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BIOCENOTIC STRUCTURE IN THE RESTORED WATER ECOSYSTEM OF THE "PISKORY" RESERVE*

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A b s t r a c t. Studies of water ecosystems of the Piskory complex were carried out from 1996 to 1998. This investigations concerned a few limnological differentiated water ecosystems. The aim of these studies was to investigate chemical and physical properties of waters and biological structure of some ecological groups. The results of the researches show a different degree of eutrophication in each ecosystem, and high biodiversity.

K e y w o r d s: lake, restoration, water biocenosis

INTRODUCTION

The "Piskory" water complex consists of more or less anthropogenically transformed water ecosystems, such as: the Big Pioter River together with its spring zone, lake Piskory with outflow and inflow. Lake Piskory was created in mid 20th century. It covers about 128 ha. As a result of lack of maintenance works, like land reclamation, and the effect of depression cone around the Nitric Factory in Puławy, there occurred a total degradation of water surface in the 80s and 90s. In 1993, there was a change in the water supply system and reduction of outflow, partly restored natural, meandering length of the Big Pioter River. As a result of restoration works the water surface in the lake was totally reconstructed. In 1996-1998, in the restored complex there were carried out monitoring investigations which formed the basis for determining the speed and directions of ecological changes.

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The aim of the investigations was to determine the physical and chemical properties of waters, as well as heavy metal concentrations in water and bottom sediments. One of the main purposes was to investigate the qualitative and quantitative structure of water biocenosis occurring in each type of water ecosystems.

MATERIALS AND METHODS

Field investigations were carried out during the spring, summer and autumn in 1996-1998. They included the chemistry of the Piskory complex waters, based on temperature, pH, conductivity, dissolved oxygen, O_2, NO_3, NH_4, PO_4, etc., as well as concentration of heavy metals in water and bottom sediments [1,3] and the structure of water biocenosis in these ecosystems.

The samples were taken from five different sites: spring zone, inflow and outflow of the lake, Lake Piskory and the Big Pioter River (Fig. 1).

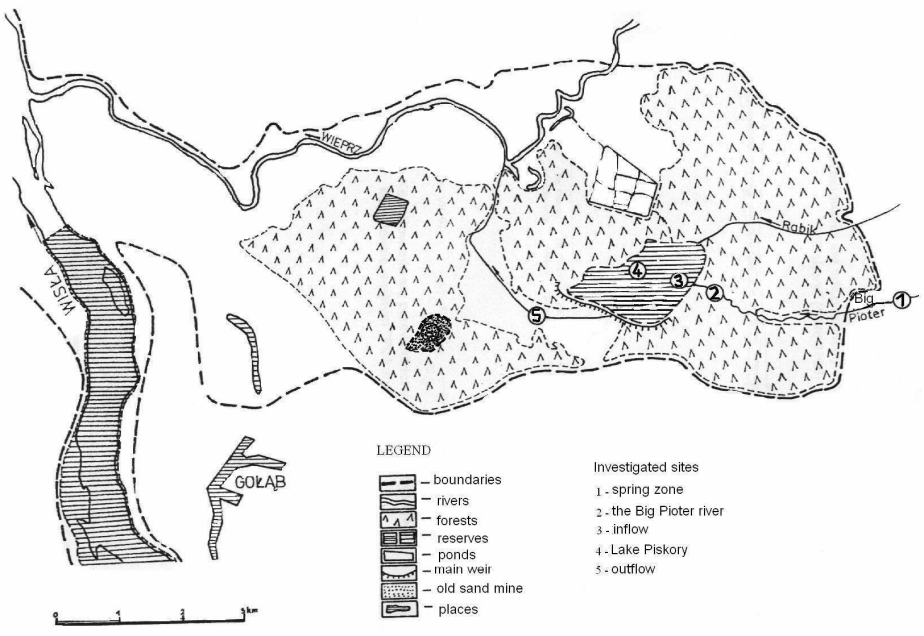

Fig. 1. Investigated sites in the Piskory water complex

Qualitative and quantitative researches of water biocenosis (phytoplankton and animals) were conducted in some habitats typical for each ecosystem. Phyto- and zooplankton samples were taken with the "Toń" sampler (volume of 10 l) from surface and bottom levels. Samples were filtered through 50 μm plankton net and preserved with formalin and glycerine solution.

