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SESSILE ALGAE IN LOWER SECTIONS OF THE MAIN TRIBUTARIES OF THE WIDAWKA RIVER*

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ABSTRACT: Sessile algae were collected from lower sections of the rivers: Rakówka, Pilsia, Krasawa, Grabia and Nieciecz. The investigated rivers lie within a cone of depression formed due to the construction of the lignite open mine Bełchatów. Quantitative and qualitative composition of algal communities was determined in the samples. In total, 417 taxa of algae and 3 taxa of bacteria were recorded - among them: 153 taxa from the Rakówka River, 211 taxa from the Pilsia River, 222 taxa from the Krasawa River, 220 taxa from the Grabia River, and 234 taxa from the Nieciecz River.

Contents

* The studies were carried out within the project WE 10.2.05 "Protection of the Environment in Large Industrial Agglomerations".

1. INTRODUCTION

Algae of the water-courses of the area of Bełchatów Industrial Region were already investigated in the main river of the region - Widawka River, in its tributary - Rakówka River and in the drainage channels of the lignite mine (K a d ł u b o w s k a et al. 1981). P a w ł o w s k i's work (1969) contains data about algae occurring in the Grabia River syrton. A list of algological studies on other water reservoirs in this area can be found in the paper by C z y ż e w s k a and O l a c z e k (1983).

Within the framework of the research project WE 10.2.05 there were undertaken investigations on sessile algae in the Widawka River and its main tributaries i.e. the Rakówka River, the Pilsia River, the Krasawa River, the Grabia River, the Nieciecz River and in the channels draining the lignite mine area. The first study on the above subject concerned sessile algae in the Widawka River (L i g o w s k i in press b).

The aim of the present study is to determine qualitative and quantitative composition of sessile algal communities in lower sections of the five above mentioned main tributaries of the Widawka River.

2. DESCRIPTION OF STUDY AREA

The investigated rivers are situated in the subprovince of Central Poland Lowland belonging to the province of Central European Lowland. Springs and upper sections of all investigated tributaries of the Widawka River are situated on Bełchatów Upland, and their middle and lower sections flow across Szczerców Valley. An exception here is the Grabia River, whose middle section flows across the Łask Upland (K o n d r a c k i 1978).

Almost the entire Widawka River along with its tributaries:

Rakówka, Pilsia, Krasawa and Nieciecz lie within a cone of depression formed due to the construction of the lignite open mine - Bełchatów (Czyżewska and Olaczek 1983).

Among the investigated tributaries of the Widawka River, the Rakówka River is a most polluted one (Hereźniak 1972), the Pilsia River is somewhat less polluted, especially in its lower section. Waters of such rivers as Grabia, Krasawa and Niecziecz are relatively clean (Szarkowski 1977, Maksymiuk 1979).

The Rakówka River is a right side tributary of the Widawka River (Fig. 1). The Rakówka River receives sewage from the towns of Bełchatów and Wola Krzysztoporska (Szarkowski 1977, Maksymiuk 1979). Its length is 20.4 km, surface of the drainage basin amounts to 147.9 km^2 and mean gradient is 1.79‰ (Maksymiuk 1980). At the place where samples were collected, near the brigde on the road from Słok to Bełchatów, the river is 4-5 m wide, and up to 0.5 m deep, its bottom is covered with silt and stones.

The Pilsia River is a right side tributary of the Widawka River (Fig. 1). In its spring section, the sewage from Zelów causes a considerable pollution of the water, while in its lower section the degree of pollution is smaller (Maksymiuk 1979). The Pilsia River is 30.0 km long, and its mean gradient is 1.95‰. Its drainage basin amounts to 192.3 km^2 (Maksymiuk 1980). At the station where samples were collected, i.e. near the road from Szczerców to Widawa, the river is about 4 m wide and its bottom is covered with sand and silt.

The Krasawa (Krasówka) River is a left side tributary of the Widawka River (Fig. 1). Its lenght is 34.2 km, mean gradient - 1.94‰ , and its drainage basin - 196 km^2 (Maksymiuk 1980). The samples were collected near the road from Szczerców to Wieluń, where the river is ca. 5 m wide and its bottom is covered with sand and stones.

The Grabia River is the largest tributary of the Widawka River (Fig. 1). Its is 82.1 km long, its mean gradient amounts to 1.07‰ , and its drainage basin amounts to 819.5 km^2 (Maksymiuk 1980). The samples were collected near the road from Górki Grabieńskie to Siedlce. At this station the river is ca.

