J. Phytol. Res. **14** (1) : 43-54, 2001

THE ALGAL FLORA AND SEASONAL VARIATIONS OF SPECIES ABUNDANCE IN KILICOZU STREAM (KIRSEHIR) TURKEY

TULAY BAYKAL*, ABEL U. UDOH and KAZIM YILDIZ****

* Gazi University, Kirsehir Education Faculty, Department of Biology, Kirsehir Turkey.

** Gazi University, Education Faculty, Department of Biology, Ankara Turkey.

The algal composition, seasonal variation in species abundance and the physical and chemical properties of Kilicozu stream were researched between March 2000 and February 2001. Samples were taken from plankton, epipelon epilithon and epiphyton at five stations. A total of 168 taxa were identified with 125 taxa belonging to Bacillariophyta, 10 to Chlorophyta, 7 to Euglenophyta and 26 to Cyanophyta. Bacillariophyta was dominant while Cyanophyta was subdominant group. *Fragilaria ulna, Achnanthes minutissima var. minutissima, Cocconeis placentula* var. *euglypta, Gomphonema olivaceum* var. *olivaceum, G. angustatum* var. *productum* and *Oscillatoria* spp. were abundant and widespread in plankton. At the exit of the dam (1st station) and the 3rd station with intake of hot water, species numbers were richer and more abundant. In April, May, June and July low level of dissolved oxygen was recorded (0.5-3 mg. l^{-1}) at the 2nd, 4th and 5th stations. In these stations, Cyanobacteria was observed to be high as a result of nitrification. In plankton the highest number of organisms recorded was 12,061.307 org.x10^3 l^{-1} (4th station). Cyanobacteria formed approximately 90% of this amount. There were more of *Oscillatoria* spp., *Sphaerotylus natans, Chrenothrix polyspora, Beggiatoa alba* and *Rhabdochromatium* sp. at these stations. The amount of Chlorophyll *a* varied between 0.027-8.5 mg l^{-1}. The growth of Cyanobacteria in plankton was parallel with that of Bacillariophyta in epipelon. The formation of anoxic medium at the 2nd, 4th and 5th stations in conjunction with organic pollution is a matter of great interest.

Keywords : Algae; Flora; Kilicozu stream; Kizilirmak river; Seasonal variation; Turkey.

Introduction

Turkey is a country with rich inland waters with approximately 145,000 km of running waters. However, studies on flora in running waters in Turkey are limited[1-15]. The freshwater flora of Turkey has not yet been studied. For this reason, the identification of species and seasonal variation are given priority. In this study, the algal flora and seasonal variations of species abundance in Kilicozu stream were researched. The physical, chemical and algological features were correlated with the level of pollution.

Kilicozu stream is found in the Central Anatolian region and flows into Kizilirmak river, the longest river in Turkey (Fig. 1). It is located on 970 m altitude. The average temperature is 11.3°C with highest 22.9°C in July and lowest-0.4°C recorded in January. The average relative humidity is 63% and average precipitation is 377.5 mm. According to Emberger, it has a semi-drought and very cold biomediterrancen climate[16]. The average flow rate of the stream is 3.4 m^3/s. But in the recent years this has fallen to 2.4 m^3/s. Geologically, the margins of the valley have aluvium soil areas as the product of the Quaternary era.

Material and Methods

Algal samples were collected monthly between January and December 2000. After fixing planktonic algae with lugol solution, counting was done by Lackey's method[17]. The amount of Chlorophyll *a* was measured with spectrophotometric method using methanol[18]. Epipelic algae were counted on temporary slides through phototactic movement method[19]. Epiphytic community was obtained from scratching and washing the surfaces of species such as *Typha latifolia* L., *Potamogeton pectinatus* L., *Juncus inflexus* L., *Salix alba* L., *Myriophyllum* sp. and *Elodea canadensis* Michx. The same process was used on stones to obtain epilithic community and samples were fixed in lugol solution. For diatoms that could not be identified on temporary slides, permanent slides method was used. Identifications were made following various literature[20-34]. Temperature, dissolved oxygen, salinity and conductivity were measured *in situ*. Other analysis were done at the State

