Padisák, J., Ács, É., Rajczy, M. & K. T. Kiss (1991): Use of algae for monitoring rivers in Hungary. In: Whitton, B. A., Rott, E. & Friedrich, G. (eds.) Use of algae for monitoring rivers: 123-128. Inst. für Botanik, Univ. Innsbruck, Innsbruck

USE OF ALGAE FOR MONITORING RIVERS IN HUNGARY

JUDIT PADISÁK, ÉVA ÁCS, MIKLÓS RAJCZY & KEVE T. KISS

SUMMARY

Algological monitoring in Hungary started in the 1960s - 1970s and its technical guidelines were elaborated by 1984. Streams and rivers are monitored at 155 sampling stations by a sampling frequency of 4-52/year. Based on trophic scales (chlorophyll-a, algal numbers) trophic states are established. A saprobic classification is made according to the list of saprobic indicator species. The paper summarizes the opinions of many Hungarian algologists involved in monitoring about the advantages and pitfalls of the existing monitoring system.

Since the authors' conviction is that computer problems and methods for handling large databases and the exploration of their information content will become one of the major difficulties in connection with algological monitoring, a pilot study was made on an already existing databank. The outcome of this study was that, however much the original single data-sets were different, large databanks can be useful in searching for variables that can be used for monitoring water quality. Simple variables (e.g. the ratio of diatoms to non-diatoms) and multivariate methods can be applied with a good measure of success.

MONITORING SYSTEM, SAMPLING SITES, SAMPLING FREQUENCY

As a result of the increasing recognition of the fact that environmental effects endanger the water quality of lakes and rivers, Water Quality Laboratories were established in the centres of the Regional Water Authorities (Fig. 1) during the 1960s - 1970s. This can be considered as the beginning of environmental monitoring. Their activity was restricted to monitoring only the large rivers and lakes. Since algologists were not employed by every authority and the concepts of biological monitoring were (and from many respects still are) obscure, these early records are rather inconsequential concerning sampling frequency, sampling sites, variables measured, etc. By 1984 technical guidelines were elaborated for water quality monitoring with fixed sampling stations and sampling frequency (Fig. 2), and then modification is currently underway.

However, the number of algologically analyzed samples does not always cover the number of samples calculated from Fig 2., because on average only a dozen algologists are employed by the Environmental Protection Authorities where the Water Quality Labs at present belong. Fig 3. shows the sampling stations where algae are studied regularly. In several regions (for example Győr) the two maps completely cover each other concerning both sampling sites and frequency, while in others (eastern Hungary) the sampling frequency is the same for large rivers but only 4/year for their tributaries.

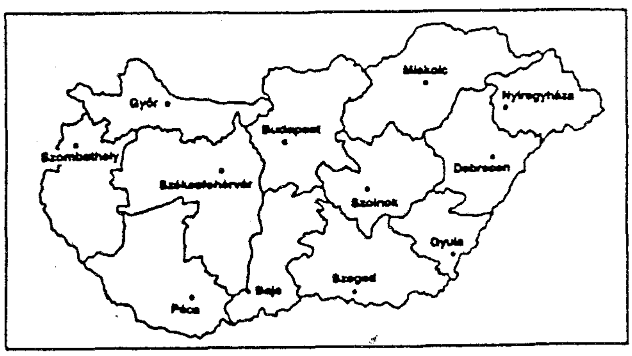

Fig. 1. Territorities and centres of the regional Environmental Protection Authorities in Hungary.

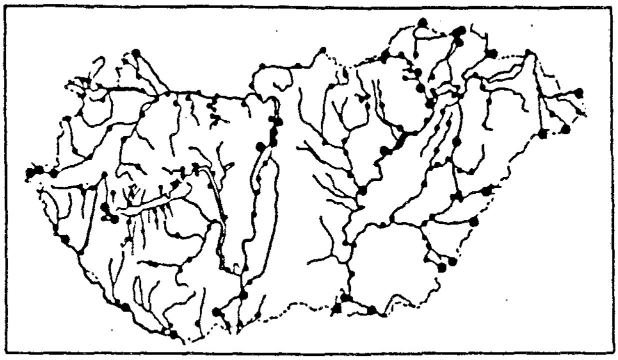

Fig. 2. Harmonizing monitoring program for rivers and water courses in Hungary. Based on technical guidelines N° MI - 10,172/2-84. After the map prepared by KGI, Institute for Environmental Protection, Section Water Quality. Sampling frequency: ● 52/year; ● 26/year.

