Case Study

Composition and Distribution of Benthic Diatoms in Different Habitats of Burdur River Basin

Burdur Nehir Havzasındaki Farklı Habitatlarda Bentik Diyatome Kompozisyonu ve Dağılımı

Ayça Oğuz[1], Aydın Kaleli[1], Reyhan Akçaalan[1], Latife Köker[1], Zeynep Dorak[1], Özcan Gaygusuz[1], Fatih Aydın[1], Tolga Çetin[2], Yakup Karaaslan[2], Meriç Albay[1]

[1] *Department of Freshwater Resource and Management, Faculty of Aquatic Sciences, Istanbul University*

ayca.oguzcam@istanbul.edu.tr (https://orcid.org/0000-0002-0711-2967), aydin.kaleli@istanbul.edu.tr (https://orcid.org/0000-0003-3843-1335), akcaalan@istanbul.edu.tr (https://orcid.org/0000-0002-0756-8972), latife.koker@istanbul.edu.tr (https://orcid.org/0000-0002-9134-2801), zdorak@istanbul.edu.tr (https://orcid.org/0000-0003-4782-3082), ozcan.gaygusuz@istanbul.edu.tr (https://orcid.org/0000-0001-6861-6221), fatih.aydin@istanbul.edu.tr (https://orcid.org/0000-0002-5003-2620), merbay@istanbul.edu.tr (https://orcid.org/0000-0001-9726-945X)

[2]*Ministry of Agriculture and Forestry, General Directorate of Water Management*

tolga.cetin@tarimorman.gov.tr (https://orcid.org/0000-0002-7817-3222) , yakup.karaaslan@tarimorman.gov.tr (https://orcid.org/0000-0001-8993-4771)

Received Date: 11.12.2019, Accepted Date: 23.12.2019

Abstract

Diatoms constitute an essential component for biomonitoring studies to determine the ecological quality of waterbodies. In this study, benthic diatoms of Burdur River Basin were investigated as a consequence of a project on river basin management plan. This is the first detailed taxonomical study of diatoms taken from 13 streams, 4 lakes and 6 reservoirs of Burdur River Basin and a total of 223 taxa have been observed. Among genera, *Navicula* Bory (27) and *Nitzschia* Hassal (27) were represented with the highest numbers of taxa and followed by *Gomphonema* Agardh with a total of 22 species. *Navicula antonii* Lange-Bertalot and *Nitzschia palea* var. *debilis* (Kützing) Grunow had the highest relative abundance with 17.1% and 15.5% respectively. As a closed basin, salinity varied greatly from fresh to saline water between the sampling stations and diatom composition contained species with a different tolerance level. *Navicula antonii* and *Nitzschia frustulum* (Kützing) Grunow observed in all habitats indicating their euryhaline characters; however *Navicula digitoconvergens* was only detected in saline Acıgöl lake with a high relative abundance (38%) in autumn. Other two dominant species were *Halamphora coffeiformis* (Kützing) Levkov and *Navicula cincta* (Ehrenberg) Ralfs in Acıgöl lake showing their tolerance to high salt content as a brackish species. According to first results, 11 species were new records for Turkish diatom flora. The high biodiversity of diatoms revealed the presence of different habitat characteristics within the basin. These results are an important contribution of Turkish diatom flora and could be useful for monitoring specific areas like Burdur River Basin.

Keywords: *Burdur River Basin, diatoms, phytobenthos, salinity tolerance*

Öz

Diyatomeler, su kütlelerinin ekolojik kalitesini belirlemek için yapılan biyolojik izleme çalışmalarında kullanılan önemli bir bileşendir. Bu çalışmada, Burdur Nehir Havzası'nın tatlı su bentik diyatomeleri nehir havzası yönetim planının hazırlanması projesi kapsamında 13 nehir, 4 göl ve 6 rezervuar olmak üzere toplam 23 noktadan örneklenmiştir. Çalışma kapsamında havzada bentik diyatomelerin ilk defa detaylı taksonomik incelenmesi yapılmış olup, toplamda 223 takson gözlenmiştir. Cinsler arasında Navicula Bory (27) ve Nitzschia Hassal (27) en fazla taksonla temsil edilmiş olup, bunu 22 tür ile Gomphonema Agardh takip etmiştir. Navicula antonii Lange-Bertalot ve Nitzschia palea var. debilis (Kützing) Grunow, sırasıyla %17,1 and %15,5 nisbi bolluk değerleri ile en yüksek nispi bolluğa sahip türler olmuştur. Kapalı bir havza olan Burdur Havzası'nda örnekleme alanlarının tuzluluk değerleri tatlı sudan tuzlu suya kadar farklılık göstermiş olup, diyatome kompozisyonu da farklı tuzluluk tolerans seviyelerine sahip türleri içermektedir. Örihalin karaktere sahip olan Navicula antonii ve Nitzschia frustulum bütün habitatlarda gözlenirken, Navicula digitoconvergens sadece tuzlu su karakterine sahip olan Acıgöl'de yüksek nisbi bolluğa (%38) ulaşmıştır. Acıgöl'de tespit edilen diğer iki dominant tür olan Halamphora coffeiformis ve Navicula cincta türleri de acısu karakterindeki sularda artış yaptığı bilinen türlerdir ve bu havzada yüksek tuzluluğa tolerans göstermişlerdir. Elde edilen ilk sonuçlara göre, 11 tür Türkiye diyatome florası için yeni kayıtlardır. Diyatomelerin yüksek biyoçeşitliliği Burdur Nehir Havzası'ndaki farklı habitat karakteristiklerinin varlığını ortaya koymuştur. Bu sonuçlar, Türkiye diyatome florasına önemli bir katkı sağlayacak ve Burdur Nehir Havzası gibi özel alanların izlenmesinde yararlı olacaktır.

Anahtar kelimeler: *Burdur Nehir Havzası, diyatomeler, fitobentoz, tuzluluk toleransı*

Introduction

Amongst the algae groups, diatoms have been a subject of study, especially in recent years due to the biomonitoring of freshwater bodies for water quality assessments. Their prompt response to the environmental changes and their presence throughout the year together with rapid reproduction stages made diatoms an essential tool for monitoring freshwater systems. Studies were conducted in various waterbodies of Turkey to detect the environmental quality of the lakes (Dalkıran et al. 2016; Şanal & Demir, 2018) and rivers (Atıcı, 1997; Karacaoğlu & Dalkıran, 2017; Demir et al. 2017; Solak et al. 2018; Çelekli et al. 2019).

Burdur River Basin is located in the southwest of central Anatolia, and it is one of the smallest basins. In the neighbouring river basins, benthic diatoms had become an interest for the researchers to determine the flora of several streams or lakes. Çiçek & Yamuç (2017) investigated epilithic algae in relation to environmental factors in Kovada Lake in Antalya River Basin. In Büyük Menderes, there were many studies concerning benthic diatoms as well; e.g., Barlas et al. (2002), studied the epilithic algae of Akçapınar Stream and Kadın Azmağı Stream.

Detection of ecological quality of rivers and lakes has become more important for the last decades in Europe, according to Water Framework Directive (WFD) regulations (Ács et al. 2004; Rimet, 2012). Similarly, studies were conducted to use biological components, including benthic diatoms, of aquatic ecosystems to assess the ecological quality based on WFD. As a result, basin-scale studies on diatom biodiversity and ecology have increased recently. Demir et al. (2017) reported diatom composition of Lake Eber and the streams in Akarçay River Basin, while Solak et al. (2018) analysed the distribution of diatoms in streams and reservoirs of Küçük Menderes River. Benthic diatom community of streams, lakes and reservoirs of Gediz River Basin was also studied by Solak et al. (2019). Unlike the other 24 river basins in Turkey, there is no data on benthic diatom composition in the lakes and streams of Burdur River Basin.

The aim of this research is to determine the benthic diatom flora of streams and lakes/reservoirs of Burdur River Basin and provide a taxonomical data for the environmental quality monitoring of the basin according to regulations of WFD (2000/60/EC).

Method

Sampling

Burdur River Basin is located in the southwest of Turkey, covering some natural lakes and wetlands such as Burdur Lake, Acıgöl Lake and Salda Lake (Figure 1). Sampling was carried out in 23 waterbodies including the streams, lakes and reservoirs. A total of 30 sampling points were selected in the basin area; however, sampling could not be performed due to the drought in seven locations (Table 1). Benthic diatom samples were taken twice a year (April and October 2018). According to Communique on Biological Monitoring (T.C. Resmi Gazete, 2019), one sample collected from lakes and reservoirs smaller than 50 ha; 2 samples in areas between 50-500 ha area and 3 samples from the lakes and reservoirs greater than 500 ha were taken. However, all samples were mixed and one subsample was prepared for each lake and reservoir. Epilithic diatom samples were collected from the submerged stones, and epiphytic samples were collected from macrophytes. Physicochemical measurements were performed monthly in 2018.

