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ELŻBIETA GRABACKA

Wpływ ścieków cukrowniczych na mikrofaunę dna w stawach rybnych*

The influence of beet sugar factory wastes on the bottom microfauna in fish ponds

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Abstract — A further stage of investigations on the possibility of utilizing beet sugar factory wastes in carp ponds, and their consequent influence, was carried out. In the microfauna of the bottom *Protozoa* quantitative and qualitative relations of the group *Ciliata* were investigated. In conditions when high concentration wastes were brought in the changes taking place in the pond during self-purification influenced distinctly the development of the bottom *Protozoa*. A succession of ecologically different communities of *Ciliata* and characteristic changes in their number were also observed. No effect consequent on several years' enrichment of the pond with beet sugar factory wastes was found in the microfauna.

The influence of beet sugar factory wastes on carp ponds has been the subject of several years' investigations carried out in the Laboratory of Water Biology of the Polish Academy of Sciences in Cracow on the territory of the Experimental Farm at Gołysz (province of Bielsko). This question, essential for the water economy of the country, poses a permanent problem on account of the very high load of organic matter in these wastes.

The present work is the second part of complex hydrobiological investigations on the possibilities of utilizing the beet sugar factory wastes in fish ponds and on their influence on the pond biocenosis, especially on the consequences of several years' fertilization of large rearing ponds.

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This stage of the work was carried out in the years 1971—1974. The investigations included a complex of hydrobiological works on a number of pond biocenosis links (Krzeczkowska-Wołoszyn 1977, Kyselowa 1977, M. Lewkowicz, S. Lewkowicz 1977, Starzecka, Ronchetti 1977, Srokosz 1977, Zięba 1977, Zygmuntowa 1977). The previous stage of this investigation cycle was carried out in the years 1967—1968.

The aim of the present work was to investigate the succession of the *Protozoa* in bottom sediments of ponds during self-purification of the water in an accumulation pond, the influence of beet sugar factory wastes periodically discharged into the assimilation carp pond, and to analyse the consequent effect of such wastes on the protozoan community in the pond mud.

Mainly studied were the group *Ciliata*, among which a several species are used to evaluate the degree of water pollution.

Liebmann's (1962) and Kahl's (1935) kyes have been used for protozoans diagnosis. As concerns the influence of the sugar factory wastes on the water pollution there are only a few short reports in Polish literature (Cabejszek J. et al. 1961, Dojlido J. et al. 1964, Kulmatycki 1931).

Method

Three carp ponds located in the territory of the Mnich complex belonging to the Experimental Farm at Gołysz were investigated. These were the ponds Zimowy Wielki, Łąkowy, and Gorol. The way in which they were utilized during the investigation period is given in Table I. The wastes brought into the pond came from the neighbouring beet sugar factory at Chybie. For four years the accumulation pond Zimowy Wielki was the main experimental pond. Enriched with undiluted beet sugar factory wastes, it was in 1971 and 1972 the subject of investigations on water self-purification. Subsequently, receiving no wastes for the two following years, it was investigated with regard to the consequent influence of wastes on fish ponds. Additional experiments were carried out in the pond Łąkowy into which diluted wastes were discharged in 1971, while the control pond Gorol underwent neither enrichment with wastes nor mineral fertilization for three consecutive years, i.e. from 1971 to 1973.

Samples for biological analyses were collected as a rule every 2 to 3 weeks, and every few days during periods preceding more important changes in the pond. These mainly concerned the final periods of self-

Tabela I. Szczegółowe dane dotyczące badanych stawów

Table I. Detailed data concerning the investigated ponds

Staw Pond	Powierzchnia Area w ha in ha	Rok badań Year of investigation	Okres doprowadzenia ścieków Period of discharge of wastes	Rozcieńczenie ścieków Dilution of wastes	Początkowe BZT_5 ścieków Initial BOD_5 of wastes
Zimowy Wielki akumulacyjny accumulation	8.0	1971	Zasilany ściekami prosto z cukrowni w okresie od XI-XII 1970 Enriched with wastes directly from sugar factory in the period from XI-XII 1970	bez rozcieńczenia without dilution	od 1500-2000 mg O_2/l from 1500-2000 mg O_2/l
		1972	Zasilany ściekami prosto z cukrowni w okresie listopada 1971 Enriched with wastes directly from sugar factory in November 1971	bez rozcieńczenia without dilution	
		1973	Bez wprowadzania ścieków Without wastes brought in	———	
		1974	Bez wprowadzania ścieków Without wastes brought in		
Łąkowy asymilacyjny assimilation	8.1	1971	Zasilany ściekami cukrowniczymi z Zimowego Wielkiego przez okres 2-3 tygodni w maju 1971 Enriched with sugar factory wastes from Zimowy Wielki during 2-3 week period in May 1971	wpuszczone ścieki uległy w stawie rozcieńczeniu w stosunku 1:5 wastes brought in were diluted in the pond in the ratio 1:5	
Gorol kontrolny control	4.0	1971 1973	Bez ścieków Without wastes	———	

