish Engineers and Architects

References : Nazmi GÜLER

Porland Porland Porcelain Industry & Trade Inc. – CEO / Tel : 05423243240 |

E-Mail : nguler@porland.com.tr

F. İrem ELBEYLİ

Gaziantep Metropolitan Municipality, Head of Housing and Urban Planning Department |

E-Mail : iremelbeyli@gaziantep.bel.tr