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Use of Cluster Analyze and Smilarity of Algae in Eastern Black Sea Region Glacier Lakes (Turkey), Key Area: Artabel Lakes Natural Park

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Abstract

In this study which is the first attempt to systematically identify algae of eighteen freshwater high mountain glacier lakes ecosystems were investigated. Samples were gathered from the lakes between August 2011 and October 2012. Secondly, some parameters of physical and chemical water quality (such as temperature, dissolved oxygen, pH, and electricity conductivity) were measured with the field and laboratory studies, so as to determine the water qualities of lakes. In particular, pH has not exceeded 7.06 in all lakes throughout the year. Physical, chemical and biological data were examined with cluster analysis, in order to categorize different characteristics of the lakes. According to data, 58 Bacillariophyta, 17 Chlorophyta, 15 Cyanobacteria, 2 Euglenophyta, 2 Pyrrophyta, and 2 Cryptophyta species were classified in total with the planktonic and benthic samples from the investigation of eighteen freshwater lakes.

1. INTRODUCTION

Glacial lakes as an environmental resource, which are used for the potential benefit of mankind, cannot be basically overemphasized, since a minimum amount of water is required on a daily basis for survival. Therefore, accessibility of water resource is essential for life.

For this purpose, trophic state of lakes is systematically evaluated by monthly sampling of a variety of physical and chemical indicators. If changes in abundance of diversity and population of species result from either direct or indirect environmental stressors, then changes in biota may be used to explain changes in the environment [1]. In this regard, indicator species are the ones that ensure some indication of the prevailing environmental conditions by their presence or abundance. Lentic ecosystems were investigated extensively for plankton from mid-20th century. These findings reveal that the dominant species, and their seasonality are highly variable in different waterbodies, based on their age, morphometry, nutrient status, and other locational factors.

The occurrence of algae under natural conditions is directly related to tolerance range (ecological optimum) which is dependent both on abiotic environmental factors (temperature, oxygen concentration, pH), and on the biotic interactions among organisms. In the multidimensional space (ecological niche), numerous anthropogenic and non-anthropogenic environmental factors affect the occurrence of organisms. Among ecosystems, altitude lakes are both emblematic of national mountains and reservoirs of biodiversity [2].

However, the lakes that these organisms exist were influenced by many factors, one of which is lake morphology. Different lake morphologies not only influence physical qualities such as temperature gradients, turbulence circulation, and stratification but also causes different levels of productivity which suggests that the lake formation process may have important effect on its biology. Apart from temperature, another factor affecting the lakes is light, which is also based on the seasons. Energy input of ponds and lakes is substantially provided by solar energy [3].

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Oxygen inside these lakes was also an important factor on the conditions of the organisms. The dissolved oxygen (DO) levels in aquatic systems probably reveal more about their metabolism than any other single balance between oxygen supply from the atmosphere and photosynthesis on one hand, and metabolic processes that consume oxygen on the other. The solubility of DO in fresh water is primarily determined by water temperature [4].

As a matter of the fact, limnological analysis can be reached by an extermination of differences in physical and biotic conditions of different lake, reservoir and river ecosystems [5]. On the other hand, among the array of dynamic environmental factors that affect metabolism, growth and reproductive capacities of organisms, functional commonality is found amidst process rates and controls of metabolism, energy fluxes and material cycling.

The habitats where algae exist also have differences. They can hold on to life on the plants and rocks as those existing in benthic habitat. Those moving freely are called phytoplankton. Algae can exist both in snowy and wholly frosted fields ecologically. However, the actual spread area 70% of algae distribute is the water. They are the major primary producers of organic carbon component in these environments. As indicated above, they can exist at high temperature to °C 70 water sources as they can exist in the frosted habitats. Some of them can develop at very salty environments. They can exist below 100 meters from surface in lakes and seas under lower light density and high pressure.

1.1. Study Area

The aims of this study are the identification of algae, the seasonable existence of the species, their intensity and identification of indicator species, interpreting the features of water springs by relating the species with each other at glacial lakes at the natural park in August 2011-September 2012. The sampling was conducted by identifying some physical features of the water in this study (Figure 1). The coordination and height related to the samples taken were provided in the table 1 below:

Biodiversity and distribution of algae of high mountain lakes in the Artabel Lakes Natural Park can be counted as Artabel Lakes (5 piece), Beş Lakes (5 piece), Kara Lakes (4 piece), Yıldız Lakes (2 piece) and Acembol Lakes (2 piece) (Figure 2 a-b).

These glacial lakes are covered with snow at least 7 or 8 months of the year. Air temperature is usually 12-18 degrees in summer and lower in winter. There is no access to the working area and it is necessary to walk for a long time.