-purification of the water in the pond, hence, before the appearance in it of oxygen. The microbenthos was collected by means of a metal tube sampler. From the contents of the sampler only a thin upper layer of mud (about 5 mm) in direct contact with the bottom water was extracted. Samples were always taken at three stations in the pond, i.e. at a point close to the platform at the water outflow, at a point situated roughly in the middle of the pond, and in the very littoral part in the region of the inflow. In the four year investigation period 312 samples were collected. The material was examined only in vivo, quantitative and qualitative analysis of *Protozoa* living in the bottom mud being carried out. On the basis of the quantitative data obtained from preparations of known volume, the numbers of *Protozoa* in 1 ml of surface layer mud were calculated.

Changes in the protozoan microfauna in the mud enriched with beet sugar factory wastes

Beet sugar factory wastes, loaded with great amounts of organic matter when introduced into fish ponds cause self-purification of the water. The physico-chemical conditions prevailing at the bottom of the pond undergo considerable changes, since it is here that the mineralization of organic components accumulated by way of fermentation and decay begins. The influence of these processes on the *Protozoa* is quite distinct. Such compounds as carbon dioxide, methane, and sulphuretted hydrogen released during the decomposition of organic matter cause a considerable deterioration of the living conditions of the aquatic fauna. The influence of these components on *Ciliata* is manifested in a reduction of the number of species and specimens; on the other hand, species better adapted to minimal amounts of oxygen or a lack of it in the environment develop more strongly.

Wastes were discharged into two ponds: Zimowy Wielki, used as an accumulation pond in 1971 and 1972, and Łąkowy which in 1971 worked as an assimilation pond taking over for a short time the wastes from Zimowy Wielki. A detailed analysis of the chemical changes taking place during water self-purification was carried out by M. Lewkowicz, S. Lewkowicz (1977).

In the three investigated cases the changes in character were very similar, i.e. there were two stages: the initial anaerobic period and the period of intensive oxidation immediately following it. As was shown by M. Lewkowicz, S. Lewkowicz (1977) in Zimowy Wielki the self-purification process and consequently the length of the anaerobic stage were similar in the two consecutive years 1971 and 1972, in spite of differences in the load of organic matter expressed in terms of BOD_5 and COD. In the two discussed cases dissolved oxygen appeared in the water only in the second half of May. In the late spring period a decrease in the load of organic matter was also noted (M. Lewkowicz, S. Lewkowicz 1977).

Biological changes in the protozoan fauna in the mud during the self-purification process in the three ponds in question were very similar to those observed in the ponds in the first phase of this type of investigation in the years 1967 to 1968. The difference between the experiments consisted in the fact that the wastes discharged into the ponds, especially into the Zimowy Wielki in December 1970, were, according to M. Lewkowicz, S. Lewkowicz (1977), much less concentrated than in the previous years and underwent mineralization sooner.

The mud was inhabited by *Protozoa* and small *Eumetozoa*. Among the former *Ciliata* dominated both in number and species differentiation. For all the ponds a total of 163 taxons of *Ciliata* was determined. A list of them with notes concerning their presence in particular ponds is presented in Table II. As concerns the pond Zimowy Wielki in the two consecutive years (1971 and 1972), the species numbers of *Ciliata* were similar. Markedly fewer species of *Ciliata* were found in the pond Łąkowy. Thus, more species could be found when wastes of higher concentration were discharged into the pond. With a considerable dilution of wastes, as was the case in the pond Łąkowy in 1971, the number of reported species was lower by about 20 per cent. Such a type of regularity had been observed in the previous work (Grabacka 1973). A numerous appearance of species of the family *Metopidae*, mainly of the genus *Metopus* (Table II), was decisive in the increased total of species. These *Ciliata* were connected with the anaerobic period. In this period, at increased pollution of the pond, the number of species always decreased, at that time almost exclusively sapropelic ones living there.

In the second period simultaneously with the appearance of oxygen in the water, the number of species (Table II) increased. Changes in the species composition were accompanied by changes in the number of *Protozoa* (fig. 1). As is shown in this figure, changes in the number of *Protozoa* in Zimowy Wielki were similar in the two successive years when the pond was filled with wastes. (The number of *Protozoa* given in figures are always the mean values calculated for the pond from the number of *Protozoa* at three investigated stations).

