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Environmental characteristics of affluents of the Dobczyce Reservoir (Southern Poland) in the preimpoundment period (1983—1985)*

2. Periphyton

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A b s t r a c t — The periphyton of the mouth section of the major affluents of the Dobczyce Reservoir was investigated. The mean weight of the coating formed by the periphyton was 2.5—5.7 g dm^{-2}, of which 2.2—5.1 g dm^{-2} consisted of mineral particles. The average quantity of chlorophyll "a" varied from 949 to 3058 μg dm^{-2}. In the warm half of the year the periphyton showed smaller amounts of mineral particles, organic matter, and chlorophyll "a", and greater coefficients of variation of these parameters than in the cold half.

K e y w o r d s: preimpoundment studies, streams, periphyton, chlorophyll "a", organic matter.

1. Introduction

In the period 1983—1985 investigations were carried out on the periphyton developing on the bottom of the major affluents of a prospective dam reservoir for water supply on the River Raba at Dobczyce. These investigations formed part of comprehensive limnological studies on the affluents of this reservoir carried out in order to assess the current state of the environment and to gather information that would permit prediction of the biological processes that would begin following flooding of the reservoir.

The periphyton of the drainage basin of the Upper Raba has so far been investigated mainly from a floristic aspect (S t a r m a c h 1960, 1966a, b, c, 1968a, b, 1969, 1970, T a r n o w s k a 1970, Ż u r e k 1971). Information concerning the content of chlorophyll „a" and the primary production is contained in a paper by B o m b ó w n a (1972a, b).

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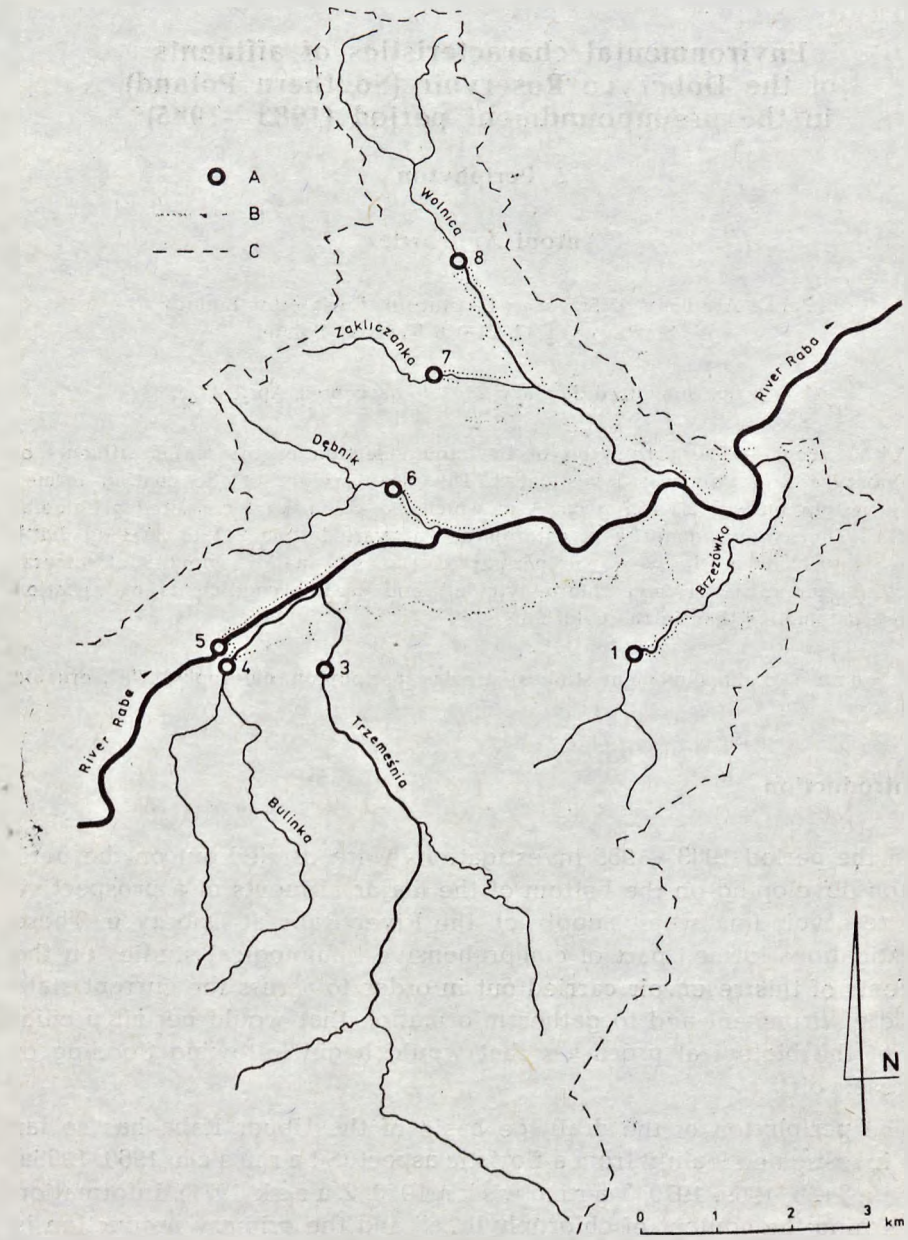

