Acta Hydrobiol., **42** (2000), 3/4, 95–122. Cracow, December 2000

Diversity of flora and fauna in running waters of the Province of Cracow (southern Poland) in relation to water quality. 6. Characteristics of rivers on the basis of phytoseston communities

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(Received 16 December 1996, Accepted 31 October 2000)

Abstract – In 1994, the mass appearance of potentially toxic cyanobacteria/cyanoprokaryota *Aphanizomenon flos-aquae* (L.) Ralfs and *Microcystis aeruginosa* Kütz. was observed in the Vistula. These species were used for estimation of the degree of water eutrophication, signalling deterioration of water quality at stations in vicinity of Cracow. Diatoms were helpful in assessment of different degrees of salinity (abundant colonies of *Bacillaria paradoxa* Gmelin, hitherto not reported from the Vistula), and pollution (numerous presence of *Cyclotella meneghiniana* Kütz. and *Fragilaria ulna* (Nitzsch) Lange-Bertalot). The stations in the middle course of the River Raba were characterized as those of good water quality (considerable share of rapidly reproducing chlorococcous green algae and desmids).

Key words: rivers, streams, phytoseston communities, indicator species, trophic state, pollution.

1. Introduction

There exists a commonly recognised belief that the bioseston of rivers is in the majority a mixture of benthic forms washed out from the substratum, with a small share of those typically planktonic, and accidentally occurring in this habitat. A considerable contribution of allochthonous forms, drifting with the water current down the rivers, originate from the dam reservoirs situated on them above (Bucka 1965, Siemińska 1952, Krzeczkowska-Wołoszyn and Bucka 1969, Bombówna and Bucka 1974, Kyselowa and Krzeczkowska-Wołoszyn 1974, Bombówna et al. 1978a, 1978b, Bucka 1986, 1991, Krzeczkowska-Wołoszyn 1991). Their numerous presence in rivers not divided by dams is also discussible.

The aim of the present elaboration is to pay attention to the dynamics of the development, especially of blue-greens and chlorococcous green algae, responding markedly to changes in the chemical composition of running waters, where they compete with diatoms more than once, or begin to dominate over them. In the recent past, the diatoms were still the group in riverine seston (Uherkovich 1970, Hanak-Szmager 1974). In the last few years mass development of blue-greens and planktonic green algae has been more often noted in strongly eutrophicated water bodies arising as a result of the river damming. They create multi-species 'water blooms', usually of the mixed type with other algae (Bucka 1987).

Taking this into consideration, a precise analysis of seston samples taken from the River Vistula and its affluents has been made. On the basis of other simultaneously investigated parameters (collective work), there was also an attempt to evaluate whether the most numerous species occurring within phytoseston communities (chiefly of cyanobacteria) are good indicators of changes in the trophic state and pollution of the rivers as those which have a greater effect on water quality.

2. Study area, material, and methods

The structure of algal communities in seston collected once (10–30 October 1994) from 38 stations was investigated. These stations were situated on the River Vistula and its tributaries, within the borders of the Province of Cracow (Fig. 1) presented by Wojtan et al. (2000). They were divided into groups according to their similarity, from the point of view of quality of the aquatic environment, when accepting the SIMI index (Stander 1970), clustered by the average linkage method. It is calculated according to the formula:

$$\mathrm{SIMI} = \left(\sum^{S} P_{ij}\, P_{in}\right) \Big/ \left(\sum^{S} P_{ij} \sum^{S} P_{in}\right)^{1/2}$$

where P_{ij} and P_{in} are average relative abundance expressed as a proportion of i-th species in the compared j-th and n-th communities, and S is the number of species. SIMI values range from 0 to 1, while value 1 indicates identical communities. The matrix of indices was imported to the SYSTAT program for making the cluster analysis.

Characteristics of stations distinguished on the studied rivers were based, above all, on the species being the most numerously represented in differentiated communities. They reflect the environmental conditions that have been in existence in a certain period, leading to the formation in the phytoseston of a specific species composition. However, it seems that for more precise and more authoritative estimations of water quality, it is necessary to have knowledge of the species ecology, both of those occurring in masses (Bucka 1989), as well as those not very numerous but presenting a certain indicator value (Turoboyski 1979). Results of biological analyses giving information about the occurrence of dominants in phytoseston communities and sessile algae (Kawecka and Kwandrans 2000), served for mutual comparison, taking into account physico-chemical investigations of the water simultaneously carried out (Wojtan et al. 2000).

Phytoseston samples were collected with a calibrated pail; 100 litres of water was filtered through a plankton net of ca. 50 μm meshes in diameter, and preserved with 4% formalin solution. For estimation the numbers of taxonomical units determined in the phytoseston, usually 2 preparations were calculated, (each every with a drop of known volume, i.e. 0.05 cm^3 (in sum 0.1 cm^3) or 3, in the case of samples poorer in algal cells. This method was applied after Starmach (1969), with a certain modification introduced in earlier publications by Bucka (1987).

For taxonomical determination of diatoms solid preparations embedded in a synthetic resin 'Pleurax' were made (Starmach 1963). Diatoms were identified applying the keys of Krammer and Lange-Bertalot (1986, 1988, 1991), introducing

