Cryptogamie, Algol., 2005, 26 (4): 373-385

Epipelic algal flora and seasonal variations of the River Yeşilırmak, Amasya, Turkey

*Elif Neyran SOYLU and Arif GÖNÜLOL**

Ondokuzmayıs University, Faculty of Arts and Science, Department of Biology, Samsun, Turkey

(Received 20 April 2004, accepted 24 November 2004)

Abstract – Between June 1999 and May 2000, the epipelic algal flora and its seasonal variations in the River Yeşilırmak were investigated. A total of 69 species were identified, most of which belonged to the Bacillariophyta. Other taxonomic groups present were Chlorophyta, Cyanoprokaryota and Euglenophyta. Pennate diatoms, especially *Nitzschia palea*, *Navicula cincta*, *N. cryptocephala*, *Amphora ovalis* and *Fragilaria ulna*, were the most abundant species, with species of centric diatoms found in lower numbers. Cyanoprokaryotes (*Cylindrospermum stagnale* and *Oscillatoria* spp.) and Euglenophytes (*Euglena deses* f. *major* and *E. satelles*) were also common. The epipelic algal flora and its seasonal variations were similiar at all stations, with the greatest number of species observed in July, September and October. A decrease in the number of algae due to rainfall was observed at all stations. Cluster analysis was applied to the epipelic algal community.

Epipelic freshwater algae / river / indicator / seasonal variation / cluster analysis

Résumé – La flore algale épipélique de la rivière Yeşilırmak (Amasya, Turquie) et ses variations saisonnières. Entre juin 1999 et mai 2000, la flore algale épipélique et ses variations saisonnières ont été étudiées dans le fleuve Yeşilırmak. 69 espèces d'algues, des Bacillariophytes en majorité, ont été identifiées. Les autres espèces appartiennent aux Cyanoprokaryotes, Chlorophytes et Euglenophytes. Parmi les Diatomées, les espèces centriques sont peu nombreuses dans le fleuve Yeşilırmak, alors que les espèces pennées sont abondantes, surtout *Nitzschia palea*, *Navicula cincta*, *Navicula cryptocephala*, *Amphora ovalis* et *Fragilaria ulna*. Des Cyanoprokaryotes (*Cylindrospermum stagnale* et *Oscillatoria* spp.) et des Euglenophytes (*Euglena deses* f. *major* et *E. satelles*) ont aussi été trouvées assez fréquemment. La flore algale épipélique et ses variations saisonnières sont semblables dans toutes les stations, avec le plus grand nombre d'espèces observé aux mois de juillet, septembre et octobre. Une diminution du nombre d'algues, due aux précipitations, a été observée dans toutes les stations. Une analyse par groupement a été appliquée à la communauté algale épipélique.

INTRODUCTION

Turkey has many rivers, but very little is known about their algal floras. Studies of the composition of algal populations are important for environmental assessment of freshwater bodies and monitoring of aquatic systems. However,

* Correspondence and reprints: enkutluk@omu.edu.tr; agonulol@omu.edu.tr
Communicating editor: Pierre Compère

before algae can be used as indicators of water quality (e.g., as part of the biological monitoring requested by the European Water Framework Directive), investigations of the species composition are necessary. In recent years, studies on the Turkish planktonic algal flora have increased, but, in contrast, the picture of the riverine epipelon is less clear. The main aims of this study were to contribute to the documentation of the largely unknown epipelic algal flora of Turkey, and to determine the community structure and seasonal variations of the epipelon in the River Yeşilırmak.

Studies on the algae of the River Yeşilırmak were first undertaken in the city centre of Tokat. In these studies the diatom flora (Altuner & Pabuçcu, 1996), the planktonic algal flora (Pabuçcu & Altuner, 1998) and the benthic algal flora (Pabuçcu & Altuner, 1999) were investigated. Seasonal variations of phytoplankton were investigated in the city centre of Amasya (Soylu & Gönülol, 2003). In addition, the algal flora and ecology of the Suat Uğurlu Dam lake (Yazıcı & Gönülol, 1994), and the algal flora and seasonal variations of the Hasan Uğurlu Dam lake (Gönülol & Obalı, 1998), which was built on the River Yeşilırmak, were also investigated.

It is well known that diatoms are sensitive to a wide range of limnological and environmental variables, and that their community structure may quickly respond to changing physical, chemical and biological conditions in the environment (Mooser *et al.*, 1996). Due to their siliceous cell walls they can be easily sampled and preserved, hence providing a permanent record against which to assess short- or longterm change (Cox, 1991; Smol, 1992; Jüttner *et al.*, 1996). Also, their taxonomy is well known and their responses to pollutants appears to be consistent in different geographical regions (Kawecka, 1981; Sabater *et al.*, 1987; Nather Khan, 1991; Katoh, 1991; Rushforth & Brock, 1991, Jüttner *et al.*, 1996). Their ubiquitous distribution in the aquatic environment and responsiveness to water quality have made diatoms a popular biological indicator of river health in Europe and North America, and increasingly in Australia. In Central Europe, the use of algae for monitoring water quality has a very long tradition and recently algae have begun to be used for this purpose worldwide. Algal indicators are effective monitoring tools. If chemical monitoring is limited, the use of diatoms for monitoring will be invaluable in remote locations subjected to pronounced change (Jüttner *et al.*, 1996).

MATERIALS AND METHODS

Study Area

The River Yeşilırmak originates at an altitude of 2801m on the western slope of Mount Köse, and after a 519 km run flows into the Black Sea over the plain of Çarşamba-Samsun. Kelkit, Çekerek, Mecitözü and Tersakan are tributaries of the River Yeşilırmak. Water input is mostly from precipitation and underground water. The average annual flow rate is 182,8 m^3 / s. The river basin covers an area of approximately 35958 km^2 and includes various deposits of different ages. These deposits are the tertiary sediments, crystaline sediments and alluvional deposits (Tekin, 1997).