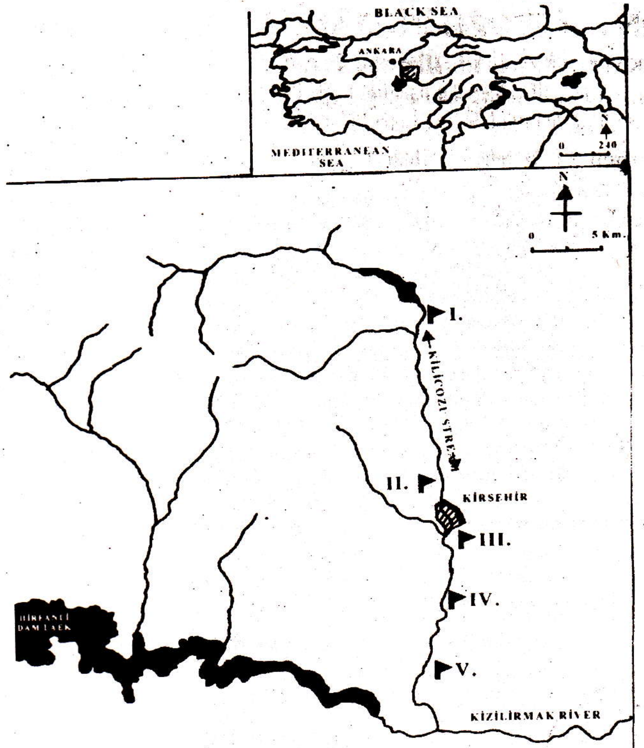

Fig. 1. Maps of location and sampling stations.

Water Works laboratory in Kayseri. The results are shown in Table 1.

The selected stations had differences in properties. For examle, the 1^{st} station is near the dam exit, the 2^{nd} has direct waste input from animal barn, the 4^{th} station is the region where industrial wastes mix with the stream. The 3^{rd} station is the site where a hot spring joins the stream. Kilicozu stream harbours all the city sewage, industrial and agricultural wastes. 5^{th} station was near the point where the stream entered the Kizilirmak river.

Results and Discussion

The stream : It was observed that throughout the period of sample-taking, there were many differences in terms of physical and chemical properties, algal compositions and species abundance between stations.

Temperature varied between 4-25°C. The 3^{rd} station, a site with an inflow of a hot spring, with temperature ranging between 11.9-25°C has an average of 18°C (Table 1). Amount of dissolved oxygen varied between 1.29-10.663 mg l^{-1}. The highest oxygen values were recorded in the months of November, December, January, February and Mach (Fig. 2). Ammonia-N value varied between 0.08-15.2 mg l^{-1} and nitrate-N between 0.01-5.09 mg l^{-1}) (Fig. 3). Turbidity was observed to be between 1-70 NTU, with highest at the 2^{nd} station, a site where barn and household wastes flow into the stream. The staion at the entrance into Kizilirmak river is richer in minerals such as Na^{+}, K^{+}, Ca^{++} and Mg^{++}. Here conductivity and salinity were higher and the later varied between 0.5-0.7 ppt.

Species composition : A total of 194 taxa were identified in all the habitats (Table 2). In terms of species number and abundance of cells, Bacillariophyta was the dominant group while Cyanophyta was subdominant. The abundance of species at the 1^{st} station, the exit of the dam is a typical representative. Among other algal species especially

Cladophora sp., *Spirogyra* sp. and *Ulothrix* sp. were observed more at the 1st station while *Euglena acus* and *E.gracilis* were more abundant in the last station. Throughout the study, *Fragilaria ulna*, *Cocconeis placentula* var. *euglypta*, *Gomphonema angustatum* var. *producta* (exept 1st station) and *Oscillatoria minima* (exept 1st station) in all habitats and in plankton, *Nitzschia palea*, *Navicula cryptocephala* (especially 1st and 3rd stations) were observed in abundance and widespread.

Seasonality of phytoplankton and epipelon : The amount of chlorophyll *a* measured varied between 0.027-8.56 mg l^{-1}. The quantity of organisms in plankton between 0.608-12.021 org. $x10^3$ cm^{-2} (Fig. 4) and in epipelon it varied between 0.211-406.115 org.$x10^3$ cm^{-2} (Fig. 5). Especially at the 3rd station species belonging to *Oscillatoria* (eg. *O. tenuis*, *O. minima*, *O. angustata*) which grow well on hot water and species of diatoms such as *F.ulna* (max. in Aug. 759.730 org.l^{-1}), *C.placentula* var. *euglypta* (max.in May 640.000 org.l^{-1}), *G. angustatum* var. *producta* (max. in May 124.700 org. l^{-1}) were generally dominant in plankton. In this station where water temperature is high in winter (average 12.5 °C), number of epipelic species were observed to be high. In December, *Navicula pupula* formed 26% of the total number of diatoms and *Nitzschia sigmoideae* 25.9%. The highest density of organisms was recorded in February (64.952 org.$x10^3$ cm^{-2}) because of the ideal water temperature (12.1°C), dissolved oxygen (8.53 mg l^{-1}), ammonia-N (1.3 mg l^{-1}) and total P (2.97 mg l^{-1}) contributed positively to the growth of organisms. Also in February the abundance of Cyanobacteria was only 3.929 org. l^{-1}. For the months of May, June and July in epipelon especially *N.palea* (Average 276.6 org.cm^{-2}, in plankton *O.tenuis* (average 1.750 org.x 10^3 l^{-1}) showed maximum growth.

