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Glony planktonowe i denne stawów doświadczalnych

Plankton and benthic algae in the experimental ponds

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A b s t r a c t — In the water of the investigated ponds plankton species, mainly of the order *Chlorococcales*, were found most numerously.

In the mud of fertilized ponds the participation of green and blue-green algae was high, while in the mud of the control pond diatoms dominated. The encountered species were mostly benthic and epiphytic species.

A great number of species occurring commonly in the plankton and in the benthic mud points to their displacement due to fish grazing, sedimentation, or water movement.

The applied nitrogen-phosphorus fertilization stimulated the development of some of the algae, mainly of the group *Chlorococcales*.

Densification of the fish stocking resulted in a decrease in the amount of algae in the bottom as a result of a more intensive grazing of fish.

The correlation between the oxygen content in the water and algae development was discussed.

In the investigations on algae in stagnant waters greater attention was so far given to plankton algae than to those inhabiting the bottom which, because of nutrient substances stored in them, are a good substrate for the development of a number of plant organisms playing an important role in the whole oxygen economy. In early spring, the development of benthic algae occurs at considerable water transparency, especially in less deep water bodies (and the ponds are just this), and under favourable light and thermal conditions.

Algae of that biotope in the lakes were investigated, among others, by K o w a l c z e w s k i et al. (1973), S t a ń c z y k o w s k a et al. (1968), and T a m á s (1967 a, b, 1971). Benthic algae in ponds were discussed by S i e m i ń s k a (1967), K y s e l o w a (1977 a, b), and K y s e l o w a (unpublished materials).

The present paper concerns materials collected in 1973 in three experimental ponds of the Experimental Fish Farm of the Polish Academy of Sciences at Gołysz in the Province of Bielsko.

The aim of the paper was to study the plankton and benthic algae composition constituting an important link in the trophic chain in the experimental ponds fertilized in different ways and with the application of differentiated fish stocking.

Simultaneously chemical investigations of the water and mud (W r ó - b e l, unpublished materials) were carried out.

Method

Two ponds (Nos 8 and 9) were chosen as experimental ponds. They were fertilized at 9 dates, every two weeks, with ammonium saltpetre and superphosphate in a total amount of 90 and 63 kg per pond respectively, a single dose being 10 kg ammonium saltpetre and 7 kg superphosphate. Fertilization was carried out on: 19th April, 27th April, 10th May, 24th May, 7th June, 22nd June, 5th July, 23rd July, 13th August. Pond No. 7 was used as a control. The pond surface areas were 1500 m^2 each.

In the investigated ponds various stocking with carp fry was applied: in pond No. 8 intensive stocking (580 specimens of 142 kg weight), in pond No. 9 moderate (135 specimens of 33.5 kg weight), and in pond No. 7 normal stocking (45 specimens of 11.5 kg weight).

Water samples were collected from 27th April till 8th September in ponds No. 8 and No. 9 and in pond No. 7 till 10th October and mud from 27th April till 10th October, initially at weekly intervals, later on at longer ones. In every pond two sampling stations were chosen: a deeper one at the outflow (about 1.5 m), and a shallower one in the upper part of the ponds (about 0.5 m in depth). The basic material for investigations on the plankton algae were 200 ml natural water and for benthic algae investigations the upper layer of the mud sampled with a tube sampler of 23.8 cm^2 surface area.

Mud was sampled twice at three places in the pond. After pouring off the water 1 cm of the bottom upper layer was carefully collected and after thorough mixing divided into two parts. One was used for chemical analyses, the other for biological analysis.

The algae occurring on the bottom of the ponds were recalculated for 1 g dry weight, whereas plankton algae for 1 ml water.

The qualitative composition of the algae is shown in Table I. Table II shows the quantitative relations of the more numerous components. Fig. 1

Tabela I. Skład jakościowy glonów w wodzie (A) i w mule (B) stawów nr 7,8,9 na stanowiskach głębokim (1) i płytkim (2)

Table I. Qualitative composition of algae in water (A) and in mud (B) of ponds Nos 7,8,9 on the deep (1) and shallow (2) stations

