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Taxonomical and numerical comparison of epipelic algae from Balik and Uzun lagoon, Turkey

Arif Gonulol*[1], Elif Ersanli[2] and Ozgur Baytut[1]

[1]Department of Biology, Faculty of Arts and Science,Ondokuz Mayis University, TR-55139, Kurupelit, Samsun, Turkey
[2]Department of Biology, Faculty of Arts and Science,Sinop University, TR-57000, Sinop, Turkey

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Abstract: *The epipelic algae of Balik lagoon and Uzun lagoon were investigated from May 2003 to December 2004. A total of 106 taxa were identified. Of these, 85 were found in Balik lagoon and 78 were found in Uzun lagoon. Water temperature of the lagoons ranged from 6.5 to 24.5°C during the sampling period. Conductivity, hardness, dissolved oxygen an pH values varied between 0.70 and 8.00 mS, 26.00 and 86.60 °f, 3.50 and 9.00 mg l^{-1} and 7.82 and 8.70 respectively. Nitrite nitrogen, nitrate nitrogen, chloride, phosphate phosphorus and sulphate concentrations in the water were also measured and ranged from 0.01 to 0.14, 0.01 to 0.24, 2.41 to 48.70, 0.01 to 0.12 and 54.00 to 104.40 mg l^{-1} respectively. Species richness (d), diversity (Shannon – Weaver, H') and evennes (J') were calculated for epipelic algae and the findings showed similar oscillations throughout the research period. Cluster analyses and multidimensional scaling (MDS) revealed a similar distribution pattern of epipelic algal flora in both lagoons.*

Key words: *Epipelic algae, Lagoons, Diversity index, Cluster, MDS, BIOENV*
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Introduction

Lagoons are important wetlands in respect of ecological significance. These wetlands located between land and sea, are the transition zones between freswater and salty water. Lagoons possess quite changable characteristics and their structure varies from freshwater media to excessive salty water media (Gilabert, 2001).

Lagoons are nutrient rich environments because of the sediment mixing as a result of shallowness. The productivity are thus at the higher levels in the lagoons (Cevik *et al*., 2008). Rich epipelic algal populations grow in lagoons in addition to phytoplankton flora. The benthic zone of the lakes has a great contribution to the algal flora of inland water and increases the yield of the lake. In this zone, the nonmotile species occured in musilaged colony and fibrious masses on the sediment and the motile species mostly covering the sediments are called epipelic algae. On the other hand, the algae attached to stones (epilithic) or clinging to other higher plant bodies in a water (epiphytic) are called dependent algae (Reid *et al*., 1995). In certain lakes, these algal assemblages are more diverse in respect of species and individual numbers. Algae have a great significance, since these primary producers are used in biomonitoring as indicator organisms of water pollution (Shektar *et al*., 2008), in ecological studies of extraordinary environments such as mangroves (Saravanakumar *et al.*, 2008) or in exploring sustainable water resources (Bhuiyan and Gupta, 2007). Diatoms occupy a great part of the epipelic algal assemblages. There are several biomonitor species among epipelic diatoms. Also, biomonitor species belonging to the other algal divisions have been growing well on sediments (Round, 1953). It has therefore been important to determine the pollution and production in lakes.

*** Corresponding author:** agonulol@omu.edu.tr

Statistical technics and advances in methodology has recently been more applicable on biomonitor algal assemblages in respect of diatoms and chemical structure of lake waters. Consequently, algal studies are supported by using these statistical technics.

There are 72 lagoons in Turkey and these occupy on area of 36000 hectares. Few algological studies have been performed in these lagoon systems. The seasonal variation of phytoplankton were investigated by Cevik *et al*. (2008) in lagoon Akyatan and Tuzla which are located in the southern Anatolia. Gokpinar *et al*. (1996) studied the phytoplankton communities of the lake Karine Dalyan and lagoon Güllük (Egemen *et al*., 1999) in the western Anatolia. The Kizilirmak and Yesilirmak lagoon series are located around the mouths of the Kizilirmak and Yesilirmak rivers in the Northern Anatolia. Among these series, the phytoplankton of Balik lagoon and Uzun lagoon (Gonulol and Comak, 1992a,b; 1993a,b), Gici lagoon (Soylu and Gonulol, 2006), Cernek lagoon (Tas and Gonulol, 2007), Karabogaz lagoon (Baytut *et al*., 2006) were investigated in the Kizilirmak lagoon series. In the delta of Yesilirmak river, Simenit lagoon (Ersanli and Gonulol, 2006), Akgol lagoon (Ersanli *et al*., 2006) were investigated in respect of algal flora. Investigations concerning benthic algae of these lagoons were also published. One of these article revealed the epiphytic diatoms attached to the *Nuphar lutea* L. in the lake Ladik, lagoon Gici and lagoon Tatli (Soylu *et al*., 2005) and the other was epiphytic diatom assemblages on mats of *Cladophora glomerata* in lake Ladik (Maraslioglu *et al.,* 2007).