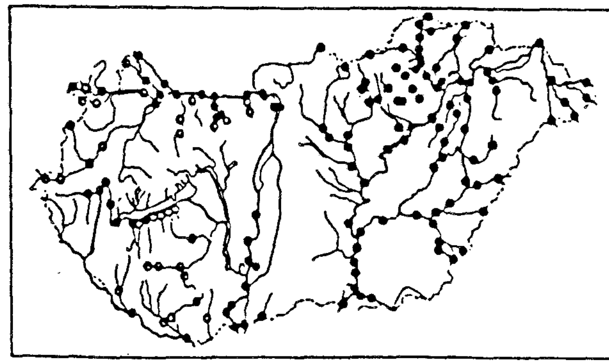

Fig. 3. Sampling sites where algological samples are regularly taken. Symbols: ● samples are both qualitatively and quantitatively analyzed; O samples are only qualitatively analyzed.

VARIABLES MONITORED

Variables that are to be measured at the stations are water and air temperature, conductivity, alkality, total hardness, pH, seston, seston dry weight, dissolved oxygen, oxygen saturation, chemical and biological oxygen demand, ortho-phosphate, TP, nitrate, nitrite, ammonia, TN, main anions and cations, chlorophyll-a and algal density.

trophic states	chlorophyll-a mg/m^3	algal numbers ind $10^6/l$
atrophic	0	0
ultra-oligotrophic	<1	<0.01
oligotrophic	1 - 3	0.01 - 0.05
oligo-mesotrophic	3 - 10	0.05 - 0.1
mesotrophic	10 - 20	0.1 - 0.5
meso-eutrophic	20 - 50	0.5 - 1
eutrophic	50 - 100	1 - 10
eu-polytrophic	100 - 200	10 - 100
polytrophic	200 - 800	100 - 500
hypertrophic	>800	>500

Table 1. Trophic classes by chlorophyll-a and algal numbers according to Felföldy (1987)

Chlorophyll-a content (at several regions, for example Szeged, Fig. 1, chlorophyll-forms too) is regularly measured. Based on the data trophic states (see Table 1) are estimated according to Felföldy (1987).

Algal samples are analyzed qualitatively, and species composition is compared to the list of saprobic indicator species given in Gulyás (1983). The Pantle-Buck index is one of ef the earliest biological variable that is calculated. In many cases not only species lists are obtained, but algae are counted by inverted microscope or, if this not available, by the agar-plate method (Németh & Vörös 1986). Algal density is compared to Felföldy's (1987) trophic scale (Table 1).

OPINIONS ABOUT THE EXISTING MONITORING SYSTEM

As a result of the activity outlined above long-term, relatively frequent quantitative algal data are available for the larger Hungarian rivers, and at least scattered information has been obtained for the algae of smaller water courses. Although many efforts were taken to organize and to standardize the algological monitoring system, the real value and the reliability of the data obtained are questionable.

It is a general opinion that it is not enough to measure the chlorophyll-a content. The phaeophytin content is also important because, for example, it can reflect heat-shock. Trophic states that are estimated by both chlorophyll-a and algal numbers (Table 1) are often different; therefore, the biomass-estimation by volumes should also be introduced as a standard method. According to several opinions, different scales ought to be applied for different water types, and it has been an urgent task to develop them.

Day-to-day studies on the rivers Maros and Tisza (south-eastern Hungary) showed that, as in shallow lakes, both chlorophyll and algal density can change even an order of magnitude from one day to the other; consequently, sampling frequency has also been a very important question in monitoring and to increase it in rivers is recommended. In running waters the frequency of sampling should always be fitted to the actual hydrometeorological conditions.

Opinions are more diverse concerning the estimates of waters by saprobic indicator algae . Several algologists rely on these results because, the presence of many a- and b-mesosaprobic species by algae (and this is mostly the case) carry the information that no serious problem arises with water quality. Others say that the routine use of saprobic indicator lists provides controversal results, if any at all, and that instead, the information content of species lists (proportion of different groups, diversity, similarity between years) should be utilized. It is also agreed that more attention should be paid to the algae in the small water courses, not only because they are important themselves, but also because they have a considerable influence on the water quality of large rivers.