Takson – Taxon	Stawy i stanowiska – Ponds and stations											
	7_1		7_2		8_1		8_2		9_1		9_2	
	A	B	A	B	A	B	A	B	A	B	A	B
1	2	3	4	5	6	7	8	9	10	11	12	13
Anabaena sp.		+	+			+		+		+		
Chroococcus sp.	+		+									
Merismopedia tenuissima Lemm.	+		+	+	+	+	+	+		+	+	+
Merismopedia sp.	+			+						+		
Oscillatoria sp.		+	+	+		+	+	+		+	+	+
Phormidium sp.								+	+	+		+
Spirulina sp.						+						
Cyanophyceae n. det.	+	+	+	+	+	+	+	+	+	+	+	+
Euglena acus Ehr.					+	+	+	+				
- tripteris (Duj.) Klebs					+		+					
Euglena sp.	+	+	+	+	+		+	+	+	+	+	+
Lepocinclis ovum (Ehr.) Lemm.								+				
Lepocinclis sp.	+	+	+		+	+	+					
Phacus brevicaudatus (Klebs) Lemm.						+	+					
- curvicauda Swir.								+				
- longicauda (Ehr.) Duj.							+					+
- pyrum (Ehr.) Stein					+			+				
- tortus (Lemm.) Skvortzow								+	+			
- triqueter (Ehr.) Duj.					+		+	+				+
Phacus sp.					+			+	+	+		
Strombomonas verrucosa var. claviformis Defl.										+		
- - var. zmiewika (Swir.) Defl.					+		+					
Trachelomonas granulata Swir.										+		
- hispida (Perty) Stein										+		
- intermedia Dang.												+
- nigra Swir.	+				+		+					
- pseudofelix Defl.						+	+		+			+
- volvocina Ehr.	+	+	+	+	+	+	+	+	+	+	+	+
Trachelomonas sp.	+	+	+	+	+	+	+	+	+	+	+	
Peridinium sp.			+									
Chroomonas sp.	+											+
Cryptomonas sp.	+		+		+	+	+	+	+	+	+	+
Anthophysa vegetans (O.F.M.) Stein												+
Chromulina sp.	+		+		+				+	+	+	
Chrysococcus minutus (Fritsch.) Nygard	+	+	+									
Chrysococcus sp.				+						+		+
Dinobryon divergens Imhof			+									
Dinobryon sp.					+	+	+					
Kephyrion Rubri-Claustrii Conrad	+		+		+							
Kephyrion sp.			+		+		+		+		+	
Pseudokephyrion hiemale Hilliard			+									
- Schilleri (Schiller) Conrad	+				+							
- minutissimum Conrad											+	
Achnanthes sp.	+	+	+	+	+	+	+	+	+	+	+	+
Amphora ovalis Kütz.		+		+		+						+
Amphora sp.				+								+
Asterionella formosa Hass.	+			+			+					
Asterionella sp.		+		+								
Caloneis sp.		+		+								
Ceratoneis arcus (Ehr.) Kütz.	+	+	+	+	+	+	+	+	+	+	+	+
- - var. amphioxys (Rabh.) Grun.										+		+
Cocconeis placentula Ehr.		+		+					+			+
Cocconeis sp.	+	+		+			+					
Cyclotella sp.	+	+	+	+	+	+	+	+	+	+	+	+
Cymatopleura solea (Bréb.) W. Sm.		+		+	+				+	+		+
Cymbella sp.	+	+	+	+	+	+	+	+	+	+	+	+
Diatoma vulgare Bory	+	+					+					
Diatoma sp.									+			
Fragilaria capucina Desm.		+		+								
Gomphonema acuminatum var. coronatum (Ehr.) W.Sm.				+				+		+		+
- constrictum Ehr.				+								
- parvulum (Kütz.) Grun.								+				
Gomphonema sp.	+	+	+	+	+	+	+	+	+	+	+	+
Gyrosigma acuminatum (Kütz.) Rabh.				+								
Gyrosigma sp.		+		+				+				
Hantzschia sp.								+				
Melosira granulata (Ehr.) Ralfs				+						+		
Meridion circulare Ag.		+										+
Meridion sp.				+								
Navicula hungarica Grun.				+								
- - var. capitata (Ehr.) Cl.			+									
- radiosa Kütz.		+					+	+				
Navicula sp.	+	+	+	+	+	+	+	+	+	+	+	+
Nitzschia acicularis W. Sm.	+	+	+	+	+	+	+	+	+	+	+	+
- dissipata (Kütz.) Grun.		+	+	+								
- linearis W. Sm.				+								
- palea (Kütz.) W. Sm.		+	+								+	+
- sigmoidea (Ehr.) W. Sm.		+		+								+
Nitzschia sp.	+	+	+	+	+	+	+	+	+	+	+	+
Pinnularia sp.		+								+		
Surirella biseriata Bréb.		+										
- ovalis Bréb.		+										
Surirella sp.	+	+	+	+	+	+	+	+	+	+	+	+
Synedra acus Kütz.	+	+	+	+			+					
- ulna (Nitzsch) Ehr.	+		+	+							+	+
Bacillariophyceae n. det.	+	+	+	+	+	+	+	+	+	+	+	+
Dichotomococcus sp.	+		+									