In Zimowy Wielki the initial period was always characterized by both a qualitative and quantitative reduction of the microfauna (fig. 1), this being caused by a lack of oxygen. During this period quantitative variations among the *Protozoa* were small. A low water temperature in the winter and early spring period must have been another inhibiting factor.

Tabela II. Spis znalezionych gatunków orzęsków w badanych stawach

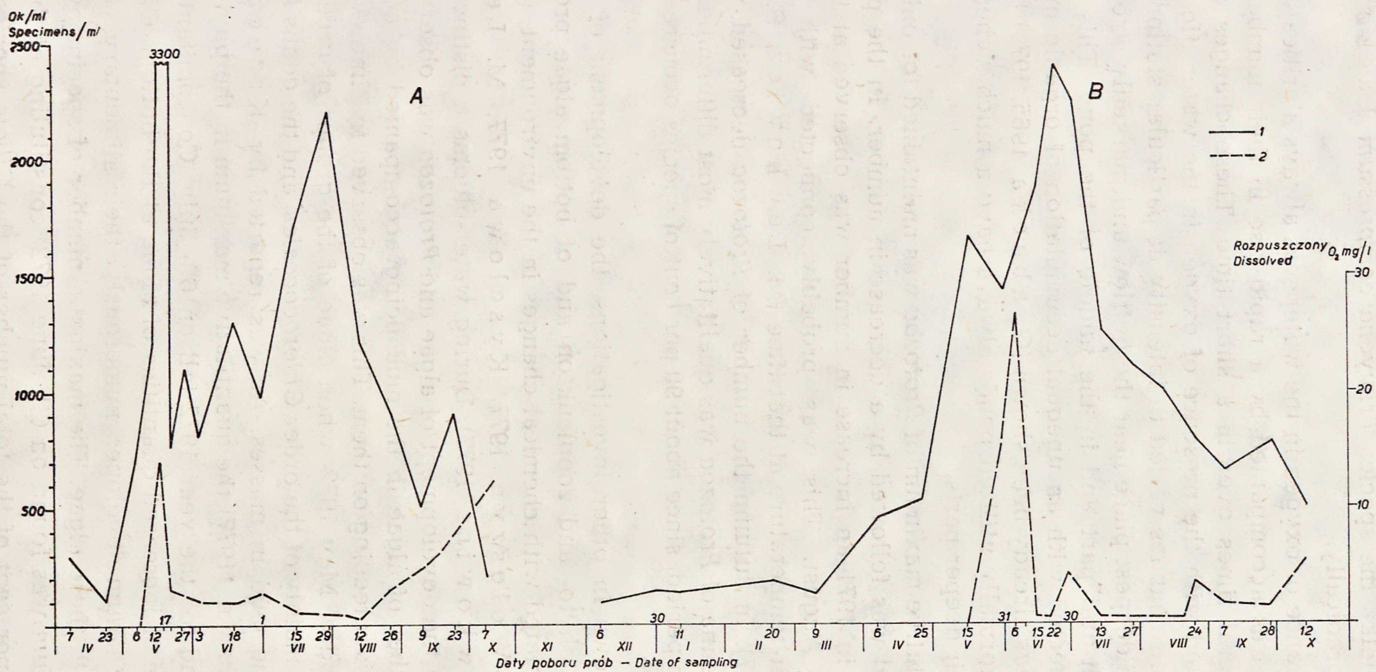
Table II. List of species of Ciliata found in the investigated ponds