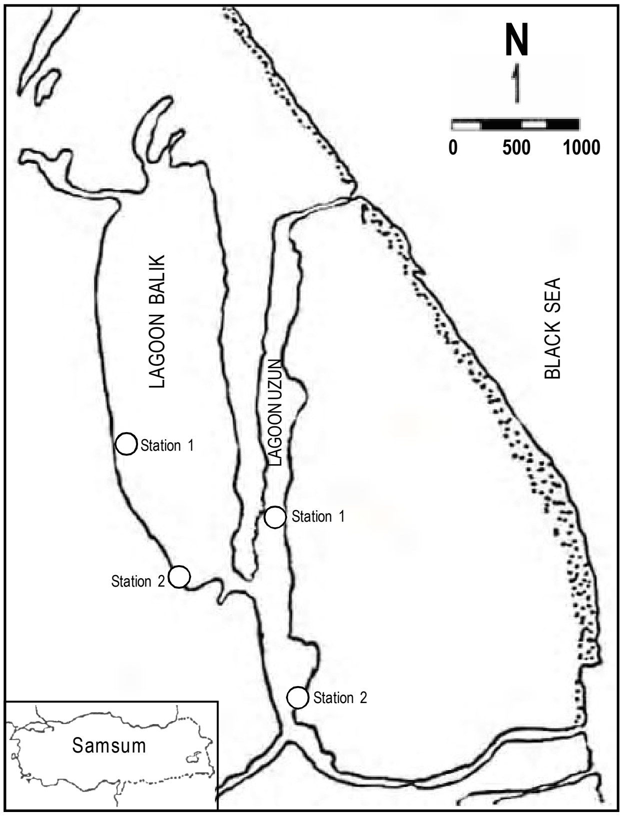

Fig. 1: The geographical location of lagoons and the sampling stations

This study is planned to determine species richness and to evaluate the structure of epipelic algal communities in the lagoons Balik and Uzun which were already investigated in respect of phytoplankton. The findings of the epipelic algae and monthly samples were also supported by using Hierrarchical cluster analysis, MDS (Multi Dimensional Scalling) ordination technique and BIOENV (correlations between similarity matrices of biological abundance data and environmental parameters) routin, respectively.

Materials and Methods

Balik lagoon and Uzun lagoon are located in the Kizilirmak Delta of the Blacksea and both of them are shallow lakes. Lagoon Balik, the largest lake in the delta, has 1390 hectares with a depth varying between 0.5-2.0 m (Anonymous, 1995). Uzun lagoon contacted with the Balik lagoon, has 253 ha (Anonymous, 1972). The lagoons of the Kizilirmak Delta are subjected to the impact of agricultural activities. The most important stresses on lagoons in this area are organic enrichments, pesticides and herbicides.

To examine epipelic algal flora in lagoons, samples were collected during the period May 2003 to December 2004. Two stations (St.) were chosen in each lagoons (Fig. 1). The algal samples were collected by using a glass tube, 0.8 cm in diameter and 1 m in length. Samples were transferred into plastic bottles and fixed with 5% formalin. Before counting the samples were homogenized at low speed until the sediment was througly mixed and was of uniform consistency. Three water-mounted slides for each sample were examined and living diatoms were collected at each station to obtain an estimate of algal relative abundance (Round, 1953; Sladeekova, 1962). At least 500 algal cells were counted at 600 x magnification. Permanent slides for the identification of diatoms were prepared from the same sample after boiling in a 1:1 mixture of concentrated H_2SO_4 and HNO_3. The acid cleaned diatoms were mounted in Naphrax high refractive index medium (Round, 1953). Species identifications were based on John *et al.* (2003) Round (1990), Sims (1996). All of the species were also checked in the algaebase web site (Guiry and Dhonncha, 2006).

At the time of sampling, water temperature and dissolved oxygen were measured with a YSI 51B oxygenmeter and conductivity was measured with a PW 9529 conductivity meter. Other chemical analyses were performed according to the standard methods (APHA, 1998) in the lagoons.

The statistical analyses were performed using PRIMER 5.0 (Multivariate Analyses Package – Plymouth Routines). The epipelic algal community data were analysed by hierrarchical clustering and MDS ordination technique. A Bray-Curtis similarity matrix was calculated from abundance data and Hierarchical agglomorative clustering performed using the complete linking method to produce a dendrogram. Additionally a multi-dimensional scaling (MDS) ordination technique was applied to the data. Patterns in community structure identified by cluster and MDS analyses were linked to environmental variables using the BIOENV procedure of PRIMER (Clarke and Warvick, 2001). Shannon diversity (H') (Shannon and Weaver, 1949), evenness (J') (Pielou, 1975) and species richness (d) were also calculated for algae and computed.

Results and Discussion

A total of 106 taxa among epipelic algae were identified. Of these, 85 were found in Balik lagoon and 78 were determined in Uzun lagoon. 44 taxa were deleted from the list since these were common at all of the four stations. The remaining taxa and their occurence are presented in Table 1. Among 85 taxa identified in the epipelic algal flora of Balik lagoon, 28 taxa from Bacillariophyta, 23 from Chlorophyta, 18 from Cyanobacteria, 13 from Euglenophyta, 2 from Xanthophyta and 1 from Cryptophyta were observed. The epipelic algal flora of Uzun lagoon consisted of 78 taxa. Of these, 25 belong to the Bacillariophyta, 27 to the Chlorophyta, 12 to the Cyanobacteria, 11 to the Euglenophyta and 3 to the Xanthophyta. According to the number of species, Bacillariophyta were dominant group in both of the lagoons as is similar in phytoplankton of some lakes (Senthilkumar and Sivakumar, 2008). *Amphora* spp., *Cocconeis* spp., *Cymbella* spp., *Encyonema* spp., *Navicula* spp. and *Nitzschia* spp. from Bacillariophyta, *Cosmarium* spp., *Scenedesmus* spp. from Chlorophyta, *Microcystis* spp. from Cyanobacteria, *Euglena* spp. and *Phacus* spp. from Euglenophyta were abundant among the epipelic algae.

