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Głony zbiorników zaporowych w kaskadzie Soły oraz przyległych odcinków rzeki

Algae of dam reservoirs in the Soła cascade and neighbouring sectors of the river

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Abstract — The influence of cascade damming of a river on seston and periphyton communities was investigated. The similarity of algae in separate reservoirs and their influence on the river were observed. The distribution of algae at various depth and the dependence of their qualitative and quantitative composition on the situation of the stations which were under the influence of differently polluted inflows were investigated.

The present work is a part of complex biological and physico-chemical investigations initiated in 1966. They are concerned with the communities of attached and sestonic algae of the River Soła and with the plankton of three dam reservoirs situated on it at Tresna, Porąbka, and Czaniec.

The River Soła is the first large right-hand affluent of the Vistula. The reservoirs situated on it have a great influence on its water regime, which is disturbed below them.

The reservoir at Tresna, exploited since 1967, has a volume of 100 million cubic metres. The reservoir at Porąbka, constructed in 1937, has a volume of 28.4 million cubic metres, and that at Czaniec of 1.3 million cubic metres.

The hydrological relations of the catchment basin of the Soła were described by Punzet (1971), the pedological and geological description of the catchment area of this river was given by Pasternak (1960), while the hydrochemical data were reported by Bombówna (1960).

The aim of the present work was to study the periodical changes in the communities of algae in the seston of the river and in the plankton of the reservoirs as well as of those attached on stones in the river. An attempt was also made to find out the possible influence of the river on the composition of algae in the reservoirs as well as the mutual influence of reservoirs on each other also with regard to eutrophication.

The left and right hand sides of the Soła were investigated above the reservoir at Tresna, its sectors between the reservoirs and below Czaniec, and the reservoirs themselves, various depths and stations being considered.

The samples were taken in September 4th and 5th 1968 and in May, 19th, July 23rd, and September 26th 1969. Periphyton was collected from a determined surface of stones. The basis of the study of the seston was 1 litre of natural water, taken from the reservoirs with a Patalas bathometer, and from the river with a pail. In 1968 30 litres of water were additionally taken from the reservoirs and filtered through a plankton net. These samples supplemented the analyses of algae of the zooplankton. They were counted in a 0.5 ml Kolkwitz chamber. The samples of natural water and of the periphyton were counted in 20 fields of view, using an eyepiece micrometer with a net of known area. The surfaces of algae projection were also measured according to the method elaborated by Starmach (1969a, b).

Characteristic of attached and sestonic algae in the River Soła

At two stations (the left and right banks) at Żywiec diatoms were usually noted (Tables I and II). Great numbers of them were observed on the left side in May and September, while in July the numbers were similar on both sides. Between the banks distinct differences in numbers occurred in the distribution of the bacteria *Sphaerotilus natans*; on the left river bank, where municipal sewage from the town of Żywiec was released, it grew very abundantly on the

Tabela I. Seston (s) rzeki Soły (ilość glonów w 1 l wody) oraz peryfiton (p) (z 1 cm² kamienia) we wrześniu 1968

Table I. Seston (s) of the River Soła (number of algae in 1 litre of water) and periphyton (p) (from 1 sq. cm of stone) in September 1968

Stanowiska Stations Grupy taksonomiczne Taxonomic groups	w Żywiecu at Żywiec		Poniżej zbiornika Below the reservoir	
	lewy brzeg left bank	prawy brzeg right bank	w Tresnej at Tresna	w Porąbce at Porąbka
Bacteriophyta	s p			102 000
Cyanophyta	s p	12 320 1 270 500		
Euglenophyta	s p			10
Pyrrophyta	s p	49 280		200
Chrysophyceae	s p	49 280		
Bacillariophyceae	s p	86 240 1 617 000	197 060 1 347 500	308 000 88 200
Chlorophyta	s p	38 500	38 500	26 460 6 840
Razem - Total	s p	184 600 3 426 500	209 380 2 656 500	308 000 114 660
				230 300 970

Tabla II. Seston (s) rzeki Soły (ilość glonów w 1 l wody) oraz periphyton (p) z 1 cm² kamienia w 1969 r. w maju-A; w lipcu-B i we wrześniu-C

Table II. Seston (s) of the River Soła (number of algae in 1 litre of water) and periphyton (p) from 1 cm² of stone in 1969 in May-A; in July-B and in September-C

Staniowiska Stations	Grupy taksonomiczne Taxonomic groups	w żywcu at żywiec		Poniżej zbiornika Below the reservoir		
		Lewy brzeg Left bank	prawy brzeg right bank	w Trzesnej at Trzebnia	w Porąbce at Porąbka	
		9 133 200 1 722 000	424 800 15 000	160 800	50 000	
A						
Bacteriophyta	s p	9 133 200 1 722 000	424 800 15 000	160 800	50 000	67 000
Cyanophyta	s p	59 400		1 911 600 844 200	141 600 1 404 850	97 900
Euglenophyta	s p	708 000 118 800		354 000		70 800
Pyrrophyta	s p		141 600 15 000	141 600	70 800	70 800
Chrysophyceae	s p			991 200	3 610 800 14 700	3 044 400 13 400
Bacillariophyceae	s p	3 398 400 6 320 280	4 389 600 1 304 200	637 200 3 215 640	1 168 200 2 263 180	3 186 000 5 560 040
Chlorophyta	s p	708 000 59 360	141 600	70 800 40 200	141 600 1 265 400	70 800 245 210
Razem - Total	s p	13 947 600 8 279 860	5 097 600 1 334 200	4 106 400 4 260 840	5 133 000 4 998 130	6 442 800 5 981 290
B						
Bacteriophyta	s p	28 036 800 629 200		141 600		
Cyanophyta	s p	283 200 424 680		192 000	1 416 000	
Euglenophyta	s p	991 200		141 600	113 300	141 600
Pyrrophyta	s p			639 200	42 500	778 800
Chrysophyceae	s p			70 800	70 800	70 800
Bacillariophyceae	s p	1 982 400 1 266 800	1 274 400 1 489 750	2 124 000 1 128 000	1 062 000 141 600	1 699 200 3 225 500
Chlorococcales	s p		14 750			52 440
Conjugales	s p		44 250			
Chlorophyta	s p	94 380	70 800 14 750	70 800 1 272 000	85 000	157 330
Fungi	s p		14 750			
Razem - Total	s p	31 293 600 2 375 140	1 345 200 1 578 250	3 188 000 2 592 000	1 373 600 1 557 600	2 690 400 3 435 270

Tab. II. cont.

