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SEASONAL COMPOSITION, BIOMASS AND PRIMARY PRODUCTIVITY OF THE PHYTOPLANKTON IN LAKITELEK BACKWATER DURING 1980 AND 1983

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Abstract

Seasonal variations in the species composition and biomass of the phytoplankton were studied in the northern region of the backwater of the River Tisza in the nature reserve at Lakitelek. Samples for the investigations were collected at monthly intervals at three sampling stations at equal intervals. The biomass and density of the hyptoplankton were measured on the basis of total algal counts. Temporal similarities in phytoplankton associations were evaluated via hierarchical cluster analyis. Primary production rates in relation to solar radiation were estimated with the oxygen light-dark bottle method.

The results indicate that the tendencies of the algal communities to undergo compositional changes were the same throughout the backwater during the period studied. However, there were obvious differences between the species compositions during periods ranging from October to March and from July to September. The winter phytoplankton was dominated by species of Chrysophyceae and Pyrrophyta, while in the late spring collections Euglenophyta and Cyanophyceae were the most frequent. In summer the small-bodied ($<10\mu$m) green algae (mainly Chlorococcales) were the most abundant. Diatoms (Centrales) were present in high individual numbers throughout the year.

The seasonal distribution pattern of the biomass showed three distinct peaks: the first maximum between December and February (16—26 mg/1), the second in May or June (6—10 mg/1) and the third in September or October (8—39 mg/1). As concern the primary production rates measured in 1981, eutrophic, polytrophic and hypertrophic subregions were differentiated in the backwater at Lakitelek.

Introduction

The northern section of the dead-arm of the River Tisza at Lakitelek is part of the Kiskunság National Park which preserves the conditions of the river prior to its regulation last century. Research into its phytoplankton started in the early 1960-s. Besides identifying the high dominancy of *Synura uvella* EHR. and *Cyclotella* sp., ÜHERKOVICH (1971) emphasized that flowering plants and the rich algal vegetation provide evidence of a higher level of limnological individualization. Regular samlings at seasonal frequency were started from 1975 by KISS, I. (1978 a, b). He described a Euglenophyton abundance in the nonprotected southern region of the backwater.

Samples for our investigations were collected continuously every month from 1980 on. In previous studies we suggested that in the northern end of the backwater, which is in a state of natural alluvium, the summer phytoplankton bloom is prevented by shade effects of the macrovegetation and by the alimentary competition of bacteria and epiphytic diatoms (KOVÁCS and DOBLER 1984). Moreover, by means of scanning electron microscopy we first identified occurrence of *Thalassiosira faurii* (GASSE) HASLE (1978) in Hungary at Lakitelek (KISS, K. T. et *al.* 1984).

The present paper reports results of algological investigations between 1980 and 1983. In this period, the qualitative and quantitative species compositions and seasonal variations in the biomass of the phytoplankton were studied. On the basis of the primary productivity and biomass, the backwater was qualified in FELFÖLDY's classification (FELFÖLDY 1980).

Materials and Methods

Sampling: Sampling areas have previously been characterized in detail (KOVÁCS and DOBLER 1984). Briefly, three sampling stations were set up along the 6 km northern section of the backwater, at 3 km intervals. The first (No. 1) was situated at the research house of the Tisza-Research Committee at the northern end. The second (No. 2) was midway between No. 1 and No. 3, located at the bridge at Tőserdő. Samples were collected from a depth of 0,2 m every month between 1980 and 1982 from the point No. 3, and between May 1982 and April 1983 from all three stations. Primary production was measured in May and July 1981.

Species composition and biomass of the phytoplankton: For this purpose 1 litre raw water was collected and subsamples of 100—500 ml were centrifuged (3000×g, 10 min). Celli dentification and counting were performed with a phase contrast microscope on 5 µl aliquots spread on the surface of a thin (1 mm) agar-agar layer (NÉMET 1982 and personal communication). The total cell count of a species was expressed in terms of individuals per litre (ind/l). The biomass was expressed in mg/l on the basis of the mean cell size multiplied by the number counted in 1 litre. Mean cell volumes were calculated from at least 25 individuals.