The climate regime of the area is characterised by the transition from the climate of the Middle Black Sea Region to that of Central Anatolia. The data used were obtained from the meteorological station in Amasya. In Amasya the average annual temperature from 1967 to 1999 was 13.9°C; the average minimum temperature was −0.6°C (December). The annual average rainfall was 397.5 mm (Anonymous, 2000).

The rivers and streams of the Yeşilırmak plain are subjected to the impact of agriculture and industrial activities. The most important stresses on rivers and streams in the Yeşilırmak plain are organic enrichments (discharge of untreated sewage), nutrients, heavy metals, pathogenic agents, pesticides, herbicides and physical changes produced by canalisation.

The three sites sampled are shown on Fig. 1. The water depth did not exceed one metre except in rainy seasons at all stations. Station 1 is situated about 2 km from the city centre towards Tokat. It is covered with thin sandy sediments. The River Yeşilırmak receives lower loads of pollutants in this station since it is located in an area with a low density of population and low industrial developments, but agricultural runoff influences the River Yeşilırmak. Station 2 is within Amasya city centre, near the city stadium. Population densities are high and sewage discharges directly into the river. The sampling area is covered with bushy trees and the ground is shaded. Station 3 is in the centre of Amasya, near a bridge

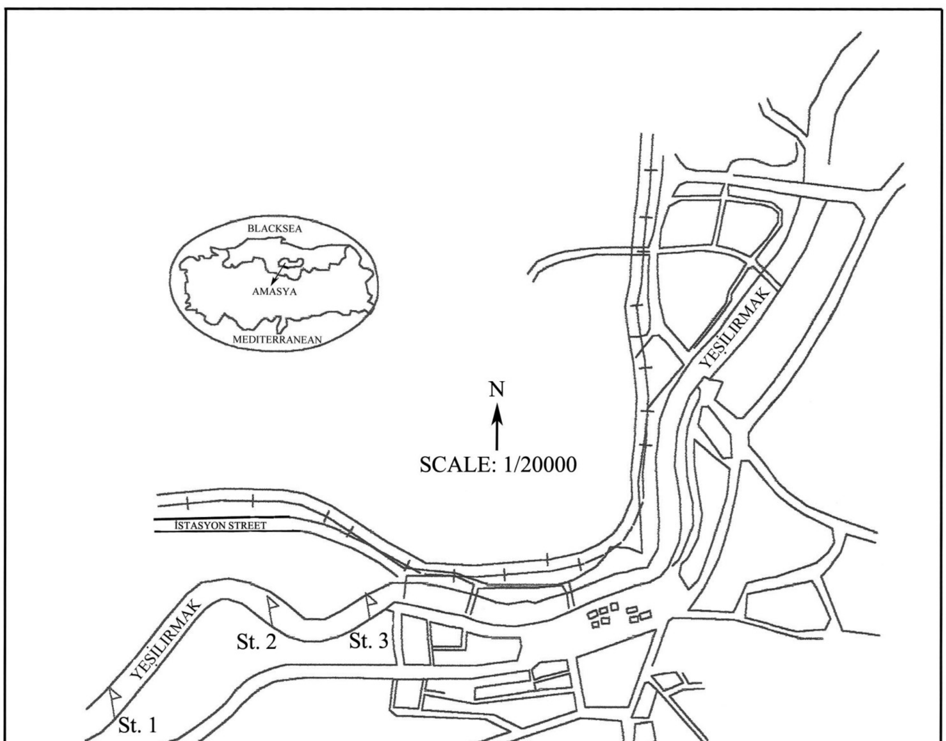

Fig. 1. Location of the study site, the River Yeşilırmak at Amasya, Turkey.

in İstasyon Street. There are fruit trees on both sides of the river and clayey-sandy silt. Population densities are high. As Jenkins *et al.* (1995) and Jüttner *et al.* (1996) point out, untreated seawage input leads to organic enrichment and deoxydation and agricultural run off from fertilizers increases nutrient loadings.

The three stations along the river were sampled monthly between June 1999 and May 2000. The algal community was sampled by means of a glass tube 0.8 cm in diameter and 1 metre in length. The pipe was moved in a circular direction over the surface of sediment, releasing the tumb to take up sediment. Samples were transferred into plastic bottles and fixed with 5% formalin. Prior to counting the samples were homogenized at low speed until the sediment was througly mixed and was of uniform consistency. 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; Sládečkova, 1962). At least 600 algal cells were counted at 600 × 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). Identifications were carried out at 1000× magnification.

Taxonomic identifications were performed following John *et al.* (2003), Krammer & Lange-Bertalot (1986; 1991a, b; 1999); Komárek & Anagnostidis (1986, 1989, 1999); Anagnostidis & Komárek (1988); Komárek *et al.* (1998); Huber Pestalozzi (1969, 1972).

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. Square root transformation of the original data was applied to reduce the weight of the most abundant species. The cluster analysis was performed with BioDiversity Professional 2.0.

RESULTS

A total of 69 species of epipelic algae was found: 45 Bacillariophyta, 11 Cyanoprokaryota, 7 Euglenophyta and 6 Chlorophyta. The list of species is given in Table 1. The environmental variables are shown in Table 2. The sampling sites were considered as a whole and the minimum, maximum and average values are listed.