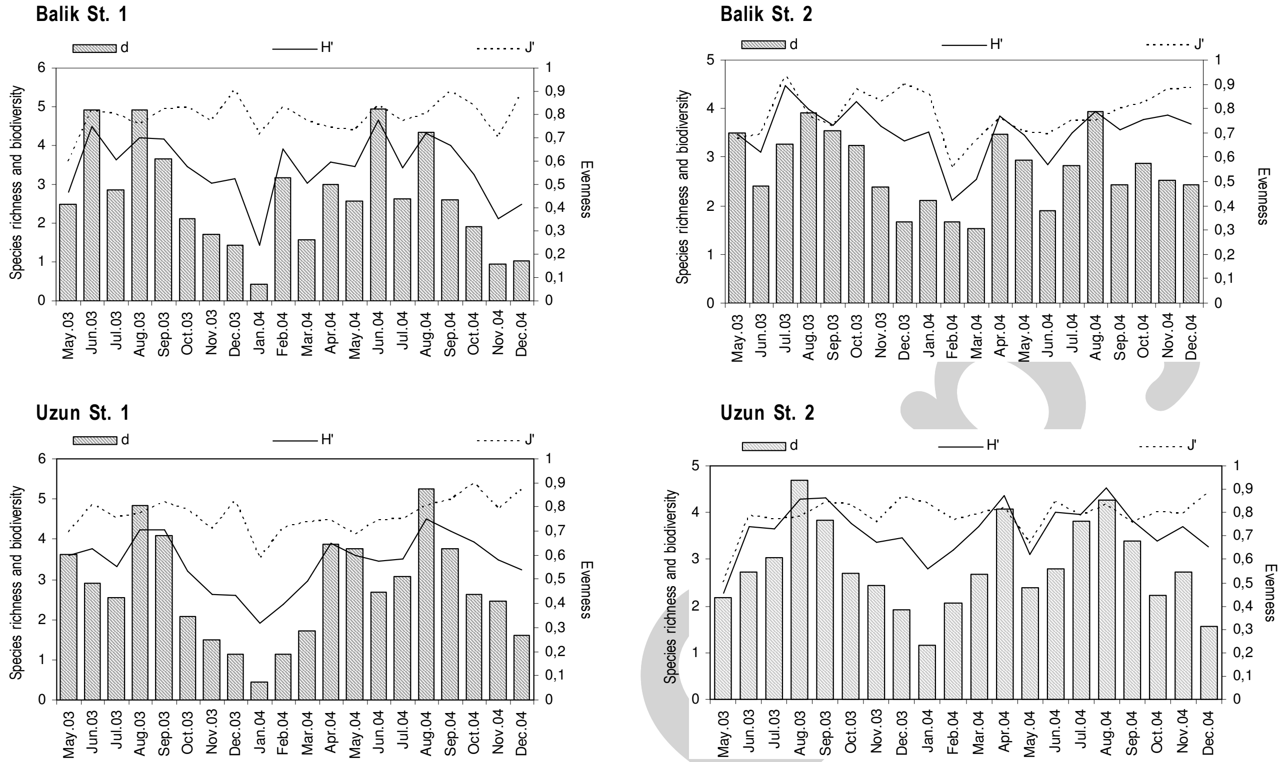

Fig. 2: Species richness (d) and Pielou's evenness (J') and Shannon Diversity index (H') of algae assemblages in lagoon Balik and lagoon Uzun

The physical and chemical properties of the lagoons measured in May 2003 and December 2004 were given in Table 2. In the lagoons, the average pH values was measured as 8.18 and 8.27 in lagoon Balik and lagoon Uzun respectively. pH values varied between 6 and 9 in the unpolluted lakes (Sisli, 1999). Accordingly, the lake was slightly alkaline. The average temperature was 15.5^{o}C. The dissolved oxygen values and conductivity determined as 6.15-6.30 mg l^{-1} and 4.10-4.35 mS, respectively. As to hardness values (55.70 and 56.30^{o}f), the lake water was between hard and very hard (Yaramaz, 1992). The nitrite and nitrate values 0.07-0.05 and 0.12-0.11 mg l^{-1}. The chloride values 21.26 and 25.65 mg l^{-1} because of lagoons are linked to the sea. The average phosphate and sulphate values in lagoons were 0.006-0.005 and 83.20-79.20 mg l^{-1}. The SO_4 values were between a few mg l^{-1} and several hundred mg l^{-1} (Sengul and Turkman, 1991). According to these results, no significant differences were found between sites.

BIOENV procedure was performed by calculating correlations between similarity matrix of abundance data and 10 environmental parameters. According to the results, best matching parameters were lagoon water temperature, conductivity and nitrate-nitrite concentrations (r = 0.902).

