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Epipelic Algal Flora in the Küçükçekmece Lagoon

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Abstract

This study on epipelic algal flora and its seasonal variations in the Küçükçekmece Lagoon, Turkey was carried out between May 2001 and June 2002. A total of 109 species were identified, most of which belonged to Bacillariophyta (64 taxa). Other taxa identified included members of Cyanophyta (26), Chlorophyta (13), Euglenophyta (5) and Phaeophyta (1). Bacillariophyta were dominant in terms of species number and abundance at five stations. The seasonality of epipelic algal flora was different at all stations. Lower total cell numbers were registered at St. 5. Pennate diatoms especially *Amphora* spp., *Navicula* spp., *Nitzschia* spp. and *Synedra* spp. were dominant during the sampling period. Cluster analysis was applied to the epipelic algal community and produced two major groups reflecting the importance of seasonal variation on the epipelic algal flora.

Keywords: epipelic algae, lagoon, Küçükçekmece Lake, Cluster analysis.

Küçükçekmece Lagünündeki Epipelik Alg Florası

Özet

Küçükçekmece lagünü epipelik alg florası ve mevsimsel değişimi üzerine olan bu araştırma, Mayıs 2001ve Haziran 2002 tarihleri arasında gerçekleştirilmiştir. Çoğunluğu Bacillariophyta (64 takson) divizyosuna ait olan toplam 109 tür belirlenmiştir. Diğer taksonlar Cyanophyta (26), Chlorophyta (13), Euglenophyta (5) ve Phaeophyta (1) üylerine aittir. Bacilllariophyta tür sayısı ve bolluğu bakımından beş istasyonda dominant olmuştur. Daha düşük organizma sayılarına 5. istasyonda rastlanmıştır. Pennat diyatomelerden özellikle *Amphora* spp., *Navicula* spp., *Nitzschia* spp. ve *Synedra* spp. örnekleme süresince dominant olmuştur. Kümeleme analizi epipelik alg kommunitesine uygulanmış ve epipelik alg florası üzerine mevsimsel değişimin etkisini gösteren iki büyük grup oluşmuştur.

Anahtar Kelimeler: epipelik alg florası, lagün, Kümeleme analizi, Küçükçekmece gölü.

Introduction

Lagoons are important ecosystems in terms of ecology and economy. These habitats are highly dynamic and productive shallow ecosystems (Barnes, 1980; Abreu *et al.*, 1994). Because of nutrients carried by rivers, their net primary productivity ranges among the highest measured are in nature and consequently, fish production is very high in these habitats (Kocataş, 1994). Benthic microalgae are recognised as important primary producers in shallow aquatic systems (Underwood *et al.*, 1990; Macintyre *et al.*, 1996). Most studies carried out in freshwater benthic systems focus on epilithic or epiphytic algae growing on hard substrates (McCormic and Stevenson, 1991; Kann, 1993; Hillebrand and Kahlert, 2001). In contrast, studies on epipelic algae or epipsammon communities are rare (Khondker and Dokulil, 1988; Cyr, 1998; Nozaki *et al.*, 2003). Benthic algal communities have been used to assess environmental conditions and the ecological integrity of streams and rivers for over 50 years (Stevenson and Smol, 2002).

The Küçükçekmece Lake is a lagoon that is connected with the Marmara Sea via a narrow channel in Turkey. Formerly the water of the lake was saline then it turned to freshwater by the river discharges. Now it is separated from the sea by a set. The lagoon has shown some sign of eutrophication, such as cyanobacterial blooms and deterioration in water quality from late spring to mid-autumn (Albay *et al*., 2005). Eutrophication is gradually increasing (Topçuoğlu *et al*., 1999) because of unplanned urbanization around the lake, heavy nutrient inputs and untreated industrial waste. At present, the lagoon is used only for fishing and for recreational purposes.

Diatoms can also be classified according to their salinity tolerance (Snoeijs and Vilbaste, 1994; Snoeijs and Potapova, 1995; Munda, 2005). In the study area there was a wide spectrum of ecologically different types, freshwater, brackish and even marine affinities.

This study was aimed at providing first baseline information on the abundance and seasonal variations of epipelic algal commun0ities in the Küçükçekmece Lagoon.