2. MATERIALS AND METHODS

2.1. Biological Study

Two kinds of sample (Benthic and planktonic) were collected and they were fixed at 4% of formaldehyde, which provides the laboratory a microscopic determination. Benthic samples taken with glass pipe from the depth (1-1,5m) and surface of underwater stones. Surface water was taken from sampling points of each lake. Analysis of the composite lake water samples were conducted in the field and/or in the laboratory with standard methods. Several components of study such as temperature, dissolved oxygen, pH, and electrical conductance were measured with the YSI water analysis kit [6]. The identified literature below was used in the identification in relation to water species; [4, 7 - 26].

2.2. Statistical Study

In order to categorize the stations according to physical and chemical status of algae, Cluster Analysis (CA) was applied to the findings, by using the "Past" package program.

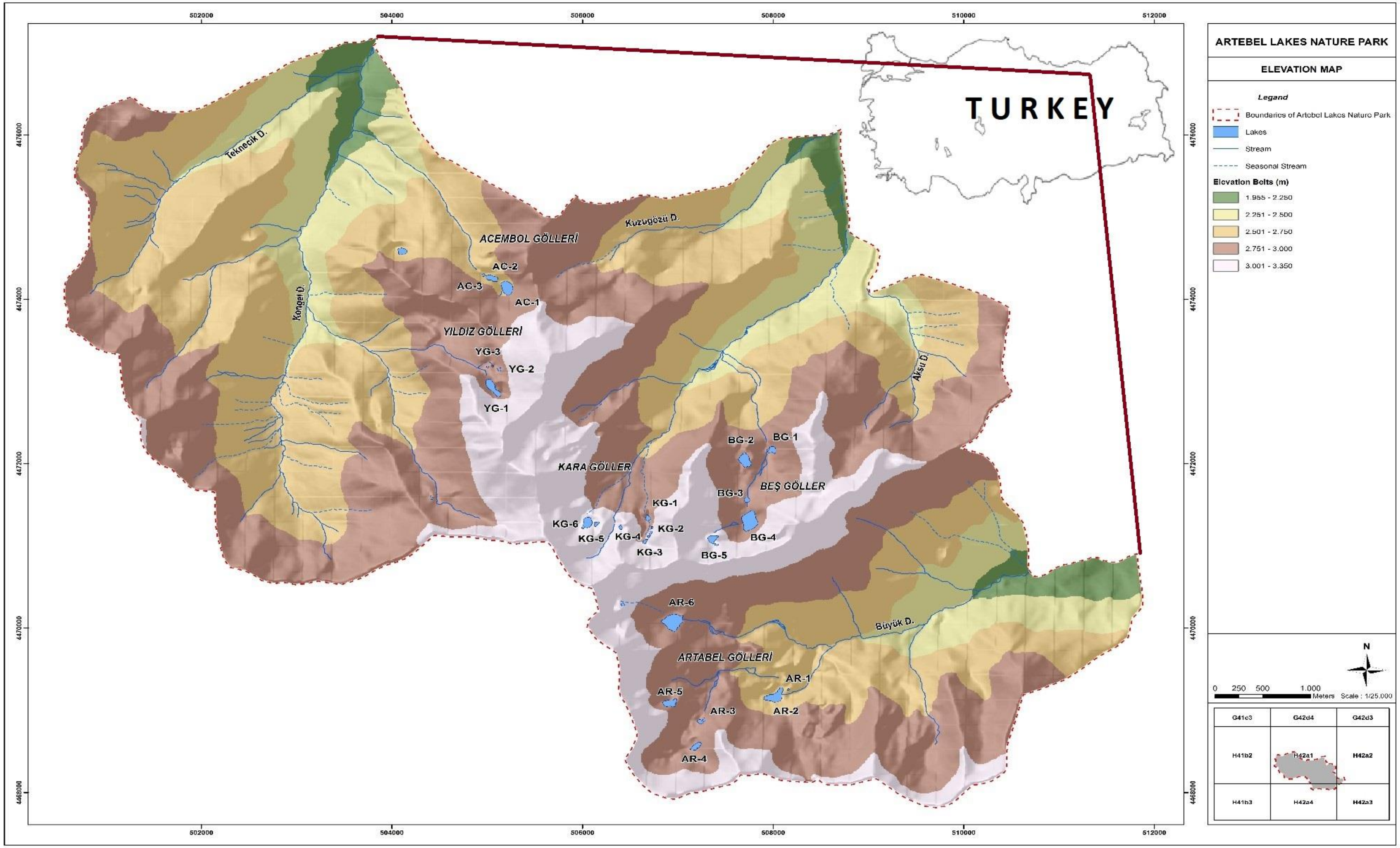

Figure 1. *Artabel Lakes Natural Park boundaries and lakes.*

Table 1. *Artabel Lakes Natural park lakes location and altitude*

Location	**X**	**Y**	**Z**
AR-1	50°81'26" E	44°69'06" N	2697 m
AR-2	50°79'91" E	44°68'97" N	2763 m
AR-3	50°71'64" E	44°68'40" N	2905 m
AR-4	50°72'17" E	44°68'67" N	2892 m
AR-5	50°69'03" E	44°68'90" N	2952 m
BG-1	50°76'64" E	44°71'87" N	2866 m
BG2	50°79'61" E	44°71'96" N	2833 m
BG-3	50°77'30" E	44°71'38" N	2915 m
BG-4	50°73'35" E	44°70'90" N	3021 m
BG-5	50°73'82" E	44°70'87" N	3024 m
KG-1	50°66'59" E	44°71'14" N	2982 m
KG-2	50°66'82" E	44°70'96" N	3012 m
KG-3	50°65'98" E	44°70'85" N	3015 m
KG-4	50°60'37" E	44°71'09" N	3030 m
YG-1	50°50'10" E	44°72'76" N	2986 m
YG-2	50°50'91" E	44°72'95" N	2978 m
AC-1	50°50'26" E	44°74'06" N	2733 m
AC-2	50°51'81" E	44°73'90" N	2741 m

AR: Artabel Lakes
BG: Beş Lakes
KG: Kara Lakes
YG: Yıldız Lakes
AC: Acembol Lakes

2.3. Findings

The aims of this study are to identify functional groups of algae; to identify the most important environmental variables affecting abundance and distribution of algae, which contribute to the understanding of the ecology of algae in high mountain lakes.

