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DIATOM MONITORING OF INLAND DUNE LAKE SEDIMENTS IN PUSZCZA NOTECKA LAKES (NORTH WIELKOPOLSKA)[*]

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A b s t r a c t. Analysis of diatom assemblages was carried out in the surface sediment in both the midlake and the littoral zone of 8 dystrophic lakes from the Puszcza Notecka area. The species composition and density of diatoms were estimated. Moreover, physicochemical analysis in all samples was conducted. The sediment of each lake was characterised by a low pH, small amounts of calcium and organic matter. Among the 145 taxa identified, the most characteristic species of cosmopolitic diatoms were: *Cymbella minuta*, *Cyclotella radiosa*, *Navicula radiosa*, *Gomphonema acuminatum*. Furthermore, taxa like *Achnanthes* spp., *Eunotia* spp., *Anomoeoneis* spp., *Frustularia rhomboides* were used as indicators of acidity. More eutrophic conditions in the littoral zone as compared to the midlake part were evident.

K e y w o r d s: diatoms, sediment, taxon ecology, humic lakes, chemistry of sediment

INTRODUCTION

Inland dune lakes, which were created in depressions among dunes, belong to an uncommon type of water ecosystems in the area of Poland [2]. The greatest complex of inland dunes is present in the Notecka Primeval Forest (Puszcza Notecka) in the North of Wielkopolska. Most lakes in this territory were created as a consequence of cutting the wide area of woodlands devastated by insect *Lymantria monacha* in the years 1922-1924 [7,14]. An increase in the level of water in spaces lacking in trees, which stabilised the level of water, resulted in a rise of the ground water level and produced in this way many small lakes. At the beginning, they were recognised as ephemeral water ecosystems. At present, many of them have *Sphagnum* floating mats and on the basis of their physico-

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chemical water parameters dystrophic nature was stated [3]. Polish references lack the limnological characteristics of these kind of ecosystems.

Phytobenthos analysis provides valuable information about changes which have taken place in the lakes in preceding years. Diatoms are very useful tools in the reconstruction of both past and present ecological conditions. Using particular taxa and community ecology, it is possible to reconstruct environmental conditions in lakes, including pH and trophic conditions. The aim of the present study was to estimate the abiotic conditions in lakes and to characterise potential pH and trophy reflected in the structure of diatom assemblages.

RESEARCH AREA AND METHODS

The research was carried out in 8 lakes in the region of Wielkopolska (Puszcza Notecka). The lakes are situated in the area of the Gorzowska Valley, between the Warta and the Noteć rivers [6]. These small water ecosystems are located among sand dunes, which are poor in nutrients, and surrounded by a large pine forest. This is the most dense forest complex in that region. They are lakes which were created a relatively short time ago (80 years ago).

Most of the lakes are small (area of 0.6-8.5 ha; max depth of 3.8 m) with high incidence of moss bog in their catchment areas (Tab. 1). The humic content reflected by water colour varies between the lakes. Two lakes were α-mesohumic, three β-mesohumic and three polyhumic. Dissolved organic carbon contents ranged from 4 to 30 mg C l^{-1} [4].

Table 1. Some characteristics of the lakes studied

Lake	Type of humic lake	Area (ha)	Max. depth (m)
Święte	β-mezo-	6.5	2.5
Moczydło	β-mezo-	2.7	1.5
Perskie	poli-	8.5	2
Zgniłe	poli-	1.4	1.2
Pokraczyn	β-mezo-	1.5	3
Pustelnik I	α-mezo α-	1.5	2
Pustelnik II	mezo-	2.1	3.8
Wilcze Błoto	poli-	0.6	2.1

Field investigations were carried out in the summer seasons of 2002 and 2003. In order to estimate whether diatom horizontal differentiation existed in the investigated lakes, transects perpendicular to the bank were realised. The material for the diatom studies was collected from the surface sediments in the deepest part of each lake (midlake station). In addition, the sampling stations corresponded to water plant communities and contained hydrophyte and helophyte assemblages occurring

in each lake. For each investigated sample of sediment three sub-samples were put together. Sixteen parameters of sediment were analysed in each sample.