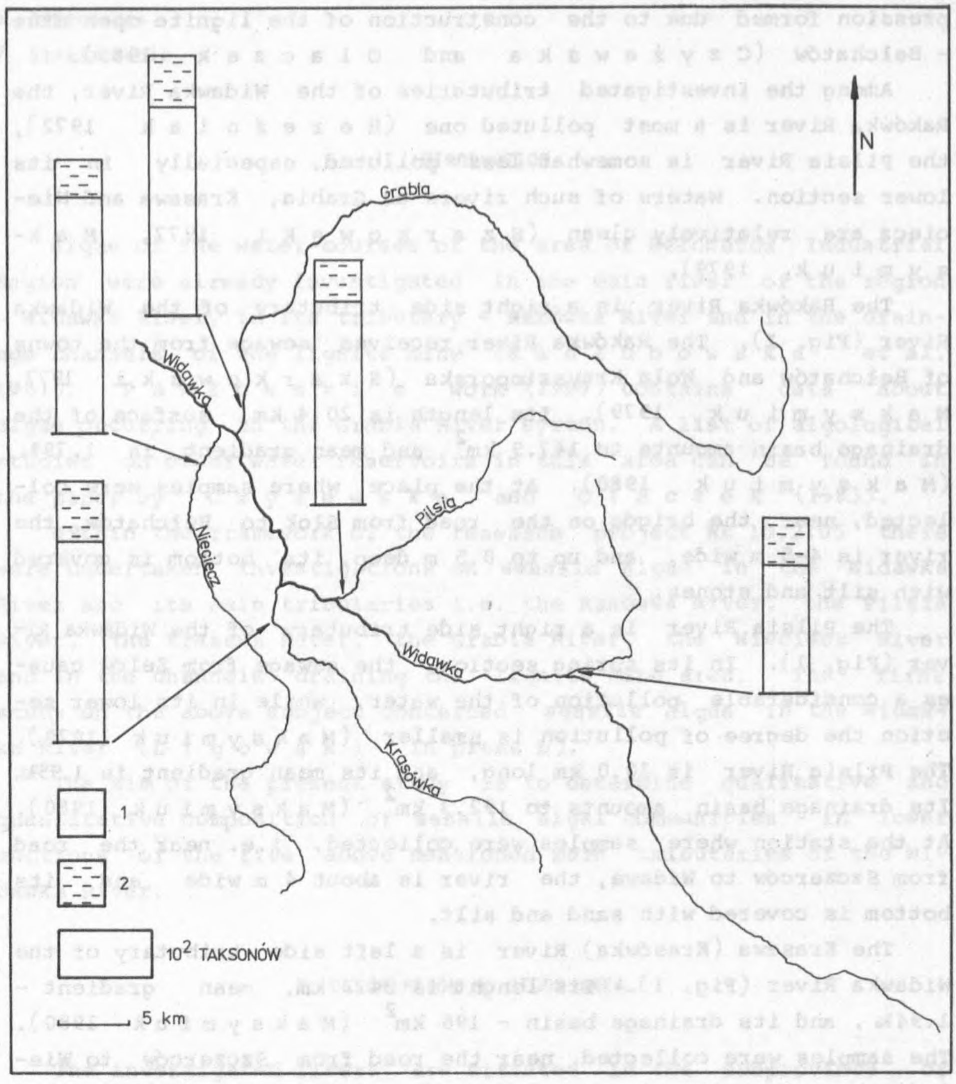

Fig. 1. Number of taxa of the sessile algae in lower sections of the main tributaries of the Widawka River

20 m wide and has a bottom covered with sand and stones and with silt in calm places.

The Niecierz River - a left side tributary of the Widawka River (Fig. 1) empties into Widawka near the town of Widawa, where the samples were taken. Its lenght is 49.5 km, mean gradient - 1.95‰, and drainage basin - 261.5 km^2 (M a k s y m i u k 1980). At the station where the samples were collected the river is about 15 m wide, and its bottom is covered with sand and stones.

The total drainage basin of the rivers: Rakówka, Pilsia, Krasawa, Grabia and Nieciecz amounts to 1617 km^2, which accounts for 66.6% of the total drainage basin of the Widawka River.

3. MATERIAL AND METHODS

The samples of permanently or accidentally sessile algae were collected near the bank of lower sections of the rivers: Rakówka, Pilsia, Krasawa, Grabia and Nieciecz on 15th May, 16th June, 15th July and 19th November 1982. Algae from stones and macrophytes were scraped off, and silt from the river's bottom was collected directly into submerged bottles. Immediately after their collecting, the samples were fixed by 2% formaline. A part of the samples were used to make permanent diatom slides in pleurax (S i e m i ń s k a 1964). In order to identify taxa, all specimens of diatoms present in permanent slides were checked. During the species determination procedure over 300 successive diatom valves were counted. These data were helpful in calculating percentage composition of diatom communities (C h o l n o k y 1968, K a l b e 1973). Algae belonging to other systematic groups were determined in water slides with glycerine added (S t a r m a c h 1955). The quantitative composition of algal community was established in the following way: the slide was done from a sample diluted in 1:4 ratio; the slide contained 0.05 cm^3 of this diluted sample and counting was performed in one-eigth part of a slide. The numbers specimens of particular diatom species were obtained taking into account percentage composition of diatom community determined on the basis of permanent slides. The algae whose number of cells accounted for over 5% the overall number of cells were recognized to be dominant.

While identifying taxa, the following papers were mainly utilized: B a r t a et al. (1976), C l e v e - E u l e r

(1951-1955), C o m p é r e (1975), H i n d a k and M a r v a n (1975), H u b e r - P e s t a l o z z i (1942, 1955), K a l b e (1973), K o r š i k o v (1953), P r e s c o t t (1973), R u ž i č k a (1973, 1977), S c h m i d t (1874-1959), S i e m i ń s k a (1964), S t a r m a c h (1966, 1968 a, b, 1972, 1977, 1983).

4. RESULTS AND DISCUSSION

4.1. Qualitative composition

A total of 417 algal taxa and 3 bacteria species were found in the samples of sessile algae from the rivers: Rakówka, Pilsia, Krasawa, Grabia and Niecierz. Among them were 30 taxa of *Cyanophyta*, 2 taxa of *Pyrrophyta*, 16 taxa of *Euglenophyta*, 316 taxa of *Chrysophyta* (with 313 taxa belonging to *Bacillariophyceae*), 52 taxa of *Chlorophyta*, and one taxon of *Rhodophyta* (Tab. I).

T a b l e I

Qualitative composition of sessile algae of lower sections of the Rivers: Rakówka, Pilsia, Krasawa, Grabia and Niecierz.
Date of sampling:
a - 1982.05.15, b - 1982.06.16, c - 1982.07.15, d - 1982. 11.18

Taxa	Station																			
	Rakówka				Pilsia				Krasawa				Grabia				Niecierz			
	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d
1	2				3				4				5				6			
Bacteriophyta																				
Leptothrix ochracea Kützing								+												
Sphaerotilus natans Kützing	+	+	+	+																
Zoogleae ramigera Itzigsohn.	+	+																		
Cyanophyta																				
Anabaena affinis Lemmermann	+																			
A. variabilis Kützing						+														
Anabaena sp.								+							+					
Cylindrospermum stagnale																				

Table I (contd.)

1	2	3	4	5	6
(Kützing) Bornet et Flahault				+	
Cylindrospermum sp.			+		
Gloeocapsa turgida (Kützing) Hollerbach		+	+	+	
Gomphosphaeria compacta (Lemmermann) Strom		+	+ +	+ +	
G. lacustris Chodat			+		
Lyngbya cryptovaginata Schkorbatoff			+ +		+
L. hieronymusii Lemmermann			+	+ +	
L. limnetica Lemmermann	+ +		+		+
Merismopedia glauca (Ehrenberg) Nägeli				+ +	+
M. tenuissima Lemmermann			+ +		+
Microcystis aeruginosa Kützing		+ +			
M. incerta (Lemmermann) Starmach		+			
Oscillatoria agardhii Gomont			+ + +	+	+ +
O. amoena (Kützing) Gomont			+		
O. brevis (Kützing) Gomont	+				
O. chalybaea (Mertens) Gomont	+				
O. limosa Agardh	+ + +		+ + +	+ +	+ + + +
O. pseudogeminata G. Schmid			+ + +		+ +
O. sancta (Kützing) Gomont	+		+		
O. tenuis Agardh	+ +		+		+
O. terebriformis Agardh				+	
Oscillatoria sp.	+ +				
Pseudanabaena schmidlei Jaag			+ +		
Pseudanabaena sp.	+				
Schizothrix sp.	+				
Spirulina maior Kützing				+	
Spirulina tennuissima Kützing			+		

Table I (contd.)