At the entrance of Kizilirmak river (5th station), in phytoplankton in spring and the beginning of summer, *G. angustatum* var. *producta* (average 248.27 org.$x10^3$ l^{-1}), in epipelon in (May, June and July) *N. palea* (average 276.658 org.$x10^3$ l^{-2}), *O. tenuis* (18.075 org.$x10^3$ l^{-1}) had reached these high values. In June, in epipelon from the group of Euglenophyta, *E. gracilis* (64.816 org.$x10^3$ l^{-1}) reached this maximum value, but in the other months, this species was observed to be rare and less in number.

In phytoplankton at the 3rd station, *C.placentula* var. *euglypta* (in Oct. 1,028.091 org.$x10^3$ l^{-1}), *G.angustatum* var. *producta* (in July 153.333 org.$x10^3$ l^{-1}) and *O.minima* (in July 214.666 org.$x10^3$ l^{-1}) had reached their maximum values (Fig. 4). At the 2nd and 4th stations, only Cyanophyta species and some members of Bacillariophyta were recorded.

The algal flora of Kilicozu stream was observed to be rich. One of the major reasons is the presence of a dam lake just before the research area. The phytoplankton community and abundance diminished rapidly by flowing into the running water[35]. In this study, the highest number of organisms (approx. 80% of total species) was recorded at the first station and showed regular abundance changes. However, the shallowness of the sampling stations provided positive conditions (e. g.penetration of light, water temperature and dissolved oxygen) for the growth of algae. Generally, the stream is enriched artificially with organic wastes that create a polluted medium. It was observed that especially at the 2nd and 4th stations that owing to nitrification that resulted in anoxic conditions, the richness in species and abundance were affected negatively. This condition was more conspicuous in benthos. Species of Cyanophyta such as *Sphaerotylus natans*, *Crenothrix* sp., *Beggiatoa* sp., *Rhabdochromatium* sp. and *Chironomid* larvae from *Oligochaetes* had shown excessive reproduction. For this reason, the stream could be evaluated as being in the mesosabrobic zone[36].

Another area of interest is the 3rd station with intake of hot spring. High temperature and increase in flow rate provided a special medium. Species such as

Table 1. Physical and chemical characteristics of Kilicozu Stream, Turkey.

	Parameters	Min.	Max.	Average
1	pH	6.26	8.55	7.6
2	Temperature (°C)	4.0	25.0	14.9
3	Conductivity (μmhos cm^{-1})	362	1450^{++}	785
4	Salinity (ppt)	0.2^{x}	0.7^{++}	0.4
5	Oxygen (mg $^{-1}$)	0.56^{++}	10.63	6.02
6	Turbidity (NTU)	1^{+}	70	18.6
7	Total solued solids (mg l^{-1})	328	854	550
8	Colour (Pt-co)	5	35	9.5
9	Total alkalinity (mg l^{-1})	201	424^{++}	325
10	Ammonia-N (mg l^{-1})	0.08^{++}	15.2^{++}	3.94
11	Nitrite-N (mg l^{-1})	0.001^{x}	2.48^{++}	0.239
12	Nitrate-N (mg l^{-1})	0.01	5.59^{++}	1.37
13	Nitrate-N (mg l^{-1})	0	27^{+}	9
14	T.hardness (mg l^{-1} $CaCO_3$)	227	562^{++}	358
15	Ortho-phosphate (mg l^{-1})	0.01^{+}	3.65^{++}	1.15
16	Total phosphate (mg l^{-1})	0.06^{x}	4.13^{++}	2.01
17	Sulfate (mg l^{-1})	11.3^{x}	141^{++}	49.8
18	Iron (mg l^{-1})	0.01^{x}	0.72	0.14
19	Sodium (mg l^{-1})	15.2^{x}	140.9^{++}	43.6
20	Potassium (mg l^{-1})	1.17^{x}	25.4^{+}	5.87
21	Calcium (mg l^{-1})	3.19^{x}	154.3^{++}	96.5
22	Magnesium (mg l^{-1})	1.58^{x}	67.1^{++}	26.8

^{x} 1st, $^{+}$2nd and $^{++}$ 5th stations

Oscillatoria were abundant and widespread in this station. At places where there was decrease in flow rate (1st, 2nd, 3rd stations), there was a formation of a rich flora. Similar condition was encountered in rivers in England[37]. Generally, in Europe and in Turkey, in plankton and benthos, Bacillariophyta is the dominant group followed by Chlorophyta[38-40]. But in Kilicozu stream, Bacillariophyta is the dominant group and Cyanophyta subdominant. Members of Chlorophyta were not encountered in stations that showed anoxic conditions. This situation has never been recorded in our running waters. The values of Chlorophyll *a* too did not show parallel increase with the abundance of organism because it is known that members of Chlorophyta and Bacillariophyta have effect on the amount of chlorophyll *a*[41].

It is therefore recommended that

Table 2. Algal species of Kilicozu Stream according to their habitat.