The samples for diatom analyses were treated with 10% HCl to remove calcium carbonate. Then they were washed several times with distilled water and boiled in 30% H_2O_2 in a water bath at a temperature of 82°C to remove organic matter. Constant slides were mounted in Naphrax. At least 500 diatom valves were counted from each slide and next the relative abundance of each taxon was calculated. The counting results formed the basis for diatom structure presenting a horizontal distribution of different ecological diatom groups including pH and trophy.

RESULTS AND DISCUSSION

The lakes sediment was strongly hydrated (80-90%), relatively rich in organic matter, and generally had a detritus gyttia texture. The pH of sediment in the lakes between 2002-2003 was within the range of 6.1 and 6.7. Due to calcium concentration in the sediment, two groups of lakes were identified: with dry mass concentration lower than 50 g Ca kg^{-1} (Pokraczyn, Pustelnik I, Pustelnik II and Wilcze Błoto lakes) and with dry mass concentration higher than 100 g Ca kg^{-1} (Perskie, Moczydło, Zgniłe and Święte lakes). Lake Pokraczyn was conspicuous due to higher magnesium concentration when compared to calcium in the sediment from other investigated lakes. These parameters indicated a strongly dystrophic character of Lake Pokraczyn. Comparatively high concentrations of total phosphate (from 1 g PO_4 kg^{-1} dry mass in Lake Pokraczyn to 9 g PO_4 kg^{-1} dry mass in Lake Zgniłe) and differentiated total iron concentration (the highest at 220 g kg^{-1} of dry mass in the case of Lake Zgniłe) were typical of the lakes. The interesting thing is that these chemical sediment parameters did not at all times reflect the division of the lakes according to the water properties. Despite higher contents of calcium in the sediment of some lakes (Pustelnik I, Pustelnik II, Perskie) the sediment did not have a dystrophic character and acid pH and very small electrolytic conductivity amounting to 50 μS cm^{-1}. Probably in these three lakes as a result of calcium precipitation from inflow waters from the catchments area the calcium deposit in sediment was gathered. At the beginning, the lakes were rich in calcium. Then, they underwent distrophication and gradually ran short of the concentration of calcium. This is a result of the creation of transition moor formation between the lakes and the catchments area which functions as a frontier [3,4].

The total number of taxa identified in all the samples studied was 145. In almost all of the lakes examined, except Lake Perskie (69) and Lake Wilcze Błoto (64), a similar distribution of about 80 taxa was observed. Although pinnate forms were the most frequent, centric forms were often more conspicuous ecologically, e.g. *Aulacoseira/Melosira* sp., *Cyclotella comensis*, *Cyclotella pseudosteligera* [1,9]. Periphytic

diatoms, especially taxa representing the genera *Gomphonema*, *Navicula*, *Nitzschia* and *Cocconeis,* dominated in the sediment taken from macrophyte stations in the littoral zone. However, planktonic forms occurred mainly in the sediment from the deepest part of each lake and were represented mainly by taxa belonging to the genera *Aulacoseira*, *Cyclotella, Fragillaria* and *Stephanodiscus*.

Based on the ecological characteristics [11] and presented there, among others, pH preferences of particular diatoms, 12 acidophilous taxa, 39 indifferent, 68 alkaliphilous, and 27 with a wide scale of tolerance were recorded. Among diatoms *Achnanthes ventralis, Anomoeoneis styriaca, Cymbella gracilis, Eunotia bilunaris v. linearis, Eunotia bilunaris v. mucophila, Eunotia paludosa, Eunotia praerupta, Frustularia rhomboids, Gomphonema parvulum, Navicula subtilissima, Pinularia nobilis* were the taxa that prefer small range of pH in waters [5,7,8]. In all the lakes high numbers of chrysophyte cysts which are characteristic for humic waters were noted. Their presence proved the dystrophic character of water in all the lakes [10].