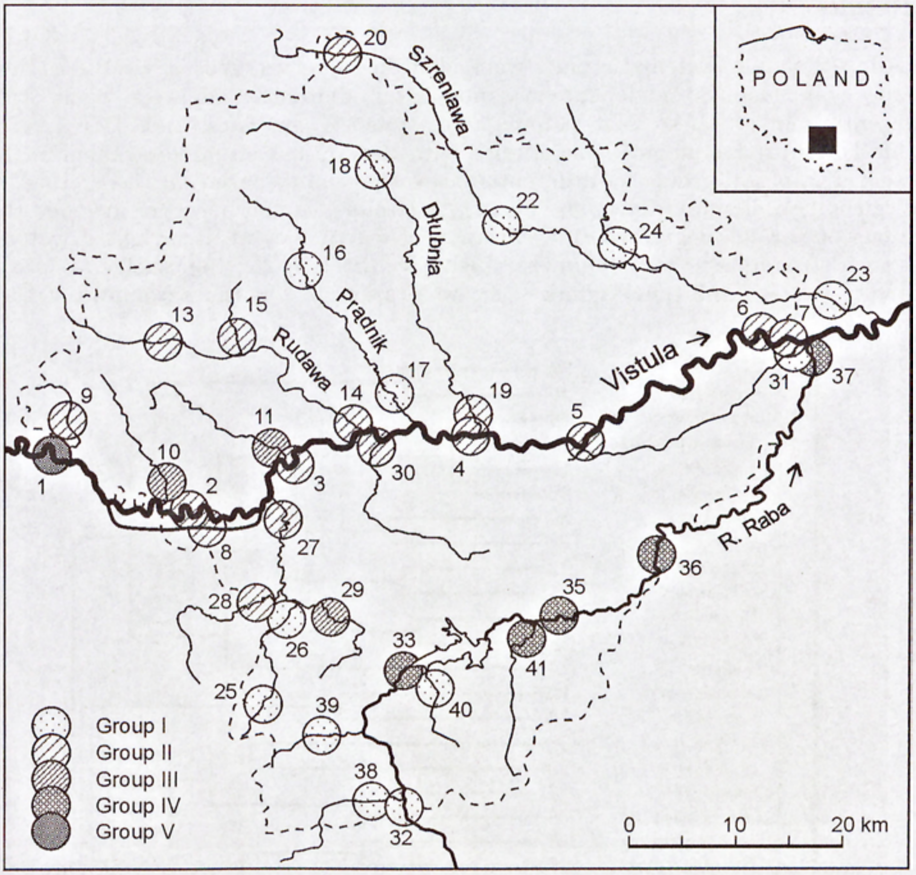

Fig. 1. Location of the studied stations in the Cracow Province and their classification according to similarities between phytoseston communities: 1–7 – the Vistula (1– Okleśna, 2 – Czernichów, 3 – Tyniec, 4 – Cracow, 5 – Niepołomice, 6 – Sierosławice, 7 – Uście Solne), 8 – the Łączany Canal, 9 – the Regulanka stream at Regulice, 10 – the Rudno stream at Przeginia, 11 – the Sanka stream above the water intake, 13, 14 – the River Rudawa (13 – Krzeszowice, 14 – Cracow), 15 – the Rudawka stream at Rudawa, 16, 17 – the Prądnik stream (16 – Ojców, 17 – Zielonki), 18, 19 – the Dłubnia stream (18 – Grzegorzowice, 19 – Zesławice), 20–23 – the River Szreniawa (20 – Przybysławice, 22 – Kacice, 23 – Biskupice), 24 – the Ścieklec stream at Mokocice, 25 – the Harbutówka stream at Biertowice, 26, 27 – the River Skawinka (26 – Radziszów, 27 – below the heated water discharge at Skawina), 28 – the Cedron stream at Wola Radziszowska, 29 – the Głogoczówka stream at Jaworzna, 30 – the Wilga stream at Swoszowice, 31 – the Drwinka stream at Świniary, 32–37 – the River Raba (32 – Lubień, 33 – Myślenice-Zarabie, 35 – Gdów, 36 – Książnice, 37 – Uście Solne), 38 – the Krzczonówka stream 1 km above its outflow into the Raba, 39 – the Trzebuńka stream at Stróża, 40 – the Trzemeśnianka stream at Łęki, 41 – the Krzyworzeka stream at Czasław.

a new nomenclature. These keys and the works of: Sládeček (1973), Hofmann (1994), and Van Dam et al. (1994) supported the data-estimating indicator value of diatom species. These last were next used for assessment of the trophic states and pollution of waters in the investigated rivers.

3. Results

Altogether 234 systematic units were identified (genera, species, and varieties) among cyanobacteria, euglenophytes, dinophytes, diatoms, and green algae with differentiation of these last, *Conjugatophyceae*: *Zygnemales* and *Desmidiales* (Table I). The rivers and streams studied with the stations situated on them might be sorted into five groups of differentiated water quality based on the method of the calculation of similarity index (Fig. 2). In Groups I a and b – were included the stations of various degree of differentiation of the quality of investigated waters, e.g. such streams as: the Szreniawa – Biskupice (Station 23), the Ścieklec – Mokocice (Station 24), and the Prądnik – Ojców (Station 16). In the Szreniawa stream

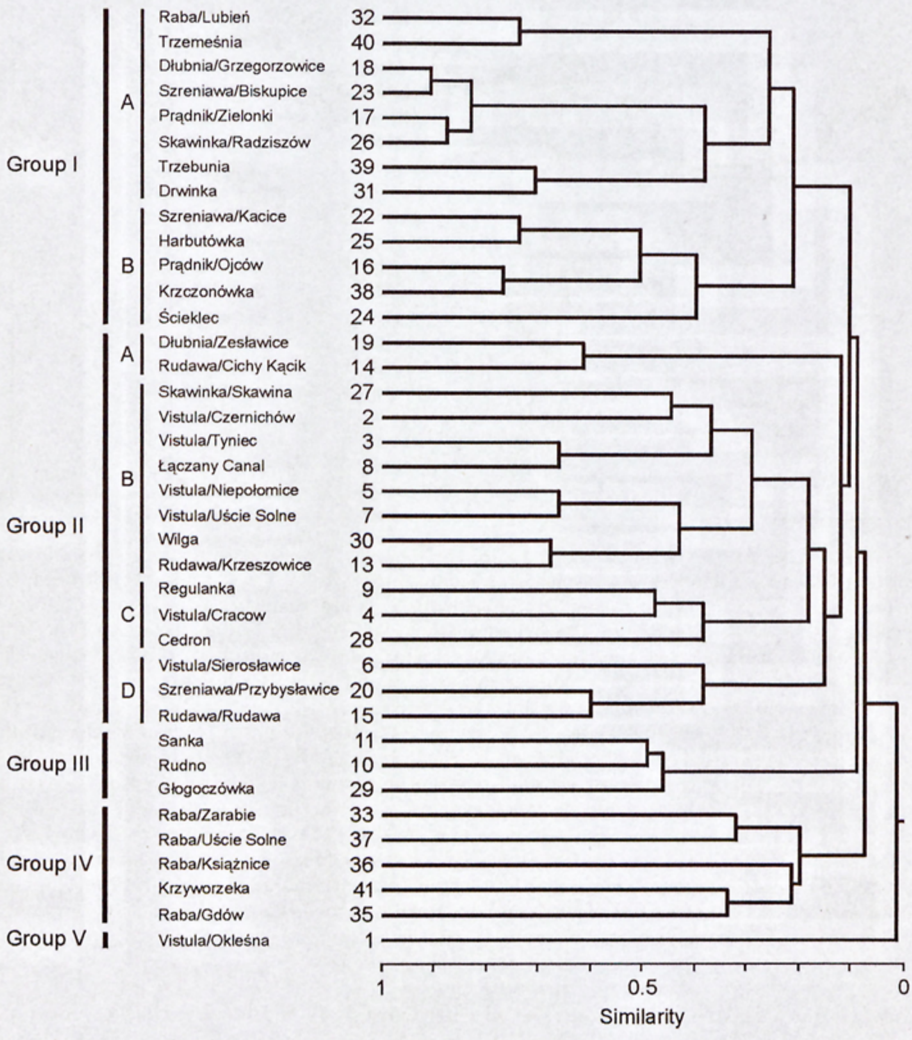

Fig. 2. Classification of stations (river/locality) on the basis of the amount of phytoseston taxa, using SIMI Index (Stander 1970).

(Station 23), Group I a, was found a mass development of blue-greens (mainly *Anabaena* spp. and *Aphanizomenon flos-aquae*), which characterized, better than diatoms, the real trophic state of the waters. However, in the Ścieklec stream (Station 24), Group I b, contained various diatom species, which attained a dominance signalizing the formation of a mixed water bloom, extremely rich in these algae. The most numerous development was revealed by the following diatoms: *Nitzschia thermalis, Surirella brebissonii* with var. *kützingii, Fragilaria ulna* and *F. ulna acus* group, *Meridion circulare, Nitzschia sigma/N. sigmoidea, Gyrosigma acuminatum*. The water of the Szreniawa stream together with the Ścieklec stream showed marked hardness along with an increased amount of phosphates, ammonia as well as nitrites, and temporary great concentrations of organic matter, causing deterioration of the oxygen conditions. In the Szreniawa – Kacice (Station 22), Group I b – a weaker growth of diatoms with the most numerous species *Fragilaria ulna* (tolerant of pollution) was noted. In the Prądnik stream (Station 16), Group I b – flowing through the Ojców National Park, was found a different of phytoseston communities manifesting a composition similar to that which is encountered in waters from pure oligothrophic to eutrophic (*Fragilaria pinnata* of wide ecological spectrum), with species tolerant of pollution and salinity (*Fragilaria ulna*), with a contribution of salt-water species (*Cymatopleura solea*), as well as that poor in electrolytes and resistant to low oxygen content (*Nitzschia sigmoidea*).

The most eutrophicated station of all those investigated in Group II a was the Dłubnia – River Zesławice (Station 19), with the mass appearance of diatoms (mainly *Asterionella formosa* and *Fragilaria ulna acus* group), and toxic blue-greens (particularly *Aphanizomenon flos-aquae*), forming a mixed water bloom (Fig. 3).