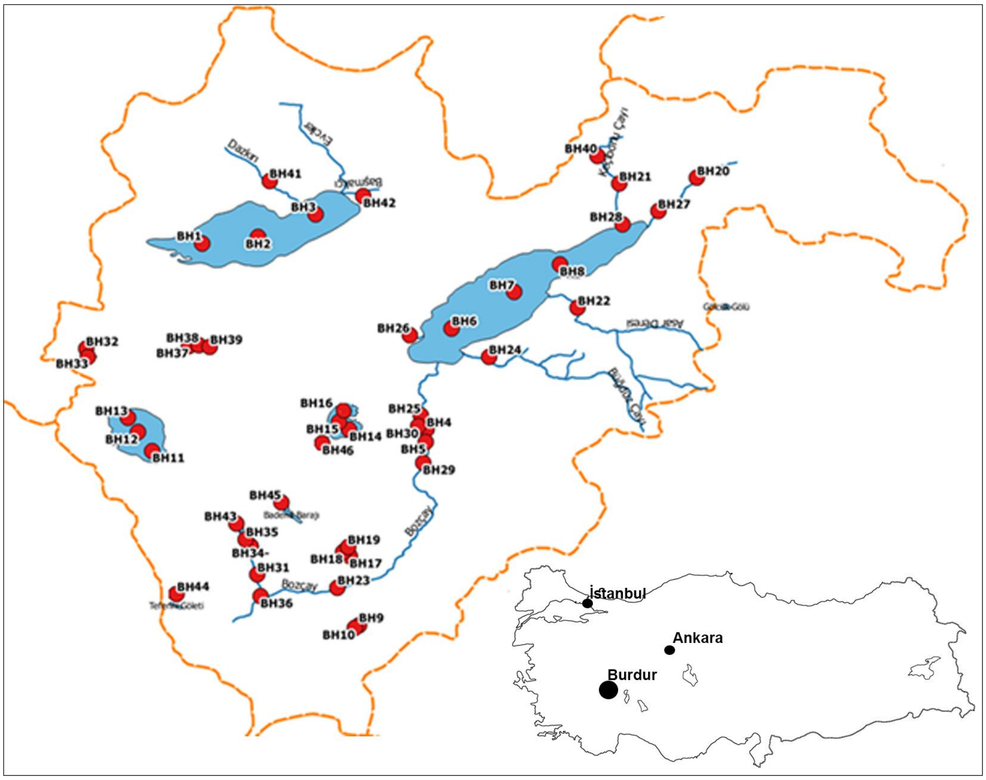

Figure 1. Study area and sampling stations.

Diatom Analysis

Samples were cleaned from organic material by boiling with H_2O_2 and washed by distilled water several times. In order to remove the carbonates, samples were treated with 10% HCl. Frustules were air-dried and mounted in Naphrax®. Zeiss Axio Observer Z1 (Carl Zeiss microscopy Gmbh, Jena, Germany) microscope was used for light microscopy (LM) observations at Limnology Laboratory, Department of Freshwater Resource and Management, Istanbul University.

Diatom valves were identified according to the following literature; Krammer & Lange-Bertalot (1986, 1988, 1991a,b), Hofmann et al. (2011) and Kulikovskiy et al. (2016). Taxonomic classification and nomenclatural on genera and taxa names follow the latest updates from Guiry & Guiry (2019) and Kociolek et al. (2019). Slides and processed materials were deposited at the collection of the Department of Freshwater Resource and Management, Istanbul University and the Ministry of Agriculture and Forestry archives.

The relative abundance of the species was expressed as percentages of the total number of frustules counted. The relative abundance (RA) of particular taxa and the taxa richness of the assemblages were estimated on the basis of at least 300 diatom valves counted per sample. The RA of the species identified in lakes, reservoirs and streams were determined separately and the species constituting higher than 5% were evaluated in Table 4.

Table 1

Burdur River Basin Sampling Coordinates

Code	Name	Category	Salinity	Province	Coordinates	
					X	Y
BH1	Acıgöl	Lake	Saline (39‰)	Afyon	37.81844	29.77163
BH2					37.82721	29.84914
BH3					37.85838	29.92875
BH4	Karaçal	Reservoir	Freshwater	Burdur	37.56175	30.08104
BH5					37.54444	30.08007
BH6	Burdur	Lake	Brackish (18.2‰)	Burdur	37.70125	30.11597
BH7					37.75088	30.20211
BH8					37.78928	30.26449
BH9	Belenli	Reservoir	Freshwater	Burdur	37.29235	29.98792
BH10					37.28849	29.98258
BH11	Salda	Lake	Brackish (1.1 ‰)	Burdur	37.53238	29.70349
BH12					37.55788	29.68351
BH13					37.57749	29.66961
BH14	Yarışlı	Lake (Dry)	-	Burdur	37.56182	29.97482
BH15					37.57202	29.96020
BH16					37.58831	29.96729
BH17	Karataş	Lake	Freshwater	Burdur	37.38701	29.97508
BH18					37.39292	29.96579
BH19					37.39989	29.97259
BH20	Gönen	Stream (Dry in October)	Freshwater	Isparta	37.90820	30.45358
BH21	Çukurharman	Stream (Dry)	-	Isparta	37.90046	30.34642
BH22	Asar	Stream	Brackish (0.53 ‰)	Burdur	37.72920	30.28935
BH23	Bozçay	Stream	Freshwater	Burdur	37.34401	29.95839

Code	Name	Category	Salinity	Province	Coordinates	
					X	Y
BH24	Büğdüz	Stream (Dry in October)	Freshwater	Burdur	37.66174	30.16703
BH25	Bozçay	Stream	Freshwater	Burdur	37.58073	30.07316
BH26	Ulupınar	Stream (Dry)	-	Burdur	37.69160	30.05794
BH27	Gönen	Stream	Brackish (1.9 ‰)	Isparta	37.86231	30.39985
BH28	Çukurharman	Stream	Brackish (0.7‰)	Isparta	37.84485	30.35068
BH29	Bozçay	Stream	Freshwater	Burdur	37.51586	30.07599
BH30	Bozçay	Stream	Freshwater	Burdur	37.56599	30.07000
BH31	Karamanlı	Stream (Dry)	-	Burdur	37.36173	29.84796
BH32	Beylerli	Reservoir	Freshwater	Denizli	37.67316	29.61199
BH33					37.66217	29.61534
BH34	Karamanlı	Reservoir	Freshwater	Burdur	37.40121	29.83880
BH35					37.41066	29.83226
BH36	Sarı	Stream (Dry)	-	Burdur	37.33204	29.85228
BH37	Akgöl	Lake (Dry)	-	Burdur	37.67674	29.75361
BH38					37.67821	29.76745
BH39					37.67559	29.78304
BH40	Keçiborlu	Stream (Dry in April)	Brackish (1.45 ‰)	Isparta	37.93891	30.31606
BH41	Dazkırı	Stream (Dry)	-	Afyon	37.90446	29.86472
BH42	Başmakçı	Stream (Dry in April)	Brackish (6 ‰)	Afyon	37.88374	29.99386
BH43	Özdere	Stream	Freshwater	Burdur	37.43224	29.81980
BH44	Tefenni	Reservoir	Freshwater	Burdur	37.31703	29.74366
BH45	Bademli	Reservoir	Freshwater	Burdur	37.43503	29.90621
BH46	Yarışlı	Stream	Freshwater	Burdur	37.43503	29.90621

Results

Physicochemical Parameters

The physicochemical measurements revealed that reservoirs, lakes and streams in the basin were generally alkaline. The mean conductivity values were generally low in reservoirs and streams (0.5 and 1.7 mS cm^{-1}, respectively) but higher in lakes (22.3 mS cm^{-1}). Notably, in Burdur and Acıgöl lakes, conductivity was higher throughout the year, and the mean conductivity values were 29.4 mS cm^{-1} and 57.2 mS cm^{-1} respectively. Significant changes were observed in dissolved oxygen values in reservoirs, lakes and streams throughout the year. Although the lowest dissolved oxygen (DO) values were observed in Burdur Lake as 2.7 mg L^{-1} and Acıgöl Lake as 1 mg L^{-1}, the average values were between 6.9 and 7.8 mg L^{-1} in the reservoirs and lakes (Table 2).

As a closed basin, salinity varied remarkably between freshwater to saline among studied areas. While all reservoirs were classified as freshwater (<0.5‰), streams were categorized between fresh to brackish water (<0.5 - 6‰). On the other hand, salinity variation was higher in lakes, from freshwater (Karataş Lake, <0.5‰) to brackish (Salda Lake, 1‰ and Burdur Lake, 18‰) and even saline environment (Acıgöl Lake, 39 ‰).

Table 2

Mean, Min and Max Values of Selected Water Quality Parameters Measured Studied Areas

	Temperature (°C)			pH			Conductivity (mS cm^{-1})			Dissolved Oxygen (mg L^{-1})			Salinity (‰)		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Reservoirs	13.7	3.8	24.0	8.5	7.4	9.3	0.5	0.2	0.6	6.9	3.0	11.4	<0,5	<0,5	<0,5
Lakes	15.2	5.1	29.0	8.8	6.4	9.6	22.3	0.5	69.6	7.8	1.0	11.4	19.4	<0,5	47.6
Streams	15.8	2.2	27.9	8.3	7.0	9.7	1.7	0.3	12.9	6.9	0.5	12.7	2.7	<0,5	7.5

Diatom Composition

Composition and distribution of diatoms have been studied in two seasons, and a total of 223 taxa belonging to 57 genera were identified; within these taxa, 11 were identified in genera level. The seasonal composition of species were presented according to sampling habitats; streams, lakes and reservoirs (Table 3).

