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Research Article

Seasonal Distribution of Algae and Some Physical and Chemical Variables of the Shallow Çağış Pond (Balıkesir, Türkiye)

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Abstract: In this study, algal composition and some physical and chemical variablesof a shallow pond in the campus of Balikesir University, Balıkesir, Türkiye was studied between August 2023 and May 2024. Seasonal samples of epilithic, epiphytic, epipelic and planctonic algae were taken atthree stations (inlet, transition and deep zones). A total of 92 species were identified, 35 species belonged to the dominant Chlorophyta, 30 belonged to Heterokontophyta, 21 to Cyanobacteria, 2 to Charophyta, 2 to Euglenozoa, 1 to Miozoa and 1 to Cryptophyta groups. Chlorophyta made 38%, Heterocontophyta made 33%, Cyanobacteria made 23%, Charophyta made 2%, Euglenozoa made 2%, Miozoa made 1% and Cryptophyta made 1% of the total number of species. The results showed that Chlorophyta was the dominant and Heterocontophyta was the subdominant group. The most dominant species from Chlorophyta were *Tetrabaena socialis* (Dujardin) H.Nozaki & M.Itoh, in November 2023 and *Ettlia pseudoalveolaris* (T.R.Deason & H.C. Bold) J. Komárek in May 2024. The dominant species from the Heterocontophyta group were *Cyclotella meneghiniana* Kützing in May 2024, *Gomphonema gracile* Ehrenberg emend van Heurck in Januaray 2024 and *Nitzschia palea* (Kützing) W.Smith in May 2024. The purpose of this study was to investigate the seasonal distribution of algae and some physical and chemical variables of the shallow Çağış Pond (Balıkesir, Türkiye).

Keywords: Algae; Çağış pond; Physical and chemical parameters; Seasonal distibution.

1. Introduction

Shallow ponds exist in a variety of shapes, depths, and sizes world-wide (Hill et al., 2021). They include seasonal, temporary or permanent water bodies (Fairchild et al., 2005; Peretyatko et al., 2007; Soininen et al., 2007). Shallow lakes and ponds have a large number of ecological niches that cause high species diversity (Reynolds, 1984; Duelli and Obrist, 2003).

Elevated temperatures can promote the growth of algae in both benthic and planktonic habitats and affect the physiology of primary producers (Li et al., 2016; Kaplan and Yıldırım, 2023). Temperature also influences the chemical and physical processes of aquatic ecosystems with implication for the dynamics of the aquatic ecosystems. Increased temperature promotes the release of nitrogen and phosphorus from sediments (Malmaeus et al., 2005).

Competition between planktonic algae and benthic algae is one of the key factors affecting shallow

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aquatic ecosystem dynamics and has become an area of great interest in freshwater ecology (Jäger and Diehl, 2016). The outcomes of such competition would not only affect the distribution of algae, but also determine the clear water or turbid water phases of shallow ponds (Mei et al., 2022).

High abundance of cyanobacteria, chlorophytes, cryptophytes, and diatoms are frequently associated with the eutrophic condition in ponds (Oladipo and Williams, 2003; Harsha and Malammanavar, 2004; Peretyatko et al., 2007). Fairchild et al. (2005), in a study of 13 eutrophic ponds, reported that the algal biomass was directly correlated with the total phosphorus and negatively correlated with light avaliablity. The goal of this study was to investigate the seasonal distribution of algae and basic physical and chemical variables in a shallow recreational pond in Çağış Campus of Balıkesir University, Türkiye.

2. Materials and Methods

Çağış Pond is located at 39º31'12"N; 28º00'45"E, 17 km southeast of Balıkesir, Türkiye (Figure 1). It was formed for recreational and aesthetic purposes in the Çağış Campus of Balıkesir University, Türkiye. It has a maximum depth of 2.5 m, a mean depth of 1 m and a surface area of 3 km^2. There is a very dense development of macrophytes at the edges of the pond. Sampling was carried out seasonally at three stations between August 2023 and May 2024.

Fig. 1. The map of the Cagis Pond and the location of thesampling station.

Water temperature (T) (°C), dissolved oxygen concentration (DO) (mgl−1), specific conductance (SC) (µS cm−1)and pH were measured 10 cm below the water surface using a Hach HQ40 model multimeter instrument. Water transparency was measured in pond using a Secchi disk. Total suspended solids (TSS)(mgl−1), phosphate-phosphorus (PO4-P) (mgl−1), nitrate–nitrogen (NO3–N) (mgl−1), and Nitrite-nitrogen (NO2-N) (mgl−1) were analyzed spectrophotometrically according to standard methods (Anonymous, 1995).

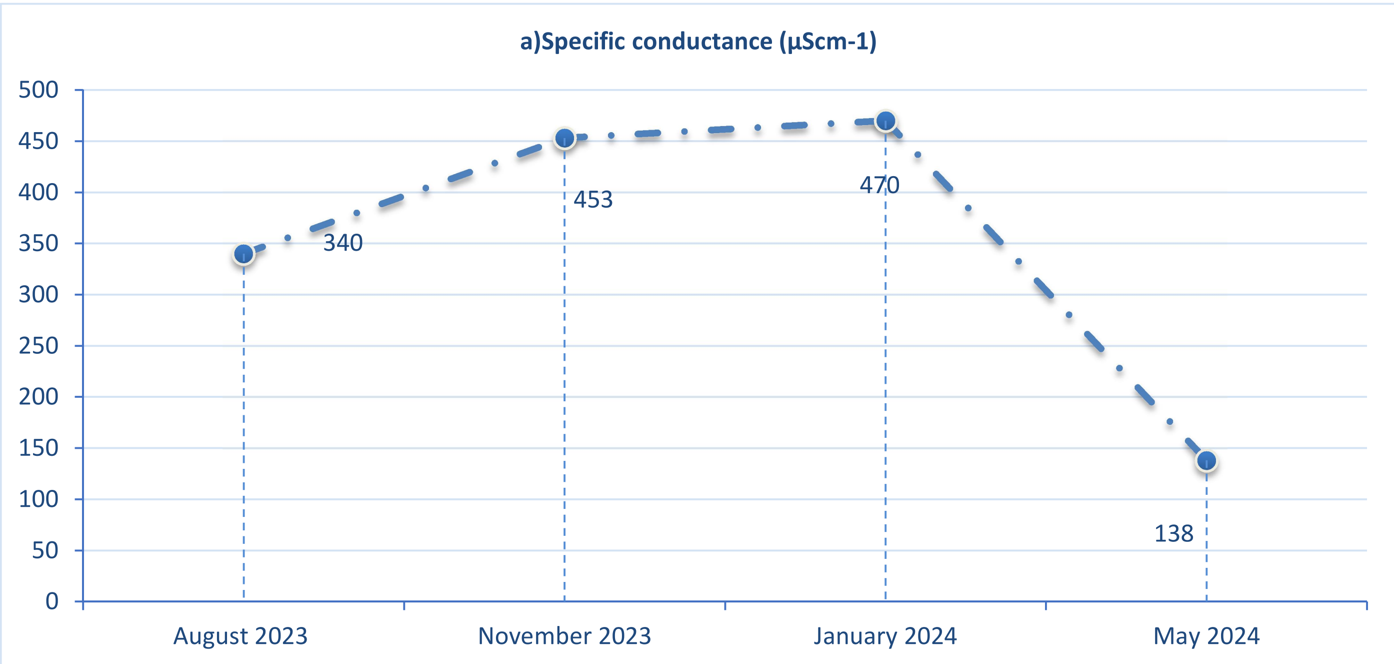
The samples for algae were taken from different habitats, including epipelic, epilithic, epiphytic and planktonic, from three stations. Planktonic samples were collected 10 cm below the surface and placed in 0.5 liter plastic bottles, wrapped in a light-tight manner, and brought to the laboratory for examination. The samples treated with 4% formaldehyde, were shaken to ensure homogeneity, then taken pouredin a 50 ml graduated cylinder and kept in the laboratory for 24 hours. Then, 45 ml of the top water removed by siphoning, and the 5 ml part that settled at the bottom was shaken and transferred to vails for later examination. For species identification and counting, 0.1 ml samples taken with a micro pipette. Countings were made using a Palmer-Maloney plankton counting chamber on an Olympus BX51 microscope with phase-contrast system and water immersion objectives.