1	2	3	4	5	6
Pyrrophyta					
Gymnodinium sp.			+ +		
Peridinium sp.			+		
Euglenophyta					
Euglena spirogyra Ehrenberg	+				
Euglena sp.	+ + + +	+ +	+	+ +	+ + +
Lepocinclis ovum (Ehrenberg) Minkiewicz				+	+
Phacus acuminatus Stokes	+	+ +	+ +		+
Ph. acuminatus var. *megaparamylica* (Roll) Huber-Post.					+
Ph. caudatus Hübner					+ +
Ph. caudatus var. *tenuis* Swirenko	+				
Ph. longicauda (Ehrenberg) Dujardin		+			
Ph. mirabilis Pochman		+			
Ph. orbicularis Hübner		+	+		+
Ph. pleuronectes (Ehrenberg) Dujardin	+ +	+			
Ph. pyrum Ehrenberg				+	
Trachelomonas hispida (Perty) Stein	+	+	+ +	+	+ +
T. hispida var. *coronata* Lemmermann		+	+	+	+
T. oblonga Lemmermann	+		+ + +		
T. volvocina Ehrenberg	+ +		+ +	+ +	+ +
Chrysophyceae					
Dinobryon sertularia var. *protuberans* (Lemm.) Krieger		+			
Mallomonas sp.	+	+			
Bacillariophyceae					
Achnanthes affinis Grun.		+	+ +	+	+ +
A. clevei Grun.					+

Table I (contd.)

1	2	3	4	5	6
A. clevei var. *rostrata* Hust.					+
A. delicatula (Kütz.) Grun.		+	+ +	+ +	+ + + +
A. exilis Kütz.			+		
A. exiqua Grun.					+
A. exiqua var. *heterovalvata* Krasske		+			
A. hungarica Grun.	+ + +	+ + + +	+ +	+	+
A. lanceolata (Bréb.) Grun.	+ + +	+ + + +	+	+ + + +	+ + +
A. lanceolata f. *capitata* O. Müll.			+	+	+ +
A. lanceolata var. *elliptica* Cl.	+ + + +		+ +	+ + +	+ + + +
A. lanceolata var. *rostrata* (Østr.) Hust.	+	+ +	+ + + +	+ + +	+ +
A. lanceolata f. *ventricosa* Hust.	+ +	+			+
A. linearis (W. Sm.) Grun.		+	+ +	+	+ +
A. microcephala (Kütz.) Grun.				+	+
A. minutissima Kütz.				+	
A. peragallii Brun et Hérib.		+ +	+		
A. saxonica Krasske					+
Amphipleura pellucida Kütz.			+		
Amphora normanii Rabh.					+
A. ovalis Kütz.	+ + +	+ + + +	+ +	+ + + +	+ + + +
A. ovalis f. *gracilis* (Ehr.) Cl.					+
A. ovalis var. *libyca* (Ehr.) Cl.			+	+ +	
A. ovalis var. *pediculus* Kütz.		+	+ + + +	+ +	+ + +
A. veneta Kütz.			+		+
Anomoeoneis sphaerophora (Kütz.) Pfitz.				+	+ +
Asterionella formosa Hass.		+ +	+ + +	+ +	
Caloneis amphisbaena (Bory) Cl.	+ + +	+ +	+ + +	+ + +	+ + +

Table I (contd.)

1	2	3	4	5	6
C. bacillum (Grun.) Mer.		+ +	+ +	+ +	+ +
C. bacillum var. *lancettula* (Schulz) Hust.		+	+ +	+	+ + +
C. silicula (Ehr.) Cl.		+ +	+ +	+ +	+
C. silicula var. *gibberula* (Kütz.) Grun.	+		+	+	
C. silicula var. *truncatula* Grun.		+ +		+	+ +
C. silicula var. *ventricosa* (Ehr.) Donk.				+	+
Compylodiscus noricus var. *hibernica* (Ehr.) Grun.		+	+	+	+
Cocconeis diminuta Pant.	+		+	+ +	+ + + +
C. disculus (Schum.) Cl.		+ +	+		
C. pediculus Ehr.			+ + + +	+ + +	+ + + +
C. placentula Ehr.	+ + + +	+ + + +	+ + + +	+ + +	+ + +
C. placentula var. *euglypta* (Ehr.) Cl.		+ + + +	+ + +	+	+ + + +
C. placentula var. *intermedia* (Hérib. et Perag.) Cl.				+	
C. placentula var. *lineata* (Ehr.) Cl.			+	+	+
C. thumensis Mayer		+ +			+ +
Cyclotella comta (Ehr.) Kütz.	+		+ +		+
C. kützingiana Thw.			+ +		+
C. meneghiniana Kütz.	+ + + +	+ + + +	+ + + +	+ + +	+ + +
Cymatopleura elliptica (Bréb.) W. Sm.		+ +	+ +	+	+ + +
C. elliptica var. *hibernica* (W. Sm.) Hust.				+	
C. elliptica var. *nobilis* (Hantzsch) Hust.				+ +	
C. solea (Bréb.) W. Sm.	+ + + +	+ + + +	+ + +	+ + +	+ + +
C. solea var. *apiculata* (W. Sm.) Ralfs		+ + +	+	+ +	+ + +

Table I (contd.)

1	2	3	4	5	6
C. solea var. *gracilis* Grun.		+	+	+	
Cymbella affinis Kütz.			+		+
C. amphicephala Näg.			+		
C. aspera (Ehr.) Cl.	+	+ + +	+		+ +
C. cistula (Hemp.) Grun.		+	+ + +	+	+
C. cistula var. *maculata* (Kütz.) VH		+	+		
C. cuspidata Kütz.	+				
C. ehrenbergii Kütz.		+ + +	+ + +	+ +	+
C. lanceolata (Ehr.) VH	–	+	+ + +	+ + +	+ +
C. naviculiformis Auersw.	+	+ + + +	+ + +	+ +	+ + +
C. parva (W. Sm.) Cl.		+			
C. prostrata (Berkeley) Cl.				+	
C. reinhardtii Grun.					+ +
C. sinuata Greg.	+	+ + +	+	+	+ + +
C. tumida (Bréb.) VH			+		
C. turgida (Greg.) Cl.	+				
C. ventricosa Kütz.	+ + +	+ + + +	+ + + +	+ + + +	+ + + +
Diatoma elongatum (Lyngb.) Ag.			+ +	+	
D. vulgare Bory	+ +		+ + +	+ + +	+ + + +
Diploneis oculata (Bréb.) Cl.			+		
D. ovalis (Hilse) Cl.	+	+ +			+
D. smithii (Bréb.) Cl.	+ +				
D. smithii var. *pumila* (Grun.) Hust.				+	
Epithemia sorex Kütz.	+	+		+	+
E. turgida (Ehr.) Kütz.	+ +	+ + + +	+	+	+ +
E. turgida var. *granulata* (Ehr.) Grun.		+ +		+	
E. zebra (Ehr.) Kütz.	+ +	+ + + +	+	+ +	
E. zebra var. *porcellus* (Kütz.) Grun.	+	+	+		
E. zebra var. *saxonica* (Kütz.) Grun.		+ +			+

Table 1 (contd.)

