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LONGITUDINAL PROFILE INVESTIGATION IN THE TISZA AND EASTERN MAIN CHANNEL I. QUANTITATIVE CHANGES IN PHYTOPLANKTON

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Abstract

Of late years, the hydrobiological investigations are unequivocally referring to that eutrophisation is a more and more frequent phenomenon in rivers and other fresh waters, as well. A concomitant of the periodical, recurrent eutrophysation of fresh waters is the quick, considerable multiplication of algae. The phytoplankton communities, rich in species and individuals, can mostly be observed at the time of the low waters in Autumn (PROWSE, TALLING 1958, UHERKOVICH 1971, SZEMES 1966, KISS KEVE 1974a, b, VÁNCSA 1974).

Our investigations in the Tisza were carried out in a period like that. We have established that in the Upper Tisza Region of swift flowing the number of algae is low, the alga association is of rheoplankton-character. After discharge of the Szamos of rich alga population into the Tisza, the quick multiplication of the phytoplankton began there, too, reaching its maxima (18 million ind./1) in the reaches between Záhony and Dombrád (Fig. 1). Below Tokaj, after the discharge of Bodrog, the number of individuals in the alga association was considerably reduced. The phytoseston of the Eastern Main Canal was similarly poor. The dominance of *Cyclotella* species, Nitzschia acicularis W. Smith, and Chlorococcales was characteristic of the algal association.

Introduction

A concomitant of the periodical, recurrent eutrophisation of fresh waters is the quick, considerable multiplication of phytoplankton. In rivers, apart from the increased mass of the vegetable nutritive materials, other ecologic factors (water speed, stream-deposit content, light climate, temperature), as well, take place in multiplying the algae. We may speak in case of rivers about a periodical, recurrent eutrophisation as the phytoplankton appears in a large mass only if the alluvial deposit-content is low and the water temperature is favourable. And that can occur mostly only on the occasion of low waters in Autumn (PROWSE, TALLING 1958, UHERKOVICH 1968a, b, 1969a, b, 1970, 1971, SZEMES 1966, KISS KEVE 1974a, b, VÁNCSA 1974).

It is characteristic of the Tisza as a river of a changeable direction of water and of large deposit-content that its quantitative and qualitative phytoseston-composition often and considerably changes during the year. We may observe well-discernible differences subject to the character of river-reaches, as well, first of all in the periods of balanced low waters (UHERKOVICH 1971).

We observed at the end of Summer, in early Autumn of every year since 1967 that plankton-alga population maxima develop in the impounded bed of Tisza at the Tiszalök reaches (KISS KEVE 1974a, b).

In the Eastern Main Canal forking from this impounded bed-section (length 98 km, breadth 40 m, depth 2.3—4.2 m, maximum water-transport 60 cubic metre/s.) a surface water-purifier is to be built for supplying the town Debrecen with drinking-water. From the point of view of purifying the drinking water, the algologic quality of the water of the main canal is very important and it is under the decisive influence of the quality of Tisza water in its reaches at Tiszalök.

The aim of our investigations is, therefore, to recognise in which part of the upper reaches of Tisza these algal associations, rich in species and individuals, develop and how they change moving with the stream in the river and Eastern Main Canal, respectively.

Sampling, method of investigation

The starting-point of our investigations was Tiszacsécse (Fig. 1). From there we sailed with the stream, striving to move, as far as possible, together with the watermass which we took the first water sample of. The water samples were taken in every 20 km, on the surface, ladling from the line of current.

We have supposed that the quality of Tisza water is under the influence of the Szamos and Bodrog, the two tributaries discharging into the Tisza at the reaches investigated: we took therefore samples from these, too, at the place before the mouth.

On the spot we have determined the water temperature and the content of dissolved oxigen. In the course of our investigations so far we have seen that there is some connection between trans-