Statistical procedures: Temporal similarities in the species composition of the phytoplankton were estimated with the CZEKANOWSKI (1909) index. Resemblance matrices and corresponding cladograms were prepared using the average chain strategy (UPGMA) from the agglomerative, hierarchy methods (SNEATH and SOKAL 1973, p. 230) for the clustering of phytoplankton associations. An investigation was also made as to which species were common and present in similar quantities relative to one another in the various phytoplankton communities.

Primary production rates and solar radiation: Primary production rates were measured in situ with the oxygen light-dark bottle method (FELFÖLDY 1980). Samples were collected with a special self-made sampling device (KOVÁCS 1984). In this manner, 200 ml bottles were filled with homogenous phytoplankton samples through a bronze net. Bottles were incubated at different depths in the backwater. Dark bottles were wrapped with aluminium foil. Oxygen was titrated by the WINKLER method. All incubations and analyses were performed in duplicate. From the light- dark oxygen results, daily rates of gross production (PG) were calculated in mg $C \cdot m^{-2} d^{-1}$ (VOLLENWEIDER 1974, p. 87). Solar radiation was recorded at hourly intervals from sunrise to sunset with a SPECTRA-PHYSICS (USA) pyrheliometer and the record was planimetrically integrated to calculate daily solar input in megajoule$\cdot m^{-2} \cdot d^{-1}$.

Results

Phytoplankton biomass and its seasonal composition

Samples were collected at sampling station No. 3 at monthly intervals between 1980 and 1982. Total cell counts of samples from a depth of 0.2 m for the sampling dates are summarized by major taxa in Table 1. The biomass of the Lakitelek backwater was composed of a total of 303 species, 24 varieties and 7 forms. The phytoplankton was dominated by Euchlorophyceae and Bacillariophyceae, though in 1981 collections indicated a more abundant presence of Cyanophyceae, Euchlorophyceae and Euglenophyta. There was a general decrease in the total number of diatom species during the period studied, whereas the species found in the biomass exhibited increasing individual numbers.

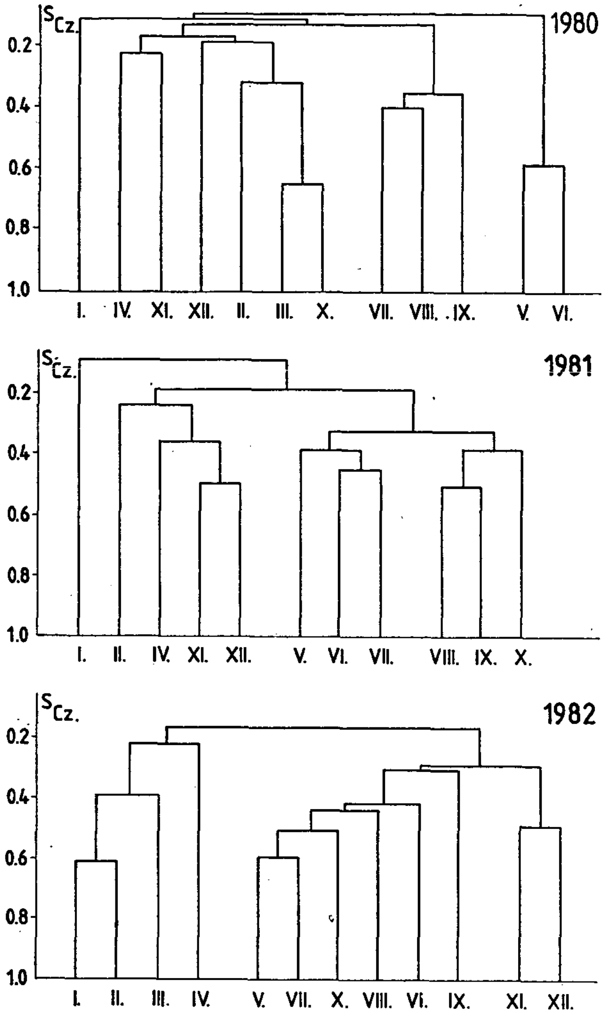

Fig. 1. Cladograms of phytoplankton composition sampled at station No. 3 in three successive years. (1980—1982), based on UPGMA cluster analysis. See details in the text