1	2	3	4	5	6
Eunotia arcus Ehr.	+	+			+
E. arcus var. *fallax* Hust.		+			
E. diodon Ehr.		+			
E. lunaris (Ehr.) Grun.	+ + + +	+ +	+	+ +	+ +
E. lunaris var. *capitata* Grun.		+		+	
E. monodon var. *maior* (W. Sm.) Hust.		+			
E. pectinalis var. *minor* (Kütz.) Rabh.				+	
E. praerupta Ehr.		+ +	+		
Fragilaria bicapitata Mayer		+ +	+		
F. brevistriata Grun.	+	+ + +	+ + +	+	+ + +
F. capucina Desm.	+				
F. capucina var. *lanceolata* Grun.			+		
F. capucina var. *mesolepta* Rabh.		+	+		
F. construens (Ehr.) Grun.	+ + + +	+ + + +	+ + + +	+ +	+ + +
F. construens var. *binodis* (Ehr.) Grun.	+ + + +	+ + + +	+ + +	+ + +	+ + +
F. construens var. *subsalina* Hust.	+	+			
F. construens var. *venter* (Ehr.) Grun.	+ + +	+ + + +	+ + + +	+ +	+ + + +
F. crotonensis Kitt.			+		+ +
F. inflata (Heid.) Hust.			+		
F. intermedia Grun.	+ +	+ + + +	+ + + +	+ + +	+
F. leptostauron (Ehr.) Hust.		+ + +	+ + +	+ +	+
F. leptostauron var. *dubia* Grun.		+	+		
F. pinnata Ehr.	+	+	+ +		
F. pinnata var. *lancettula* (Schum.) Hust.				+	

Table I (contd.)

1	2	3	4	5	6
F. vaucheriae (Kütz.) Boye Pet.	+			+	
F. virescens Ralfs.					
F. virescens var. *capitata* Østr.	+	+			
F. virescens var. *elliptica* Hust.	+			+	
F. virescens var. *oblongella* Grun.				+	
Frustulia vulgaris (Thw.) De Toni	+ +	+ + +	+ + + +	+ + +	+ + + +
Gomphonema acuminatum Ahr.	+	+ + +	+		+ + +
G. acuminatum var. *brebissonii* (Kütz.) Cl.	+	+ +			
G. acuminatum var. *coronatum* (Ehr.) W. Sm.		+ + +	+	+ +	+ + +
G. acuminatum var. *trigonocephalum* (Ehr.) Grun.	+	+ + +			+
G. angustatum (Kütz.) Rabh.	+ + +	+ + + +	+ +	+ +	+
G. angustatum var. *productum* Grun.				+	+ + +
G. angustatum var. *sacrophagus* (Greg.) Grun.			+	+ +	+
G. angustatum var. *undulatum* Grun.					+
G. augur Ehr.		+			
G. augur var. *gautieri* V.H.					+
G. constrictum Ehr.	+ +	+ +	+ + +	+ + +	+ + +
G. gracile Ehr.			+ +		+
G. intricatum Kütz.		+	+	+	+
G. intricatum var. *pumilum* Grun.					+
G. intricatum var. *vibrio* (Ehr.) Cl.		+			
G. lanceolatum Ehr.	+	+ +			+

Table I (contd.)

1	2	3	4	5	6
G. longiceps var. *subclavatum* Grun.		+	+		
G. olivaceum (Lyngb.) Kütz.			+ + +	+ + +	+ + + +
G. olivaceum var. *calcareum* Cl.			+	+ +	+
G. olivaceum var. *minutissimum* Hust.			+		
G. parvulum (Kütz.) Grun.	+ + + +	+ + + +	+ + +	+ + +	+ + + +
G. parvulum var. *micropus* (Kütz.) Cl.			+	+ +	+
G. parvulum var. *subellipticum* Cl.			+	+	
Gyrosigma acuminatum (Kütz.) Rabh.					+ +
G. attenuatum (Kütz.) Rabh.	+	+ +	+ +	+	+ +
G. kützingii (Grun.) Cl.		+ +	+	+ +	+ + +
Hantzschia amphioxys f. *capitata* Hust.	+	+ + +		+	+ +
Melosira arenaria Moore				+	
M. granulata (Ehr.) Ralfs		+ +		+	
M. granulata var. *angustissima* (O. Müll.) Hust.		+	+		+
M. islandica O. Müll.		+			
M. italica (Ehr.) Kütz.	+	+ +		+	+ +
M. italica f. *curvata* (Pant.) Hust.					+
M. italica var. *tenuissima* (Grun.) O. Müll.		+			
M. varians Ag.	+ + +	+ + +	+ + + +	+ +	+ + + +
Meridion circulare Ag.	+ + + +	+ + + +	+ + + +	+ + +	+ + + +
M. circulare var. *constricta* (Ralfs) V.H.	+	+		+	+
Navicula amphibola Cl.	+	+ +			
N. anglica Ralfs	+		+		+
N. bacilliformis Grun.	+	+ +	+		+

Table I (contd.)

1	2	3	4	5	6
N. bacillum Ehr.	+	+ + +	+ + + +	+ + +	+ + +
N. bacillum var. *gregoryana* Grun.				+	
N. bacillum var. *rostrata* Mayer				+	
N. binodis Ehr.		+			
N. cari Ehr.		+ +	+ + +	+	+
N. cincta (Ehr.) Kütz.	+	+ + + +		+	+ + + +
N. cincta var. *heufleri* Grun.					+
N. clementis Grun.			+ +	+	+
N. cocconeiformis Greg.					+
N. contenta Grun.					+
N. costulata Grun.		+ +	+ + +	+ +	+ +
N. crypotocephala Kütz.	+ + +	+ + +	+ + + +	+ + + +	+ + + +
N. cryptocephala var. *intermedia* Grun.		+ + +	+ + + +	+ + +	+ + + +
N. cryptocephala var. *veneta* (Kütz.) Grun.		+	+ + + +	+ +	+ +
N. cuspidata Kütz.	+ +	+	+ + +	+ + +	+
N. cuspidata var. *ambigua* (Ehr.) Cl.	+ + +	+	+		+ + + +
N. dicephala (Ehr.) W. Sm.	+ +	+ +	+ +	+ + +	+
N. dicephala var. *neglecta* (Krasske) Hust.	+	+		+	
N. digitoradiata (Greg.) A. Sm.		+		+ + +	+
N. exigua (Greg.) O. Müll.	+ +	+ + +	+ + + +	+ + + +	+ + + +
N. gastrum Ehr.	+	+ + +	+ +	+ +	+ +
N. gracilis Ehr.	+		+ + + +	+ + +	+ + + +
N. graciloides Mayer	. +		+	+	
N. gregaria Donk.	+ + +		+ + +	+ + +	
N. halophila (Grun.) Cl.	+ + +				
N. hungarica Grun.					+
N. hungarica var. *capitata* (Ehr.) Cl.	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +

Table I (contd.)

