

**Assessment of the trophic state of the water
of the Dobczyce dam reservoir and its selected tributaries
(southern Poland) by the method
of the *Chlorella pyrenoidosa* Chick. biotest***

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Abstract – An algal growth test was used to show the trophic state of the water of the Dobczyce Reservoir and its direct tributaries. The Dobczyce Reservoir showed a lower trophic level than its affluents. So far, the reservoir has been mesotrophic, but shows a tendency to increase from year to year. The trophic level of its water was less than that of the Goczałkowice Reservoir, which was eutrophic.

Key words: bioassay, trophic state, algae, river, dam reservoir

Ocena trofii wód Zbiornika Dobczyckiego i jego wybranych dopływów (południowa Polska) metodą biotestu na glonie *Chlorella pyrenoidosa* Chick. Za pomocą testu glonowego badano trofię wody Zbiornika Dobczyckiego i jego dopływów. Trofia zbiornika była niższa niż jego dopływów. Wykazano, że Zbiornik Dobczycki jest zbiornikiem mezotroficznym, lecz z wyraźnie zaznaczoną tendencją wzrostu trofii z roku na rok. Jego trofia była niższa niż Zbiornika Goczałkowickiego ocenionego jako eutroficzny.

1. Introduction

The pollution of surface waters, including those of reservoirs supplying drinking water brings about the necessity of estimation of the process of their eutrophication. The application of the same algal species as a testing organism is particularly useful in comparison of the fertility of different waters, because the total activity of all the water components is decisive for the growth and algae yield of obtained.

In Poland, investigations on some Upper Silesian rivers (Bednarz 1985), the River Nida (Starzecka et al. 1988), the forest catchment of the Traczkówka and Drwinka streams (Bednarz et al. 1984, 1987) and the River Vistula between the 33rd and 58th kilometre of its course (Bednarz 1988) with the application of the algal species *Chlorella pyrenoidosa* Chick. were successfully carried out.

The aim of the present work was to assess the trophic state of the potable water for the city of Kraków supplied by the reservoir located in the River Raba at

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Dobczyce and to determine the effect of the direct catchment area on the trophic state of the reservoir waters.

2. Study area, material and methods

The Dobczyce Reservoir and its direct catchment area are situated within the Wieliczka Upland, built of Silesian flysh of various age and mosaic distribution. The greater part of the catchment area soils are formed of fine-grained sands, originating from flysh rocks (Pasternak 1961). The reservoir is chiefly fed by the River Raba, those waters constitute 88.6% of the total input to the reservoir. The rest is supplied through the direct catchment of the reservoir (8.8%), and atmospheric precipitation on the surface of its water (2.6%) (Mazurkiewicz 1988).

The investigations involved the reservoir itself (Station 1), the River Raba above (Station 2) and below it (Station 3), and the streams Brzezówka (Station 4) with a forest-agricultural, and Trzemesnia (Station 5) with an agricultural-forest type of catchment, belonging to the direct catchment area of the reservoir (fig. 1). The investigations of the trophic level of the water were carried out at monthly intervals, from April 1992 to May 1993 at all stations, and those of the reservoir