Additionally, YSI model water analysis set was utilized for some physical and chemical analyses in the sample field and indicated in table 2. The organisms collected and identified from sample areas were revealed in table 3. Also determine their abundance.

Artabel Lake-1

Artabel Lake-2

Artabel Lake-3

Artabel Lake-4

Artabel Lake-5

Beş Lakes-1

Beş Lakes-2

Beş Lakes-3

Figure 2a. *Artabel Lakes Natural Park (Photo: by Tahir ATICI)*

Beş Lakes-4

Beş Lakes -5

Kara Lakes -1

Kara Lakes -2

Yıldız Lakes -1

Yıldız Lakes -2

Acembol Lakes -1

Acembol Lakes -2

Figure 2b. *Artabel Lakes Natural Park (Photo: by Tahir ATICI*

Table 2. *Annual averages of physicochemical parameters of Artabel Lakes Natural Park*

Parameter	T (°C)	TDS (mg/l)	Salinity (% 0.0)	DO(mg/l)	pH	EC mikroS/cm
AR-1	11,47	0,018	0,01	4,3	6,68	20
AR-2	16,38	0,018	0,01	4,22	6,74	12
AR-3	14,28	0,019	0,01	4,4	6,78	23
AR-4	15,04	0,019	0,01	3,9	6,71	23
AR-5	13,02	0,03	0,02	4,3	6,55	35
BG-1	13,36	0,011	0,01	3,95	6,36	13
BG-2	9,9	0,025	0,02	4,1	7,05	27
BG-3	14,5	0,01	0,01	3,65	6,86	12
BG-4	12,07	0,032	0,02	4,2	7,06	37
BG-5	12	0,034	0,02	4,03	7	39
KG-1	12,5	0,012	0,01	4,46	6,66	15
KG-2	7,9	0,021	0,01	4,0	6,85	19
KG-3	13,36	0,019	0,01	4,4	6,7	13
KG-4	9,9	0,019	0,02	3,9	6,55	27
YG-1	14,5	0,03	0,01	4,3	6,63	12
YG-2	12,07	0,011	0,02	3,9	7	37
AC-1	14,1	0,025	0,01	4,1	6,86	39
AC-2	13,5	0,015	0,02	3,6	7	15

2.4. Statistical Data

In this study, Cluster Analysis (CA) was applied to the limnologic and biological data to categorize freshwater lakes of the Artabel, based on the algae groups including Bacillariophyta, Chlorophyta, Cyanobacteria, Euglenophyceae, Pyrrophyceae and Cryptophyceae statuses of the lakes.

According to the results of Cluster Analysis which was based on population densities, maximum similarity was observed between Beş Lakes-2 and Artabel-1 Lakes while minimum similarity was observed between Kara Lakes-3 and Beş Lakes-4 (Figure 3).