1	2	3	4	5	6
N. hungarica var. *lüneburgensis* Grun.				+	+ +
N. integra (W. Sm.) Ralfs	+ + + +	+ + + +	+ +	+ +	+ + +
N. lanceolata (Ag.) Kütz.		+			+
N. menisculus Schum.		+ +	+ + +	+	+ + +
N. menisculus var. *meniscus* (Schum.) Hust.			+		
N. minima Grun.				+	
N. mutica Kütz.		+			+
N. mutica var. *cohnii* (Hilse) Grun.			+		
N. mutica var. *nivalis* (Ehr.) Hust.	+				
N. oblonga Kütz.		+ +	+ + + +	+	+ +
N. oppugnata Hust.		+	+ +	+ +	+
N. pelliculosa (Bréb.) Kütz.				+	
N. placentula (Ehr.) Grun.	+ + +	+ + + +	+ + +	+ +	+ +
N. placentula var. *jenissejensis* (Grun.) Meist.					+
N. placentula f. *latiuscula* (Grun.) Meist.				+	
N. placentula f. *rostrata* Mayer		+ +	+ +	+ + +	+
N. protracta Grun.	+ + +	+ + + +	+ + +	+	+ + +
N. protracta f. *elliptica* Gallik			+		
N. protracta f. *subcapitata* (Wisł. et Por.) Hust.				+ +	+
N. pupula Kütz.	+ +	+	+ + + +	+ +	+ + +
N. pupula var. *capitata* Hust.			+	+	+
N. pupula var. *elliptica* Hust.					+
N. pupula var. *rectangularis* (Greg.) Grun.		+ +	+ + +	+ +	+ + +
N. pygmaea Kütz.			+ +	+ +	+ +

Table I (contd.)

1	2				3				4				5				6			
N. radiosa Kütz.					+	+	+		+	+	+	+	+				+	+		
N. radiosa var. *tenella* (Bréb.) Grun.					+						+							+		
N. reinhardtii Grun.	+	+				+	+		+	+	+	+	+	+	+	+	+	+	+	+
N. reinhardtii var. *gracilior* Grun.										+				+	+			+		
N. rhynchocephala Kütz.					+	+	+	+	+	+	+		+	+	+		+	+		
N. rotaena Grun.	+	+		+	+	+	+	+	+				+	+			+			+
N. subhamulata Grun.									+	+		+					+			
N. tuscula (Ehr.) Grun.				+								+								
N. viridula Kütz.		+	+	+	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+
N. viridula var. *avenacea* (Bréb.) Grun.										+			+	+	+		+	+	+	
N. viridula var. *capitata* Mayer						+					+				+	+			+	
N. viridula var. *slesvicensis* (Grun.) Cl.		+			+	+		+		+				+	+		+	+		
Neidium affine (Ehr.) Cl.																			+	
N. affine var. *amphirhynchus* (Ehr.) Cl.	+	+	+	+	+	+					+	+	+	+	+		+		+	
N. bisulcatum (Lagerst.) Cl.													+							
N. dubium (Ehr.) Cl.				+				+		+	+	+	+		+	+	+	+		
N. dubium f. *constrictum* Hust.														+			+			
N. iridis (Ehr.) Cl.																			+	
N. iridis var. *amphigomphus* (Ehr.) V.H.					+									+						
N. iridis var. *ampliatum* (Ehr.) Cl.						+			+	+						+				+
N. iridis f. *vernale* Reich.			+			+			+	+		+						+	+	
N. opulentum Hust.													+					+		
N. productum (W. Sm.) Cl.			+															+	+	
Nitzschia acicularis W. Sm.	+	+	+	+		+			+	+	+	+	+	+	+	+	+	+	+	+
N. acuta Hantzsch												+	+				+			
N. amphibia Grun.			+			+		+				+	+		+	+			+	+

Table I (contd.)

1	2	3	4	5	6
N. angustata (W. Sm.) Grun.					+
N. apiculata (Greg.) Grun.					+ +
N. capitellata Hust.	+				
N. dissipata (Kütz.) Grun.	+		+ + + +	+	+ +
N. fonticola Grun.		+	+ + +	+	+ + +
N. frustulum (Kütz.) Grun.	+ +	+	+ +		+ +
N. gracilis Hantzsch				+	+
N. hantzschiana Rabh.					+
N. heidenii var. *pamirensis* Boye P.		+			+
N. hungarica Grun.					+
N. kützingiana Hilse					+ +
N. linearis W. Sm.	+ + + +	+ +	+	+ +	+ + +
N. palea (Kütz.) W. Sm.	+ + + +	+ +	+ + +	+ + +	+ + + +
N. palea var. *tenuirostris* Grun.	+				
N. parvula Lewis			+		
N. recta Hantzsch	+		+ +	+	+
N. sigmoidea (Ehr.) W. Sm.		+	+	+ +	+ + + +
N. sinuata var. *tabellaria* Grun.					+
N. stagnorum Rabh.	+ +			+ + +	
N. sublinearis Hust.		+			
N. thermalis Kütz.	+		+		+ +
N. thermalis var. *minor* Hilse					+
N. trybionella Hantzsch					+
N. trybionella var. *debilis* (Arn.) Mayer					+
N. vermicullaris (Kütz.) Grun.				+ + +	
Opephora martyi Hérib.	+ + + +	+ + + +	+ + + +	+ + +	+ + + +
Pinnularia acoricola Hust.			+		
P. borealis Ehr.	+		+ +	+ +	+
P. braunii (Grun.) Cl.				+	

Table I (contd.)

1	2	3	4	5	6
P. gibba Ehr.		+ +		+	+
P. gibba var. *subundulata* Mayer				+	
P. globiceps var. *krookei* Grun.					+
P. interrupta W. Sm.		+ +	+		+
P. lata (Bréb.) W. Sm.		+		+	
P. legumen Ehr.		+			
P. maior (Kütz.) Cl.		+		+	
P. maior var. *lacustris* Meist.		+			
P. mesolepta (Ehr.) W. Sm.		+		+ +	
P. mesolepta var. *angusta* Cl.	+ +	+			
P. microstauron (Ehr.) Cl.	+	+ +		+ +	+ +
P. microstauron f. *biundulata* O. Müll.		+			
P. microstauron var. *brebissonii* (Kütz.) Hust.		+ +	+	+	+
P. nobilis Ehr.		+ + +			
P. platycephala (Ehr.) Cl.		+			
P. viridis (Nitzsch) Ehr.	+	+ + +	+ + +	+ + +	+ + +
P. viridis var. *intermedia* Cl.	+				
Rhoicosphenia curvata (Kütz.) Grun.		+ +	+ + + +	+ + + +	+ + + +
Rhopalodia gibba (Ehr.) O. Müll.		+			+
Stauroneis acuta W. Sm.		+	+		+
S. anceps Ehr.	+ + +	+	+		+ +
S. anceps f. *gracilis* (Ehr.) Cl.				+	+
S. anceps f. *linearis* (Ehr.) Cl.	+	+			
S. phoenicentron Ehr.	+ + + +	+ + + +	+	+ + +	+ +

Table I (contd.)