Table 3

Diatom Composition and Distribution in Streams, Lakes and Reservoirs of Burdur River Basin

Taxa	Stream		Lake		Reservoir	
	Sp.	Aut.	Sp.	Aut.	Sp.	Aut.
Achnanthes petersenii Hustedt	+					
Achnanthidium eutrophilum (Lange-Bertalot) Lange-Bertalot	+					+
Achnanthidium minutissimum (Kützing) Czarnecki	+	+			+	
Achnanthidium minutissimum var. jackii (Rabenhorst) Lange-Bertalot	+	+	+	+	+	+
Adlafia minuscula var. *muralis* (Grunow) Lange-Bertalot		+				
Amphora aequalis Krammer		+				
Amphora alpestris Levkov		+				
Amphora copulata (Kützing) Schoeman & R.E.M. Archibald		+				+
Amphora inariensis Krammer		+				+
Amphora indistincta Levkov						+
Amphora lange-bertalotii Levkov & Metzeltin						+
Amphora ovalis (Kützing) Kützing		+			+	+
Amphora pediculus (Kützing) Grunow	+	+			+	+
Amphora stechlinensis Levkov & Metzeltin	+					+
Anomoeoneis sphaerophora Pfitzer		+				
Aulacoseira ambigua (Grunow) Simonsen					+	+
Aulacoseira italica (Ehrenberg) Simonsen	+					
Berkeleya sp.		+	+	+		+
Caloneis amphisbaena (Bory) Cleve		+				
Caloneis bacillum (Grunow) Cleve					+	
Caloneis silicula (Ehrenberg) Cleve			+			
Cocconeis lineata Ehrenberg	+	+		+	+	+

Taxa	Stream		Lake		Reservoir	
	Sp.	Aut.	Sp.	Aut.	Sp.	Aut.
Cocconeis pediculus Ehrenberg	+	+				
Cocconeis placentula var. *placentula* Ehrenberg	+	+		+	+	+
Craticula accomoda (Hustedt) D.G. Mann						+
Craticula ambigua (Ehrenberg) D.G. Mann	+	+		+	+	+
Craticula buderi (Hustedt) Lange-Bertalot*	+	+				
Craticula cuspidata (Kützing) D.G. Mann	+					
Craticula subminuscula (Manguin) Wetzel & Ector	+	+				
Craticula sp.		+				
Cyclostephanos dubius (Hustedt) Round		+				
Cyclostephanos invisitatus (Hohn& Hellermann) Theriot, Stoermer & Håkasson						+
Cyclotella meneghiniana Kützing	+	+			+	
Cymbella affinis Kützing	+					+
Cymbella cymbiformis Agardh	+	+	+	+	+	+
Cymbella dorsenotata Østrup	+					+
Cymbella excisa Kützing		+				
Cymbella helvetica Kützing						+
Cymbella lanceolata (Agardh) Agardh			+			
Cymbella lange-bertalotii Krammer*		+			+	+
Cymbella neocistula Krammer						+
Cymbella vulgata Krammer		+				
Cymbopleura amphicephala (Nägeli) Krammer		+	+		+	+
Cymbopleura inaequalis (Ehrenberg) Krammer						+
Cymbopleura rhomboidea Krammer						+
Cymbellafalsa diluviana (Krasske) Lange-Bertalot & Metzeltin	+					
Diatoma moniliformis (Kützing) D.M. Williams	+			+	+	
Diatoma tenuis C. Agardh		+				
Diatoma vulgaris Bory	+	+				
Diploneis elliptica (Kützing) Cleve					+	
Diploneis krammeri Lange-Bertalot & E. Reichardt	+				+	
Diploneis parma Cleve		+				
Dorofeyukea kotschyi Kulikovskiy et al.		+			+	

Taxa	Stream		Lake		Reservoir	
	Sp.	Aut.	Sp.	Aut.	Sp.	Aut.
Encyonema caespitosum Kützing	+	+	+		+	+
Encyonema hebridicum Grunow ex Cleve						+
Encyonema lacustre (C. Agardh) Pantocsek		+				+
Encyonema lange-bertalotii Krammer		+				
Encyonema latum Krammer		+				
Encyonema leibleinii (C. Agardh) Silva et al.			+		+	
Encyonema minutum (Hilse) D.G. Mann		+			+	+
Encyonema silesiacum (Bleisch) D.G. Mann		+	+	+	+	+
Encyonema ventricosum (C. Agardh) Grunow	+				+	+
Encyonema vulgare Krammer*					+	+
Encyonopsis cesatii (Rabenhorst) Krammer		+			+	
Encyonopsis microcephala (Grunow) Krammer		+		+	+	
Encyonopsis minuta Krammer & E. Reichardt				+	+	
Encyonopsis subminuta Krammer & E. Reichardt	+	+		+	+	+
Encyonopsis sp.		+				
Epithemia adnata (Kützing) Brébisson		+				
Epithemia gibba (Ehrenberg) Kützing		+				+
Epithemia smithii Carruthers				+		+
Epithemia sorex Kützing		+		+		
Fallacia pygmaea (Kützing) Stickle & D.G. Mann	+	+	+	+	+	
Fragilaria gracilis Østrup						+
Fragilaria henryi Lange-Bertalot					+	
Fragilaria pararumpens Lange-Bertalot, G. Hofmann & Werum				+		
Fragilaria radians (Kützing) D.M. Williams & Round	+	+				
Fragilaria tenera var. *nanana* (Lange-Bertalot) Lange-Bertalot & S. Ulrich		+				
Fragilaria vaucheriae (Kützing) J.B. Petersen	+		+	+	+	+
Frustulia sp.					+	
Geissleria decussis (Østrup) Lange-Bertalot & Metzeltin						+
Gomphonema auritum A. Braun ex Kützing*					+	
Gomphonema calcareum Cleve				+		
Gomphonema clavatum Ehrenberg	+	+				

Taxa	Stream		Lake		Reservoir	
	Sp.	Aut.	Sp.	Aut.	Sp.	Aut.
Gomphonema drutelingense E. Reichardt*	+					
Gomphonema exilissimum (Grunow) Lange-Bertalot & E. Reichardt*		+				+
Gomphonema innocens E. Reichardt	+					
Gomphonema italicum Kützing		+				+
Gomphonema lippertii E. Reichardt & Lange-Bertalot		+				
Gomphonema minusculum Krasske		+				
Gomphonema minutum (C. Agardh) C. Agardh		+				
Gomphonema olivaceum (Hornemann) Brébisson	+	+	+	+	+	+
Gomphonema pala E. Reichardt		+				
Gomphonema parvulum (Kützing) Kützing	+	+			+	
Gomphonema pseudoaugur Lange-Bertalot	+	+				
Gomphonema pumilum (Grunow) E. Reichardt & Lange-Bertalot	+	+		+		+
Gomphonema pumilum var. *rigidum* E. Reichardt & Lange-Bertalot		+				
Gomphonema rhombicum Fricke					+	
Gomphonema saprophilum (Lange-Bertalot & E. Reichardt) Abraca et al.	+					
Gomphonema subclavatum (Grunow) Grunow		+				
Gomphonema tergestinum (Grunow) Fricke						+
Gomphonema truncatum Ehrenberg			+		+	
Gomphonema sp.		+				
Gyrosigma acuminatum (Kützing) Rabenhorst					+	
Gyrosigma attenuatum (Kützing) Rabenhorst		+				
Halamphora coffeiformis (C. Agardh) Levkov		+	+	+		+
Halamphora veneta (Kützing) Levkov		+		+		+
Hantzschia abundans Lange-Bertalot	+				+	
Hantzschia amphioxys (Ehrenberg) Grunow		+				
Hippodonta capitata (Ehrenberg) Lange-Bertalot, Metzeltin & Witkowski		+			+	
Hippodonta hungarica (Grunow) Lange-Bertalot, Metzeltin & Witkowski				+		
Lemnicola exigua (Grunow) Kulikovskiy, Witkowski & Plinski	+				+	
Lemnicola hungarica (Grunow) Round & Basson		+				