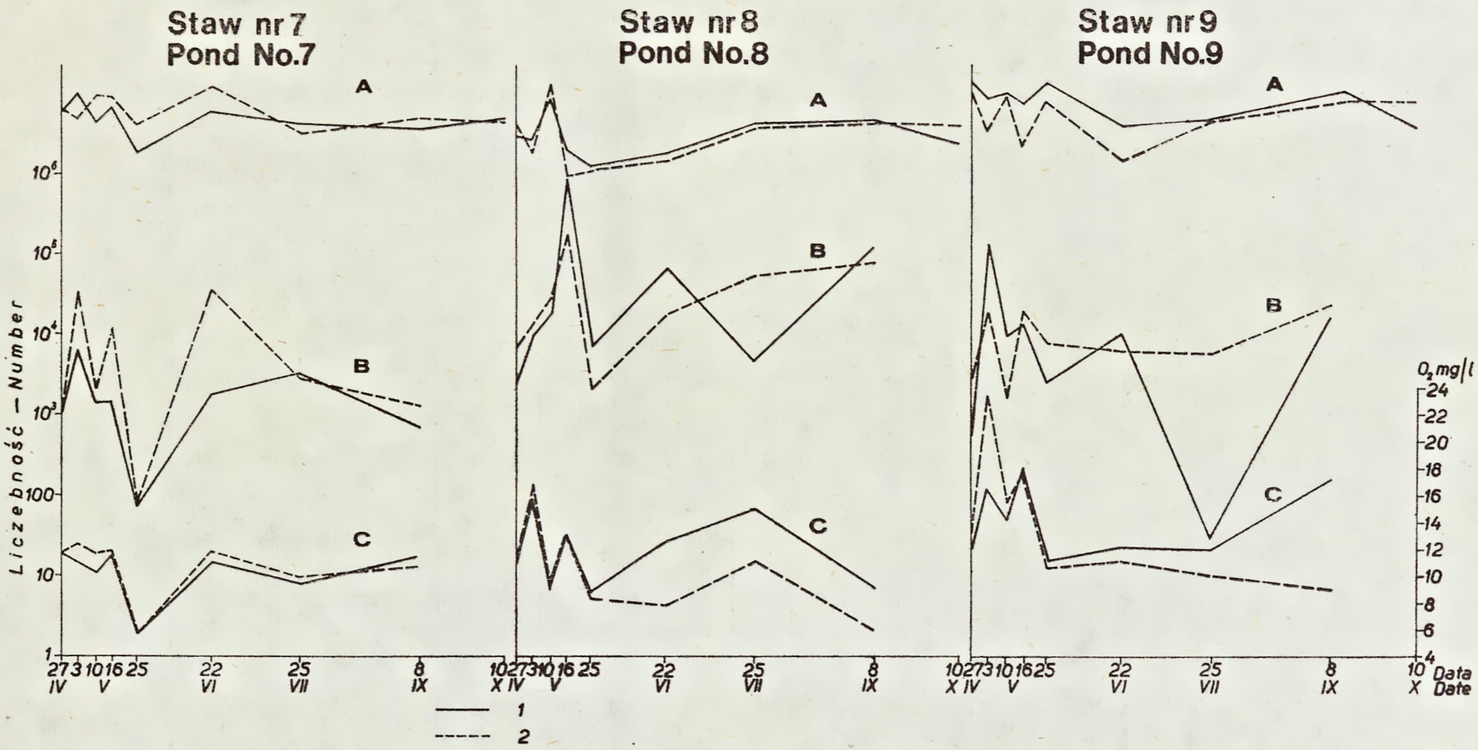
cont. tab. 1

1	2	3	4	5	6	7	8	9	10	11	12	13
Chlamydomonas sp.	+	+	+	+	+	+	+	+	+	+	+	+
Eudorina elegans Ehr.									+			
Pandorina morum (Müll.) Bory	+				+		+		+	+	+	
Phacotus sp.											+	
Actinastrum Hantzschii Lagerh.	+				+				+			
Ankistrodesmus arcuatus Korschik.	+	+	+		+		+	+			+	
- falcatus (Corda) Ralfs	+	+			+	+	+	+	+	+	+	+
- minutissimus Korschik.						+				+		
- pseudomirabilis Korschik.	+	+	+		+	+	+	+	+	+	+	+
- spiralis (Turn.) Lemm.					+		+					
Ankistrodesmus sp.	+	+	+	+	+	+	+	+	+	+	+	+
Characium sp.					+	+	+	+	+			
Coelastrum microporum Naeg.	+	+	+		+	+	+	+	+	+	+	+
- proboscideum Bohl.	+		+		+		+	+	+		+	
- reticulatum (Dang.) Senn.	+						+					
Coelastrum sp.	+	+	+	+	+	+	+	+	+	+	+	+
Crucigenia apiculata (Lemm.) Schmidle	+	+	+	+	+	+	+		+	+	+	
- fenestrata Schmidle	+											
- quadrata Morren	+	+	+	+	+	+	+	+		+		
- rectangularis (A.Br.) Gay	+		+			+						
- tetrapedia (Kirchn.) W.et W.	+		+		+	+	+	+			+	
Dictyosphaerium pulchellum Wood	+				+		+				+	
Dictyosphaerium sp.	+	+	+		+	+	+	+	+		+	
Elakatothrix gelatinosa Wille					+		+	+			+	
Franceia tenuispina Korschik.					+		+		+			
Golenkinopsis sp.									+			
Juranyella Javorkae Hortob.					+	+						
Kirchneriella sp.	+		+	+	+	+	+	+	+		+	
Lagerheimia genevensis Chod.	+								+		+	+
- wratislaviensis Schroeder	+											
Lagerheimia sp.							+		+		+	+
Lambertia sp.	+		+	+	+		+	+	+		+	
Nephrochlamys Willeana (Printz) Korschik.			+		+		+				+	
Oocystis Borgei Snow			+		+	+						
- elliptica West			+									
- pusilla Hansg.			+									
Oocystis sp.	+		+	+	+	+	+	+	+	+	+	+
Pediastrum Boryanum (Turp.) Menegh.	+	+	+	+	+	+	+	+	+	+	+	+
- duplex Meyen	+	+	+	+	+		+	+	+	+	+	+
- - var. reticulatum Lagerh.									+			
- tetras (Ehr.) Ralfs					+	+	+	+	+	+	+	
- - var. tetraëdron (Corda) Rabenh.									+			
Pediastrum sp.		+										
Raphidonema sp.					+							
Scenedesmus acuminatus (Lagerh.) Chod.	+	+	+	+	+	+	+	+	+	+	+	+
- - biseriatus Reinh.	+		+				+		+	+	+	+
- acutiformis Schroed.								+				
- acutus Meyen	+		+	+	+	+	+	+	+	+	+	
- apiculatus W. et W. Chod.										+		
- armatus (Chod.) G.M. Smith	+	+	+	+	+		+	+	+	+	+	+
- balatonicus Hortob.		+										
- bicaudatus (Hansg.) Chod.	+	+		+		+	+	+	+	+		+
- bijugatus (Turp.) Kütz.						+						
- circumfusus var. bicaudatus Hortob.				+								
- denticulatus Lagerh.	+	+		+	+	+	+	+	+	+	+	
- ecornis (Ralfs.) Chod.	+	+	+	+	+	+	+	+	+	+	+	+
- granulatus W. et W.	+						+			+		
- quadricauda (Turp.) Bréb.	+	+	+	+	+	+	+	+	+	+	+	+
- var. biornatus Kiss									+	+	+	
- - var. longispina (Chod.) G.M. Smith	+	+		+	+				+	+		+
- - - f. capricornus (Skuja) Uherkov.										+		+
- intermedius Chod.				+	+	+			+	+		+
- - var. balatonicus Hortob.						+		+		+		+
- - var. bicaudatus Hortob.						+			+		+	
- opoliensis P. Richt.										+		
- spinosus Chod.	+	+	+	+	+	+	+	+	+	+	+	+
- verrucosa Roll												+
Scenedesmus sp.	+	+	+	+	+	+	+	+	+	+	+	+
Schroederia setigera (Schroed.) Lemm.			+								+	
Sphaerocystis Schröteri Chod.	+		+							+		+
Spherocystis sp.										+		
Tetraëdron caudatum (Corda) Hansg.	+		+		+		+		+		+	
- incus (Teil) G.M. Smith	+	+									+	
- minimum (A.Br.) Hansg.	+	+	+	+	+	+	+	+	+	+	+	+
- trigonum (Naeg.) Hansg.				+	+	+	+	+		+		+
- regulare var. incus Teil.	+											
Tetrastrum glabrum (Roll) Ahlstr. et Tiff.			+		+	+	+	+			+	
- heteracanthum Schill.					+		+		+			+
- staurogeniaeforme (Schroed.) Lemm.					+		+		+			
Treubaria eurycantha (Schmidle) Korschik.	+											
- triappendiculata Bern.	+		+									
Trochiscia sp.										+		
Westella botryoides (W. West) Wild.					+							
Closterium aciculare Tuffen West					+							
- gracile Bréb.					+	+	+				+	
Closterium sp.						+	+		+		+	
Cosmarium sp.	+		+	+			+	+		+		
Spirogyra sp.					+	+		+				
Staurastrum alternans Bréb.						+						
- tetracerum (Kütz.) Ralfs									+	+		+
Staurastrum sp.		+										
Chlorophyta n. det.	+	+	+	+	+	+	+	+	+	+	+	+

