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WINTER PHYCOFLORA AND PHYSICO-CHEMICAL PARAMETERS OF A HUMIC LAKE-STREAM SYSTEM IN THE KUŹNIK NATURE RESERVE (THE WIELKOPOLSKA REGION, POLAND)†

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A b s t r a c t. In winter (06.02.2001) some chosen physico-chemical and phycological parameters of a humic lake-stream system were examined (the Kuzniczek Lake, about 0.2 ha; the Kuźnik Mały Lake, 1.68 ha; the Kuźnik Duży Lake, 1.08 ha) situated in the basin of the Strumień Stream in the Kuźnik Nature Reserve (the Wielkopolska Region, Poland). There were 102 taxa of algae affirmed from 10 systematic groups. Physico-chemical and phycological autonomy of the Kuźniczek Lake pointed to a profile very close to a distrophic one among all of lakes examined. In the Kuźnik Mały Lake and the Kuźnik Duży Lake quality domination of *Bacillariophyceae* and *Cyanoprkaryota* was observed. DOC concentrations at the sites examined were between 4.3 and 14.8 mg Cl^{-1}.

K e y w o r d s: winter algae, physical and chemical parameters, humic lake – stream system, "Kuźnik" Nature Reserve

INTRODUCTION

Most papers about algae and physico-chemical parameters of lakes, especially humic lakes and peat-bogs, concentrated on the growing season with only limited data available on winter algae [9,10,16]. It is clear that under ice, development of algae is shaped by factors different from those at work in the growing season [16,17]. Snow cover plus white ice can reduce the under ice light flux to near zero

†Dedicated to memory of Mirosława Adamczewska (†2001) – our fellow worker, a specialist of encironmental and analytic chemistry

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[13]. An abundance of algae occurs during winters with an ice-cover induced by nutrients and other growth-promoting substances from the non-frozen soils [12]. The winter period is associated with a low [1,8] or high [4,14] abundance and biomass of algae.

MATERIALS AND METHODS

The present research covered a system of hydrologically differentiated lakes located in the basin of the Strumień in the west trough of the Kuźnik Nature Reserve. The Nature Reserve Kuźnik is situated in its main part within the town border of Pila (the northern Wielkopolska region). The first of the lakes examined – the Kuźniczek Lake (an area of about 0.3 ha) is without an outlet, the second – the Kuźnik Mały Lake (1.68 ha) has an outlet at higher water levels and the third one – the Kuźnik Duży Lake (1.08 ha) is with an outlet all year round and flowable by higher water levels.

Research was performed on 06/02/2001. Samples of water were collected from holes drilled in 10 cm thick ice cover in the sites situated next to the phytolitoral. In the case of the Kuzniczek Lake, sites were situated in the north-east part of the lake close to the gathering of *Phragmites australis* (KL1) and in the south-west part at the gathering of *Sphagnum* sp. (KL2). In the case of the Kuźnik Mały Lake (KLM) and the Kuźnik Duży Lake (KDL) sites were situated in the central part of the west coast. There were also water samples from the Strumień Stream located between the Kuźnik Mały Lake and the Kuźnik Duży Lake –S1 and from sites below KDL – S2. Air and water temperature and water was taken in the area dissolved oxygen concentration, electrolytic conductivity, pH and the together with water flow in the stream. Five litres of water was taken from each site. It was poured into 1 litre containers. Two litres were taken for phycological analyses out of which was preserved with Lugola liquid, the other was left unpreserved for the survival marking of algae. Three litres of water were designated for physico-chemical analyses, 2 of which were preserved with chloroform and sulphuric acid, respectively, the 3rd litre was not preserved. In tests on water, colour, general and carbonate hardness, concentration of N, P, Ca, Mg, chlorides, sulfates, Na, K and Fe were marked according to standard methods [5,15]. Dissolved organic carbon (DOC) was marked by the method described by Górniak [6]. Dissolved humic substances RSH were calculated according to the formula: RSH (mg C l^{-1})=0.594 x DOC-0.525 [6].

The present work constitutes a part of research on some chosen biological and physico-chemical parameters of habitatually valuable, boggy-lake ecosystems in the northern Wielkopolska region.