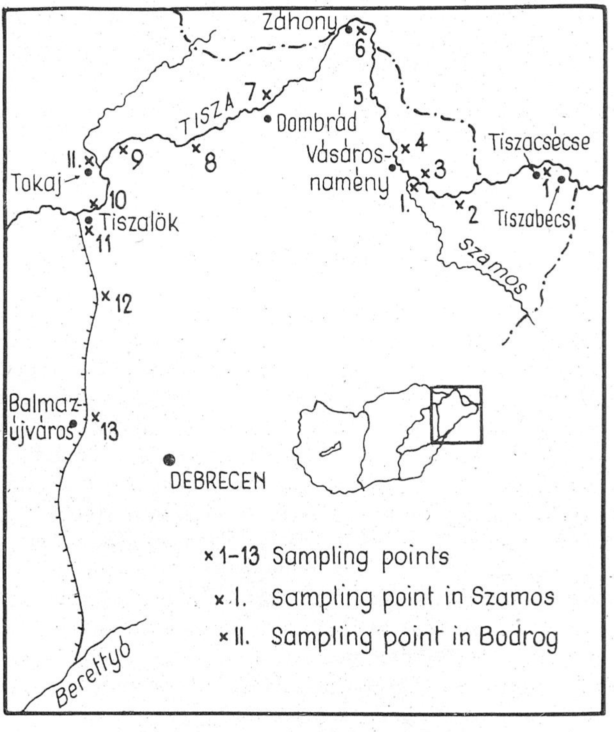


Fig. 1. Sketch map of the Tisza, Szamos, Bodrog, Eastern Main Canal with sampling points.

parence, favourable light climate of Tisza water and the phytoplankton mass multiplied in it (KISS KEVE 1974b, c). We have therefore carried out informative measurings by means of Secchi's disc and underwater light-measurings with Photronic cell. As it is not our aim to give a detailed optical characterisation of the Tisza water and of that of the Eastern Main Canal, we drew up a Table only about the transmission coefficient reckoned on the basis of measurings ($T_{K\ 0,2-1,2\ m}$) (Tab. 2) that is informing us about the light climate of water (FELFÖLDY and KALKÓ 1958, ENTZ and FILLINGER 1961). Fig. 1.

The qualitative investigation of algae was carried out from settled samples and plankton semples netted at the same time. Quantitative analysings were performed with Utermöhl's method (1958).

The results of investigation

UHERKOVICH has carried out several longitudinal-section investigations in the Tisza from Tiszabecs till Szeged, establishing that the algal associations of the river become, as a rule, real plankton associations in the lake-like bed-section dammed up by the sluice at Tiszalök, here it is that the number of species and individuals begins to increase considerably (UHERKOVICH 1968a, b, 1969a, b, 1971). An exception was only found in September 1967 when the rise in the individual number of algae started already at Vásárosnamény, reaching the maxima at Dombrád with an individual number of 11.4 million per litre. Below Tokaj, the number of algae considerably decreased (1—2 mill. ind./l) and till Szeged it has changed but a little. UHERKOVICH has completed his above-mentioned observation in a letter by mentioning that at investigating he took the sample of Vásárosnamény below the inflow of Szamos; it is therefore very probable that the high individual number was caused by the Sza-

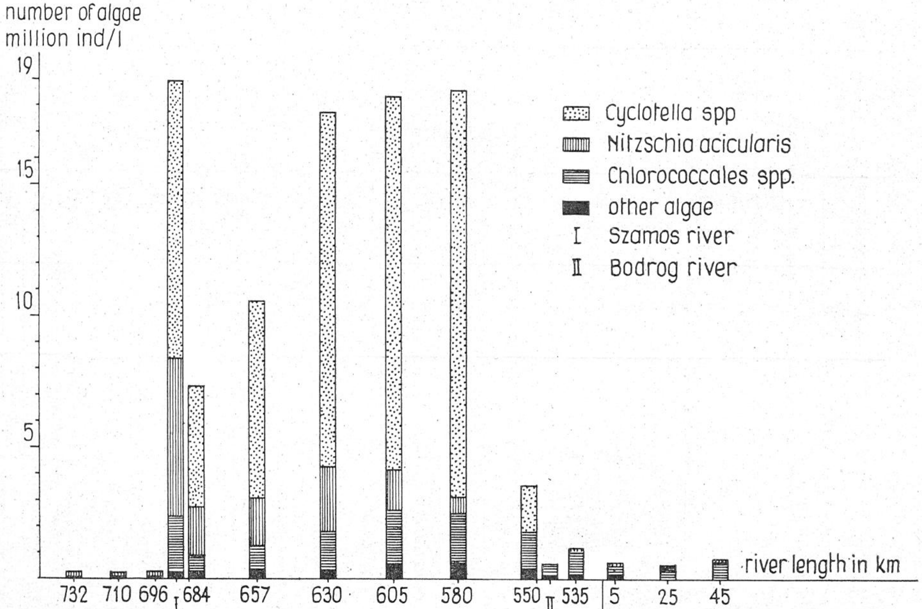


Fig. 2. Quantitative conditions of the phytoplankton of the Tisza, Szamos, Bodrog, Eastern Main Canal between 24—29 August 1973.