Fig. 1. Catchment basin of the Dobczyce reservoir. A — sampling stations; B — range of the reservoir; C — borderline of the catchment basin of the reservoir

The aim of the present work was to present a quantitative characterization of the coatings formed by periphyton in the mouth sections of the reservoir feeders, and to illustrate the changes of the major constituents of these coatings in the annual cycle.

2. Study area, material, and method

The material was collected monthly from April 1983 to September 1985, at seven stations (Brzezówka — Station 1, Trzemeśnia — Station 3, Bulinka — Station 4, Raba — Station 5, Dębnik — Station 6, Zakliczanka — Station 7, and Wolnica — Station 8) lying at an altitude of 270 m (the normal water level of the future reservoir) (fig. 1). Altogether, 121 samples were collected, 22 of them in the Brzezówka, 26 in the Trzemeśnia, 9 in the Bulinka streams, 24 in the River Raba, 10 in the Dębnik, 11 in the Zakliczanka, and 10 in the Wolnica streams. A detailed description of the stations and the reservoir and its catchment basin is given by Mazurkiewicz (1988).

Entire coatings covering submersed stones were removed and the area of projected surfaces of the stones measured by weighing their shapes drawn on cardboard (Mastyński 1972). The weight of the coatings and their mineral and organic components per unit area of bottom was determined by weighing homogenized material that had been dried and subsequently calcined. The content of chlorophyll „a" was measured by the extinction of acetone extracts of homogenized periphyton (Golterman, Clymo 1969). From the results obtained, means ($\bar{x} = \frac{\Sigma x}{n}$), standard deviations ($\sigma = \sqrt{\frac{\Sigma (x - \bar{x})^2}{n - 1}}$) and coefficients of variation ($V = \frac{100\,\sigma}{\bar{x}}$) were calculated.

3. Results

The coatings covering the stony bottom of the investigated affluents form macroscopic algal thalli, among which settle particles of the mineral and organic suspension carried by the streams. In all the affluents, algal communities of similar composition were found. In the biomass of the algae covering the stones *Cladophora glomerata* (L.) Kütz. had the greatest share. It was accompanied constantly or periodically by *Ulothrix zonata* (Weber et Mohr) Kütz., *U. oscillarina* Kütz., *Stigeoclonium tenue* (Ag.) Kütz., *Hydrurus foetidus* (Villars) Trevisan, and representatives of the genera *Spirogyra* Link, *Oedogonium* Link, and *Vaucheria* De Cand. In the Brzezówka stream (Station 1), thalli of *Batrachospermum arcuatum* Kylin were also found.

Table I. Mean weight (g dm^{-2}) of the coatings formed by the periphyton, and the mineral particles and organic matter contained in them on the bottom of the major affluents of the Dobczyce Reservoir in 1983-1985

