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Physical-chemical and biological parameters of two neighbouring post-exploitation clay-pits**,***

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A b s t r a c t. The aim of the study was to determine the physical-chemical and biological (aquatic vegetation cover and plankton structure) parameters of two post-exploitation clay-pits. As a result of the study it was found that even though the examined water bodies were situated within a very short distance, were of the same origin and of a similar time of origination, they differed from each other in many aspects.

K e y w o r d s: post-exploitation clay-pits, physical-chemical parameters, aquatic vegetation cover, plankton structure

INTRODUCTION

Small water reservoirs may be divided according to their trophy and origin into old river-beds, semi-natural eutrophic ponds, dystrophic within peat-bog area or typical anthropogenic water reservoirs. Clay-pits that originate from clay excavation belong to the most frequently appearing post-exploitative reservoirs within the area of Poland (Puchalski, 1985). During the first phase after originating the clay-pits are very scanty taxonomically, but with the passage of time the diversity of organism population increases and these reservoirs may become semi-natural.

All the organisms that live within the pond are dependent upon each other for growth and development, so they create a food-web. These organisms range from the microscopic producers to the larger predators, each obtaining its nourishment from those around. Moreover, all the organisms depend on external influences, such as *eg* physical-chemical parameters of water, the catchment area surrounding the pond or the depth of water that determines the macrophyte cover, which can modify considerably the pond environment.

The aim of the examination carried out on two closely situated clay-pits, characterized by the same origin, was to determine the influence of the physical-chemical parameters (including concentration of phosphorus and nitrogen, oxygen, conductivity, water hardness and reaction), as well as differentiated predation pressure on the biological structure of inhabiting organisms. The investigation of plankton communities included the open water zones as well as macrophyte stands of both water reservoirs.

MATERIAL AND METHODS

The research was made on two post-exploitation reservoirs located in the north-western part of Poznań. They both originated at the same time (at the beginning of the XX century) as a result of ceramic clay mining. Moreover, both clay-pits were situated within a short distance (about 20 m). However, they differed in area, in the maximum depth (No. 1 - 5 m, No. 2 - 0.6 m) and mean depth, as well as in the ichtyofauna presence (fish were only present in the first water body).

In the summer of 2005 in the zone of open water and within the littoral the oxygen concentration, pH and conductivity were measured. Moreover, samples for chemical analysis and for phyto- and zooplankton examination as well as material for investigation of density and biomass of

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macrophytes were collected. Chemical analysis was conducted according to Standard Methods for Examination of Water and Wastewater (1992). The plankton samples were taken in triplicate (n = 15) at each site using a plexiglass core sampler (method for sampling in the littoral zone recommended by *eg* Schriver *et al*., 1995).

To estimate the species diversity of rotifers inhabiting particular zones in the lake, the Shannon and Weaver coefficient was applied (Margalef, 1957).

Additionally, the Mann-Whitney U-test was applied in order to determine the effect of site on the distribution of phyto- and zooplankton densities (N=15).

RESULTS

Comparing both clay-pits in respect to all the parameters, considerable differences were found. They differed in their morphometry. The first one had sloping banks and, as a consequence, a narrow phytolittoral, while the second one was shallow with soft banks.

Also the physical-chemical features differed in both reservoirs. Only reactivity was similar – they were both alkaline, while the concentrations of phosphorus (P_{TR}, P_T) and oxygen (O_2) indicated mesotrophic conditions in the first water body and hypertrophy in the second one. The concentration of ammonium nitrogen (NNH_4), electrical conductivity (EC) and the total water hardness ($CaCO_3$) were low in the first clay-pit and much higher in the second one. Moreover, water visibility (Secchi Disc Visibility – SDV) was not alike in the two ponds, 4 and 0.6 m respectively (Table 1).

Phytosociological study revealed that both ponds were characterized by very great syntaxonomical poverty. In the first one the rush zone was created only by *Pragmitetum communis* with the participation of individual specimens of *Epilobium hirsutum* and *Rumex hydrolapathum.* In the open water stands of *Myriophylletum spicati* and single individuals of *Ceratophyllum demersum* were present. In the second water body *Phragmitetum communis* created a narrow rush zone which - from the south - was surrounded by a hedge of willows. There was only one community of elodeides - *Ceratophylletum submersi* - present, which covered 20% of the bottom. Moreover, the water surface was in 60% covered by a thick layer of green algae *Enteromorpha intestinalis.*

The biometric investigation of plants showed the highest densities and vegetation biomass in the bed of *Myriophylletum spicati* in pond No. 1. A lower density with the lowest biomass was recorded for *Ceratophylletum submersi* in pond No. 2. Among *Phragmitetum* the lowest density and medium biomass per water unit was found.