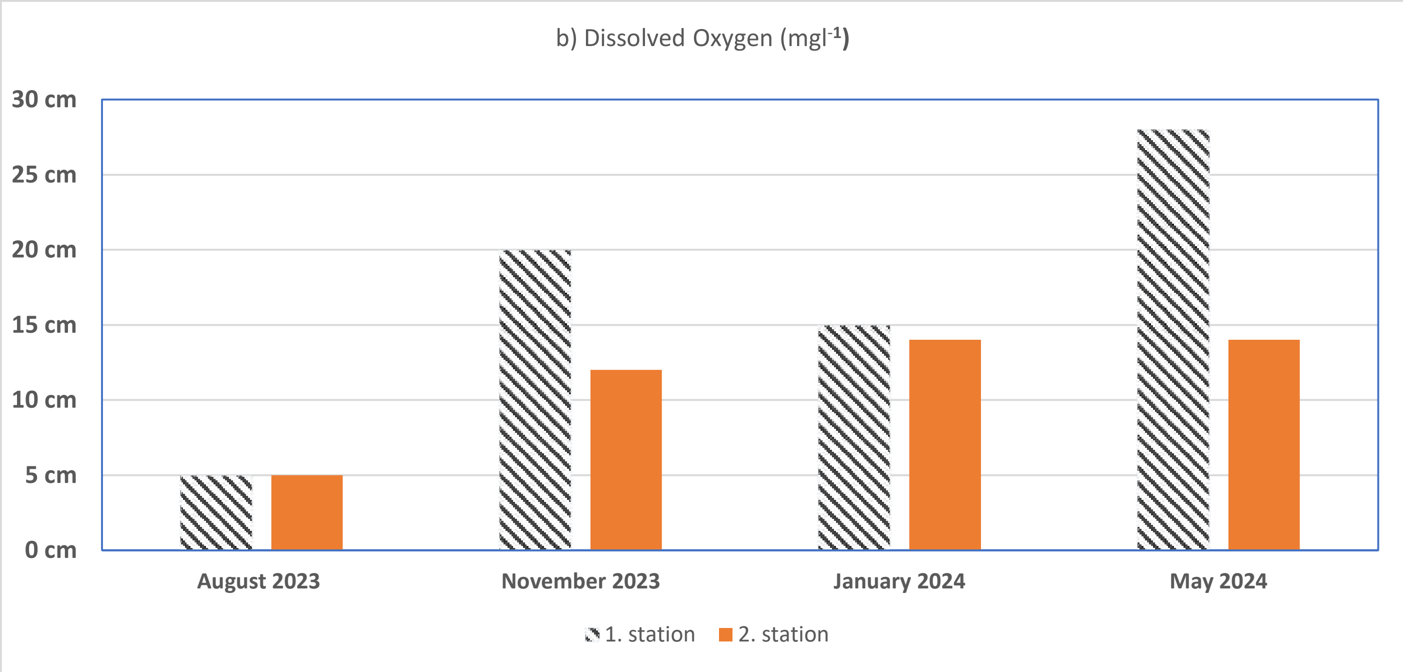
Epilithic samples were collected from rock samples with an average size of 0.14 m2 - 0.18 m2 at each station. Samples were brought to the laboratory while maintaining their humidity. Then, the rock samples were placed in a container and scraped with a brush in water, allowing the samples to pass into the water. Likewise, the plant samples were brought to the laboratory in a humid environment and the flora on the plant was transferred to the water by scraping them with a brush. The samples for the surface growing algae (epipelic algae) were obtained by drawing a glass tube (0.7 cm in diameter and 1 m long) along the sediment. Then, after these samples were fixed with 4% formaldehyde, they were placed in 50 ml graduated cylinders and kept in the laboratory for 24 hours, and 45 ml top water was removed and the remaining 5 ml was transferred to small glass bottles for examination. After the labeling process, they were stored in a suitable environment and has been preserved.