Materials and Methods

Study Site

Küçükçekmece Lake, situated in the western part of the city of Istanbul (41º00' N-28º43' E) and has a surface area of 15.22 km^2 and a maximum depth of 20 m (Figure 1). The lagoon is fed by three small rivers the Nakkaş River, the Ispartakule River and Sazlıdere (Oktay and Eren, 1994).

The climate regime of the area is a subtropical type of Mediterrenean macroclimate. In this region, the average annual temperature from 1990 to 2000 was 14.4ºC, the annual average rainfall was 666.8 mm (Anonymous, 2000).

Station 1 is situated on the west of lagoon was covered with small-grained clay and sandy sediments. Station 2 is situated in the southwest of the lake and covered with gravel and pebble. Station 3 is situated in the south of the lagoon and is connected with the Marmara Sea via a narrow channel. This station is covered by clay sediments. Station 4 is on the east of the lake. This area of the lake was filled site with rocks and stones. Station 5 is situated in the north and protected side of the lagoon as a small bay. *Ulva* sp. and *Enteromorpha* sp. were important in this region of the lagoon (Figure 1).

The algal community was sampled from five sites at biweekly intervals from May 2001 to June 2002. The algal community was sampled by means of a glass tube 0.8 cm in diameter and 1 meter in length. The pipe was moved in a circular direction over the surface of sediment, releasing the tumb to take up seddiment. Samples were transferred into plastic bottles and fixed with 5% formalin. At least three water-mounted slides were examined for algae and living diatoms from every station to obtain an estimate of algal relative abundance (Round, 1953; Sládećková, 1962). At least 600 algal cells were counted at 600x 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. Slurries were rinsed several times in distilled water until neutral pH was reached. On a slide warmer, slurries were dried overnight on coverslips, and permanent slides for identification of diatoms were prepared from the mounted microscope slides using Naphrax high refractive index medium (Round, 1953). Identifications were carried out at 1000x magnification under immersion oil.

Taxonomic identifications were performed according to Komárek and Anagnostidis (1986; 1989; 1999), Anagnostidis and Komárek (1988); Krammer and Lange-Bertalot (1991a; 1991b; 1999a; 1999b), John *et al*. (2003).

The epipelic algal community data were analysed by cluster analysis (complete linkage method). This technique was applied to Bray-Curtis' dissimilarity matrices computed on abundance values with Biodiversity Professional 2.0.

Results

A total of 116 algal species were identified, most of which belonged to Bacillariophyta (64 taxa). Other taxa identified included members of Cyanophyta (26), Chlorophyta (13), Euglenophyta (5) and Phaeophyta (1). The list of species is given in Table 1.

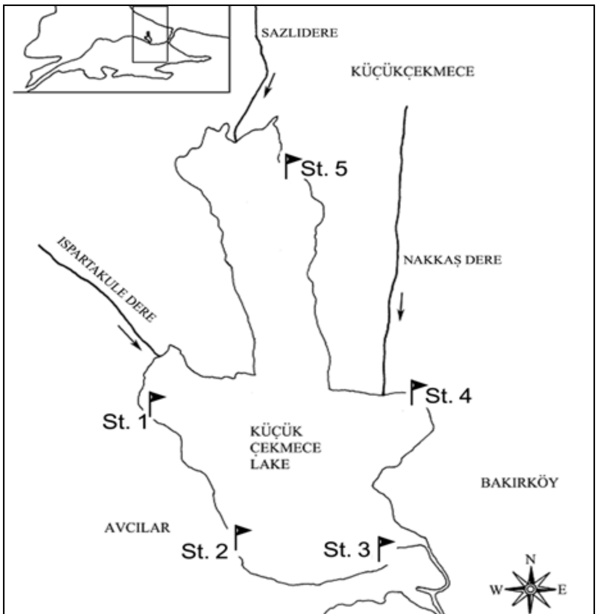

Figure 1. Lake Küçükçekmece with sampling stations.