Hierarchical clustering of abundance for the algal species produced two distinct association groupings every year (Fig. 1). One group consisted of summer associations (May—October), dominated by green algae: *Chlorococcum infusionum* (0.3—3.1 million ind/1), *Crucigenia tetrapedia* (0.5—20.0 million ind/1) and *Ankistrodesmus angustus* (1.0—1.7 million ind/1). The total counts of *Oocystis lacustris, Scenedesmus granulatus* and *Siderocelis minutissima* were relatively high (up to 3.2 million ind/1) in 1981, as were those of *Ankistrodesmus minutissimus, Crucigenia pulchra, Nephrochlamis subsolitaria, Scenedesmus coartatus* and *S. securiformis* (1.0—2.0 million ind/1) in 1982. In addition, two diatoms were typically present: *Stephanodiscus dubius* and *S. hatzschii* (1.1—2.2 million ind/1).

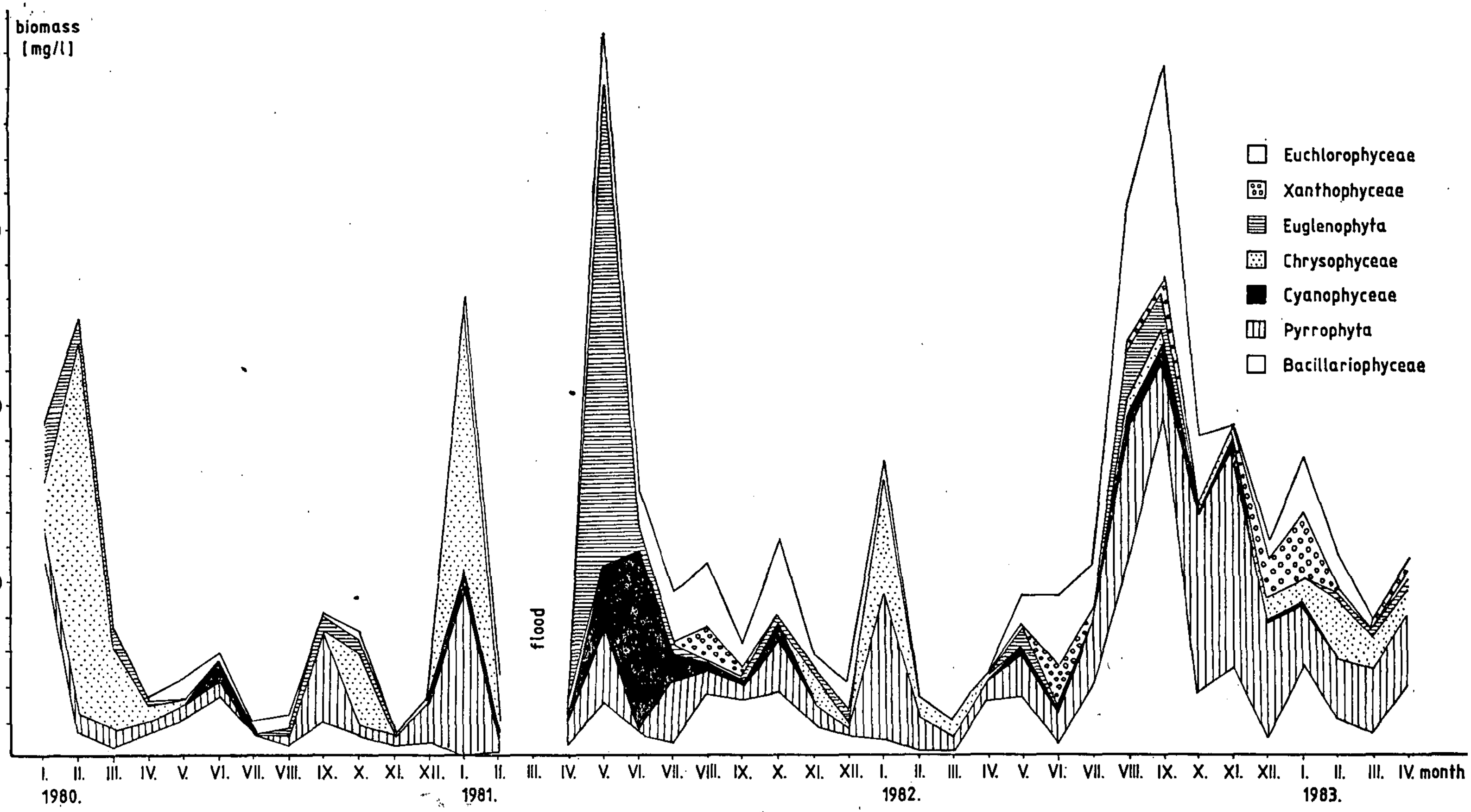

Fig. 2. Seasonal fluctautions of total phytoplankton biomass and composition by major taxa at sampling station No. 3