Tabela II. Iczniejsze glony występujące na dnie (A) na 1 g suchej masy i w wodzie (B) w 1 ml (średnie z dwóch stanowisk)

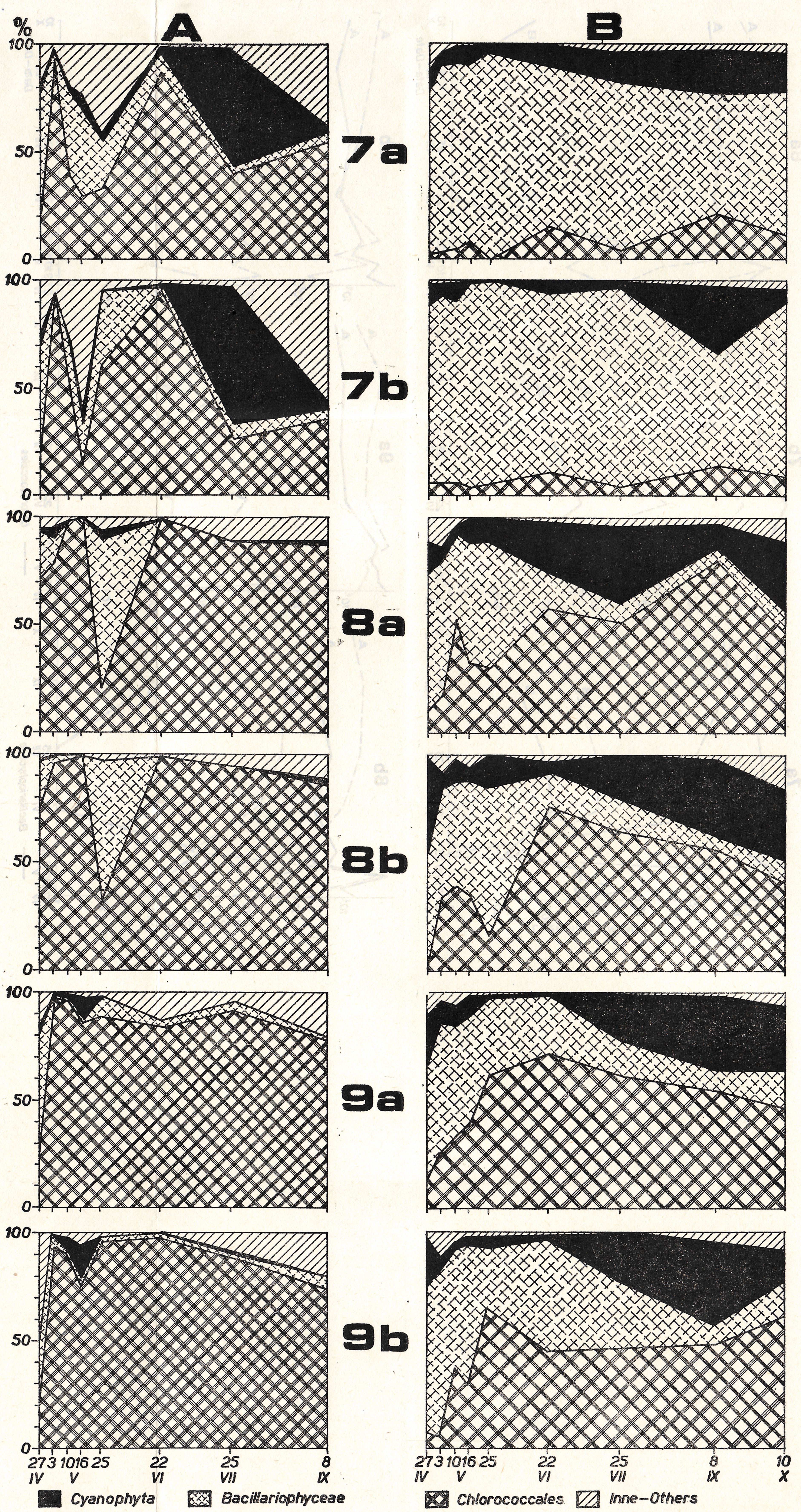
Table II. Algae occurring in greater numbers on the bottom (A) per 1 g of dry weight and in water (B) in 1 ml (means from two sampling stations)