Table 1. The list of algae present in the epipelon

CYANOPHYTA	BACILLARIOPHYTA
Chrooccoccales	**Pennales (*Continued*)**
Aphanocapsa sp.	*Fragilaria fasciculata* (C. Agardh) Lange-Bertalot
Chroococcus limneticus Lemmerman	*Fragilaria ulna* (Nitzsch) Lange-Bertalot var. *oxyrhnynchus* (Kützing) Van Heurck
Coelosphaerium kuetzingianum Naegeli	*Geissleria acceptata* (Hustedt) Lange-Bertalot & Metzeltin
Merismopedia affixa Richter	*Gomphonema angustatum* (Kützing) Rabenhorst
Merismopedia glauca (Ehrenberg) Naegeli	*Gyrosigma acuminatum* (Kützing) Rabenhorst
Merismopedia punctata Meyen	*Gyrosigma fasciola* (Ehrenberg) Griffith et Henfrey
Merismopedia tenuissima Lemmermann	*Gyrosigma obscurum* (W. Smith) Griffith et Henfrey
Microcystis aeruginosa Kutzing	*Gyrosigma peisoneis* (Grunow) Hustedt
Hormogonales	*Gyrosigma scalproides* (Rabenhorst) Cleve
Jaaginema kuetzingianum (Nägeli) Anagnostidis & Komárek	*Navicula amphibola* Cleve
Jaaginema pseudogeminatum (G.Schmid) Anagnostidids & Komarek	*Navicula cryptonella* Lange-Bertalot
Jaaginema quadripunctatum (Brühl & Biswas) Anagnostidis & Komarek	*Navicula exiqua* (W. Gregory) Grunow
Komvophoron constrictum (Szafer) Komárek & Anagnostidis	*Navicula gregaria* Donkin
Limnothrix planctonica (Woloszynska) Meffert	*Navicula exiqua* (W. Gregory) Grunow
Oscillatoria obtusa Gardner	*Navicula radiosa* Kützing
Oscillatoria princeps (Vaucher) Gomont	*Navicula radiosa* var. *tenella* Grunow
Oscillatoria subbrevis Schmidle	*Navicula ramosissima* (Agardh) Cleve
Phormidium chalybeum (Mertens ex Gomont) Anagnostidis & Komárek	*Navicula salinarum* Grunow
Phormidium formosum (Bory de saint-Vincent) Anagnostidis & Komárek	*Navicula tripunctata* (O. F. Müller) Bory
Phormidium granulatum (Gardner) Anagnostidis	*Navicula tripunctata* var. *schizomenoides* (Van Heurck) Patrick
Phormidium limosum (Dillwyn) P.C.Silva	*Nitzschia commutata* Grunow
Phormidium tergestinum (Kützing) Anagnostidis & Komárek	*Nitzschia keutzingiana* Hisle
Planktolyngbya limnetica (Lemmermann) Komarkova-Legnerova & Cronberg	*Nitzschia thermalis* Kützing
Pseudanabaena catenata Lauterborn	*Pinnularia* sp.
Pseudanabaena limnetica (Lemmermann) Komarek	*Pleurosigma elongatum* W. Smith
Spirulina sp.	
Tychonema bornetii (Zukal) Anagnostidis & Komárek	*Pleurosigma salinarum* Grunow