The other group, composed of winter phytoplankton communities (between October and March), was characterized by the mass production of *Synura uvella* (up to 20.0 million ind/1), *Chrysococcus biporus, Kephyrion inconstans* and *Stephanodiscus hatzschii* (0.5—7.2 million ind/1). Mention should be made of the striking blooms of the small-bodied *Stephanodiscus dubius* (39.5 million ind/1) and *Gloeocapsa siderochlamys* (14.0 million ind/1) in January 1980 and 1981 respectively.

The biomass showed three distinct peaks, one each in winter, late spring and fall (Fig. 2). The winter maximum, ranging between 16 and 26 mg/1, could be attributed to an increased abundance of *Chrysococcus biporus, Kephyrion inconstans, Synura uvella* and the larger-bodied (10—40 µm) *Cryptomonas erosa* and *C. ovata.* Further, *Stephanodiscus dubius, S. hantzschii, Asterogloea gelatinosa* and *Gloeocapsa siderochlamys* were occasionally present in high individual numbers and contributed significant to the winter biomass.

In late spring and early summer, chrysophytes were progressively replaced by Euglenophyta species generating a biomass maximum of 6—10 mg/1 (Fig. 2). Following the flood of 1981, when the backwater was flushed by the River Tisza, a pronounced bloom of *Oscillatoria (O. planctonica, O. limnetica* and *O. nigra)* and Euglenophyta *(E. proxima, E. polymorpha* and *Lepocinclis ovum)* yielded an extremely high bimass level (42 mg/1).

In fall, the maximum biomass oscillated between 8 and 12 mg/1 and could be attributed to the larger-bodied (12—15 µm) *Stephanodiscus dubius, Chlorococcum infusionum* and *Crucigenia tetrapedia.*

Horizontal distribution of phytoplankton

Samples were taken from a depth of 0.2 m beneath the surface at all three sampling stations (Nos. 1—3) at monthly intervals between May 1982 and April 1983. The results of species identification and counting are summarized by major taxa in Table 2. The phytoplankton along the backwater was composed of 268 species, 23 varieties and 10 forms, predominated by Euchlorophyceae, Bacillariophyceae and Euglenophyta. Total counts of species identified were relatively high at sampling station No. 2, but low at No. 1.

The hierarchical clustering of abundance for phytoplankton species sampled at station No. 1 revealed a shift from a predominantly Chrysophytes assemblage dominated by *Chrysococcus biporus, Dinobryon divergens, Chromulina* sp. (1.0—3.5 million ind/1) and *Synura uvella* (5.7—18.5 million ind/1) during February and March, to a predominantly Pyrrophyta and Euglenophyta assemblage dominated by *Chroomonas acuta, Cryptomonas erosa, C. ovata, Trachelomonas planctonica, T. verrucosa, T. volvocinopsis* and *T. volvocina* (0.2—1.3 million ind/1) in summer. Pyrrophyta dominated in the fall collections (Fig. 3).

At sampling stations Nos. 2 and 3, seasonal variations in the phytoplankton produced two distinct association groupings (Fig. 3). Firstly, the summer samples collected during May and October were dominated by Chlorococcales, *Ankitrodesmus angustus, Chlorococcum infusionum* and *Crucigenia tetrapedia,* as well as by the diatoms *Stephanodiscus dubius* and *S. hantzschii* with high total cell counts (1.4—60.0 million ind/1). *Crucigenia pulchra* (1.0—13.0 million ind/1) was also found at point No. 3. The September association slightly resembled to the summer one and showed an abundant presence of blue-green algae: *Aphanothece* sp., *Chroococcus minutus* and