The Shannon diversity (H'), evenness (J') and species richness (d) were calculated (Fig. 2). The richest diversity was observed in June (04) with a 4.64 index coefficient at St.1 and August (04) with a 4.51 index coefficient in St.2, respectively for lagoon Balik. The richest diversity for lagoon Uzun was found in August (04) with a 4.52 index coefficient at St.1 and July (03) with a 4.45 index coefficient in St. 2. According to the evenness values, the maximum and minumum index were determined in July 04 (0.94) and May 03 (0.60) at St.1 and January 04 (0.95) and May 03 (0.69) at St.2 in lagoon Balik. In lagoon Uzun the maximun and minimum values of the evenness were found in December 04 (0.88) and May 03 (0.50) at St. 1 and July 03 (0.93) and February 04 (0.55) at St. 2. The richest month for the species richness during the sampling period for lagoon Balik was June 04 with a 4.94 index coefficient St. 1 and August 04 with a 5.24 index coefficient St. 2. In lagoon Uzun the richest month was represented by August 03 (4.69) at St. 1 and August 04 (3.92) in St. 2. According to these findings, both of these lagoons showed more or less similar increasing and decreasing trends during the sampling period.

The result of Cluster analysis indicated that samples divided into two main clusters at St. 1 in Balik lagoon (Fig. 3). The first group contained autumn, spring and summer samples. Autumn was characterized by *Microcystis aeruginosa* that made up 19–18–17% of the total organisms in August 03, September 03 and August 04, respectively. However, *Amphora ovalis* constitued 31% of the total organisms in July 03. *Oscillatoria tenuis* also made up 36% of total organisms in March 04. The second group included winter and summer samples. In July 04, *Aphanizomenon flos-aquae* and *Amphora ovalis* occupied 18 and 26% of total organisms together with *Euglena gracilis*.

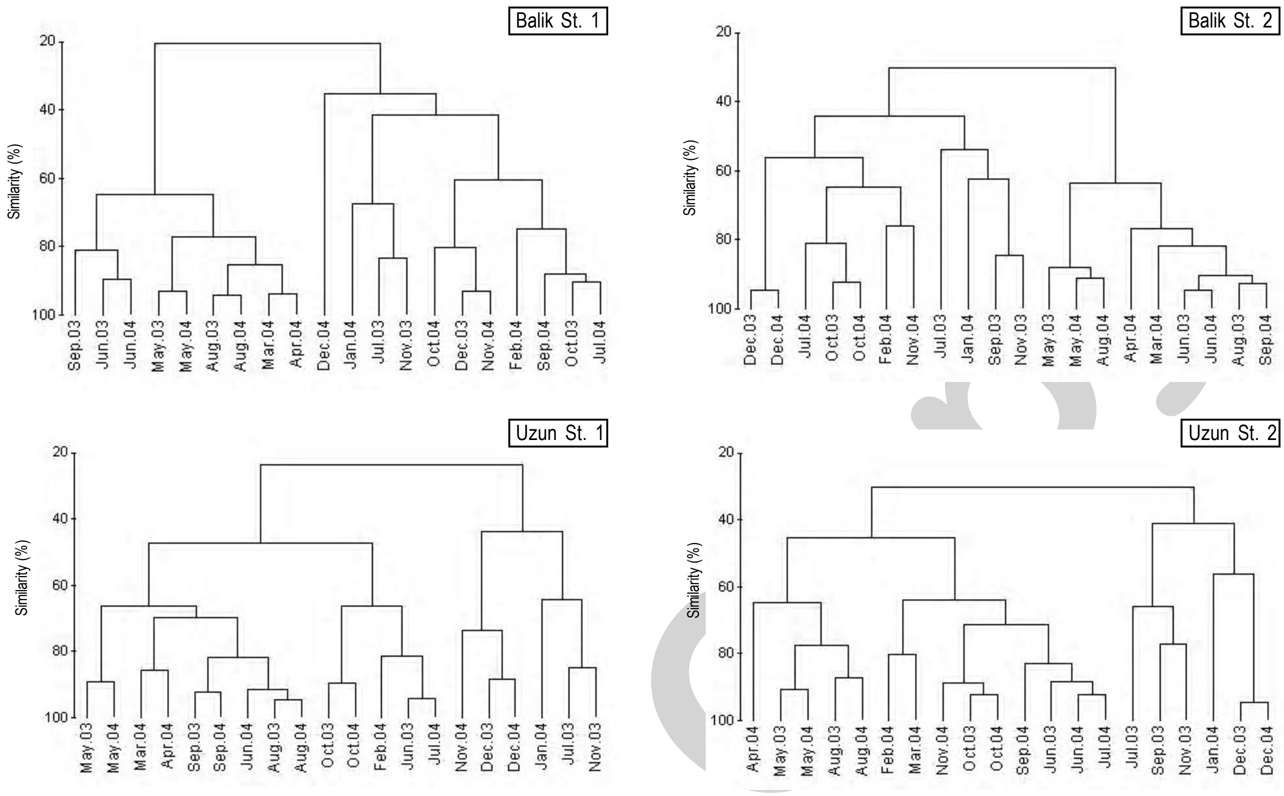

Fig. 3: Cluster analysis of months according to the calculation of Bray - Curtis similarity index in lagoon Balik and lagoon Uzun