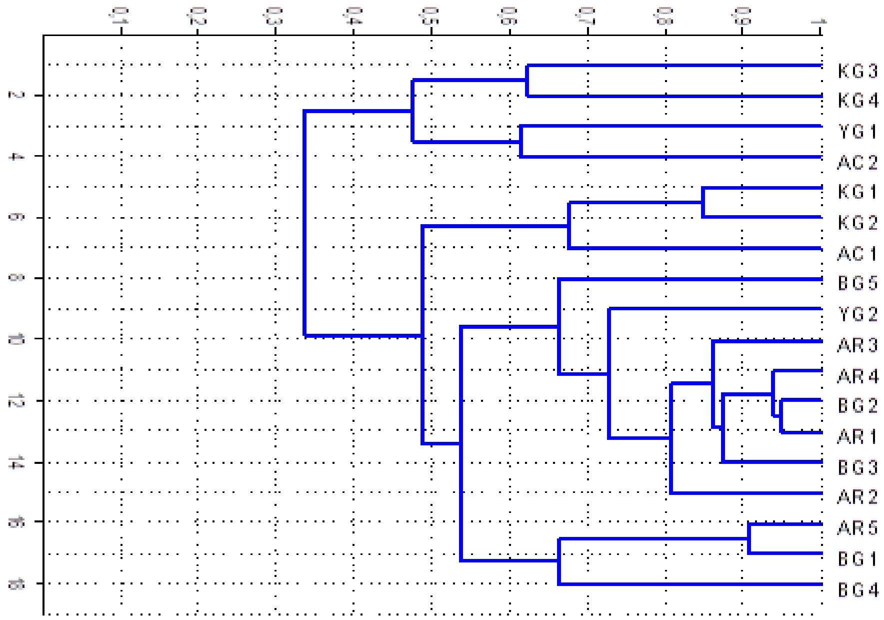

Figure 3. Similarity Dendogram in terms of Cluster Analysis results of Algae species

Table 3. *Artabel Lakes Natural Park Lakes and Abundance in the number of Algae*

Code	Taxon	BE:Benthic P: Planktonic	AR1	AR2	AR3	AR4	AR5	BG1	BG2	BG3	BG4	BG5	KG1	KG2	KG3	KG4	YG1	YG2	AC1	AC2
BACILLARIOPHYCEAE																				
BC1	*Amphora ovalis*	BE, P	D	D	D	D	C		C	D	D		D	D				D		D
BC2	*Anomoeoneis sphaerophora*	BE	D	D	D	D			D	D		D	D	D	D	D	D	D	D	D
BC3	*Achnanthes lanceolata*	BE, P	C	C	C	C	C	C	C	C	C	C	C					C	C	
BC4	*Amphora ovalis*	BE	D	D	D	D	D	D	D	D		D	D	D				D	D	
BC5	*Caloneis silicula*	BE		D	D	D			D	D		D	D	D	D	D	D	D	D	D
BC6	*Campylodiscus hibernicus*	BE	D	D	D	D	D		D	D	D	D	D	D	D	D	D	D	D	D
BC7	*Cocconeis placentula*	BE, P	D	D	D	D	D	D	D	D	D	D					D			
BC8	*Cyclotella ocellata*	BE, P	C	C	C	C	C	C	C	C		C	C	C				C	C	
BC9	*Cymatopleura elliptica*	BE	D		D	D	D	D		D	D	D	D	D	D	D	D	D	D	D
BC10	*Cymatopleura solea*	BE, P	D		D	D			D	D					D		D	D	D	D
BC11	*Cymbella affinis*	BE, P	A	B	D	C	B	D	A	B	D	C					A	B		
BC12	*Cymbella cistula*	BE, P	D		D	D			D	D										
BC13	*Cymbella minuta*	BE, P	D	D		D			D	D							D			D
BC14	*Cymbella lanceolata*	BE, P		C		C			C	C										
BC15	*Cymbella tumida*	BE, P	D		D		D	D		D								D	D	
BC16	*Cymbella amphicephala*	BE, P	D		D	D			D	D										
BC17	*Denticula elegans*	BE, P	D	D	D	D	D		D	D	D	D								
BC18	*Diploneis ovalis*	BE, P	C		C	C			C	C			C	C	C	C	C	C	C	C
BC19	*Diatoma hiemale*	BE		C	C	C			C	C							C			
BC20	*Diatoma vulgaris*	BE, P	D	D	D	D			D	D		D								
BC21	*Didymosphaenia geminata*	BE, P	D	D	D	D	D	D	D	D	D									
BC22	*Epithemia argus*	BE	C	C	C	C	C	C	C		C		C		C		C	C	C	C
BC23	*Epithemia turgida*	BE, P	C	C	C	C	C	C	C		C						C	C		C
BC24	*Fragilaria ulna* var. *ulna*	BE, P	D	D	D	D			D			D						D		
BC25	*Fragilaria contruens*	BE, P	C	C	C	C	C	C	C			C		C		C				C
BC26	*Fragilaria dilatata*	BE, P	C	D	C	C			C	D		C								
BC27	*Fragilaria arcus*	BE, P	C	C	C	C			C	C		C	C	C				C		
BC28	*Gomphoneima angustatum*	BE	C		D	C			C	C		C					C			
BC29	*Gomphonema constrictum*	BE	D	D	D	D	D	D	D	D			D	D				D	D	
BC30	*Gomphonema parvalum*	BE	D	D	D	D	D	D	D	D		D			D		D			
BC31	*Gomphonema olivaceum*	BE, P	D	D	D	D	D	D	D	D	D		D	D				D	D	
BC32	*Gyrosigma acuminatum*	BE, P	C	C	C	D	C	C	C	C			C	C				C	C	