Table 1. *Quantitative composition of phytoplankton in the Tisza, Szamos, Bodrog and in Eastern Main Canal*

Sampling points	1	Szamos	4	5	8	9	Bodrog	10	11	13
Asterionella formosa							2,5		5	
Attheya zachariasi		40	5	10	300	60	5	30		3
Ceratoneis arcus	2									
Cyclotella spp.	20	10 560	4600	7 500	15 450	1750	50	120	115	55
Cymbella ventricosa	2									
Diatoma vulgare	23		5	3						
Gomphonema olivaceum	2			3						
Melosira granulata var. angustissima							27,5	5	5	5
M. varians							2,5			3
Navicula cryptocephala	2	10		5					5	
Nitzschia acicularis	165	5 880	1880	1 960	620	30	27,5	10	20	10
N. longissima var. reversa		10	8		5					
N. palea	0,5	10	4							
Rhisosolenia eriensis		60	35	50	150	240		100	25	
Rhoicosphenia curvata	2,5									
Synedra actinastroides			15	17	25	20			5	
S. acus	1	10	5	5	8	20		12	5	
S. ulna		10	5	8	30	20		12		5
other Bacillariophyceae	20	30	45	40	50	20		5	5	
total Bacillariophyceae	240	16 620	6612	9 593	16 638	2160	87,5	294	190	81
Actinastrum hantzschii		110	50	65	140	110		40	20	15
Ankistrodesmus acicularis	1	100	40	50	35	30	10	20	20	5
A. angustus	1	530	140	170	300	210	60	240	90	160

A. arcuatus		50	17	27	20	16	27,5	10	5	5
A. longissimus var. acicularis	0,5		3	5	40	10	7,5	7	5	
Coelastrum cambricum				2						
C. microporum		60	10	7	30	38	17,5	5	20	5
C. sphaericum		30				30	7,5	8		
Crucigenia apiculata		10	10	5	30	27	5	5		5
C. tetrapedia	1	190	30	20	115	140	42,5	140	60	170
Dictyosphaerium pulchellum	0,5	10	8	10	10	7		5		5
Didymocystis planctonica	0,5	40	15	13	60	70	30	55	15	60
D. tuberculata		20	8	10	60	40	10	20	5	10
Kirchneriella lunaris	1	500	120	135	105	90	5	45	5	25
K. obesa	0,5	10	12	18	25	20	30	10	5	40
Lagerheimia longiseta			5	8	60	18		5		
Oocystis borgei		90	20	18	100	60		15	10	15
Pediastrum boryanum			2	3		5				5
P. duplex			3							
Scenedesmus acuminatus		70	15	55	90	45	5	15	10	8
S. acutus		10	5	10	25	10				
S. denticulatus					15	8	2,5		5	3
S. ecornis	0,5	10	3		10	8	2,5	20		4
S. granulatus	1		8	5	10	5		5		5
S. intermedius		50	10	12	75	50	7,5	15	10	10
S. opoliensis	0,5	20	4	10	18	7			5	
S. protuberans					7		2,5	5		
S. quadricauda	1	140	50	45	200	100	22,5	50	45	10
S. spinosus			3	5	10	12	5	80	5	
other Scenedesmus spp.	0,5		3	3	50	22	17,5	12	5	3
Schroederia setigera		80	18	32	70	47		5		5

Sampling points	1	Szamos	4	5	8	9	Bodrog	10	11	12
Siderocelis ornata			10	15	15	15				5
Siderocystopsis fusca			5	3	15	15				3
Tetraedron minymum	1		8	5	15			5		3
T. muticum						5				3
T. triangulare				3				5		2
Tetrastrum glabrum		40	7	5	30	5	25	5	5	17
T. staurogeniaeforme			3		5	7	2,5		5	
Treubaria triappendiculata						5				3
other Chlorococcales	2		60	115	105	120	70	60	25	60
total Chlorococcales	12,5	2 140	705	899	1 895	1407	420	840	380	664
Lyngbya limnetica		10	2	7	5	5				
Merismopedia tenuissima							22,5	5		
other Cyanophyta		40	10	12		5	10	3	5	5
Euglena spp.		20	3	3		5			5	
Strombomonas spp.		10	2	3						
Trachelomonas spp.		10		5	20	10	2,5		5	
Dinobryon spp.	1,5		3	10	10					
Mallomonas spp.	3		3	5		3		5		
Chlamydomonas spp.		20	8	10		5	2,5		10	5
Eudorina elegans					8	15		8		
Gonium pectorale		30	12	10					15	
Pandorina morum									5	
Closterium acutum		10					10		10	
Cosmarium obtusatum	7		5	5		5				
Staurastrum paradoxum			6		5	5			5	
other algae	2	10		8	9	15				5
total phytoplankton 1000 ind/lit.	266	18 950	7370	10 560	18 590	3540	575	1150	635	765

mos water rich in algae. (I am deeply indebted to him for this valuable completion). In the present series of our investigations we have observed a similar case that I want to report on with fuller particulars.