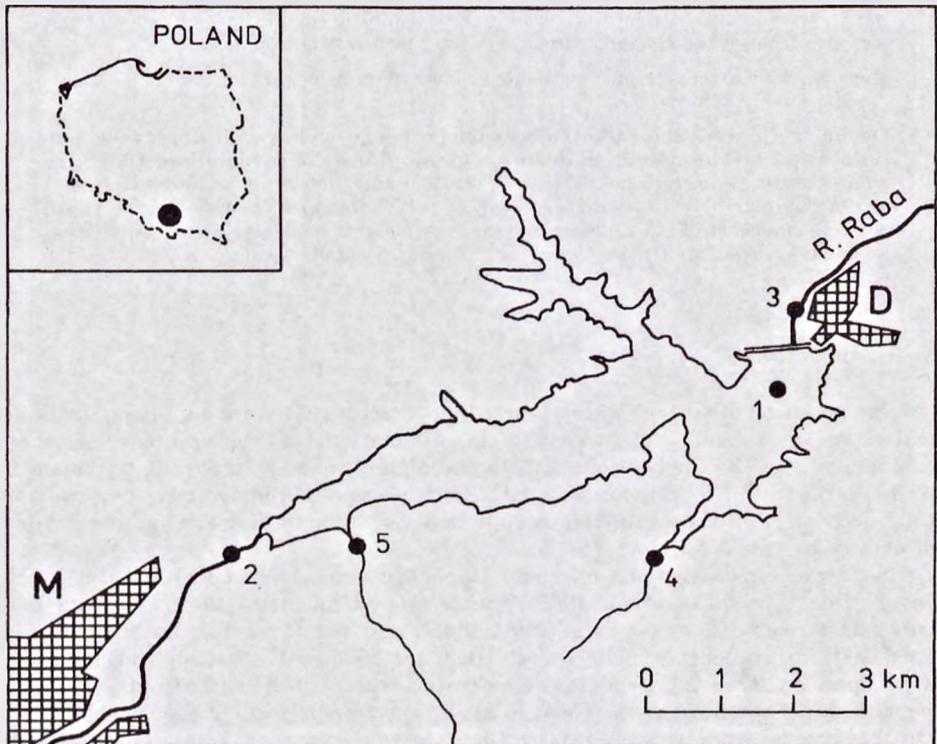


Fig. 1. Localization of the investigated stations: 1 — Dobczyce Reservoir, 2 — River Raba above the reservoir, 3 — River Raba below the reservoir, 4 — Brzezowka stream, 5 — Trzemesnia stream. Towns: D — Dobczyce, M — Myslenice.

alone from May 1993 to April 1994. For comparison, water from the Goczałkowice Reservoir, situated in the upper section of the River Vistula was taken three times (January, April, June) in 1994.

Altogether 83 water samples were taken. After the removing the seston by filtering through Whatman GF/C glass fibre, the water was inoculated with a culture of the alga *C. pyrenoidosa* strain 366 (Bednarz and Nowak 1971) and cultivated under laboratory conditions up to the stationary phase of culture growth. Cultures growing in the same conditions in the mineral medium L_{5m} (Jankowski 1964) constituted control. The dry mass yield (dried at 105 °C) of the control cultures was assumed as 100% and the yield of test cultures were compared with it. A detailed description of the method is given by Bednarz (1985).

The values of pH, N-NH₄ and P-PO₄ concentrations and that of the N/P relation were determined in the samples of water taken in the period from April 1992 to May 1993 from the Dobczyce Reservoir, the River Raba, and the Brzezówka and Trzemesnia streams, in parallel with the algal test. The obtained results were statistically analysed using the computer program STATGRAPHICS 3.0.

3. Results

3.1. Chemical parameters of the water

The investigated waters were showed an alkaline reaction. The lowest mean pH values occurred in the River Raba below the reservoir (7.91, SD 0.31) and in the Brzezówka stream (7.95, SD 0.18), while the highest ones were observed in the reservoir (8.26, SD 0.30) and the River Raba above the reservoir (8.04, SD 0.38).

The highest mean concentration of the ammonia form of nitrogen (N-NH₄) was noted in the River Raba above the reservoir (0.830 mg dm⁻³, SD 0.351), and the lowest one below it (0.370 mg dm⁻³, SD 0.188). The waters of the River Raba above the reservoir were the richest in the nitrate form of nitrogen (N-NO₃; 1.620 mg dm⁻³, SD 0.686) and those of the Trzemesnia stream the poorest (0.294 mg dm⁻³, SD 0.133). Phosphorus (P-PO₄), however occurred in its highest average concentration in the waters of the Brzezówka stream (0.295 mg dm⁻³, SD 0.300), and in its lowest one in the reservoir (0.041 mg dm⁻³, SD 0.058). The range of fluctuations of the N/P coefficient was greatest in the waters of the reservoir and the smallest in that of the Brzezówka stream. Small N/P fluctuations were also observed in the River Raba below the reservoir and in the Trzemesnia stream (fig. 2).