1	2	3	4	5	6
S. pygmaea Krieg.		++		+	
S. smithii Grun.			+	++	++++
Stephanodiscus astraea var. *minutulus* (Kütz.) Grun.			+		
S. hantzschii Grun.		+	+++	+	+++
Surirella angustata Kütz.	+++	+++	++	++	++
S. biseriata Bréb.		+++	++	+	++
S. biseriata var. *bifrons* (Ehr.) Hust.			+	+	
S. biseriata var. *bifrons* f. *punctata* Meist.					+
S. biseriata var. *rostrata* Schulz			+		
S. elegans Ehr.		+			
S. linearis W. Sm.	+			+	+
S. linearis var. *constricta* (Ehr.) Grun.		++		+	
S. ovalis Bréb.				+	
S. ovata Kütz.	++++	+++		+++	++++
S. ovata var. *pinnata* (W. Sm.) Hust.	++				
S. ovata var. *pseudopinnata* Mayer					++
S. robusta var. *splendida* (Ehr.) VH					+
S. tenera Greg.			+	+	
S. turgida W. Sm.				+	
Synedra acus Kütz.	+	+	+++	+	
S. capitata Ehr.		+			
S. parasitica (W. Sm.) Hust.		+	+++		+
S. parasitica var. *subconstricta* Grun.				+++	++
S. pulchella (Ralfs) Kütz.		+	++		
S. rumpens Kütz.			+	+	
S. ulna (Nitzsch.) Ehr.	++++	++++	++++	++++	++++

Table I (contd.)

1	2	3	4	5	6
S. ulna var. *aequalis* (Kütz.) Hust.	+	+			
S. ulna var. *biceps* (Kütz.) Schönf.	+	+ +	+	+	+ +
S. ulna var. *danica* (Kütz.) Grun.		+			
S. ulna var. *oxyrhynchus* (Kütz.) VH	+		+ + +		+ +
S. ulna var. *spathulifera* Grun.	+		+		
Tabellaria fenestrata (Lyngb.) Kütz.					+
T. flocculosa (Roth.) Kütz.		+ + + +			
Xanthophyceae					
Tribonema viride Pasch.		+	+		
Chlorophyta					
Actinastrum hantzschii Lagh.	+		+		
Ankistrodesmus gracilis (Reinsch) Korš.			+		
Chlamydomonas sp.	+ +	+	+ + +		+
Cladophora glomerata (L.) Kütz.			+ +	+ +	+
Closterium acerosum (Schrank) Ehr.	+ + +			+	
C. ehrenbergii Menegh.	+ +		+	+	+
C. leiblenii Kütz.			+ + +	+	+ + +
C. lineatum Ehrenb.				+	+
C. littorale Gay					+
C. lunula (O. Müll.) Nitzsch	+				+
C. parvulum Näg.	+			+	
C. rostratum Ehrenb.				+	
C. strigosum Bréb.			+ +	+	
Coelastrum cambricum Arch.		+			
C. microporum Näg.		+ +		+ +	
C. reticulatum (Dang.) Senn.		+			

Table I (contd.)

1	2	3	4	5	6
Cosmarium botrytis Menegh.				+	+
C. reniforme Arch.				+	
Crucigenia quadrata Morren		+ +	+		
C. tetrapedia (Kirchn.) W. et G. S.		+			
Euastrum dubium Näg.		+			
Microspora amoena (Kütz.) Rabenhorst		+		+	
M. quadrata Hasen	+		+		
M. stagnorum (Kütz.) Lagerh.	+ +				
Monoraphidium contortum (Thur.) Kom. Legn.				+	
Oedogonium sp.			+	+	
Pandorina morum (O. F. Müller) Bory			+	+	
Pediastrum biradiatum Meyen		+			
P. boryanum (Turp.) Menegh.	+	+	+ + +	+ + +	
P. duplex Meyen		+	+ +	+	+
P. tetras (Ehr.) Ralfs		+			
Scenedesmus abundans (Kirchn.) Chod.	+		+ +		
S. acuminatus (Lagh.) Chod.	+		+	+	
S. acutiformis Schröd.			+ +		
S. acutus Meyen			+ +	+ +	+
S. brasiliensis Bohl.	+			+	
S. denticulatus Lagerh.			+		
S. disciformis (Chod.) Fott et Kom.			+		
S. intermedius Chod.	+				
S. obliquus (Turp.) Kütz.				+	
S. opoliensis P. Richt.	+				
S. quadricauda (Turp.) Bréb.	+ + +	+ + +	+ + +	+ + +	+ + +
S. velitaris Kom.		+	+ +		+
Spirogyra sp.	+ +			+	
Staurastrum gracile Ralfs		+			

Table I (contd.)

1	2	3	4	5	6
S. punctulatum Bréb.					+
Stigeoclonium tenue Kütz.	+				
Stigeoclonium sp.	+				
Tetraedron incus (Teil.) G. M. Sm.		+			
Tetrastrum staurogeniaeforme (Schröd.) Lemm.		+			
Ulothrix sp.	+		+		
Vaucheria sp.		+	+ + +	+	+ +
Rhodophyta					
Chantransia chalybaea (Roth) Fries		+ +		+ +	

The smallest number of sessile algae taxa was observed in the Rakówka River (Fig. 1), where especially low number of diatom taxa was found (Tab. II). The lower sections of other investigated tributaries of the Widawka River have similar number of sessile algae. Number of species in these rivers is considerable.

T a b l e II

Number of taxa of the sessile algae in lower sections of main tributaries of the Widawka River

Group	River				
	Rakówka	Pilsia	Krasawa	Grabia	Nieciecz
Cyanophyta	10	6	16	10	8
Pyrrophyta			2		
Euglenophyta	8	8	7	6	10
Chrysophyceae	1	2			
Bacillariophyceae	113	174	173	179	202
Xanthophyceae		1	1		
Chlorophyta	19	18	23	24	14
Rhodophyta		1		1	
Total	151	210	222	220	234

A similar number of species was observed in the lower section of the Widawka River (L i g o w s k i in press b). No major differences in the number of identified algae according to size of the river were revealed.