Zoobenthos samples were taken by means of the Kajak tube sampler (sampling area of 19.6 cm^2). The collected sediments were sieved through a 250 μm mesh size. In the laboratory the organisms remaining in the net were selected and next preserved.

Then plankton and zoobenthos were counted using an inverted microscope as well as an electron microscope and identified as to species composition.

Fish composition of water complex "Piskory" was verified on the basis of oral information from forest administration of the Zagórki region and of the researchers' own observations.

RESULTS AND DISCUSSION

Physical and chemical properties of waters in water complex "Piskory"

The investigations have established that the waters of the water complex "Piskory" have got a diverse amount of dissolved organic matter. Moreover, they were characterised by high oxidation and conductivity changes. Content of the basic forms of nitrogen and phosphorus was diverse too. The ammonium and nitrogen concentration were relatively low, and the highest values occurred in Lake Piskory, whereas the lowest in the Big Pioter River. Concentration of phosphorus compounds periodically achieved high values, and the highest one occurred in the Big Pioter River and the lowest one in the spring zone (Tab. 1).

Table 1. Physical and chemical properties of water ecosystems of the Piskory water complex (1996-1998)

Site	Temperature	pH	Conductivity μS cm^{-2}	O_2 (mg dm^{-3})	O_2 (%)	Suspension (mg dm^{-3})	N-NO_3 (mgN dm^{-3})	N-NH_4 (mgN dm^{-3})	PO_4 mgP dm^{-3})	Ptot. (mgP dm^{-3})	Water hardness (mval dm^{-3})
Spring zone	13.6	6.95	944	6.8	68.5	10.1	0.366	0.326	0.049	0.165	4
Big Pioter river	13.07	7.5	592	9	87	3.3	1.326	0.293	0.13	0.099	3.8
Inflow	14.8	7.3	550	7.1	69	5.2	0.961	0.349	0.106	0.155	3.5
Lake Piskory	15.6	7.2	492	6	57	1.6	0.265	0.46	0.112	0.081	3
Outflow	11.8	7.3	523	8.8	83	2.4	0.222	0.354	0.099	0.11	3.8

The content of heavy metals in water is determined by a lot of factors, among them water reaction (pH), oxidation, concentration of humus substance. The water reaction plays a particularly important role in the shaping of heavy metals concentration level in water ecosystems. In general the ions of heavy metals are mobile in acid waters [4]. The waters of the water complex "Piskory" had acid or even slightly alkaline water reaction. Hence, heavy metals concentration in these waters was rather diverse, and typical for clean waters (Tab. 2).

Table 2. Heavy metals concentration in water and bottom sediments of the Piskory complex (1996-1998)

Site	Water					Bottom sediments					
	Mn (µg dm^{-3})	Zn (uµg dm^{-3})	Cu (uµg dm^{-3})	Pb (uµg dm^{-3})	Cd (uµg dm^{-3})	Fe (g kg^{-1})	Mn (mg kg^{-1})	Zn (mg kg^{-1}	Cu (mg kg^{-1})	Pb (mg kg^{-1})	Cd (mg kg^{-1})
Spring zone	148.3	54.7	7.35	1.48	0.36	21.4	185	24	13.3	1.72	0.34
Big Pioter river	210	40.1	3.8	3.8	0.15	9.36	50.8	38.1	5.2	4.5	0.66
Inflow	150	20.1	1.9	1.9	0.08	33.8	323	36.3	4.9	3.54	0.49
Lake Piskory	83.4	29.5	11.5	1.22	0.61	8.06	173	135	17	29.2	1.32
Outflow	350	16.3	4.6	1.72	0.2	0.48	56.2	7.3	1.1	2	0.22

Water biocenosis

Water biocenosis occurring in the water complex "Piskory" was characterised by high species diversity.