Data - Date	27.IV	.V	10.V	16.V	25.V	22.VI	25.VII	8.IX	10.X
Takson - Taxon									
Staw nr 7 - Pond No. 7									
A									
Cyanophyceae varia	600 080	441 760	586 610	312 260	33 850	474 200	374 620	1 019 330	510 370
Achnanthes sp.	240 530	427 270	568 340	321 390	233 130	348 130	335 760	292 360	151 510
Gomphonema sp. div.	1 473 260	322 450	236 540	198 310	96 840	1 169 980	744 740	343 640	712 040
Navicula sp. div.	96 590	161 230	119 860	594 940	296 120	379 800	180 620	139 050	208 030
Nitzschia sp. div.	90 200	1 418 270	1 747 880	2 460 760	640 220	1 834 200	442 160	653 450	767 230
Bacillariophyceae n. det.	2 181 420	4 132 120	2 524 240	2 676 160	1 231 560	2 531 080	691 500	517 590	1 123 590
Scenedesmus sp. div.	167 060	346 090	138 120	295 190	29 140	442 650	59 840	242 140	163 710
B									
Merismopedia tenuissima	–	–	–	–	–	–	130	1 570	
Cryptomonas sp.	10	–	130	2 290	10	180	30	210	
Achnanthes sp.	270	10	20	120	–	90	10	10	
Nitzschia sp. div.	70	100	230	490	10	130	70	20	
Bacillariophyceae n. det.	130	340	140	180	10	120	30	3	
Chlamydomonas sp.	50	50	50	1 660	1	–	10	50	
Ankistrodesmus sp. div.	210	2 750	230	200	–	40	230	20	
Dictyosphaerium pulchellum	–	14 630	10	20	–	14 170	–	20	
Scenedesmus sp. div.	10	240	350	500	10	680	50	50	
Staw nr 8 - Pond No. 8									
A									
Cyanophyceae varia	625 700	49 450	661 780	133 930	125 570	226 040	850 280	802 860	771 390
Nitzschia sp.	–	122 050	907 040	27 980	157 690	51 170	54 540	82 520	62 330
Surirella sp.	–	185 840	616 720	211 480	182 530	15 900	74 670	–	9 630
Bacillariophyceae n. det.	1 730 030	775 310	2 757 200	420 180	235 090	126 510	215 230	122 760	142 940
Ankistrodesmus sp. div.	54 960	358 990	4 391 020	295 850	81 790	62 980	180 820	126 050	13 180
Coelastrum sp. div.	4 250	–	–	–	–	332 520	1 315 140	451 040	45 620
Scenedesmus sp. div.	200 630	140 380	290 310	52 770	105 130	318 750	485 350	1 551 900	766 850
B									
Ankistrodesmus sp. div.	2 550	5 560	18 560	1 950	60	1 740	–	660	
Coelastrum sp. div.	–	–	–	20	30	2 690	21 580	22 350	
Crucigenia sp.	–	–	–	20	–	710	–	28 930	
Dictyosphaerium pulchellum	–	1 810	12 250	529 510	–	26 010	–	1 190	
Oocystis sp.	–	–	–	10	110	2 350	40	5 300	
Scenedesmus sp.	100	40	140	90	270	1 240	2 780	16 920	
Staw nr 9 - Pond No. 9									
A									
Merismopedia tenuissima	–	–	–	–	–	–	–	1 173 090	115 100
Cyanophyceae varia	2 037 890	386 670	443 610	310 590	286 550	20 890	885 280	1 945 090	926 110
Nitzschia sp. div.	261 450	681 030	713 330	246 910	347 530	132 540	144 670	402 270	246 490
Bacillariophyceae n. det.	4 822 340	2 390 290	2 415 160	1 702 110	2 215 970	286 760	410 850	153 130	110 750
Coelastrum sp. div.	–	–	–	–	–	14 420	1 085 860	744 850	32 560
Scenedesmus quadricauda	605 960	466 780	1 894 590	1 222 620	4 550 980	1 180 860	518 800	672 190	475 410
Scenedesmus sp. div.	601 760	674 860	221 800	293 270	1 469 500	221 050	61 720	2 718 530	2 270 690
B									
Cyanophyceae varia	20	140	230	2 190	–	–	–	–	
Coelastrum sp. div.	–	–	–	–	–	2 020	2 010	1 700	
Dictyosphaerium pulchellum	50	66 150	5 790	4 120	–	400	–	–	
Oocystis sp. div.	–	–	20	450	1 740	3 280	90	230	
Scenedesmus quadricauda	20	140	420	7 620	2 420	230	30	470	
Scenedesmus sp. div.	50	90	10	140	360	830	170	10 450	