3.2. Yield of test cultures

In the period from April 1992 to May 1993 the highest trophic level among the waters flowing into the Dobczyce Reservoir was registered on the River Raba above the reservoir, which was evidenced by the yield of the test algal species *C. pyrenoidosa*, constituting 16.9–90.6% of the control culture yield (the mean annual value 37.3%), and the lowest level in the Brzezówka stream (13.9–69.9%, mean 32.5%). The smallest fluctuations of the trophic level occurred in the water of the Trzemesnia stream (18.9–67.2%, mean 31.1%) (fig. 3 and 4). The waters of the River Raba below the reservoir regularly showed a lower trophic level than those above it, often being lower than that of the waters of the reservoir itself (13.5–80.3%, mean 33.8%).

With regard to season, the lowest trophic level of the waters flowing into the reservoir was found in autumn in the Brzezówka (24.6% of the control yield) and

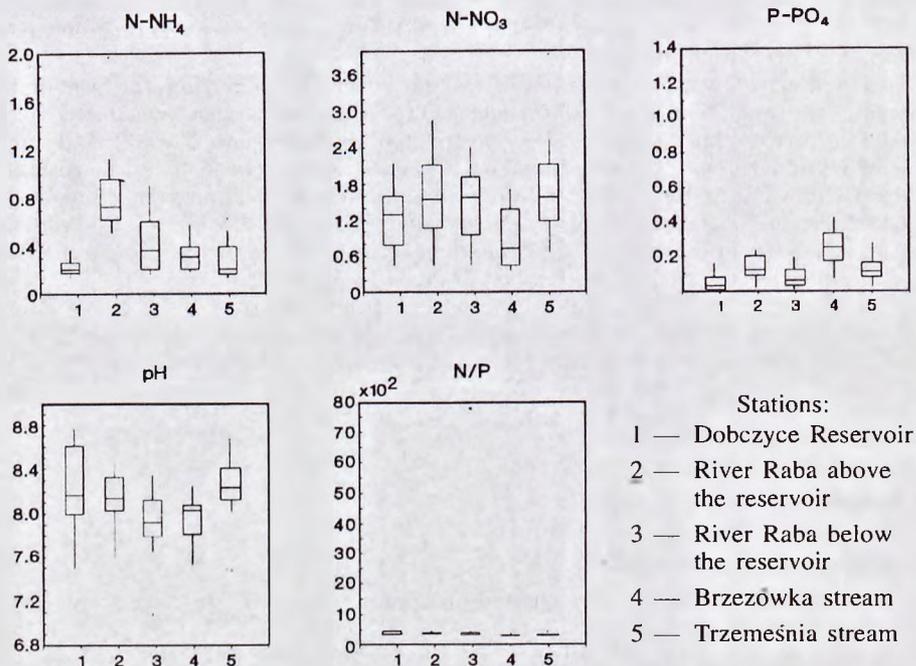


Fig. 2. Some chemical parameters of the water at investigated stations from April 1992 to May 1993. Concentrations of N and P are given in mg dm^{-3} .

Trzemesnia (25%) streams, and in the River Raba below the reservoir (21.8%), and in the River Raba above the reservoir in summer (31.7%). However, the highest trophic level of all the waters was found in winter (Trzemesnia stream: 41.9%, Brzezówka stream: 43%, the River Raba above the reservoir: 49.8%, and the River Raba below the reservoir: 45.5%) (fig. 4).

On the basis of the results of the growth test with the *C. pyrenoidosa*, obtained within a two-year-investigation period (from April 1992 to June 1994), concerning the waters of the Dobczyce Reservoir it was found that from year to year a constant rise in its trophic level took place (the mean annual yield amounting to 28.3% in 1992–1993, and in the following year 40.9%) (fig. 3 and 5), with great fluctuations (13.3–79.8% of the control culture yield).

With regard to season, in the waters of the reservoir the lowest trophic level was found in summer of 1992 (< 20% of the control yield) and in autumn of the following year 1993 (< 30% of the control yield). The highest level occurred in winter 1992/1993 (> 40% of the control yield) and in spring of year 1993 (> 60% of the control yield) (fig. 5). A similar seasonal pattern, i.e. the lowest trophic level in summer or autumn and the highest in winter was found in the waters feeding the reservoir (figs 4 and 5).