In the course of sampling we could observe that at Tiszacsécs the Tisza has the character of upper reaches, its flowing is swift, its bed is gritty, its water is clear, of transparent bluish-green colour. The rather swift water detaches algae from the diatom-grass living, fixed on, sticked to the stones of the bed. In the phytoseston we have found many a rheon organism (*Diatoma vulgare* BORY, *Ceratoneis arcus* KÜTZ., *Gomphonema olivaceum* (LYNGB.) KÜTZ., *Rhoicosphenia curvata* (KÜTZ.) GRUN., *Cosmarium obtusatum* Schmidle), besides these, however, as a characteristic plankton-element, the *Cyclotella* species, *Nitzschia acicularis* W. SMITH are constituting already 65 per cent of the total population (cf.: Table). The rather swift water, however, does not make possible any more considerable multiplication of plankton-organisms. Till the inflow of the Szamos this picture does hardly change.

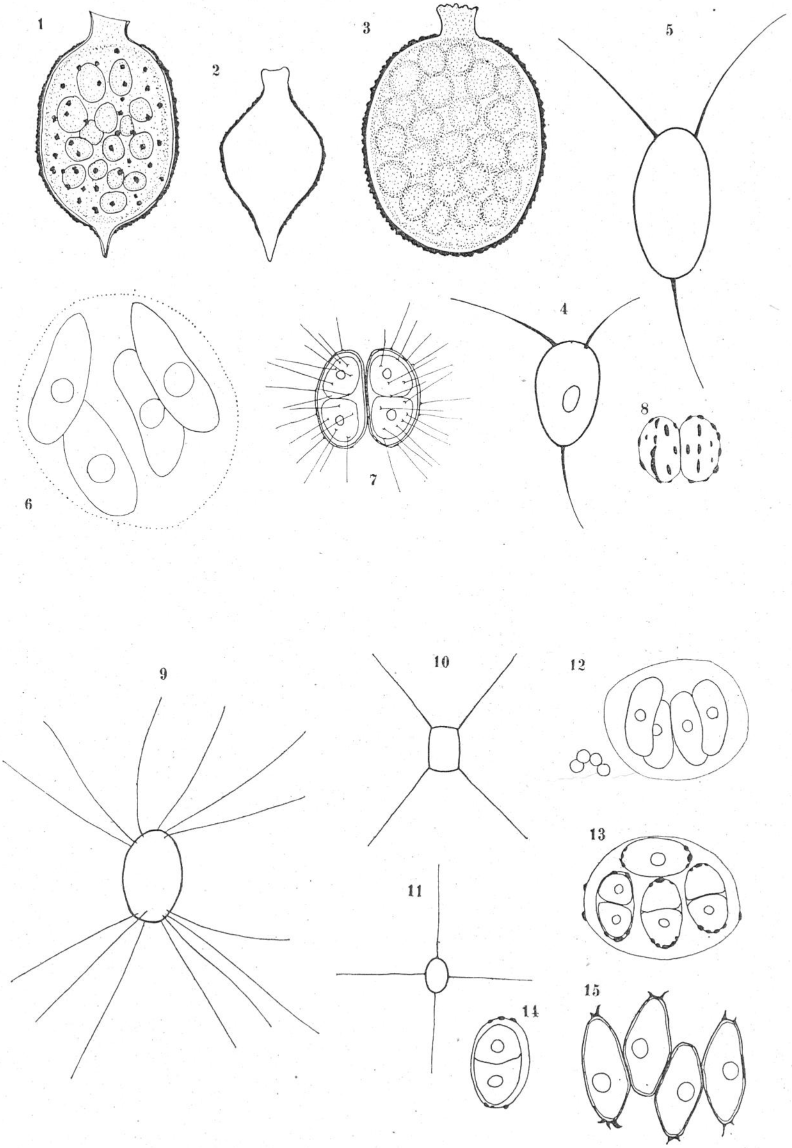
A considerable qualitative change in the Tisza was caused by the water of Szamos. The greenish, brownish Szamos, abounding in water and flowing into the Tisza at Vásárosnamény, brought into it a very rich algal association. The water of Szamos is characterised by the dominance of plankton-elements. The individual number of *Cyclotella* species (10560 thousand ind./l) ,*Nitzschia acicularis* W. SMITH (5880 thousand ind./l) is prominently high. Apart from them, the characteristic components of the alga population are *Attheya zachariasi* J. BRUN., *Rhisosolenia eriensis* H. L. SMITH, and the Chlorococcales-group, rich in specious.