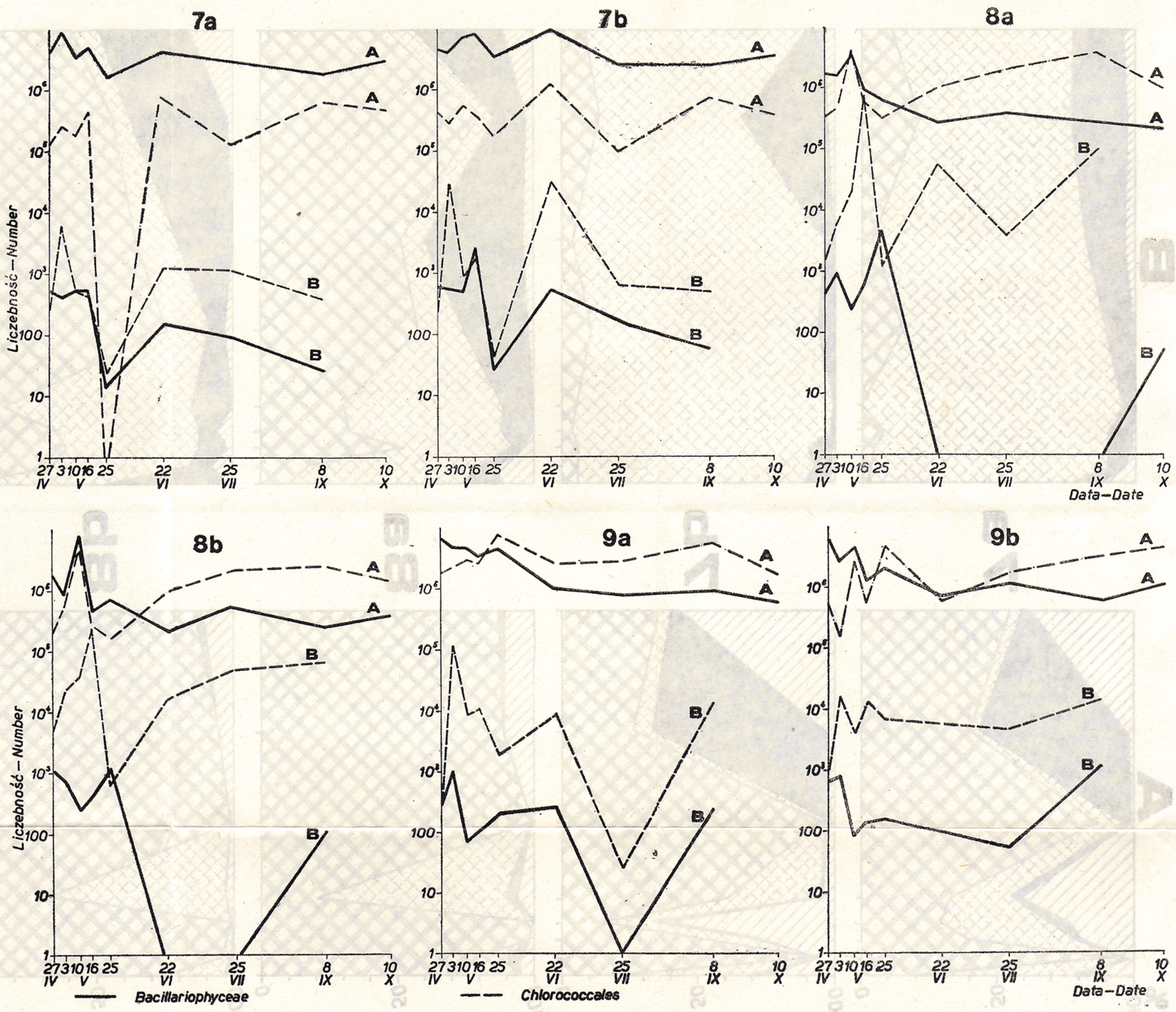
Ryc. 1. Ogólna ilość glonów w mule (A) na 1 g suchej masy i w wodzie (B) w 1 ml oraz (C) zawartość O_2 mg/l. 1 — stanowisko głębsze; 2 — stanowisko płytsze

Fig. 1. Total amount of algae in the mud (A) per 1 g dry weight and water (B) in 1 ml and (C) O_2 content mg/l. 1 — deeper station; 2 — shallower station



Ryc. 2. Procentowy udział najliczniejszych grup glonów w wodzie (A) i w mule (B) na stanowiskach głębszych (a) i płytszych (b) w stawach nr 7, 8 i 9

Fig. 2. Percentage share of the most numerous algae groups in the water (A) and in the mud (B) at deeper stations (a) and shallower (b) in ponds Nos 7, 8 and 9



Ryc. 3. Ilość najliczniejszych grup glonów w mule (A) i w wodzie (B) na stanowiskach głębszych (a) i płytszych (b) w stawach nr 7, 8 i 9

Fig. 3. Number of the most numerous algae groups in the mud (A) and in the water (B) at deeper stations (a) and shallower (b) in ponds Nos 7, 8 and 9

presents the total amount of algae, while fig. 3 their division into particular systematic groups. Fig. 2 gives the percentage share of particular groups of the algae.

Plankton algae

In the control pond the main part was played by chlorococcous algae both in the shallower and in the deeper place (Table I). Their total number differed at these two stations (fig. 1) being greater at the shallower station. This was most evidently marked in May and June. At the shallower place, at a much greater number of algae, *Dictyosphaerium pulchellum,* occurring mostly in the form of single cells, was the dominant species, whereas, at the deeper station species of the genus *Ankistrodesmus* were prevalent (Table II).

The second place, as far as numbers are concerned, was occupied by diatoms. Their number was in the shallower place twice as great as in the deeper one. This was most remarkable on 16th May. Diatoms of the genus *Synedra* and *Nitzschia* dominated at that time.

Of other algae the greatest number of specimens of the genus *Cryptomonas* occurring in that pond was found in the shallower place on 16th May. On that day this species constituted about 36 per cent of the total amount of the algae. On 25th July great amounts of the blue-green alga *Merismopedia tenuissima* occurred at these two stations constituting in the deeper and shallower place 55 per cent and 65 per cent of the total amount of the plankton algae respectively. Algae belonging to other systematic groups were all small importance.

In pond No. 8 chlorococcous algae, constituting at both stations about 90 per cent of the total amount of algae (fig. 2) were the predominant group.

The quantitative maximum of *Chlorococcales,* for which mainly *Dictyosphaerium pulchellum* were responsible occurred in the middle of May (fig. 3). In summer the genera *Coelastrum* and *Crucigenia* were mainly found, but in smaller numbers. As a rule *Chlorococcales* occurred more numerously at the shallower station.

Diatoms were usually more numerous at the deeper place; this was best seen in the maximum on 25th May when *Nitzschia acicularis* occurred very numerously. At the same time a diatom maximum with dominance of the same species was noted at the shallower place.

At the deeper station of that pond euglenoids occurred only in June; they reached their maximum on 8th September with *Trachelomonas volvocina* dominating. At the shallower place they occurred only at the last two dates of sampling with the same species dominating in July; in September, however, *Phacus brevicaudatus, Lepocinclis* sp., and *Trachelomonas volvocina* prevailed.

Cryptophyceae were more common at the deeper station and in September they occurred more abundantly than at other dates.