The Vistula at Stations 2–7 and Station 8 – the Łączany Canal (Groups II b and partially c, d) on the basis of physico-chemical data was not classified to any of the three classes of water purity, and was recognized as beyond the classification. A decisive significance in this classification were parameters such as: high electrolyte conductivity, high concentration of chlorides and sulphates, as well as of nutrients and organic matter, with low oxygen content, which gave evidence of strong pollution (the most numerous *Oscillatoria tenuis* – Stations 5 and 7) and salinity of its waters (*Bacillaria paradoxa* – mass occurrence of dense ribbon-like colonies – Station 4) with halophilous species (*Cyclotella meneghiniana* – Stations 6 and 7).

In the Szreniawa – Przybysławice (Station 20), Group II d – there took place an intensive growth of diatoms which are typical of biotopes rich in electrolytes (*Nitzschia thermalis*) and preferring salted inland waters (*Entomoneis paludosa* var. *subsalina*). They were accompanied by the euglenophytes (*Euglena proxima, Trachelomonas* spp.) preferring waters rich in organic matter.

Stations 20 and 22 localized in the upper course of the Szreniawa stream (consecutively at Przybysławice and at Kacice) were extremely poor in sessile algae (Kawecka and Kwandrans 2000) and zooseston (Żurek 2000). The afore-named authors found in the periphyton only single cells of diatoms and dying filaments of blue-greens and green algae that has not been confirmed by analysis of phytoseston.

The stations on the Vistula chosen according to their degree of similarity resulting from the water quality, corresponded with the structure of the indicator species. These were used for estimation, both of the state of water eutrophication (particularly cyanobacteria, chlorococcous green algae being an important component in the self-purification process of water), e.g. in the Vistula – Cracow

Fig. 3. Composition and abundance of the phytoseston communities in rivers and streams of the Cracow Province in October 1994 (numbers of stations explained in Fig. 1).

(Station 4), and volvocalean greens in the Vistula – Sierosławiec (Station 6), as well as being helpful in the evaluation of different degrees of salinity and pollution (principally diatoms) and resistance to the above environmental conditions (contribution of various tolerant species in the Vistula – Niepołomice (Station 5).

Group III represented pure habitats of high water quality (e.g. the Sanka – an affluent of the Vistula (Station 11), with poor microflora and typical species of fresh and salt water, as well as attached to clean waters (*Ceratium hirundinella*).

Group IV comprised the stations of the River Raba (Station 33 – Zarabie) and its affluent the Krzyworzeka – Czasław (Station 41), which in general showed good water quality. This was proved by the numerous share of diatom *Achnanthes minutissima* attached to well-oxygenated waters. These waters were the purest among the investigated stations of the middle course of the River Raba. They were characterized by low concentration of nutrients and often occurring oxygen supersaturation. The exception constituted the Raba reach, at Uście Solne (Station 37), with species (chiefly desmids) of damaged cell structures (i.e. genus *Closterium* spp.), which gave evidence of a certain degradation of this water environment.

In Group V, only one station was found, i.e. the Vistula – Okleśna (Station 1), with a sufficiently numerous contribution, especially of blue-greens, volvocalean greens (*Eudorina elegans*), desmids, and diatoms. These communities were characterised by numerous species, sufficiently rich in them, which pointed to eutrophication of the water.

In general at the studied stations, the phytoseston communities were distinguished by:

1. Great diversity of species, often cosmopolitan of wide ecological amplitude,

2. Large numbers of some species that corresponded with the criterion given for water blooms. These were formed by: cyanoprokaryota – *Aphanizomenon flos-aquae* (with associated species: *Anabaena* spp., *Oscillatoria* spp. and *Microcystis aeruginosa*), and diatoms, especially *Asterionella formosa, Cyclotella chaetoceras, Bacillaria paradoxa, Nitzschia thermalis* (with associated species: *Fragilaria ulna, Surirella brebissonii* var. *kützingii, Meridion circulare, Cyclotella meneghiniana, Nitzschia sigma/N. sigmoidea, Diatoma vulgaris*), the above mentioned species occurred the most abundantly in such rivers as: the Dłubnia – Zesławice (Station 19), the Szreniawa – Biskupice (Station 23), the Ścieklec – Mokocice (Station 24) and the Vistula – Cracow (Station 4), in which were formed multi-species water blooms,

3. Very small numbers of species, such as, e.g.: *Campylodiscus echeneis* – in the Regulanka stream (Station 9), the Rudno (Station 10), and the Rudawa – Krzeszowice (Station 13).

The richest in species were the stations on the following rivers: the Szreniawa Biskupice (67 taxa), the Vistula – Niepołomice and the Vistula – Sierosławiec (50 and 51 taxa consecutively), the Wilga – Swoszowice (53 taxa), and the Trzemeśnianka (49 taxa), whole the poorest in species were the stations on the River Drwinka (9 taxa) and also the Regulanka stream (13 taxa), similarly as in the rivers Rudawka and Rudawa. In the Drwinka there developed a fairly abundant community of desmids (different however, from the afore-cited), represented by the genera – *Spirogyra* and *Zygnema* with associated diatoms *Fragilaria ulna*.

Among the phytoseston taxa there were the following differentiated categories of species:

1. Species typical of strongly eutrophicated waters (cyanobacteria as above and diatoms – *Aulacoseira granulata* and *Asterionella formosa*, as well as chlorococcous green algae – *Scenedesmus* spp., *Pediastrum* spp.),

2. Species attached to slightly eutrophicated waters, with mean or increased electrolyte content (*Nitzschia vermicularis*) and to eutrophicated inland waters (*Melosira varians, Cocconeis pediculus*),

3. Species often encountered at the seacoast, and in inland waters rich in electrolytes (*Bacillaria paradoxa, Campylodiscus echeneis, Entomoneis paludosa* var. *subsalina, Nitzschia sigma*),

4. Freshwater and salt water species (*Surirella brebissonii* with var. *apiculata, Gyrosigma acuminatum, Cymatopleura solea, C. elliptica, Stauroneis phoenicentron, Gomphonema olivaceum*),

5. Species tolerant of pollution and salinity (*Fragilaria ulna, Nitzschia palea/N. capitellata, Cyclotella meneghiniana, Diatoma vulgaris, Navicula veneta*),

6. Species preferring waters usually clean, poor in electrolytes (*Nitzschia sigmoidea)* resistant to low oxygen content,

7. Species resistant to pollution and able to adapt of altered conditions in the aquatic environment, such as chlorococcous green algae (mainly genus *Scenedesmus* spp.), playing a great role in the self-purification process of waters, owing to their short life cycles, that ensure rapid renewal of their populations,

8. Species typical of waters strongly polluted and eutrophicated (*Oscillatoria tenuis, Nitzschia acicularis*),

9. Species resistant to toxic substances (*Stigeoclonium tenue*),

10. Species characteristic of pure waters (*Ceratium hirundinella, Fragilaria pinnata, Microspora amoena, Cocconeis placentula*),

11. Species preferring well-oxygenated waters (*Meridion circulare, Nitzschia linearis, Achnanthes minutissima*),

12. Species living in pure and polluted waters (*Nitzschia dissipata, Amphora ovalis* var. *pediculus*),

13. Species of brackish water – and salt-loving, hitherto not reported from the stations on the Vistula investigated at that time, (i. e. *Bacillaria paradoxa* – (Station 4), *Amphora coffeaeformis* (Station 6), and *Entomoneis paludosa* var. *subsalina* (Stations 2 and 4–7, as well).

4. Discussion

In running waters the physico-chemical parameters are subjected to seasonal and spatial differentiation depending on the hydrological conditions, which subsequently have a bearing on the structure of various communities of biocenosis, *inter alia* drift flora (e.g. phytoseston) as more labile in relationship to the communities of sessile algae.

A high contribution of some species in phytoseston, particularly of blue-greens or chlorococcous greens, as well as volvocalean green algae, also gives evidence concerning their ability to tolerate wide variations of environmental conditions. Its effect is a displacement of these algae, due to the constant flow of water masses to different distances along with river course, depending on its type (lowland, montane), depth, current velocity, etc. This explains, to a certain degree, the presence of taxa which often represent, in large or excessive numbers, the other algal communities, in comparison with those that colonise the riverine bed of a studied river. These are planktonic cyanobacteria typical of stagnant water reservoirs, in which appear water blooms.