The water of Szamos was considerably diluted in the Tisza, exerting a decisive influence on its quality. The difference between the two waters could be seen well even on their colours. The Tisza was above Vásárosnamény bluish green, the Szamos however greenish brown. It was interesting to observe that the two kinds of water were not mixed entirely with each other even for two km below flowing together.

The algae getting from the Szamos to the Tisza, found favourable conditions, began to multiply quickly and reached the maximum individual number between Záhony and Dombrád. The dominance of *Nitzschia acicularis* W. SMITH fell more and more into the background, on the other hand, the species *Cyclotella* became predominant, forming 76—83 per cent of the total population. It is obvious how rich in species the order Chlorococcales is from among which the species *Actinastrum hantzschii* LAGERH., *Ankistrodesmus angustus* BERN., *Crucigenia tetrapedia* (KIRCH.) W. et G. S. WEST, *Kirchneriella lunaris* (KIRCH.)MOEB., and *Scenedesmus* are to be emphasised. An interesting dash of colour in the population is *Attheya zachariasi* J. BRUN. (300 thousand ind./l) and *Rhisosolenia eriensis* H. L. SMITH (240 thousand ind./l), found in an unusually high number. These planktonic silica algae of an extremely fine silica skeleton can only multiplied in the Tisza in quiet, silent periods with small water.

Between Dombrád and Tokaj, first of all owing to the decrease in the individual number of *Nitzschia acicularis* W. SMITH and *Cyclotella* species, the phytoplankton population was reduced to a quarter. The Bodrog flowing into the Tisza at Tokaj gets on with diluting its water and the algal association at Tiszalök as well as in the Eastern Main Canal can already be called poor, first of all as regards the individual number. As new elements from the Bodrog, the species *Melosira granulata* var. *angustissima* MÜLL., *Merismopedia tenuissima* LEMM., *Gomphosphearia naegeliana* (UNGER) LEMM. are to be emphasised.

In order to reduce the extent of Tab. 1, we have not published there the species found in a lesser individual number. Therewere left out of the Table for similar reasons



List of taxonomical figures

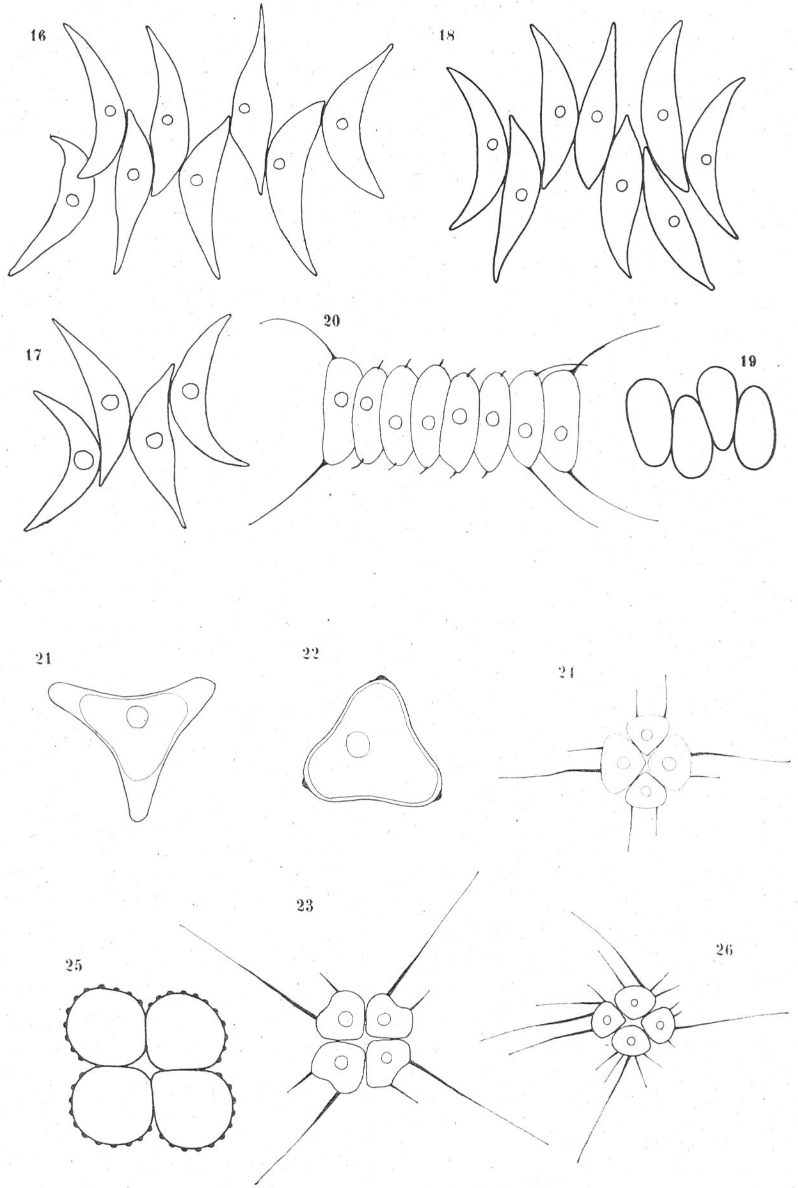
1. *Strombomonas deflandrei* var. *szolnokiensis*
2. *Strombomonas fluviatilis*
3. *Trachelomonas scabra*