Taxa	Stream		Lake		Reservoir	
	Sp.	Aut.	Sp.	Aut.	Sp.	Aut.
Lindavia balatonis (Pantocsek) Nakov et al.					+	+
Luticola ventricosa (Kützing) D.G. Mann	+				+	
Mastogloia elliptica (C. Agardh) Cleve		+				
Mastogloia smithii Thwaites ex W. Smith	+	+	+	+		
Mastogloia cf. *pseudosmithii* Lee et al.			+			
Melosira varians C. Agardh		+			+	
Navicymbula pusilla (Grunow) Krammer	+	+	+	+	+	+
Navicula antonii Lange-Bertalot	+	+	+	+	+	+
Navicula capitatoradiata H. Germain	+	+	+	+	+	+
Navicula cari Ehrenberg		+				+
Navicula cincta (Ehrenberg) Ralfs		+	+		+	
Navicula cryptocephala Kützing	+	+				+
Navicula cryptotenella Lange-Bertalot	+	+	+	+		+
Navicula digitoconvergens Lange-Bertalot				+		
Navicula erifuga Lange-Bertalot	+					
Navicula gottlandica Grunow					+	
Navicula gregaria Donkin						+
Navicula hanseatica Lange-Bertalot & Stachura					+	
Navicula lanceolata Ehrenberg	+				+	
Navicula menisculus Schumann	+				+	+
Navicula metareichardtiana Lange-Bertalot & Kusber	+	+				
Navicula notha J.H. Wallace	+				+	+
Navicula phyllepta Kützing		+				
Navicula rhynchotella Lange-Bertalot	+					
Navicula rostellata Kützing					+	
Navicula simulata Manguin		+	+			
Navicula striolata (Grunow) Lange-Bertalot			+			
Navicula tripunctata (O.F. Müller) Bory	+	+				+
Navicula trivialis Lange-Bertalot						+
Navicula upsaliensis (Grunow) M. Peragallo			+			
Navicula vandamii Schoeman & R.E.M. Archibald		+				
Navicula veneta Kützing	+	+				

Taxa	Stream		Lake		Reservoir	
	Sp.	Aut.	Sp.	Aut.	Sp.	Aut.
Navicula viridula var. *germainii* (Wallace) Lange-Bertalot		+		+		+
Navicula sp.				+		
Neidium affine (Ehrenberg) Pfitzer						+
Nitzschia alpina Hustedt	+	+			+	+
Nitzschia amphibia Grunow	+	+	+		+	
Nitzschia bulnheimiana (Rabenhorst) H.L. Smith*		+				
Nitzschia capitellata Hustedt	+	+				+
Nitzschia denticula Grunow	+	+			+	+
Nitzschia desertorum Hustedt				+		
Nitzschia dissipata (Kützing) Rabenhorst	+	+	+		+	+
Nitzschia filiformis (W. Smith) Van Heurck		+				
Nitzschia fonticola (Grunow) Grunow	+			+		+
Nitzschia frustulum (Kützing) Grunow	+	+	+	+		+
Nitzschia gracilis Hantzsch				+		
Nitzschia hantzschiana Rabenhorst	+	+			+	
Nitzschia heufleriana Grunow	+				+	
Nitzschia inconspicua Grunow	+	+	+	+		+
Nitzschia linearis W. Smith	+	+	+		+	
Nitzschia palea (Kützing) W. Smith	+	+		+	+	+
Nitzschia palea var. *debilis* (Kützing) Grunow		+				+
Nitzschia palea var. *minuta* (Bleisch) Grunow	+					
Nitzschia pusilla Grunow	+			+		
Nitzschia recta Hantzsch ex Rabenhorst					+	
Nitzschia rosenstockii Lange-Bertalotii	+					
Nitzschia sociabilis Hustedt		+				+
Nitzschia solita Hustedt	+			+		
Nitzschia supralitorea Lange-Bertalot		+				+
Nitzschia tenuis W. Smith	+					
Nitzschia tubicola Grunow		+				
Nitzschia umbonata (Ehrenberg) Lange-Bertalot		+				
Pantocsekiella iranica (Nejdsattari et al.) Kiss et al.		+		+		+
Pantocsekiella ocellata (Pantocsek) Kiss & Ács	+	+			+	+

Taxa	Stream		Lake		Reservoir	
	Sp.	Aut.	Sp.	Aut.	Sp.	Aut.
Paraplaconeis minor (Grunow) Lange-Bertalot*					+	
Paraplaconeis placentula (Ehrenberg) Kulikovskiy & Lange-Bertalot	+			+		
Pinnularia brebissonii (Kützing) Rabenhorst	+	+			+	
Pinnularia divergens W. Smith					+	+
Pinnularia suchlandtii Hustedt			+		+	
Pinnularia sp.		+				
Placoneis anglophila (Lange-Bertalot) Lange-Bertalot*					+	
Placoneis clementis (Grunow) E.J. Cox						+
Placoneis clementioides (Hustedt) E.J. Cox *					+	
Placoneis ignorata (Schimanski) Lange-Bertalot						+
Placoneis sp.						+
Planothidium frequentissimum (Lange-Bertalot) Lange-Bertalot	+	+	+	+		
Planothidium lanceolatum (Brébisson ex Kützing) Lange-Bertalot		+				
Planothidium rostratum (Østrup) Lange-Bertalot	+					
Pseudofallacia monoculata (Hustedt) Liu, Kociolek & Wang	+					
Pseudostaurosira brevistriata (Grunow) D.M. Williams & Round	+	+				
Reimeria sinuata (W. Gregory) Kociolek & Stoermer						+
Rhopalodia gibberula (Ehrenberg) Otto Müller		+		+		+
Sellaphora absoluta (Hustedt) Wetzel et al.						+
Sellaphora pupula (Kützing) Mereschkovsky	+	+	+	+	+	+
Sellaphora sp.				+		
Stauroneis acidoclinata Lange-Bertalot & Werum*				+	+	
Stauroneis gracilis Ehrenberg			+			
Staurosira dubia Grunow					+	
Staurosira venter (Ehrenberg) Cleve & J.D. Möller				+		
Staurosirella pinnata (Ehrenberg) D.M. Williams & Round		+				
Stephanodiscus astraea (Kützing) Grunow			+		+	
Surirella amphioxys W. Smith						+
Surirella angusta Kützing		+				+
Surirella brebissonii Krammer & Lange-Bertalot	+	+				

Taxa	Stream		Lake		Reservoir	
	Sp.	Aut.	Sp.	Aut.	Sp.	Aut.
Surirella librile (Ehrenberg) Ehrenberg		+			+	
Surirella minuta Brébisson ex Kützing	+	+				
Surirella ovalis Brébisson	+	+				
Surirella robusta Ehrenberg	+					+
Surirella subsalsa W. Smith	+					
Tabularia fasciculata (C. Agardh) D.M. Williams & Round	+					
Tryblionella angustata W. Smith	+	+				
Tryblionella apiculata W. Gregory	+	+	+	+		
Tryblionella brunoi (Lange-Bertalot) Cantonati & Lange-Bertalot						+
Tryblionella calida (Grunow) D.G. Mann		+				
Tryblionella hungarica (Grunow) Frenguelli	+	+				
Ulnaria acus (Kützing) Aboal	+	+			+	+
Ulnaria biceps (Kützing) Compère	+	+			+	
Ulnaria delicatissima (W. Smith) Aboal & P.C. Silva		+			+	+
Ulnaria ulna (Nitzsch) Compère	+	+			+	

Note. Sp= Spring*, Aut*= Autumn*,* * =New records.

Amongst the diatom genera, *Navicula* Bory and *Nitzschia* Hassall were represented with the highest numbers of taxa (27) in the river basin, this was followed by *Gomphonema* Agardh (22), *Encyonema* Kützing (10) and *Cymbella* Agardh (9). 20 genera were represented with only one species. 136 species were identified in spring, while the number of species increased to 174 in autumn. The species number varied between the environments; 131 taxa were observed in reservoir samples, while 61 and 160 taxa found in lake and stream samples, respectively. The taxa numbers also showed a variance in different habitats between spring and autumn. Total 78 taxa found in spring whereas 86 taxa were detected in autumn in the reservoirs. There were 34 taxa in spring with an increase to 45 taxa in autumn in lakes, and the highest species diversity was found in streams, 90 and 124 taxa in spring and autumn, respectively.

The most abundant species was *Navicula antonii* (17.1%) in the whole basin. The other common taxa (≥5%) observed were *Nitzschia palea* var. *debilis* (15.5%), *Tabularia fasciculata* (6.6%) *Cyclotella meneghiniana* (5.6%), *Nitzschia frustulum* (5.4%), and *Amphora pediculus* (5.3%). The remaining numbers of species showed less than 5% occurrences in the samples (Figure 2;3;4).

The most abundant species in the studied areas differed significantly according to the sampling period (Table 4). The number of species which exceeded 5% was higher in spring than in autumn. Diatom material observed in the reservoir samples showed that *Pantocsekiella iranica* (in autumn), *P. ocellata* and *Ulnaria delicatissima* (in spring) were the most abundant species (14%, 17% and 17%, respectively). In the lake samples, abundant species changed and *Achnanthidium minutissimum* var. *jackii* (in autumn) and *Encyonema caespitosum* (in spring) were the most abundant taxa (20% and 35%). On the other hand, especially in autumn, only two species, *Nitzschia palea* var. *debilis* (38%) and *Navicula antonii* (38%), were dominant in the stream samples and other species remained below total RA 5%.