Staniowiska Stations	Grupy taksonomiczne Taxonomic groups	w żywcu at żywiec		Poniżej zbiornika Below the reservoir		
		Lewy brzeg Left bank	prawy brzeg right bank	w Trzesnej at Trzebnia	w Porąbce at Porąbka	
		369 600 590 000 <td></td> <td>511 330</td> <td></td> <td></td>		511 330		
C						
Bacteriophyta	s p	369 600 590 000				
Cyanophyta	s p	4 800	78 670	609 020	28 300 2 589 250	28 300 74 530
Euglenophyta	s p	14 400 98 330				28 300
Pyrrophyta	s p			3 200 76 130		
Xanthophyceae	s p			1 600	323 660	1 825 890
Chrysophyceae	s p	201 600			84 900	56 600
Bacillariophyceae	s p	225 600 3 245 020	379 200 1 179 990	70 400 4 034 790	339 700	424 500 111 790
Chlorococcales	s p	491 670				
Conjugales	s p	98 330	157 330	304 510		141 500
Chlorophyta	s p	9 600	114 900 39 330	3 200 152 660	56 600	
Razem - Total	s p	825 600 4 523 350	494 100 1 966 650	78 400 5 176 710	509 500 2 912 910	679 200 2 012 210

stones while on the left bank it occurred in much smaller numbers, such great communities not being formed there. On the floccules of *Sphaerotilus natans*, *Anthophysa vegetans* and the species of the genus *Euglena* were often noted. Other bacteria, colourless flagellates, and *Ciliata* were observed as well. In 1968 at both banks, but more numerously at the right one, blue-green algae of the family *Oscillatoriaceae* appeared. From green filamentous algae *Stigeoclonium* sp. was encountered at both banks but *Ulothrix* sp. appeared only at the left one, sporadically in 1968 and in greater numbers in 1969. Chlorococcous green algae accompanied other algae in small numbers at the left bank in 1968 and at the right one in 1969.

In the Soła seston at Żywiec great numbers of *Sphaerotilus natans* were commonly noted at the left bank where the floccules of this bacterium separated from stones flowed down the river. An increase in its numbers was noted in July. Other bacteria, such as *Zooglea ramigera* and *Beggiatoa* sp., also occurred there. On both sides of the Soła in seston communities *Bacillariophyceae* were an important component, showing distinctly greater numbers and richer composition at the right bank. From other groups of algae *Cyanophyceae* of the family *Oscillatoriaceae* were sporadically noted at both sides (chiefly in September). Only in 1969 at the left bank were greater numbers of euglenins encountered (May and July). In the first year of investigation a fairly numerous appearance of *Dinophyceae*, *Cryptophyceae*, and *Chrysophyceae* was characteristic, while in the second year among *Chlorophyta* one species *Coelastrum microporum* prevailed (right bank). At this bank from *Protozoa Halteria grandinella* and *Vorticella* sp., and among *Rotatoria Brachionus angularis* were sporadically observed.

The periphyton of the Soła at the station below Tresna was characterized by the prevalence of diatoms: in 1968 of species *Navicula cryptopcephala*, *Synedra acus*, and *S. ulna*, and in 1969 of *Achnanthes* sp., *Cymbella* sp., or *Gomphonema*. In May 1969 attached green alga *Cylindrocapsa* sp. and in September *Mougeotia* of the family *Zygnemataceae* were fairly numerous. Blue-green algae with the dominance of genus *Oscillatoria* also occurred in September. In both years *Stigeoclonium* sp. was observed, in July 1969 its numbers being very great. In this period *Oedogonium* sp. also commonly occurred there.

In 1968 the seston of this station was characterized by diatoms (Table III), chiefly *Cyclotella* sp. and *Navicula* sp. div. Other diatoms, similarly as euglenins, *Dinophyceae*, *Cryptophyceae*, *Chrysophyceae*, and green algae were only encountered as single specimens. In 1969 periodical changes were observed in the composition of algae. In the month of May unidentified blue-green algae were most numerous, followed by *Chrysophyceae*, chiefly *Chrysococcus minutus* and genus *Kephyrion*. The species of this genus were described in detail in another work (Krzeczkowska-Wołoszyn et al. 1971). Among more numerous diatoms *Diatoma vulgare* var. *breve*, and among euglenins the genus *Trachelomonas* should be mentioned. The least numerous *Pyrrophyta*

were represented only by the genus *Cryptomonas*. In July diatoms dominated, amounting to 60 per cent of the total number of algae, with the dominance of *Cyclotella* sp. and *Asterionella formosa*. The genus *Cryptomonas* played a greater role with regard to numbers than it did in May. In September a distinct decrease in the number of algae was noted but the dominance of diatoms was still maintained.

In 1968 the station on the Soła below Porąbka was characterized by the dominance of diatoms, chiefly of the genus *Gomphonema*, in the periphyton. *Sphaerotilus natans* was also noted here. In the next year only in May were greater numbers of the blue-green alga *Oscillatoria* sp. and green alga *Ulothrix* sp. noted. In July an increase in their numbers was observed and in September diatoms were absent while a strong development of blue-green algae, chiefly of the family *Oscillatoriaceae*, occurred.

In 1968 insignificant numbers of euglenins, diatoms, and green algae were observed in the seston. In May 1969 *Chrysophyceae* (*Chrysococcus* and *Kephyrion*) were most numerous (over 70 per cent). Also among the most numerous (over 20 per cent) were diatoms, chiefly *Nitzschia* sp. and *Cyclotella* sp. In July diatoms prevailed (over 77 per cent), chiefly *Cyclotella comta* and *Asterionella formosa*, while the number of *Chrysophyceae*, which dominated in May, considerably decreased. In September the dominance of diatoms (over 60 per cent) with the prevalence of *Cyclotella comta*, *Nitzschia* sp. and *Diatoma vulgare*, was further maintained.