Another serious problem is the use of the huge amount of records provided by the recent monitoring system. Records exist mostly in original protocols. Sometimes reports are compiled in which the records are summarized, but are not scientifically analyzed, and it is only a minor amount which appears as scientific publication. In several regions of the country records including the former ones are being computerized, but in others this has yet to be done. Therefore, we cannot expect any summary in the near future.

The authors' opinion is that the computer problems, handling large databases and the exploration of their information content will become one of the major difficulties in connection with algological monitoring. For this reason a pilot study was made on an already existing databank.

USE OF DATABANKS

In 1979 the computerizing of all the published Hungarian algological records started in the Botanical Department of the Hungarian Natural History Museum, Budapest. Currently the datebase comprises the data published before 1975.

To assess the information that can be obtained by use of such a databank from the point of view of monitoring and water quality in general, data of streams and rivulets were chosen. Among the 72,883 computerized records 1555 for streams and rivulets were published in 65 publications between 1870 and 1975. For analyzing databank records no preconceptions were made; the only restriction was to keep as high a level of comparativity as possible based only on the number of records published for the given localities. After excluding the scattered floristic records and including some other results which appeared after 1975, we selected the records of 14 items (streams/areas/localities with fast flowing water). Two unpublished data-sets were also added to the above database. For 6 of the above 16 only diatom data are available. Information is given in Table 2.

	stream/locality	record N°	references	note
1	Aszófői séd	189	Kol (1957), Tamás (1957)	unpolluted
2	Pécsely patak	110	Kol &Tamás (1955)	unpolluted
3	Gaja patak	115	Vida (1974)	only diatoms, unpolluted
4	Hegyadó árok	63	Cholnoky & Hofler (1949)	only diatoms, unpolluted
5	Bükk II.	59	Padisák unpublished	unpolluted
6	Szőlőhegyaljai patak	60	Szabados (1952)	unpolluted
7	Rigóc patak	221	Uherkovich (1976)	fishponds
8	Bükk I.	37	Hevesi (1971), Hortobágyi (1965)	unpolluted
9	Laskó patak (Egerszalók)	47	Estók & Milinki (1989)	below a goose farm, at dam
10	Laskó patak (Újlőrincfalva)	40	Estók & Milinki (1989)	well below damned
11	Rákos patak	20	Ács unpublished	polluted (industrial, household)
12	Margitsziget	60	Istvánffy (1892)	thermal, unpolluted
13	Ráckeve	22	Cholnoky (1922)	only diatoms, unpolluted
14	Zagyva	17	Szemes (1948)	only diatoms, unpolluted
15	Pápa	43	Gallik (1886)	only diatoms, unpolluted
16	Pilis	22	Cholnoky (1922)	only diatoms, unpolluted

Table 2: List of the tested 16 Hungarian streams.

652 taxa belonging to 143 genera were found in these 16 data-sets. Most of the taxa occurred only at one locality. The distribution of the above number of taxa in frequency classes is given on Fig. 4. Species which were quite frequently found, but occurred only in unpolluted waters are indicated by a single, those which occurred in at least 50 % of cases in polluted waters are indicated by a double asterisk. There is a clear difference between the frequency distribution of diatoms and non-diatoms. Non-diatoms appear to be less constant elements; only two (Oscillatoria limosa ** Ag., and Scenedesmus quadricauda** /Turp./ Bréb.) occurred at a maximum of four localities. Diatoms are more widespread: Navicula cryptocephala Kütz. occurred at 11 localities, the further more common species are (number of occurrences in brackets): Surirella ovalis Bréb. (10), Synedra ulna /Nitzsch./ Ehr. (10), Achnanthes minutissima Kütz. (9), Navicula hungarica var. capitata /Ehr./ Cleve (9), Amphora ovalis Kütz. (8), Cymatopleura solea /Bréb./ W. Smith (8), Navicula gracilis * Kütz. (8), Rhoicosphenia curvata /Kütz./ Grun. (8), Cocconeis placentula Ehr. (7), Gomphonema olivaceum /Lyngb./ Kütz. (7), G. parvulum /Kütz./ Grun. (7), Meridion circulare Ag. (7), Achnanthes lanceolata * Bréb. (6), Amphora ovalis var. pediculus Kütz. (6), Cymatopleura elliptica /Bréb./ W. Smith (6), Cymbella affinis Kütz. (6), C. ventricosa Kütz. (6), Diploneis puella* /Schum./ Cleve (6), Frustulia vulgaris* /Thwait./ De Toni (6), Gyrosigma acuminatum /Kütz./ Rabh. (6), Hantzschi amphioxys /Ehr./ Grun. (6), Melosira varians ** Ag. (6), Navicula lanceolata Kütz. (6), Nitzschia dissipata * /Kütz./ Grun. (6), N. linearis /W. Smith/ Hust. (6),