In Balik at St. 2 a cluster diagram was constitued by two assemblages. The first group was formed by winter, autumn and summer samples. *Amphora pediculus* was constisted of 23–28–20% of the total organisms in February 04, March 04, April 04, respectively. *Cymbella naviculiformis* was another dominating species which was found to be 37% of total organisms in July 04 and 33 % of the total organisms in September 04. *Navicula cryptocephala* was present along the year and reached to 47% of the total organisms in June 04. *Microcystis flos-aquae* was 24% of the total organisms in August 04. *Cylindrospermum licheniforme* was 18% of the total organisms in May 03 and 26% of the total organisms in May 04. The second group was formed by spring and summer samples and was characterized by dominance or decline of *Nitzschia palea* and *Euglena oxyuris* var. s*kvortzovii.*

In Uzun at St.1 a cluster diagram was constitued by three assemblages at the lowest hierarchical level. The first one was formed by summer and spring samples. *Cymbella naviculiformis* was consisted of 35% of the total organisms in March 04. *Protoderma sarcinoideum* was 22% of the total organisms in June. *Cylindrospermum licheniforme* was 22% of the total organisms in May 03 and 22% of the total organisms in June 04. Also *Oscillatoria tenuis* was reached 18 -14% of the total organisms in May 04 and in April 04, respectively. The second group was formed by winter and summer samples. *Amphora pediculus* consisted of 19% of the total organisms in June 03 and *Microcystis aeruginosa* was 28% of the total organisms in October 03. While *Navicula cryptocephala* was 19% of the total organisms in July 03, *Cymbella naviculiformis* reached to 47% of the total organisms in February 04. The third one was winter and summer samples. *Nitzschia palea* was present along the year and reached 40% in November 03, 32% in December 03 and 22% in November 04. *Navicula cryptocephala* was 30% in January 04. *Euglena acus* comprised 29–19–33% of total organisms in December 03, November 04 and December 04, respectively. Also *Euglena oxyuris* var. *skvortzovii* was 12% of the total organisms in December 04.

Two clusters were seperated at St. 2 in Uzun lagoon. The first group was a large cluster formed by all season samples. While *Amphora ovalis* was 20% of the total organisms in January 04, 14% of the total organisms in February 04. *Encyonema prostratum* made up 18% of the total organisms November 04. *Nitzschia palea* was 29% of the total organisms in October 03, 0% in November 03, 20% in December 03, 30% in October 04, 20% in November 04, 17% in September 04. *Chlamydomonas globosa* was 25% in July 03 and in July 04. *Euglena oxyuris* was 13–15–25% in November 03, December 03, December 04, respectively. The second one is formed by spring and summer samples. *Amphora pediculus* was conssted of 12% in March 04. *Navicula cryptocephala* made up 20–22% of the total organisms in June 03 and March 04, respectively. *Surirella biseriata* var. *constricta* was17% in June 04. *Navicula salinarum* reached to 50% in May 03 and 27% in May 04. Also

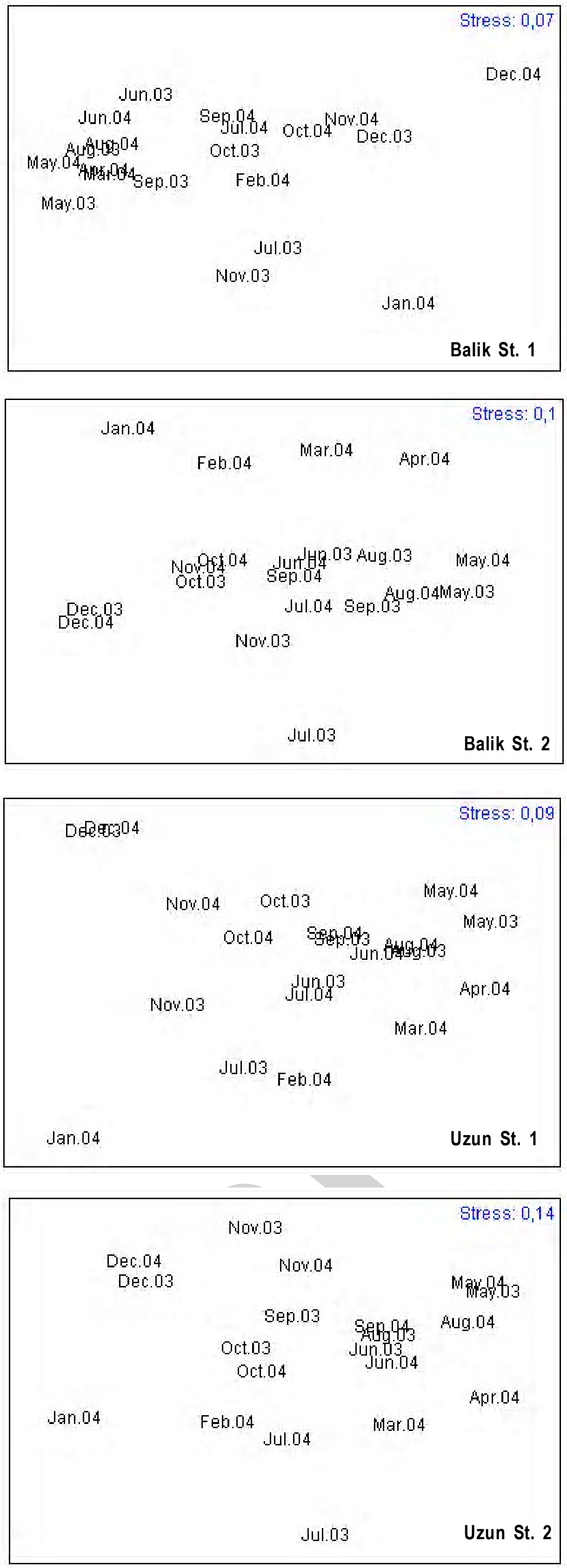

Fig. 4: MDS analysis of months in lagoon Balik and lagoon Uzun

Table - 1: The list of the recorded taxa and their difference at the stations in lagoons (Common 44 taxa are omitted).