At the station of the Soła below Czaniec samples were taken only in 1969. In May and July diatoms dominated in the periphyton, chiefly the genera *Achnanthes*, *Cymbella*, *Gomphonema*, and the species *Cocconeis placentula* and others. Greater numbers of *Cocconeis placentula* in May were connected with the development of *Cladophora* sp. In September in the periphyton of this station *Xanthophyceae* (*Tribonema* sp.) distinctly dominated.

In May, unlike in the former station, the dominance of *Chrysophyceae* over *Bacillariophyceae* was no larger observed in the seston, but their similar share in the communities being found. In July diatoms (over 50 per cent) continued to prevail, chiefly *Cyclotella comta* and the genera *Achnanthes* and *Navicula*. Very striking were the great numbers of the genus *Cryptomonas*. The total number of algae decreased as autumn approached. In September the prevalence of the diatoms (62 per cent) *Achnanthes*, *Cyclotella*, *Cymbella*, and *Nitzschia* continued. The number of chlorococcous green algae (*Crucigenia*, *Pediastrum*, *Scenedesmus*, and *Tetraëdron*) was greater at this period than previously.

Description of the plankton in dam reservoirs

Tresna. In September 1968 (fig. 1) the dominance of diatoms, especially of *Cyclotella*, was chiefly observed at a depth of 5 m. Other algae such as *Cryptomonas* and *Mallomonas producta* also occurred. Weak settlement was found

Tabela III. Skład jakościowy perifytonu (p) i sestonu (s) rzeki Soły oraz planktonu (pl) zbiorników zaporowych.

Table III. Qualitative composition of periphyton (p) and seston (s) of the River Soła and plankton (pl) of dam reservoirs

Takson Taxon	Soła the Soła		Przesna at Porąbka		Czanleć at Porąbka		Soła the Soła		Przesna at Porąbka		Czanleć at Porąbka	
	P	S	P	Pl	P	Pl	P	S	P	Pl	P	Pl
<i>Beggiatoa alba</i> (Vauch.) Trév.												
<i>Sphaerotilus natans</i> Kütz.												
<i>Zoogloea ramigera</i> Itz.												
<i>Bacteriophyta</i> n. det.												
<i>Aphanocapsa</i> sp.												
<i>Gomphosphaeria Nageliana</i> Lemm.												
<i>Gomphosphaeria</i> sp.												
<i>Hormogonales</i> n. det.												
<i>Iyngbya</i> sp.												
<i>Oscillatoria limosa</i> Agardh												
<i>Oscillatoria</i> sp.												
Oscillatoriaceae												
Felonemataceae												
<i>Phormidium</i> sp.												
Pleurocapsaceae												
<i>Cyanophyta</i> n. det.												
<i>Euglena acus</i> Ehr.												
<i>Euglena</i> sp.												
<i>Lepocinclis</i> sp.												
<i>Phacus caudatus</i> Hübner												
<i>Phacus</i> sp.												
<i>Strombomonas verrucosa</i> (Daday) Defl. var <i>zmiawika</i> (Swir.) Defl.												
<i>Trachelomonas hispida</i> (Ferty) Stein												
- - var. <i>coronata</i> Lemm.												
- <i>nigra</i> Swir.												
<i>Trachelomonas planctonica</i> Swir.												
- - var. <i>oblonga</i> Dreß.												
- <i>pseudofelix</i> Defl.												
- <i>rugulosa</i> Stein												
- <i>volvocina</i> Ehr.												
<i>Trachelomonas</i> sp.												
Euglenophyceae												
<i>Ceratium hirundinella</i> Duj.												
<i>Glennodinium</i> sp.												
<i>Gymnodinium</i> sp.												
<i>Peridinium</i> sp.												
<i>Cryptomonas</i> sp.												
<i>Anthophysa vegetans</i> (O.F.M.) Stein												
<i>Chrysooccus minutus</i> (Fritsch) Nyg.												
<i>Dinobryon bavaricum</i> Imhof												
- <i>divergens</i> Imhof												
<i>Dinobryon</i> sp.												
<i>Kephyrion planctonicum</i> Hilliard												
- <i>Rubri-Claustri</i> Conrad												
<i>Kephyrion</i> sp. div.												
<i>Mallomonas producta</i> Ivanof												
<i>Mallomonas</i> sp.												
<i>Pseudokephyrion crassa</i> Hilliard												
- <i>Entzii</i> Conrad												
- <i>hiemale</i> Hilliard												
- <i>inflatum</i> Hilliard												

Tab. III. cont.