BC33	*Melosira varians*	BE, P	D	D	D	D	D	D	D	D	D	D					D	D		
BC34	*Navicula bacillum*	BE	D		D	D			D	D			D	D				D	D	
BC35	*Navicula pygmea*	BE	C	C	C	C	C	C	C	C	C	C					C	C		
BC36	*Navicula pupula*	BE, P	C		C	C			C	C			C	D				D	D	
BC37	*Navicula reinhardii*	BE, P	C	C		C			C	C							C			C
BC38	*Navicula radiosa*	BE	D	D	D			D		D			D	D				D	D	
BC39	*Navicula cryptocephala*	BE, P		D	D		D	D		D								D	D	
BC40	*Navicula capitatoradiata*	BE, P	D		D	D			D	D			D	D				D	D	
BC41	*Navicula margalithii*	BE, P	D	D	D	D	D		D	D	D	D								
BC42	*Nitzchia amphibia*	BE, P	D	D	D	D			D	D		D	D	D				D		
BC43	*Nitzschia obtusa*	BE, P	D	D	D	D			D	D		D	D	D				D		
BC44	*Nitzschia tryblionella*	BE	D	D	D	D			D	D		D					D			
BC45	*Nitzschia gracilis*	BE, P	D	D	D	D	D	D	D	D		D					D			
BC46	*Nitzschia palea*	BE, P	D	C	D	C	B	C	D	C		C	B	C				C	D	
BC47	*Nitzschia aciculoroides*	BE, P	D	D	D	D	D	D	D	D										
BC48	*Nitzschia perminuta*	BE, P	D		D	D			D	D								D		
BC49	*Pimularia biceps*	BE, P	C	C		C	C	C	C		C	C		C	C		C	C	C	C
BC50	*Pinnularia gibba*	BE, P	C	C	C	C	C	C	C	C	C	C					C	C		
BC51	*Pinnularia subcapitata*	BE	D		D	D			D	D			D	D				D	D	
BC52	*Rhoicosphaenia abbreviata*	BE	C	C		C			C	C								C	C	
BC53	*Rhoipalodia gibba*	BE, P	C	C		C			C	D			D	D				D	D	
BC54	*Surirella ovalis*	BE	C		C	C			C	C								C	C	
BC55	*Surirella brebissonii*	BE, P	C	D	C	C			C	D		C					C	D		C
BC56	*Surirella robusta*	BE, P	D	D	D	D			D	D		D					D	D		D
BC57	*Surirella angusta*	BE, P	D	D	D	D	D	D	D	D		D				D	D			D
BC58	*Ulnaria ulna*	BE, P	D	D	D	D	D	D	D		D	D	D	D				D	D	
	CHLOROPHYCEAE																			
CH1	*Ankistrodesmus falcatus*	BE, P	D	D	D	D	D	D	D	D		D	D	D				D	D	
CH2	*Chlorella vulgaris*	P	D	D	D	D			D	D			D	D				D		
CH3	*Closterium attenuatum*	P	D	D	D	D			D	D		D					D	D		
CH4	*Coelastrum microporum*	P	D	D	D	C	D	D	D	D	D						D	D		
CH5	*Cosmarium formosulum*	P	D	D	D	D	D	D	D		D	D	D	D				D	D	
CH6	*Cosmarium impressulum*	P	D	D	D	D	D	D	D	D			D		D	D	D	D		D
CH7	*Kirchnerielle obesa*	P	D		D	D			D	D							D			D
CH8	*Oocystis parva*	P	D	D	D	D	D	D	D	D	D	D					D	D		
CH9	*Pediastrum dublex*	BE, P	D		D	D			D	D			D	D				D	D	