RESULTS AND DISCUSSION

The physico-chemical parameters measured at subsequent research sites, located along a humic lake-stream system in the Kuźnik Nature Reserve are presented in Table 1. A floristic list of algae observed at the sites tested has been presented in Table 2.

The lowest pH value among the research sites was detected in the water from the Kuźniczek Lake (ca.5.5 pH). It also showed the lowest concentration of Ca, Mg, sulfates and the lowest values of general and bicarbonate hardness. Such concentration levels are generally known as typical for the lakes described as distrophic by the Naumann-Thieneman classification. The Kuźniczek Lake was characterized by the lowest concentration of Na, chlorides and sulfates. Tendencies similar to described above, were found in the Skrzynka Lake in the Wielkopolska National Park, with a peat-bog with *Sphagnum* [3] in its direct basin. Concentrations of K and Fe in the water of the Kuźniczek Lake were the highest in all sites tested. Basing on the results obtained a tendency towords an increase in pH value and conductivity was observed with the lowering of the basin. An opposite tendency was found for water colour. Similar levels of some of the physico-chemical parameters tested in the sites below the Kuźniczek Lake may result from a connecting role of the Strumień Stream at least temporarily. The outlying physico-chemical distinction of the Kuźnik Lake is probably also a consequence of the biggest share, peat-bogs with *Sphagnum* in its direct basin.

Concentration levels of DOC, and RSH were used to rate waters of the sites tested [2] with respect to alpha- and beta-mezohumic water (the Kuźniczek Lake 2 and the Kuźnik Mały Lake) with an exception of the oligohumic waters of the Kuźnik Duży Lake.

One hundred- and - two algae taxa detected in all sites was relatively high as compared to other lake-peatland ecosystems tested in winter [10]. It resulted from a high taxonomic variety of algae in individual sites (Fig. 1). Łaźniewska [11] studied flora of various peatland habitats in the "Zakret" Nature Reserve (the Masurian Lanscape Park) and noted less than 10 algae taxa in winter. A high numbers of taxa could result from the site position in the coastal zone of the lakes rich in taxa due to their bordering character.

In the Kuźniczek Lake a quality domination of *Euglenophyceae* and *Conjugatophyceae* was observed (Fig. 1). *Bacillariophyceae* and *Cyanoprokaryota* dominated in both Kuźnik Lakes. An increase in the share of *Cyanoprokaryota* in the lakes along the Strumień Stream basin was also observed. In the water of the Stru-

T a b l e 1. Physico-chemical parameters of water at the sites of humic lake-stream system in the "Kuźnik" Nature Reserve (2001.02.06., KL1 – the Kuźniczek Lake 1, KL2 – the Kuźniczek Lake 2, KML – the Kuźnik Mały Lake, S1 – the Strumień Stream 1, KDL – the Kuźnik Duży Lake 2, S2 – the Strumień Stream 2)

Parameters/ sites tested	KL1	KL2	KML	S1	KDL	S2
Air-temperature (^oC)	4.0	4.0	4.0	4.0	4.0	4.0
Water temperature (^oC)	0.2	0.1	-0.2	-0.8	0.7	0.1
Depth (research sites) (m)	0.30	0.25	0.40	0.01	0.50	0.025
Dissolved oxygen (mg O_2 l^{-1})	0.0	0.0	1.1	5.4	0.9	7.3
pH	5.55	5.43	6.37	7.73	7.14	7.75
Conductivity (μS cm^{-1})	36.4	32.9	360	346	366	373
Colour (mg Pt l^{-1})	68	80	80	34	30	25
N-NH_4 (mg N l^{-1})	0.4	0.7	1.1	0.34	0.3	0.26
N-NO_2 (mg N l^{-1})	0.0005	0.0005	0.003	0.002	0.0045	0.004
N-NO_3 (mg N l^{-1})	0	0	0	0	0	0
Organic N (mg N l^{-1})	0.79	2.1	1.14	1.27	1.1	0.93
Total N (mg N l^{-1})	1.1905	2.8005	2.243	1.612	1.4045	1.194
Total P (mg PO_4 l^{-1})	0.24	0.50	0.56	0.18	0.18	0.50
PO_4-orto. (mg PO_4 l^{-1})	0.12	0.40	0.10	0.08	0.06	0.06
Ca (mg l^{-1})	2.85	1.79	65.5	64.2	68.5	69.2
Mg (mg l^{-1})	1.74	1.09	6.9	6.1	6.1	7.4
Total water hardness (m val l^{-1})	0.286	0.019	3.68	3.79	3.93	4.07
Carbonate water hardness (mg Ca CO_3 l^{-1})	14.24	9.26	192.24	188.68	195.8	202.92
Alkalinity (m val l^{-1})	0.23	0.20	3.60	3.50	3.60	3.80
SO_4^- (mg l^{-1})	2	1	8	6	8	10
Cl^- (mg l^{-1})	4	4	12	9	8	10
Na (mg l^{-1})	1.25	1.35	5.21	4.60	4.40	4.60
K (mg l^{-1})	0.98	1.48	0.85	0.76	0.65	-.68
Fe (mg l^{-1})	0.87	0.58	0.07	0.07	0.06	0.06
DOC dissolved organic carbon (mg C l^{-1})	9.3	12.8	14.8	8.1	4.3	7.5
RSH dissolved humus substances (mg C l^{-1})	5.00	7.08	8.27	4.29	2.03	3.93