Gatunek - Species	Staw - Pond							
	Zimowy Wielki				Gorol			Łąkowy
	1971	1972	1973	1974	1971	1972	1973	1971
Askenasia volvox Clap. et L.					+		+	
Aspidisca costata Dujardin	+	+	+	+	+	+	+	+
- herbicola Kahl			+	+	+			+
- lynceus Ehrb.	+	+	+	+	+		+	+
- sulcata Kahl								+
- turrita Ehrb.		+	+		+			+
- sp.	+		+		+			
Atopodinium sp.	+	+	+	+			+	+
Caenomorpha lauterborni Kahl		+						
- medusula Perty	+	+						
- sapropelica Kahl								+
- universalis Levander		+			+			
- sp.	+	+						
Chilodonella cucullulus P.F. Müller		+	+	+			+	
- dentata Fouque							+	
- uncinata Ehrb.	+	+	+	+	+	+	+	+
- sp.	+	+	+		+		+	+
Cinetochilum margaritaceum Perty	+	+	+	+	+	+	+	+
Codonella cratera Leidy		+					+	
Coleps amphacanthus Ehrb.	+		+	+	+	+	+	
- hirtus Nitzsch	+	+	+	+	+	+	+	+
- - var. minor Kahl							+	
Colpoda cucullus O.F. Müller								+
- steini Maupas			+					
- sp.			+					
Colpidium sp.								+
Cristigera setosa Kahl		+						
- sp.			+					
Ctedostema sp.				+				
Cyclidium citrullus Cohn	+			+	+	+	+	+
- heptatrichum Schwewiakoff		+						
- oblongum Kahl	+		+					
- sp.	+		+	+	+			+
Didinium alveolatum Kahl	+							
- balbianii Fabre-Dom.	+	+						
- nasutum O.F. Müller		+						
- sp.	+	+	+	+	+		+	
Dileptus cygnus Clap. et L.				+				
- monilatus Stokes							+	
- sp.					+		+	
Enchelys vermicularis Smith		+						
- sp.		+						
Epalxis mirabilis Roux		+						
- striata Kahl		+	+					
- sp.	+	+		+	+			+
Euplotes eurystomus Wrześniowski					+			
- patella Müller fo. alatus Kahl	+	+	+					
- - fo. latus Kahl			+		+			
- - fo. typicus Kahl		+	+	+	+			
- sp.					+			
Frontonia acuminata Ehrb.	+		+	+	+			+
- leucas Ehrb.			+	+	+		+	+
- sp.							+	

Gatunek - Species	Staw - Pond: Zimowy Wielki 1971	1972	1973	1974	Gorol 1971	1972	1973	Łąkowy 1971
Glaucoma sp.							+	
Halteria grandinella O.F. Müller	+	+	+	+	+	+	+	+
Hemiophrys pleurosigma Stokes		+						
- sp.	+	+	+					
Holophrya simplex Schewiakoff			+	+				
- sp.	+		+	+	+			
Holosticha sp.		+						
Lacrymaria cucumis Penard		+	+					
- olor O.F. Müller		+	+		+		+	
- sp.			+					
Lembadion bullinum Perty					+			
- lucens Maskell					+		+	+
- magnum Stokes					+		+	
Lionotus anguilla Kahl			+					
- cygnus O.F. Müller			+	+			+	
- fasciola Ehrb.- Wrześniowski							+	
- lamella (Ehrb.) Schewiakoff	+		+	+	+			
- sp.	+	+	+	+	+	+	+	+
Loxocephallus sp.	+	+	+	+	+		+	+
Loxodes striatus Engelmann	+		+	+	+	+	+	+
- ristrum O.F. Müller				+	+			+
- vorax Stokes					+			
- sp.					+			
Loxophyllum helus Stokes			+	+			+	+
- rostratum Cohn				+				
- uninucleatum Kahl							+	
- sp.							+	+
Mesodinium acarus Stein	+		+	+			+	+
- cinctum Calkins			+	+			+	+
- pulex Clap. et L.				+				+
- sp.	+			+		+	+	
Metopus acuminatus Stokes		+						
- campanula Kahl		+						
- es O.F. Müller	+	+			+		+	
- fuscus Kahl	+							+
- micrans Jankowski	+	+	+					
- minimus Kahl	+	+						
- nasutus Da Cunha		+						
- ovalis Kahl		+						
- pulcher Kahl	+		+					
- spinosus Kahl		+	+				+	
- spiralis Smith	+	+						
- striatus Mc Murrich		+		+				
- tenuis Kahl		+						
- undulans Stokes	+	+	+				+	
- sp.	+	+	+	+	+		+	+
Mylestoma sp.					+		+	
Nassula aurea Ehrb.		+	+					
- sp.		+	+		+			+
Oxytricha div. sp.	+	+	+	+	+	+		+
Paramecium bursaria (Ehrb.) Focke			+					+
- caudatum Ehrb.	+	+	+	+	+		+	+
Paruroleptus lacteus Kahl	+							
- magnificus Kahl		+						
- musculus Kahl	+	+	+	+				
- sp.	+	+	+	+			+	+