	Balik lagoons		Uzun lagoons	
	St. 1	St. 2	St. 1	St. 2
Bacillariophyta				
Amphora commutata Grunow	-	+	-	+
Anomoeoneis sphaerophora (Ehrenberg) Pfitzer	-	-	-	+
Caloneis silicula (Ehrenberg) Cleve	-	+	+	+
Cocconeis pediculus Ehrenberg	+	-	+	+
Cyclotella ocellata Pantocsek	+	-	+	-
Cymatopleura solea (Brébisson) W. Smith	+	+	+	-
Craticula cuspidata (Kutzing) D.G.Mann	-	+	-	+
Diploneis pseudovalis Hustedt	-	+	-	-
Encyonema minutum (Hisle ex Rabenhorst) D.G.Mann	+	-	-	+
Encyonema prosttatum (Berkeley) Kutzing	-	+	-	+
Encyonema silesiacum (Bleisch) D.G.Mann	-	+	+	+
Entomoneis alata (Ehrenberg) Ehrenberg	+	-	+	-
Entomoneis paludosa (W. Smith) Reimer	-	+	+	+
Epithemia sorex Kützing	+	-	-	+
Gomphonema parvulum (Kutzing) Kutzing	+	+	-	-
Gomphonema truncatum Ehrenberg var. *capitatum* (Ehrenberg) R. M. Patrick	+	-	-	-
Mastoglia smitthii Thwaites	-	-	+	-
Melosira varians Agardh	+	+	-	-
Navicula placentula (Ehrenberg) Kutzing	+	-	+	+
Navicula radiosa Kutzing	-	-	-	+
Navicula salinarum Grunow in Cleve et Grunow	+	+	-	+
Navicula tripunctata (O.F. Muller) Bory	+	-	+	+
Navicula veneta Kutzing	+	-	-	-
Nitzschia acicularis (Kutzing) W. Smith	+	-	+	+
Nitzschia dissipata (Kutzing) Grunow	+	+	-	+
Nitzschia fonticola Grunow in Cleve et Moller	+	-	+	+
Nitzschia umbonata (Ehrenberg) Lange-Bertalot	+	-	-	-
Pinnularia interrupta W.Smith	-	-	-	+
Stauroneis smithii Grunow	-	+	-	-
Surirella brebissonii Krammer et Lange-Bertalott var. *brebissonii*	-	+	+	+
Surirella biseriata Brebisson in Brebisson et Godey var. *constricta* (Grunow) Hustedt	-	-	+	+
Synedra acus Kutzing	-	+	+	-
Tryblionella angustata W.Smith	+	+	-	-
Tryblionella levidensis (W.Smith) Grunow	+	-	+	-
Chlorophyta				
Chlorella ellipsoidea Gerneck	-	-	-	+

Contd. ....