In such a case, the evaluation of waters in the aspect of their trophic state (and pollutions) that has been carried out exclusively on the basis of the communities

Table I. List of phytoseston taxa recorded in rivers and streams of the Cracow Province. Abundance categories: + – <10 10^3 ind. L^{-1}, m – 10–500 10^3 ind. L^{-1}, ● – >500 10^3 ind. L^{-1}.

	Taxa	Stations																					
		Vistula								Left-side tributaries													
		1	2	3	4	5	6	7	8	9	10	11	13	14	15	16	17	18	19	20	22	23	24
	CYANOPROKARYOTA																						
1	*Anabaena circinalis* (Kütz.) Hansg. / *spiroides* Kleb.																					●	
2	– *solitaria* Kleb. f. *planctonica* (Brunth.) Komárek																					○	
3	*Aphanizomenon flos-aquae* (L.) Ralfs	+	+	+	+	+	+	+	+				+	+				+	●			○	
4	*Gomphosphaeria naegeliana* (Unger) Lemm.	+	+	+	+	+	+	+	+														
5	*Lyngbya* sp.				+							+					+		○				
6	*Microcystis aeruginosa* Kütz.	+	+	+	+	+			+					+					+			○	
7	*Merismopedia glauca* (Ehr.) Näg.	+																					
8	Oscillatoria sp.	+			+							+			+				○				
9	– *brevis* (Kütz.) Gom.					+														+			
10	– *limosa* Agardh												+				+						
11	– *tenuis* Agardh	+	+	+		+	+	+						+					+			○	
12	*Phormidium* sp.					+	+	+					+					+					
13	– *autumnale* (Agardh) Gom.																		+			+	
	EUGLENOPHYCEAE																						
14	*Euglena* sp.							+				+									+		
15	– *acus* Ehr.													+					+		+	+	
16	– *oxyuris* Schmarda																					+	
17	– *polymorpha* Dang.	+											+										
18	– *proxima* Dang.																	+		○		+	○
19	– *tripteris* (Duj.) Klebs							+					+	+					○				
20	– *viridis* Ehr.																	+					
21	*Lepocinclis ovum* (Ehr.) Lemm.																					+	
22	*Phacus* sp.																	+					
23	– *longicauda* (Ehr.) Duj.																		○				
24	– *pleuronectes* (O. F. Müll.) Duj.			+																			
25	– *tortus* (Lemm.) Skv.																	+				+	
26	*Trachelomonas* sp.																	+	+				○

Table I. *continued*

	Taxa	Stations																					
		Vistula								Left-side tributaries													
		1	2	3	4	5	6	7	8	9	10	11	13	14	15	16	17	18	19	20	22	23	24
27	– *intermedia* Dang.			+													+	+					
28	– *hispida* (Perty) Stein																			○			
29	– *volvocina* Ehr.				+													+	○	+		+	+
30	– *verrucosa* Stokes		+															+		+	+	+	+
31	– *pseudofelix* Defl.																	+					
32	– *scabra* Playf.																	○					+
	DINOPHYCEAE																						
33	*Ceratium hirundinella* (O. F. Müll.) Bergh		+			+	+	+		+	+	+	+		+				+			+	
34	*Gymnodinium* sp.						+	+															
35	Peridinium sp.			+	+																	+	
36	– *cinctum* (O. F. Müll.) Ehr.																		○				
	XANTHOPHYCEAE																						
37	*Characiopsis* sp.																						
	BACILLARIOPHYCEAE																						
38	*Actinocyclus normanii* (Gregory ex Grev.) Hust.	+	+	+				+										+					
39	*Achnanthes sp.*											+						+		+	+		+
40	– *lanceolata* (Bréb.) Grun.										+											+	+
41	– *minutissima* Kütz.																						
42	*Amphora* sp.																				+		
43	– *coffeaeformis* (Agardh) Kütz.				+		+																
44	– *pediculus* (Kütz.) Grun.										+									+			
45	*Asterionella formosa* Hassal					+	+												●	+			
46	*Aulacoseira granulata* (Ehr.) Simonsen	+	+			+		+	+					+								+	
47	*Bacillaria paradoxa* Gmelin	+	+	+	●	+	+	+			+			+								+	
48	*Caloneis* sp.																				+		
49	– *amphisbaena* (Bory) Cl.															+	+	+				+	
50	– *bacillum* (Grun.) Cl.												+				+			+			
51	– *silicula* (Ehr.) Cl.																						

52	*Campylodiscus echeneis* Ehr.									+	+		+										
53	*Cocconeis pediculus* Ehr.											+			+		+					+	+
54	– *placentula* Ehr.							+				+				+	+				+		
55	– *placentula* var. *euglypta* Ehr.															+							+
56	*Cyclotella* sp.	+			+	+	+	+	+					+						+			
57	– *chaetoceros* Lemm.																		○			+	+
58	– *comta* Kütz.		+																				
59	– *meneghiniana* Kütz.	+	+	+		+	+	+	+					+								+	
60	– *pseudostelligera* Hust.													+									
61	*Cymbella affinis* Kütz.																						
62	– *lanceolata* (Ehr.) Kirchn.									+	+											+	
63	– *minuta* Hilse / *silesiaca* Bleisch			+																	+		+
64	– *prostrata* (Berkely) Cl.																						
65	*Cymatopleura elliptica* (Bréb.) W. Sm.										+				+		+						
66	– *solea* (Bréb.) W. Sm.										+				+	○	+				+	+	
67	– *solea* var. *apiculata* (W. Sm.) Ralfs															+	+	+	○		+	+	
68	*Diatoma vulgaris* Bory				+	+						+	+	+		+	+	+	○	+	+	+	+
69	– *vulgaris* var. *brevis* Grun.													+							+		+
70	*Entomoneis paludosa* var. *subsalina* (Cl.) Krammer		+		+	+	+	+												○			
71	*Eunotia pectinalis* (Dillwyn?, O.F. Müll.?, Kütz.) Rabenh.																						+
72	*Fragilaria* sp.						+					+					+	+					
73	– *capucina* Desm.																						
74	– *capucina* var. *vaucheriae* (Kütz.) Lange-Bertalot														+								
75	– *crotonensis* Kitton																		+				
76	– *fasciculata* (Agardh) Lange-Bertalot		+																				
77	– *pinnata* Ehr.										+					○							
78	– *pulchella* (Ralfs) Lange-Bertalot	+	+	+											+								
79	– *ulna* (Nitzsch) Lange-Bertalot		+		+	+	+	+			+	+	+	+		○	○	○			○	+	○
80	*ulna* group *acus*			+		+	+	+						+					○	+		+	○
81	*Gomphonema* sp.																						
82	– *angustatum* (Kütz.) Rabenh.																			+	+		
83	– *augur* Ehr.																						
84	– *constrictum* Ehr.																						
85	– *olivaceum* (Hornemann) Bréb.		+														+		○	+	○	+	
86	– *olivaceum* var. *calcareum* Cl.																						
87	– *parvulum* (Kütz.) Kütz.				+		+										+		+	+			+