SPECIES	PLANKTON	EPIPELIC	EPILITHIC	EPIPHYTIC
DIVISION : BACILLARIOPHYTA				
Melosira varians C.A. Agardh	+	+	+	+
Aulocoseira ambigua (Grun.) Simonsen.			+	
Cyclotella comta (Ehr.) Kütz.		+	+	+
C. ocellata Pantocksek	+	+	-	-
C.meneghiniana Kützing.		+		
Stephanodiscus dubius (Fricke) Hustedt	+	+		
S. hantzschii Grun.	+			
Diatoma vulgare Bory	+	+	+	+
Synedra acus Kütz.	+			
S. acus var. *angustissima* Grun		+		
Fragilaria capucina var. *vaucheria* (Kützing) Lange-Bertalot	+			
F. intermedia Grun.	+			
F. ulna (Nitasc.) Lange-Bertalot	+	+	+	+
Achnanthes affinis Grun.		+		+
A. bahusiensis (Grun.) Lange-Bertalot	+	+		
A. clevei Grun.	+	+		
A. delicatula Kütz.	+			
A. hungarica Grun.	+		+	
A. lanceolata de Brebisson	+			+
A. lanceolata var. *rostrata* Hust.	+		+	
A. minutissima Kütz. var. *minutissima*	+	+	+	+
Achnanthes sp.		+		
A. thermalis Rabenhorst	+			
Conccconeis placentula Ehr.	+	+		
C. placentula var. *euglypta* (Ehr.) Cleve	+	+	+	+
Rhoicosphenia curvata (Kütz.) Grun.	+	+	+	+
Gyrosigma acuminatum (Kütz.) Rabh.	+	+	+	+
G. strigile W.Sm.		+		
Diploneis ovalis (Hilse) Cleve	+	+	+	
Nedium dubium (Ehr.) Cleve		+		
N. iridis var. *amphigomphus* (Ehr.) Van Heurck		+		
Stauroneis pygmaea Krieger	+			
S. smithii Grun.	+	+		+
Anomoeoneis sphaerophora (Ehr.) Pfitzer		+		

Navicula anglica Ralfs		+		
N. capitatoradiata	+	+	+	
N. accomoda Hustedt	+			
N. cincta (Ehr.) Ralfs	+	+		
N. cryptocephala Kütz.	+	+	+	
N. cryptocephala var. *veneta* (Kütz.) Grun.	+	+		+
N. cryptotenella Lange-Bertalot	+			
N. cryptofallax Lange-Bert.& Horm.	+	+		+
N. cuspidata Kütz.		+		
N. decussis Oestrup		+	+	
N. festiva Krasske	+	+		
N. gastrum Ehr.		+		
N. gracilis Ehr.	+	+	+	+
N. gregaria Donkin.	+	+		
N. halophila var. *robusta* Hustedt	+	+		
N. hungarica var. *capitata* (Ehr.) cleve		+		
N. menisculus Schumann	+	+		
N. nivalis Ehr.		+		
N. pupula Kützing	+	+	+	+
N. pygmaea Kütz.	+	+		

N. radiosa Kütz.	+	+	+	+
N. radiosa var. *tenella* (Breb.) Grun	+	+		+
N. reinhardtii Grun.		+		
N. rhynchocephala Kütz.		+		
Navicula sp.	+	+		
N. submolesta Hustedt	+			
N. trivialis Lange-Bertalot var. *trivialis*		+		
N. virudula var. *rostellata* (Kützing) Cleve	+			
Caloneis amphisbaena (Bory) cleve	+	+		
C. bacillum (Grun.) Mereschkowsky	+	+		
Caloneis sp.	+			
C. ventricosa (Ehr.) Meister		+	+	
Pinnularia acuminata W. Smith		+		
P. borealis Ehr.		+		
P. brebissonii (Kütz) Rabh	+	+		
P. gibba Ehr.		+		
P. legümen Ehr.				
P. stomatophora Grunow		+		
P. viridis (Nitzch.) Ehr.	+		+	
Cymbella affinis Kütz.	+	+		+

