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CHANGES IN THE MOSAIC-LIKE WATER SURFACES OF THE LAKE VELENCE AS REFLECTED BY REED PERIPHYTON STUDIES

É. ÁCS[1], K. BUCZKÓ[1] and GY. LAKATOS[2]

[1]*Department of Botany, Hungarian Natural History Museum*
H–1476 Budapest, Pf.: 222, Hungary
[2]*Institute of Ecology, Kossuth Lajos University*
H–4010 Debrecen, Pf.: 14, Hungary

Long-term changes of the reed cover of the Lake Velence (12 years) were summarised for this paper, with emphasis on the results of investigations in 1989 and 1990. On the basis of the analyses it appeared that the water surface of the lake had lost its former mosaic-like character, which was primarily caused by intensive reed harvesting. Due to the scarcity of water since 1989, the salinity of the lake was increasing, as indicated by the increasing relative abundance of *Chaetoceros muelleri* as well as other factors. Scarcity of water also explains that algal fields detached from the basement are getting wide-spread even in protected areas (still preserving the water quality characteristic of the dark brown water surfaces), especially species of filamentous blue algae.

Key words: algae, periphyton, mosaic-like water surfaces, Lake Velence, Hungary

INTRODUCTION

Lake Velence is the second largest alkaline lake in Hungary. In the formation of the bed of the 10–15,000 years old lake, tectonic forces, eolian processes, as well as the closing of the outlets contributed most.

Sodification of the water was largely promoted by the primeval reed field which practically closed the outlets of the lake (FELFÖLDY 1981). The water level of the Lake Velence had considerable changes from time to time, as it is characteristic of sodaic lakes in general and even went dry once in every 100 years. Currently we have information of 13 dry periods. The last desiccation was registered between 1863 and 1866. By the help of the Dinnyés dam and the Dinynyés-Kajtor channel building at the end of the last century, the water level of the lake became regulable. It was further supported by two additional water reservoirs built on the inlet of the Császár-stream (Pátka and Zámoly reservoirs).

Due to the originally extent reed cover, the water quality of the lake was mosaic-like (FELFÖLDY 1972). On the SW parts, the small inner lakes surrounded by reed fields were characterised by dark brown water, while the water of the open surface at the middle of the lake was grey due to grains of silt perturbed by the wind. Reed fields at the NE parts of the lake enclosed brownish water surfaces with algae, while the riparian parts without reed was characterised by green water. The quality of certain water surfaces was changeable depending on the courses of the wind; these were of transitional character.

In course of a restoration work in the eighties 4.1 km^2 of reed fields were cleared, aiming at better recreation circumstances.

The water chemical conditions of the lake are known from the works of FELFÖLDY (1972a, 1973, 1974, 1975, 1977) and GORZÓ (mscr.). Phytoplankton studies were performed by BARTHA (1977, 1979, 1980), BARTHA and HAJDU (1978), periphyton studies by LAKATOS (1975, 1976, 1978, 1983, 1986, 1989), LAKATOS and BARTHA (1989), LAKATOS and ÁCS (1990), LAKATOS *et al.* (1991), ÁCS and LAKATOS (1990), ÁCS *et al.* (1991).

The present paper discusses the investigations of the reed cover of Lake Velence in 1989 and 1990. Studies in 1988 have already been published in details (ÁCS and LAKATOS 1990, ÁCS *et al.* 1991, LAKATOS and ÁCS 1991). For the evaluation of the formation of the mosaic-like character as well as for the interpretation of certain remarkable changes, data gathered in 1988 were also used, as well as the observations by LAKATOS and BARTHA (1989).

MATERIALS AND METHODS

Algal coating samples were collected in July 1988, 1989 and 1990 from the side of the reed-fields facing the open water surfaces, from the green reed stems just under the water surface level (5–35 cm below the surface). Sampling points coincided with those of LAKATOS and BARTHA (1989) who collected samples in 1978. Their points were originally selected with an eye based on the water