Table I. *continued*

	Taxa	Stations																					
		Vistula								Left-side tributaries													
		1	2	3	4	5	6	7	8	9	10	11	13	14	15	16	17	18	19	20	22	23	24
88	– *truncatum* Ehr.																						
89	*Gyrosigma acuminatum* (Kütz.) Rabenh.									+		+		+	+	○	○	+	○		+	+	○
90	*Hantzschia amphioxys* (Ehr.) Grun.																						
91	*Melosira* sp.																						
92	– *nummuloides* (Dillwyn) Agardh		+																				
93	– *varians* Agardh		+	+	○	+	+	+	+		+	+		+						+	+	+	+
94	*Meridion circulare* (Greville) C.A. Agardh																	+		+	+	+	○
95	*Navicula* sp.																	+			+		
96	– *capitata* Ehr.			+	+															+		+	+
97	– *capitatoradiata* Germain													+		+							
98	– *cryptocephala* Kütz.				+		+			+	+	+				+	+	+			+	+	+
99	– *cuspidata* (Kütz.) Kütz.																				+		
100	– *exigua* (Gregory) Grun.										+												
101	– *gregaria* Donkin										+	+											
102	– *lacunolaciniata* Lange-Bertalot et Bonik																+						
103	– *menisculus* Schumann									+	+						+	+	○		+		+
104	– *radiosa* Kütz.																					+	+
105	– *rhynchocephala* Kütz.																						+
106	– *salinarum* Grun. / *trivialis* Lange-Bertalot					+		+	+	+	+	+				+							
107	– *slesvicensis* Grun. / *viridula* (Kütz.) Ehr.		+			+		+						+		+	+	○		+		+	+
108	– *subminuscula* Manguin																						
109	– *tripunctata* (O. F. Müll.) Bory			+	+	+	+			+				+		+	+					+	
110	– *veneta* Kütz.	+			+					+				+		+	+	+			+		+
111	*Neidium* sp.																				+		
112	– *dubium* (Ehr.) Cl.															+							
113	– *productum* (W. Sm.) Cl.													+									
114	*Nitzschia* sp.																	+		+	+		+
115	– *acicularis* (Kütz.) W. Sm.			+	+	+	+	+	+					+		+					+	+	+
116	– *angustata* Grun.																						
117	– *amphibia* Grun.	+			+			+															

118	– *calida* Grun.														+								
119	– *dissipata* (Kütz.) Grun.																			+		+	+
120	– *linearis* (Agardh) W. Sm.									+			+				+	+	○	+		+	+
121	– *hungarica* Grun.																						
122	– *palea* (Kütz.) W. Sm.			+				+			+	+				+						+	
123	– *palea / capitellata* Hust.	+			○	+	+	+	+														
124	– *recta* Hantzsch.							+				+	+			+							
125	– *sigma* (Kütz.) W. Sm.	+	+	+	+	+	+	+					+	+		○	+						
126	– *sigmoidea* (Nitzsch) W. Sm.									+	+	+		+		○	○	+	○			+	
127	– *sigma / sigmoidea*																					+	○
128	– *thermalis* (Kütz.) Auerswald		+				+							+						○	+	+	●
129	– *vermicularis* (Kütz.) Hantzsch												+					○		+	+	+	
130	*Opephora martyi* Heribaud																			+	+		
131	*Stauroneis phoenicentron* (Nitzsch.) Ehr.										+					+	+	+					
132	*Stephanodiscus rotula* (Kütz.) Hendey		+	+		+																	
133	*Surirella* sp.																			+			
134	– *angusta* (Kütz.)				+																		+
135	– *biseriata* Bréb.											+											
136	– *brebissonii* Krammer et Lange-Bertalot				+											+	+	+		+	+	+	+
137	– *brebissonii* var. *kuetzingii* Krammer et Lange-Bertalot						+									+	+	+	○		+	+	○
138	– *elegans Ehr.*									+	+				+								
139	– *linearis* W. Sm.												+										+
140	– *splendida* (Ehr.) Kütz.																						
141	*Thalassiosira pseudonana* Halse et Heimdal				+																		
	CHLOROPHYCEAE																						
142	*Actinastrum aciculare* Playf.																					+	
143	*Ankistrodesmus* sp.														+							+	
144	– *falcatus* (Corda) Ralfs						+	+															
145	– *longissimus* (Lemm.) Wille						+																
146	– *pseudomirabilis* Korš.																					+	
147	– *minutissimus* Korš.						+																
148	*Botryococcus braunii* Kütz.			+	+	+			+														
149	*Chaetophora* sp.														+								
150	*Characium* sp.																	+					
151	*Chlamydomonas* sp.															+	+	+	○	+		+	+

Table I. *continued*

	Taxa	Stations																					
		Vistula								Left-side tributaries													
		1	2	3	4	5	6	7	8	9	10	11	13	14	15	16	17	18	19	20	22	23	24
152	*Cladophora* sp.											+											
153	– *glomerata* (L.) Kütz.		+			+											+		+				
154	*Coelastrum* sp.																					+	
155	– *microporum* Näg.					+	+	+														+	
156	– *proboscideum* Bohl.		+		+	+																+	
157	*Coleochaete* sp.														+								
158	*Crucigenia apiculata* Schmidle	+							+					+								+	
159	– *irregularis* Wille																			+			
160	– *quadrata* Morren					+	+													+			
161	– *rectangularis* (Näg.) Gay						+																
162	– *tetrapedia* (Kirchn.) W. et G. S. West																					+	
163	*Dictyosphaerium* sp.							+															
164	– *ehrenbergii* Näg.																						
165	– *pulchellum* Wood					+																	+
166	*Eudorina elegans* Ehr.	+	+	+		+	+		+										○				
167	*Enteromorpha* sp.			+	+	+	+	+	+														
168	*Lagerheimia wratislaviensis* Schröd.												+										
169	*Micractinium quadrisetum* (Lemm.) G. M. Sm.						+																
170	*Microspora* sp.			+	+	+			+														
171	– *amoena* (Kütz.) Rabenh.									+													
172	*Monoraphidium* sp.						+																
173	*Oedogonium* sp.																						
174	*Pandorina morum* (Müll.) Bory					+	+												○				
175	*Pediastrum biradiatum* Meyen		+	+	+		+																
176	– *boryanum* (Turp.) Menegh.	+	+	+	+	+	+	+						+						+			
177	– *duplex* Meyen	+	+	+	+			+	+					+					○				○
178	– *simplex* Meyen	+		+	+				+					+					+				
179	*Raphidonema longiseta* Vischer			+		+	+	+						+			+	+	+	+			
180	*Scenedesmus* sp.					+		+											+				
181	– *acuminatus* (Lagerh.) Chod.																		○	+		+	○

182	– *acuminatus* var. *biseriatus* Reinh.			+	+	+	+	+							
183	– *armatus* Chod.						+		+						
184	– *arcuatus* (Lemm.) Lemm.						+								
185	– *bicaudatus* Dedus.		+	+			+	+						+	+
186	– *bijuga* (Turp.) Lagerh.						+								
187	– *brasiliensis* Bohl.				+									+	
188	– *ecornis* (Ehr.) Chod.							+					+		
189	– *intermedius* Chod.					+	+	+							
190	– *lefevrii* Defl.														
191	– *longus* Meyen var. *naegelii* (Bréb.) G. M. Sm.														
192	– *maximus* (W. et G. S. West) Chod.														
193	– *obliquus* (Turp.) Kütz.						+	+						+	
194	– *opoliensis* P. Richt.				+	+	+	+						+	+
195	– *protuberans* Fritsch												○		+
196	– *producto-capitatus* Schmula			+											
197	– *quadricauda* Chod.	+				+					+			+	
198	– *quadricauda* var. *maximus* W. et G. S. West					+	+	+				+			
199	– *spinosus* Chod.					+	+	+						+	+
200	*Schizomeris leibleinii* Kütz.	+	+												
201	*Sphaerocystis schroeterii* Chod.														
202	*Stigeoclonium* sp.	+	+			+	+								
203	*Stigeoclonium tenue* Kütz.									+					
204	*Tetrastrum staurogeniaeforme* (Schröd.) Lemm.														+
205	*Tetraedron minimum* (A. Br.) Hansg.												+	+	
	CONJUGATOPHYCEAE														
	Zygnemales														
206	*Mougeotia* sp.		+						+	+					
207	*Spirogyra* sp.	+	+			+		+						+	
208	*Zygnema* sp.		+								+				
	Desmidiales														
209	*Closterium* sp.							+							
210	– *aciculare* T. West					+									
211	– *acerosum* (Schrank) Ehr.	+	+	+	+	+		+		+					
212	– *dianae* Ehr.														
213	– *ehrenbergii* Menegh.	+		+		+									