4—5. *Chodatella balatonica*

6. *Coenocystis reniformis* var. *tiszae*
7. *Dicellula planctonica*
8. *Didymocystis inconspicua*
9. *Lagerheimia longiseta*
10. *Lagerheimia quadriseta*
11. *Lagerheimia wratislaviensis*
12. *Nephrocytium agardhianum* var. *szolnokiense*

13—14. *Oocystis pseudocoronata*

15. *Scenedesmus aculeolatus*



16—18. *Scenedesmus acuminatus* var. *bernardii*
19. *Scenedesmus intermedius* var. *acadutus*
20. *Scenedesmus quadricauda* var. *setosus*
21. *Tetraedron muticum*
22. *Tetraedron triangulare*
23—24. *Tetrastrum heteracanthum*
25. *Tetrastrum punctatum*
26. *Tetrastrum triacanthum* var. *abundans*

10 μ
1—3.
10 μ
4—26.

the "sub-special" categories, varieties and forms (i. e., those inside a species); these are enumerated as follows. As some of the taxons published here constitute new data of presence in the water system of Tisza, we are publishing their sampling points, as well. (*Tf:* Upper Tisza Region: Tiszabecs—Vásársonamény; *Tkf:* Upper part of the Medium Tisza Region: Vásárosnamény—Tiszalök; *Sz:* Szamos; *B* Bodrog; *EMC:* Eastern Main Canal; these abbreviations are given on the basis of Uherkovich's paper, 1971).

Aphanisomenon flos-aquae (L.) RALFS—B, *Gomphosphaeria naegeliana* (UNGER) Lemm.—B, *Merismopedia glauca* (EHRBG.) NAEG.—EMC, *Microcytis flos-aquae* (WITTR.) KIRCH.—*Sz, Euglena proxima* DANG.—*Tkf, Strombomonas deflandrei* var. *szolnokiensis* UHERKOV.—*Tkf, S. fluviatilis* (LEMM.) DEFL.—*Sz, Trachelomonas scabra* PLAYFAIR—*EMC, T. stokesiana* PALMER—*Tkf, Dinobryon divergens,* IMHOF—*Tkf, D. sertularia* EHRBG.—*Tf, D. sociale* EHRBG.—*Tf, Mallomonas caudata* IWANOFF—*Tf, Tkf, M. tonsurata* TEIL.—*Tf, Centritractus belenophorus* LEMM.—*Tkf EMC, Achnantes minutissima* (KÜTZ.) GRUN. — *Tf, Cyclotella comta* (EHRBG.) KÜTZ.—*Tkf, EMC, C. kützingiana*)THWAIT.) CHAUVIN—*Tkf, EMC, C. meneghiniana* KÜTZ.—*Tf, Tkf, EMC, Diatoma vulgare* var. *breve* GRUN.—*Tf, D. vulgare* var. *capitulatum* GRUN.—*Tf, D. vulgare* var. *productum* GRUN.—*Tf, Tkf, Gyrosigma kützingii* (GRUN.) CLEVE—*Tkf, Nitzschia sigmoidea* (EHRBG.) W. SMITH—*Tkf, Stephanodiscus astraea* (EHRBG.) GRUN—*Tkf, Sz, EMC, S. tenuis* HUST.—*Tkf, Surirella ovata* KÜTZ.—*Tf, Synedra acus* var. *radians* (KÜTZ.) HUST.—*Tkf, S. ulna* var. *oxarhynchus* (KÜTZ.) van HEURCK—*Tf, Tkf, Sz, EMC, Chodatella balatonica* SCHERF—*Tkf, Coenocystis reniformis* var. *tiszae* UHERKOV.—*Tkf. Dicellula planctonica* SWIR.—*Tkf, Didymocystis inconspicua* KORSCHIK.—*B, Franceia tenuispina* KORSCHIK.—*Tkf, Lagerheimia quadriseta* (LEMM.) G. M. SMITH—*B, L. wratislaviensis* SCHROED.—*Sz, Nephrocytium agardhianum* var. *szolnokiense* UHERKOV.—*EMC, Oocystis pseudocoronata* KORSCHIK—*Tkf, EMC, Scenedesmus aculeolatus* REINSCH.—*Tkf, S. acuminatus* var. *bernardii* (G. M. SMITH) DESSUS.—*Tkf, B, S. acuminatus* f. *tortuosus* (SKUJA) UHERKOV.—*Tkf, S. acutus* f. *alternans* HORTOB.—*Tkf, Sz, S. acutus* f. *costulatus* (CHOD.) UHERKOV.—*Tkf, S. ecornis var. disciformis* CHOD.—*Tf, Tkf, Sz, S. intermedius* var. *bacaudatus* HORTOB.—*Tkf, EMC, S. intermedius* var. *bicaudatus* HORTOB.—*Tkf, B, EMC, S. quadricauda* var. *maximus* W. et G. S. WEST—*Tkf, Sz, EMC, S. quadricauda* var. *setosus* KIRCH.—*Sz, Tetraedron caudatum* var. *incisum* LAGERH.—*Tkf, B, T. minimum* var. *apiculato-scrobiculatum* (REINSCH, LAGERH.) SKUJA—*Tkf, EMC, Tetrastrum heteracanthum* (NORDST.) CHOD.—*EMC, T. punctatum* (SCHMIDLE) AHLSTR. et TIFF.—*Tkf, T. triacanthum* var. *abundans* KORSCHIK—*Tkf, EMC, Closterium acutum* var. *variabile* (LEMM.) KRIEG.—*B, EMC, C. leibleinii* KÜTZ.—*Tf, Staurastrum punctulatum* BRÉB.—*Tkf.*