A similar comparison related to the diatom structure of trophic spectrum preference was made. The found taxa mainly prefered eutrophic waters (55), but also oligo-mesotraphentic taxa (13) and meso-eutraphentic taxa (35) were observed. Furthermore, 42 diatom taxa had wide trophic preference and can abundantly occur in lakes of different trophy. Other very abundant taxa included *Cyclotella meneghiniana, Eunotia bilunaris, Nitzschia sigmoidea, Cocconeis placentula, Cymbella lanceolata, Navicula lanceolata, Fragilaria ulna* which are known as indicative of eutrophic character of the water [5,9,10]. Eutrophic taxa of diatoms were in more cases observed at greater numbers in the littoral zone, similarly to the results obtained by Bubak and Bogaczewicz-Adamczak [1].

Differentiation was also observed at the level of dominating taxa (Tab. 2).

Table 2. Dominant diatom taxa in the surface sediment samples (relative abundance %)

Lake	Dominant taxon (%)	Subdominant taxon (%)
Święte	*Fragilaria* spp. complex (49)	*Tabellaria fenestrata* (10)
Moczydło	*Navicula lanceolata* (37)	*Fragilaria* spp. complex (22)
Perskie	*Cyclotella comensis* (33)	*Navicula lanceolata* (12)
Zgniłe	*Fragilaria* spp. complex (54)	*Cymbella minuta* (11)
Pokraczyn	*Cyclotella pseudosteligera* (31)	*Fragilaria* spp. complex (29)
Pustelnik I	*Fragilaria* spp. complex (45)	*Pinularia borealis* (27)
Pustelnik II	*Fragilaria* spp. complex (52)	*Eunotia bilunaris* v. *mucophila* (12)
Wilcze Błota	*Fragilaria* spp. complex (36)	*Pinularia mesolepta* (10)

The group of dominants characteristic of acid waters with a low nutrient content included: *Eunotia bilunaris* var. *mucophila*, *Cyclotella comensis*, *C. pseudosteligera, Pinularia mesolepta*. They were more or less frequent and abundant. *Fragillaria* spp. complex dominated in most of the lakes lakes, irrespective of the macrophyte station, with the highest dominance level (54%) in Zgniłe Lake. The

species of *Fragilaria* complex formed more than half of the total diatom cell numbers (Tab. 2). *Fragilaria construens*, *F. exigua*, *F. brevistriata* and others can be abundant in nutrient–poor waters but also in alkaline and eutrophic waters [5,9,10]. Dominant *Tabellaria fenestrata* is an indifferent species which was characteristic of oligotrophic and mesotrophic waters with a pH close to 7 and found favourable conditions for its development in Święte Lake. The other species were not frequent and had low density. The characteristic special variation of the pH and trophy spectrum structure in the spatial transect in Lake Święte is clearly shown in Figures 1 and 2. *Charetum intermediae* station (charophytes meadow) was characterised by higher number of taxa, density and particpation of both periphytic (e.g. *Cocconeis placentula*, *Gomponema* spp.) and eutrophic forms compared to the midlake station.

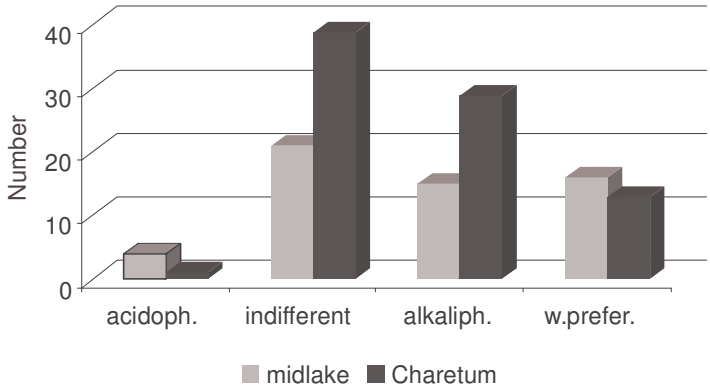

Fig. 1. Numbers of diatom taxa with different pH preferences in spatial transect in Lake Święte (acidoph. – acidophilous; alkaliph. – alkaliphilous; w.prefer. – wide preferences)