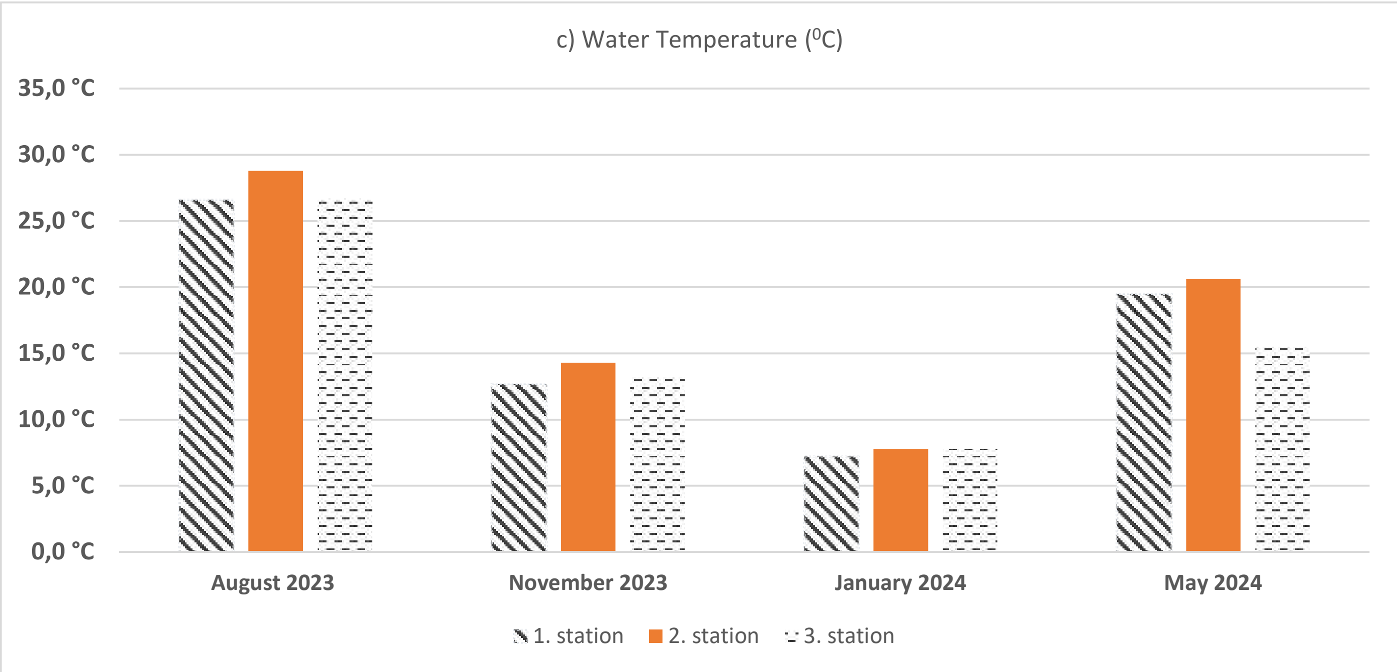
Taxonomic books such as John et al. (2003), Round FE (1956), Round et al. (1990), Huber– Pestalozzi (1950, 1961, 1962, 1969, 1982, 1983), Kramer ve Lange-Bertalot (1986, 1991), Sims (1996), Komarek ve Anagnostidis (2008), were used for species identification. The species were also checked at https://www.algaebase.org/ (Guiry et al., 2014)