Diatoms appear to be a dominant algae in all the rivers studied. They constituted 74.8% of all species in the Rakówka River, 82.5% in the Pilsia River, 77.6% in the Krasawa River, 81.4% in the Grabia River, and 86.3% in the Nieciecz River. These values correspond to those met in other rivers in Poland. Such diatoms as *Navicula hungarica* var. *capitata* and *Synedra ulna* can be found in all samples, and *Cymbella ventricosa*, *Meridion circulare* and *Opephora martyi* in almost all of the samples.

The number of algal taxa in lower sections of some rivers in tne Central Poland is presented in Tab. III. In most rivers, the number of taxa of algae ranged from 195 to 263. The smallest number of taxa among various investigated rivers was discovered in the most polluted lower sections of the Rakówka River and the Bzura River. A high number of taxa identified in the Bobrówka River resuts from a considerable number of collected samples and from the drifting of pond algae to the river.

T a b l e III

Number of taxa of the sessile algae in lower sections of some rivers in Central Poland

River		Number of taxa
Bobrówka	(Ligowski in press a)	373
Bzura	(Rakowska 1976)	180
Grabia		220
Krasawa		222
Luciąża	(Kalinowska-Kucharska 1984 b)	238 (diatoms only)
Nieciecz		234
Pilsia		210
Rakówka	(Kadłubowska et al. 1981)	160
Rakówka		151
Rawka	(Rakowska 1984)	263
Strawa	(Kalinowska-Kucharska 1984 a)	237 (diatoms only)
Widawka	(Ligowski in press b)	195

It is interesting to note permanent presence of *Sphaerotilus natans* in the Rakówka River growing on stones and other objects on the river bottom. In spring also *Zoogleae ramigera* could be found there. (Tab. I). According to saprobic systems (Zelinka and Marvan 1961 quoted after F o t t 1971, Fjerdingstad 1964 quoted after E t t l 1980) *Zoogleae ramigera* is an indicator of the polysaprobic zone, while *Sphaerotilus natans* develops in flowing polysaprobic waters with a small amount of oxygen. The presence of these bacteria is accompanied by algal community with *Euglena* spp. and *Nitzschia palea*. T u r o b o y s k i (1979) believes that a community of diatoms growing with *Sphaerotilus natans* evidences that waters belong to α-mesosaprobic zone. Kolkwitz and Marsson (1908-1910 after P a l u c h 1973) are of the opinion that *Sphaerotilus natans* is an indicator of polysaprobic and α-mesosaprobic zones, and *Zoogleae ramigera* is an indicator of polysaprobic zone alone. Taking into account the above system an analysis of Tab. I indicates that the lower section of the Rakówka River in May and June should be considered more polluted than in later months. However, all the samples contained a considerable number of photosynthetic plants, which does not allow to classify this water among the most polluted.

The presence of the iron bacterium *Leptothrix ochracea* considered to be a "starving" from of *Sphaerotilus natans* was discovered in the sample taken from the Pilsia River in November. This is a species found in waters poor in organic compounds (P a l u c h 1973). In saprobic systems, this bacterium is considered to be an indicator of the oligosaprobic zone (P a l u c h 1973) similary to red alga *Chantransia chalybaea* (F o t t 1971) found also in this river. It is only in this river that *Tabellaria flocculosa*, another indicator of oligosaprobic waters (F o t t 1971) can be found. The permanent presence of single diatom specimens may be however caused by the drifting of their solid frustules by water currents in the river. *Chantransia chalybaea* was also found in the lower section of the Grabia River (Tab. I) and at various stations of the Widawka River (L i g o w s k i in press b).

Vaucheria sp. growing abundantly on the concrete bottom of the Widawka River (K a d ł u b o w s k a et al. 1981, L i g o w s k i in press b) was found in lower sections of its main tributaries in the Pilsia River, the Krasawa River, the Grabia River, and the Nieciecz River (Tab. I). *Vaucheria* sp. is considered to be an indicator of ß-mesosaprobic zone (F o t t 1971) or oligosaprobic zone (Fjerdinstad after E t t l 1980). The absence of this taxon in the lower section of the polluted Rakówka River is concordant with these opinions.

Several rare species of algae were found in the Widawka River basin. They will be analyzed in a separate study.

4.2. Quantitative composition

The largest number of cells was found in the lower section of the Rakówka River - on the average 8.1×10^6 per 1 cm^3. The smallest number of cells was observed in November - 0.5×10^6 per 1 cm^3, and the biggest in May - 23×10^6 per 1 cm^3 (Fig. 2). Together with algae, the bottom was covered by very abundant bacteria *Sphaerotilus natans* and *Zoogleae ramigera*, which were not counted. It was observed that the number of attached algal cells tended to decline during the vegetation season. Diatoms, among which *Nitzschia palea* constantly dominated, were found in the largest quantities. Blue-green algae belonging to *Oscillatoria* and euglenoid *Euglena* were found to be quite abundant.

In the Pilsia River the smallest number of algal cells was observed. This number ranged here from 0.19×10^6 per 1 cm^3 in July to 0.88×10^6 per 1 cm^3 in June (Fig. 2). In lower section of this river, the average number of 0.6×10^6 attached algae cells per 1 cm^3 was found. Among the dominant species were diatoms of the genus *Fragilaria* and mainly - *Fragilaria construens* with its varieties.

The average number of 6.7×10^6 cells per 1 cm^3 was observed in the lower section of the Krasawa River. The smallest number of algae cells per 1 cm^3 was discovered in July - 4.0×10^6 and the largest in June - 9.2×10^6 (Fig. 2). In late spring (May and June), apart from the dominant diatoms, there could be found blue-green algae from the genus *Oscillatoria* in large quantities. Among diatoms, *Navicula cryptocephala* and species from the genus *Fragilaria* were dominant.