Diatoms dominated the epipelic algae. The greatest number of diatoms was observed in autumn (October and December at St. 3 with 33 species, October and November at St. 2 with 31 species, October at St. 1 with 29 species). The lowest richness was observed at St. 1 and St. 2 in June, at St. 3 in May. The number of diatom species was high, especially in July, September and October. The number of Cyanoprokaryota species started to increase at St. 1 and St. 3 in October, at St. 2 in November. The species richness of other divisions did not show seasonal variation.

Total cell number of epipelic algae community showed different seasonal trends at the different sampling stations (Fig. 2). Until October, St. 2 and St. 3 were similar, but then there was an increase in the number of species at St. 2, against a decrease at St. 3. While maximum numbers were observed at St. 2 and St. 3 (139095 and 84666 cells per cm^2, respectively) in September, a minimum number was found at St. 1 (334 cells per cm^2) in June. Peaks of epipelon were recorded during summer and winter in St. 1 (June and October). Total cell number reached

Table 1. List of algae present in the epipelon and their occurrence at the stations.

	St.1	*St. 2*	*St.3*
Bacillariophyta			
Achnanthes lanceolata (Brėb.) Grun.	+	+	+
Amphora ovalis Kütz.	+	+	+
Amphora veneta Kütz.	+	+	+
Cocconeis pediculus Ehr.	+	+	+
Cocconeis placentula Ehr.	+	+	+
Cymatopleura solea (Brėb.) W. Smith	+	+	+
Cymbella affinis Kütz.	+	+	+
Cymbella cymbiformis C.Agardh		+	
Cymbella ventricosa C.Agardh		+	+
Diatoma vulgaris Bory			+
Diploneis ovalis (Hilse) Cleve		+	
Fragilaria ulna (Nitz.) Lange-Bertalot	+	+	+
Fragilaria ulna var. *acus* (Kütz.) Lange-Bertalot	+	+	+
Gomphonema olivaceum (Horn.) Brėb. var. *olivaceum*	+	+	+
Gomphonema parvulum (Kütz.) Grun.			+
Gyrosigma acuminatum (Kütz.) Rabenh.	+	+	+
Gyrosigma scalproides (Rabh.) Cleve	+	+	+
Melosira varians C. Agardh	+	+	+
Meridion circulare (Grev.) C.Agardh			+
Navicula capitata var. *hungarica* (Grun.) Ross	+	+	
Navicula cincta (Ehr.) Kütz.	+	+	+
Navicula capitatoradiata Germain	+	+	+
Navicula cuspidata Kütz. var. *cuspidata*	+	+	+
Navicula elginensis (Gregory) Ralfs	+		+
Navicula radiosa Kütz.	+	+	+
Navicula rhynchocephala Kütz.	+	+	+
Navicula tripunctata (O.F.Müll.) Bory	+	+	
Navicula veneta Kütz.	+	+	+
Nitzschia acicularis (Kütz.) W. Smith	+	+	+
Nitzschia amphibia Grun.	+	+	+
Nitzschia constricta (Nitz.) W. Smith	+	+	+
Nitzschia palea (Kütz.) W. Smith	+	+	+
Nitzschia sigmoidea (Ehr.) W. Smith	+		+
Nitzschia vermicularis (Kütz.) Hantzsch.	+	+	+
Oxyneis binalis (Ehr.) Round	+		
Pinnularia biceps W. Gregory	+		
Pinnularia brebissonii (Kütz.) Rabenh.	+	+	+
Rhoicosphenia curvata (Kütz.) Grun.		+	
Sellaphora pupula (Kütz.) Mereschowsky	+	+	+
Stauroneis smithii Grun.	+	+	
Surirella brebissonii Krammer & Lange-Bertalot var. *kuetzingii* Krammer & Lange-Bertalot	+	+	+
Surirella linearis W. Smith var. *helvetica* (Brun) Meister	+	+	+
Surirella ovalis Brėb.	+	+	

Table 1. List of algae present in the epipelon and their occurrence at the stations. *(suite)*

	St.1	*St. 2*	*St.3*
Chlorophyta			
Cosmarium lundellii Delp.	+	+	+
Spirogyra ellipsospora Transeau		+	+
Spirogyra varians (Hass.) Kütz.			+
Tetraedron regulare Kütz.			+
Ulothrix subtilissima Rabenh.		+	+
Cyanoprokaryota			
Anabaena catenula (Kütz.) Born. et. Flah.	+	+	+
Anabaena sp.	+		
Cylindrospermum stagnale (Kütz.) Born. et Flah.	+	+	+
Jaaginema lemmermannii (Woloszynska) Anagnostidis & Komárek	+	+	+
Merismopedia glauca (Ehr.) Naeg.		+	
Oscillatoria curviceps C. Agardh ex Gomont	+	+	+
Oscillatoria guttulata Van Goor	+	+	+
Phormidium acutissimum (C. Agardh ex Gomont) Anagnostidis & Komárek	+	+	+
Phormidium tenue (Gomont) Anagnostidis & Komarek	+	+	+
Pseudanabaena limnetica Lemmerm.	+	+	+
Spirulina major (Kütz.) Gomont	+	+	+
Euglenophyta			
Euglena deses f. *major* Popowa	+	+	+
Euglena minuta Prescott	+	+	+
Euglena satelles Brasl.-Spect.	+	+	+
Euglena pseudoviridis Chod.	+		+
Euglena viridis Ehr.	+	+	+
Phacus acuminatus A. Stokes		+	+
Phacus arnoldii Swir.		+	+

Table 2. Variation of the most important environmental characteristics in the river River Yeşilırmak at Amasya. This table was based on the data taken by Tekin (1997).