	Surirella minuta Brébisson in Kützing
BACILLARIOPHYTA	*Surirella striatula* Turpin
Centrales	*Synedra fasciculata* Ehrenberg var. *truncata* (Greville) Pantocsek
Aulacoseira granulata (Ehrenberg) Simonsen	*Tabularia fasciculata* (C.Agardh) Williams & Round
Aulacoseira italica (Ehrenberg) Simonsen	*Tryblionella angustata* W. Smith
Coscinodiscus excentricus Ehrenberg	*Tryblionella hungarica* (Grunow) Frenguelli
Cyclotella meneghiniana Kützing	*Ulnaria ulna* (Nitzsch) P.Compére in Jahn et al.
Cyclotella ocellata Pantocsek	**CHLOROPHYTA**
Cyclotella radiosa (Grunow) Lemmermann	**Volvocales**
Melosira moniliformis (O.F. Müller) Agardh	*Eudorina elagans* Ehrenberg
Melosira nummuloides (Dilwyn) Agardh	*Pandorina morum* (O.F.Müller) Bory
Melosira varians Agardh	**Chlorococcales**
Paralia sulcata (Ehrenberg) Cleve	*Ankistrodesmus* sp.
Pleurosira laevis (Ehrenberg) Compére	*Monoraphidium* sp.
Pennales	*Oocystis* sp.
Achnanthes brevipes Agardh var. *brevipes*	*Pediastrum duplex* Meyen
Achnanthes brevipes var. *intermedia* (Kützing) Cleve	*Scenedesmus intermedius* Chodat
Achnanthes clevei Grunow var. *rostrata* Hustedt	**Ulotricales**
Achnanthes houckiana Grunow var. *rostrata* Shultz	*Cylindrocapsa* sp.
Achnanthes lacunarum Hustedt	*Enteromorpha* sp.
Achnanthes parvula Kützing	*Ulothrix* sp.
Amphora coffeaeformis (Agardh) Kützing	*Ulva* sp.
Amphora commutata Grunow	**Cladophorales**
Amphora ovalis (Kützing) Kützing	*Cladophora* sp.
Amphora pediculus (Kützing) Grunow	**Zygnematales**
Amphiprora costata W. Smith	*Spirogyra* sp.
Astartiella welsiae (Reimer) Witkowski et Lange- Bertalot	**EUGLENOPHYTA**
Caloneis amphisbaena (Bory) Cleve	**Euglenales**
Catacombus gaillonii (Bory) D.M.Williams & Round	*Euglena gracilis* Klebs
Ceratoneis closterium Ehrenberg	*Euglena sanguinea* Ehrenberg
Cocconeis pediculus Ehrenberg	*Euglena subehrenbergii* Skuja
Cocconeis placentula Ehrenberg var. rouxii (Héribaud et Brun) Cleve	*Lepocinclis* sp.
Entomoneis costata (Hustedt) Reimer	*Trachelemonas intermedia* Dangeard
Fallacia cryptolyra (Brockmann) Stickle & Mann in Round, Crawford & Mann	**PHAEOPHYTA**
Fallacia cryptolyra (Brockmann) Stickle & Mann in Round, Crawford & Mann	**Ectocarpales**
Fragilaria capucina Desmaziérez var. *vaucheriae* (Kützing) Lange-Bertalot	*Ectocarpus siliculosis* (Dillwyn) Lyngbye