Table 4

Species Identified Above 5% of the Total RA in Reservoirs, Lakes And Streams

	Spring (%)		Autumn (%)	
Reservoirs	*Pantocsekiella ocellata*	17	*Pantocsekiella iranica*	14
	Ulnaria delicatissima	17	*Encyonema lacustre*	9
	Cymbella cymbiformis	13	*Nitzschia palea*	6
	Aulacoseira ambigua	10	*Amphora pediculus*	5
	Encyonema ventricosum	5		
Lakes	*Encyonema caespitosum*	35	*Achnanthidium minutissimum* var. *jackii*	20
	Fragilaria vaucheriae	19	*Encyonopsis subminuta*	17
	Navicymbula pusilla	19	*Gomphonema calcareum*	11
	Navicula capitatoradiata	9	*Nitzschia fonticola*	7
			Mastogloia smithii	6
			Berkeleya sp.	8
Streams	*Tabularia fasciculata*	15	*Nitzschia palea* var. *debilis*	38
	Cyclotella meneghiniana	13	*Navicula antonii*	38
	Amphora pediculus	11		
	Nitzschia frustulum	11		
	Nitzschia dissipata	7		
	Nitzschia palea	7		

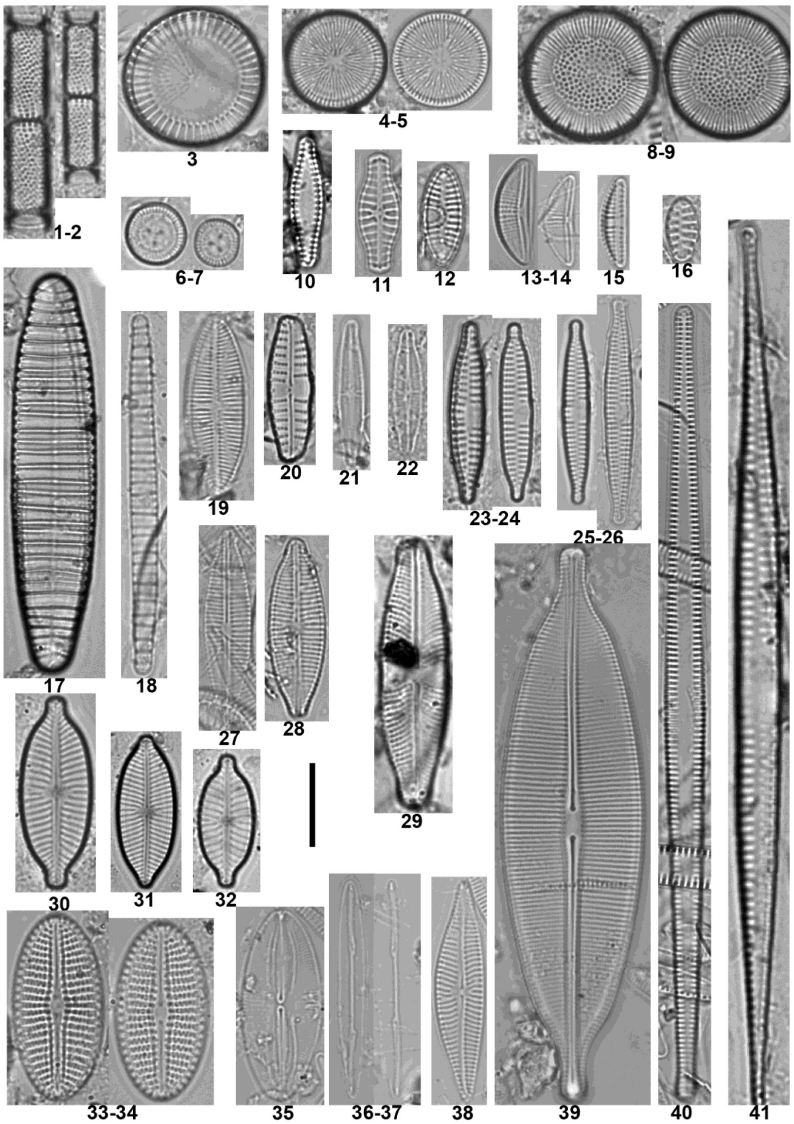

Figure 2. Common Diatoms of Burdur River Basin **1-2.** *Aulacoseira ambigua*; **3.** *Cyclotella meneghiniana*; **4-5.** *Pantocsekiella iranica*; **6-7**. *P. oceallata*; **8-9.** *Lindavia balatonis*; **10**. *Pseudostaurosira brevistriata*; **11.** *Hippodonta capitata*; **12.** *Planothidium frequentissimum*; **13-14.** *Halamphora veneta*; **15.** *Amphora pediculus*; **16.** *Staurosirella pinnata*; **17.** *Diatoma vulgaris*; **18.** *D. moniliformis*; **19.** *Lemnicola hungarica*; **20.** *Reimeria sinuata*; **21.** *Achnanthidium minutissimum*; **22.** *A. minutissimum* var. *jackii*; **23-24.** *Fragilaria vaucheriae*; **25-26.** *F. radians*; **27.** *Craticula buderi*; **28.** *C. accomoda*; **29.** *Stauroneis acidoclinata*; **30.** *Placoneis clementoides*; **31.** *Paraplaconeis minor*; **32.** *Placoneis anglophila*; **33-34.** *Diploneis parma*; **35.** *Fallacia pygamea*; **36-37.** *Berkeleya* sp.; **38.** *Navicymbula pusilla*; **39.** *Craticula ambigua*; **40.** *Tabularia fasciculata*; **41.** *Ulnaria acus*. Scale bar: 10 µm.

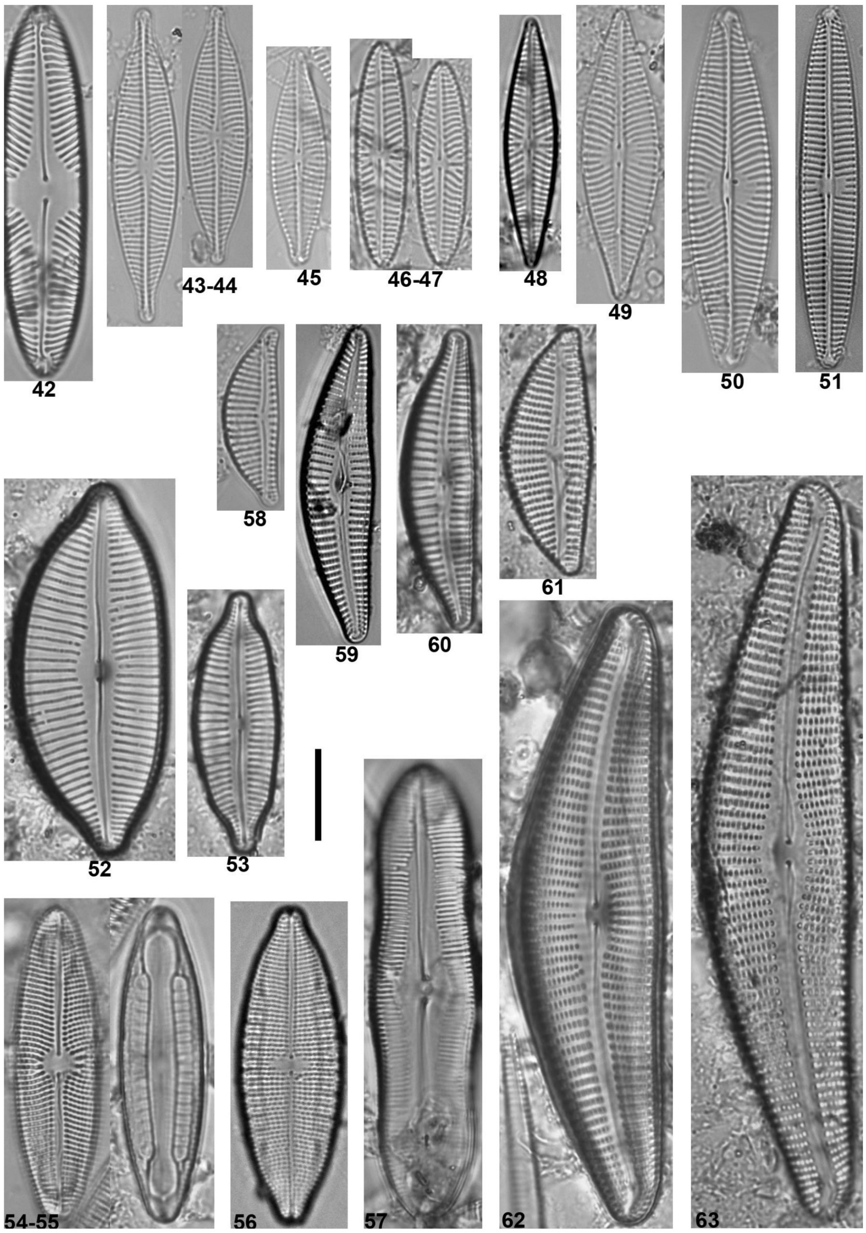

Figure 3. **42.** *Pinnularia brebissonii*; **43-44**. *Navicula capitatoradiata*; **45.** *N. veneta*; **46-47.** *N. cincta*; **48.** *N. cryptotenella*; **49.** *N. trivialis*; **50.** *N. exilis*; **51.** *N. tripunctata*; **52.** *Cymbopleura amphicephala*; **53.** *C. lata*; **54-55.** *Mastogloia elliptica*; **56.** *M. smithii*; **57.** *Pinnularia silicula*; **58.** *Encyonema ventricosum*; **59.** *E. vulgare*; **60.** *Cymbella affinis*; **61.** *Encyonema caespitosum*; **62.** *Cymbella lange-bertalotii*; **63.** *C. cymbiformis*. Scale bar: 10 µm.