Variable	*Minimum*	*Maximum*	*Average*
Dissolved O_2 (mg l^{-1})	3.7	9.6	6.6
pH	7.3	8.6	7.9
Conductivity (µS cm^{-1})	600	1700	1150
Alkalinity (mg l^{-1} $CaCO_3$)	140	610	375
Ca^{2+} (mg l^{-1})	51.2	142.4	96.8
Mg^{2+} (mg l^{-1})	8.2	63.6	35.9
PO_4^{3} (mg l^{-1})	0.07	1.18	0.62
NH_3-N (mg l^{-1})	0.01	3.38	1.69
SO_4^{2-} (mg l^{-1})	224.5	453.5	339
NO_3^- (mg l^{-1})	5.5	29.6	17.5

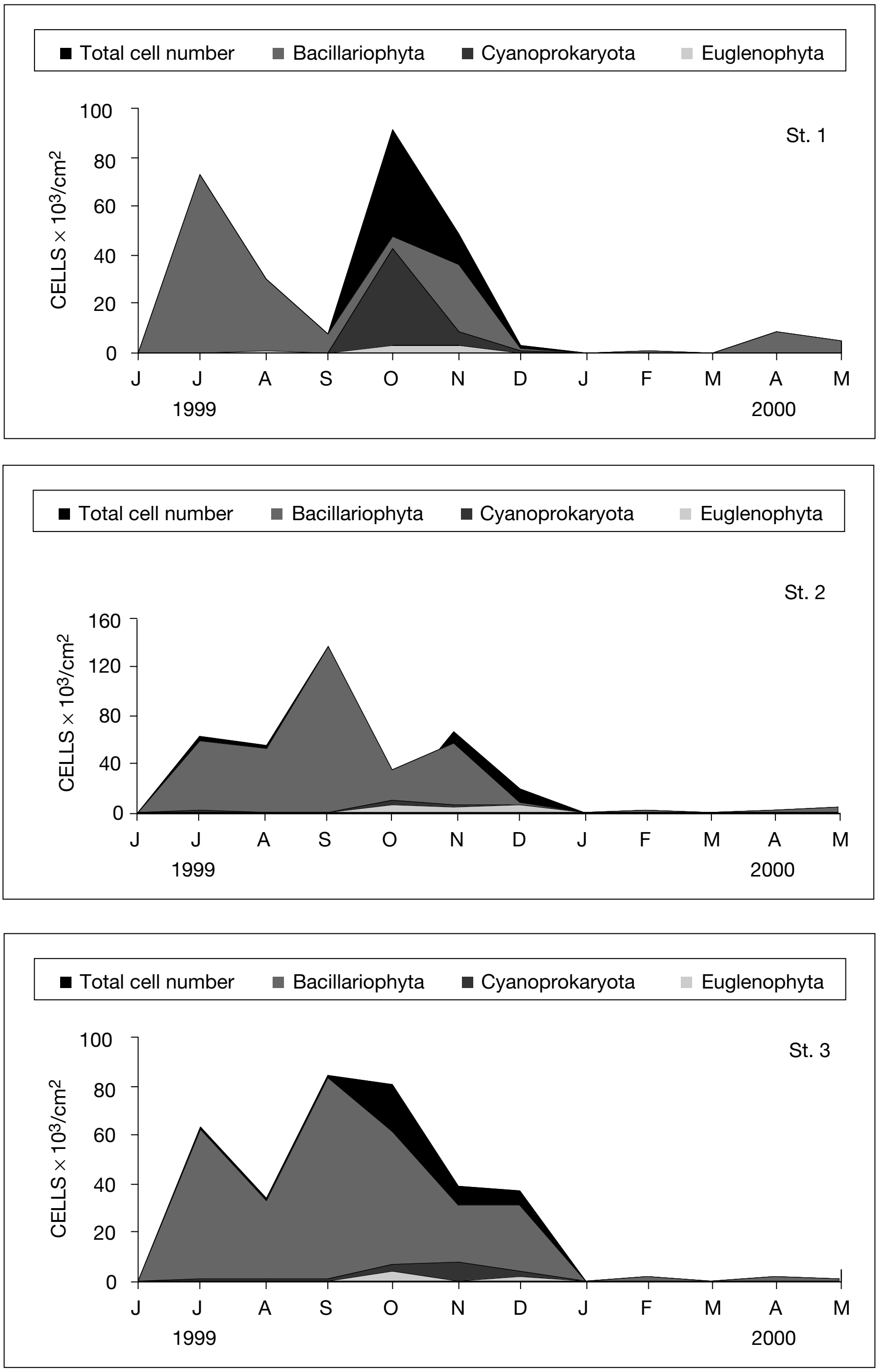

Fig. 2. Temporal, spatial variations in the total cell number (cells/cm^2) of epipelic algae and comparison of epipelon composition at three sampling sites of the River Yeşilırmak.

the highest level at St. 2, with 139095 cells per cm^2 in September. Bacillariophyta comprised 99.8% of the overall assemblage. Cyanoprokaryota reached its maximum level (5450 cells per cm^2) in St. 1, comparatively to the Bacillariophyta in October. Euglenophyta showed small variations between September and January.

Navicula spp. and *Nitzschia* spp. were always recorded and *Fragilaria* spp. were usually found at all stations. *Amphora* spp. were usually found at St. 1, sometimes at St. 2 and St. 3. *Gyrosigma* spp., *Pinnularia* spp., *Cocconeis* spp., *Cymatopleura solea* and *Euglena* spp. were sometimes recorded at all sampling stations. *Melosira varians,* a centric diatom, and *Achnanthes lanceolata,* a pennate diatom, were found to be rare at the three sampling stations. Additionally *Amphora ovalis, Navicula rhynchocephala, Nitzschia constricta, Stauroneis smithii, Pinnularia brebissonii* were rare.