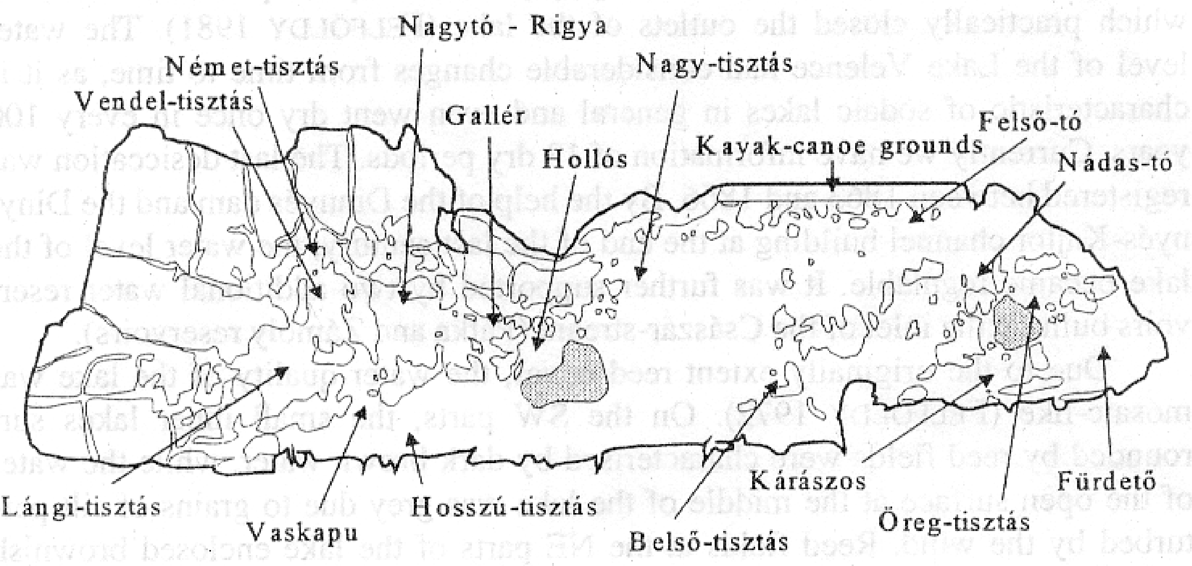

Fig. 1. Sampling sites

quality existing in those days. Besides these an additional sampling point was selected at the 'Német-tisztás', which is located within the protected area (Fig. 1).

The elaboration method of the samples has already been published in details (ÁCS *et al.* 1991). Cluster analysis based on Czekanowski-index (CZEKANOWSKI 1909), was performed with the WPGM fusion algorithm using the software package SYNTAX III (PODANI 1988).

Sampling points and their abbreviations on the Figures, correspond with the water quality districts of 1978, are as follows:

a) regions of dark brown water: Vendel-tisztás (Ve), Nagytó-Rigya (Na), Gallér (Ga), Vaskapu (V), Hollós (Ho), Német-tisztás (Né)

b) regions of grey water: Nagy-tisztás (Nt), Felső-tó (Fe), Nádas-tó (N), Belső-tisztás (B)

c) regions of algal brown water: Öreg-tisztás (Ö), Kárászos (K)

d) regions of green water: Fürdető (Fü)

e) regions of water with transitional character: Hosszú-tisztás (Ht), Lángi-tisztás (L), Kayak-canoe grounds (Kk)

RESULTS AND DISCUSSION

From the coatings in 1989 and 1990, 119 and 110 algal taxa were identified respectively (Table 1). Their distribution according to phyla is summarised in Table 2.

There were remarkable changes in the reed coating of Német-tisztás (Né). The sample taken from this site in 1988 did not appear as separate from the others on the dendrogram of the cluster analysis (Fig. 3). In the subsequent year this sample joined to the rest at 0.42 similarity rate (Fig. 4), while in 1990 it formed a considerably separate group together with the sample of the neighbouring Vendel-tisztás (Ve) (Fig. 5). Changes in the taxonomic composition are demonstrated on Fig. 6.

It is remarkable that the taxon number of blue algae has increased, together with their individual number. While in 1988 and 1989 the three predominant algal organisms were diatoms (*Achnanthes minutissima* = ACHMIN, *Cymbella lacustris* = CYMLAC, *Fragilaria capucina* var. *vaucheriae* = FRACVV, and *A. minutissima*, *F. construens* = FRACON, *Rhoicosphenia abbreviata* = RHOABB respectively), in 1990, two filamentous blue-green algal taxa were found in high quantities (*Oscillatoria chlorina* = OSCCHL, *Pseudanabaena tenuis* = PSETEN), though the most abundant was a diatom (*Cocconeis placentula* = COCPLA) again. The two blue-green algae can be described as inhabitants of base sediments, i.e. rotting silt (FELFÖLDY 1972b). Due to the extremely dry years since 1989, an increasing deficiency of water appeared in the lake. In 1990