cont. tab. II

Gatunek - Species	Staw - Pond							
	Zimowy Wielki				Gorol			Łąkowy
	1971	1972	1973	1974	1971	1972	1973	1974
Phascolodon vorticella Stein			+					
Plagiopyla nasuta Stein		+						
- ovata Kahl		+	+	+			+	
- sp.								+
Platynema sociale Penard		+		+				
- solivagum Kahl			+	+	+			+
- sp.				+				+
Pleuronema coronatum Kent				+	+			+
- crassum Dujardin								+
- marinum Dujardin								+
Prorodon ovum Ehrb. - Kahl		+	+	+				+
- platyodon Blochmann						+		
- teres Ehrb.	+			+	+	+		+
- div. sp.	+	+	+	+	+		+	+
Rhagadostoma sp.			+			+	+	
Saprodinium sp.	+				+			+
Saprophilus sp.		+						
Spathidium chlorelligerum Kahl		+						
- faurei Kahl		+						
- papilliferum Kahl			+					
- sulcatum Kahl		+						
- viride Kahl		+						
- sp.		+	+	+			+	+
Spirostomum ambiguum Müller - Ehrb.				+				
- filum (Ehrb.) Penard			+	+	+	+		
- intermedium Kahl			+					
- minus Roux			+	+	+		+	
- teres Clap. et L.			+	+			+	
- Stentor coeruleus Ehrb.	+	+	+	+	+	+		+
- multiformis (O.F. Müller) Stein	+							
- polymorphus Ehrb. - Stein			+	+	+	+		
- roeseli Ehrb.	+	+	+	+		+		
Stichotricha aculeata Wrześniowski			+				+	+
- - fo. sapropelica Kahl		+						
- secunda Perty		+			+			
Strobilidium gyrans Stokes				+	+		+	
Stylonychia mytilis Ehrb.				+	+		+	
- sp.					+			
Trachelocerca phoenicopterus Cohn							+	
- sp.							+	
Trachelophyllum div. sp.	+	+	+	+	+		+	
Trimyena compressum Lackey		+						
Urocentrum turbo O.F. Müller			+		+	+		+
Uroleptus dispar Stokes		+		+				+
- limnetis Stokes	+	+			+		+	
- longicaudatus Stokes		+			+		+	
- rattulus Stein	+	+	+	+	+	+		
- sp.	+		+	+	+	+	+	+
Urosoma sp.	+							
Urostyla grandis Ehrb.					+			+
- div. sp.	+	+	+	+	+		+	+
Vorticella similis Stokes			+	+				
- sp.	+	+	+	+	+	+	+	+
Ciliata n. det.							+	



Ryc. 1. Liczebność pierwotniaków w 1 ml mułu osadu dennego stawu ściekowego Zimowy Wielki w roku 1971 (A) i 1972 (B). 1 — ilość pierwotniaków, 2 — tlen rozpuszczony

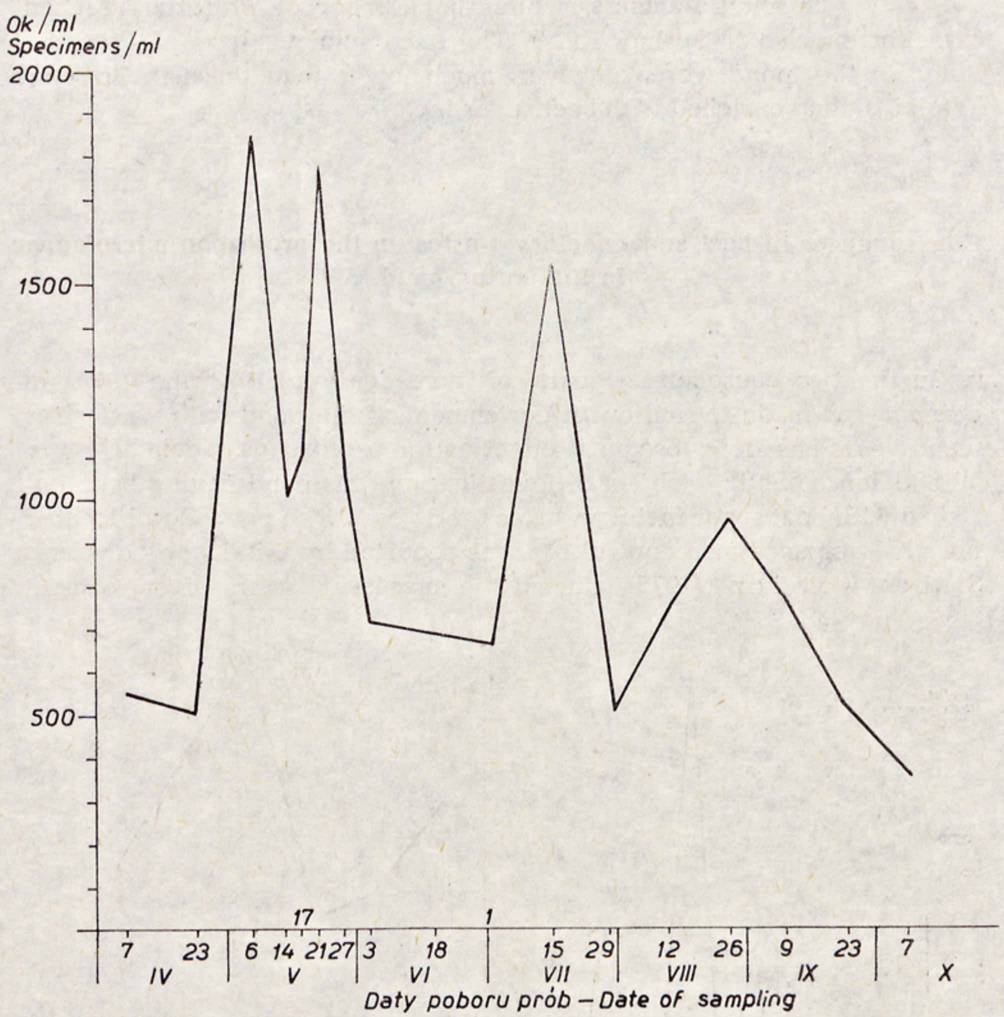
Fig. 1. Number of *Protozoa* in 1 ml of bottom mud of the pond with wastes, Zimowy Wielki, in 1971 (A) and 1972 (B). 1 — number of *Protozoa*, 2 — dissolved oxygen