Nitzschia palea reached its highest relative abundance at St. 1, contributing 90.2% of all algae in July. While *Nitzschia palea* was dominant, *Navicula cincta*, *N. cryptocephala*, *Nitzschia amphibia* were subdominant at all stations in summer. Algal densities were rather low in February, March, April, May, and no algae were found in January and March due to rainfall.

Cosmarium spp. at St. 2 and *Ulothrix subtilissima* at St. 1 were scarce. *Cylindrospermum stagnale* reached highest relative abundance (31143 cells per cm^2) contributing 40% of the assemblage at St. 1 in October. This species was generally found at St. 1 but was rare at St. 2 and St. 3. *Anabaena* spp. and *Spirulina major* were sometimes found at St. 2.

The diagram obtained by cluster analysis indicates that at the lowest hierarchical level two clusters are clearly separated at St. 1 (Fig. 3). The first one is formed by summer, winter and spring samples by the absolute prevalance of *Nitzschia palea* and *Navicula cryptocephala.* The association between April and May samples is most significant, with bonds to February, and to a lesser degree, December. This group is characterized by the decline of *Cymatopleura solea* and *Gyrosigma acuminatum.* The second group includes summer and autumn samples and is characterized by the dominance of *Nitzschia palea* together with *Oscillatoria guttulata*. In St. 2 a cluster diagram was constitued by two assemblages at the lowest hierarchical level. The first one is formed by only summer samples, characterized by a high development of *Nitzschia palea.* The second group is a large cluster formed by all season samples and is characterized by the dominance of *Navicula cryptocephala, Navicula cincta* and *Nitzschia palea.* The associations between August and September, February and April samples are most significant. Two clusters are separated at the lowest hierarchical level in St. 3. The first group includes summer, winter and spring samples and is characterized by the dominance of *Nitzschia palea* together with *Navicula cincta.* The second one is formed by summer, autumn and winter by the absolute prevalance of *Nitzschia palea* and *Navicula cryptocephala.* The asssociation between November and December samples is most significant.

DISCUSSION AND CONCLUSIONS

In this study, community variation between habitats was not marked, and was confined to fluctuations in the relative abundances of a few species. The River Yeşilırmak was characterised by low abundance of epipelic algae during the sampling periods.

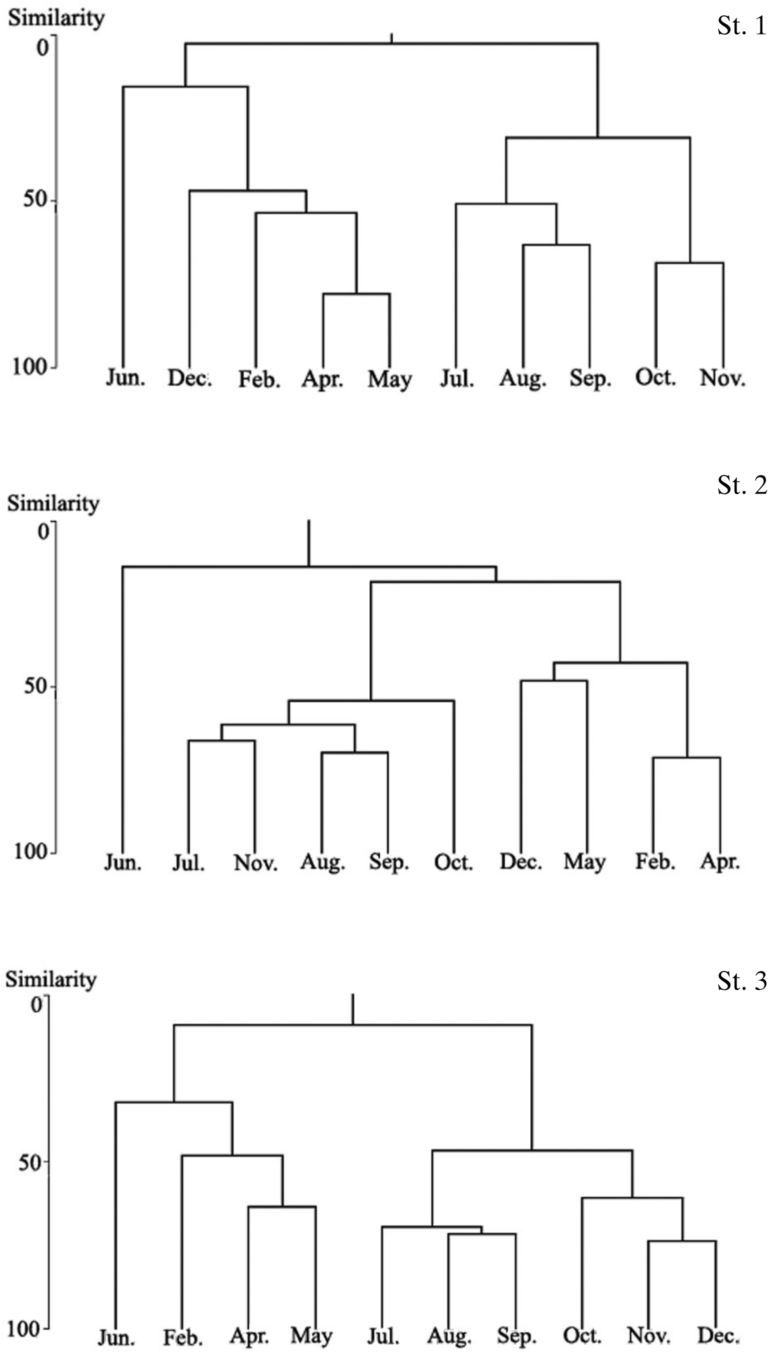

Fig. 3. Dendrograms for hierarchical clustering of the months samples in the River Yeşilırmak. The samples were clustered based on Bray-Curtis similarity using the complete linkage method in the period 2000-2001.