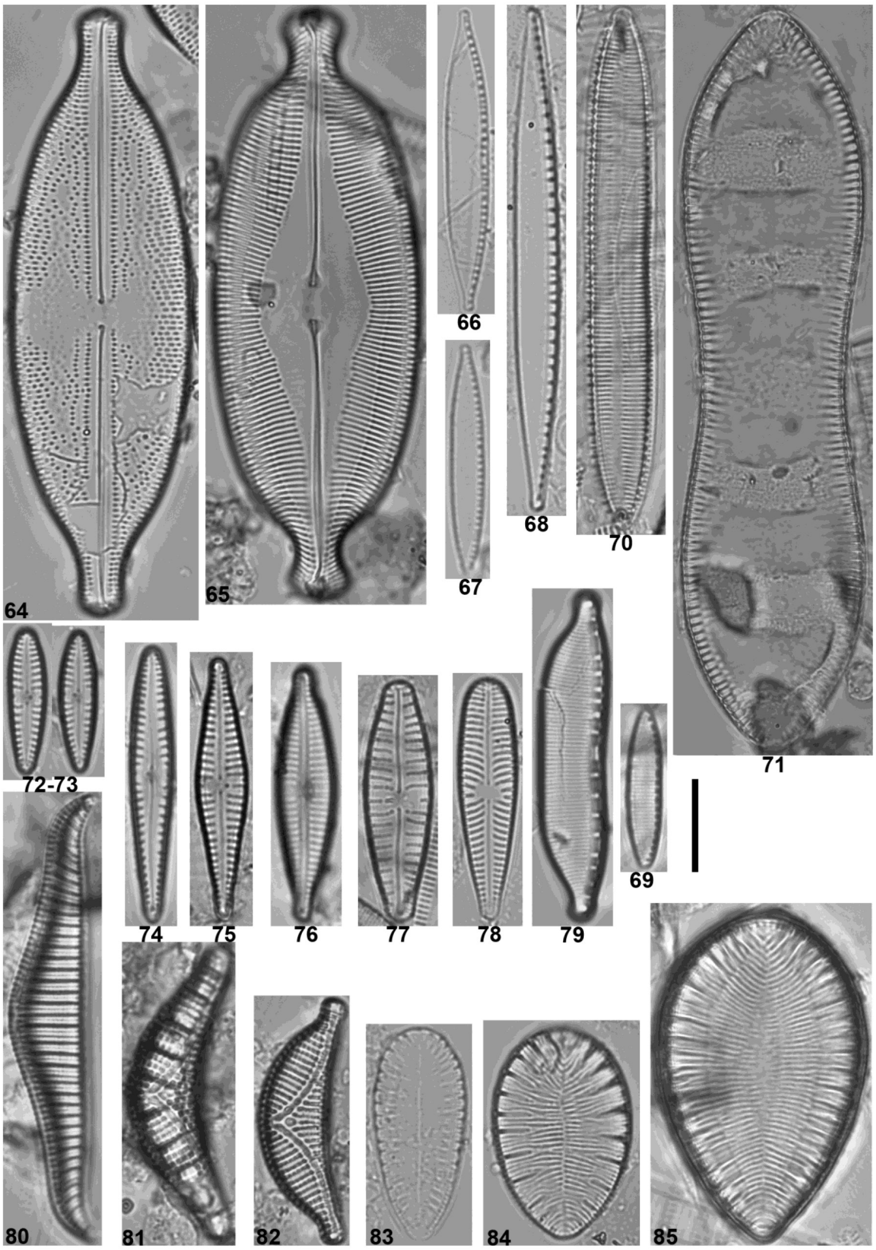

Figure. 4. **64.** *Anomoeoneis sphaerophora*; **65.** *Caloneis amphisbaeana*; **66.** *Nitzschia palea*; **67.** *N. palea* var. *debilis*; **68.** *N. recta*; **69.** *N. bulnheimiana*; **70.** *Tryblionella hungarica*; **71.** *Surirella librile*; **72-73**. *Gomphonema pumilum* var. *rigidum*; **74.** *G. pumilum*; **75.** *G. auritum*; **76.** *G. exilissimum*; **77.** *G. drutelingense*; **78.** *G. olivaceum*. **79.** *Hantzschia amphioxys*; **80.** *Epithemia gibba*; **81.** *E. smithii*; **82.** *E. sorex*; **83.** *Surirella minuta*; **84.** *S. brebissonii*; **85.** *S. ovalis*. Scale bar: 10 µm.

Discussion and Conclusion

Burdur River Basin is one of the two smallest basins out of 25 in Turkey. In this research, diatom composition and its distribution through the streams, lakes and reservoirs of the basin were studied for the first time in detail, and the diversity was found relatively higher in comparison with different river basins. Solak et al. (2018) found 94 taxa from Küçük Menderes River Basin, Çelekli et al. (2018) reported 80 taxa from the North Aegean catchment while 148 taxa reported from western Black Sea River catchment (Özer et al., 2018) and Demir et al. (2017) observed 64 diatom taxa from Akarçay River Basin. Similarly, 65 diatom taxa were found in Aras River catchment (Çelekli et al., 2019). The highest number of taxa observed in Burdur area could be the result of the variation of physico-chemical and geological characteristics of the aquatic ecosystems in the basin. The lower diversity was also detected in several diatom composition studies conducted in some lakes and rivers, Çiçek & Yamuç (2017) found out 42 diatom taxa in Eğirdir Lake, Isparta Province and Karacaoğlu & Dalkıran, (2017) detected 134 taxa in Nilüfer Stream and Şanal & Demir (2018) studied epiphytic samples of Lake Mogan and 58 diatoms species were observed. Since the samples were taken seasonally or even monthly in these studies, a more diverse diatom community was typically expected in comparison to the present study. However, focusing on one type of ecosystem (lake or river) and relatively similar characteristics of sampling points compared to whole basin studies could be the reason for detecting lower diversity of diatoms.

Diatom diversity of Burdur River Basin varied among streams (160 taxa), lakes (61 taxa) and reservoirs (131 taxa). Besides, the diatom community structure also differed among the habitats (Table 4). *Pantocsekiella ocellata, P. iranica* and *Ulnaria delicatissima* were dominant species in the reservoirs, but did not observe as dominant species in other habitats.

The seasonal changes of dominant taxa were also remarkable in the same habitat. The most distinct variation was in streams. Dominant taxa number was six in spring and declined to two species in autumn when *Navicula antonii* (37.7 %) and *Nitzschia palea* var. *debilis* (37.8 %) were dominant and constituted 74.4% of total abundance.

Navicula Bory and *Nitzschia* Hassall are generally the most diverse and widespread genera in freshwater diatoms (Karacaoğlu & Dalkıran, 2017; Kociolek et al. 2019). In Burdur River Basin, the results are consisted with this general trend and *Navicula* and *Nitzschia* species diversity were high; however, their relative abundances were low. Aside from the dominant taxa, *Navicula antonii* and *Nitzschia palea* var. *debilis*, only *Navicula capitatoradiata*, *Nitzschia dissipata*, *N. frustulum* and *N. palea* were represented over 5%.

Diatoms are essential tools for bio-assessment of aquatic ecosystems and the identification of the taxa together with its ecological requirements would contribute further to the detection of water quality. Burdur River Basin is a closed basin, which has no connection to the sea and salinity gradient of the habitats were very broad. Therefore, the species composition found in the basin comprised the species with different tolerances to the salinity. Some species prefer waters with high salinity, while others may have a wide salinity tolerance (Schröder et al., 2015). In the present study, we detected *Navicula antonii* and *Nitzschia frustulum* in all habitats with different salinity. Although *N. antonii* and *N. frustulum* species are generally defined as freshwater species, they have also been identified in Ebro Estuary which is a salt wedge estuary in the Mediterranean (Rovira et al., 2009; Costa-Böddeker et al., 2017). Our results confirmed their euryhaline characteristics based on their presence in the basin from fresh to saline habitats.

Two unique habitats related to salinity in the basin are Burdur and Acıgöl Lakes. Our observations indicated that some taxa which are present in brackish and marine waters found in these sampling areas. Specifically, the brackish species, *Halamphora coffeiformis* and *Navicula cincta* were dominant in Acıgöl Lake and their relative abundance was 69% for *N. cincta* in spring and 40% for *H. coffeiformis* in autumn. Similarly, species such as *Berkeleya* sp., *H. coffeiformis, Navicula simulata, Tryblionella apiculata*, which are known to be found in both marine and brackish waters, also showed significant presence in Burdur Lake. Some taxa like *Tabularia fasciculata* which is common in the marine coastal areas (Baytut and Gönülol, 2016) were observed in the river basin with an accomplice of a high number of taxonomically complex taxa (*Navicula*, *Nitzschia*, *Tryblionella*, *Surirella*). Species like *Halamphora coffeiformis*, *Navicula capitatoradiata*, *N. cincta*, *N. erifuga*, *N. hanseatica*, *Nitzschia tubicola*, *Tryblionella apiculata*, *T. hungarica* were assigned to marine or brackish water ecosystems and also in freshwaters with high electrolyte content (Guiry & Guiry, 2019). Furthermore, Akbulut (2010) reported *N. cincta* and *T. apiculata* in the Tuz Lake basin which is under the brackish, saline category. Species with high tolerance to salinity living in brackish waters or freshwaters with high conductivity could be found in different habitats, like some freshwater taxa observed in the marine coasts. Another taxon which generally referred to as marine species is *Berkeleya* sp. (Figure 2). This species resembles *Berkeleya fennica*, a brackish species previously reported from the Baltic Sea (Witkowski et al. 2000) and occurred mainly in brackish and a few freshwater habitats of Burdur river basin. Nevertheless, ultrastructure details are needed for the identification of the taxa.