Conversely to the first series of investigations from the years 1967—1968, of no polysaprobic period in the microfauna of the bottom was observed in Zimowy Wielki, the species *Trimyena compressum* Lackey being found only sporadically.

The appearance of oxygen in the water was always a critical moment for *Ciliata*. It was accompanied by a rapid rise in their number which increased several times over in a short time. These changes are certainly correlated with the presence of oxygen in the water (fig. 1). The above-described changes varied in intensity at particular stations, being weakest at the deepest place near the outflow and markedly strongest in the shallow littoral part and in the middle of the pond. This is most probably connected with an unequal accumulation of organic matter in the pond. As has already been shown (Grabacka 1965, 1971) the shallow parts in normally utilized ponds always have a much richer microfauna than their deeper parts.

The quantitative maximum of *Protozoa* was maintained for only about one month and was followed by a decrease in number. In the pond Zimowy Wielki in 1971 an increase in number was observed at the turn of July and August. This was probably connected with an increase in water temperature at that time (M. Lewkowicz, S. Lewkowicz 1977). In autumn the number of *Protozoa* decreased. To sum up, the microfauna of *Protozoa* was qualitatively most differentiated during the oxygen period, since about 90 per cent of species occurred at that time.

As was shown in other investigations, the development of various groups of the phyto- and zooplankton and of bottom algae proceeded in stages correlated with chemical changes in the environment (Krzeczkowska-Wołoszyn 1977, Kyselowa 1977, M. Lewkowicz, S. Lewkowicz 1977). During water-blooms a distinct correlation between the development of algae and *Protozoa* was observed, the increased number of algae in the mud being accompanied by a distinct increase in *Ciliata* feeding on them. This was observed in Zimowy Wielki towards the end of May 1972, when algae of the groups of green algae and *Flagellata*, mainly of the order *Chlorococcales*, and the genus *Euglena* appeared in the mud in masses. As was reported by Krzeczkowska-Wołoszyn (1977) the quantitative maximum in the phytoplankton of this pond for the year 1972 fell on 6th July. Concomitantly with the appearance of increased quantities of algae at the bottom, *Ciliata* of the genus *Spathidium* developed numerously, their alimentary vacuolae being filled with these algae. The maximum number of specimens of the genus *Spathidium* was found on 6th June 1972, constituting at that time from 15 to 20 per cent of the total number of the *Ciliata* species at the bottom. Apart from them, increased numbers of *Ciliata* belonging to the



Ryc. 2. Liczebność pierwotniaków w 1 ml osadu dennego stawu ściekowego Łąkowy w 1971 roku