Seasonal variation in the total cell number of epipelic algae was different among stations. Total cell numbers were rather low at St. 5. Highest densities were observed at St. 1 (296974 cells per cm^2) in June, lowest at St. 1, St. 3 and St. 4 in January 2002. Cyanophyta reached their maximum level in June 2001 (102215 cells per cm^2) and in June 2002 (274207 cells per cm^2) at St. 1. *Merismopedia* comprised 92% and 83% of the overall assemblage in June 2001 and June 2002, respectively. The highest contribution of Bacillariophyta to total cell numbers was on March 17 in St. 1. *Navicula* comprised 97% of total cell number in that month. The seasonal variations of Chlorophyta and Euglenophyta were rather low, comparatively to those of Bacillariophyta and Cyanophyta (Figure 2).

Amphora spp. and *Nitzschia* spp. were recorded at all dates and at all sampling stations and *Oscillatoria* spp. were always found in St. 3. The same species were usually found in St. 4 and St. 5.

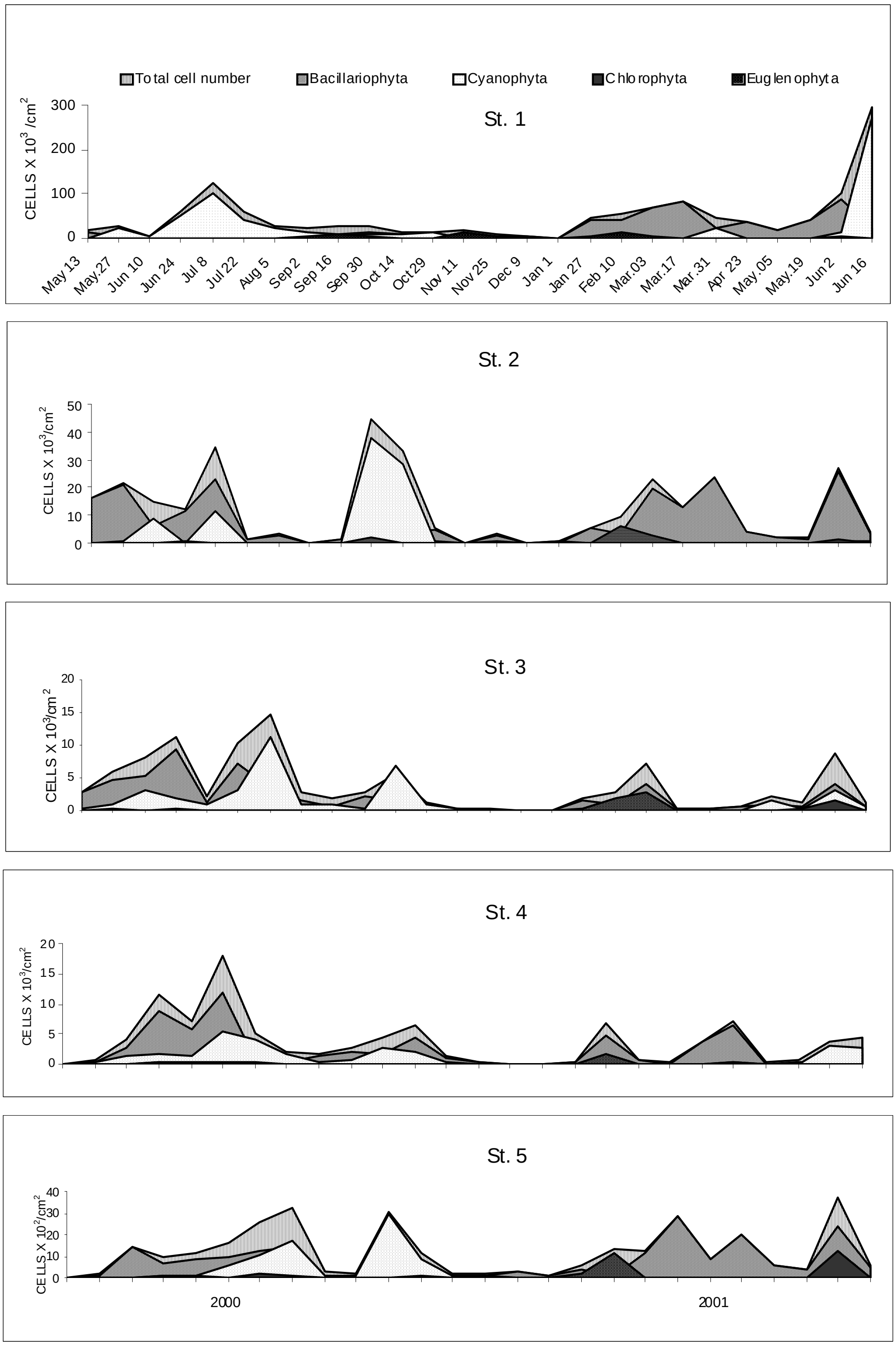

Figure 2. The seasonality of epipelic algae at the sampling stations.

Pleurosira laevis (Ehrenberg) Compére, *Coscinodiscus excentricus* Ehrenberg, *Entomoneis costata* (Hustedt) Reimer, *Ceratoneis closterium* Ehrenberg, *Surirella* spp., *Chroococcus limneticus* Lemmermann, *Coelosphaerium kuetzingianum* Naegeli, *Microcystis aeruginosa* Kützing, *Lyngbya* sp., *Eudorina elegans* Ehrenberg, *Pandorina morum* (O.F.Müller) Bory, *Pediastrum duplex* Meyen, *Ectocarpus siliculosis* (Dillwyn) Lyngbye were rare at all sampling stations.

The diagram obtained by cluster analysis indicates that at the lowest hierarchical level, two clusters are clearly separated at St. 1 (Figure 3). The first one is formed by a winter sample (January 1).