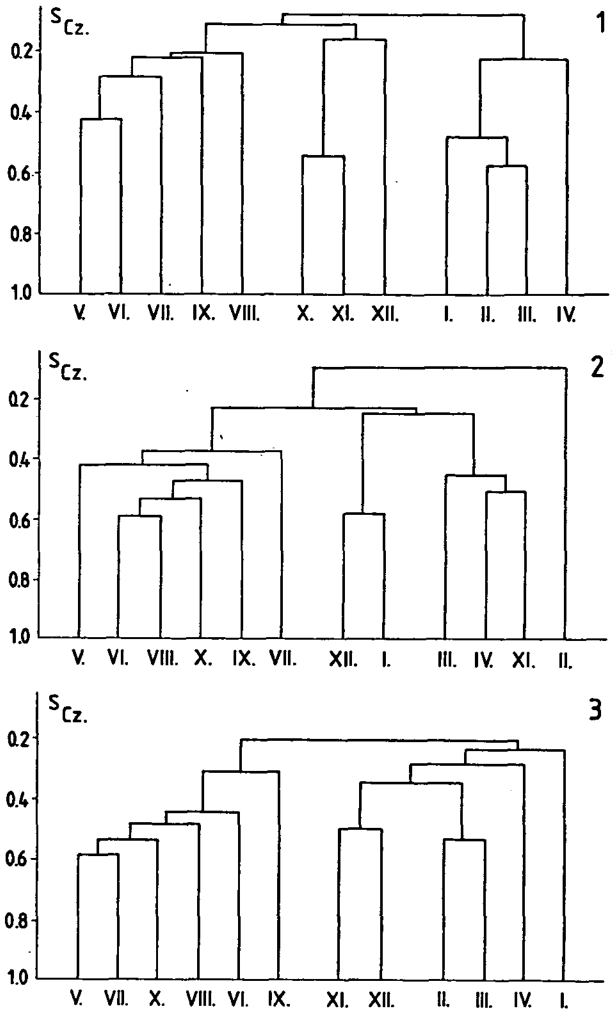

Fig. 3. Hierarchical classification of phytoplankton communities sampled at stations Nos. 1—3 during May 1982 and April 1983. Similarities were calculated on the basis of species abundances

Gomphosphaeria lacustris (1.4—1.9 million ind/1). Secondly, the winter phytoplankton were dominated by the Chrysophyceae *Dinobryon divergens*, *D. sertularia*, *Chromulina* sp. and *Chrysococcus biporus* (1.2—13.9 million ind/1), and the diatom *Rhisosolenia longiseta* (3.2—5.6 million ind/1). *Synura uvella* constituted 53% of the total cell count in February sampling area at No. 2, while *Asterogloea gelatinosa* contributed up to 72% of the total cell count in January at No. 3.

Table 1. *Total counts of phytoplankton species displayed by major taxa. Samples were taken for three years (1980—1982) at station No. 3 (at the bridge at Tőserdő)*

Taxa	Counts of species identified annually 1980	1981	1982	Total counts of species	Species occurring every year
Cyanophyceae	8	19	19	27	3
Euglenophyta	22	27	22	40	11
Pyrrophyta	10	15	10	17	6
Xanthophyceae	9	9	11	13	7
Chrysophyceae	18	15	15	18	13
Bacillariophyceae	62	42	38	82	18
Euchlorophyceae	65	99	94	134	41
Conjugatophyceae	2	3	0	3	0
Sum total:	193	229	204	334	99

Table 2. *Horizontal distribution of phytoplankton species summarized by major taxa. Samples were collected at all three stations (Nos. 1—3) during May 1982 and April 1983*

Taxa	Counts of species identified from the three stations No. 1	No. 2	No. 3	Total counts of species	Species occurring in all sampling areas
Cyanophyceae	16	14	18	24	8
Euglenophyta	22	23	22	37	10
Pyrrophyta	12	11	11	14	9
Xanthophyceae	11	11	11	14	9
Chrysophyceae	17	17	16	18	14
Bacillariophyceae	33	51	43	63	23
Euchlorophyceae	67	100	99	126	52
Conjugatophyceae	4	0	0	4	0
Sum total:	182	227	220	301	124