The analysis of zooplankton communities of both clay-pits revealed the presence of 81 taxa (50 Rotifera, 20 Cladocera, 11 Copepoda), however, the naumber of taxa differed greatly in both ponds (47, 19, 9 in the first and 13, 6, 5 in the second one, respectively). Moreover, taxonomical differentiation between the examined stations was also noticed, where the vegetated zones were characterized by higher values than the open water areas. Rotifers dominated taxonomically over crustaceans, irrespective of the sampling station (Fig. 1a).

However, on analysing the zooplankton densities the rotifer dominance over crustaceans was only recorded in clay-pit No. 1, while in No. 2 crustaceans reached a higher abundance (due to the massive occurrence of *Daphnia magna* Straus – 60% and *Eucyclops macruroides* (Lilljeborg) – 29% of total zooplankton densities of *Ceratophyllum* zone). The mean zooplankton numbers in one litre of water, irrespective of the station, accounted for 229 ind l^{-1} in the first one and 45 in the second one, dominated by crustaceans (Fig. 1b). The statistical analysis revealed significant differences in the rotifer densities between both examined ponds ($Z = 3.1820$, $p = 0.0015$).

The community of dominants was created by 18 species, but only *Keratella cochlearis* (Gosse) and *Trichocerca similis* (Wierzejski) dominated in both water bodies.

T a b l e 1. Physical-chemical parameters of water from investigated clay-pits

Site	EC μScm^{-1}	pH	Concentration (mg l^{-1})				
			$CaCO_3$	O_2	P_{TR}	P_T	$N\text{-}NH_4$
Clay-pit No. 1							
1	573	9.6	121	9.4	3	20	33
2	572	9.47	133	8.3	21	34	33
3	566	9.84	132	10.9	3	27	0
Clay-pit No. 2							
4	2617	9.2	792	14	82	113	131
5	2627	9.21	811	13	104	124	154

Clay-pit No. 1: 1 - open water, 2 - *Phragmites australis*, 3 - *Myriophyllum spicatum*; Clay-pit No. 2: 4 - open water, 5 - *Ceratophyllum submersum*; EC – electrical conductivity, P_{TR} – total reactive phosporus, P_T – total phosphorus.

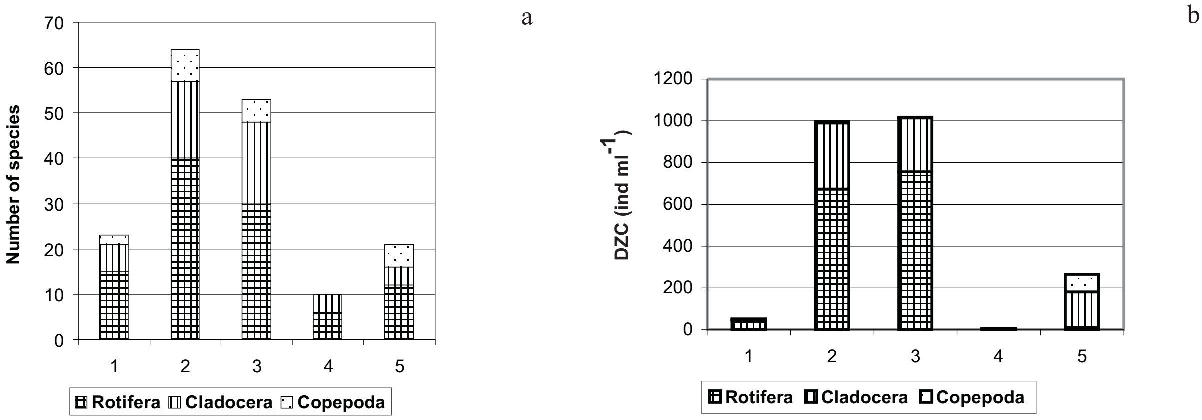

Fig. 1. The number of zooplankton species (a) and the densities of zooplankton community (DZC) (b). Clay-pit No. 1: 1 - open water, 2 - *Phragmites australis*, 3 - *Myriophyllum spicatum*; Clay-pit No. 2: 4 - open water, 5 - *Ceratophyllum submersum*.