Table I. *continued*

	Taxa	Stations																					
		Vistula								Left-side tributaries													
		1	2	3	4	5	6	7	8	9	10	11	13	14	15	16	17	18	19	20	22	23	24
214	– *gracile* Bréb.	+	+	+	+	+	+	+	+										○				
215	– *setaceum* Ehr.				+	+	+	+															
216	– *littorale* Gay																						
217	– *moniliferum* (Bory) Ehr.																						
218	– *strigosum* Bréb.	+												+									
219	– *parvulum* Näg.																						
220	– *pritchardianum* Arch.																						
221	*Cosmarium botrytis* Menegh.																						
222	– *formosulum* Hoffm.																						
223	– *subcrenatum* Hantzsch																						
224	*Desmidium* sp.																						
225	*Micrasterias* sp.																						
226	*Penium phymatosporum* Nordst.	+																					
227	*Pleurotaenium* sp.		+																				
228	*Staurastrum* sp.	+																					
229	– *gracile* Ralfs																						
	RHODOPHYTA																						
230	*Chantransia* sp.									+		+						+					

Table I. *continued*

	Taxa	Stations															
		Right-side tributaries							River Raba and tributaries								
		25	26	27	28	29	30	31	32	33	35	36	37	38	39	40	41
	CYANOPROKARYOTA																
1	*Anabaena circinalis* (Kütz.) Hansg. / *spiroides* Kleb.			+								+					
2	– *solitaria* Kleb. f. *planctonica* (Brunth.) Komárek																
3	*Aphanizomenon flos-aquae* (L.) Ralfs			+													
4	*Gomphosphaeria naegeliana* (Unger) Lemm.		+	+		+					+	+	+				
5	*Lyngbya* sp.			+													
6	*Microcystis aeruginosa* Kütz.		+	+													
7	*Merismopedia glauca* (Ehr.) Näg.													+		+	
8	Oscillatoria sp.					+				+							
9	– *brevis* (Kütz.) Gom.											+					
10	– *limosa* Agardh				+	+	+									+	
11	– *tenuis* Agardh	+	+	+	+	+	+										
12	*Phormidium* sp.																
13	– *autumnale* (Agardh) Gom.																
	EUGLENOPHYCEAE																
14	*Euglena* sp.																
15	– *acus* Ehr.						+										
16	– *oxyuris* Schmarda																
17	– *polymorpha* Dang.																
18	– *proxima* Dang.																
19	– *tripteris* (Duj.) Klebs																
20	– *viridis* Ehr.																
21	*Lepocinclis ovum* (Ehr.) Lemm.																
22	*Phacus* sp.																
23	– *longicauda* (Ehr.) Duj.																
24	– *pleuronectes* (O. F. Müll.) Duj.																
25	– *tortus* (Lemm.) Skv.																
26	*Trachelomonas* sp.				+		+										

Table I. *continued*

	Taxa	Stations															
		Right-side tributaries							River Raba and tributaries								
		25	26	27	28	29	30	31	32	33	35	36	37	38	39	40	41
27	– *intermedia* Dang.																
28	– *hispida* (Perty) Stein																
29	– *volvocina* Ehr.			+													
30	– *verrucosa* Stokes																
31	– *pseudofelix* Defl.																
32	– *scabra* Playf.																
	DINOPHYCEAE																
33	*Ceratium hirundinella* (O. F. Müll.) Bergh		+	+						+	+						
34	*Gymnodinium* sp.																
35	Peridinium sp.																
36	– *cinctum* (O. F. Müll.) Ehr.																
	XANTHOPHYCEAE																
37	*Characiopsis* sp.															+	
	BACILLARIOPHYCEAE																
38	*Actinocyclus normanii* (Gregory ex Grev.) Hust.																
39	*Achnanthes sp.*	+			+	+	+										
40	– *lanceolata* (Bréb.) Grun.			+							+						
41	– *minutissima* Kütz.		+	+			+		+	+	+	+	+	+		+	+
42	*Amphora* sp.				+												
43	– *coffeaeformis* (Agardh) Kütz.																
44	– *pediculus* (Kütz.) Grun.											+	+	+		+	
45	*Asterionella formosa* Hassal																
46	*Aulacoseira granulata* (Ehr.) Simonsen											+					+
47	*Bacillaria paradoxa* Gmelin											+					
48	*Caloneis* sp.																
49	– *amphisbaena* (Bory) Cl.				+		+										
50	– *bacillum* (Grun.) Cl.																
51	– *silicula* (Ehr.) Cl.				+												

52	*Campylodiscus echeneis* Ehr.																
53	*Cocconeis pediculus* Ehr.	○	+				+		+	+	+	+	+	+	+	+	+
54	– *placentula* Ehr.				+							+					
55	– *placentula* var. *euglypta* Ehr.	+	+						+		+	+	+	+	+	+	+
56	*Cyclotella* sp.	+			+				+	+		+	+			+	
57	– *chaetoceros* Lemm.			+			+		+		+					+	
58	– *comta* Kütz.			+							+						
59	– *meneghiniana* Kütz.	+	+	+	+	+					+	+				+	+
60	– *pseudostelligera* Hust.																
61	*Cymbella affinis* Kütz.				+				+	+		+	+	+	+	+	+
62	– *lanceolata* (Ehr.) Kirchn.						+			+	+	+	+		+		
63	– *minuta* Hilse / *silesiaca* Bleisch						+				+	+				+	
64	– *prostrata* (Berkely) Cl.										+					+	+
65	*Cymatopleura elliptica* (Bréb.) W. Sm.		+		+							+	+				
66	– *solea* (Bréb.) W. Sm.						+										
67	– *solea* var. *apiculata* (W. Sm.) Ralfs		+		+	+											
68	*Diatoma vulgaris* Bory	+	+	+	+		+		+		+	+	+	+			+
69	– *vulgaris* var. *brevis* Grun.		+														
70	*Entomoneis paludosa* var. *subsalina* (Cl.) Krammer																
71	*Eunotia pectinalis* (Dillwyn?, O.F. Müll.?, Kütz.) Rabenh.																
72	*Fragilaria* sp.													+			
73	– *capucina* Desm.											+	+	+		+	
74	– *capucina* var. *vaucheriae* (Kütz.) Lange-Bertalot						+				+						
75	– *crotonensis* Kitton						+						+				+
76	– *fasciculata* (Agardh) Lange-Bertalot																
77	– *pinnata* Ehr.										+	+	+				+
78	– *pulchella* (Ralfs) Lange-Bertalot			+													
79	– *ulna* (Nitzsch) Lange-Bertalot	○	+		+	+	○	+		+			+	+	+	+	+
80	*ulna* group *acus*			+				+									
81	*Gomphonema* sp.									+							
82	– *angustatum* (Kütz.) Rabenh.	+							+					+			
83	– *augur* Ehr						+										
84	– *constrictum* Ehr.						+										
85	– *olivaceum* (Hornemann) Bréb.	+	+				+		+		+	+	+		+	+	
86	– *olivaceum* var. *calcareum* Cl.						○										
87	– *parvulum* (Kütz.) Kütz.						+									+	