T a b l e 2. List of taxa collected from the sites tested in the "Kuźnik" Nature Reserve (2001.02.06., KL1 – the Kuźniczek Lake 1, KL2 – the Kuźniczek Lake 2, KML – the Kuźnik Mały Lake, S1 – the Strumień Stream 1, KDL – the Kuźnik Duży Lake 2, S2 – the Strumień Stream 2; Scale of abundance: 1 – single, 2 – few, 3 – fairly numerous, 4 – numerous, 5 – abundant)

Phycoflora	LK1	LK2	LKM	S1	LKD	S2
CYANOPROKARYOTA						
Fortiea spirulina fo. *goesingense* (Palik) V. Polianskij	2					
Aphanothece sp.	2	2				
Synechococcus aeruginosus Nägeli	2	2		1		
Aphanothece stagnina (Sprengel) A. Braun in Rabenchorst	2	2		1	1	
Gleocapsa minima (Keissler) Hollerbach		2			2	1
Merismopedia sp.		1				
Cyanothece aeruginosa (Nägeli) Komarek			2			
Dactylococcpsis fascicularis Lemmermann			2			
Aphanocapsa sp.			1			
Gloeocapsa limnetica (Lemmermann) Hollerbach			1	1		
Oscilatoria limosa Agardh			1		3	
Aphanocapsa cf. *holsatica* (Lemmermann) Cronberg et Komarek			1		2	1
Phormidium sp.				2	5	1
Oscillatoria cf. *proboscidea* Gomont				1	2	
Oscillatoria cf. *fulgens* Böcher				1	2	
Pseudoanabaena catenata Lauterborn					2	
Chroococcus turgidus (Kützing) Nägeli					2	
Pseudospirulina amoena Pankow et Jahnke					2	
Oscillatoria gracilis Böcher					1	
BACILLARIOPHYCEAE						
Fragilaria sp.	1					
Pinularia rupestris Hantzsch in Rabemhorst 1861	4				1	
Frustulia saxonica Rabenhorst	3	3				
Eunotia exigua (Breb.) Rabenhorst	2	2				
Tabelaria floculosa (Roth) Kützing		3				

Table 2. Continued

Cymbella compacta Ostrup			2			
Gomphonema cf. *bavaricum* Reichardt et Lange-Bertalot			2			
Navicula sp.			2			
Nitzschia sp.			1			
Cymbella affnis Kützing			1			
Gomphonema sp. 2			1			
Fragilaria biceps (Kützing) Lange-Bertalot			2		3	
Melosira varians Agardh			1		2	
Cymbella sp.			1		2	
Aulacoseira islandica O. Müll.			1		2	
Cyclotella sp.					3	
Gomphonema sp. 1					2	
Fragilaria crotonensis Kitton					1	
Diatoma ehrenbergii Kützing					1	
Cymbella lanceolata (Ehr.) van Heurck					1	
CHRYSOPHYCEAE						
Dinobryon bavaricum Imhof		1				
Dinobryon sertularia Ehrenberg			2	3	5	5
Dinobryon cylindricum var. *alpinum* (Imhof) Bachmann					2	2
Dinobryon attenuatum (Hilliard) Hilliard						1
XANTOPHYCEAE						
Botryodiopsis arhiza Borzi			5	4	2	
Characiopsis minima Pascher			1	2		1
Ophiocytium maius Nägeli			1			
Myxochloris sphagnicola Pascher				2		
Characiopsis cf. *varians* Pascher				1		
CHLOROPHYCEAE						
Coenochloris sp. 2.	2					
Ancistrodesmus falcatus (Corda) Ralfs	2	3				
Pandorina smithii Chodat	2	2				
Coenochloris sp. 1.	2				1	
Monoraphidium minutum (Näg.) Kom.-Legn.		1				
Monoraphidium contortum (Thur.) Kom.-Legn.			2	2		