Parameter	Stations	$\bar{x}$	σ	V	Warm half-year (May - October)			Cold half-year (November-April)		
					$\bar{x}$	σ	V	$\bar{x}$	σ	V
Total coating	1- Brzezówka	4.47	4.27	95.5	4.89	4.86	99.4	3.75	3.14	83.7
	3- Trzemeśnia	2.96	2.19	74.0	3.36	2.59	77.1	2.33	1.19	51.1
	4- Bulinka	5.66	5.55	98.1	5.65	6.49	114.9	5.68	4.24	74.6
	5- Raba	2.96	2.11	71.3	2.35	1.53	65.1	3.83	2.57	67.1
	6- Dębnik	3.01	2.63	87.4	1.79	1.55	86.6	4.82	3.07	63.7
	7- Zakliczanka	5.01	4.06	81.0	6.23	4.68	75.1	3.54	2.98	84.2
	8- Wolnica	2.48	1.81	73.0	1.98	1.35	68.2	3.16	2.22	70.2
Mineral particles	1- Brzezówka	3.84	3.93	102.3	4.17	4.45	106.7	3.25	2.98	91.7
	3- Trzemeśnia	2.36	1.89	80.1	2.67	2.24	83.9	1.85	1.01	54.6
	4- Bulinka	5.09	5.18	101.8	5.08	6.06	119.3	5.10	3.92	76.9
	5- Raba	2.24	1.59	71.0	1.82	1.21	66.5	2.83	1.91	67.5
	6- Dębnik	2.54	2.43	95.7	1.34	1.21	90.3	4.34	2.83	65.2
	7- Zakliczanka	4.43	3.73	84.2	5.57	4.18	75.0	3.06	2.95	96.4
	8- Wolnica	2.25	1.79	79.5	1.86	1.35	72.6	2.78	2.26	81.3
Organic matter	1- Brzezówka	0.64	0.47	73.4	0.72	0.55	76.4	0.49	0.25	51.0
	3- Trzemeśnia	0.61	0.47	77.0	0.69	0.58	84.1	0.47	0.19	40.4
	4- Bulinka	0.57	0.38	66.7	0.57	0.44	77.2	0.58	0.32	55.2
	5- Raba	0.72	0.59	81.9	0.52	0.38	73.1	0.99	0.74	74.7
	6- Dębnik	0.46	0.42	91.3	0.44	0.54	122.7	0.50	0.22	44.0
	7- Zakliczanka	0.58	0.45	77.6	0.67	0.56	83.6	0.48	0.29	60.4
	8- Wolnica	0.23	0.23	100.0	0.11	0.10	90.9	0.38	0.27	71.0

The total weight of the coatings formed by periphyton on average reached 2.5—5.7 g dm^{-2} (Table I). Those covering the bottom of the Bulinka (Station 4), Zakliczanka (Station 7), and Brzezówka streams (Station 1) had the greatest weight. The widest range of variation in weight was found in the Bulinka (Station 4), Brzezówka (Station 1), and Dębnik streams (Station 6). The main component of the coatings were mineral particles (settled suspended matter and fine sand), their weight on average reaching 2.2—5.1 g dm^{-2} (Table I). The greatest quantity of mineral particles is retained by the periphyton developing on the bottom of the Bulinka (Station 4), Zakliczanka (Station 7), and Brzezówka (Station 1) streams, while quite a wide range in the variation of this component was found in the Brzezówka (Station 1), Bulinka (Station 4), and Dębnik (Station 6) streams. The average amount of organic matter (algae, invertebrates, and detritus) found on the bottom of the investigated affluents varied from 0.2—0.7 g dm^{-2} (Table I). In the warm half of the year (May--October) the most organic matter was found on the bottom of the Brzezówka (Station 1), Trzemeśnia (Station 3), Zakliczanka (Station 7), and Bulinka (Station 4) streams and in the cold one (November—April) on the bottom of the River Raba (Station 5) and Bulinka stream (Station 4). The greatest range of the fluctuation in the amount of organic matter was found in the warm half of the year in the Dębnik (Station 6) and Wolnica (Station 8) streams and in the cold half in the River Raba (Station 5), and the Wolnica (Station 8) and Zakliczanka (Station 7) streams.

The content of chlorophyll „a" in the periphyton was, on average, 949—3058 μg dm^{-2} (Table II). The most chlorophyll „a" was found on the bottom of the Bulinka (Station 4) and Trzemeśnia (Station 3) streams, and

Table II. Mean content of chlorophyll "a" in the periphyton ($\mu g\ dm^{-2}$) and in the organic matter of the coatings formed by the periphyton (‰) on the bottom of the major affluents of the Dobczyce Reservoir in 1983–1985