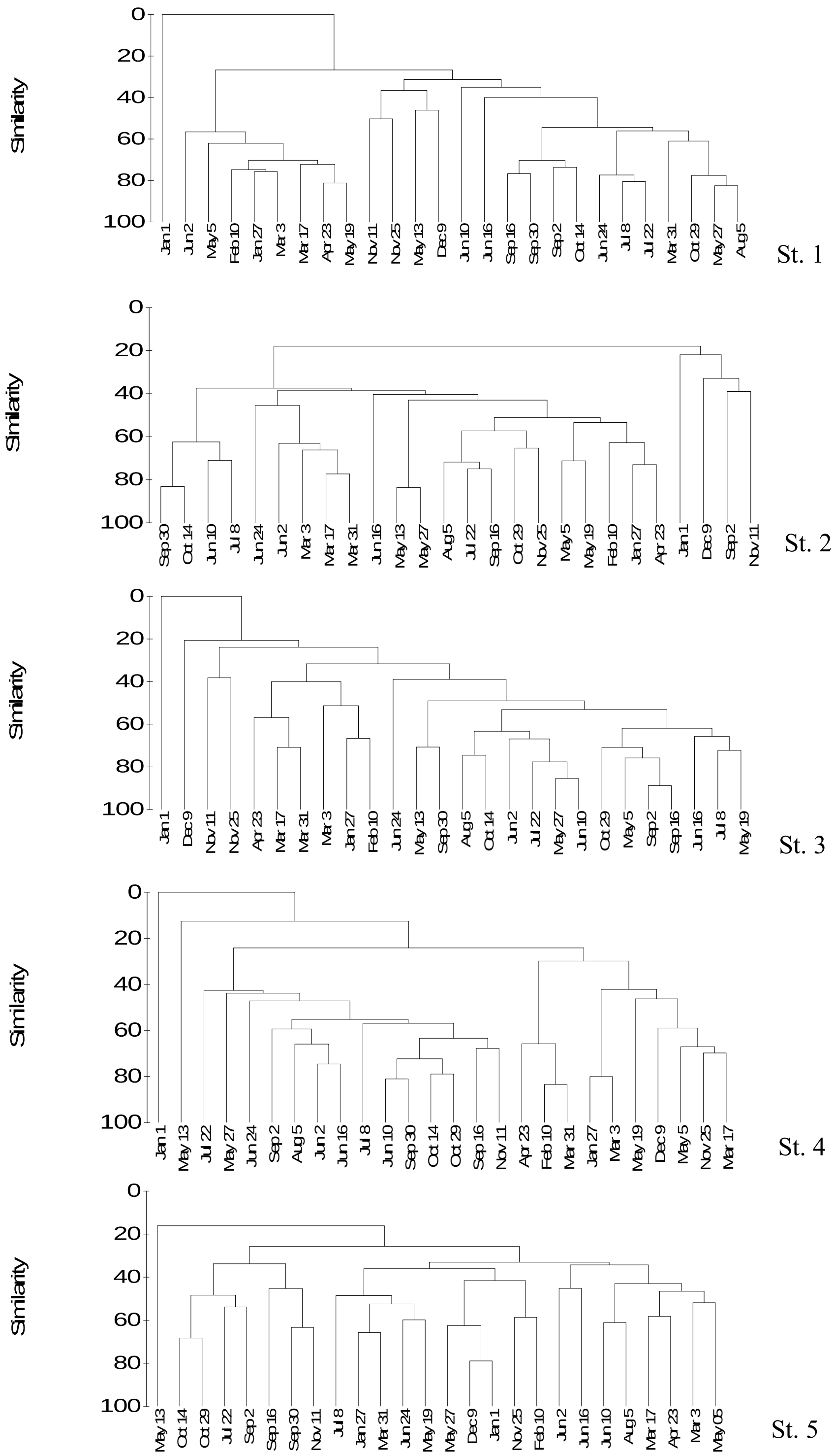

Figure 3. Dendrograms using complete linking of Bray-Curtis similarities at the five stations in Küçükçekmece Lagoon, calculated from cell number data during 2000–2001.