Additionally, a certain diversification was noticed when analysing the species diversity index which in the first pond reached high values (in the range between 2.43 and 2.95 depending on the sampling station), and lower in the second one (from 1.27 to 2.08).

The quality analysis of phytoplankton revealed that in both clay-pits representatives of five taxonomical groups were present: *Cyanoprokaryota*, *Chlorophyta*, *Bacillariophyceae*, *Cryptophyceae* and *Dinophyceae*. In pond No. 1 in the rush zone the greatest number of taxa of prokariotic and eukariotic algae occurred (46). Green algae dominated (22 taxa), mainly from the order *Chlorococcales*. A considerable participation was also found for diatoms (13). The remaining groups were represented by several species. In the open water zone 27 taxa were observed, with green algae dominating (13). In pond No. 2, in the open water the poorest taxonomical structure (13) was found. Neither of the systematic algae groups had distinctive dominance. There were also no dinophlagellates recorded. In the stand of *Ceratophyllum demersum* 17 taxa were noticed, with diatoms prevailing (9). Similar to the open water a lack of dinophlagellates was found in that area (Fig. 2a).

The statistical analysis revealed significant differences in the phytoplankton densities between both examined ponds ($Z = 2.6538$; $p = 0.0079$). It was noted that the highest abundance of phytoplankton (971 ind ml^{-1}) was characteristic for the open water of the first clay-pit due to dominance of cryptomonads (*Chroomonas acuta* Utermőhl and *Cryptomonas ovata* Ehr). The participation of blue-greens, green algae and diatoms of this station was similar (119 ind ml^{-1}), while dinophlagellates reached the lowest number (17). Additionally, the blue-green *Planktothrix agardhii* (Gom.) Anagn. Et Kom. belonged to dominating species. In the rush zone of this pond the dominance of green algae *Mougeotia* sp., diatoms *Cymbella ventricosa* Kütz. and *Epithemia sorex* Kütz. as well as dinophlagellate *Ceratium hirundinella* (O. F. Müll.) Bergh was recorded. In clay-pit No. 2, both in the *Ceratophyllum* zone and in the open water, diatoms dominated (*Nitzschia palea* (Kütz.) W. Sm., *Cocconeis placentula* Ehr.). The lowest phytoplankton abundance was found in this water body among the hornwort stand (221 ind ml^{-1}) (Fig. 2b).

DISCUSSION

The comparison of two clay-pits situated within a very short distance, that were of the same origin and similar time of origination, showed a great differentiation in their physical-chemical, syntaxonomical as well as the phyto- and zooplankton communities structure. The method of exploitation was decisive for the morphometric features of both excavations (Podbielkowski and Tomaszewicz, 1996). In the first pond the sloping banks and very narrow littoral zone hindered plant rooting and this contributed to its syntaxonomical and floristic poverty. However, chemical parameters and transparency of water indicated mesotrophy in this reservoir and they contributed to a considerable, for such a small pond, differentiation of the plankton communities. The second clay-pit was of hypereutrophic character and the mat of *Enteromorpha intestinalis* floating on the water surface contributed to great overshading which, in connection with the chemism of water, resulted in impoverishment of plankton communities and of the floristic structure.

The plankton communities, both phyto- and zooplankton, were more diverse in the macrophyte zones of the examined clay-pits. It seems, therefore, probable that the mosaic of habitat, followed by increased heterogeneity, determined the taxonomical structure of the plankton communities. The role of aquatic vegetation in the water