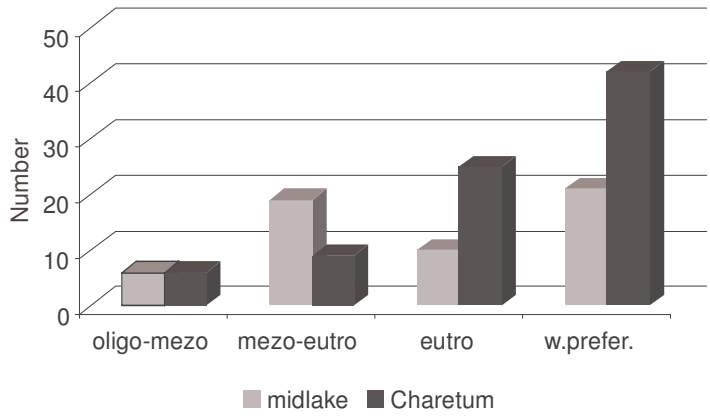

Fig. 2. Number of diatom taxa representing different trophic groups in spatial transect in Lake Święte (oligo-mezo – oligo-mesotraphentic; mezzo-eutro – meso-eutraphentic; eutro- eutraphentic; w.prefer. – wide preferences)

The diatoms of midlake sediment indicated more acid and oligotrophic waters in comparison with those of the macrophyte station in the littoral zone. Differences between peaks were the same in most of the lakes. The taxonomical composition and the quantitative relations of diatoms in our study were similar to those characteristic for humic lakes from the north part of Poland [1]. The nutrient supply of investigated lakes is not high enough for developing dense diatom communities. The trophic status of the sediment of the lake can reach more eutrophic level during the growing season in the littoral during low water periods, which was observed in most of the investigated lakes.

CONCLUSIONS

From the analysis of changes in the qualitative composition of diatoms in 8 dystrophic lakes, the following results were obtained:

1. 145 taxa of diatoms were recorded.
2. A constant increase in the numbers in the direction of littoral took place in most of the lakes.
3. In most of the lakes the alkaliphilous and indifferent forms in the littoral stations increased up to an average of 28 and 39 of the total number of taxa, respectively.
4. In each lake different dominant taxa were noted.
5. More eutrophic conditions were found in the littoral zone as compared to the midlake part of the lakes.

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MONITORING OKRZEMEK OSADÓW DENNYCH ŚRÓDWYDMOWYCH JEZIOR PUSZCZY NOTECKIEJ (PÓŁNOCNA WIELKOPOLSKA)

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S t r e s z c z e n i e. Badania zbiorowisk okrzemek powierzchniowej warstwy osadów dennych prowadzono w 8 płytkich (głęb. maks. do 4 m), dystroficznych jeziorach na obszarze Puszczy Noteckiej. W każdym zbiorniku w transektach przecinających obszar śródjezierza pobrano próby powierzchniowych osadów dennych. W próbach określono skład ilościowy i jakościowy okrzemek, jak i również wykonano analizy fizyczno-chemiczne osadów. Osady charakteryzowały się silnie kwaśnym odczynem, niewielką zawartością wapnia oraz zasobnością w materię organiczną. Analiza okrzemkowa osadów w badanych jeziorach wykazała wyraźną dominację taksonów o charakterze kosmopolitycznym (np. *Cymbella minuta*, *Cyclotella radiosa*, *Navicula radiosa*, *Gomphonema acuminatum*). Równocześnie w jeziorach spotykane były gatunki wskaźnikowe, zwłaszcza w odniesieniu do odczynu wody (np. *Achnanthes* spp., *Eunotia* spp., *Anomoeoneis* spp., *Frustularia rhomboides*).

S ł o w a k l u c z o w e: okrzemki, osady denne, ekologia gatunku, jeziora humusowe, chemia osadów