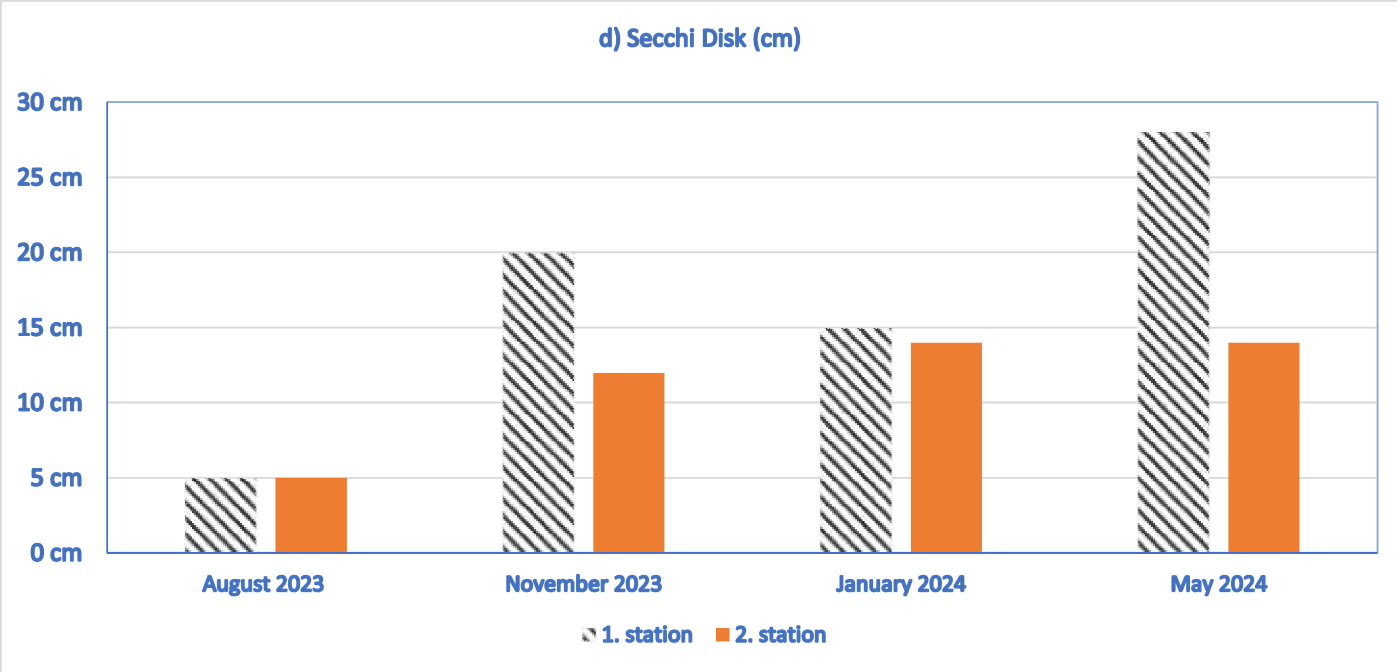
3. Results

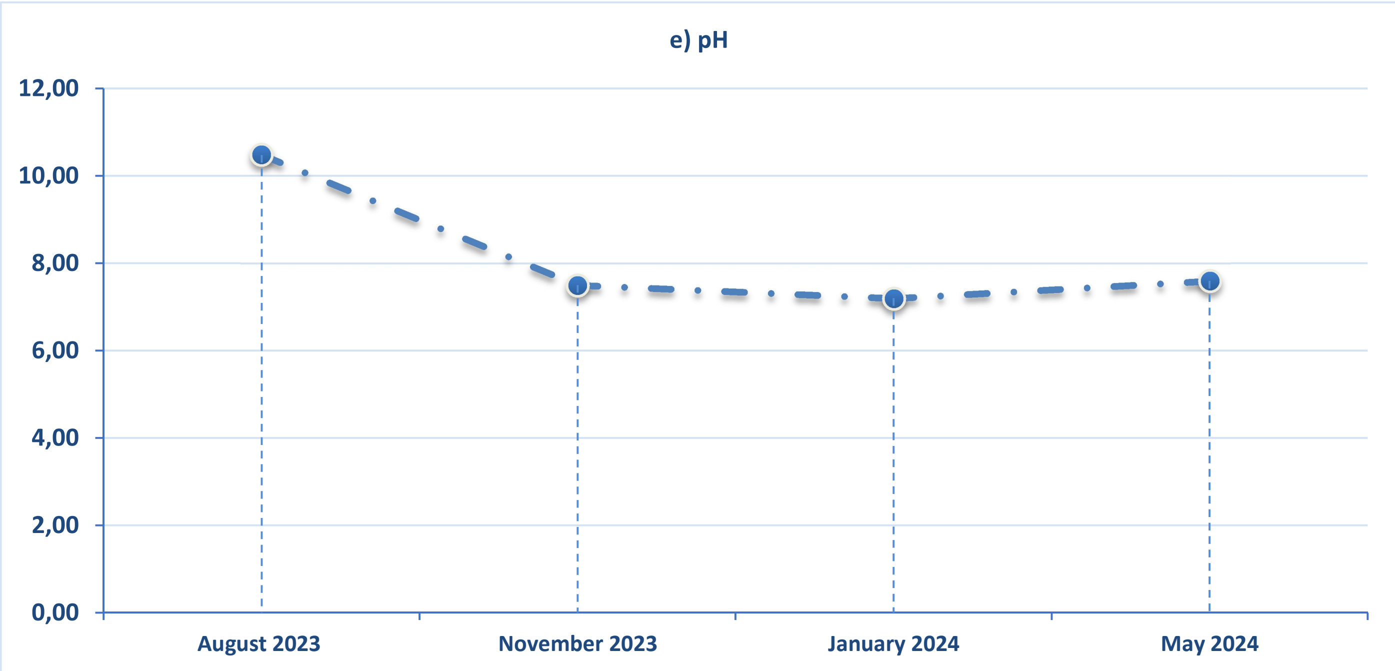
The following values of physical and chemical pamaters were measured between August and Many 2024 in the Çağış Pond. Sepecific conductance ranged from 138 µScm^{-1} in May 2024 to 470 µScm^{-1} in January 2024 (Figure 2a). Dissolve oxygen ranged from 5 mgl^{-1} in August 2023to 28 mgl^{-1} in May 2024 (Figure 2b). Water temperature ranged from 7.2 °C in January 2024 to 28.8 °C in August 2023 (Figure 2c). Secchi disk depth ranged from 5 cm in August 2023 to 28 cm in May 2024 (Figure 2d). pH ranged from 7.2 in January 2024 to 10.48 in August 2023 (Figure 2e). Total suspended solids (TSS) ranged from 0.1618 gl^{-1} in August 2023to 0.6986 gl^{-1} in January 2024 (Figure 2f). Nitrate-nitrogen (NO_3-N) ranged from 0.01 mgl^{-1} in August 2023to 10 mgl^{-1} in January 2024 (Figure 2g). Nitrite-nitrogen (NO_2-N) ranged from 0.01 mgl^{-1} in August 2023to 0.1 mgl^{-1} in January 2024 (Figure 2h). Phosphate-phosphors (PO_4-P) ranged from 0.5 mgl^{-1} in in January 2024 to 1 mgl^{-1} in November and May 2024 (Figure 2i).