C. amphicephala var. *hercynica* (A.Schmidt) Cleve		+		
C. cuspidata Kütz.		+		
C. helvetica Kütz.			+	
C. lanceolata (Ehr.) Van Heurck	+	+	+	+
C. obtisiuscula (Kütz) Grun.	+	+		
Cymbella prostrata (Barkeley) Cleve				+
C. sinuata Greg. var. *sinuata*			+	
C. tumida (Breb.) Van Heurck				+
C.ventricosa Kütz.		+	+	+
A. ovalis Kütz.	+	+		+
A. pediculus Kütz.	+	+		
A. veneta Kütz.	+	+		
Gomphonema angustatum (Kütz.) Rabh.		+		
G. angustatum var. *producta* Grun.	+	+		+
G. augur Ehr. var. *sphaerophorum* (Ehr.) Lang Bertalot		+		
G. constrictum var. *capitata* (Ehr.) Cleve		+	+	+
G. dichotomum Kütz.		+		
G. intricatum Kütz	+		+	+
G. olivacea (Lyngbye) Dawson	+	+	+	+
G. olivaceum (Lygb.) Kütz. var. *olivaceum*	+			
G. parvulum (Kütz.) Grun.	+	+		
G. parvulum var. *micropus* (Kütz.) Cl.		+		+
Denticula tenuis Kütz.	+	+		+
D. kützingii Grunow.			+	
Nitzschia acicularis W.Smith	+	+		+
N. angustata (W.Sm.) Grun.		+		
N. amphibia Grun.	+		+	
N. closterium (Ehr.) W.Sm.		+		
N. constricta (Kütz.) Ralf		+		
N. dissipata (Kütz.) Grun.	+	+		
N. dubia W. Smith	+	+		+
N. gracilis Hantssch.	+	+		
N. hantzschiana Rabh.	+	+	+	
N. hungarica var. *capitata* (Ehr.) Cleve.	+	+		
N. inconspiqua Grun	+			
N. intermedia Hantzsch	+	+		+
N. linearis W.Smith	+	+		
N. obtusa W.Smith	+			
N. palea (Kütz.) W.Smith	+	+		+

N. palea var. *debilis* (Kütz.) Grun.	+	+		+
N. romana Grun.	+	+		
N. sigmoideae (Ehr.) W.Smith.	+	+		+
N. stagnorum Rabh.		+		
N. tryblionella Hantzsch	+	+		
N. umbonata (Ehr.) Lange-Bertalot		+	+	+
Nitzschia sp.	+	+		
Hantzschia amphioxys (Ehr.) Grun.		+		
Cymatopleura elliptica (Breb.) W.Smith	+	+		+
C. solea (Breb.) W.Smith	+	+		+
Surirella angustata Kütz.		+		+
S. linearis W.Smith		+		+
S. ovalis Breb.	+	+		+
S. ovata Kütz.	+	+		+
S. ovata var. *splendida* (Ehr.) Van Heurck		+		
Campylodiscus noricus var. *hibernica* Ehr.		+		
DIVISION : CHLOROPHYTA				
Clamydomonas globosa Snow	+	+		
Ulothrix cylindricum Prescott	+			
Microspora floccosa (Vauch.) Thuret			+	
Stigeoclonium sp		+		+
Cladophora fracta (Dillw.) Kuetzing	+		+	+
Oedogonium sp.		+		
Spirogyra dubia Kuetzing		+		
S. subsalsa Kuetzing		+		+
S. varians (Hass.) Kuetzing				+
S. Weberi Kuetzing				+
Closterium littorale Gay				
C. lunula (Müll.) Nitzsch ex Ralfs				
C. moniliferum (Bory) Ehr.		+		
Closterium sp.	+			
DIVISION : EUGLENOPHYTA				
Euglena acus Ehrb.	+	+		
E. charchowiensis Swir		+		
E. gracilis Klebs.		+		
E. spirogyra Ehrenberg		+		
Trachelomonas hispida (Perty) Stein		+		
Phacus Norstedtii Lemm.		+		
P. orbicularis Hülon		+		
Phacus sp.	+	+		
DIVISION : CYANOPHYTA				
Chroococcus minutus (Kuetz.) Naegeli	+			

C. turgidus (Kuetz.) Naegeli	+	+		
Merismopedia glauca (Ehrenb.) Naegeli	+	+		+
M. punctata Meyen		+		
Holopedia geminata Lagerh.	+	+		
Gomphosphaeria aponina Kg.	+	+		
Dactylococcopsis acicularis Lemm.	+			
Spirulina major Kuetzing	+	+		
Oscillatoria angusta Koppe	+	+		
O. curviceps C.A. Agardh		+		
O. formosa Bory		+		
O. guttulata Van Goor	+	+		
O. limnetica Lemm.	+	+	+	+
O. minima Gicklhorn	+	+		+
O. ornata Kg.			+	
O. planktonica Wol.	+	+		
O. prolifica (Grev.) Gomond.				+
O. sancta (Kuetz.) Gomont				+
O. Splendida Greville	+	+		
O. tenuis C.A. Agardh	+	+	+	+
Oscillatoria sp.	+	+		
Phormidium mucicola Navmann & Huber Pestaloz.	+	+		
Lynbya Lauterbornii (Schmidle) Uterm.	+	+		
Anabaena affinis Lemm.		+		
Beggiatoa alba (Vauch.)	+			
Crenothrix polyspora Cohn		+		
Lamprocystis rosea-persicina (Kg.) Schroter	+			
Rhabdochromatium roseum (Cohn.) Winogr.	+			
Sphaerotylus natans Kg.	+			