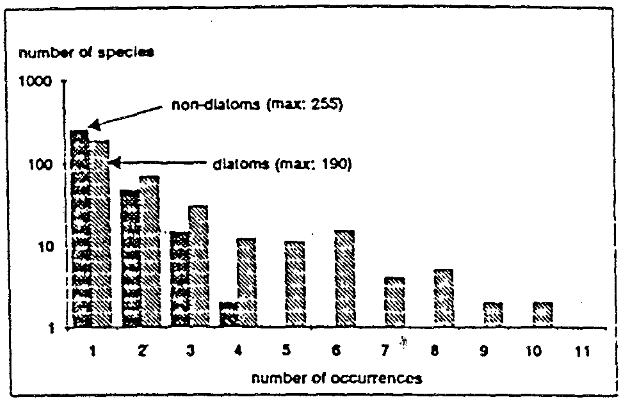

Fig. 4. Number of species (logarithmic scale) in different frequency classes (sum of 10 Hungarian streams). Frequency numbers correspond to the number of occurrences.

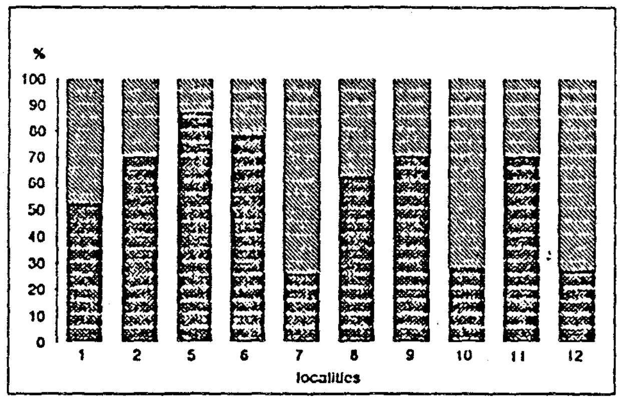

Fig. 5. Proportion (%) of diatoms (below) to non-diatoms (above) in 10 Hungarian streams. See Table 2. for locality numbers.