In the pond No. 9 *Chlorococcales* were almost always prevalent. Their very abundant occurrence at these two stations in May, was characteristic this being due to the species *Dictyosphaerium pulchellum*.

At initial sampling dates blue green algae of the family *Oscillatoriaceae*, not identified more precisely, occurred at these two stations.

Diatoms were also somewhat more numerous at the initial and final dates, but at that time too they gave priority in number to the chlorococcous algae.

Benthic algae

In the control pond No. 7 diatoms were always a group of benthic algae dominating at these two stations. They usually occurred in greater numbers at the shallower station where the maximum was reached later (22nd June) than at the deeper place (maximum on 3rd May). The genera *Nitzschia, Gomphonema, Achnanthes,* and *Navicula* dominated. Their share percentage was, as a rule, very high since at the deeper station it reached from 67 to 96 per cent and at the shallower one from 81 to 95 per cent. Only in September their share at these two stations was about 50 per cent of the total amount of the algae. This was influenced by a more intensive development of blue-green algae and of *Chlorococcales*.

A fairly popular group in that habitat were also blue-green algae. Their number maxima were about 20 and 31 per cent of the total amount of the algae at the deeper and shallower place respectively. Apart from the genera *Merismopedia* and *Oscillatoria* there occurred a small filamentous, closely not defined blue-green algae of the family *Oscillatoriaceae,* the same which was found in the plankton.

The green algae, though occurring constantly, played a lesser numerical role in the mud. The most frequently encountered ones were chlorococcous algae, mainly species of the genus *Scenedesmus*. Of other orders *Volvocales* and *Conjugales* occurred sporadically.

In pond No. 8 two distinct periods in diatom occurrence were marked at the both stations: the first till 25th May, characterized by an abundant occurrence (from 40 to 69 per cent) and a later one, with their smaller participation (from 5 to 16 per cent).At these two stations their amounts were similar, and their maxima occurred on 10th May. A much more pronounced maximum was found at the shallower station. The genera *Nitzschia, Surirella,* and *Navicula* dominated.

At the time of a decreased diatom occurrence (from 22nd June) an increase in the participation of chlorococcous algae took place. These algae were present among the benthic algae during the whole investigation period. A quantitative maximum was found, however, at these two stations on 10th May. Species of the genus *Ankistrodesmus* dominated at that time.

The previously mentioned blue-green algae played also a certain part in the mud of that pond. They occurred constantly at these two stations, with a general prevalence in number in the shallower place. Their maximum numbers at the shallower place, constituting 40 per cent of all the algae, were found in the first and the two last investigation periods. On the other hand, the quantitative maximum at the deeper station occurred on 25th July their number constituting almost 36 per cent of the overall number of algae (fig. 2).

Other systematic groups constituted a small percentage of the algae composition.

In pond No. 9 *Bacillariophyceae* and next after them *Chlorococcales* (Table II) were also the algae prevailing in the mud. Similarly as in pond No. 8 two analogous periods of their occurrence were noticed.

Similar diatom maxima occurred at these two stations as early as on 27th April. The dominant role was played by the genera *Surirella, Gomphonema, Nitzschia, Navicula,* and *Achnanthes*.

Participation of *Chlorococcales*, present during the whole investigation period, increased from 25th May when at these two stations their maximum occurred. The genus *Scenedesmus* and particularly *Sc. acuminatus* and *Coelastrum microporum* dominated at that time.

Blue-green algae, present all the time, were found most abundantly at these two stations in September when they constituted from 35 to 38 per cent of the total number of algae. Not identified small benthic filamentous blue-green algae and *Merismopedia tenuissima* prevailed.

In that pond more algae occurred at the deeper station.

Discussion on results

Among the algae from the water depth the most frequent were plankton or tychoplankton species, above all of the class *Chlorophyceae* of the order *Chlorococcales*. *Bacillariophyceae* and *Cyanophyceae* developed in a much smaller number. The first ones were found more numerously at earlier dates after the submersion of the ponds, whereas the latter ones were most abundant in the control pond at later dates. As regards the special composition, mainly *Dictyosphaerium pulchellum, Coelastrum microporum*, and the genera Ankistrodesmus, Oocystis, Crucigenia occurred. Of other systematic groups we can mention the blue-green alga *Merismopedia tenuissima*, the chrysophite *Chromulina* sp., of the *Cryptophyceae Cryptomonas* sp., and of the euglenoids *Trachelomonas volvocina*.

Species of benthic and epiphytic origin occurred concomitantly. And so, not closely determined blue-green algae of the family *Oscillatoriaceae* and diatoms mainly of the genera *Synedra* and *Nitzschia* were found there.

In the mud samples from the control pond diatoms prevailed over other groups of algae, whereas in the mud of fertilized ponds green and blue-green algae had a remarkable quantitative share. Diatoms were also found there in greater numbers after the flooding of the pond, whereas blue-green algae appeared at later dates. They were most frequently species living in the benthic mud or epiphytic species, among others the genera *Gomphonema, Achnanthes, Surirella, Navicula,* and *Nitzschia*. Blue-green algae of the family *Oscillatoriaceae* and *Merismopedia tenuissima* and green algae of the order *Volvocales* (*Chlamydomonas*) were also frequent. Of the order *Chlorococcales* mainly species of the genera *Scenedesmus, Ankistrodesmus,* and *Coelastrum,* always abundant in the plankton of the discussed ponds, were also recorded.

A similar situation was found in the bottom by Kyselowa (1977 a). According to that author diatoms and in the second place green algae were prevalent. The quantitative composition of the algae and the dominants were also very similar.

When investigating the algae from the water and mud of the winter ponds, Siemińska (1947) found that among all the algae developing in winter, diatoms occurred most numerously, often forming unispecies communities on the mud. The author emphasises their favourable influence on the oxygen conditions in the ponds.