CH10	*Pediastrum simplex*	BE, P	D	D		D			D	D							D			D
CH11	*Scenedesmus acuminatus*	P	D	D		D	D	D		D			D	D				D	D	
CH12	*Scenedesmus ellipticus*	P	D		D	D			D	D								D	D	
CH13	*Scenedesmus opoliensis*	BE, P	D		D	D			D		D		D	D				D	D	
CH14	*Scenedesmus quadricauda*	P	D	D	D	D	D		D	D	D	D								
CH15	*Staurastrum cyclocanthum*	P	D	D	D	C			D	D		C	D	D				D		
CH16	*Stigeoclonium polymorphum*	BE, P	D	C	D	D			D	C		D						C		
CH17	*Tetraedron regulare*	P	D	D	D	D	D	D	D	D		D					D			
CYANOPHYCEAE																				
CY1	*Anabaena affinis*	P	D	D	D	D			D	D		D	D	D				D		
CY2	*Anabaena spiroides*	P	D	D	D	D			D	D		D					D			
CY3	*Chroococcus limneticus*	P	D	D		D	D	D		D	C		D		D			D		D
CY4	*Chroococcus turgidus*	BE, P	D	D	D	D			D	D		D					D			
CY5	*Gomphosphaenia aponina*	BE, P	C	D	D	C	D	D	C	D		C					C			
CY6	*Lyngbya epiphytica*	BE, P	D		D	D			D	D			D	D			D			D
CY7	*Merismopedia punctata*	P	D	D	D	D	D	D	D		D	D	D	D				D	D	
CY8	*Merismopedia tenuissima*	P	D	D	D	D	D	D	D	D									D	
CY9	*Microcystis aeruginosa*	P	D		D	D			D	D								D		
CY10	*Oscillatoria limnetica*	P		D	D	D	D	D	D	D	D	D			D	D	D	D		D
CY11	*Oscillatoria limosa*	P	D	D	C	D	D	D	D	D	C	D	D	D	D	D	D	D	C	D
CY12	*Oscillatoria rubescens*	P	C	C		D			C	C							C			D
CY13	*Oscillatoria tenuis*	BE, P	D	D		D			D	D			D		D		D		D	
CY14	*Phormidium mucicola*	BE, P	D	D	D	D	D	D	D	D	D	D					D	D		
CY15	*Spirulina major*	BE, P	D		D	D			D	D								D	D	
EUGLENOPHYCEAE																				
EU1	*Euglena acus*	BE, P	D	D	D	D			D	D								D		
EU2	*Trachelomonas robusta*	BE, P	C		D	D			C	D								D	D	
PYRROPHYCEAE																				
PR1	*Ceratium hirundinella*	BE, P	D	C	D	D			D	C		D								
PR2	*Peridinium cinctum*	BE, P	D	D	D	D			D	D		D					D			
CRYPTOPHYCEAE																				
CR1	*Cryptomonas ovata*	BE, P	D	D	D	D			D	D		D	C	D	C	D	D			
CR2	*Dinobryon divergens*	BE, P	D	D	C	D			D	D		D								

**** A = plentiful 76-100 individuals per mL***
C = poor 25-49 individuals per mL
B = abundant 50-75 individuals per mL
D = slight 1-24 individuals per mL

3. RESULTS AND DISCUSSION

Additionally, Cluster Analysis (CA) was applied to the limnologic and biological data in order to categorize the Artabel lakes based on their physicochemical status. According to the Cluster Analysis, which was based on physicochemical values, maximum similarity was observed between Beş Lakes-4 and Yıldız Lakes-2 Lakes while minimum similarity was observed between Beş Lakes-4 and Artabel Lakes (Figure 4).