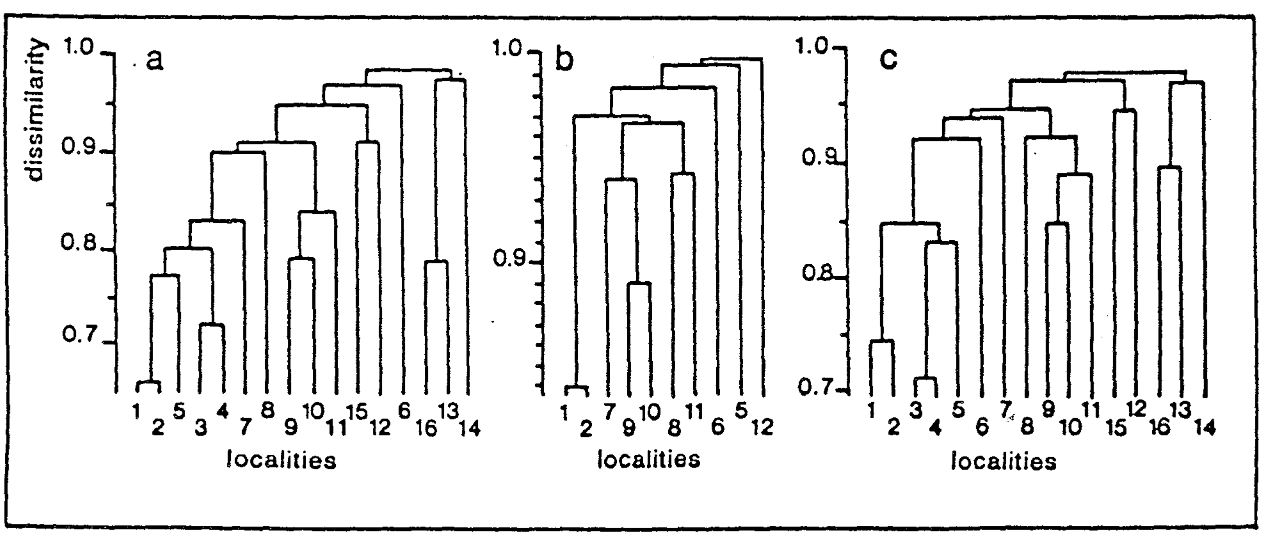

Fig 6. Results of the cluster analyses of the tested 16/10 Hungarian streams. See Table 2. for locality numbers. a: only diatoms; b: only non-diatoms; c: diatoms + non-diatoms.

Surirella angustata Kütz. (6), Synedra acus ** Kütz. (6), Caloneis amphisbaena ** /Bory/ Cleve (5), Fragilaria crotonensis Kitton (5), Gomphonema angustatum /Kütz./ Rabh. (5), G. angustatum var. producta Grun. (5), Gyrosigma spencerii ** /W. Smith/ Cleve (5), Navicula dicephala /Ehr./ W. Smith (5), N. viridula Kütz. (5), Nitzschia acicularis /Kütz./ W. Smith (5), N. palea ** W. Smith (5), N. vermicularis /Kütz./ Grun. (5), Stauroneis smithii ** Grun. (5), Amphora veneta ** Kütz. (4), Cocconeis pediculus** Ehr. (4), C. placentula var. euglypta ** /Ehr./ Cleve (4), Cyclotella meneghiniana Kütz. (4), Diploneis oculata ** /Bréb./ Cleve (4), D. ovalis ** /Hilse/ Cleve (4), Navicula radiosa** Kütz. (4), Nitzschia amphibia Grun. (4), N. dubia** W. Smith (4), N. sublinearis** Hust. (4) and Stauroneis anceps Ehr. (4).

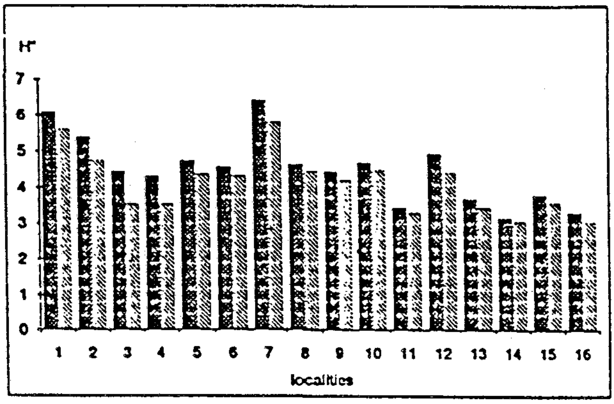

Fig. 7. Generic diversities (left) and diversity maxima (= $\log_2$ genus number; right) of algae in 16 Hungarian streams. See Table 2. for locality numbers.

A plot of the percentage proportion of diatoms to non-diatoms at different localities (where both groups were studied) is given in Fig. 5. The proportion of diatoms was higher than 50 % except for localities 7, 10 and 12 (compare toTable 2), which are polluted or thermal waters. In cluster analyses (Jaccard similarity index /Jaccard 1908/, WPGMA fusion algorithm /Sneath & Sokal 1973/) polluted/thermal localities were mostly separated or were only loosely connected to the main groups (Fig. 6). Based on the number of subspecific taxa belonging to the same genera, generic diversities were calculated (Fig. 7). The plot first of all reflects that how much the given study analytic was (H' and H'max are the highest for localities 1, 2 and 7; compare to Table 2.), on the other hand polluted/thermal (except for loc. 11) waters had slightly higher diversities than the unpolluted ones.

The outcome of the above pilot study is that, however much the original single data-sets differ (more than a century passed between the first and the last, taxonomic concepts changed in the interval, both spatially and temporally the studies were not similarly analytic etc.), large databanks can be useful in searching for parameters that can be used for testing water quality on monitoring level. Simple variables (in this case, for example, the ratio of diatoms to non-diatoms) and multivariate methods can be applied with a good measure of success.