Tamás (1967a, b, 1971) investigated the phytobenthos of the lake Balaton. She also found a prevalence of benthic and epiphytic species with pelagial ones as accompanying. Diatoms dominated over green and blue-green algae and over other groups of algae. The qualitative composition reported by her showed also some concurrence with those observed in the ponds at Gołysz.

Pratt, Cyrus (1948) described *Oscillatorietum* associations from small water bodies and mentioned a number of species of the uppermost bottom layer, mainly of the diatom group, common with those found at Gołysz.

Most of the green algae species in the mud of the investigated fertilized ponds and the control pond could have originated from the water as a result of sedimentation. This is supported by the registered species composition. Whereas the algae developing on the bottom could have passed into the water, both due to having been carried upwards as a result of physiological processes and mechanical action. In shallow reservoirs a great role is played by water movement caused by winds or intensive fish grazing.

A differentiated fish stocking greatly influenced the number of bottom algae. It was found that at medium stocking many more algae were noted at the bottom in the pond No. 9 than in the pond No. 8 where intensive fish stocking was applied. This is, as a rule, corroborated by the findings from the control pond. At densified stocking a more intensive fish grazing; hence, consumption of algae must have taken place.

The applied fertilization influenced markedly the increase in number of the chlorococcous green algae in the water and in the mud of the ponds. The smallest amount of algae of the order *Chlorococcales* and evident dominance of *Bacillariophyceae* was found in the mud of the control pond No. 7.

These data are consistent with those given by other authors investigating the influence of that type of fertilization on plankton communities (Januszko 1971, Januszko et al. 1977, Krzeczkowska-Wołoszyn 1977, Kyselowa 1973).

As to the oxygen content in the water (Wróbel — typescript) a positive correlation with the amount of algae was found in most cases (fig. 1). This referred both to plankton and benthic communities. Attached algae influenced greatly the concentration of oxygen in the water in spring. This was specially pronounced at the shallower station in pond No. 7. At shallower stations of the other ponds, moreover, differences in oxygen content occurred in spring under the influence of fertilization. The oxygen maximum, found at that time in pond No. 8, was caused by an increasing number of algae in the water. The most favourable oxygen conditions prevailed at that time in pond No. 9 where the O_2 content was 24 mg/l. This oxygen maximum seems to depend, to a high extent, on the qualitative composition of the plankton algae. At the time when *Ankistrodesmus* sp. dominated in the pond No. 8, *Dictyosphaerium pulchellum,* a very good oxygen producer, prevailed among the chlorococcous algae in pond No. 9. It is worth mentioning that, in those ponds, apart from diatoms and blue-green algae numerous *Chlorococcales* appeared among the attached algae.

As oxygen content is concerned, the role of attached algae was also maintained in the summer period, though at that time plankton algae exerted a decisive influence.

From the middle of summer till autumn a decrease in oxygen content was found in pond No. 8 at an increasing number both of plankton and attached algae. This might have been the consequence both of deterioration of photosynthetic conditions caused by self-shadowing, and of a periodical intensification of destruction of organic matter after a previous abundance in the quantities of algae taking place in the middle of summer in the deeper part of the two fertilized ponds.

STRESZCZENIE

Badania dotyczyły stawów doświadczalnych w Gołyszu, z których w dwóch (nr 8 i 9) zastosowano nawożenie azotowo-fosforowe oraz zróżnicowaną obsadę kroczkami karpia. Staw nr 7 stanowił kontrolę.

Prześledzono rozwój glonów w planktonie oraz na dnie, w okresie użytkowania stawów, w 1973 r.

W toni wodnej najczęściej stwierdzano gatunki planktonowe, przede wszystkim *Chlorophyta* z rzędu *Chlorococcales* (tabela I). Mniej licznie notowano *Bacillariophyceae* i *Cyanophyceae* (tabela II). Dominantami były planktonowe zielenice *Dictyosphaerium pulchellum, Coelastrum microporum* oraz gatunki rodzajów *Ankistrodesmus, Scenedesmus, Oocystis* i *Crucigenia*. Towarzyszyły im gatunki pochodzenia dennego lub porośłowe, najczęściej sinice z rodzaju *Oscillatoriaceae* i okrzemki, głównie z rodzajów *Synedra* i *Nitzschia*.

W próbach mułu stawu kontrolnego zachodziła zawsze zdecydowana przewaga *Bacillariophyceae* nad pozostałymi grupami glonów (ryc. 2). Natomiast w stawach nawożonych duży udział liczebny wykazywały też zielenice i sinice (ryc. 3). Także i w mule okrzemki wykazywały większe nasilenie z wiosną, a sinice w jesieni.

Większość gatunków zielenic spotykanych w mule badanych stawów nawożonych i stawu kontrolnego mogła pochodzić z planktonu, w rezultacie sedymentacji, za czym przemawia rejestrowany skład gatunkowy. Natomiast glony rozwijające się na dnie mogły przechodzić do wody zarówno na skutek wynoszenia ich w górę w wyniku procesów fizjologicznych, jak i mechanicznego działania. W płytkich bowiem zbiornikach dużą rolę odgrywa ruch wody wywołany czy to przez wiatry, czy też intensywne żerowanie ryb.

Stosowane nawożenie wpłynęło najwyraźniej na zwiększenie liczebności zielenic chlorokokkowych w wodzie oraz w mule stawów. Najmniejsza ilość glonów z rzędu *Chlorococcales*, a najwyraźniejsza dominacja *Bacillariophyceae* wystąpiły w mule stawu kontrolnego.

Zagęszczenie osady wpłynęło na zmniejszenie ilości glonów na dnie, w związku z intensywniejszym żerowaniem ryb.

Nawiązując do warunków tlenowych w omawianych stawach, stwierdzono w większości przypadków dodatnią korelację między zawartością tlenu w wodzie a ilością glonów zarówno w odniesieniu do gatunków planktonowych, jak i dennych (ryc. 1).

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