Table 1. List of taxa

Taxa	1989	1990
Cyanophyta		
Anabaena catenula (Kütz.) Born. et Flah. ?	+	+
Anabaena sp.		+
Anabaenopsis sp.	+	
Aphanocapsa grevillei (Hass.) Rabenh.	+	+
Chroococcus minutus (Kütz.) Nägeli	+	+
Lyngbya kützingii Schmidle		+
L. limnetica Lemmerm.	+	+
Merismopedia glauca (Ehrbg.) Nägeli	+	+
M. tenuissima Lemmerm.	+	+
Microcystis aeruginosa Kütz.		+
Nostoc sp.		+
Oscillatoria amphibia Agh. ?	+	
O. chlorina Kütz.	+	+
O. mougeotii Kütz.		+
O. planctonica Wolosz.		+
O. tenuis Agh.	+	+
Oscillatoria sp.	+	+
Pseudanabaena tenuis Koppe	+	+
Snowella lacustris (Chodat.) Kom. et Hindák	+	+
Spirulina laxissima G. S. West		+
S. subtilissima Kütz.	+	+
Synechococcus cedrorum Sauv.		+
Euglenophyta		
Euglena acus Ehr.	+	
E. polymorpha Dang.	+	+
Phacus caudatus Hübner	+	
P. acuminatus Stokes	+	
P. curvicauda Swir.	+	+
Phacus sp. I.	+	+
Phacus sp. II.	+	
Chrysophyta, Xanthophyceae		
Goniochloris fallax Fott	+	+

Taxa	1989	1990
Chrysophyta, Bacillariophyceae		
Achnanthes minutissima Kütz.	+	+
Amphora libyca E.	+	
A. ovalis (Kütz.) Kütz.	+	+
A. pediculus (Kütz.) Grun.	+	
A. veneta Kütz.	+	+
Anomoeoneis sphaerophora (Ehr.) Pfitzer	+	+
A. sphaerophora costata (Kütz.) Schmid		+
A. sphaerophora f. *sculpta* Krammer		+
Aulacoseira granulata var. *angustissima* (O. Müller) Simons	+	+
A. italica var. *tenuissima* (Grun.) Simonsen	+	
Caloneis silicula (Ehr.) Cl.	+	+
Campylodiscus clypeus Ehr.	+	+
C. hibernicus Ehr.	+	+
Centrales sp.	+	+
Chaetoceros muelleri Lemmerm.	+	+
Cocconeis neothumensis Krammer	+	+
C. pediculus Ehr.	+	+
C. placentula Ehr.	+	+
Cyclotella meneghiniana Kütz.	+	+
Cymatopleura solea (Bréb.) W. Smith	+	
Cymbella affinis Kütz.	+	
C. aspera (Ehr.) Cleve	+	
C. caespitosa (Kütz.) Brun.	+	
C. cistula (Ehr.) Kirchn.	+	+
C. cymbiformis Ag.	+	+
C. delicatula Kütz.	+	+
C. lacustris (Ag.) Cl.	+	+
C. leptoceros (Ehr.) Kütz.	+	
C. microcephala Grun.	+	+
C. minuta Hilse	+	
C. prostrata (Berkeley) Cl.	+	
C. silesiaca Bleisch	+	
Diatoma tenuis Ag.	+	+
D. vulgare Bory	+	

Taxa	1989	1990
Diploneis oblongella (Nägeli) Cleve-Euler		+
Entomoneis alata (Ehr.) Ehr.	+	+
E. costata (Hust.) Reimer	+	+
Epithemia adnata (Kütz.) Bréb.		+
E. sorex Kütz.	+	+
Eunotia bilunaris (E.) Mills	+	
Fragilaria capucina var. *rumpens* (Kütz.) Lange-Bert.	+	+
F. capucina var. *vaucheriae* (Kütz.) Lange-Bert.	+	+
F. construens (Ehr.) Grun.	+	+
F. nana Steemann-Nielsen	+	+
F. pinnata Ehr.	+	+
F. pulchella (Ralfs) Lange-Bert.	+	+
F. ulna (Nitzsch) Lange-Bert.	+	+
F. ulna var. *acus* (Kütz.) Lange-Bert.	+	+
Fragilaria sp.	+	
Frustulia rhomboides var. *crassinervia* (Bréb.) Ross		+
Gomphonema angustum Ag.		+
G. gracile Ehr.	+	
G. olivaceum (Hornemann) Bréb.	+	+
G. olivaceum var. *calcareum* (Cl.) Cl.	+	+
G. parvulum (Kütz.) Kütz.	+	+
Gomphonema sp.	+	+
Gyrosigma acuminatum (Kütz.) Rabenh.	+	+
Mastogloia smithii Thwaites	+	
Melosira varians Ag.		+
Navicula capitata Ehr.	+	
N. capitata var. *hungarica* (Grun.) Ross	+	+
N. cryptocephala Kütz.	+	+
N. cuspidata (Kütz.) Kütz.	+	+
N. halophyla (Grun.) Cl.	+	+
N. lanceolata (Ag.) Ehr	+	+
N. lenzii Hust.	+	+
N. margalithii Lange-Bert.	+	
N. oblonga Kütz.	+	+
N. pseudotuscula Hust.	+	