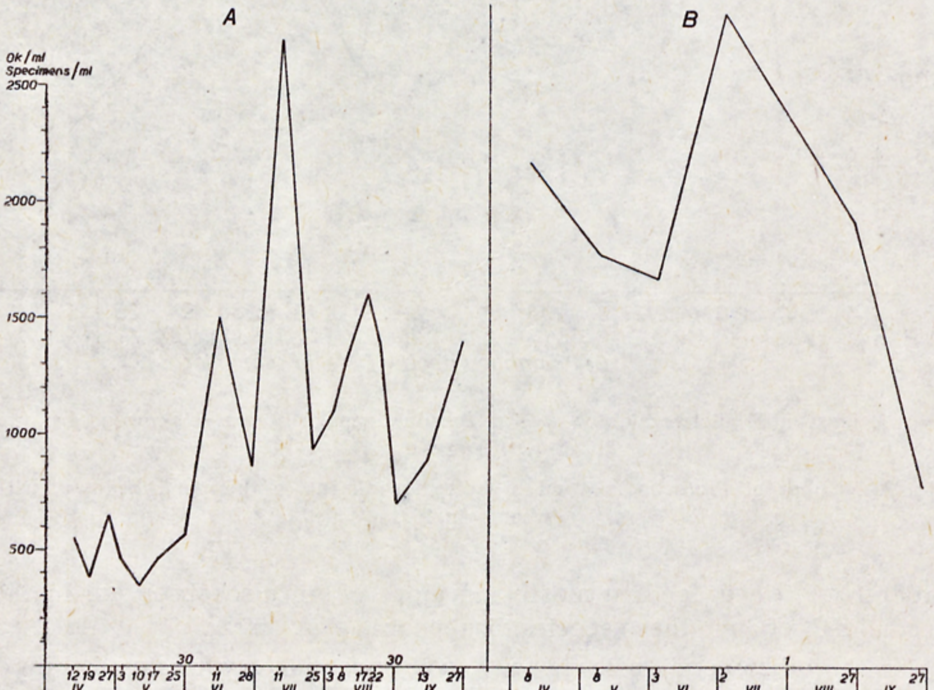
Fig. 2. Number of *Protozoa* in 1 ml of bottom sediment in the pond Łąkowy, with wastes, in 1971

order *Hypotricha*, feeding mostly on algae, were also observed. In the second half of June these species disappeared.

In the other pond enriched with beet sugar factory wastes, Łąkowy, the character of quantitative changes and the succession of *Ciliata* was slightly different. The pond Łąkowy was in fact quite similar to a normally utilized and intensively fertilized carp pond. Changes in the protozoan number in this pond are presented in fig. 2. No distinct stages in the succession of *Ciliata* were observed there. Saprobionts appeared sporadically and in small numbers, while the number of *Protozoa* reached a maximum also in spring (May). The maximum numbers of *Protozoa* found in that pond were, however, much lower than those in Zimowy Wielki, a pond enriched with beet sugar factory wastes.

Consequences of beet sugar factory wastes on the protozoan microfauna in the bottom mud

In the two consecutive years of investigation, 1973 and 1974, an attempt was made to find out if enrichment of the pond with wastes for many years has any subsequent effect on the protozoans. Again, Zimowy Wielki served as the subject of investigation, this pond having been enriched with beet sugar factory wastes for 5 years. The pond Gorol located near by was used as a control. As was reported by M. Lewkowicz, S. Lewkowicz (1975), during the successive years of enrichment



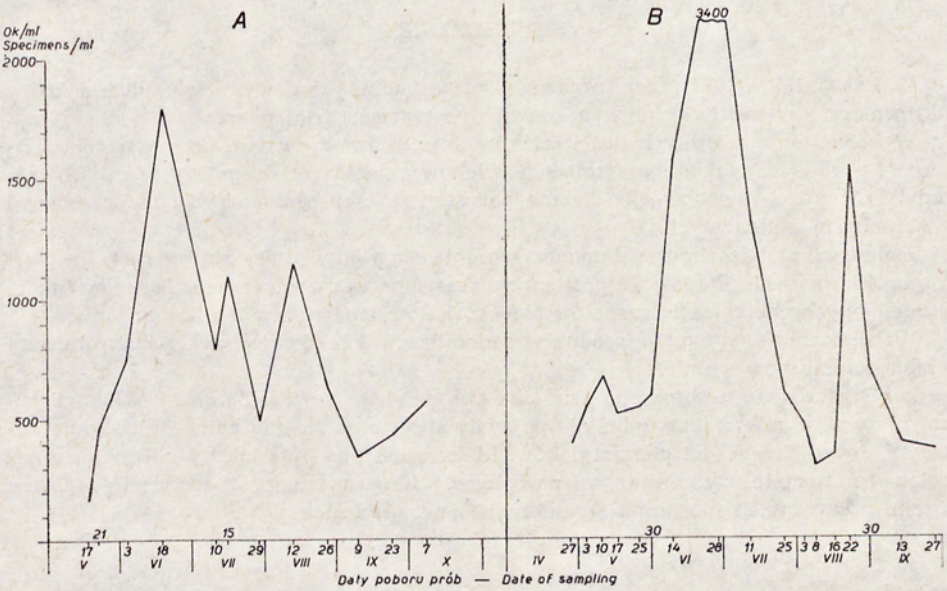
Ryc. 3. Liczebność pierwotniaków w 1 ml osadu dennego stawu pościekowego Zimowy Wielki w roku 1973 (A) i 1974 (B)

Fig. 3. Number of *Protozoa* in 1 ml of bottom sediment of the post-waste pond Zimowy Wielki in 1973 (A) and 1974 (B)

a permanent deterioration of environmental conditions was observed in Zimowy Wielki. With a vigorous development of the zooplankton there occurred a decrease in oxygen and the role of primary producers was taken over by vascular vegetation instead of the phytoplankton.