Closterium acutum Brebisson	-	-	-	+
Closterium acutum var. *variabile* (Lemmermann) Willi Krieger	-	-	+	-
Closterium dianae Ehrebberg ex Ralfs	-	-	+	-
Coenococcus polycoccus (Korshikov) Hindak	+	-	+	-
Coleochaete orbicularis Pringsheim	+	-	-	+
Cosmarium bioculatum Brébisson ex Ralfs	+	-	-	+
Cosmarium botrytis Meneghini ex Ralfs	-	+	-	+
Cosmarium granatum Brebisson in Ralfs	+	-	-	-
Cosmarium humile (F.Gay) Nordstedt	-	+	-	-
Cosmarium meneghinii Brebisson	+	+	+	-
Cosmarium phaseolus Brebisson	-	-	+	-
Cosmarium trilobulatum Reinsch	-	+	-	-
Klebsormidium subtile (Kutzing) Tracanna ex Tell	-	+	-	+
Monoraphidium minutum (Nageli) Komarkova-Legnerova	+	-	-	-
Monoraphidium irregulare (G.M. Smith) Komárkova-Legnerova	+	-	-	-
Oedogonium sp.	-	-	+	-
Oocystis elliptica West	-	+	-	+
Pediastrum boryanum (Turpin) Meneghini	+	-	+	-
Pediastrum tetras (Ehrenberg) Ralfs	+	+	-	+
Protoderma sarcinoideum (Groover et Bold) Tupa	-	-	+	-
Protoderma viride Kutzing	+	-	-	+
Scenedesmus acuminatus (Lagerheim) Chodat	+	-	+	-
Scenedesmus communis E.H. Hegewald	-	-	-	+
Scenedesmus ecornis (Ehrenberg) Chodat	+	-	+	-
Scenedesmus ellipticus Corda	-	+	-	-
Scenedesmus quadricaudus (Turpin) Brébisson var. *quadrispina* (Chodat) G.M. Smith	+	+	+	-
Schroederia setigera (Schroder) Lemmerman	+	+	-	+
Sphaerocystis schroeteri Chodat	-	-	+	+
Spirogyra weberi Kutzing	+	+	-	+
Staurastrum dispar Brebisson	-	-	-	+
Tetraedron minimum (A. Braun) Hansgirg	+	+	+	-
Tetrastrum komarkeii Hindak	+	-	+	-
Cyanophyta				
Aphanizomenon aphanizomenoides (Forti) Hortobagyiet Komarek	+	-	-	-
Chroococcus gomontii Nygaard	-	-	+	-
Chroococcus limneticus Lemmermann	-	+	+	+
Chroococcus turgidus (Kutzing) Nageli	+	-	+	+
Chroococcus turgidus var. *maximus* Nygaard	-	+	-	-
Cylindrospermum licheniforme (Bory) Kutzing ex Bornet et Flahault	+	+	+	+
Eucapsis minuta F. E. Fritsch	-	+	-	+
Gloeotrichia pisum (C.Agardh) Thuret ex Bornet et Flahault	-	+	-	-
Gomphosphaeria aponina Kutzing	-	+	-	+
Lyngbya hieronymusii Lemmermann	-	+	-	-
Merismopedia glauca (Ehrenberg) Nageli	+	-	+	+
Microcystis aeruginosa (Kutzing) Kützing	+	-	+	+
Microcystis flos-aquae (Wittrock) Kirchner in Engler-Prantl	-	+	-	-
Microcystis robusta (Clark) Nygaard	-	+	-	+
Nodularia harveyana (Thuret) Bornet et Flahault	+	+	-	+
Oscillatoria agardhii Gomont	+	-	+	+
Oscillatoria amphibia Agardh ex Gomont	-	+	-	-
Oscillatoria curviceps C. Agardh	-	+	+	+
Snowella lacustris (Chodat) Komárek et Hindák	-	+	-	-
Euglenophyta				
Euglena gracilis G.A. Klebs	+	+	-	+
Euglena oxyuris Schamarda	-	-	+	+
Euglena oxyuris var. *skvortzovii* (Popowa) Popowa	+	+	+	-
Phacus anacoelus A. Stokes	-	+	-	-
Phacus caudatus K. Hubner	+	-	-	-
Phacus circulatus Pochmann	-	+	-	-
Phacus curvicauda Svirenko	+	-	+	+
Phacus longicauda (Ehrenberg) Dujardin	+	-	+	+
Phacus nordstedtii Lemmermann	+	-	-	-
Phacus onyx Pochmann	+	-	+	+
Phacus pusillus Lemmermann	-	+	+	+
Phacus skujae Skvortsov	+	-	+	+
Phacus tortus (Lemmermann) Skvortsov	+	+	+	-
Phacus turgidulus Pochmann	-	-	+	-
Strombomonas acuminatus (Schmarda) Daflandre	+	+	-	-
Trachelomonas pulcherrima Playfair var. *minor* Playfair	-	-	+	+
Xanthophyta				
Goniocloris mutica (A. Braun) Fott	+	+	-	+
Goniochloris fallax Fott	-	-	-	+
Ophiocytium cochleare (Eichwald) A. Braun	-	+	-	+
Cryptophyta				
Cryptomonas ovata Ehrenberg	-	+	-	-

+ = Present, - = Absent

Contd..........

Cylindrospermum licheniforme was 26% in May 03 and 28% of the total organisms in May 04.

A feature of MDS is the production of distortion or 'stress' between the similarity ranking and the corresponding distance rankings produced. This stress level gives an indication of the adequacy of the MDS representation. Stress levels between 0.01 and 0.2 can give a potentially useful 2-dimensional Picture (Clarke and Warvick, 2001) and it was therefore decided that further consideration of patterns highlighted by MDS would only be carried out for plots with stresses less than 0.2. The results of MDS analyses were similar to those cluster analyses results. MDS ordination 2-dimentional was performed using the similarities between samples

Table - 2: Variation in the physico-chemical characteristics in the Balik and Uzun lagoon during 2003-2004

Variable	Balik lagoon			Uzun lagoon		
	Minimum	Maximum	Average	Minimum	Maximum	Average
pH	7.82	8.55	8.18	7.84	8.70	8.27
Temperature (°C)	7.00	24.0	15.5	6.50	24.5	15.50
Dissolved oxygen (mg l^{-1})	3.50	8.80	6.15	3.60	9.00	6.30
Conductivity (mS)	0.70	7.50	4.10	0.70	8.00	4.35
Total hardness °f	26.60	84.80	55.70	26.0	86.60	56.30
Nitrite (NO_2-N) mg l^{-1}	0.00	0.14	0.07	0.00	0.10	0.05
Nitrate (NO_3-N) mg l^{-1}	0.00	0.24	0.12	0.00	0.22	0.11
Chloride (Cl) mg l^{-1}	2.41	40.12	21.26	2.60	48.70	25.65
Phosphate (PO_4) mg l^{-1}	0.00	0.12	0.06	0.00	0.10	0.05
Sulphate (SO_4) mg l^{-1}	65.00	101.4	83.20	54.00	104.40	79.20