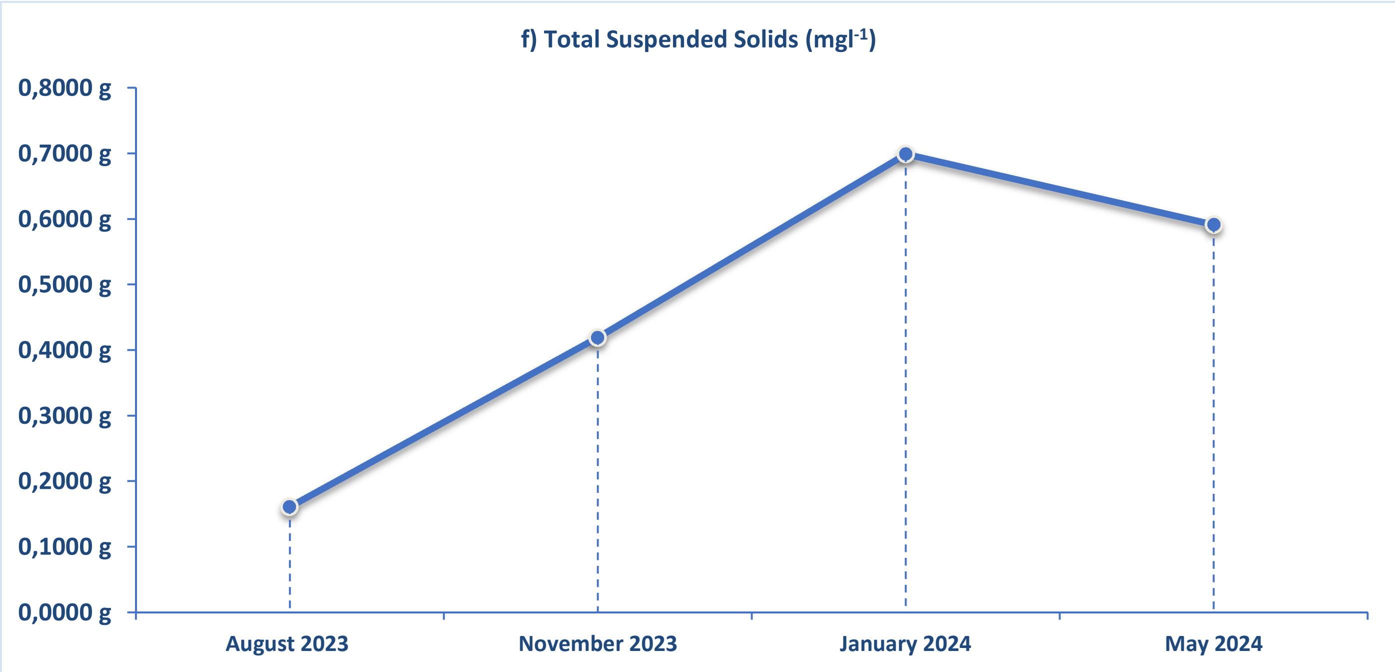


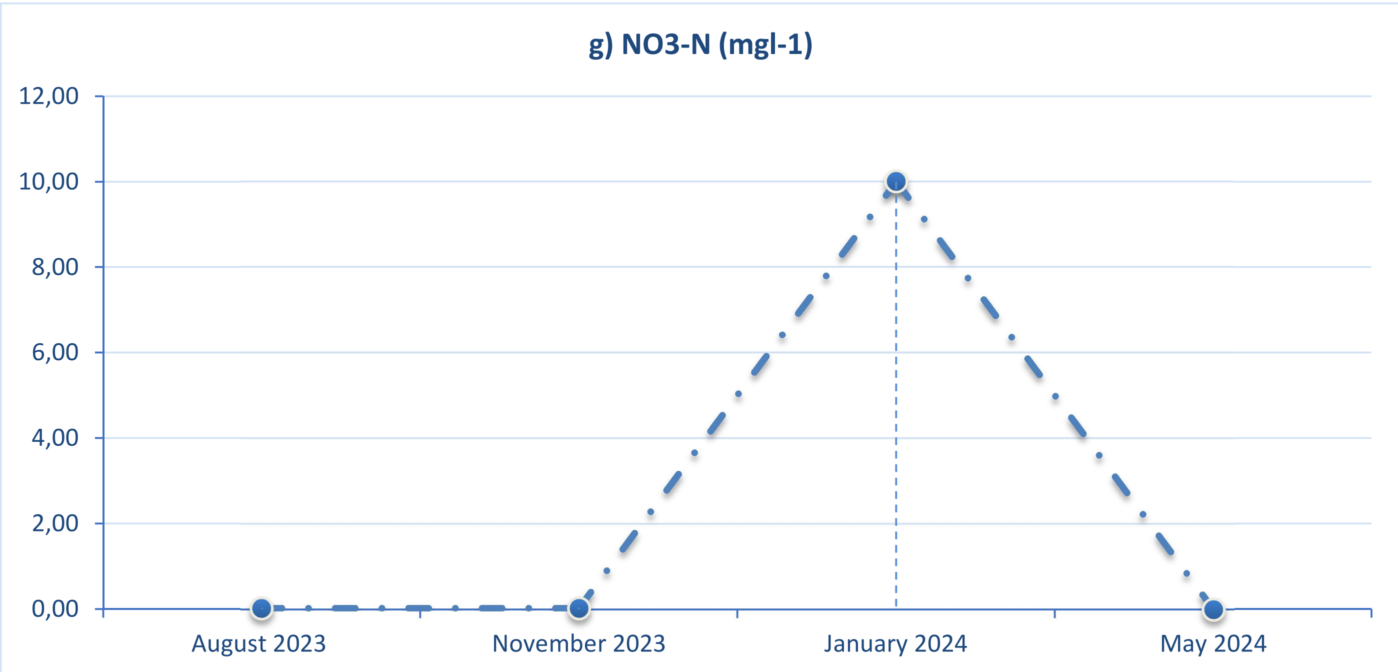

b) Dissolved Oxygen (mgl-1)
30 cm
25 cm
20 cm
15 cm
10 cm
5 cm
0 cm
August 2023
November 2023
January 2024
May 2024
1. station
2. station

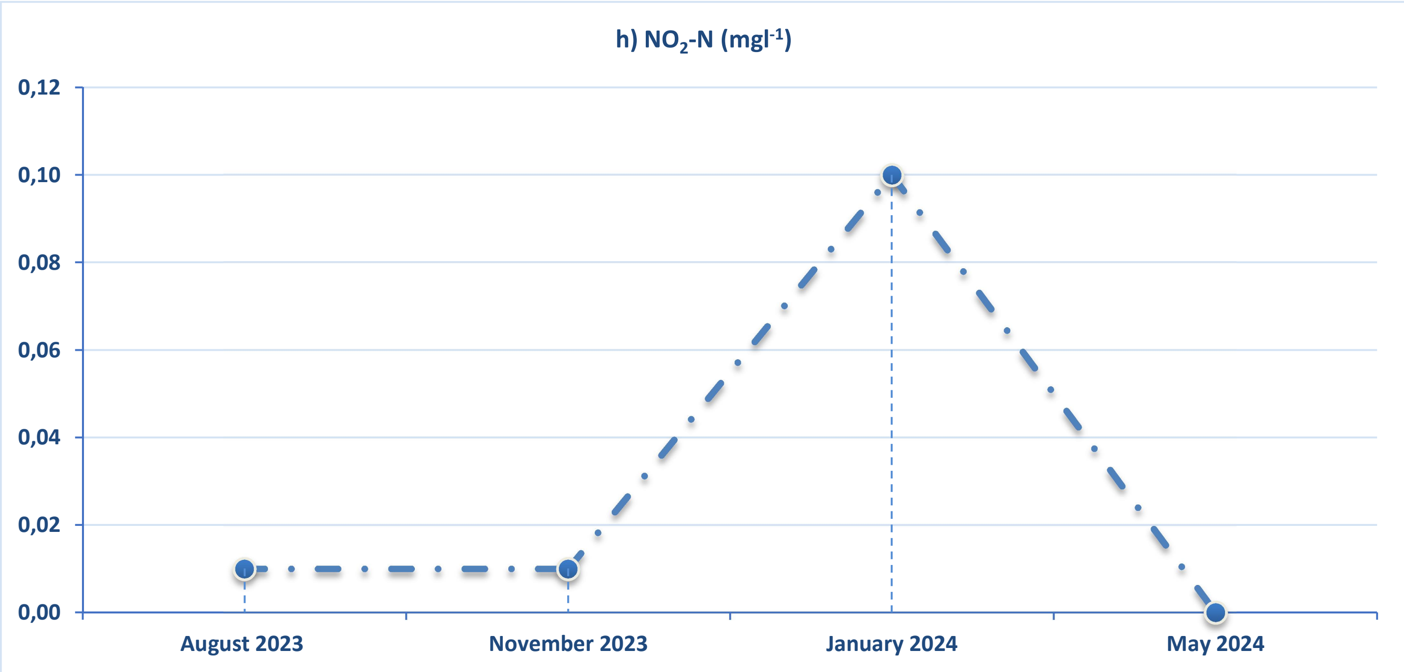

c) Water Temperature (0C)
35,0 °C
30,0 °C
25,0 °C
20,0 °C
15,0 °C
10,0 °C
5,0 °C
0,0 °C
August 2023
November 2023
January 2024
May 2024
1. station
2. station
3. station


d) Secchi Disk (cm)
30 cm
25 cm
20 cm
15 cm
10 cm
5 cm
0 cm
August 2023
November 2023
January 2024
May 2024
1. station
2. station


e) pH
12,00
10,00
8,00
6,00
4,00
2,00
0,00
August 2023
November 2023
January 2024
May 2024


f) Total Suspended Solids (mgl-1)
0,8000 g
0,7000 g
0,6000 g
0,5000 g
0,4000 g
0,3000 g
0,2000 g
0,1000 g
0,0000 g
August 2023
November 2023
January 2024
May 2024


g) NO3-N (mgl-1)
12,00
10,00
8,00
6,00
4,00
2,00
0,00
August 2023
November 2023
January 2024
May 2024