In the Grabia River, the smallest number of cells was ob-

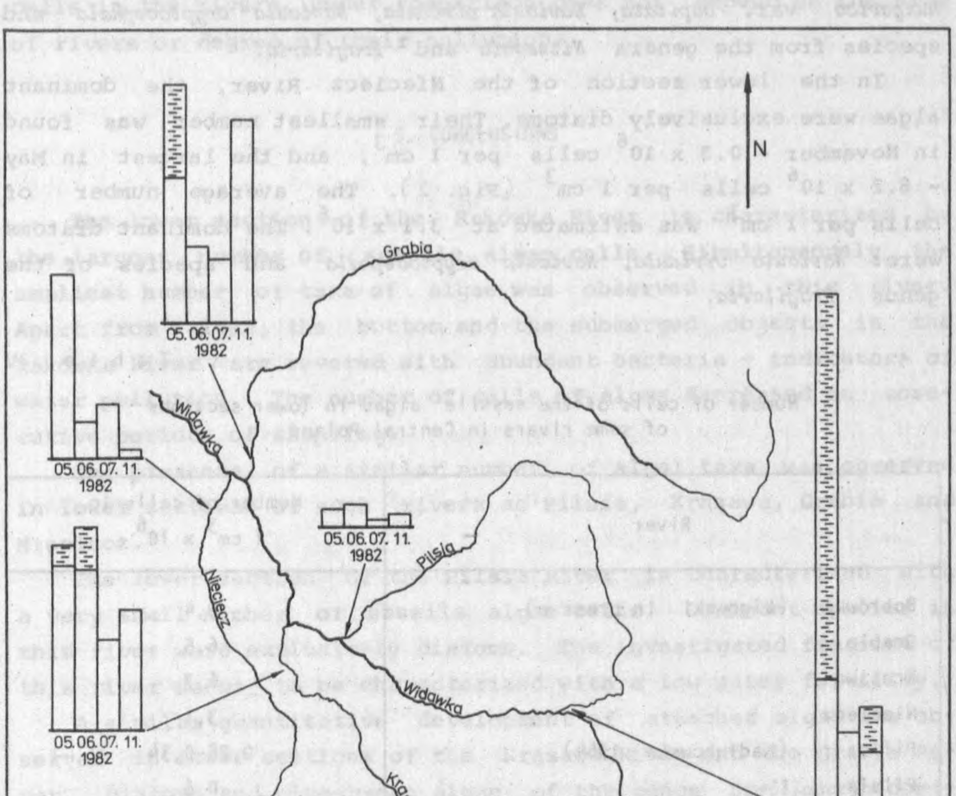

Fig. 2. Number of cells of the sessile algae in lower sections of the main tributaries of the Widawka River

served in July - 2.8 x 10^6 per 1 cm^3, and the largest in May - 10.7 x 10^6 per 1 cm^3 (Fig. 2). On the average the number of cells amounted to 6.5 x 10^6 per 1 cm^3. Blue-green alga *Oscillatoria limosa* was dominant in May (40.5% of the total number of cells) and in the remaining months - diatoms, mainly: *Navicula* *hungarica* var. *capitata*, *Navicula viridula*, *Navicula cryptocephala* and species from the genera *Nitzschia* and *Fragilaria*.

In the lower section of the Niecierz River, the dominant algae were exclusively diatoms. Their smallest number was found in November - 0.3 x 10^6 cells per 1 cm^3, and the largest in May - 8.2 x 10^6 cells per 1 cm^3 (Fig. 2). The average number of cells per 1 cm^3 was estimated at 3.1 x 10^6. The dominant diatoms were: *Navicula viridula*, *Navicula cryptocephala* and species of the genus *Fragilaria*.

Table IV

Number of cells of the sessile algae in lower sections of some rivers in Central Poland

River		Number of cells in 1 cm^3 x 10^6
Bobrówka	(Ligowski in press a)	9,4
Grabia		6,5
Krasawa		6,7
Nieciecz		3,1
Pilica	(Kadłubowska 1964)	0,28-0,34
Pilsia		0,6
Rakówka		8,1
Rawka	(Rakowska 1984)	29,0
Widawka	(Ligowski in press b)	6,0

The comparison with the number of attached algae cells recorded in lower sections of some rivers in Central Poland (Tab. IV) shows that the number of cells in 1 cm^3 in the Grabia River, the Krasawa River and the Rakówka River approaches that observed in the Bobrówka River (Ligowski in press a) and the Widawka River (Ligowski in press b). An exceptionally small number of cells per 1 cm^3 was observed in the Pilica River (Kadłubowska 1964) and the Pilsia River. The largest number of cells per 1 cm^3 is reported by Rakowska (1984) from the Rawka River - a right side tributary of the Bzura River. This comparison seems to indicate that the number of algal cells in the rivers under comparison does not depend on the size of rivers or degree of their pollution.

5. CONCLUSIONS

The lower section of the Rakówka River is characterized by the largest number of sessile algae cells. Simultaneously the smallest number of taxa of algae was observed in this river. Apart from algae, the bottom and the submerged objects in the Rakówka River are covered with abundant bacteria - indicators of water pollution. The number of cells of algae decreased in cosecutive periods of sampling.

The presence of a similar number of algal taxa was observed in lower sections of such rivers as Pilsia, Krasawa, Grabia and Nieciecz.

The lower section of the Pilsia River is characterized with a very small number of sessile algae cells. Dominant species in this river were exclusively diatoms. The investigated fragment of this river seems to be characterized with a low water fertility.

A similar quantitative development of attached algae was observed in lower sections of the Krasawa River and the Grabia River. Diatoms and blue-green algae of the genus *Oscillatoria* dominated in these rivers in spring. Maximum growth of diatoms was observed in spring months and in November. Dominant species of diatoms in the Krasawa River and in the Grabia River were also similar.

Only during the spring season an intensive growth of diatoms was recorded in the lower section of the Nieciecz River. Among dominant species other groups of algae were not recorded. The number of diatom taxa identified in this river was the highest.

Vaucheria sp., which is present in large quantities on the concrete bottom of the Widawka River (K a d ł u b o w s k a et al. 1981, L i g o w s k i in press b) was observed in lower sections of such rivers as Pilsia, Krasawa, Nieciecz, and Grabia in small quantities on the solid substrate like stones and piles. The presence of *Vaucheria* sp. was not discovered in the most polluted river of the Widawka basin - Rakówka.

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7. STRESZCZENIE

Badania glonów osiadłych głównych dopływów Widawki podjęte zostały w związku ze zmianą warunków hydrologicznych na tym obszarze, spowodowaną przez odkrywkę węgla brunatnego Bełchatów. Na podstawie prób zebranych w maju, czerwcu, lipcu i listopadzie 1982 r. z ujściowych odcinków Rakówki, Pilsi, Krasawy, Grabi i Niecieczy (rys. 1) określono skład jakościowy i ilościowy glonów osiadłych. Zidentyfikowano 417 taksonów glonów, z czego 313 należało do okrzemek oraz 3 gatunki bakterii (tab. I). Najczęściej występującymi glonami są okrzemki: *Navicula hungarica* var. *capitata*, *Synedra ulna*, *Cymbella ventricosa*, *Meridion circulare* i *Opephora martyi*. Najmniejszą liczbę gatunków stwierdzono w ujściowym odcinku Rakówki (tab. II). Jednocześnie w tej rzece występowała największa liczba komórek glonów (rys. 2). Fakty te oraz występowanie indykatorów wód α-mezosaprobowych i polisaprobowych wskazują na zanieczyszczenie ujściowego odcinka Rakówki. W składzie ilościowym we wszystkich rzekach dominowały okrzemki (rys. 2). W Krasawie, Grabi i Niecieczy obserwowano wiosenne maksimum rozwojowe glonów. Pilsia charakteryzuje się małą liczbą komórek glonów osiadłych w jej odcinku ujściowym.

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