Phytoplankton was represented by 44 taxa which belonged to six groups. Among them there were blue-green algae, *Chlorophyceae* and diatoms dominated. The highest number of taxa – 25 occurred in the inflow waters and the lowest one in the spring zone, only 7 (Fig. 2). The highest abundance of phytoplankton was observed in Lake Piskory, and the lowest one in the spring zone (Tab. 3).

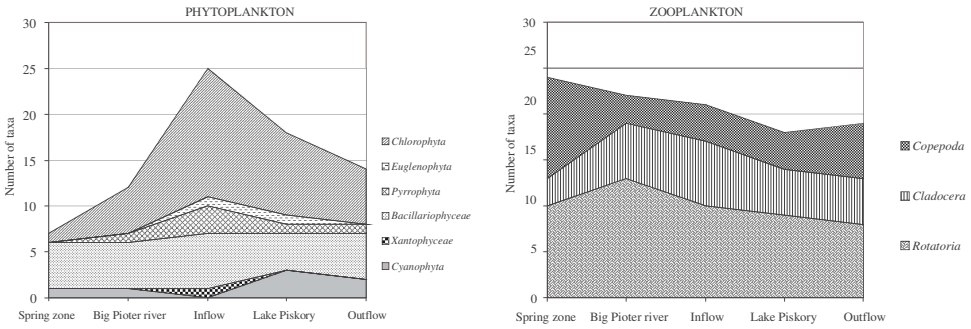

Fig. 2. Number of phytoplankton and zooplankton taxa in the Piskory water complex

Qualitative and quantitative structure of phytoplankton shows a distinct increase of nutrient-enrichment in the water complex "Piskory", as well as ecological degradation. It could be a result of an unstable trophic status of waters in this complex. The high number and diversity of blue-green algae might indicate such conditions [9].

Table 3. Qualitative and quantitative structure of phytoplankton in Piskory water complex (ind. dm^{-3})

Taxa	Spring zone	Big Pioter river	Inflow	Lake Piskory	Outflow
Cyanophyta					+
Anabaena sp.					
Aphanothece calcthrata	+	+		+	+
Aphanizomenon sp.				+	
Oscillatoria				+	
Xantophyceae					
Pseudostaurastrum limneticum			+		
Bacillariophyceae					
Asterionella formosa			+		
Cymbella lanceolata	+				
Cymatopleura solca				+	
Diatoma vulgare			+		
Diatoma ssp.		+			
Fragillaria sp.	+	+	+	+	+
Melosira sp.	+	+		+	+
Meridion circulare					+
Navicula sp.	+		+	+	+
Nitzschia sp.	+	+			
Synedra ulna		+	+		
Tabellaria flacculosa			+		+
Pyrrophyta					
Ceratium hirudionella			+		
Glenodirium dinobryonis			+		
Glenodirium sp.			+		
Peridinium cinctum		+			
Peridinium sp.				+	+
Euglenophyta					
Trachelomonas hispida				+	
Trachelomonasvolvocina			+		
Chlorophyta					
Closterium acutum	+		+		
Closterium acerosum			+		
Closterium moniliferum				+	
Coenoccocus planctonicus				+	
Cosmarium simplicius		+			
Cosmarium sp.		+	+	+	+
Cosmocladium sp.			+		
Crucigenia tetrapedia			+		
Dictyosphaerium pulchellum			+		
Desmidium sp.			+	+	
Pediastrum boryanum		+		+	+
Pseudosphaerocystis lacustris			+		
Scenedesmus dimorphus				+	
Scenedesmus magnus			+	+	+
Scenedesmus quadricauda		+	+	+	+
Spirogyra crassa			+		
Spirogyra setiformis			+		
Staurastrum allernos			+		
Staurastrum sp.		+	+	+	+
Ulotrix zonata					+
Abundance	94	3319	268	4038	1940

Animals were represented by 107 species which belonged to three ecological groups: zooplankton, zoobenthos, and fishes.