ACKNOWLEDGEMENTS

Many Hungarian algologists, those who are working in Water Quality Laboratories of the regional Environmental Protection Authorities (WQL-EPA), contributed to this manuscript, both by providing information about the existing monitoring system and by making their experiences and opinions available. The authors thank Dr Oszkár Balázs-Dacskó (North Hungarian Regional Waterworks), Éva T. Bartalis (WQL-EPA, Győr), Dr György Gorzó (WQL-EPA, Székesfehérvár), Dr József Hamar (WQL-EPA, Szolnok), Dr Mária Hegedűs (WQL-EPA, Szeged), Krisztina Kelemen (WQL-EPA, Szolnok), Dr Imre Oldal (WQL-EPA, Pécs), Antal Schmidt (WQL-EPA, Baja), Dr Ferenc Vasas (WQL-EPA, Gyula) and Éva Vízkeleti (WQL-EPA, Szombathely) for their help in compiling the manuscript.

REFERENCES

Cholnoky B (1922) Adatok Budapest Bacillariea-inak elterjedése ismeretéhez [Contribution to the knowledge of distribution of diatoms in Budapest]. Botanikai Közlemények 20, 66-79. [in Hungarian]

Cholnoky B, Hofler K (1949) Über den Diatomeenbewuchs eines Mühlrades. Österr. Bot.Zeitschr. 221-231.

Estók B, Milinki E (1989) Changes in the quality of water in Laskó stream and the storage built on h Egerszalók. Tiscia (Szeged) 24, 11-22.

Felföldy L (1987) A biológiai vízminősítés [Biological methods for classification water quality] Vízügyi hidrobiológia 16., VÍZDOK Budapest. [In Hungarian]

Gallik O (1886) Az édesvízi Diatomaceákról (Bacillariák) általában, azon fajok felsorolásával, melyel vidékünkön találtam [On freshwater diatoms in general with a compendium of species that we found in the surroundings of Pápa]. A Pápai Katholikus Gymnasium Értesítője 1885-1886, 3-([In Hungarian]

Gulyás P (1983) KGST biológiai módszerek [COMECON biological methods].- Vízügyi hidrobioló(12., VÍZDOK Budapest. [In Hungarian]

Hevesi A (1971) Az algák és a mohák szerepe a bükki forrásmészkő képződésében [The role of alg and mosses in the formation of the Bükk spring-water limestone]. Abstracta Botanica (Budapes 1, 14-30. [In Hungarian]

Hortobágyi T (1965) A Bükk hegység algái [Die Algen des Bükk-Gebirges]. Hidrológiai Közlöny 4 309-313. [In Hungarian]

Istvánffy Gy (1892) A margitszigeti vízesés növényzete [Waterfall vegetation on Margitsziget]. Magy Növénytani Lapok 15, 57-69. [In Hungarian]

Jaccard P (1908) Novelles recherches sur la distribution florale. Bull. Soc. Vand. Sci, Nat. 44: 22 270.

Kol E (1957) Az Aszófői séd mikrovegetációja I. Algák (a kovamoszatok kivételével) [Mikrovegetatio des Aszófői Séd Baches I. (mit Ausnahme der Diatomeen)]. Annal. Biol. Tihany 24, 103-130. [I Hungarian]

Kol E, Tamás G (1955) A Pécsely patak mikrovegetációja [Microvegetation of the Pécsely brook Annal. Biol. Tihany 22, 87-105. [In Hungarian]

Sneath PHA, Sokal RR (1973) Numerical taxonomy. Freeman, San Francisco.

Szabados M (1952) A diósjenői Szőlőhegyaljai patak algái [Die Algen des Szőlőhegyaljai-Baches be Diósjenő]. Ann. biol. Univ. Hung. 1, 413-418. [In Hungarian]

Szemes G (1948) A Zagyva folyó kovamoszatainak elterjedése a forrástól a torkolatig [Die Verbreitung der Bacillariophyten des Zagyva-Flusses von der Quelle bis zur Mündung]. Borbásia 8, 89-113. [In Hungarian]

Tamás G (1957) Az Aszófői séd kovamoszatai [Diatomen des Aszófői Séd Baches]. Annal. Biol Tihany 24, 133-154. [In Hungarian]

Uherkovich G (1976) Die Mikrophyten des Rigóc-Baches und seiner Weiher (Komitat Somogy, Ungarn). Dunántúli dolgozatok 10, 5-17.

Vida L (1974) A Gaja patak bakonynánai szurdokának kovamoszattársulásai [The diatom communities of the ravine of Gaja brook near Bakonynána]. Botanikai Közlemények 61, 157-167. [In Hungarian]