Searching into the causes of the quantitative and qualitative changes in the algal population, we may emphasise the following points of view.

In the reaches between Tiszacsécse and Vásársonamény the cause of the low number of algae may be the higher water speed. Here is the phytoseston of rheoplankton-character. In the reaches at Vásárosnamény and lower the water speed is no more a high one in the time of the low waters in Autumn, then there is an opportunity for the multiplication of planktonic forms.

The development of the rich algal association in the Tisza was unequivocally released by the inflow of the Szamos. It is to be supposed that vegetable nutritive materials were transported by the Szamos into the Tisza where the plankton-algae coming from the Szamos began to multiply quickly. This quick multiplying was promoted by that these suspended loads could depose from the slowly flowing water of the Tisza, the light climate of water was therefore, favourable. The transparence of water ($T_{K\ 0,2-1,2\ m}$) is great, its value is corresponding to the clear water of the Balaton (FELFÖLDY and KALKÓ 1958, ENTZ and FILLINGER 1961). Parallel with the quick multiplication of algae, the dissolved-oxygen content became, of course, higher, as well (Tab. 2).

Table 2. *Some data of water quality in the Tisza and in Eastern Main Canal (24—29 August 1973)*

Sampling points	River length in km	Sampling date	Water temp. C°	O_2 mg	O_2 in p. c.	TK p. c. 0,2—1,2 m	Secchi-s disc transparency in/cm	Total number of algae 1000 ind/
1	732	Aug. 24.	20	12,5	136	71	140	266
2	710	24	20	11,9	130	69	136	259
3	696	25	20	12,1	132	70	130	277
4	684	25	22	11,0	125	64	85	8 370
5	657	26	20	12,9	140	65	70	10 560
6	630	26	20	13,7	150	58	75	17 780
7	605	27	20	12,0	132	63	78	18 350
8	580	27	20	13,7	150	65	80	18 590
9	550	28	20	12,0	132	62	70	3 540
10	535	28	23	10,4	120	58	65	1 150
11	5	29	20,5	8,3	90	52	62	635
12	25	29	21,5	8,3	92	50	56	580
13	45	29	22	8,9	100	52	60	765

The cause of the impoverishment in the periphery of Tokaj may be partly the depletion of nutritive materials, partly the decrease in water transparence and partly the diluting effect of the Bodrog water, poor in algae. It wants more investigations to decide this problem in a more precise way.