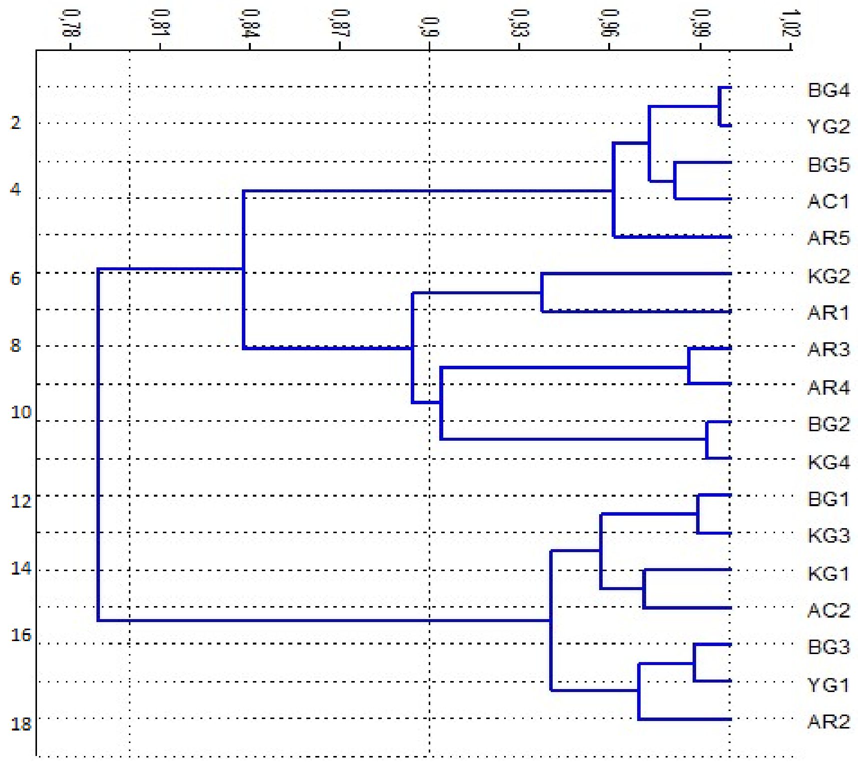

Figure 4. *Clustering dendogram of the lakes in terms of physical and chemical features*

The similarity significant value of the clusters formed as a result of clustering analysis in terms of physicochemical features in Artabel Lakes Natural Park lakes were presented below in table 4. Lakes

Table 4. *Similarity percentages of lakes in terms of algae*

Correlations						
	T	TDS	Salinity	DO	pH	EC
T	1					
TDS	-,136	1				
Salinity	-,392	,359	1			
DO	,068	,333	-,298	1		
pH	-,191	,239	,448	-,275	1	
EC	-,277	**,542***	**,621****	-,001	,426	1

Percentage variance values, cumulative percentage variance values and component loadings (before and after rotation) were presented in table 5. Totally 5 factors (AR, BG, KG, YG and AC) explain 75.287 % of the total variance according to total percentage variance after rotation.

Table 5. *Total variances*

Comp.	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	37,352	36,620	36,620	37,352	36,620	36,620	28,184	27,631	27,631
2	14,835	14,544	51,164	14,835	14,544	51,164	17,037	16,703	44,334
3	12,152	11,913	63,078	12,152	11,913	63,078	15,352	15,051	59,385
4	6,592	6,463	69,540	6,592	6,463	69,540	8,904	8,730	68,114
5	5,862	5,747	75,287	5,862	5,747	75,287	7,316	7,173	75,287

The parameter loadings bigger than 0.5 identified for 5 factors after rotation were presented in table 6.

Table 6. *Component matrix*

	Component				
	1	2	3	4	5
BC44	,899				
CY2	,899				
PR2	,899				
CY4	,899				
CH17	,886				
BC45	,886				
BC7	,874				
CY5	,872				
BC20	,841				
CH8	,815				
BC35	,815				
BC50	,815				
BC33	,815				
CY14	,815				
CH3	,809				
BC41	,809				
BC17	,809				
CH14	,809				
BC26	,793				
BC30	,789				
PR1	,765				
BC28	,755				
BC11	,749				
BC57	,747				
CR2	,747				
BC56	,739				
BC55	,720				
BC19	,692				
BC24	,665				
BC47	,663				
CH4	,643			,502	
CY12	,641				
BC21	,630			,528	
BC37	,606				
CH10	,606				
BC13	,606				
BC14	,601				
CH16	,582				
CH15	,537			-,534	
CY15		,886			
CH12		,886			
BC54		,886			
EU2		,822			
BC34		,821	,501		
BC51		,821	,501		
CH9		,821	,501		
BC40		,821	,501		
BC10		,800			

BC48		,792			
CY9		,792			
BC36		,780			
BC18		,758			
CH13		,671			
BC16	,582	,671			
BC12	,582	,671			
BC52		,623			
EU1	,602	,618			
CH7	,533	,595			
CY6		,536			
BC8			,893		
BC4			,893		
CH1			,893		
BC46			,851		
BC29			,848		
BC32			,847		
BC31			,785		
CH11			,779		
BC58			,758		
CY7			,758		
CH5			,758		
BC38			,721		
BC3			,644		
BC43			,571	-,503	
BC27			,571	-,503	
BC42			,571	-,503	
CY1			,571	-,503	
CH2		,559	,568		
BC2				-,754	
BC5				-,715	
CR1				-,688	
BC23				,613	
BC15				,591	
BC22				,569	
BC39				,522	
EC					-,873
CH6					,653
TDS					-,627
SAL					-,610
pH					-,569
CY13					,512