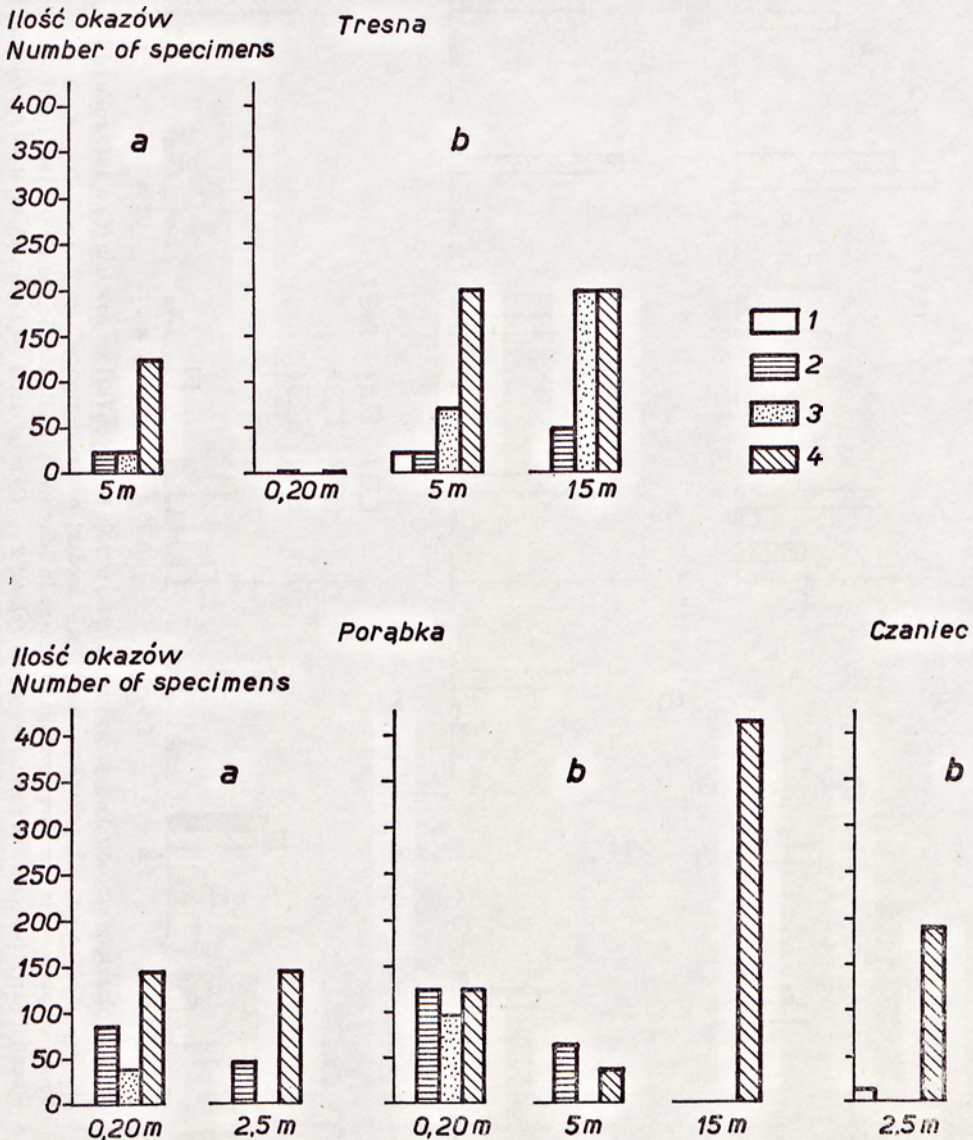
Takson - Taxon	Soła					Takson - Taxon	Soła				
	the Soła		at Fresna	at Porąbka	at Czaniec		the Soła		at Fresna	at Porąbka	at Czaniec
	p	s	pl	pl	pl		p	s	pl	pl	pl
<i>Crucigenia quadrata</i> Morren		+				<i>Scenedesmus quadricauda</i> Chod.			+	+	
- <i>tetrapedia</i> (Kirchn.) West et West		+	+		+	- <i>rostrato-spinosus</i> Chod.			+		
<i>Dictyosphaerium pulchellum</i> Wood			+	+	+	- <i>spinus</i> Chod.				+	
<i>Didymocystis planctonica</i> Korschik.				+	+	<i>Scenedesmus</i> sp. div.	+	+	+	+	
<i>Didymocystis</i> sp.				+		<i>Siderocelis ornata</i> Fott			+		
<i>Elakatothrix gelatinosa</i> Wille				+		<i>Siderocystis fusca</i> Korschik.				+	
<i>Franceia Droescheri</i> (Lemm) G.M. Smith			+			<i>Sphaerocystis Schroeteri</i> Chod.		+	+	+	
<i>Golenkinia radiata</i> Chod.			+	+		<i>Tetraedron minimum</i> (A. Braun) Hansg.		+	+	+	
<i>Kirchneriella</i> sp.	+	+	+	+	+	<i>Westella linearis</i> G. S. Smith				+	
<i>Lagerheimia ciliata</i> (Lagerh.) Chod.				+		<i>Cladophora</i> sp.	+				
<i>Nephrochlamys Willeana</i> (Printz.) Korschik.				+	+	<i>Oedogonium</i> sp.	+				
<i>Oocystis</i> sp.	+		+			<i>Stigeoclonium</i> sp.	+				
<i>Pediastrum Boryanum</i> (Turp.) Menegh.		+	+	+		<i>Ulothrix zonata</i> Kütz.	+				
- <i>duplex</i> Meyen			+	+	+	<i>Ulothrix</i> sp.	+				
- <i>tetras</i> (Ehr.) Ralfs		+				<i>Closterium acutum</i> Bréb.			+		
<i>Scenedesmus acutus</i> Meyen	+					- <i>gracile</i> Bréb.			+		
- <i>arcuatus</i> Lemm.			+			<i>Cosmarium phaseolus</i> Bréb.				+	
- <i>balatonicus</i> Hortob.				+		- <i>subrenatum</i> Hantzsch.	+	+			
- <i>bicaudatus</i> (Hansg.) Chod.			+	+		<i>Cosmarium</i> sp.	+			+	
- <i>circumfusus</i> Hortob.			+	+		<i>Mougeotia</i> sp.	+				
- - var. <i>bicaudatus</i> Hortob.			+	+		<i>Sphaerzosma</i> sp.			+	+	
- <i>denticulatus</i> Lagerh.		+	+	+		<i>Staurastrum alternans</i> Bréb.			+	+	
- <i>ecornis</i> (Ralfs) Chod.		+	+			- <i>tetracerum</i> (Kütz.) Ralfs				+	
- - var. <i>disciformis</i> Chod.			+	+		<i>Staurastrum</i> sp.		+	+		
- <i>granulatus</i> W. et G.S. West		+	+	+	+	<i>Chlorophyta</i> n. det.	+	+	+	+	
- - var. <i>verrucosus</i> (Roll) Deduss				+		<i>Asterothrix raphidioides</i> (Reinsch) Printz	+				
- <i>intermedius</i> Chod. var. <i>bicaudatus</i> Hortob.				+		<i>Leptomitus lacteus</i> Ag.				+	

Tab. III. cont.