Table I. *continued*

	Taxa	Stations															
		Right-side tributaries							River Raba and tributaries								
		25	26	27	28	29	30	31	32	33	35	36	37	38	39	40	41
88	– *truncatum* Ehr.													+		+	
89	*Gyrosigma acuminatum* (Kütz.) Rabenh.			+	+	+	+		+		+	+	+		+	+	
90	*Hantzschia amphioxys* (Ehr.) Grun.						+										
91	*Melosira* sp.			+			+								+		
92	– *nummuloides* (Dillwyn) Agardh																
93	– *varians* Agardh	+	+	+	+		+	+	+	+	+	+	+		+	+	+
94	*Meridion circulare* (Greville) C.A. Agardh																
95	*Navicula* sp.	+									+			+			
96	– *capitata* Ehr.				+		+									+	
97	– *capitatoradiata* Germain										+				+		
98	– *cryptocephala* Kütz.	+	+		+		+										
99	– *cuspidata* (Kütz.) Kütz.						+										
100	– *exigua* (Gregory) Grun.				+				+	+			+	+			
101	– *gregaria* Donkin	○	+	+	+	+	+					+				+	
102	– *lacunolaciniata* Lange-Bertalot et Bonik																
103	– *menisculus* Schumann	+	+												+		+
104	– *radiosa* Kütz.																
105	– *rhynchocephala* Kütz.	+			+											+	
106	– *salinarum* Grun. / *trivialis* Lange-Bertalot			+		+		+			+				+		
107	– *slesvicensis* Grun. / *viridula* (Kütz.) Ehr.	+	+	+	+		+				+				+	+	+
108	– *subminuscula* Manguin	+															
109	– *tripunctata* (O. F. Müll.) Bory	+	+	+	+				+		+			+	+	+	
110	– *veneta* Kütz.	○	+				+		+	+	+	+	+	+	+	+	+
111	*Neidium* sp.																
112	– *dubium* (Ehr.) Cl.		+			+	+									+	
113	– *productum* (W. Sm.) Cl.				+												
114	*Nitzschia* sp.	+															
115	– *acicularis* (Kütz.) W. Sm.	+											+				
116	– *angustata* Grun.		+				+										
117	– *amphibia* Grun.						+										

118	– *calida* Grun.	+		+													
119	– *dissipata* (Kütz.) Grun.		+				+						+		+	+	+
120	– *linearis* (Agardh) W. Sm.		+												+	+	
121	– *hungarica* Grun.						+										
122	– *palea* (Kütz.) W. Sm.	+	+				+				+		+		+	+	+
123	– *palea / capitellata* Hust.	+	+	+		+											
124	– *recta* Hantzsch.				+											+	
125	– *sigma* (Kütz.) W. Sm.			+		+	+							+		+	
126	– *sigmoidea* (Nitzsch) W. Sm.	+	+		+	+	+					+		+	+	+	
127	– *sigma / sigmoidea*																
128	– *thermalis* (Kütz.) Auerswald	+		+	+		+		+					+		+	
129	– *vermicularis* (Kütz.) Hantzsch																
130	*Opephora martyi* Heribaud																
131	*Stauroneis phoenicentron* (Nitzsch.) Ehr.																
132	*Stephanodiscus rotula* (Kütz.) Hendey																
133	*Surirella* sp.		+														
134	– *angusta* (Kütz.)																
135	– *biseriata* Bréb.						+										
136	– *brebissonii* Krammer et Lange-Bertalot		+														
137	– *brebissonii* var. *kuetzingii* Krammer et Lange-Bertalot						+						+		+		
138	– *elegans Ehr.*				+		+										
139	– *linearis* W. Sm.				+		+										
140	– *splendida* (Ehr.) Kütz.				+	+	+										
141	*Thalassiosira pseudonana* Halse et Heimdal																
	CHLOROPHYCEAE																
142	*Actinastrum aciculare* Playf.																
143	*Ankistrodesmus* sp.																
144	– *falcatus* (Corda) Ralfs																
145	– *longissimus* (Lemm.) Wille																
146	– *pseudomirabilis* Korš.																
147	– *minutissimus* Korš.																
148	*Botryococcus braunii* Kütz.																
149	*Chaetophora* sp.																
150	*Characium* sp.																
151	*Chlamydomonas* sp.																

Table I. *continued*

	Taxa	Stations															
		Right-side tributaries							River Raba and tributaries								
		25	26	27	28	29	30	31	32	33	35	36	37	38	39	40	41
152	*Cladophora* sp.				+											+	
153	– *glomerata* (L.) Kütz.	+	+						+	+	+	+	+				
154	*Coelastrum* sp.																
155	– *microporum* Näg.																
156	– *proboscideum* Bohl.																
157	*Coleochaete* sp.																
158	*Crucigenia apiculata* Schmidle													+			
159	– *irregularis* Wille																
160	– *quadrata* Morren																
161	– *rectangularis* (Näg.) Gay																
162	– *tetrapedia* (Kirchn.) W. et G. S. West	+		+													
163	*Dictyosphaerium* sp.																
164	– *ehrenbergii* Näg.															+	+
165	– *pulchellum* Wood												+			+	
166	*Eudorina elegans* Ehr.																
167	*Enteromorpha* sp.		+														
168	*Lagerheimia wratislaviensis* Schröd.																
169	*Micractinium quadrisetum* (Lemm.) G. M. Sm.																
170	*Microspora* sp.					+	+						+				+
171	– *amoena* (Kütz.) Rabenh.															+	
172	*Monoraphidium* sp.																
173	*Oedogonium* sp.		+		+						+			+		+	
174	*Pandorina morum* (Müll.) Bory																
175	*Pediastrum biradiatum* Meyen									+							
176	– *boryanum* (Turp.) Menegh.		+	+		+			+	+	+	+	+		+	+	+
177	– *duplex* Meyen			+												+	
178	– *simplex* Meyen			+													
179	*Raphidonema longiseta* Vischer																
180	*Scenedesmus* sp.															+	
181	– *acuminatus* (Lagerh.) Chod.									+							

182	– *acuminatus* var. *biseriatus* Reinh.																
183	– *armatus* Chod.																
184	– *arcuatus* (Lemm.) Lemm.										+					+	+
185	– *bicaudatus* Dedus.			+													
186	– *bijuga* (Turp.) Lagerh.													+			
187	– *brasiliensis* Bohl.															+	
188	– *ecornis* (Ehr.) Chod.			+							+						
189	– *intermedius* Chod.																
190	– *lefevrii* Defl.										+						
191	– *longus* Meyen var. *naegelii* (Bréb.) G. M. Sm.													+			
192	– *maximus* (W. et G. S. West) Chod.													+			
193	– *obliquus* (Turp.) Kütz.		+						+	+		+					
194	– *opoliensis* P. Richt.			+									+				
195	– *protuberans* Fritsch																
196	– *producto-capitatus* Schmula																
197	– *quadricauda* Chod.											+		+			
198	– *quadricauda* var. *maximus* W. et G. S. West																
199	– *spinosus* Chod.															+	
200	*Schizomeris leibleinii* Kütz.																
201	*Sphaerocystis schroeterii* Chod.					+											
202	*Stigeoclonium* sp.											+	+				+
203	*Stigeoclonium tenue* Kütz.																
204	*Tetrastrum staurogeniaeforme* (Schröd.) Lemm.																
205	*Tetraedron minimum* (A. Br.) Hansg.																
	CONJUGATOPHYCEAE																
	Zygnemales																
206	*Mougeotia* sp.						+			+		+	+				+
207	*Spirogyra* sp.						+	+			+			+	+	+	+
208	*Zygnema* sp.							+									
	Desmidiales																
209	*Closterium* sp.																
210	– *aciculare* T. West																
211	– *acerosum* (Schrank) Ehr.	+		+	+		+		+	+		+	+		+		+
212	– *dianae* Ehr.																
213	– *ehrenbergii* Menegh.					+	+	+	+		+	+	+				

Table I. *continued*

	Taxa	Stations															
		Right-side tributaries							River Raba and tributaries								
		25	26	27	28	29	30	31	32	33	35	36	37	38	39	40	41
214	– *gracile* Bréb.			+													
215	– *setaceum* Ehr.																
216	– *littorale* Gay	+														+	
217	– *moniliferum* (Bory) Ehr.		+		+					+	+		+		+	+	
218	– *strigosum* Bréb.				+			+									+
219	– *parvulum* Näg.								+								
220	– *pritchardianum* Arch.													+			
221	*Cosmarium botrytis* Menegh.							+									
222	– *formosulum* Hoffm.											+	+				
223	– *subcrenatum* Hantzsch												+				
224	*Desmidium* sp.			+													
225	*Micrasterias* sp.												+				
226	*Penium phymatosporum* Nordst.																
227	*Pleurotaenium* sp.																
228	*Staurastrum* sp.												+				
229	– *gracile* Ralfs																
	RHODOPHYTA																
230	*Chantransia* sp.	+		+													

of sessile algae, seems to be incomplete, because it does not comprise other conditions of the riverine habitat, in which dominate the communities of drift flora. Their constant study at chosen stations in the river, not only reflects the actual trophic state of its waters, but facilitates catching of the changes in their structure and abundance, during lower and raised river stages, which in biological monitoring of surface running waters is important for the assessment of the correct class of their purity.