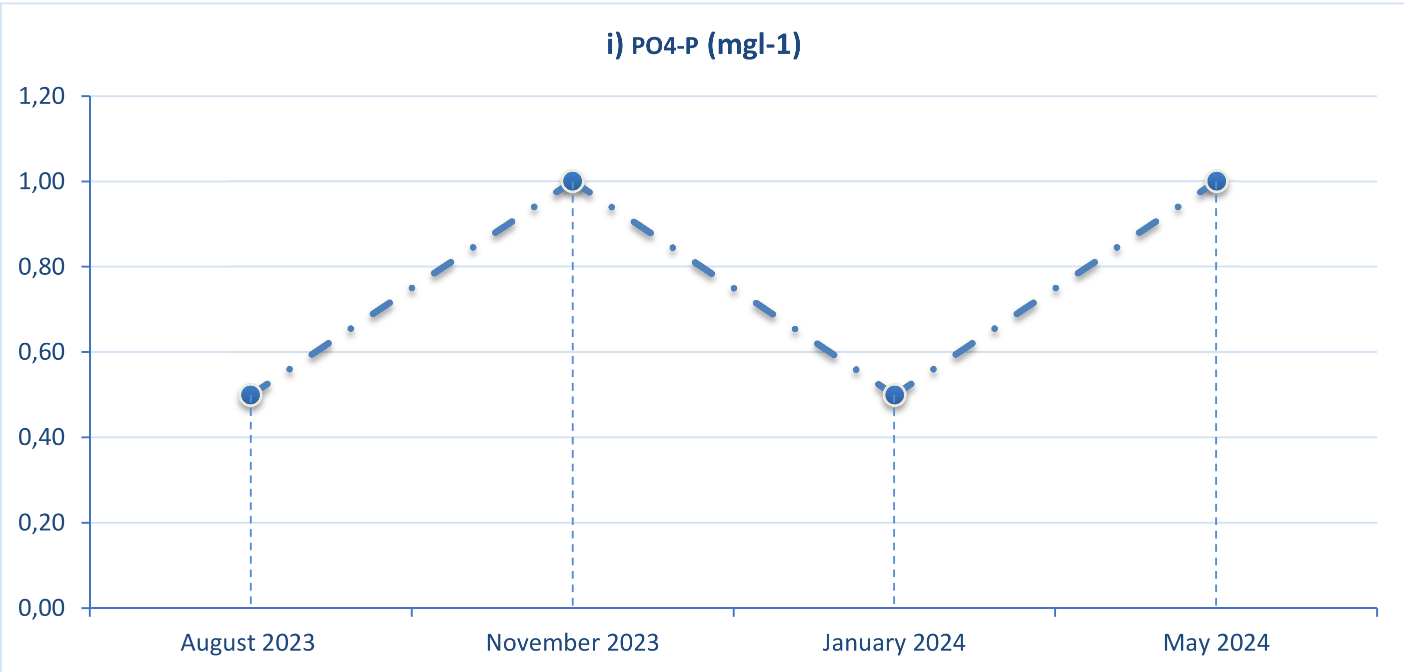


Figure 2. a) Sepecific conductance, b) Dissolve oxygen, c) Water temperature, d) Secchi disk, e) pH, f) Total suspended solids (TSS), g) Nitrate-nitrogen (NO_3-N), h) Nitrite-nitrogen (NO_2-N) and i) Phosphate-phosphors (PO_4-P) values of the Çağış Pond.

A total of 92 species were identified, 35 belonged to the dominant group Chlorophyta, 30 belonged to Heterocnotophyta, 21 to Cyanobacteria, 2 to Charophyta, 2 to Euglenozoa, 1 to Miozoa and 1 to Cryptophyta group (Table 1).

Table 1. List of algae in the Çağış Pond.

CHAROPHYTA
ZYGNEMATOPHYCEAE
Closterium acutum var. linea (Perty) West & G.S.West (Epipelic)
C. nordstedtii var. polystichum (Nygaard) Ruzicka (Epiphytic Epipelic)
CHLOROPHYTA
CHLOROPHYCEAE
Acutodesmus acuminatus (Lagerheim) Tsarenko (Planktonic)
A. dimorphus (Turpin) Tsarenko (Planktonic)
Ankistrodesmus falcatus (Corda) Ralfs (Planktonic)
A. gracilis (Reinsch) Korshikov (Planktonic)
Coelastrella oocystiformis (J.W.G.Lund) Hegewald & Hanagata (Epilithic)
Coelastrum astroideum De Notaris (Planktonic)
Desmodesmus communis (E.Hegewald) E.Hegewald (Planktonic)
D. magnus (Meyen) P.Tsarenko (Planktonic)
D. opoliensis var. mononensis (Chodat) E.Hegewald (Planktonic)
D. protuberans (F.E.Fritsch & M.F.Rich) E.Hegewald Planktonic)
Ettlia pseudoalveolaris (T.R.Deason & H.C.Bold) J.Komárek (Planktonic)
Monoraphidium contortum (Thuret) Komárková-Legnerová (Planktonic)
Pediastrum duplex var. rugulosum Raciborski (Planktonic)
Pseudopediastrum boryanum (Turpin) E.Hegewald (Planktonic)
Scenedesmus acuminatus (Lagerheim) Chodat (Planktonic)
S. longispina R.Chodat (Planktonic)
S. obliquus (Turpin) Kützing (Planktonic)
Sphaerocystis planctonica (Korshikov) Bourrelly (Planktonic)
Tetrabaena socialis (Dujardin) H.Nozaki & M.Itoh (Planktonic)
Tetraedrum minimum (A.Braun) Hansgirg (Planktonic)
T. muticum (A.Braun) Hansgirg (Planktonic
Treubaria triappendiculata C.Bernard (Planktonic)
Uronema curvatum Printz (Epiphytic, Epilithic, Epipelic)
TREBOUXİOPHYCEAE
Actinastrum fluviatile (J.L.B.Schröder) Fott (Planktonic)
A. hantzschii Lagerheim (Planktonic)
A. hantzschii var. *subtile* J.Woloszynska (Planktonic)
Franceia ovalis (Francé) Lemmermann (Planktonic)
Golenkiniopsis solitaria (Korshikov) Korshikov (Planktonic)
Lagerheimia ciliata (Lagerheim) Chodat (Planktonic)
Micractinium pusillum Fresenius (Planktonic)
Mucidosphaerium pulchellum (H.C.Wood) C.Bock, Proschold & Krienitz (Epiphytic)
Oocystis borgei J.W.Snow (Planktonic)
O. marssonii Lmmermann (Planktonic)