1st factor explains 27.63% of the total variance and this factor is composed of algae types coded as BC44, CY2, PR2, CY4, CH17, BC45, BC7, CY5, BC20, CH8, BC35, BC50, BC33, CY14, CH3, BC41, BC17, CH14, BC26, BC30, PR1, BC28, BC11, BC57, CR2, BC56, BC55, BC19, BC24, BC47, CH4, CY12, BC21, BC37, CH10, BC13, BC14, CH16 and CH15. All taxon are loaded positively for this factor.

2nd factor explains 16.7% of the total variance and this factor is composed of algae types coded as CY15, CH12, BC54, EU2, BC34, BC51, CH9, BC40, BC10, BC48, CY9, BC36, BC18, CH13, BC16, BC12, BC52, EU1, CH7, CY6, BC53, BC8, BC4, CH1, BC46, BC29, BC32, BC31, CH11, BC58, CY7, CH5, BC38, BC3, BC43, BC27, BC42, CY1, CH2. All taxon are loaded positively for this factor.

3rd factor explains 15.05% of the total variance and this factor is composed of algae types coded as CY15, CH12, BC54, EU2, BC34, BC34, BC51, CH9, BC40, BC8, BC4, CH1, BC46, BC29, BC32, BC31, CH11, BC58, CY7, CH5, BC38, BC3, BC43, BC27, BC42, CY1, CH2. All taxon are loaded positively for this factor.

4th factor explains 8,73% of the total variance and this factor is composed of algae types coded as CH4, BC21, CH15, BC43, BC27, BC42, CY1, BC2, BC5, CR1, BC23, BC15, BC22, BC39. All taxon are loaded positively for this factor. CH4, BC21, BC23, BC15, BC22, BC39 taxon are loaded negatively for this factor, all other taxon are loaded positively for this factor.

5th factor explains 7.17% of the total variance and this factor is composed of EC, TDS, salinity and pH parameters and algae types coded as CH6 and CY13. All taxon are loaded positively for this factor, all physicochemical parameters are loaded negatively for this factor.

Algae are primary producer creatures in water environment. They turn carbon dioxide and water into carbohydrate via the effect of light and provide the increase in trophy level and dissolved oxygen percentage in water environment. They form the first circle in food chain by ensuring their own development. In this way, they carry importance in terms of their contribution to the production and their relation with upper level species of food chain.

4. SUMMARY AND CONCLUSIONS

96 taxon (species and sub-species) belonging to 6 different algae class were identified in the research field. 58 taxon were recorded belonging to Bacillariophyceae class. It was observed that Navicula has the most taxon followed by Nitzschia and others. Chlorophyceae was the second in terms of species number. 17 taxon were identified belonging to this class. Scenedesmus was found important in terms of species number in these kinds. 15 taxon identified belonging to Cyanophyceae family. Oscillatoria has the furthest species in this class. 2 taxon were identified belonging to Euglenophyceae class and only Euglena has existed as important species. 2 taxon were identified belonging to Pyrrophyceae that belong to Peridinium and Ceratim species. Cryptophyceae class were represented with 2 taxon and Cryptomonas species was identified belonging to these species. The Bacillariophyceae (diatom) group was especially the most dominant class in terms of algae diversity.

Bacillariophyceae was identified as the dominant species based in the samples in Artabel Lakes Natural Park. This group is represented as the furthest species in Turkey freshwater. Chlorophycea followed by Cyanophyceae are the second dominant group in terms of species diversity in the research field. This situation shows similarity to a great extent with other studies in Turkey. However, there is insufficiency in terms of species diversity and distribution.

Richness was not observed in terms of species compositions in both benthic and planktonic habitats due to the high altitude, snow melting of the lakes and lack of total daylight in the samples taken from chosen 18 lake stations in Artabel Lakes Natural Park. The identified water heat in 18 lakes in Artabel Lakes Natural Park and other parameters give clues about why species diversity is poor. Low heat as well as the existence of cold snow water and low daylight prevents the development and reproduction of the species. The similar studies support the findings mentioned above [27, 28] and Green Lake Valley (5 lakes) of Colorado [29] those lakes oligotrophic and alpine, lakes with low annual primary production also. The identified species were only observed in terms of diversity in Artabel Lake- 1, Artabel-2, Beş Lakes-4, Beş Lakes-5 and Yıldız Lakes.

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