Taxa	1989	1990
N. pupula Kütz.	+	
N. radiosa Kütz.	+	+
N. rynchocephala Kütz.	+	+
N. veneta Kütz.	+	+
Nitzschia acicularis (Kütz.) W. Smith		+
N. angustata Grun.	+	+
N. capitellata Hust.	+	
N. dissipata (Kütz.) Grun.	+	
N. frustulum (Kütz.) Gru	+	+
N. linearis (Ag.) W. Smith	+	+
N. pusilla Grun.	+	+
N. sigmoidea (Nitzsch) W. Smith		
Nitzschia sp. I.	+	+
Nitzschia sp. II.	+	
Nitzschia sp. III.	+	+
Ophiocytium capitatum Wolle	+	+
Pinnularia interrupta W. Smith	+	
P. subcapitata Gregroy	+	
Rhoicosphenia abbreviata (Ag.) Lange-Bert.	+	+
Rophalodia gibba (Ehr.) O. Müller	+	+
Skeletonema potamos (Weber) Hasle	+	
Surirella ovalis Bréb.	+	+
S. peisonis Pant.	+	
Cryptophyta		
Cryptomonas erosa Ehr.		+
C. ovata Ehr.		+
Chlorophyta		
Cladophora fracta (Dillw.) Kütz.	+	
Closterium moniliferum (Bory) Ehr.	+	+
Coelastrum microporum Nägeli in A. Br.	+	+
C. pseudomicroporum Kors.	+	
C. sphaericum Nägeli	+	+
Cosmarium granatum Bréb.	+	+
C. laeve var. *westii* Krieg. et Gerl.	+	+
C. polygonatum Halász	+	+

Taxa	1989	1990
C. tenue (Arch.) W. West	+	+
C. trilobulatum (Reinsch.) W. West	+	+
Crucigenia quadrata Morr.	+	+
C. tetrapedia (Kirchn.) W. et G. S. West		+
Didymocystis planctonica Kors.	+	+
Golenkinia radiata Chod.	+	
Lagerheimia ciliata (Lagerh.) Chod.	+	
L. genevensis (Chod.) Chod.	+	
L. subsalsa Lemmerm.	+	+
Monoraphidium contortum (Thur.) Kom.-Legn.	+	
M. griffithii (Berk.) Kom.-Legn.	+	+
M. minutum (Nägeli) Kom.-Legn.	+	+
Mougeotia sp.	+	+
Oedogonium sp.	+	+
Oocystis borgei Snow	+	+
O. lacustris Chod.	+	+
O. solitaria Wittr. in Wittr. et Nordst.	+	+
Pediastrum boryanum (Turp.) Menegh.	+	+
P. tetras (Ehr.) Ralfs	+	+
Scenedesmus acuminatus (Lagerh.) Chod.	+	+
S. acutus Meyen.	+	+
S. apiculatus (W. et G. S. West) Chod.	+	
S. armatus Chod.	+	+
S. ecornis (Ehr.) Chod.	+	+
S. opoliensis P. Richt.	+	+
S. quadricauda (Turp.) Bréb.	+	+
S. spinosus Chod.	+	+
Schroederia setigera (Schröd.) Lemmerm.	+	
S. spiralis (Printz) Kors.		+
Spirogyra sp.	+	
Staurastrum cingulum (W. et G. S. West) G. M. Sm.	+	+
Tetraëdron caudatum (Corda) Hansg.	+	+
T. minimum (A. Br.) Hansg.	+	+
Tetrastrum glabrum (Roll) Ahlstr. et Tiff.		+

Table 2. Distribution of taxa

	1989	1990
Cyanophyta	14	20
Euglenophyta	7	3
Chrysophyta		
Xanthophyceae	1	1
Bacillariophyceae	84	64
Cryptophyta		2
Chlorophyta	39	33
Sum	145	123

the reservoir went dry. The estimated amount of missing water was about 12–14 × 106 m^3 in 1993, which was one third of the total water stock of the lake. Due to the shortage of water, the algal cover of the basement in the Német-tisztás got degraded, broken, and floated to the surface causing anaerobic conditions underneath (GORZÓ mscr.).

The dendrograms of the 1978 and 1988 surveys show fairly distinct groups for the samples collected from planktonically eutrophised water districts (Fürdető, Öreg-tisztás, Kárászos) (Figs 2–3). These samples, however, cannot be distinguished from the rest on the 1989 and 1990 graphs (Figs 4–5).