O. solitaria Wittrock (Planktonic)
ULVOPHYCEAE
Urospora microscopica Levring (Epiphytic, Epilithic, Epipelic)
CRYPTOPHYTA
CRYPTOPHYCEAE
Cryptomonas nordstedtii (Hansgirg) Senn (Planktonic)
CYANABACTERIA
CYANOPHYCEAE
Anabaena circinalis Rabenhorst ex Bornet & Flahault (Planktonic)
A. planctonica Brunnthaler (Planktonic)
Anabaenopsis ballygungii (Banerji) Komárek&Anagnostidis (Planktonic)
A. circularis (G.S.West) V.V.Miller (Planktonic)
Anathece clathrata (W.West & G.S.West) Komárek, Kastovsky & Jezberová (Planktonic)
Arthrospira platensis Gomont (Planktonic)
Geitlerinema lemmermannii (Woloszynska) Anagnostidis (Planktonic)
Jaaginema homogeneum (Frémy) Anagnostidis & Komárek (Planktonic)
Limnococcus limneticus (Lemmer.) Comarco. Jezber., Mosquito. & Zapo. (Planktonic)
Limnothrix planctonica (Woloszynska) Meffert (Planktonic)
Merismopedia minima Beck (Planktonic)
M. tenuissima Lemmermann (Planktonic)
Microcystis aeruginosa (Kützing) Kützing (Planktonic)
M. protocystis Crow (Planktonic)
Oscillatoria limosa C.Agardh ex Gomont (Epipelic)
O. subbrevis Schmidle (Epipelic)
Phormidium formosum (Bory de Saint-Vincent ex Gomont) Anagnostidis & Komárek (Epiphytic, Epipelic)
Pseudanabaena limnetica (Lemmermann) Komárek (Planktonic)
Raphidiopsis mediterranea Skuja (Planktonic)
Spirulina laxissima G.S.West (Epiphytic)
S. subtilissima Kützing ex Gomont (Epiphytic)
MIOZOA
DINOPHYCEAE
Peridiniopsis polonica (Woloszynska) Bourrelly (Planktonic)
EUGLENOPHYTA
EUGLENOPHYCEAE
Euglenaria clavata (Skuja) Karnkowska & E.W.Linton (Epipelic)
Euglena acus var. *detonii* (Oye) Huber- Pesttalozzi (Epipelic)
HETEROCONTOPHYTA
BACILLARIOPHYCEAE
Amphora eximia J.R.Carter. (Epiphytic, Epilithic Epipelic)
Craticula cuspidata (Kutzing) D.G.Mann. (Epipelic)
C. halophila (Grunow) D.G.Mann (Epipelic)

	Cymatopleura solea (Brébisson) W.Smith (Epilithic Epipelic)
	Cymbella cistula (Ehrenberg) O.Kirchner (Epiphytic, Epilithic)
	Encyonema minutum (Hilse) D.G.Mann (Epiphytic, Epilithic)
	Fragilaria capucina Desmazières (Epiphytic, Epilithic)
	F. crotonensis Kitton (Epiphytic, Epilithic)
	F. nanana Lange-Bertalot (Epiphytic, Epilithic)
	F. ulna (Nitzsch) Lnage-Bartalot (Epiphytic, Epilithic Epipelic)
	Gomphonema gracile Ehrenberg emend van Heurck. (Epiphytic, Epilithic)
	G. olivaceum (Hornemann) Brébisson (Epiphytic, Epilithic)
	G. parvulum (Kützing) Kützing (Epiphytic, Epilithic)
	Halamphora montana (Krasske) Levkov (Epiphytic, Epilithic)
	Hantzschia amphioxys (Ehrenberg) Grunow (Epipelic)
	Neidium productum (W.Smith) Cleve (Epiphytic, Epilithic)
	Nitzschia acicularis (Kützing) W.Smith (Epipelic)
	N. amphibia Grunow (Epipelic)
	N. palea (Kützing) W.Smith (Epipelic)
	N. recta HantzschexRabenhorst (Epipelic)
	Pinnularia microstauron (Ehrenberg) Cleve (Epiphytic, Epilithic, Epipelic)
	P. viridis (Nitzsch) Cleve (Epiphytic, Epilithic, Epipelic)
	Surirella brebissonii var. kuetzingii Krammer & Lange-Bertalot (Epipelic)
	Tryblionella calida D.G.Mann (Epipelic)
	Ulnaria acus (Kützing) M.Aboal (Epiphytic, Epilithic)
	U. ulna (Nitzsch) P.Compère (Epiphytic, Epilithic)
COSCİNODİSCOPHYCEAE	
	Aulocoseira granulata (Ehrenberg) Simonsen (Epilithic Epipelic)
	Melosiralineata (Dillwyn) C.Agardh (Epiphytic, Epilithic)
	M. varians C.Agardh (Epiphytic, Epilithic)
MEDİOPHYCEAE	
	Cyclotellameneghiniana Kützing (Epilithic Epipelic)

Chlorophyta made 38%, Heterocontophyta made 33%, Cyanobacteria made 23%, Charophyta made 2%, Euglenozoa made 2%, Miozoa made 1%, and Cryptophyta made 1% of the total number of species during the study. The results showed that Chlorophyta was the dominant and Heterocontophyta was the subdominant group (Figure 3).