<i>Planctomyces Bekefi</i> Gimesi			+			<i>Floesoma</i> sp.			+	+
Fungi n. det.				+		<i>Polyarthra euryptera</i> Wierz.			+	+
<i>Codonella</i> sp.			+	+	+	- <i>vulgaris</i> Carlin			+	+
<i>Halteria grandinella</i> (O.F.) Müll.		+				<i>Polyarthra</i> sp.			+	+
<i>Vorticella</i> sp.		+				<i>Synchaeta</i> sp.			+	+
<i>Anureopsis fissa</i> (Gosse)				+		<i>Rotatoria</i> (ova)				+
<i>Asplanchna</i> sp.				+		<i>Bosmina longirostris</i> O.F. Müll.			+	+
<i>Brachionus angularis</i> Gosse		+				<i>Daphnia cucullata</i> G.O. Sars			+	+
<i>Euchlanis dilatata</i> Ehr.			+			<i>Cladocera</i> (ova)			+	+
<i>Keratella cochlearis</i> (Gosse)		+	+	+		<i>Cyclopidae</i>	+	+	+	+
- - var. <i>tecta</i> Gosse			+	+		<i>Nauplii</i>			+	+

in the surface layer to 1 m, while at 15 m it was even greater than at 5 m (at the dam).

In the distribution of planktonic animals greater density was noted at a depth of 2.5 m than to 1 m; they were chiefly *Codonella* sp., *Keratella*



Ryc. 1. Pionowe rozmieszczenie planktonu w zbiornikach zaporowych w Tresnej, Porąbce i Czaniecu we wrześniu 1968 roku (w tysiącach okazów glonów w litrze wody): a — środek; b — przy zaporze
Fig. 1. Vertical distribution of plankton in the dam reservoirs at Tresna, Porąbka, and Czaniec in September 1968 (in thousands of algae specimens per litre of water): a — central part; b — near the dam; 1 — *Bacteriophyta*; 2 — *Pyrrophyta*; 3 — *Chrysophyceae*; 4 — *Bacillariophyceae*

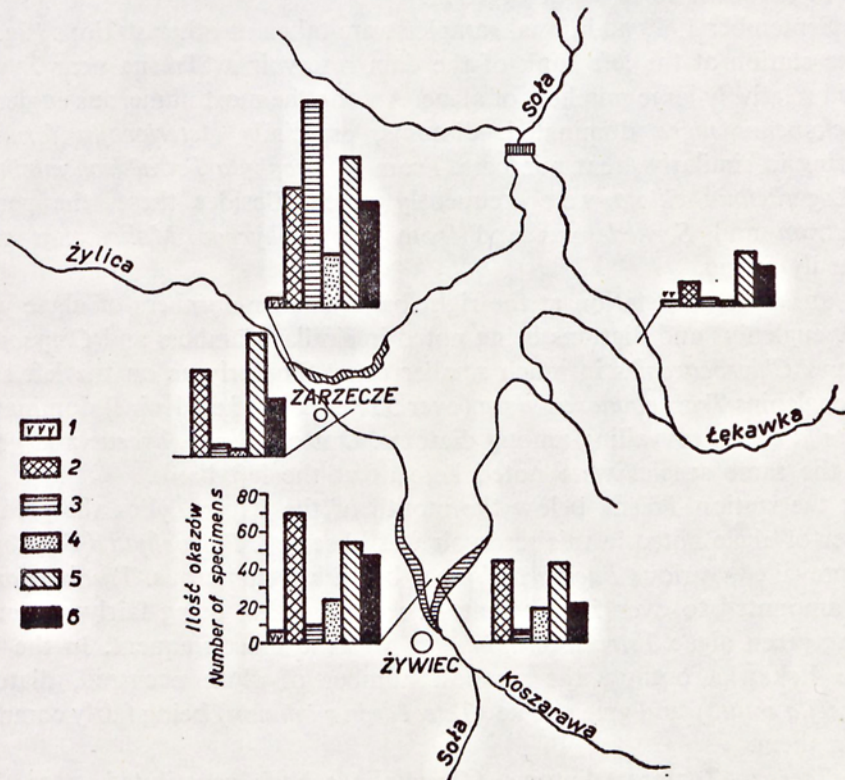


Ryc. 2. Pionowe rozmieszczenie planktonu w zbiorniku zaporowym w Tresnej w maju (A), lipcu (B) i we wrześniu (C) w 1969 roku (w tysiącach okazów glonów w litrze wody): a — środek; b — przy zaporze

Fig. 2. Vertical distribution of plankton in the dam reservoir at Tresna in May (A), July B and September (C) 1969 (in thousands of algae specimens per litre of water): a — central part; b — near the dam; 1 — *Bacteriophyta*; 2 — *Cyanophyta*; 3 — *Euglenophyta*; 4 — *Pyrrophyta*; 5 — *Chrysophyceae*; 6 — *Bacillariophyceae*; 7 — *Chlorophyta*

cochlearis, and *Cyclopidae*, as well as their larval stages. These observations in general agree with the data of Krzanowski (1971).

In May 1969 (fig. 2) in the middle of the reservoir as well as at the dam *Chrysophyceae* (*Chrysococcus*, *Kephyrion*, *Pseudokephyrion*, and *Dinobryon*) were the most numerous component, *Bacillariophyceae* (*Synedra*, *Cyclotella*, *Nitzschia*, and *Diatoma*) being less numerous. In the middle great numbers of *Chroomonas* and *Cryptomonas* also occurred. In the central part no distinct vertical differentiation was observed among the algae, while their greatest



Ryc. 3. Poziome rozmieszczenie planktonu w zbiorniku zaporowym w Tresnej we wrześniu 1969 roku (w tysiącach okazów glonów w litrze wody — średnie z różnych głębokości)

Ryc. 3. Horizontal distribution of plankton in the dam reservoir at Tresna in September 1969 (in thousands of algae specimens per litre of water — means from different depths): 1 — *Cyanophyta*; 2 — *Euglenophyta*; 3 — *Pyrrophyta*; 4 — *Chrysophyceae*; 5 — *Bacillariophyceae*; 6 — *Chlorophyta*

numbers were noted at a depth of 5 m, a distinct decrease in these numbers being found at 15 m. In July, with a similar total number of algae, diatoms dominated, especially *Asterionella formosa* and *Cyclotella comta*. Only in the middle were great numbers of the genus *Cryptomonas* also noted, mainly in the layer near the surface. Down to a depth of 10 m no significant differences were observed in the settlement of algae, a decrease in the numbers occurring

as deep as 15 m. In September small numbers of algae were noted as compared with the previous periods. At both stations diatoms still prevailed (*Cyclotella*, *Gomphonema*, *Asterionella*, and *Cymbella*), euglenins (*Trachelomonas nigra* and *T. volvocina*) or chlorococcous algae (*Tetraëdron minimum* and *Scenedesmus*) being less numerous. These algae were much more numerous at previous terms than in September, but they were then present in insignificant percent because of the strong development of other groups. Also in this period at both stations was noted a general tendency of the algae to aggregate in the water layer down to a depth of 10 m.