The coating of the planktonically eutrophised waters can be characterized by a low taxon number (LAKATOS and BARTHA 1989). In 1978, the taxon number of the sampling sites Fürdető and Öreg-tisztás were smaller than at the other three sampling years (Fig. 7). Though the sampling site Kárászos belonged to the brown water district, too, its individual number of planktonic algae was smaller than at the other two sampling points (LAKATOS and BARTHA 1989). In the last ten years, there was a general sinking observable in the trophic level of the NE parts of the lake. The artificial reed field planted at Kápolnásnyék in 1986–87 reserved 25–30% of nitrogen and 90–100% of phosphorus (GORZÓ mscr.). Probably this fact can explain the rise in the taxon number of the coating observable since 1988. Salinisation as a consequence of the sinking water level may be the cause of the increasing relative abundance of the siliceous alga *Chaetoceros muelleri* (Fig. 8) since 1988. This species is well known for its resistance to higher salinity. In 1978 samples taken from different water quality regions of the lake formed several distinct clusters at 50% level of SICC (Similarity Index Community Coefficient) (CUNG *et al.* 1991) (Fig. 2). By 1988 all the samples joined at higher levels of similarity than 50% (Fig. 3). Since 1989 we have observed a gradual separation of the algal coating of the Német-tisztás, while all the

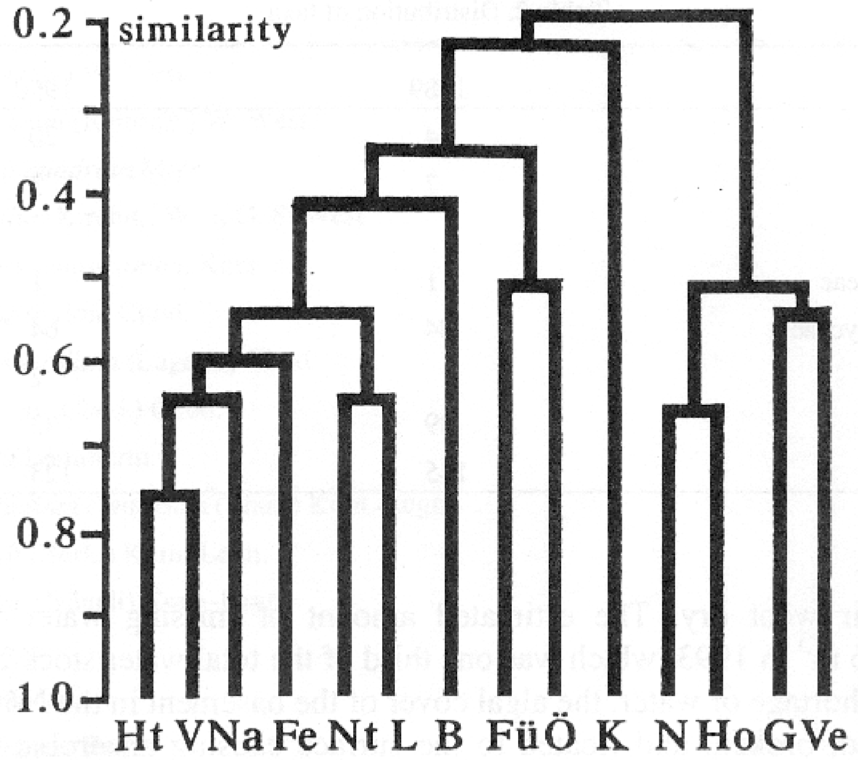

Fig. 2. Dendrogram of the 1978 samples based on the Czekanowski-index. See the text for abbreviations