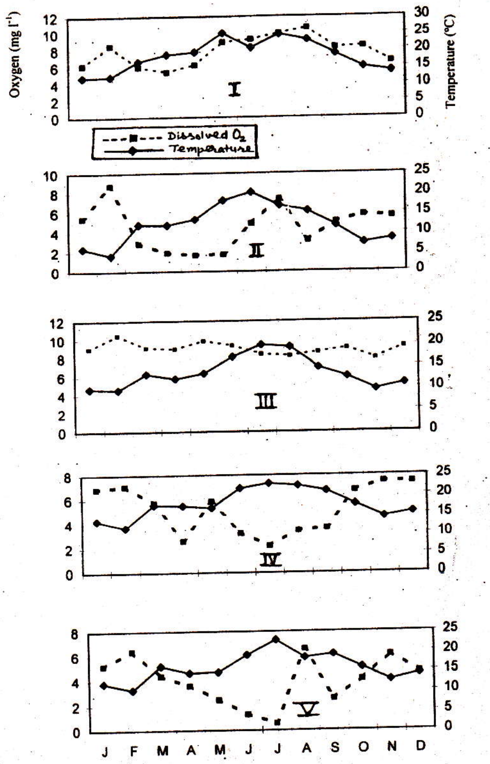

Fig. 2. Seasonal changes in quantity of water surface temperature and oxygen in five stations. (J-D for months January-December)

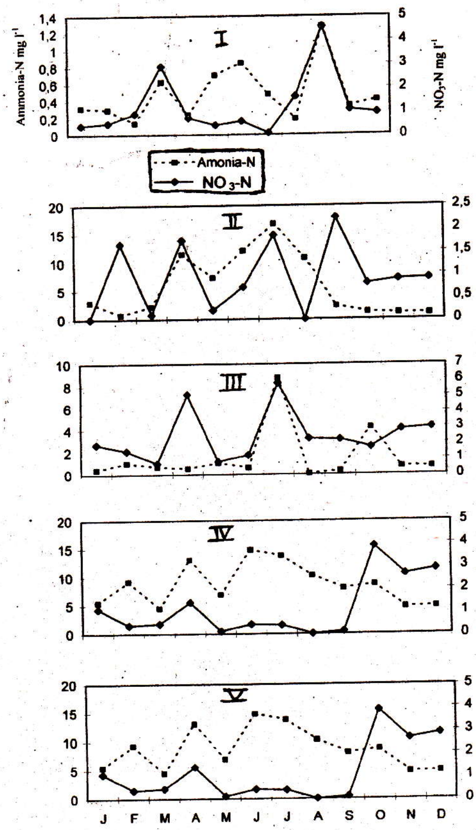

Fig. 3. Ammonia nitrogen and nitrate-nitrogen concentration in the upper of the water in five stations. (J-D for months January-December)

more ecological researches be carried out in Kilicozu stream because of its critial conditions.

References

1. Yildiz K 1984, *Algae Communities of Meram Stream, I. Phytoplankton Community, Bulletin of Science, Faculty of Arts and Science, Selcuk Univ.*, **3**: 213-217.
2. Yildiz K 1985, *J. of Science*, A_2, 9,2; 428-434.
3. Yildiz K 1987, *Diatoms of the Porsuk River, Turkey, TU J. Biol.* **11** 162-181.
4. Yildiz K and Ozkiran U 1991, *Tr. J. of Botany* **15** 166
5. Yildiz K, Sen B and Aykulu G 1992, *Diatoms of the Longest River (Kizilirmak) of Turkey and Their Distribution with Respect to Pollution*, 12th International Diatom Symposium, Renesse, Holland., p: 135.
6. Yildiz K, Sen B and Aykulu G 1994, *Principal Diatoms in Major Running waters of Central Anatolia (Turkiye)*, 13th International Diatom Symposium, Italya, P: 221.
7. Yildiz K and Atici T 1996, *The Diatoms of Ankara Stream, Gazi Univ., Faculty of Arts and Science, J. of Science* **6** 59
8. Yildiz S, Sen B Baykal T 2000, *Aburdant and wide-Spread Diatom Found in Some Running Waters of the Central Anatolion Region, Univ. of Firat, J. of Science and Engineering*, **12** 37
9. Altuner Z 1988, *Nowa Hedwigia* **46** 1-2; 255-263.
10. Altuner Z and Gurbuz H 1991, *Tr. J. of Botany* **15** 253
11. Sen B, Alp M T and Ozrenk F 1996, *A Study of the diatoms of the River Asi Occurring in the Region Where the River Flows into the Mediterranean*, 13th National Biology Congress, Istanbul.
12. Ertan O O and Morkoyunlu A 1998, *Tr. J. of Botany* **20** 239
13. Kilinc S 1999, *J. of Egirdir Faculty of Water Products* **6** 136
14. Baysal A, Kolayli S and Sahin B 1998, *Tr. J. of Botany* **22** 163
15. Atici T and Yildiz K 1996, *Tr. J. of Botany* **20** 119
16. Akman Y and Daget Ph 1981, *Extrait du Bulletin de I a Sociate Laguadocienne de Geographie* **5-3**,