Table 3. *Primary gross production(PĞ) in relation to solar radiation and biomass. Eutrophication of the sampling areas was classified according to* Felföldy *(1980)*

Date	Sampling station	Primary production rate (PČ) $mgC \cdot m^{-2} \cdot d^{-1}$	Solar radiation $MJ \cdot m^{-2} \cdot d^{-1}$	Biomass $g \cdot m^{-2}$	Eutrophication class
30. 05. 1981	No. 1.	676	18,2	4,7	Meso-eutrophic
	No. 2.	2324		33,6	Eu-polytrophic
	No. 3.	2831		37,6	Polytrophic
30. 06. 1981	No. 1.	1007	13,2	10,4	Eutrophic
02. 07. 1981	No. 2.	3416	20,4	58,4	Polytrophic
03. 07. 1981	No. 3.	5121	19,5	86,1	Hypertrophic

Primary production rates

The primary gross productions (PĞ) measured simultaneously at the three sampling points at the end of May 1981 with the oxygen light-dark bottle method were significantly different in the longitudinal section of the backwater (Table 3). Correlating with the biomass measured from the same raw-water samples, the highest production rate (2831 mg C $\cdot m^{-2} \cdot d^{-1}$) was found at sampling station No. 3 and the lowest value (676 mg C $\cdot m^{-2} \cdot d^{-1}$) at No. 1.

A month later, however, the productivity with unchanged solar radiation was nearly twice that for the summer phytoplankton bloom (Table 3). The production rates revealed eutrophic, polytrophic and hypertrophic regions in the Lakitelek backwater.

Discussion

Although there were pronounced seasonal changes in the species composition of the phytoplankton, the most characteristic *Synura uvella* was predominantly present throughout the period studied, with the only exception of the mild winter in 1982.

In spring, Chrysophytes were usually replaced by Euglenophyta and Cyanophyceae species, contributing up to 30—40% and 1—2%, respectively, of the total biomass, but the individual numbers of *Dinobryon divergens* and *D. sertularia* increased strikingly. An extremely high mass production of Euglenophyta and filamentous blue-green algae *(Oscillatoria)* was recorded following the spring flood in 1981, when these taxa contributed up to 74% of the total biomass. It was presumed that this phenomenon was due to the decreased alimentary competition accompanying the flush effect of the flood.

However, the obvious increase in dominancy of the small-bodied ($< 10 \mu m$) Igreen algae *(Ankistrodesmus, Crucigenia* and *Siderocelis)* and the occurrence of certain Pyrrophyta species *(Chroomonas* and *Cryptomonas)* provided a further evidence of the advanced eutrophication of this backwater. Blooms of Centrales *(Cyclotella* and *Stephanodiscus)* were found typical not only of the Lakitelek backwater, but of other dead-arms of the River Tisza too (Dobler and Kovács 1982, 1984).

It was also found that *Ceratium hirundinella*, which dominated in the middle of the 1970-s (Kiss, I. 1978a), had almost completely disappeared from the phytoppankton in the 1980-s. On the other hand, the only known occurrence of *Thalassiosira faurii* (Gasse) Hasle in Hungary was recently identified (in small numbers) in summer collections from the Lakitelek backwater (Kiss, K. T. et *al.* 1984). Otherwise, *Th. faurii* has been recovered from lakes in Central Africa (Ethiopia, Kenya, Congo and Tanzania) (Hasle 1978).

The primary production rate results suggested that the Lakitelek backwater is about twice as eutrophic as for example, the Tihany Basin of Lake Balaton (Herődek 1977), probably because of the isolation and greater agricultural disturbance of the former, while a similar productivity has been revealed in Lake Velence (Felföldy 1981) and in the Keszthely Basin of Lake Balaton (Vörös et *al.* 1983).

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A lakiteleki Holt-Tisza fitoplanktonjának összetétele. Biomasszája és primer produkciója 1980—1983 között

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Kivonat

A Lakiteleki holtág északi, védett szakaszán 1980 és 1982 között egy, 1982 májusa és 1983 áprilisa között három ponton havonta vett minták feldolgozásával vizsgálta a fitoplankton összetételének és biomasszájának éves változását. 1981 nyarán két alkalommal mérte az elsődleges tertermelés intenzitásának, a biomassza mennyiségének és az inszolarizációs felületi teljesítmény összefüggéseit.