The second group is a large cluster formed by all the other samples. In St. 2, two clusters are separated at the lowest hierarchical level. The first group is formed by all season samples. The second group includes winter and autumn samples characterized by an absolute decline in total cell numbers. The association between May 13 and May 27 samples is most significant. Two clusters are clearly separated at the lowest hierarchical level in St. 3. The first one is formed by only January 1 samples. The second group is a large cluster formed by all season samples. The association between September 2 and September 16 is most significant, with bonds to May 5, and to a lesser degree, October 29. In St. 4 a cluster diagram was constitued by two assemblages at the lowest hierarchical level. The first group includes only winter sample (January 1). The second group is formed by all season samples. In St. 5 a cluster diagram constitued by two assemblages. The first group is formed by only spring sample (May 13) and characterized by the low total cell numbers. The second group is formed by all season samples. The association between December 9 and January 1 is most significant with bonds to May 27.

Discussion

The seasonal development of epipelic algae is strictly associated with temporal variations of some important environmental factors. It is known that during winter, low algal growth is due to low irradiance and water temperature, as well as to the dilution of algal cells along the water column. Generally algal densities were high in spring and summer while algal number decreased in autumn and winter. Epipelic algae community showed a clear decrease at all stations in December and January. Despite substantial research into relationships between diatoms and temperature, studies have shown little evidence of direct temperature control over diatoms (Anderson, 2000). The winter diatom decrease could be related to increased rainfall. Monthly average rainfall reached its highest levels in December (102.4 mm and 73.6 mm) when average water temperature reached its lowest level (5.1ºC and 6ºC).

In the Küçükçekmece Lagoon some marine species (*Pleurosira laevis* and *Paralia sulcata* (Ehrenberg) Cleve) that were not seen before in any Turkish lakes were registered. *Pleurosira laevis* and *Paralia sulcata* (Ehrenberg) Cleve were highly detected at St. 5 in June 2002 and St. 4 in October 2001, respectively. A halophilic species, *Amphora coffeaeformis* was common at all stations in the Küçükçekmece Lagoon. Although this species is defined as marine species by Round (1984), Patrick and Reimer (1966) stated that this species grew well in the brakish water, freshwater and soil where the conductivity is high. *Achnanthes brevipes* var. *intermedia*, a mesohalobien species (Patrick and Reimer, 1966) was registered at all stations in the Küçükçekmece Lagoon. It is stated that this species is found in eustarine systems and salt lakes (Krammer and Lange-Bertalot, 1991b).

Bacillariophyta were dominant in terms of species number and abundance throughout the year. Diatoms are the most common and diverse group of algae in freshwater and important components of ecosystems. These communities play an important role as primary producers in aquatic ecosystems. They have been extensively used as indicators of environmental change, e.g eutrophication, acidification, salinification, sea level change and land use change, because they have narrow optima and tolerance for many environmental variables. Pennate diatoms, especially *Amphora* spp., *Navicula* spp., *Nitzschia* spp. and *Fragilaria* spp. were dominant during the sampling period. The epipelic community in the littoral zone of the most lowland lakes is relatively homogenous, often being dominated by small *Fragilaria* taxa. These taxa take advantage of the favourable light conditions in the shallow water of littoral zones, but they are poor indicators of water quality having a broad tolerance to nutrient conditions (Bennion *et al*., 2001). Furthermore, diatom species that are facultatively heterotrophic (utilising various sources of DOC), may have a selective advantage under conditions of low irradiance caused by overlaying cells in a benthic mat or by bankside vegetation or turbid water (Hill, 1996) Such an ability has been demonstrated in two common benthic diatom genera, *Navicula* and *Nitzschia* (Admiraal and Peletier, 1979). The taxonomic composition of the sediment microflora in our study was almost exclusively restricted to diatoms, as typical of mesotrophic lakes (Aberle and Wiltshire, 2006). Mass occurences of green algae or cyanobacteria are known to be directly linked to high water column nutrient loadings (Aberle and Wiltshire, 2006). The lagoon has shown some sign of eutrophication, such as cyanobacterial blooms and deterioration in water quality from late spring to mid-autumn (Albay *et al.*, 2005). Eutrophication is gradually increasing (Topçuoğlu *et al.*, 1999) because of unplanned urbanization around the lake, heavy nutrient inputs and untreated industrial waste.

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