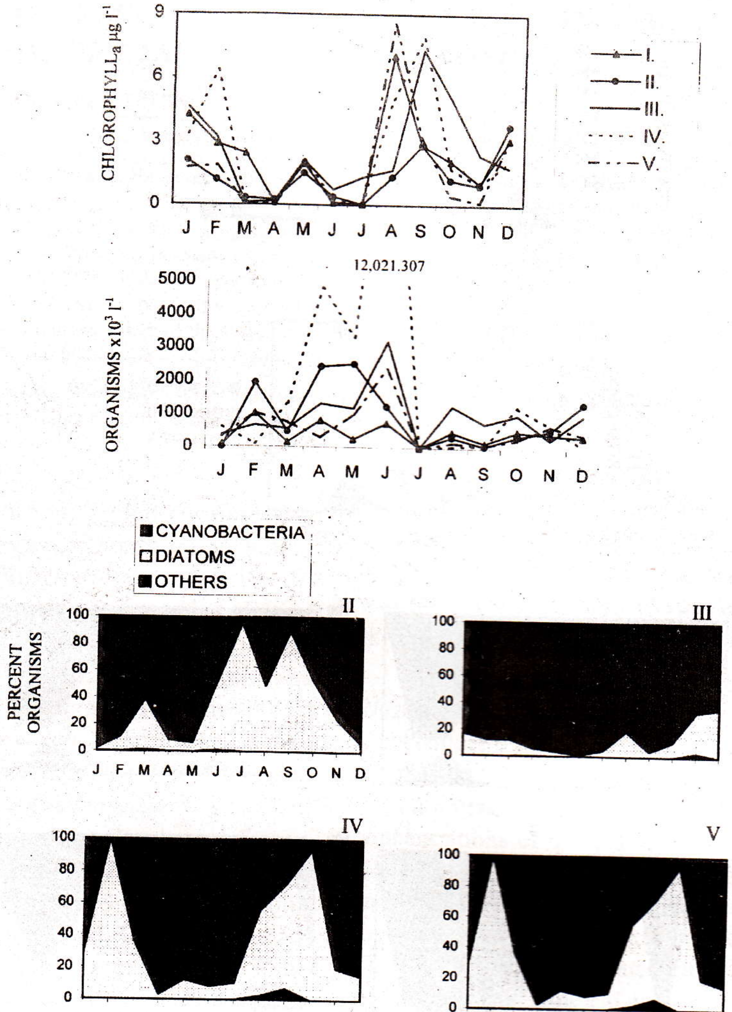

Fig. 4. Seasonal variations in surface phytoplankton composition; its abundance (assessed by org. number) and percent organisms.

269-300.

17. Bakan N and Atay D 1988, *Ankara Univ. Fen Bil. Enst., SU*-608.
18. Youngman R E 1978, *Measurament of Chlorophyll a* Wather Reseach Center, Tech. Rep., TR-82.
19. Round F E 1953, *J. Ecol.* **41** 174 Yorkshire.
20. Huber G.-P. 1882, Das Phytoplankton des Susswassers 8. Teil, Halite, Conjigatophyceae, Zygnematales and Desmidiales, E. Schweizerbartsche Verlagsbuchhandlung, 542., Stutgart.
21. Huber G.-P. 1938, *Das Phytoplankton Des Susswassers, 1. Teil*, E. Schweizerbartsche Verlagsbuchhandlung, 342 p., Stutgard.
22. Huber Pestalozzi G 1942, *Das Phytoplankton des Susswassers, Systematik und Biologie, 2. Teil, (Diyatomen)*, E. Schweizerbartsche Verlagsbuehhandlung, 549 pp., Stutgart.
23. Hustedt 1930, *Die Suswasser-Flora Mitteleuropas,* Heft 10,G Fischer, 466 pp. Jena
24. Hustedt F 1985, *The Pennat Diatoms a translation of HUSTEDT's "DIE KIESELALGEN, 2. TEIL"* With supplement by Norman G. Jensen, Koeltz Scientific Books, 917 pp., Germany.
25. Patrick R and Reimer C W 1966, *The Diatoms of The United States, Acad. Nat. Sci.* Philadelphia Monogr., 1,2,1-688.
26. Prescott G W 1975, *Algae of the Western Great Lakes Area,* W.M.C. Brown Company Publishers, Dubugue Lowa, 977 p. USA.
27. Korshicov D A 1987, *The Freshwater Algae of The Ukrainian S.S.R.,* V. Bishen Singh Mahendra Pal Singh And Koeltz, 412 p. Germany
28. Krammer K and Lange-Bertalot H 1986, *Subwasserflora von Mitteleuropa, Bacillariophyceae, Band 2/2. 2. Teil: Bacillariaceae, Epithemeicae, Surrirellaceae,* Gustav Fischer Verlag, 610 pp.,