Az algatársulások szezonális változása a vizsgált periódusban mintavételi helyenként szignifikáns különbséget nem mutatott. A fitoplankton összetételét időben vizsgálva az októbertől márciusig illetve a júliustól szeptemberig terjedő időszak különbségét mutatta ki. A holtág vízterét a téli Chrysophyceae és Pyrrophyta dominancia után május—június hónapokban az Euglenophyta törzs és a Cynophyceae osztály fajainak egyedszámnövekedése jellemezte. Nyáron a 10 μ alatti Chlorococcales zöldalgák tömeges megjelenését regisztrálta. Feltűnő volt a Centrales rend fajgazdagsága, őszi, téli és tavaszi tömegprodukciója. A biomassza annuális változása három jellemző

csúcsot mutatott. Az első maximum decembertől februárig (16—26 mg/l), a második május és június között (6—10 mg/l), a harmadik szeptembertől októberig (8—39 mg/l) volt mérhető. Az 1981 nyarán mért primer produkció alapján a holtág északi vége eutrófnak, a középső és a hídnál levő területe poli- illetve hipertrófnak bizonyult.

Состав фитопланктона, биомассы и первичной продукции Лакителекской мертвой тисы в 1980—1983 годах

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Резюме

В северной частьи охраняемого Лакителекского Мёртвого русла в 1980—1983 годах ежемесячно в рех местах брались пробы для изучения состава фитопланктона и смены их биомассы. Летом 1981 года в вдух случаях были определены взаимные отношения между эффективностью первичного объема биомассы и инсоляционной поверхностью.

На протяжении исследуемого периода водорослевые сообщества не показали никакие сигнификативные изменения. В составе фитопланктона значительные изменения возникли в периоды октябрь-март и июльсентрябрь. Зимой в старице доминировали Chrysophyceal и Pyrrophyta, а в период с мая по июнь — ствол Euglenophyta и класс Cyanophyceal. Летом зарегистрировали здесь массовое появление Chlorococcales. Осенью, зимой и весной наблюдалось появлеиие большого количества представителей порядка Centrales, что представляет большой интерес. В биомассе появились три максимума: I — от декабря до февраля (16—26 mg/l), II — в мае и июне (6—10 mg/l), а III — в сентрябре и октябре (8—39mg/l). На основании исследований, проведенных летом 1981 года, было установлено, что в северном конце Лолителекской Мёртвой Тисы преобладают эутрофы, а в средней части и около моста — поли — или гинертрофы.

Sastavj biomasa i primarna produkcija fitoplanktona Mrtve—Bise Lakitelek u periodu 1980—1983. godine

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Abstrakt

Na zaštićenoj deonici severnog dela mrtvaje Lakitelek, ispitivanja sastava i godišnjih promena biomase fitoplanktona vršena su u periodu 1980—1982. godine na jednom punktu, a od maja 1982. do aprila 1983. godine na tri punkta. U toku leta 1981. godine, merenja intenziteta primarne produkcije i uslovljenosti biomase i insolacione površine, vršena su u dva navrata.

Sezonske promene sastava fitoplanktonske zajednice, u toku perioda ispitivanja na mestima uzimanja proba, nisu pokazivale signifikantne razlike. U odnosu na vremensku dinamiku prikazane su razlike u sastavu fitoplanktona za period od oktabra do marta, odnosno od jula do septe=bra. U mrtvaji, nakon zimske dominacije Chrysophyceae i Pyrrophyta, u periodu maj—juni se javlja povećavanje brojnosti vrsta algi iz razdela Euglenophyta i klase Cyanophyceae. Tokom leta se registruje masovna pojava zelenih Chlorococcales algi, u količini ispod m. Uočljivo je bogatstvo vrsta algi iz reda Centrales, njihova jesenja, zimska i prolećna masovna produkcija. Promena produkcije biomase pokazuje tri karakteristična maksimuma: prvi od decembra do februara (16—26 osnovu utvrdjene primarne produkcije u toku leta 1981. godine, severni kraj mrtvaja spada u eutrofnu kategoriju, dok je srednji deo i područje oko mosta po kvalitetu poli- odnosno hipertrofan.