Table 2. Continued

Coelastrella striolata Chodat				2		
Echinosphaeridium nordstedtii Lemmermann					1	
Monoraphidium sp.						1
CONJUGATOPHYCEAE						
Staurastrum inflexum Breb.	2					
Spirogyra sp.	2					
Cosmoastrum hystrix (Ralfs) Pal.-Mordv.	2					
Pleurotaenium sp.	1					
Pleuroatenium minutum v. minutum (Ralfs) Delp.	1					
Staurodesmus sp.	1					
Zygnema sp. 1	3	3				
Cosmarium amoneum var. amoneum Breb.	2	2				
Micrasterias truncata var. *truncata* (Cordsa) ex Breb.		2				
Tetmemorus sp.		2				
Pleurotaenium ehrenbergii var. *ehrenbergii* (Breb.) de Bary		2				
Staurastrum sp.		2				
Closterium sp.		1				
Cosmarium sp. 1		1				
Zygnema sp. 2			1			
Cosmarium bioculatum (Breb.) ex Ralfs var. bioculatum			1			
Closterium diane var. *diane* Ehrenb. ex Ralfs 1848					1	
Cosmarium sp. 2					1	
CRYPTOPHYCEAE						
Cryptomonas sp.		1	1			
Cryptomonas cf. *tenuis* Pascher				1		
DINOPHYCEAE						
Peridinium raciborski var. *palustre* Lindemann	1					
Peridinium aciculiferum Lemmermann		1			1	
Gymnodinium mitratum Schiller			2	3		3
Gymnodinium uberrimum (Allman) Kofoid et Swezy			1			2
Peridinium bipes Stein			1			

Table 2. Continued

Woloszynskia pascheri (Suchlandt) v. Stosch				2	3	2
Gymnodinium wawrikae Schiler				1		1
Gymnodinium sp.					4	1
RAPHIDOPHYCEAE						
Gonyostomum semen (Ehrenberg) Diesing	1	1				
EUGLENOPHYCEAE						
Phacus longicauda v. *insecta* Huber-Pestalozzi	2					
Euglena sp.	1					
Entonosiphon sp.	1					
Patelomonas cf. *sulcata* Stokes	1					
Trachelomonas granulosa Playfair						
Trachelomonas armata var. *heterospina* Swirenko	3	3				
Astasia sp. 1	2	2				
Euglena acus Ehrenberg	2	2				
Astasia cf. *longa* Pringsheim		2				
Astasia sp. 2		2				
Trachelomonas volvocina Ehrenberg		2				
cf. *Heteronema* sp.		1				
Phacus curvicauda Swirenko		1				
Patelomonas sp.		1				
Menoidium tortuosum var. *tortuosum* (Stokes) Senn		2		1		
Phacus acuminatus var. *acuticaudata* (Roll) Pochmann					1	

mień Stream 1, between the Kuźnik Mały Lake and the Kuźnik Duży Lake *Cyanoprokaryota, Xantophyceae* and *Dinophyceae* were dominant. Though, in the Strumień Stream 2 site below the Kuźnik Duży Lake, *Dinophyceae, Chrysophyceae and Cyanoprokaryota* were predominant.