On the basis of the data of UHERKOVICH (1968b, 1971) and of the results of our own investigations it may be established, to sum up, that in the upper regions of the Tisza, below the inflow of the Szamos, in case of low water, at the end of Summer, in Autumn, rich phytoplankton associations may develop. We can observe some cases when this rich population goes on with growing, in the reaches between Záhony and Dombrád it achieves the maximum value of individual number, in the lower bed regions, however, it becomes poorer. The causes of this change could not be duly cleared up, as yet, it is however doubtless that the small water speed, the degree of supply with nutritive material and light take a part in it.

References

ENTZ, B. AND FILLINGER, M. (1961): Adatok a Balaton fényklímájának ismeretéhez (Data to the knowledge of the light climate of the Balaton); A víz zavarosságának okairól és kihatásairól (About causes and effects of the water turbidity). — Annal. Biol. (Tihany) *28*, 49—89.

FELFÖLDY, L. and KALKÓ, ZS. (1958): A vízalatti fényviszonyok és a fotoszintézis összefüggése a Balatonban, 1957 nyarán (Connection between the underwater light conditions and photosynthesis in the Balaton, in Summer 1957). — Annal. Biol. (Tihany) *25*, 303—329.

KISS K. T. (1974a): Vízvizsgálatok a Keleti Főcsatornán II. A planktonalgák mennyiségi változásai (Water investigations in the Eastern Main Canal II. Quantitative changes in planctonalgae). — Hidrol. Közl. *54*, 406—417.
KISS K. T. (1974b): Effect of the turbidity of water on the development of algal association in the Tisza. — Tiscia (Szeged) *9*, 9—24.
KISS K. T. (1974c): Ecological factors of formation of Cyclotella population maxima in the Eastern Main Canal and in the river Tisza (Hungary). — Acta Biol. Debrecina (In print).
LUND, J. W. G. (1965): The ecology of the freshwater phytoplankton. — Biol. Rev. *40*, 231—293.
MOED, J. R. (1973): Effect of combined action of light and silicon depletion on Asterionella formosa Hass. — Verh. Internat. Verein. Limnol. *18*, 1367—1374.
PROWSE, G. A., TALLING, J. F. (1958): The seasonal growth and succession of planktonalgae in the White Nile. — Limnol. and Ocean. *3*, 222—238.
SZEMES, G. (1966): Untersuchungen über das Phytoplankton der ungarischen Donaustrecke in Herbstmonaten. — Opusc. Zool. Budapest *6*, 157—185.
UHERKOVICH, G. (1960): Adatok a Tisza potamofitoplanktonja ismeretéhez, II. A tiszalöki vízlépcső hatása a Tisza algavegetációjára (Data to the knowledge of the potamophytoplanktons in the Tisza II. Influence of the river barrage at Tiszalök on the algal vegetation of the Tisza). — Hidrol. Közl. *40*, 239—245.
UHERKOVICH, G. (1964): Adatok a Tisza potamofitoplanktonja ismeretéhez IV. A Keleti Főcsatorna fitoplanktonjáról (Data to the knowledge of the potamophytoplankton in the Tisza IV. On the phytoplankton of the Eastern Main Canal). — Hidrol. Közl. *44*, 514—520.
UHERKOVICH, G. (1968a): Adatok a Tisza potamofitoplanktonja ismeretéhez VI. A népesség-maximumok kialakulásának kérdéséhez (Data to the knowledge of the potamophytoplankton in the Tisza VI. To the problem of the formation of population-maxima). — Hidrol. Közl. *48*, 315—322.
UHERKOVICH, G. (1968b): Über verschiedene Typen der Algenmassenvermehrung in der Tisza (Theiß). — Tiscia (Szeged) *4*, 11—20.
UHERKOVICH, G. (1969a): Adatok a Tisza potamofitoplanktonja ismeretéhez VII. A népességmaximumok sajátos formáiról (Data to the knowledge of the potamophytoplankton in the Tisza VII. On the peculiar forms of population-maxima). — Hidrol. Közl. *49*, 31—35.
UHERKOVICH, G. (1969b): Über das Phytoseston der eutrophierten Theiß (Tisza) I. Beobachtungen im Juli 1968. — Tiscia (Szeged) *5*, 37—47.
UHERKOVICH, G. (1970): Seston Wisly od Krakowy po Tczew. Über das Wisla-Phytoseston zwischen Kraków und Tczew. — Acta Hydrobiol. (Kraków) *12*, 161—190.
UHERKOVICH, G. (1971): A Tisza lebegő paránynövényei (A Tisza fitoszesztonja) The suspended micro-plants of the Tisza)The phytoseston of the Tisza). — Damjanich Múzeum, Szolnok.
UTERMÖHL, H. (1958): Zur Vervollkommung der quantitativen Phytoplankton Methodik. — Verh. Internat. Verein. Limnol. *9*, 1—38.