Diatoms were also dominant in the studies of other Turkish rivers (Altuner, 1988; Altuner & Gürbüz, 1989; Arslan & Gönülol, 1992; Altuner & Pabuçcu, 1996). Pennate diatoms were dominant, forming 65% of the epipelic algal flora. The most common species were *Nitzschia palea, Navicula cincta, N. rhynchocephala, N. cryptocephala* and *Cocconeis placentula.* Motile diatoms, such as *Nitzschia* and *Navicula,* are abundant in streams dominated by unstable substrata due to presence of disturbances, and thus can reflect sedimentation in streams (Bahls, 1993; Pringle, 1990; Stevenson & Pan, 1999). These species were also common in the River Karasu (Fırat) (Altuner & Gürbüz, 1990), Samsun-İncesu Stream (Arslan & Gönülol, 1992), the River Yeşilırmak (Tokat) (Pabuçcu & Altuner, 1998) and the River Çekerek (Pabuçcu & Altuner, 1999).

Similar seasonal variations were observed at the different stations where the benthic algal flora of the River Yeşilırmak (Amasya) was examined. Algal densities showed a clear decrease at all stations in December. This could be due to the monthly average rainfall reaching its highest level in December (42.8 mm) and the average temperature reaching its lowest level (6.3°C). In agreement with what has already been suggested by Claps (1996), a reduction in algal population after the spring floods could be seen. The epipelic algal flora of the River Yeşilırmak was affected in the same way by the flood in spring. Similar conditions were also observed in Karasu (Fırat) River (Altuner & Gürbüz, 1990) and Meram Stream (Yıldız, 1985). However, floods affected periphyton communities in different ways in a Pampean River in Argentina (Solari & Claps, 1996). In our study area two planktonic taxa (*Pseudanabaena limnetica* and *Anabaena catenula*) were found. As the river is shallow the habitats studied were readily mixed with each other. The same phenomenon was also observed in other rivers (Yıldız, 1987; Altuner & Gürbüz, 1989; Pabuçcu & Altuner, 1998).

The algal peak in autumn coincides with the one observed in the River Avon by Aykulu (1982) and in the River Samborombon by Claps (1996). Another algal peak was observed in summer.

Benthic algae are sensitive to environmental variation and thus their species composition should reflect major environmental patterns in this region (Pan *et al.*, 1996; Stevenson & Pan, 1999). Diatoms have been used as indicators of environmental conditions in streams (Kutka & Richards, 1996; Pan *et al.*, 1996; Stevenson & Pan, 1999). They have also been used as indicators of water pollution in Asian countries, such as Japan (Watanabe *et al.*, 1986; Lobo & Kobayasi, 1990; Katoh, 1991; Lobo *et al.*, 1995); Nepal (Jüttner *et al.*, 1996) and Malaysia (Nather Khan, 1991).

Nitzschia palea and *Fragilaria ulna* are common diatoms of polluted rivers in different regions of the world. *Nitzschia palea* and *Oscillatoria* spp. together indicate pollution (Palmer, 1980). In addition, it is suggested that *Oscillatoria* spp., which are indicators of pollution, are more prolific in polluted regions (Şen *et al.*, 1990). These species are found in our study area, and also in the River Yeşilırmak (Tokat) (Pabuçcu & Altuner, 1999) and the River Sakarya (Atıcı, 1997).

The cluster analyses revealed that St. 1 and St. 3 tended to have similar epipelon composition in terms of relative abundances of species. However, the cluster for both sampling stations showed that there is relative dissimilarity between sampling periods in the River Yeşilırmak. Only small groups of months presented similarity >60%. The importance of seasonal influence on the epipelon is confirmed when analyzing the groups formed in the cluster analysis. At all sampling stations, the monthly samples corresponding to each climate season cluster together. The relative spatial discontinuity in epipelon community structure of the

River Yeşilırmak could reflect a combination of environmental factors that characterize each sampling site; and could be explained mainly by the discharge of sewage and the degree of point or non point pollution.

REFERENCES

ALTUNER Z., 1988 — A Study of the diatom flora of Aras River, Turkey. *Nova Hedwigia* 46: 225-263.

ALTUNER Z. & GÜRBÜZ H., 1989 — Karasu (Fırat) Nehri fitoplankton topluluğu üzerinde bir araştırma. [A study on the phytoplankton of the Karasu (Fırat) River]. *İstanbul Üniversitesi Su Ürünleri Dergisi* 3(1-2): 151-176.

ALTUNER Z. & GÜRBÜZ H., 1990 — Karasu (Fırat) Nehri'nin epilitik ve epifitik algleri üzerine bir araştırma. [A study on the epilithic and epiphytic algae of the Karasu (Fırat) River]. X. Ulusal Biyoloji Kongresi, Erzurum, pp.193-203.

ALTUNER Z. & PABUÇCU K., 1996 — Yeşilırmak Nehri (Tokat) diyatome (Bacillariophyta) florası. [Diatom (Bacillariophyta) flora of the River Yeşilırmak (Tokat)]. 13. Ulusal Biyoloji Kongresi, İstanbul, Cilt V, Hidrobiyoloji Seksiyonu, pp. 266-276.

ANAGNOSTIDIS K. & KOMÁREK J., 1988 — Modern approach to the classification system of Cyanophytes. 3-Oscillatoriales. *Archiv für Hydrobiologie.* Suppl. 80, *Algological Studies* 80: 327-472.