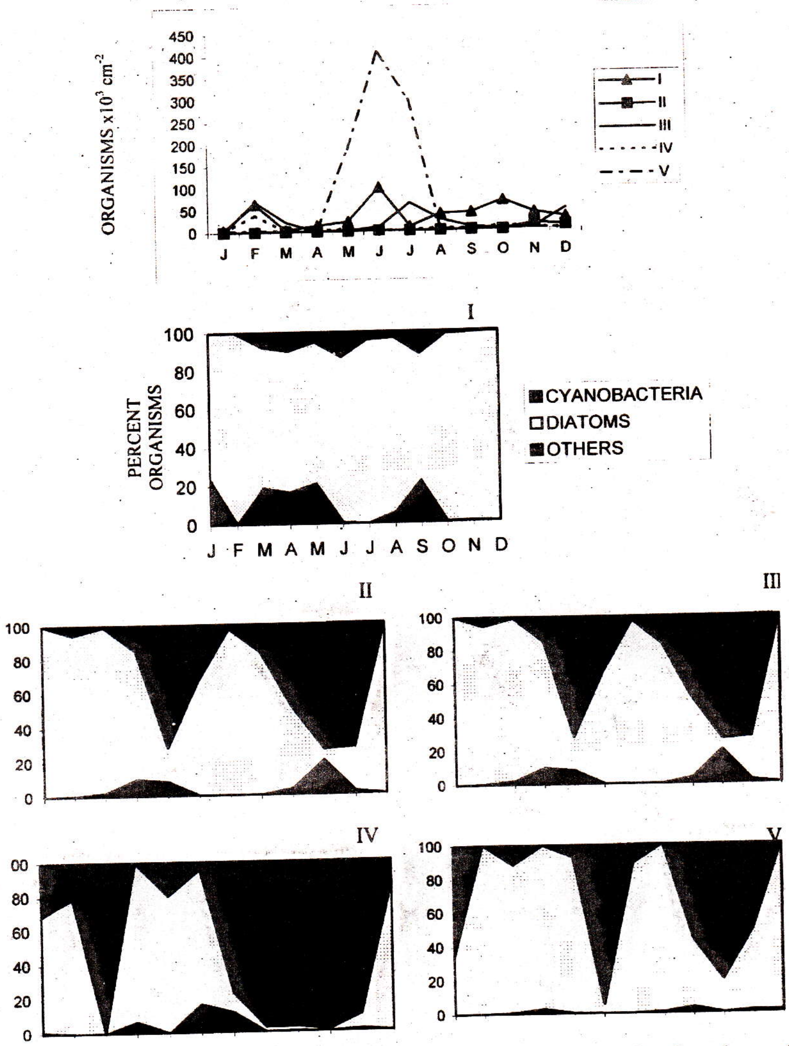

Fig. 5. Seasonal variations in surface epiphelic algae compostion its abundance (assessed by org. number) and percent organisms.

Stuttgart.

29. Krammer K and Lange-Bertalot H 1991 a, *Subwasserflora von Mitteleuropa, Bacillariophyceae, Band 2/2, 3. Teil: Centrales, Fragilariaceae,* Gustav Fischer Verlag, 576 pp., Stutgart.
30. Krammer K and Lange-Bertalot H 1991 b, *Subwasserflora von Mitteleuropa, Bacillariophyceae, Band 2/4, 4. Teil: Achnanthaceae, Kritische Erganzungen zu Navicula (Lineolatae) und Gomphonema Gesamtliteraturverzeichnis,* Gustav Fischer Verlag, 436 pp., Stuttgart.
31. Krammer K and Lange-Bertalot H 1997, *Subwasserflora von Mitteleuropa, Bacillariophyceae, Band 2/1, 1. Teil: Naviculaceae,* Gustav Fischer Verlag, 876 pp., Stuttgart.
32. Germain H 1981, *Flora des Diatomees, Diatomophycees,* Societe Nouvella des Editions Boubee, 441 p., Paris.
33. Foged N 1981, *Diatoms in Alaska, J. Cramer* 310 p., Germany.
34. Cox J E 1996, *Identification of Freshwater Diatoms from Live Material*:Principal Scientific Officer, Department of Botany, The Natural History Museum, London. UK.
35. Hynes H B N 1972, *The Ecology of Running Waters*, Liverpoll Univ. Press.
36. Lampert W and Sommer U 1997, *Limnoecology : The Ecology of Lakes and Streams*, Oxford Univ. Press, New York.
37. Antonie S E Benson-Evans K 1985, *Int. Revue ges. Hydrobiol.* **70** 575
38. Aykulu G 1982, *Br. Phycol. J.* **17** 27
39. Butcher R W 1946, *J. Ecol.* **33** 268
40. Douglas B 1958, *J. Ecol.* **49** 295
41. Lund J W G and Talling J F 1957, *Bot. Rev.* **23** 489