Chlorophyll "a" in:	Stations	-	σ	V	Warm half-year (May – October)			Cold half-year (November-April)		
					$\bar{x}$	σ	V	$\bar{x}$	σ	V
Periphyton	1- Brzezówka	1773	1197	67.5	1304	595	45.6	2644	1570	59.4
	3- Trzemeśnia	2678	1485	55.4	2616	1364	52.1	2787	1771	63.5
	4- Bulinka	3058	2486	81.3	2378	1529	64.3	3737	3293	88.1
	5- Raba	2515	2151	85.5	1712	1062	62.0	3585	2787	77.7
	6- Dębnik	1732	1700	98.1	1128	1217	107.9	2639	2090	79.2
	7- Zakliczanka	949	838	88.3	509	574	112.8	1301	899	69.1
	8- Wolnica	1155	1019	88.2	663	506	76.3	2139	1101	51.5
Organic matter	1- Brzezówka	3.78	2.99	79.1	2.67	2.27	85.0	5.68	3.27	57.6
	3- Trzemeśnia	4.84	2.79	57.6	4.76	3.26	68.5	4.96	1.92	38.7
	4- Bulinka	9.69	6.38	65.8	8.26	7.21	87.3	12.54	4.80	38.3
	5- Raba	3.91	2.52	64.4	3.57	1.91	53.5	4.38	3.23	73.7
	6- Dębnik	4.90	4.23	86.3	4.80	5.31	110.6	5.04	2.55	50.6
	7- Zakliczanka	2.33	1.80	77.2	0.93	0.88	94.6	3.73	1.24	33.2
	8- Wolnica	6.02	4.65	77.2	5.31	3.31	62.3	7.05	6.26	88.8

Table III. Comparison of the means ($\bar{x}$) and coefficients of variation (V) of the investigated parameters of the coatings formed by the periphyton of the major affluents of the Dobczyce Reservoir in the cold and warm half-years from 1983–1985

Parameter		Warm half-year (May–October)		Cold half-year (November-April)	
		$\bar{x}$	V	$\bar{x}$	V
Total coating	$g\ dm^{-2}$	3.75	83.8	3.87	70.7
Mineral particles	$g\ dm^{-2}$	3.22	87.8	3.32	76.2
Organic matter	$g\ dm^{-2}$	0.53	86.9	0.56	56.7
Chlorophyll "a" in periphyton	$\mu g\ dm^{-2}$	1473	74.4	2690	69.8
Chlorophyll "a" in organic matter	‰	4.33	80.3	6.20	54.4

River Raba (Station 5). Relatively wide variations in this parameter occurred in the warm half or the year in the Zakliczanka (Station 7) and Dębnik (Station 6) streams, and the River Raba (Station 5). The average content of chlorophyll „a" in the organic matter of the coatings varied from 2.3—9.7‰ (Table II). This index reached its highest values in the Bulinka (Station 4) and Wolnica (Station 8) streams. A relatively high range in its variation was found in the warm half of the year in the Dębnik (Station 6), Zakliczanka (Station 7), Bulinka (Station 4), and Brzezówka (Station 1) streams and in the cold one in the Wolnica stream (Station 8), River Raba (Station 5) and Brzezówka stream (Station 1).

At all the investigated stations the periphyton was fairly similar, the greatest average quantities of the particular components of the coatings it formed being only 2—4 times greater than the smallest ones. This results from the fairly similar habitat conditions (the character of the bottom, velocity of the current, concentration of nutrients) prevailing in all the affluents of the Dobczyce Reservoir. The variations in the share of com-

ponents of the coatings are high (the coefficients of variation usually exceeding 80%); this evidences low stability of the coatings formed on the bottom of the affluents.

All the investigated elements of the coatings formed by the periphyton reach greater numbers in the cold half-year than in the warm one (Table III); such a pattern is distinct, especially in the case of the content of chlorophyll „a" in the periphyton and the organic matter of the coatings. The coefficients of variation, however, were greater in the warm half-years than in the cold ones, especially in the case of the content of chlorophyll „a" in the organic matter.

4. Discussion

Comparison of the results obtained with those of previous investigations (B o m b ó w n a 1972a, b) seems to show that the periphyton of the stations investigated does not differ in its composition from other localities in the catchment area of the Upper Raba, and that during recent years no distinct qualitative changes have taken place in it. Neither has the content of chlorophyll „a" changed in the coatings formed by periphyton; in the Raba between Myślenice and Dobczyce, B o m b ó w n a (1972a) found a content of chlorophyll „a" around 10—40 μg cm^2.