In this research, a total of 223 taxa were found with a 11 new records for Turkey. These taxa were *Craticula buderi*, *Cymbella lange-bertalotii*, *Encyonema vulgare*, *Gomphonema auritum*, *G. drutelingense*, *G. exilissimum*, *Nitzschia bulnheimiana*, *Paraplaconeis minor*, *Placoneis anglophila*, *Placoneis clementoides* and *Stauroneis acidoclinata*. The results would contribute to the knowledge of diatom distribution in Turkey and Burdur River Basin, in particular. To determine the ecological quality of the river basins, taxonomical results would be a supplement for the physicochemical parameters for further studies. The results extend the biogeography of diatoms in Turkey and contribute to the knowledge of the diatom composition and distribution in the river basin.

Acknowledgements

This study was supported by the Ministry of Agriculture and Forestry, General Directorate of Water Management.

References

Akbulut, A. (2010). The diatom composition of the Salt Lake Basin and its relationship with salinity. *Ekoloji*, *159*, 150–159. doi: 10.5053/ekoloji.2010.7418

Atıcı, T. (1997). Sakarya River pollution and algae. *Ekoloji ve Çevre Dergisi*, *6(24)*, 28–32 (in Turkish).

Ács, É., Szabó, K., Tóth, B. & Kiss, K.T. (2004). Investigation of benthic algal communities, especially diatoms of some Hungarian streams in connection with reference conditions of the Water Framework Directives. *Acta Botanica Hungarica*, *46*, 225–278.

Barlas, M., Mumcu, M.F., Solak C.N. & Çoban, O. (2002). Akçapınar Deresi ve Kadın Azmağı Deresi (Muğla) epilitik alg florasının su kalitesine bağlı olarak incelenmesi. VI. Ulusal Biyoloji Kongresi. 4–7 Eylül 2002, Malatya, pp. 65–68 (in Turkish).

Baytut, Ö., & Gönülol, A. (2016). Phytoplankton distribution and variation along a freshwater-marine transition zone (Kızılırmak River) in the Black Sea. *Oceanological and Hydrobiological Studies*, *45*(4), 453–465.

Costa-Böddeker, S., Schwarz, A., Huy, H. Đ., & Schwalb, A. (2017). Diatom assemblages in surface sediments along nutrient and salinity gradients of Thi Vai estuary and Can Gio mangrove forest, Southern Vietnam. *Estuaries and coasts*, *40*(2), 479-492.

Çelekli, A., Toudjani, A.A., Lekesiz, H. & Çetin, T. (2018). Ecological quality assessment of running waters in the North Aegean Catchment with diatom metrics and multivariate approach. *Limnologica*, *73*, 20–27. https://doi.org/10.1016/j.limno.2018.09.001

Çelekli, A., Kayhan, S., Lekesiz, Ö., Toudjani, A.A. & Çetin, T. (2019). Limno-ecological assessment of Aras River surface waters in Turkey: application of diatom indices. *Enviromental Science and Pollution Research*, *26* (8), 8028–8038. https://doi.org/10.1007/s11356-019-04295-y

Çiçek, N. L., & Yamuç, F. (2017). Using epilithic algae assemblages to assess water quality in Lake Kovada and Kovada Channel (Turkey), and in relation to environmental factors. *Turkish Journal of Fisheries and Aquatic Sciences*, *17*(4), 701-711.

Dalkıran, N., Zünbülgil, B., Karacaoğlu, D., & Şükran, Dere (2016). Uluabat Gölü Epifitik Diyatomelerinin Uzun Dönemdeki Değişimi. *Journal of Limnology and Freshwater Fisheries Research*, *2*(3), 153-163 (in Turkish).

Demir, N., Çetin, T., Gök, C., & Şanal, M. (2017). First biological monitoring in the Akarçay Basin according to the water framework directive: Phytoplankton and phytobenthos. *Turkish Journal of Water Science & Management*, *1*(1), 90–105.

Guiry, M. D., & Guiry, G. M. (2019). *AlgaeBase*. World-wide electronic publication, National University of Ireland, Galway. Accessed at http://www.algaebase.org

Hofmann G., Werum, M., & Lange-Bertalot, H. (2011). Diatomeen im Süßwasser – Benthos von Mitteleuropa. Bestimmungsflora Kieselalgen für die ökologische Praxis. Über 700 der häufigsten Arten und ihre Ökologie. A.R.G. Gantner Verlag, Rugell. pp.908.

Karacaoğlu, D., & Dalkıran, N. (2017). Epilithic diatom assemblages and their relationships with environmental Epilithic diatom assemblages and their relationships with environmental variables in the Nilüfer Stream Basin, Bursa, Turkey. *Environmental Monitoring Assessment*, *189*, 1–22.

Kociolek, J.P., Balasubramanian, K., Blanco, S., Coste, M., Ector, L., Liu, Y., … Witkowski, J. (2019). *DiatomBase*. Retrieved August 31, 2017, from http://www.diatombase.org

Krammer, K. & Lange-Bertalot, H. (1986). Bacillariophyceae. 1. Teil: Naviculaceae. Ettl, H., Gerloff, J., Heynig, H. and Mollenhauer, D (Ed.). *Süsswasser flora von Mitteleuropa, Band 2/1.* Stuttgart: Gustav Fischer Verlag.

Krammer, K., & Lange-Bertalot, H. (1988). Bacillariophyceae. 2. Teil: Bacillariaceae, Epithemiaceae, Surirellaceae. Ettl, H., Gerloff, J., Heynig, H. and Mollenhauer, D. (Ed.). *Süsswasserflora von Mitteleuropa, Band 2/2.* Stuttgart: Gustav Fischer Verlag.

Krammer, K., & Lange-Bertalot, H. (1991a). Bacillariophyceae. 3. Teil: Centrales, Fragilariaceae, Eunotiaceae. Ettl, H., Gerloff, J., Heynig, H. and Mollenhauer, D. (Ed.). *Süsswasserflora von Mitteleuropa, Band 2/3*. Stuttgart: Gustav Fischer Verlag.

Krammer, K., & Lange-Bertalot, H. (1991b). Bacillariophyceae. 4. Teil: Achnanthaceae, Kritische Ergänzungen zu *Navicula* (Lineolatae) und Gomphonema, Gesamtliteraturverze ichnis Teil 1-4. Ettl, H., Gärtner, G., Gerloff, J., Heynig, H. And Mollenhauer, D. (Ed.). S*üsswasserflora von Mitteleuropa, Band 2/4*. Stuttgart: Gustav Fischer Verlag.

Kulikovskiy, M., Glushchenko, A.M., Kuznetsova, I.V., & Genkal, S.I. (2016). *Identification book of diatoms from Russia*. pp. 1-804, 165 pls. Yaroslavl: Filigran. [in Russian].

Özer, T., Erkaya, I.A., Solak, C.N., & Udoh, A.U. (2018). Diversity and ecology of algae from Melen River (Western Black Sea River Catchment) in Turkey. *Turkish Journal of Fisheries and Aquatic Sciences*. *18*, 1187–1194.

Rimet, F. (2012). Recent views on river pollution and diatoms. *Hydrobiologia*, *638*, 1–24.

Rovira, L., Trobajo, R., & Ibanez, C. (2009). Periphytic diatom community in a Mediterranean salt wedge estuary: the Ebro Estuary (NE Iberian Peninsula). *Acta Botanica Croatica*, *68*(2), 285-300.

Schröder, M., Sondermann, M., Sures, B., & Hering, D. (2015). Effects of salinity gradients on benthic invertebrate and diatom communities in a German lowland river. *Ecological indicators*, *57*, 236-248.

Solak, C.N., Çetin, T., Kaleli, A. (2018). Distribution of benthic diatom (phytobenthos) composition in Küçük Menderes River Basin. *Turkish Journal of Water Science & Management*, *2*, 2–35.

Solak, C.N., Çetin, T., Karaaslan, Y., Kaleli, A., Yılmaz, E., Duran, M., Kıvanç, G., Kirmençe, T., Koyunluoğlu, Ş.A., Çankaya, F., Yılmaz, D. (2019). Common Diatoms of Phytobenthos in Gediz River Basin. *Turkish Journal of Water Science &Management, 3*(2), 58-70.

Şanal, M., & Demir, N. (2018). Use of the epiphytic diatoms to estimate the ecological status of Lake Mogan. *Applied Ecology and Environmental Research*. *16*(3), 3529–3543.

Turkish Official Gazette. (2019). *Biyolojik İzleme Tebliği* (Publication No: 30808) Retrieved from https://www.resmigazete.gov.tr/eskiler/2019/06/20190621.pdf

Water Framework Directive. (2000). *Common implementation strategy for the water framework directive* (2000/60/EC).