An analysis of the species composition and the number of protozoans in Zimowy Wielki in the years 1973 and 1974 permits the statement that many years' enrichment of this pond with beet sugar factory wastes had very few or no consequences. As concerns the species composition itself the differences were insignificant. The general tendency here also was an increase in the number of *Protozoa* during the investigation period, especially in summer. These changes were, however, not so rapid as in the periods of enrichment of the pond with beet sugar factory wastes and the quantitative maximum was much lower. The microfauna occurring there was similar in composition to that of a normally utilized fish pond. Saprobionts were only an additional element appearing in spring and during the summer in small numbers. No polysaprobic species occurred. In the development of the macrofauna no stages were observed, since during the whole time of observations no shortage of oxygen occurred.

Increased numbers of *Protozoa* were observed in the pond Zimowy Wielki at the beginning of spring 1974 (fig. 3). These facts cannot, however, be associated with the subsequent influence of wastes on the micro-



Ryc. 4. Liczebność pierwotniaków w 1 ml osadu dennego stawu kontrolnego Gorol w roku 1971 (A) i 1973 (B)

Fig. 4. Number of *Protozoa* in 1 ml of bottom sediment of the control pond Gorol in 1971 (A) and 1973 (B)

fauna since, as M. Lewkowicz, S. Lewkowicz report (1975), no accumulation of organic matter was found in the bottom sediments of these ponds. The cited authors also showed no influence of wastes on the content of mineral and organic forms of nitrogen and phosphorus or on the primary production.

The above-given increase in the number of *Protozoa* in the mud in the spring period could be connected with increased water temperature and larger amounts of bacteria.

The control pond Gorol was investigated only during two years, i.e. 1971 and 1973. Changes in the number of *Protozoa* in this pond are presented in fig. 4. Gorol was not the best choice for a control pond since it was a fertile one. As reported by M. Lewkowicz, S. Lewkowicz (1975), the content of organic matter in the soil of the pond was much higher than in Zimowy Wielki. The occurrence of large amounts of *Rhizopoda* in the bottom microfauna was characteristic of Gorol. These protozoans were found here in numbers much greater than in any other pond throughout the whole investigation period, especially in 1973. The share of *Rhizopoda* in particular samples reached 20 to 30 per cent. There occurred both testaceous *Rhizopoda* (*Testacea*) and *Amoebina*. These *Protozoa occurred most* frequently in August, contributing to the second quantitative peak in the pond Gorol in 1974 (fig. 4).

STRESZCZENIE

W latach 1971—1974 przeprowadzono dalsze badania nad wykorzystaniem ścieków cukrowniczych w stawie karpiowym oraz ich następczym działaniem.

Wprowadzenie znacznych ilości ścieków do stawów wyzwalało proces samooczyszczania się wody. Szybkość mineralizacji ścieków zależała od stopnia zanieczyszczenia wody. Przy dużej koncentracji ścieków początkowy etap samooczyszczania przebiegał w warunkach beztlenowych.

Zmiany w stawie podczas samooczyszczania się wody odbiły się na rozwoju pierwotniaków dennych. Etapowość postępującego samooczyszczania wyraziła się w sukcesji odmiennych ekologicznie zespołów orzęsków oraz zmianami w ich liczebności.

Wzbogacenie wody przez produkty mineralizacji ścieków wpływało korzystnie na liczebność orzęsków w dnie.

Nie stwierdzono następczego działania kilkuletniego nawożenia stawu ściekami cukrowniczymi na mikrofaunę, gdyż nie pojawiły się istotne zmiany ani w składzie gatunkowym, ani w liczebności pierwotniaków. Mikrofauna dna była bardzo zbliżona do mikrofauny normalnie użytkowanego i nawożonego stawu rybnego. Wiąże się to zapewne z brakiem akumulacji substancji organicznych w osadach dennych stawu.

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Adres autorki — Author's address

dr Elżbieta Grabacka

Zakład Biologii Wód, Polska Akademia Nauk, ul. Sławkowska 17, 31-016 Kraków