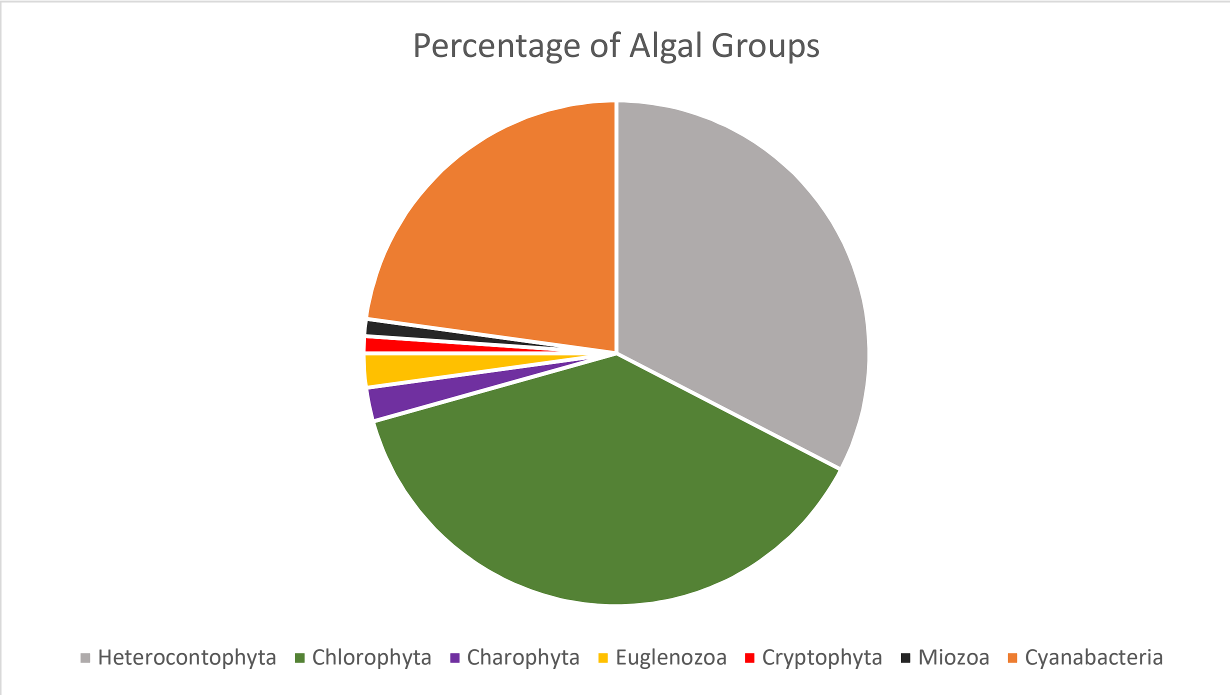
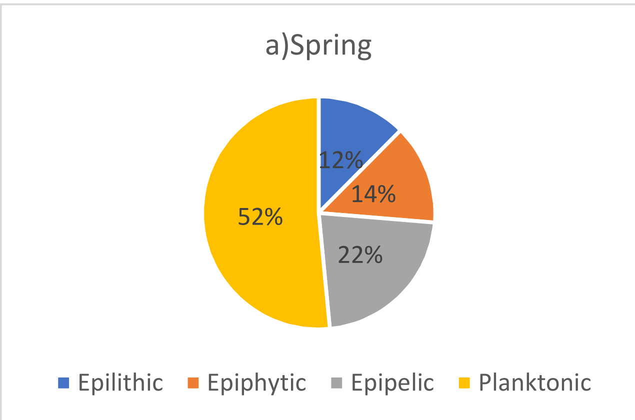


Figure 3. The total percentage compositon of the algal groups in the Çağış Pond.

In the spring, epilithic alage made 12%, epiphytic alage made 14%, epipelic alage made 22% and planktonic algae made 52%of the total number of algae. In the summer, epilithic alage made 12%, epiphytic alage made 30%, epipelic alage made 39% and planktonic algae made 12% of the total number of algae. In the fall, epilithic alage made 15%, epiphytic alage made 4%, epipelic alage made 31% and planktonic algae made 31% of the total number of algae. In the winter, epilithic alage made 13%, epiphytic alage made 21%, epipelic alage made 26% and planktonic algae made 40% of the total number of algae.



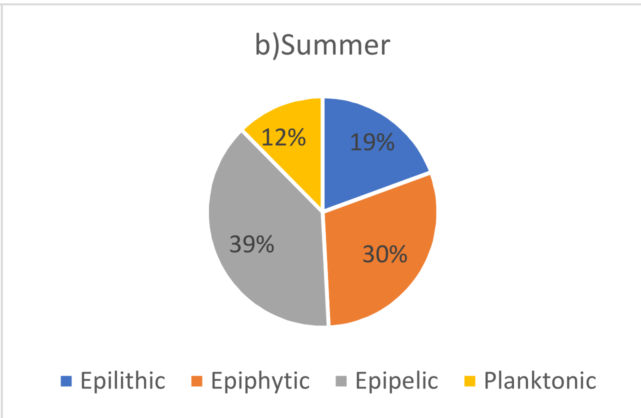


Figure 4. The variation of epilithic, epiphytic, epipelic and dplanktonic algae of the pond during a) spring, b) summer, c) fall and d) winter.

4. Discussion

The nutrient concentrations and Secchi disk depth values clearly show that the pond was a eutrophic mater body (Carlson, 2007). A total of 92 species were identified during the study. Chlorophyta had a large number of species (35) being the dominant group.Round (1956) indicated that certainChlorophyta species prefered eutrophic water bodies, being coherent with our results.

T. socialis from Chlorophyta dominanted algae in November 2023. This chorophyte has a remarkable ability to thrive in shallow lakes and is is a common member of eutrophic lake phytoplankton in this region (Çelik and Sevindik, 2015). Another dominant species of Chlorophyta was *E. pseudoalveolaris. Ettlia* species are known as a highly settleable and productive microalga and shown to be effective in removing nutrients and capturing suspended solids from eutrophic pond waters (Rezvani et al., 2017) being coherent with the the conditions of Çağış Pond.*C. meneghiniana, N. palea*and *G. gracile*were the dominant diatom species. The blooms of *C. meneghiniana* and *N. palea* is a common phenomenon in shallow lakes, sepecially during small-scale turbulence (Wang et al., 2012).

The most remarkble results of this study were the the high abundance of planktonic versus benthic algae during spring and fall which are seasons for circulations in temperate regions(Stefanoff et al., 2018). Our results suggests that spatial heterogeneity contributed to patterns of planktonic versus benthic algal ratio in this shallow pond. Since nutreint concentrations are not at the limiting level, spring and fall overturn resuspend benthic algea into plagic zone which increased the abundance of phytoplankton. Schelske et al. (1995) showed the importance of wind-induced resuspension of sediments in the shallowLake Apopka, Florida where planktonic diatoms that settle to the benthic environment, accounted for a large component of the phytoplankton during the wind events .

In conclusion, the nutrient concentrations, Secchi disk depth values and dominant alagal species showed that Çağış Pond was a eutrophic mater body. Finally, our results clearly showed that the high abundance of planktonic versus benthic algae during spring and fall was related to seasonal circulations in the pond.

Conflicts of Interests
Authors declare that there is no conflict of interests

Financial Disclosure
Author declare no financial support.

Statement contribution of the authors
This study's experimentation, analysis and writing, etc. all steps were made by the authors.

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