In September 1969 additional samples were taken at other stations (fig. 3).

The station at the left bank of the dam reservoir at Tresna near Żywiec showed relatively large numbers of algae. Among the most numerous euglenins *Trachelomonas nigra* dominated, diatoms, especially *Asterionella formosa*, occurring in similarly great numbers. From *Chlorophyta* *Tetraëdron minimum* and *Lagerheimia ciliata* were frequently noted. Besides these, the genera *Coelastrum* and *Scenedesmus* and from *Chrysophyceae* *Mallomonas* were repeatedly found.

In an analogous station at the right bank smaller numbers of algae were found, euglenins and diatoms being noted in similar numbers and *Chrysophyceae* and *Chlorococcales* in much smaller ones. Similarly as on the left side, from euglenins *Trachelomonas nigra* (over 50 per cent of euglenins) dominated, *Cyclotella comta* prevailing among diatoms. Out of *Chrysophyceae* and green algae the same species were noted here as at the left bank.

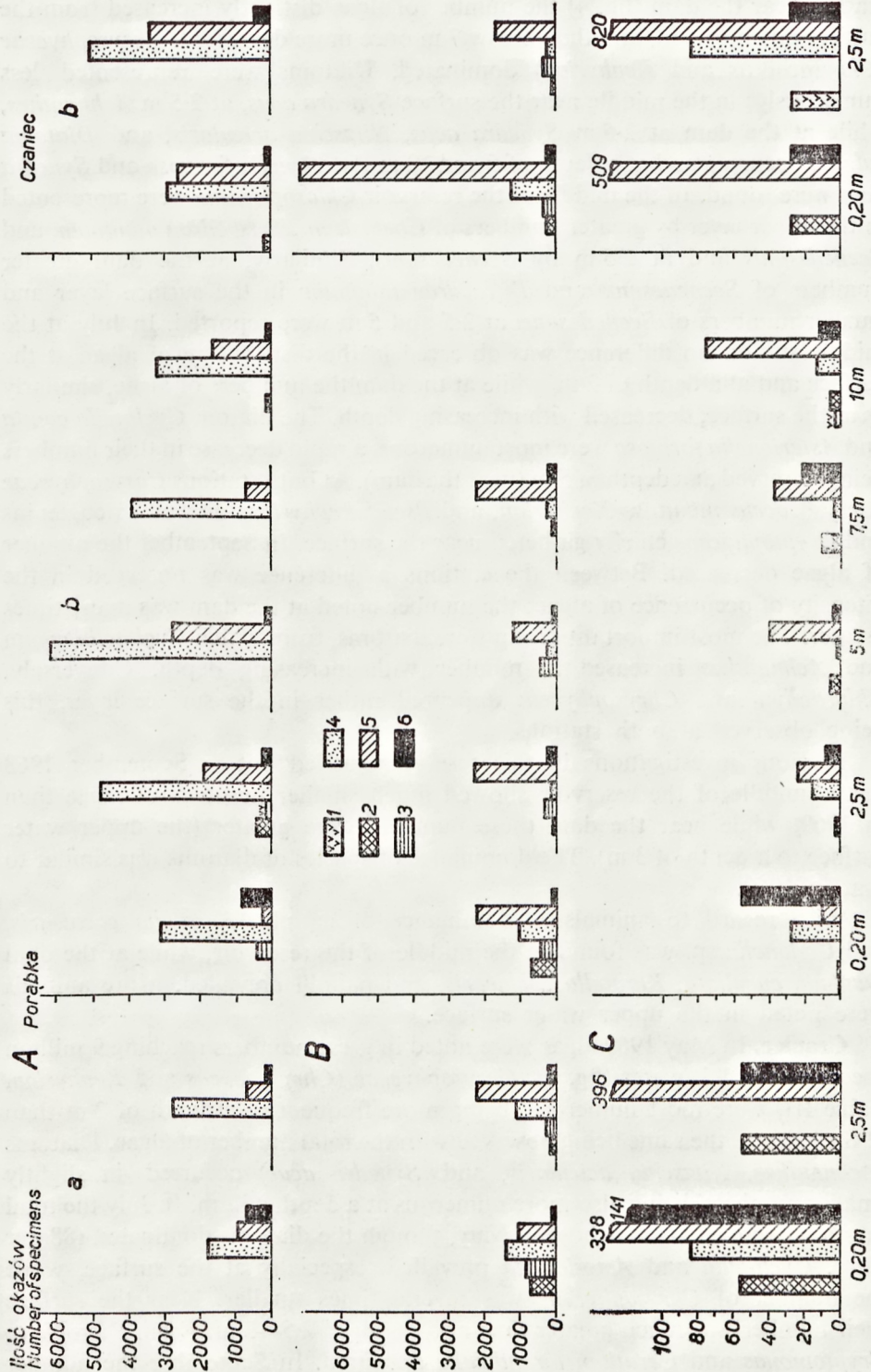
At the station Tresna below the mouth of the River Żylica the greatest number of algae noted in this reservoir was observed. *Pyrrophyta* (*Cryptomonas*) prevailed, various *Bacillariophyceae* being less numerous. *Trachelomonas nigra* amounted to over 50 per cent, *T. volvocina* also being fairly common. Among green algae *Tetraëdron minimum* was the most frequent. In the bay of the Łękawka outflow the smallest number of algae occurred, diatoms (*Cyclotella comta*) and green algae (*Tetraëdron minimum*) being fairly common among them.