ANONYMOUS, 2000 — Ministry of Agriculture and Forestry, Meteorological Bulletin, Mean and Extreme Temperature and Rainfall Values, Ankara, Turkey.

ARSLAN N. & GÖNÜLOL A., 1992 — Samsun İncesu Deresi'nin alg florası üzerinde araştırmalar. [Studies on the algal flora of the İncesu Stream, Samsun – Turkey]. *Doğa Turkish Journal of Botany* 16: 311-334.

ATICI T., 1997 — Sakarya Nehri Kirliliği ve Algler. [The pollution and the algae of the River Sakarya]. *Ekoloji Çevre Dergisi*, Temmuz-Ağustos-Eylül, 1997, sayı:24.

AYKULU G., 1982 — The epipelic algal flora of the River Avon. *British Phycolological Journal* 17: 27-38.

BAHLS L.L., 1993 — *Periphyton Bioassessment Methods for Montana Streams*. Helena, Montana, Water Quality Bureau, Department of Health and Environmental Sciences, 22 p.

CLAPS C., 1996 — Structure and dynamics of epipelic algae from a plain river (Samborombon River, Buenos Aires, Argentina). *Archiv für Hydrobiologie* 137: 251-263.

COX E.J., 1991 — "What is the basis for using diatoms as monitors of river water quality?" *In*: Whitton, B.A. *et al* (eds.), *The use of algae for monitoring rivers.* Austria, University of Innsbruck, pp. 33-41.

GÖNÜLOL A. & OBALI O., 1998 — A study on the phytoplankton of Hasan Uğurlu Dam Lake (Samsun-Turkey). *Turkish Journal of Biology* 22: 447-461.

HUBER-PESTALOZZI G., 1969 — *Das Phytoplankton des Süsswassers, Systematik und Biologie, Part 4: Euglenophyceen*. Stuttgart, E. Schweizerbart'sche Verlagsbuchhandlung (Nägele u. Obermiller), 606 p.

HUBER-PESTALOZZI G., 1972 — *Das Phytoplankton des Süsswassers, Systematik und Biologie, Part 6: Fott. B. Chlorophyceae (Grünalgen), Ordnung Tetrasporales*. Stuttgart, E. Schweizerbart'sche Verlagsbuchhandlung (Nägele u. Obermiller), 116 pp.

JENKINS A., SLOAN W. T. & COSBY B.J., 1995 — Stream chemistry in the Middle Hills and high mountains of the Himalayas, Nepal. *Journal of Hydrology* 166: 61-79.

JOHN D. M., WHITTON B. A. & BROOK A.J., 2003 — *The Freshwater Algal Flora of the British Isles: an identification guide to freshwater and terrestrial algae*. Cambridge, The Natural History Museum and The British Phycological Society, Cambridge University Press, 702 p.

JÜTTNER I., ROTHFRITZ H. & ORMEROD S.J., 1996 — Diatoms as indicators of river quality in the Nepalese Middle Hills with consideration of the effects of habitat specific sampling. *Freshwater Biology* 36: 475-486.

KATOH K., 1991— Spatial and seasonal variation of diatom assemblages composition in a partly polluted river. *Japanese Journal of Limnology* 52: 229-239.

KAWECKA B., 1981 — Sessile algae in European mountain streams. 2. Taxonomy and autoecology. *Acta Hydrobiologica* 23: 17-46.

KOMÁREK J. & ANAGNOSTIDIS K., 1986 — Modern approach to the classification system of Cyanophytes 2- Chroococcales. *Archiv für Hydrobiologie,* Suppl. 43: 157-226.

KOMÁREK J. & ANAGNOSTIDIS K., 1989 — Modern approach to the classification system of Cyanophytes. 4. Nostocales. *Archiv für Hydrobiologie,* Suppl. 82, *Algological Studies* 56: 247-345.

KOMÁREK J. & ANAGNOSTIDIS K., 1999 — *Cyanoprokaryota, Chroococcales, Süßwasserflora von Mitteleuropa.* Stuttgart, New York, Gustav Fisher Verlag, 19/1, 548 p.

KOMÁREK J., ELORANTA P. & LHOTSKY P., 1998 — Cyanobacteria/ Cyanophyta. Morphology, taxonomy, ecology. *Archiv für Hydrobiologie*, Suppl. 129, *Algological studies*, 94, 382 p.

KRAMMER K. & LANGE-BERTALOT H., 1986 — *Bacillariophyceae. 1. Naviculaceae*, *Süßwasserflora von Mitteleuropa.* Stuttgart, New York, Gustav Fischer Verlag, 2/1, 876 p.

KRAMMER K. & LANGE-BERTALOT H., 1991a — *3. Bacillariophyceae. Centrales, Fragilariaceae, Eunoticeae*, *Süßwasserflora von Mitteleuropa*. Stuttgart, New York, Gustav Fischer Verlag, 2/3, 577 p.

KRAMMER K. & LANGE-BERTALOT H., 1991b — *4. Bacillariophyceae. Achnanthaceae, Kritische Ergänzungen zu* Navicula *(Lineolatae) und* Gomphonema *Gesamtliteraturverzeichnis*, *Süßwasserflora von Mitteleuropa*. Stuttgart, New York, Gustav Fischer Verlag, 2/4, 437 p.

KRAMMER K. & LANGE-BERTALOT H., 1999 — *Bacillariophyceae. 2. Bacillariaceae, Epithemiaceae, Surirellaceae, Süßwasserflora von Mitteleuropa.* Stuttgart, New York, Gustav Fischer Verlag, 2/2, 596 p.