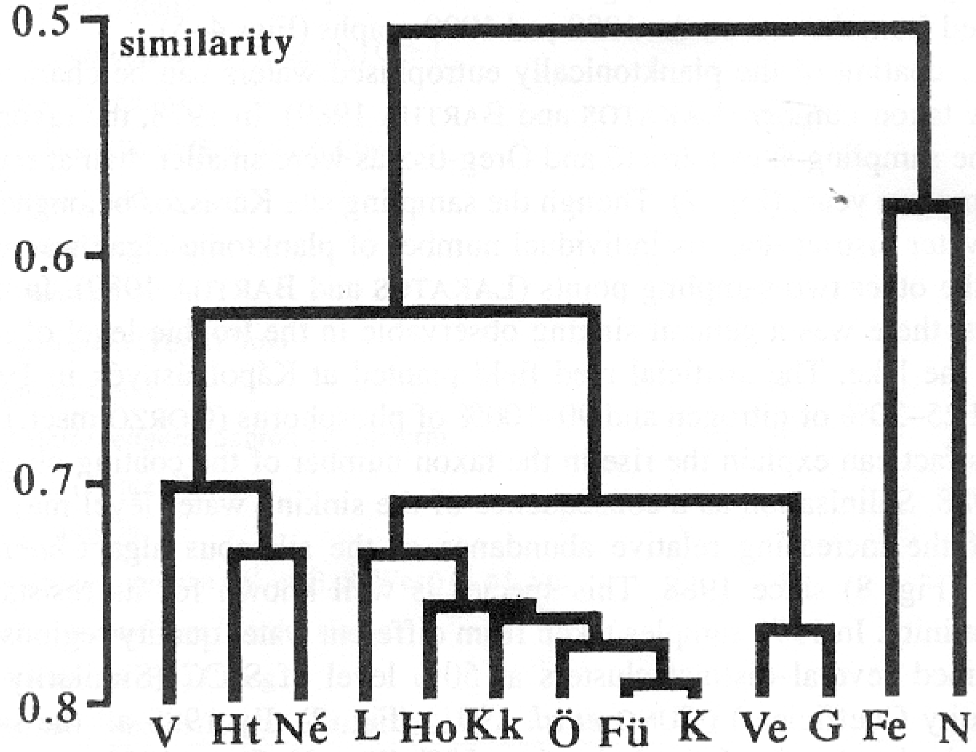

Fig. 3. Dendrogram of the 1988 samples based on the Czekanowski-index. See the text for abbreviations

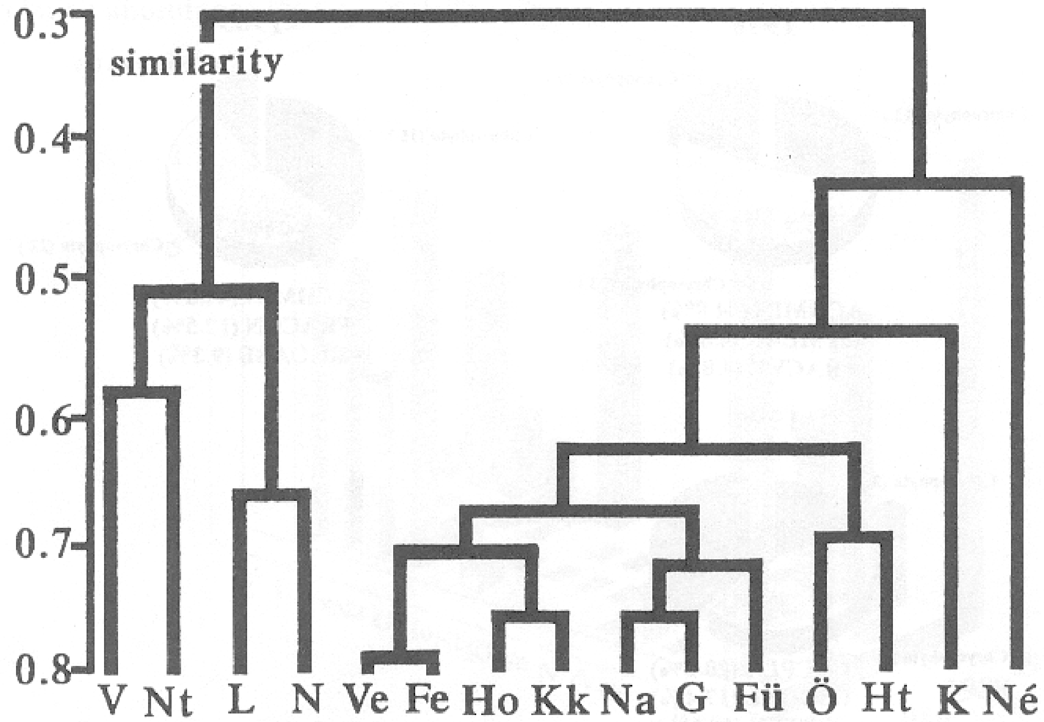

Fig. 4. Dendrogram of the 1989 samples based on the Czekanowski-index. See the text for abbreviations

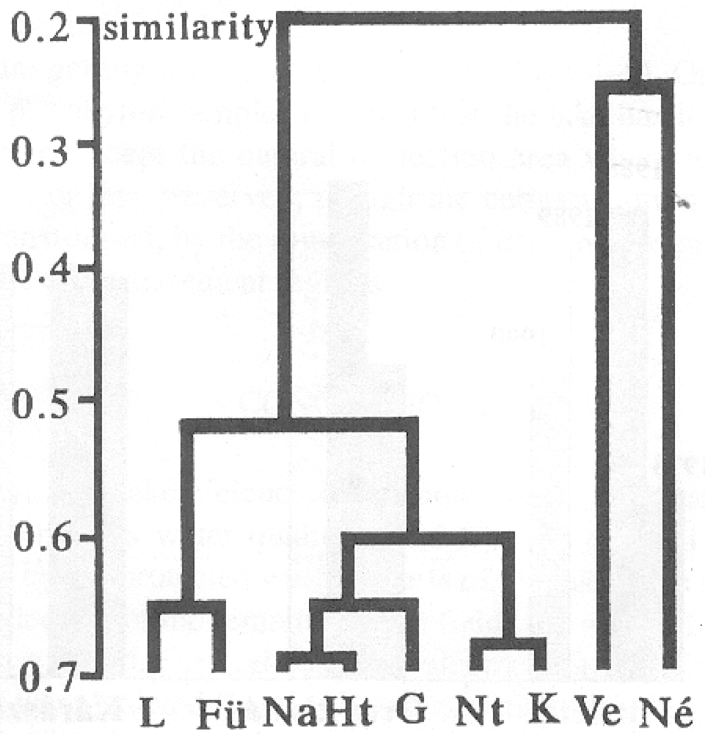

Fig. 5. Dendrogram of the 1990 samples based on the Czekanowski-index. See the text for abbreviations