In Tresna—Zarzecze diatoms (*Cyclotella comta*) constituted more than 40 per cent of the total number of algae. Euglenins were less numerous, *Trachelomonas nigra* and then *T. volvocina* prevailing among them. Among chlorococcous algae *Tetraëdron minimum* prevailed.

Porąbka. In May 1969 at the station in the middle of reservoir similar numbers of algae were noted at the surface and at a depth of 2.5 m, while at the

Ryc. 4. Pionowe rozmieszczenie planktonu w zbiornikach zaporowych w Porąbce i Czańcu w maju (A), lipcu (B) i wrześniu (C) w 1969 roku (w tysiącach okazów glonów w litrze wody); a — środek; b — przy zaporze

Fig. 4. Vertical distribution of plankton in the dam reservoirs at Porąbka and Czańciec in May (A), July (B) and September (C) 1969 (in thousands of algae specimens per litre of water); a — central part; b — near the dam; 1 — *Cyanophyta*; 2 — *Euglenophyta*; 3 — *Pyrrophyta*; 4 — *Chrysophyceae*; 5 — *Bacillariophyceae*; 6 — *Chlorophyta*



station near the dam (fig. 4) the number of algae distinctly increased from the surface down to 5 m, and then below 7 m once more decreased. *Chrysophyceae* (*Chrysococcus* and *Kephyrion*) dominated. Diatoms were represented less numerous; in the middle near the surface *Synedra acus*, at 2.5 m *Achnanthes*, while at the dam at 2.5 m *Synedra acus*, *Nitzschia acicularis*, and *Diatoma vulgare* occurred and at a depth of 5 and 10 m *Asterionella formosa* and *Synedra acus* were found. In the middle of the reservoir *Chlorophyceae* were represented in the upper layer by greater numbers of *Coelastrum*, *Tetraëdron minimum*, and *Scenedesmus* and at 2.5 m by *Scenedesmus*. Similarly, at the dam greater numbers of *Scenedesmus* and *Tetraëdron minimum* in the surface layer and smaller numbers of *Scenedesmus* at 2.5 and 5 m were reported. In July at the middle station no difference was observed in the distribution of algae at the surface and at a depth of 2 m, while at the dam the numbers of algae, similarly as at the surface, decreased with increasing depth. The diatom *Cyclotella comta* and *Asterionella formosa* were most numerous, a rapid decrease in their numbers being observed at a depth of 5 m (near the dam). At both stations *Chrysophyceae* (*Chrysococcus minutus*, *Kephyrion*, and *Pseudokephyrion*) as well as euglenins and *Cryptophyceae* chiefly gathered near the surface. In September the number of algae decreased. Between the stations a difference was observed in the intensity of occurrence of algae; the number noted at the dam was many times greater. The most important group were diatoms, from which *Cyclotella comta* and *Achnanthes* increased in number with increasing depth. Conversely, *Chlorophyta* and *Chrysophyceae* appeared rather in the surface layer, this being observed at both stations.

Previous investigations in this reservoir carried out in September 1968 in the middle of the reservoir showed much smaller numbers of algae than in 1969, while near the dam these numbers were greater (the upper water surface to a depth of 3 m). The dominance of species of diatoms was similar to that in 1969.

With regard to animals, a dominance of nauplii, *Keratella cochlearis*, and *Codonella* sp. was found in the middle of the reservoir, while at the dam *Daphnia cucullata*, *Keratella cochlearis*, and nauplii prevailed. More animals were noted in the upper water surface.

Czaniec. In May 1969 algae were noted in great numbers reaching 9 million specimens in 1 l. water (fig. 4). *Chrysophyceae* (*Chrysococcus* and *Kephyrion*, Table III) were most numerous, being more frequent at a depth of 2 m than at the surface, the same being observed with the total number of algae. Diatoms (*Achnanthes*, *Nitzschia acicularis*, and *Synedra acus*) occurred in slightly smaller numbers, being also more numerous at a depth of 2 m. In July the total numbers were similar to those in May, though the diatoms dominated (88 per cent). *Cyclotella* and *Asterionella* prevailed, especially at the surface, while the number of *Chrysophyceae* was several times smaller. Near the surface their number was much greater than at a depth of 2.5—3 m. From *Pyrrophyta* *Cryptomonas* and *Ceratium hirundinella* appeared. In September the number

of plankton distinctly decreased. Various species were noted here with a certain prevalence of diatoms: *Gomphonema*, *Navicula*, and *Cymbella*, chiefly at a depth of 2 m.

In 1968 plankton was only sampled at a depth of 2.5 m. In this period much smaller numbers of algae were found than in 1969. A marked prevalence of diatoms also occurred, the dominance of the same species being observed. Very small numbers of planktonic animals, with the dominance of *Daphnia cucullata*, nauplii, and *Codonella*, were noted in this period.

Recapitulation

In 1969 in the communities of the Soła no essential changes were observed in relation to the investigations of 1968. Differences continued between the banks of the Soła above the reservoir at Tresna, chiefly consisting in a much more numerous occurrence of *Sphaerotilus natans*, other bacteria, and colourless flagellata at the left bank and of diatoms and blue-green algae at the right one. Possibly, this state was brought about by a great inflow of municipal sewage from the town of Żywiec at the right side of the river. The general composition of the periphyton indicated considerable pollution of the river in this region, this being also supported by the character of the seston. Differences between the two banks were also shown by physico-chemical studies (Wróbel 1968, typescript). The amount of chlorophyll in the periphyton of the left bank was 16 $\mu\text{g/l}$., the oxygen content 7.84 mg/l., and at the right bank 32 $\mu\text{g/l}$. and 9.92 mg/l respectively.

The stations on the Soła below the dam reservoirs differed distinctly from those above Tresna. Here abundant development of *Sphaerotilus natans* was never observed, while these stations showed a similar composition of periphyton and seston, which both below Tresna and Porąbka and Czaniec indicated an amelioration in the state of purity of the water. Previous studies carried out on the Soła (Krzeczkowska-Wołoszyn, Bucka 1969) also stressed the high degree of pollution of the sector in the region of the town of Żywiec, in general weak pollution being found below the reservoirs at Tresna and Porąbka.