The presence of 49 zooplankton species was noted. The quantity dominance of Rotifera (21 species) over *Crustaceans* was recorded. *Crustaceans* included 13 species of *Cladocera* and 15 species of *Copepoda* (Fig. 2). Among *Rotatoria* occurred mainly eurybiontic species, typical for eutrophic water ecosystems. There were no rare or new species for Polish fauna. The highest number of species was observed in the Big Pioter River – 13 species; and the smallest one in outflow zone, only 8 species. The highest abundance of Rotifers was found in Lake Piskory, and the lowest in its outflow zone (Tab. 4). Such diversity could indicate different environmental conditions in the waters of the "Piskory" complex. *Keratella cochlearis*, *K. quadrata*, *Asplanchna priodonta* and *Polyarthra vulgaris* dominated in each of the investigated water ecosystems. Poor species composition and rather small abundance of Rotifers can indicate that the degree of trophy in the waters of the "Piskory" complex is still low. Planktonic Rotifers of Piskory complex were represented by several species typical for clean waters, such as: *Asplanchna priodonta*, *Kellicottia longispina*, *Brachionus angilaris* [5,7]. There were also some characteristic species of cold and good oxygen conditions, like *Notholca caudata*, *N. acuminata*.

The highest number of *Crustacean* species was found in the spring zone – 14 species. However, the lowest number was observed in the Big Pioter River and in Lake Piskory, respectively nine in each site (Fig. 2). The leading group among *Crustacean* was formed by *Cladocera* and two species were dominant - *Chydorus sphaericus* and *Bosmina longirostris*. Among copepods only one species was the most numerous – *Mesocyclops oithoides*. The mean abundance of *Cladocera* and *Copepoda* reached rather low values, which may show adverse habitat conditions. The crustacean zooplankton was represented by species typical for oligo- and eutrophic waters [10].

In zoobenthos 47 species were found. The highest number was constituted by *Chironomidae* – 13 species, and *Mollusca* – 15 species. The highest number of zoobenthos species occurred in the inflow zone – 22 species, and the smallest in the spring zone, only 17 species (Tab. 5). *Oligochaeta*, *Hirudinea*, *Mollusca* and some species of *Chironomidae* (*Chironmus plumosus*, *Procladius*) were regarded as dominant. Qualitative structure of dominant species, especially Oligochaeta, can indicate high trophy of the water complex "Piskory", and its partial swamping. There were some species typical for clean waters, such as *Gammarus pulex* and species from the *Simmulidae* family [2,6].

Fishes were represented by 11 species in the water complex "Piskory".

Table 4. Qualitative structure of zooplankton in the Piskory water complex

Taxa	Spring zone	Big Pioter river	Inflow	Lake Piskory	Outflow
Rotatoria					
Asplanchna priodonta	+	+		+	+
Brachionus quadridentatus				+	
Brachionus sp.				+	
Cephalodella gibba			+		+
Colurella adriatica		+			+
Filina longiseta	+	+	+		
Kellicottia longispina			+	+	
Keratella cochlearis	+	+	+	+	+
Keratella quadrata	+	+	+	+	+
Lecane closterocerca		+			+
Lecane lunaris	+	+	+		
Lepadella ovalis	+	+	+		
Mytylina mucronata			+		
Mytylina ventralis		+			
Notholca acuminata		+			+
Notholca caudata	+				
Notholca squamula	+	+		+	
Polyarthra vulgaris			+	+	+
Trichocerca rattus		+			
Trichotria pocillum	+	+	+		
Bdelloidea non det	+			+	
Abundance	18	40	13	72	16
Cladocera					
Acroperus harpae					+
Alona affinis		+	+		+
Alona quadrangularis		+	+		
Alona rectangula		+			
Bosmina longirostris		+	+		+
Ceriodaphnia quadrangula				+	
Chydorus sphaericus	+	+	+	+	+
Daphnia cuculata				+	
Daphnia longispina			+	+	
Diaphanosoma brachyurum			+		
Eucercus lamellatus	+				+
Scapholeberis mucronata				+	
Simocephalus vetulus	+	+	+		
Abundance	9	3	3	3	2
Copepoda					
Acanthocyclops longuidoides	+				+
Acanthocyclops viridis	+				
Attheyella crassa					+
Bryocamptus (Rh) veberi	+				
Campthocamptus staphyl.	+				
Cyclops strenuus			+		
Eucyclops macruroides	+				
Eucyclops phaleratus	+				
Eucyclops serrulatus	+	+	+	+	
Eudiaptomus graciloides					+
Macrocyclops albidus	+				
Mesocyclops oithonoides				+	+
Paracyclops affinis	+				
Kopepodity	+	+	+	+	+
Naupli	+	+	+	+	+
Abundance	24	4	3	3	2