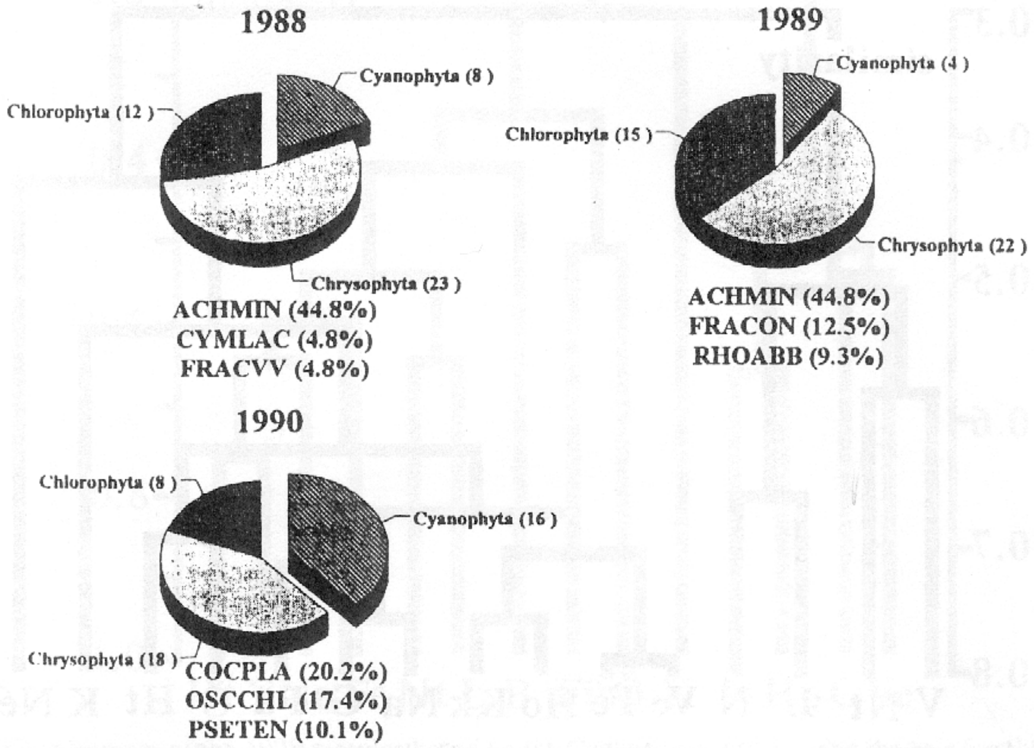

Fig. 6. Taxonomic composition of reed-periphyton of Német-tisztás sampling site in 1988, 1989 and 1990 with 3–3 dominant species. See text for abbreviations

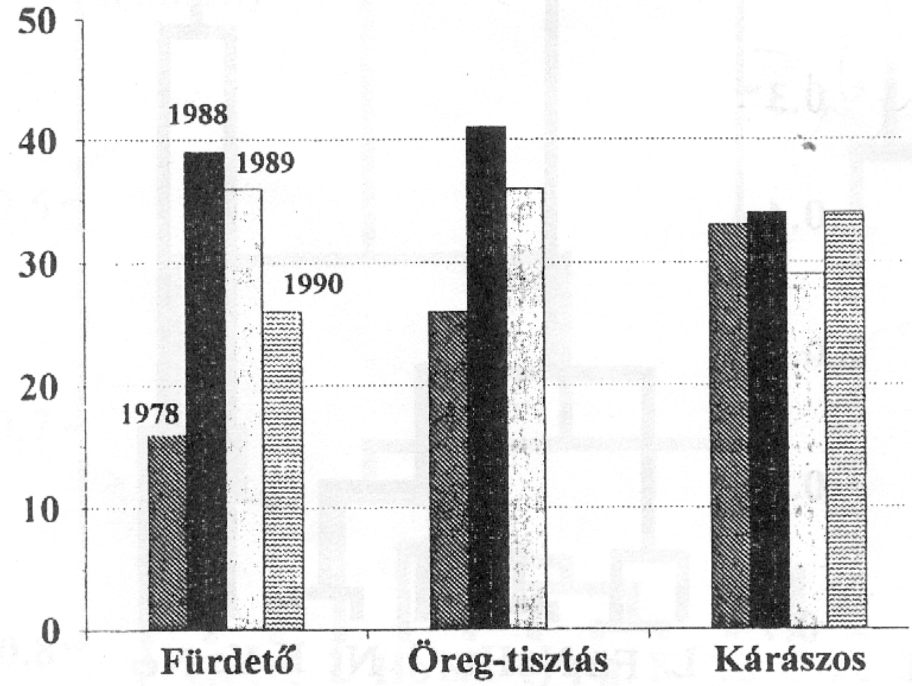

Fig. 7. Changes of the number of taxa at Fürdető, Öreg-tisztás and Kárászos sampling sites in the four examined years