KUTKA F.J. & RICHARDS C., 1996 — Relating diatom assemblage structure to stream habitat quality. *Journal of North American Benthogical Society* 15: 496-80.

LOBO E. A. & KOBAYASI H., 1990 — Shannon's diversity index applied to some freshwater diatom assemblages in the Sakawa River system (Kanagawa Pref., Japan) and its use as an indicator of water quality. *Japanese Journal of Phycology* 38: 229-243.

LOBO E. A., KATOH K. & ARUGA Y., 1995 — Response of epilithic diatom assemblages to water pollution in rivers in the Tokyo Metropolitan area. *Japanese Freshwater Biology* 34: 191-204.

MOOSER K.A., MACDONALD G.M. & SMOL J.P., 1996 — Applications of freshwater diatoms to geographical research. *Progress in Physical Geography* 20: 21-52.

NATHER KHAN I.S.A., 1991 — Effect of urban and industrial wates on species diversity of the diatom community in a tropical river, Malaysia. *Hydrobiologia* 224: 175-184.

PABUÇCU K. & ALTUNER Z., 1998 — Planktonic algal flora of Yeşilırmak River Tokat (Turkey). *Bulletin of Pure and Applied Sciences* vol. 17 B (No.2): 101-112.

PABUÇCU K. & ALTUNER Z., 1999 — Çekerek (Tokat) Irmağı bentik diyatomeleri mikrografisi. The micrography of the benthic diatoms of the River Çekerek (Tokat)]. Uluslar arası katılımlı 14. Ulusal Elektron Mikroskop Kongresi, Uludağ Üniv., Bursa.

PALMER C.M., 1980 — *Algae and Water pollution.* New York, Castle House Publication Ltd. 100 p.

PAN Y., STEVENSON R. J., HILL B., HERLIHY A. & COLLINS G., 1996 — Using diatoms as indicators of ecological conditions in lotic systems: a regional assessment. *Journal of North American Benthogical Society* 15: 481-95.

PRINGLE C., 1990 — Nutrient spatial heterogeneity: effects on community structure, physiognomy, and diversity of stream algae. *Ecology* 71: 905-20.
ROUND F.E., 1953 — An investigation of two benthic algal communities in Malham Tarn, Yorkshire. *Journal of Ecology* 41: 97-174.
RUSHFORTH S.R. & BROCK J.T., 1991 — Attached diatom communities from the lower Truckee River, summer and fall, 1986. *Hydrobiologia* 224: 49-64.
SABATER S., SABATER F. & TOMAS X., 1987 — Water quality and diatom communities in two Catalan rivers (N. E. Spain). *Water Research* 21: 901-911.
SLÁDEČKOVA A., 1962 — Limnological investigation methods for periphyton (Aufwuchs) community. *Botanical Review* 28: 86-350.
SMOL J.P., 1992 — Paleolimnology: an important tool for effective ecosystem management. *Journal of Aquatic Ecosystem Health* 1: 49-58.
SOLARI L.C. & CLAPS M.C., 1996 — Planktonic and benthic algae of a Pampean River (Argentina): Comparative analysis. *Annals of Limnology* 32: 89-95.
SOYLU E. N. & GÖNÜLOL A., 2003 — Phytoplankton and seasonal variations of the River Yeşilırmak, Amasya, Turkiye. *Turkish Journal of Fisheries and Aquatic Sciences* 3: 17-24.
STEVENSON R.J. & PAN Y., 1999 — Assessing ecological conditions in rivers and streams with diatoms. *In*: Stoermer, E. & Smol, J.P.(eds.), *Effects of Human-Induced Changes on Hydrologic Systems*. Proceedings of a Symposium in Jackson es Association, Bethesda, Maryland, pp. 659-68.
ŞEN B., ÇETIN A.K. & NACAR Y., 1990 — Evlerden gelen deterjanlı suların karıştığı küçük bir kanal içindeki alg gelişmeleri üzerine gözlemler. [A study on the growth patterns of algae in the wastewaters of a small water-collecting channel]. X. Ulusal Biyoloji Kong., Erzurum, pp. 86-94.
TEKIN S., 1997 — Yeşilırmak Nehri Amasya şehir merkezi bölümünde ve Tersakan Çayında kirlilik araştırması. [An investigation on the pollution of the River Yeşilırmak and Tersakan Stream in the city center of Amasya-Turkey]. Yüksek Lisans Tezi, Ondokuz Mayıs Üniversitesi, Fen Bilimleri Enstitüsü, s 44.
WATANABE T., ASAI K., HOUKI A., TANAKA S. & HIZUKA T., 1986 — Saprophilous and eurysaprobic diatom taxa to organic water pollution and diatom assemblages index (DAIpo). *Diatom* 2: 23-73.
YAZICI N. & GÖNÜLOL A., 1994 — Suat Uğurlu Baraj Gölü (Çarşamba, Samsun-Türkiye) fitoplanktonu üzerinde floristik ve ekolojik bir araştırma. [A floristical and ecological study on the phytoplankton of Suat Uğurlu Dam lake (Çarşamba, Samsun-Turkey)]. *Su Ürünleri Dergisi* Cilt No:11, sayı: 42-43, 71-93.
YILDIZ K., 1985 — Meram Çayı alg toplulukları üzerinde araştırmalar, Kısım III-Sedimanlar üzerinde yaşayan algler. [Algae communities of Meram Stream Part III- Algae living on sediments]. *Doğa Bilim Dergisi* A_2 , 9, 2: 428-434.
YILDIZ K., 1987 — Porsuk Çayının Bacillariophyta dışındaki algleri. [Algae except Bacillariophyta in the Porsuk River]. *Doğa Botanik Dergisi*, Cilt:1, Sayı 1, 204-210.