Table 5. Qualitative and quantitative structure of zoobenthos in Piskory water complex

Taxa	Spring zone	Big Pioter river	Inflow	Lake Piskory	Outflow
Oligochaeta	+	+	+		+
Hirudinae	+		+	+	+
Crustacea	+	+	+	+	+
Insecta					
Coleoptera	+			+	+
Megaloptera	+	+	+		+
Ephemeroptera		+	+	+	+
Heteroptera	+		+		
Trichoptera		+		+	
Diptera				+	
Chironomidae					
Ablabesmyja monilis		+	+		+
Chironomus plumosus		+	+	+	
Clinotanypus nervosus		+			+
Cryptochironomus defectus		+	+	+	
Microtendipes chloris		+	+		+
Micropsectra praecox	+	+	+		+
Odontomya sp.	+				
Paratendipes albimanus		+			+
Pentapedilum exectum				+	
Procladius sp.	+		+	+	+
Serromya sp.			+		
Tanytarsus lauterborni		+			
Tanytarsus lobatifrous		+			+
Simulidae		+			
Ceratopogonidae	+	+	+	+	
Mollusca					
Anisus sp.			+		
Bythynia tentaculata		+	+	+	+
Gyraulus albus				+	
Gyraulus sp.			+	+	+
Lymnea stagnalis	+				
Lymnea (Galba) sp.	+				
Lymnea (Radix) sp.			+	+	+
Musculium lacustre	+			+	
Pisidium casertanum			+		+
Pisidium milium		+		+	
Planorbarius corneus	+	+	+	+	+
Planorbis planorbis	+				
Planorbis sp.	+		+	+	
Segmentia nitida	+				
Viviparus viviparus			+		
Abundance	3395	1661	5242	2461	3545
Total taxa	17	19	22	19	18

CONCLUSIONS

1. The high diversity of species composition occurring in the water ecosystems of the “Piskory” complex still showed a high degree of naturalness.

2. Stabilization of the water level influenced the increase of qualitative and quantitative species differentiation in the water ecosystems of the Piskory complex.

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KSZTAŁTOWANIE SIĘ STRUKTURY BIOCENOTYCZNEJ W PODDANYCH RENATURALIZACJI EKOSYSTEMACH WODNYCH W REZERWACIE „PISKORY”

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Streszczenie. Do kompleksu wodnego „Piskory” należą mniej lub bardziej antropogenicznie przekształcone ekosystemy wodne, takie jak: rzeka Duży Pioter wraz ze strefą źródliskową, staw Piskory wraz z dopływami i odpływami. Staw Piskory utworzony w połowie XIX w. Zajmuje powierzchnię ok. 128 ha. W latach 1996-1998 przeprowadzono w zrenaturyzowanym kompleksie wodnym monitoringowe badania, które dały podstawę do określenia tempa i kierunków zmian ekologicznych. Duże zróżnicowanie gatunkowe

zespołów zasiedlających wody jeziora Piskory wskazuje na wysoki jeszcze poziom naturalności tego specyficznego ekosystemu. Stabilizacja poziomu wód w kompleksie wodnym Piskory wpłynęła na wzrost zróżnicowania struktury siedliskowej oraz struktury jakościowej i ilościowej zasiedlających go fito- i zoocenoz.

S ł o w a k l u c z o w e: jezioro, renaturalizacja, ekosystemy wodne