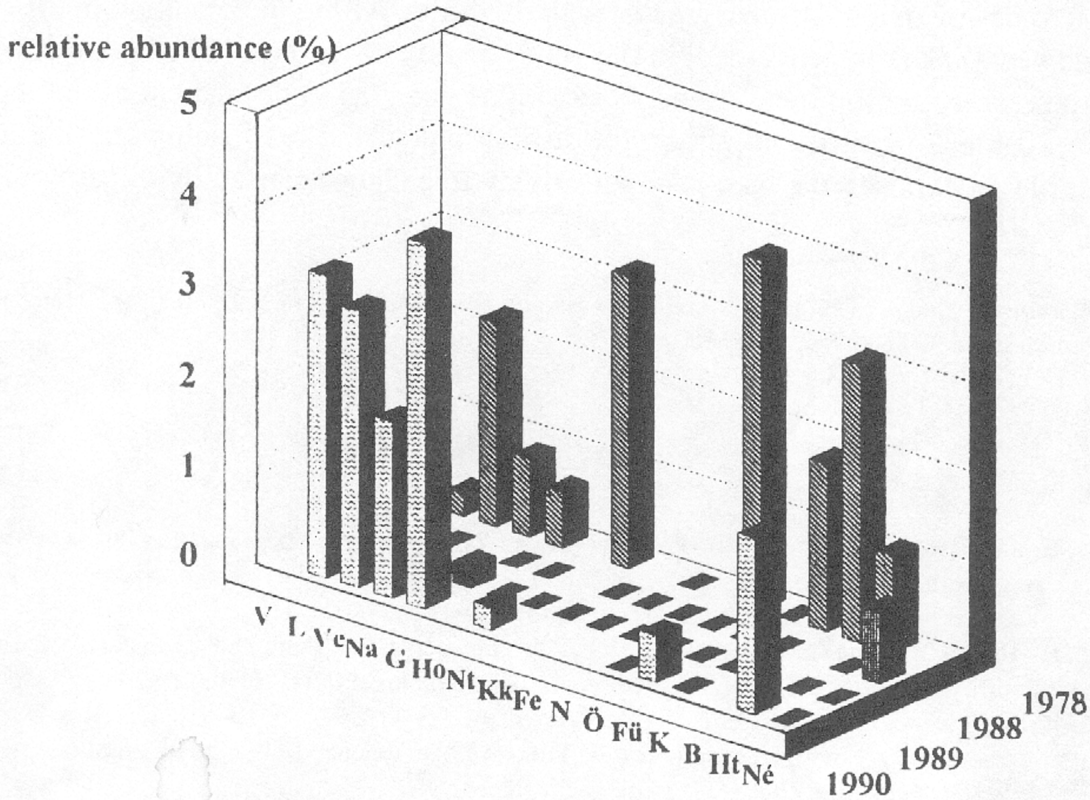

Fig. 8. Changes of relative abundance of *Chaetoceros muelleri* in the four years examined

other samples are getting more and more similar (Figs 4–5). On the basis of the analyses of the periphyton samples it seems that the lake has lost its former mosaic-like character, except the natural protection area where the original water quality was more or less preserved, though the composition of its algal coating has been also transformed, by the immigration of certain blue-green algae originally characteristic of the basement regions.

CONCLUSIONS

By our days the Lake Velence has almost completely lost the former mosaic-like character of its water quality. Traces of the original water quality is maintained only by the protected western parts of the lake. Due to artificial interference, by the clearing of the remaining reed fields the water of formerly distinct regions have been mixed. Formerly, the unwelcome effects of local deterioration of water quality were isolated (local) effects (e.g. mass fish decay due to temporary decrease of oxigen), but lately the disadvantageous effects could spread almost without obstacles throughout the whole lake (e.g. the mass spread of the toxic blue-green alga *Microcystis aeruginosa* Kütz. within the plankton in the last three years). The improvement in the water quality of the lake achieved in course of the reconstruction measurements cannot be considered permanent as the more than 20 km long artificial shore, the low extent of the reed fields and the low water level exposed the lake very sensitively to changes caused by diffuse pollutions.

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