The development of periphyton is of great importance in the process of self-purification of the water in a stream. In the light of the results obtained, the mouth sections of the Bulinka stream (Station 4), the River Raba (Station 5), and the Trzemeśnia stream (station 3) seem to possess the most efficiant „biological filters" (a high content of chlorophyll „a" in the periphyton throughout the year). In the Brzezówka (Station 1) and Zakliczanka (Station 7) streams in the warm half-year there was a high content of organic matter on the bottom and a small content of chlorophyll „a" in the organic matter of the periphyton. In the Dębnik (Station 6) and Wolnica (Station 8) streams, however, the periphyton is rather poorly developed (a small amount of chlorophyll „a" in the periphyton and a low weight of the coatings). This is caused by the small quantity of nutrients in the water (Dębnik stream) or a character of the bottom unfavourable to the development of the periphyton (Wolnica stream). Thus, in the most polluted affluents of the Dobczyce Reservoir, in the Wolnica and Zakliczanka streams (M a z u r k i e w i c z 1988) the process of self-purification is probably least efficient.

The process of natural self-purification of the water of the affluents of the reservoir is disturbed by flooding, during which the periphyton is destroyed mechanically and the mineral particles and organic matter retained in the coatings are carried further. This takes place especially in the warm half-year (May-October). In order to maintain its capacity for self-purification at as high a level as possible it is recommended that the

catchment area be managed in such a way that, while maintaining the natural character of its affluents, irregularities in discharge might be reduced.

5. Polish summary

Środowiskowa charakterystyka dopływów zbiornika dobczyckiego (Polska Południowa) w okresie poprzedzającym jego zalanie (1983—1985)

2. Peryfiton

W latach 1983—1985 prowadzono badania nad peryfitonem rozwijającym się na dnie przyujściowych odcinków ważniejszych dopływów wodociągowego zbiornika zaporowego, zbudowanego na rzece Rabie w Dobczycach (ryc. 1). Masę powłok formowanych przez peryfiton oraz ilość ich składników mineralnych i organicznych określono poprzez ważenie wysuszonego, a następnie wyprażonego zhomogenizowanego materiału. Zawartość chlorofilu „a" oznaczono mierząc ekstyncję acetonowych ekstraktów zhomogenizowanego peryfitonu.

Powłoki pokrywające dno badanych dopływów tworzą makroskopowe płachy glonów (głównie *Cladophora glomerata* (L.) Kütz.), pomiędzy którymi osadzają się cząstki transportowanej przez potok zawiesiny mineralnej i organicznej. Całkowita masa powłok przeciętnie osiąga 2,5—5,7 g dm^{-2} (tabela I). Głównym składnikiem powłok są cząstki mineralne (osadzone zawiesiny i drobny piasek); ich masa średnio wynosi 2,2—5,1 g dm^{-2}. Ilość substancji organicznych (glony, bezkręgowce oraz detrytus) znajdujących się na dnie badanych dopływów waha się w granicach 0,2—0,7 g dm^{-2}. Zawartość chlorofilu „a" w peryfitonie przeciętnie wynosi 949—3,058 µg dm^{-2} (tabela II), a średnia zawartość chlorofilu „a" w materii organicznej powłok waha się w granicach 2,3—9,7‰. Wszystkie badane elementy powłok formowanych przez peryfiton występują w półroczu ciepłym (V—X) w ilościach mniejszych niż w półroczu zimnym (XI—IV), natomiast ich współczynniki zmienności są większe w półroczu ciepłym (tabela III).

Rozwój peryfitonu ma duże znaczenie dla przebiegu procesu samooczyszczania wody w potoku. Najsprawniej działający „biologiczny filtr" wydają się posiadać przyujściowe odcinki Bulinki, Raby i Trzemeśni (duża ilość chlorofilu „a" w powłokach przez cały rok). W Brzezówce i Zakliczance natomiast występuje w półroczu ciepłym duża ilość materii organicznej na dnie i mała ilość chlorofilu „a" w materii organicznej powłok, a w Dębniku i Wolnicy peryfiton jest rozwinięty stosunkowo słabo (mała ilość chlorofilu „a" w powłokach i mała masa powłok). Tak więc w najbardziej zanieczyszczonych dopływach zbiornika dobczyckiego, w Wolnicy i Zakliczance, proces samooczyszczania prawdopodobnie przebiega najmniej skutecznie.

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