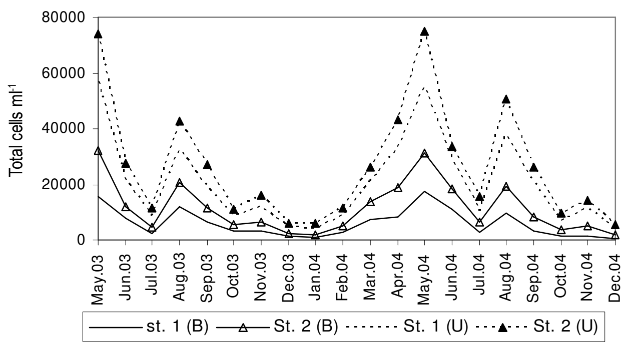

Fig. 5: Monthly variations of total cells at stations in lagoon Balik (B) and Uzun (U)

(Fig. 4). In Balik at St.1 shows that June 03, June 04 and August 03, August 04 and April 04, Marc 04 are closely related, while December 04 and January 04 are progressively more distant. In Balik at St.2, similarly December 03, December 04 and October 04, October 03, November 04 and June 03, June 04, September 04 are related. In Uzun St.1 September 03–04, August 03–04, June 04 are closely related, while January 04 are distant other groups. In Uzun at St.2 December 03–04 and October 03–04 and May 03–04, August 04 and September 04, August 03, June 03, June 04 are related also July 03 distant other groups.

Seasonal variations of the total organisms at epipelic algae are in Fig. 5. Total cell number of epipelic algae community showed similar seasonal variations in each lagoon. However total organisms in Uzun lagoon were much higher than Balik lagoon. Peaks of epipelon were observed May 2003–2004 in lagoon Balik at St. 1 (15726 and 17516 cells per cm^2, respectively) and St. 2 (17161 and 19859 cells per cm^2, respectively). In lagoon Uzun total cells number reached 16270 cells per cm^2 in May 2003 and 13914 cells per cm^2 in May 2004 at St.1 and 25037 and 23716 cells per cm^2, respectively in May 2003 –2004 in St. 2. Minimum numbers of total organisms was found at St. 1 with 325 cells per cm^2 Balik lagoon and 866 cells per cm^2 at St. 1 in Uzun lagoon in December 04.

Similar composition and distribution of epipelic algal flora were observed at the sampling stations in each lagoon. Of the epipelon, the most common group of algae was Bacillariophyta, comprising 42 and 43% of the total taxa, respectively in Balik lagoon and Uzun. Species of *Amphora*, *Navicula* and *Nitzschia* were always recorded in all seasons at all stations in lagoons. While *Cyclotella* spp. were usually found at St.1 and sometimes at St. 2 in Balik lagoon, this species were usually present at all stations Uzun lagoon. *Cyclotella* spp. are indicator species for transition to eutrophy (Round, 1956). *Cocconeis* spp. were largely present in Uzun lagoon, always recorded at St. 1 and usually present at St. 2 in Balik lagoon. Additionally *Surirella* and *Synedra* spp. were rare in Uzun lagoon. *Gomphonema parvulum*, *Navicula capitata*, *Navicula radiosa* appeared to be indicative of high levels of high-pollution. Also, *Gomphonema olivaceum* was found in nutrient-rich environments (Reavie and Smol, 1998).

From Chlorophyta, While *Scenedesmus* spp. were usually recorded at all stations lagoon Balik, sometimes present in lagoon Uzun. *Cosmarium* spp. were usually present in lagoons at St. 1. Species of *Chroococcuss*, *Merismopedia*, *Aphonizomenon*, *Oscillatoria* and *Spirulina* from Cyanobacteria were observed at stations in lagoons.

Euglenophyta are more abundant in polluted water and in water rich in organic matter (Round, 1956). *Euglena* spp. were always present at St. 2 and largely present at St. 1 in both lagoons. *Phacus* spp. were largely found at all stations either lagoons. *Trachelomonas* spp. were sometimes recorded at either St. 2 and seldom present at St. 1 in lagoons.

Only one species from Cryptophyta (*Cryptomonas ovata*) was identified in lagoon Balik but was not observed in lagoon Uzun. Xanthophyta was represented by three species (*Goniocloris mutica, G. fallax* and *Ophiocytium cochleare*).

A similar distribution pattern of epipelic algal flora in both lagoons were observed according to results of the counting method which was also supported by cluster and MDS analyses. No significant differences among sampling stations in respect of environmental parameters and prevailing physico-chemical factors on epipelic algal community were found to be temperature, conductivity and nitrate-nitrite concentrations during the sampling period. In spite of similar physico-chemical characteristics and akin distributional patterns between Balik lagoon and Uzun lagoon, epipelic cell density in Uzun lagoon was much higher than the cell density in Balik lagoon. This, to the authors' opinion, may be because of differences in agricultural activities (various manuring processes with different origin, using different pesticides *etc*.) around lagoons and/or wastewater input discharging from human settlement area located near Uzun lagoon. It is concluded that the studies on epipelic algal flora together with the appliance of further ecometric statistical analyses biological data, can be good indicators in pollution monitoring, in discovery of new drinking water sources and fisheries industry and can fill the gaps in our knowledge of aquatic ecosystems.

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