Witkowski, A., Lange-Bertalot, H., & Metzeltin, D. (2000) *Diatom Flora of Marine Coasts I*. In: Iconographia Diatomologica 7. Konigstein: Koeltz Scientific Books.

Extendend Turkish Abstract
(Genişletilmiş Türkçe Özet)

Burdur Nehir Havzasındaki Farklı Habitatlarda Bentik Diyatome Kompozisyonu ve Dağılımı

Diyatomeler, sucul sistemlerdeki biyolojik izleme çalışmalarında önemli bir bileşendir. Avrupa Birliği Su Çerçeve Direktifi'nin (2000/60/AT) (SÇD) yürürlüğe girmesini izleyen yıllarda, uyum süreçleri kapsamında Türkiye'de de havza bazında izleme çalışmaları başlamıştır. Bu çerçevede, Türkiye'deki 25 havza içerisinde en küçük alana sahip iki havzadan biri olan Burdur Havzası'nın bentik diyatome kompozisyonu ilk defa bu çalışma ile detaylı olarak incelenmiştir.

Fitobentoz (diyatome) örneklemesi Nisan ve Ekim 2018'de iki dönemde gerçekleştirilmiş, fizikokimyasal parametreler ise Ocak-Aralık 2018 döneminde aylık olarak izlenmiştir. Havzada örnekleme noktası olarak belirlenen toplam 30 istasyonun 7'sinin her iki örnekleme döneminde kuru olduğunun tespit edilmesi nedeniyle 13'ü akarsu, 4'ü doğal göl ve 6'sı rezervuar olmak üzere toplamda 23 istasyonda örnekleme çalışması gerçekleştirilmiştir. 21.06.2019 tarihli Resmi Gazete'de yayınlanan Biyolojik İzleme Tebliği uyarınca fitobentoz örneklemesinde ağırlıklı olarak nehirlerde epilitik alg örneklemesi, göl ve rezervuarlarda ise epifitik alg örneklemesi yapılması gerekmektedir. Ancak, özellikle su seviyesindeki değişimler ve suyun fizikokimyasal özelliklerine bağlı olarak makrofit tespit edilemeyen göl ve rezervuarlarda ikinci sırada önerilen epilitik algler örneklenmiştir. Alınan örnekler %10 HC1 ile muamele edilmiş sonrasında H_2O_2 ile yakılarak organik maddelerin uzaklaştırılması sağlanmıştır. Diyatome örnekleri Naphrax® kullanılarak sabit preparatlar haline getirilmiştir. Sayım ve teşhisler için Zeiss Axio Observer Z1 (Carl Zeiss mikroskobu Gmbh, Jena, Almanya) mikroskobu kullanılmıştır. Fitobentoz türlerinin teşhisinde Krammer ve Lange-Bertalot (1986; 1988; 1991 a, b), Hofmann ve ark., (2011), Kulikovskiy ve ark., (2016), Guiry ve Guiry (2019) ve Kociolek ve ark., (2019) kaynaklarından yararlanılmıştır. Her bir örnekten en az 300 diyatome frustülü sayılarak, türlerin nispi bolluğu, sayılan toplam frustüllerin yüzdesi olarak ifade edilmiştir (% cinsinden nispi bolluk).

Fizikokimyasal ölçümler, havzada yer alan göl, rezervuar ve nehirlerin genel olarak alkali yapıda olduğunu ortaya koymuştur. Ortalama elektriksel iletkenlik (Eİ) genel olarak rezervuar (0,5 mS cm^{-1}) ve nehirlerde (1,7 mS cm^{-1}) düşük tespit edilirken göllerde (22.3 mS cm^{-1}) nispeten daha yüksek ölçülmüştür. Özellikle doğal göller içerisinde yer alan Acıgöl (57.2 mS cm^{-1}) ve Burdur (29.4 mS cm^{-1}) göllerinin Eİ değerlerinin yıl boyunca diğer örnekleme noktalarına göre oldukça yüksek olduğu görülmüştür. Yıl boyunca tüm istasyonlarda çözünmüş oksijen (ÇO) değerlerinde önemli değişiklikler gözlemlenmiştir. Burdur ve Acıgöl'de zaman zaman çok düşük ÇO değerleri gözlense de (sırasıyla, 2,7 mg L^{-1}; 1mg L^{-1}) ortalama değerler Burdur Gölü için 6,05 mg L^{-1}, Acıgöl için ise 7,75 mg L^{-1} olarak tespit edilmiştir. Havzada çalışılan 13 akarsu, 4 göl ve 6 baraj gölünde toplam 223 takson gözlenmiştir. İlkbaharda 136 tür tespit edilirken, sonbaharda tür çeşitliliği 174 tür olarak tespit edilmiştir. Cins seviyesinde en çok tür çeşitliliği 27 adet tür ile *Navicula* ve *Nitzschia* cinslerinde olup bunu 22 adet tür ile *Gomphonema* cinsi izlemiştir. *Navicula antonii* ve *Nitzschia palea* var. *debilis* türleri 17,1 % ve 15,5 % ile en yaygın türler olarak tespit edilmiştir. *Craticula buderi, Cymbella lange-bertalotti, Encyonema vulgare, Gomphoenma auritum, G. drutelingense, G. exilissimum, Nitzschia bulnheimiana, Paraplaconeis minor, Placoneis anglophila, Placoneis clementoides ve Stauroneis acidoclinata* olmak üzere toplamda 11 tür Türkiye sularında ilk kez gözlenmiştir. Rezervuar, göl ve akarsularda tespit edilen tür sayıları farklılık göstermiş ve en yüksek tür çeşitliliğine akarsularda rastlanılmıştır. Çeşitliliğin akarsularda 160 tür ve rezervuarlarda 131 tür arasında değiştiği görülmüş,

bununla birlikte, göllerde biyolojik çeşitlilik daha düşük bulunmuştur (61 tür). Rezervuar, göl ve akarsu istasyonlarında tespit edilen türlerin kendi içlerinde nispi bollukları hesaplanmış ve toplam nispi bolluğun %5 ve üzerini oluşturan türler ayrıca değerlendirilmiştir. Buna göre, rezervuar örneklerinde *Pantocsekiella iranica* (%14) ve *P. ocellata* (%17) ve *Ulnaria delicatissima* (%17) en bol bulunan türler olurken, göl örneklerinde bu türlerin yerini *Achnanthidium minutissimum var. jackii* (sonbaharda %20) ve *Encyonema caespitosum* (ilkbaharda %35) almıştır. Akarsu örneklerinde ise ilkbaharda *Tabularia fasciculata* (%15) en bol bulunan tür olurken sonbaharda *Nitzschia palea var. debilis* (%38) ve *Navicula antonii* (%38) dışında toplam nispi bolluğun %5'inin üzerine çıkan türün olmadığı görülmüştür. *Navicula* ve *Nitzschia* cinslerine ait türler tatlı su habitatlarında yüksek çeşitliliğe sahip ve yaygın olarak bulunan cinslerdir. Burdur Nehir Havza'sında da bu cinslere ait tür çeşitliliği yüksek bulunsa da, *N antonii* ve *N. palea* var. *debilis* türleri dışında toplam nispi bollukları düşük bulunmuştur.

Burdur Nehir Havzası, denizle bağlantısı olmayan kapalı bir havzadır ve Burdur ve Acıgöl gibi yüksek tuzluluk karakterindeki göllere sahiptir. Bu çalışma sonucunda, havzada acısu ve deniz kıyı bölgelerinde yayılış gösterdiği bilinen bazı türler tespit edilmiştir. Özellikle Acıgöl'de acısularda bulundukları bilinen *Halamphora coffeiformis* ve *Navicula cincta* türleri oldukça yüksek sayılara ulaşmıştır. Benzer şekilde, hem deniz hem de acı sularda bulunduğu bilinen *Berkeleya* sp*., Halamphora coffeiformis, Navicula simulata, Tryblionella apiculata* gibi türlerin Burdur Gölü'nde önemli miktarda varlık gösterdiği tespit edilmiştir. Havzada tespit edilen, *Navicula capitatoradiata, N. erifuga, N. hanseatica, Nitzschia tubicola, Tryblionella apiculata, Tabularia fasciculata* gibi türlerin ekolojik tercihleri açısından deniz ve acısularda bulunduklarına dair kayıtlar mevcuttur (Guiry & Guiry, 2019). *Navicula antonii* türü ise havzada farklı tuzluluk seviyelerine sahip tüm alanlarda bulunmuştur. Bu durum türün örihalin bir tür olduğunu göstermektedir.

Burdur Nehir Havzası'nda yapılan bu çalışma bölgedeki ilk detaylı çalışmadır ve Türkiye diyatome florasına 11 yeni kayıt türün ilave edilmesini sağlamıştır. Burdur Havzası'nda gözlenenen yüksek biyoçeşitlilik havza içi sucul ekosistemlerin çeşitliliğinin bir sonucudur. Ayrıca, bu çalışmada kapalı bir havza olan Burdur Havzası'nın diğer havzalardan daha farklı diyatome kompozisyonuna sahip olduğu gözlenmiştir. Elde edilen veriler, Burdur Havzası benzeri özel alanlarda yapılacak izleme çalışmalarında önemli olacaktır.