CONCLUSIONS

Clear physico-chemical and floristic differences between the Kuźniczek Lake and other sites tested is interesting in the context of geomorphological research showing that the Kuźnik Lake and the Kuźnik Mały Lake were single water reser-

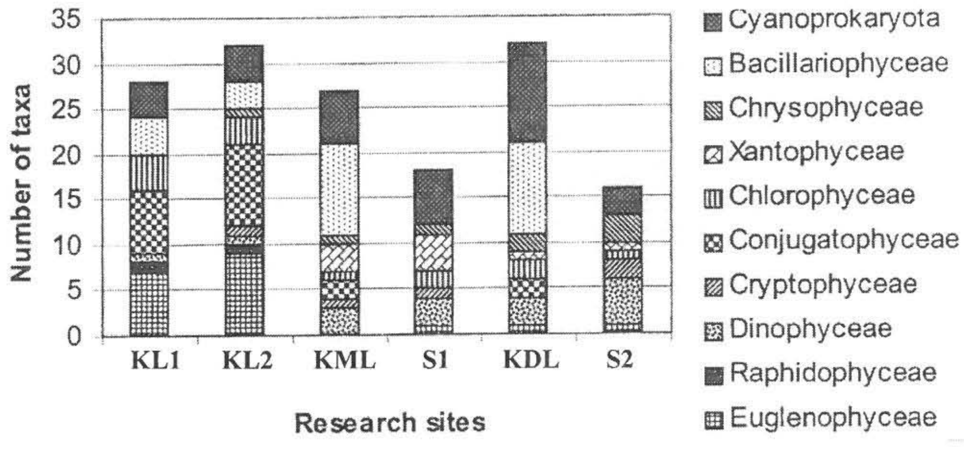

Fig. 1. Changes in the taxonomic structure of phycoflora in the sites tested in the "Kuźnik" Nature Reserve (2001.02.06., KL1 – the Kuźniczek Lake 1, KL2 – the Kuźniczek Lake 2, KML – the Kuźnik Mały Lake, S1– Stream Strumień 1, KDL – the Kuźnik Duży Lake 2, S2 – Stream Strumień 2)

voirs in the past (B. Nowaczyk, P.M. Owsianny, not published data). Changes in the physico-chemical and phycological parameters noted along the basin slope in the Kuźnik Nature Reserve seem to show, a decreasingly distrophic character of the lakes studied. It may result from a lowering rate of peatlands with Sphagnum in the direct basins of the lakes as well as the change in the hydrological characteristics of lakes to which become more open.

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ZIMOWA FYKOFLORA I WARUNKI FIZYCZNO-CHEMICZNE UKŁADU JEZIORA HUMUSOWE – STRUMIEŃ W REZERWACIE PRZYRODY KUŹNIK (WIELKOPOLSKA)

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S t r e s z c z e n i e. Badaniami (06.02.2001.) fizyczno-chemicznymi i fykologicznymi objęto układ zróżnicowanych hydrologicznie jezior Kuzniczek, Kuźnik Mały i Kuźnik Duży w zlewni niewielkiego Strumienia w z rezerwacie przyrody "Kuźnik" (Wielkopolska). W wodzie Kuźniczka stwierdzono najniższe spośród badanych stanowisk wartości pH, wapnia, magnezu, twardości ogólnej i wodorowęglanowej, sodu, chlorków i siarczanów. Takie koncentracje są uznawane za typowe dla jezior opisywanych jako dystroficzne. Wyższy, podobny poziom wartości niektórych parametrów fizyczno-chemicznych dla stanowisk poniżej Kuźniczka wynika raczej z połączenia stanowisk Strumieniem. Fykoflorę reprezentuje 102. taksony glonów z 10 grup systematycznych. W Kuźniczku jakościowo dominowały *Euglenophyceae* i *Conjugatophyceae*, w jeziorach Kuźnik Mały i Kuźnik Duży natomiast *Bacillariophyceae* i *Cyanoprokaryota*. W Strumieniu pomiędzy Kuźnikami dominowały *Cyanoprocaryota*, *Xantophyceae* i *Dinophyceae*, a na stanowisku poniżej Kuźnika Dużego – *Dinophyceae*, *Chrysophyceae* i *Cyanoprokaryota*. Zmiana wartości badanych parametrów stanowiskach wzdłuż spadku zlewni Strumienia wskazuje jak się wydaje na zmniejszający się charakter dystroficzny badanych jezior. Przyczyną takiego stanu, poza zmniejszającym się udziałem torfowisk ze *Sphagnum* w zlewniach bezpośrednich jezior, może być zmiana charakteru hydrologicznego jezior na bardziej otwarty.

S ł o w a k l u c z o w e: zima, glony, parametry fizyczne, chemiczne, jezioro humusowe, strumień, rezerwat przyrody