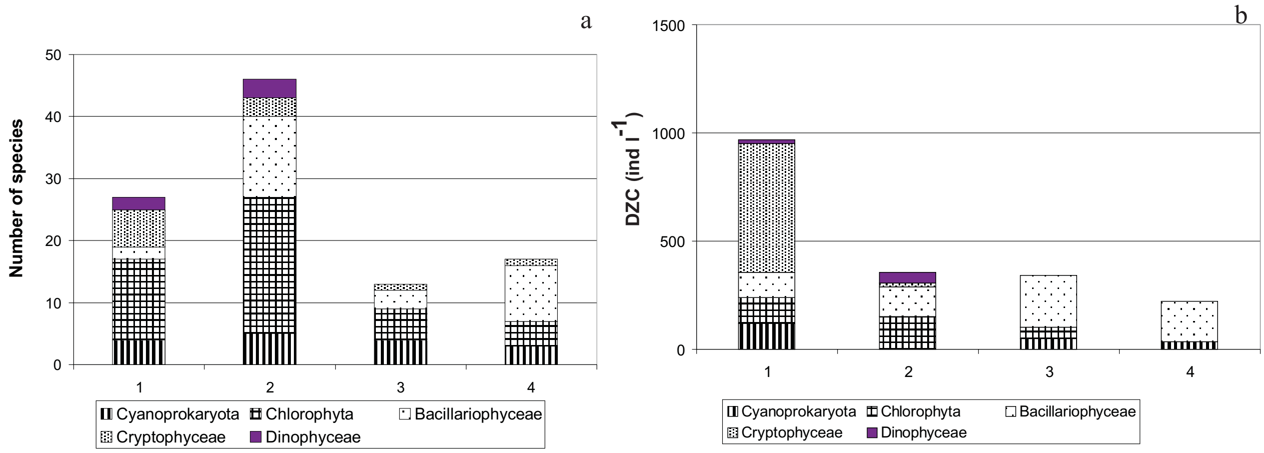

Fig. 2. The number of phytoplankton species (a) and the densities of phytoplankton community (DZC) (b). Clay-pit No. 1: 1 - open water, 2 - *Phragmites australis*; Clay-pit No. 2: 3 - open water, 4 - *Ceratophyllum submersum*.

reservoirs is not only dependent on the area covered by the littoral zone – its biomass, but also on its species composition which differs in quality, density and seasonality (Pieczyńska, 1988). The structural complexity of macrophyte communities is likely to provide a wide variety of potential refugia for zooplankton from predators (Timms and Moss, 1984; Paterson, 1993; Walsh, 1995). Moreover, the increasing complexity of macrophytes causes an increased diversity of water plant microhabitats (Duggan, 2001), which is reflected in the richer plankton communities among spatially and morphologically complicated macrophyte stands. Additionally, the highest diversity of plankton communities within the vegetated stands is probably connected with the fact that more physically and biologically complicated habitats create more available niches (Currie, 1991). The high taxonomical diversity of phytoplankton communities in pond No. 1 is also probably due to the numerous appearance of tychoplanktonic (pseudoplanktonic) species from periphytic assemblages, that must have become disattached from the macrophyte substratum through the process of water waving (Kawecka and Eloranta, 1994). Among these *eg* diatoms of genus *Cocconeis*, *Gomphonema*, *Cymbella* and *Fragilaria* occurred. The high densities of phytoplankton in the pelagic zone of this water body was connected with the high participation of cryptomonads. The large numbers of algae of this group indicated the changeable and unstable nature of conditions in shallow reservoirs.

Another important factor that influenced the plankton composition and dynamics in the examined ponds was the presence of fish which reduce the densities of large filter-feeding zooplankton (Dawidowicz and Gliwicz, 1987; Pijanowska and Prejs, 1996). In the first water body, where fish were present, a typical zooplankton structure with dominating rotifers was observed. Also, phytoplankton developed in great amount due to the lack of great filtrators. A different situation was found in pond No. 2, where there was a lack of fish. The quantity ratio of rotifers and crustaceans was opposite. It is a known phenomenon that in the absence of vertebrate predation in a water body larger crustaceans may win the competition over smaller rotifers and suppress rotifers through exploitative and interference competition (Gilbert, 1988; Wickham and Gilbert, 1990). The small numbers of phytoplankton in this pond among *Ceratophyllum demersum* may be due to large crustaceans (with dominating *Daphnia magna*) feeding on algae and/or suppression of the algae development by hornwort. Numerous studies show that this macrophyte species may restrict phytoplankton growth through releasing allelopathic substances (Wium-Andersen, 1987; Mjelde and Faafeng, 1997; van Donk and van de Bund, 2002; Gross *et al*., 2003).

CONCLUSIONS

1. The analysis of the distribution of plankton communities between two neighbouring water reservoirs of the same origin revealed that the differentiated morphometric features of both ponds and the related macrophyte cover as well as physical-chemical parameters of water, and the structure of particular microhabitats determined the variation in phytoplankton and zooplankton occurrence.

2. In the absence of fish in one of the examined ponds, the competition between organisms played an important role.

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