Investigation of phytoseston communities simultaneously with studies of sessile algae, or their exclusive preference in biological monitoring of rivers, in spite of criticism, is still applied in practice.

Recently, many authors have endeavoured to use diatoms alone for river classification. According to Whitton (1991) they prevail over other algal groups, on account of their better elaborated taxonomy.

Another conception concerning the evaluation of water quality was presented by Fernandez-Pinas et al. (1991). They recommended for this purpose the use of some genera from cyanobacteria (*inter alia Oscillatoria, Anabaena, Nostoc*), found in the seston of two rivers studied in central Spain. They analysed the development of these blue greens using Spearman's correlation index (Bell et al. 1982), against a background of seasonal variability and chosen physico-chemical parameters determined in a riverine environment during sample collection. The authors pointed out great differences, which should not be generalized, as concerns the structure and development of cyanoprokaryota. The relationship between eutrophic conditions and the appearance of cyanobacteria in freshwater ecosystems cannot be attributed to all their genera.

Their studies showed that high concentrations of phosphates and ammonium nitrogen in river water, are associated with very low concentrations of dissolved oxygen. Therefore, some genera of cyanobacteria (e.g. *Oscillatoria*) reach greater abundance in these trophic conditions, so they may be indicators of the trophic state of the waters. However, other blue greens (e.g. *Nostoc*) dominate in waters of the opposite trophic state, which took place in the rivers investigated by the above authors.

In the present writer's studies on the phytoseston of the rivers in the Province of Cracow, the following cyanobacteria occurred in masses or also were very numerous: *Aphanizomenon flos-aquae, Anabaena* spp., *Oscillatoria* spp. Generally, they are recognised as potentially toxigenic and having a negative effect on the organoleptic properties of water. Consequently, the ascertainment of their dense populations in the phytoseston of some rivers causes a feeling of fear, as concerns a safe use of such waters for recreation or immediate consumption.

In the case of evaluation of the toxic effect of running waters on the basis of abundant occurrence of some cyanobacteria, admitted to being an indicator species, one may accept their decisive prevalence over diatoms.

The dam reservoirs in the catchment basin of the Upper Vistula and damming reaches of this river are subjected to strong eutrophication (Wróbel 1983). After the raised water stages in summer water blooms are formed mainly caused by the development of cyanobacteria (e.g. their presence in the Goczałkowice Reservoir is the most often connected with *Microcystis aeruginosa, Anabaena spiroides*, and *Aphanizomenon flos-aquae*). Bednarz and Żurek (1988) reported a more numerous appearance of this last blue-green in a mixed association – *inter alia* with the diatom – *Asterionella formosa*, on the basis of their own studies of seston (at the turn of 1982 and 1983) in a polluted sector of the Upper Vistula (first Stations 1–6, especially the weir at Łączany).

On the example of the Rożnów Reservoir it was confirmed that the phytoseston structure in the river below the dam has changed as the effect of an intensive and mass occurrence of algae in the reservoir itself (Bucka 1986).

One should take into consideration the possibility of the formation in these rivers, under favourable conditions, of a specific phytoseston composition with a mass share of planktonic cyanobacteria, this being a symptom of increased eutrophication of the water environment.

In summing up, the River Vistula is sewage-loaded; moreover, owing to hydrotechnical construction (weirs), it has a reduced velocity of water flow. This reflects the slowing down of the course of the self-purification process (Kwandrans 1988), in comparison, e.g. with the River Raba characterized by a faster flow (differentiated in particular seasons of the year) and greater potential possibilities towards self purification of the waters (Bombówna 1966). In this process such an important role in phytoseston is played by chlorococcous algae of short life cycles, resistant to pollution, and adapting to altered environmental conditions. For example, Kawecka and Kwandrans (2000) report dense populations of diatom *Achnanthes minutissima* (indicator of waters rich in oxygen) in the periphyton of the Raba, among abundant aggregates of the filamentous green alga *Cladophora glomerata*.

The ignoring of phytoseston studies, especially those concerning the dominance of some planktonic cyanoprokaryota, not found or sparsely noted in rivers among assemblages of sessile algae, restricts a reliable evaluation of the quality of their waters and their division into the appropriate class of water purity.

This was confirmed in the case of phytoseston studies at some stations of the rivers and streams which were enclosed in Group I a (especially the Szreniawa – Biskupice (Station 23) with an intensive contribution of *Anabaena* spp. in the association with *Aphanizomenon flos-aquae*. These cyanoprokaryota were not found in the composition of sessile algal communities (Kawecka and Kwandrans 2000).

Moreover, the cyanophytes dominated in the phytoseston of the majority of stations, mainly in the Dłubnia – Zesławice (Station 19), Groups II a–d, with a mass appearance of *Aphanizomenon, Oscillatoria* spp., *Phormidium* sp., and *Microcystis aeruginosa*. Among them, particularly *Microcystis* and *Aphanizomenon*, form strong surface water blooms in reservoirs of stagnant waters. Commonly, they are recognized as some indicators of increased water eutrophication, which with their occurrence in masses are dangerous, on account of the production of toxins.

The results obtained from phytoseston analyses, although based on once-collected samples, provided important data, stressing out the usefulness of investigations of its communities, to catch not only chlorococcous green algae, excessively developed within them in recent years, but also planktonic cyanoprokaryota (e.g. *Aphanizomenon flos-aquae*). This species has a wide autecological amplitude, that permits its acceptance as a certain qualitative indicator for assessment of the trophic state of environments, according to criteria given by Burchardt et al. (1994).

In effect, the characteristics of rivers on the basis of studies of the structure of the phytoseston community, with division into groups according to degree of their similarity with use of the SIMI index (Stander 1970), gave opposite configurations of stations, from the point of view of the quality of aquatic environment, within one group. For example, in Groups I a and b, there have been found: the Szreniawa – Biskupice (Station 23), The Ścieklec – Mokocice (Station 24), the Prądnik – Ojców (Station16) and the tributaries of the Raba (e.g. the Trzebuńka – Station 39 and the Krzczonówka – Station 38), which represented the aquatic environments from strongly eutrophicated and polluted to clean.

The calculation of the SIMI index is based on the number of taxa differentiated in phytoseston, this requiring their accurate and often difficult systematic determinations. The number of species affects the distribution of stations in separate groups, which may be problematic, in the case of incomplete taxonomical composition and not referring to the conditions prevailing in the particular aquatic environments comprised by studies.

Thus, it should be remembered that for an authoritative, i.e. more objective, evaluation of water quality, it is very important and necessary, for final interpretation of the results obtained, also to be familiar with the ecology of the species, both of the dominants and those not very numerous, but nevertheless representing a certain indicator value. Among ecological features, their vitality and expansion signalize changes in the investigated habitat, and at the same time, point to directions of its transformation.

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