In three reservoirs similar dominance of the groups of phytoplankton was observed in particular seasons, thus in May always that of *Chrysophyceae* while in July and September of *Bacillariophyceae*. A similar scheme of dominance of algae settling the reservoirs at Tresna and Porąbka in 1967 was reported by Bombówna and Bucka (1974). A decrease in the number of algae was found in September, indicating that the reservoir grew poorer at the end of the season.

A general tendency was observed of algae gathering in the upper water layers, in the case of *Chrysophyceae* to a depth of 5 m, often with maximum numbers at 2.5 m, and of diatoms to that of 10 m. Among *Chrysophyceae* the nanoplanktonic strongly phototactic species (Huber-Pestalozzi 1941) *Chrysococcus minutus* amounted to a considerable share.

This scheme corresponds to the content of chlorophyll and to the primary production of the phytoplankton, which are usually greater in the upper layer of the water (to a depth of 5 m).

Within the reservoir at Tresna distinct quantitative differences were observed between the stations of its upper part and those situated lower. At the station at Tresna below the mouth of the River Żylica the greatest number of algae in this reservoir, and near Żywiec at the left side also a relatively great one with the dominance of euglenins, were noted. At these stations a greater number of zooplankton were also reported (Krzanowski 1969). This was most probably the influence of the Soła and Żylica which brought in large amounts of mineral compounds in this part of the reservoir.

The stations at the right bank and at the bay of the mouth of the Łękawka differed greatly from these stations in the smaller numbers of algae. No regularities were found in the scheme of the numbers of algae between the middle parts of reservoirs and the stations near the dams.

The total number of algae, similar in the discussed reservoirs, does not seem to show any decrease in their eutrophication in the cascade, as is indicated by the distinctly decreasing amounts of chlorophyll and primary production (Wróbel, Bombówna 1973) as well as of zooplankton (Krzanowski 1969). However, a decrease in the eutrophication in the cascade might have been in some measure indicated by the uneven development of certain groups of algae. Thus both in May and in September greater numbers of chlorococcous algae were noted at Tresna and Porąbka than at Czaniec, and in July the same was observed of euglenins, chiefly certain species of the genus *Trachelomonas*. Similarly, *Cryptophyceae*, which at Czaniec were not noted in May and September, were a very frequent component of the plankton at Tresna, mainly in its upper part and at the mouth of the polluted River Żylica, and at Porąbka. Numerous authors connect their occurrence with greater eutrophication of the water. These algae are characteristic for waters with organic pollution (Turboyski 1970, Kyselowa 1973).

The calculated total surfaces of algae active in the assimilation processes also did not indicate any decrease in the eutrophication in the cascade. However, among euglenins and *Cryptophyceae* typical groups of fertile waters, the smallest surfaces were found at Czaniec, this supporting the results of chemical observations.

The positive influence of reservoirs on the state of purity of the river should be stressed; the very strongly polluted sector of the Soła in the region of Żywiec (left side) differed distinctly from the sectors of this river below the reservoirs.

Dam reservoirs create favourable conditions for the development of planktonic algae which are important in the process of water self-purification. The planktonic species developing in these reservoirs, such as *Chrysophyceae* (*Kephyrion*, *Chrysococcus*, *Mallomonas*), euglenins (*Trachelomonas nigra*), diatoms (*Cyclotella comta*, *Asterionella formosa*), and many green chlorococcous algae were found in the river seston below the reservoirs.

The action of river phytocenoses on the reservoirs situated below them was also observed since in their plankton various species of diatoms, often attached ones, originating from the river, were noted.

STRESZCZENIE

Badano glony osiadłe i sestonowe rzeki Soły na niektórych jej odcinkach w rejonie kaskady oraz plankton zbiorników zaporowych. Badania prowadzono w latach 1968 i 1969.

Soła w rejonie Żywca wykazywała znaczny stopień zanieczyszczenia, objawiający się obfitym występowaniem bakterii *Sphaerotilus natans*, innych bakterii oraz bezbarwnych wiciowców, obok okrzemek i sinic. Zbiorowiska glonów na Sole poniżej zbiorników świadczyły o poprawie stanu czystości wody.

W zbiornikach obserwowano podobną dominację fitoplanktonu w poszczególnych sezonach, a to w maju *Chrysophyceae*, natomiast w lipcu i we wrześniu *Bacillariophyceae*. Zaznaczył się również spadek ilości glonów we wrześniu, co świadczyłoby o zubożeniu zbiorników pod koniec sezonu.

Obserwowano ogólną tendencję obfitszego grupowania się glonów w górnych warstwach wody, a mianowicie złotowiciowców do 5 m, a okrzemek do 10 m głębokości.

Stwierdzono oddziaływanie zanieczyszczenia Soły i Żylicy na górne partie zbiornika w Tresnej, wykazującej szczególną obfitość glonów z przewagą euglenin, co świadczy o wyższym stopniu troficzności. Mniejszą liczebnością glonów odznaczało się natomiast stanowisko położone przy ujściu nie zanieczyszczonej Łękawki.

Ogólna liczba glonów, dosyć podobna w omawianych zbiornikach, nie wskazywałaby na spadek ich troficzności w kaskadzie, jak świadczą o niej wyraźnie zmniejszające się ilości chlorofilu i produkcji pierwotnej. Na spadek troficzności mógł natomiast wskazywać niejednakowy rozwój niektórych wskaźnikowych grup glonów jak chlorokokkowych, euglenin i kryptomonad, liczniejszych w górnej, zanieczyszczonej części zbiornika w Tresnej i Porąbce niż w Czańcu.

Zbiorniki zaporowe stwarzają korzystne warunki dla rozwoju glonów planktonowych, ważnych w procesie samooczyszczania wód. Wiele z nich obserwowano też w sestonie rzeki poniżej zbiorników. Stwierdzono również oddziaływanie fitocenozy rzeki na leżące poniżej zbiorniki; notowano bowiem w ich planktonie różne gatunki okrzemek, często poroślowych, występujące w rzece.

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