The value of the obtained yields of dry mass of *C. pyrenoidosa* cultivated in the reservoir waters depended on the concentration of P-PO_4 ($r = 0.56$, $p < 0.04$) and that of N-NO_3 ($r = 0.60$, $p < 0.05$). Among the reservoir affluents, a statistically

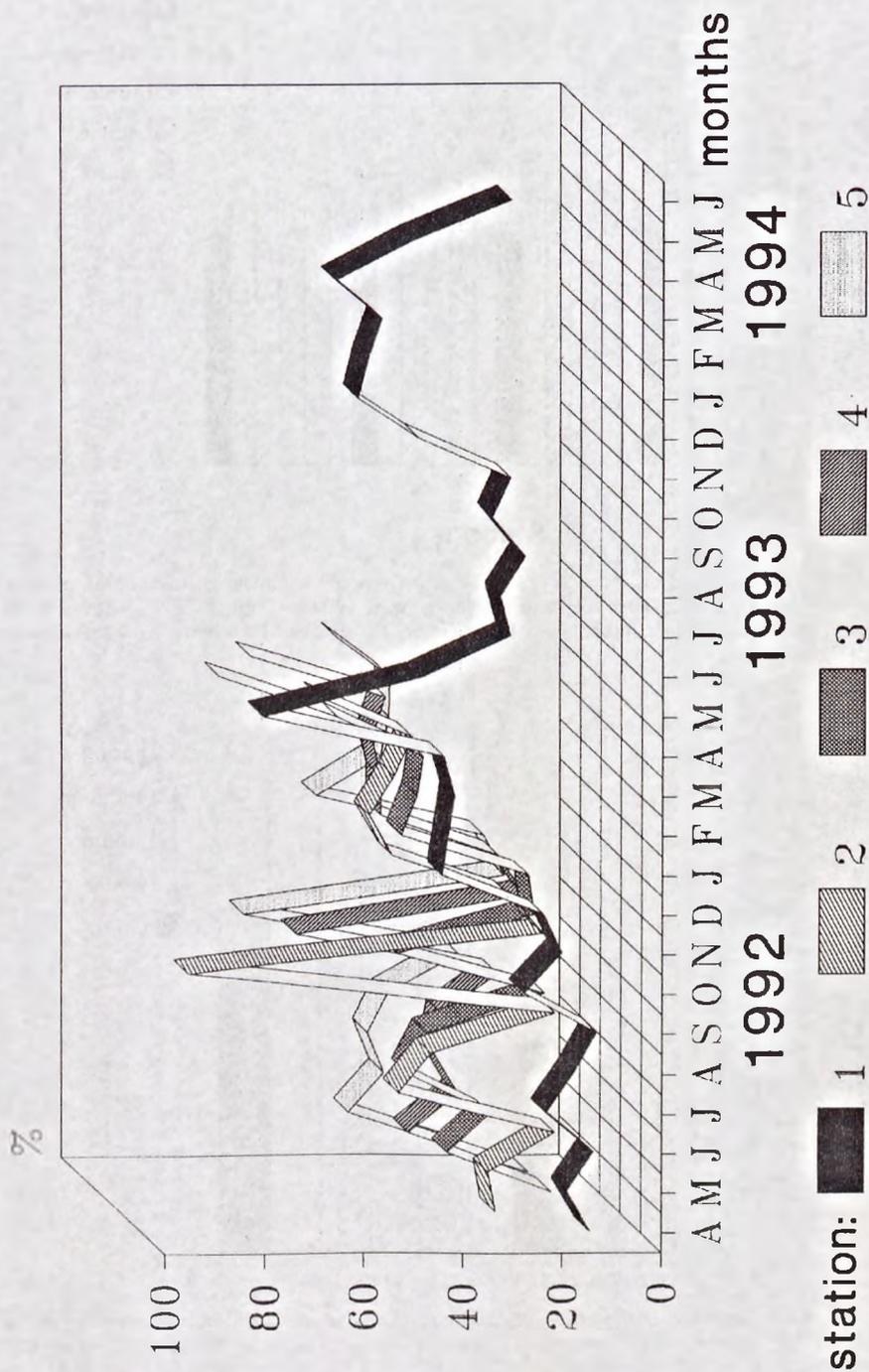


Fig. 3. Relative yield of dry mass of *Chlorella pyrenoidosa* Chick. cultures cultivated in water from investigated stations: 1 — Dobczyce Reservoir, 2 — River Raba above the reservoir, 3 — River Raba below the reservoir, 4 — Brzeżowska stream, 5 — Trzemesnia stream.

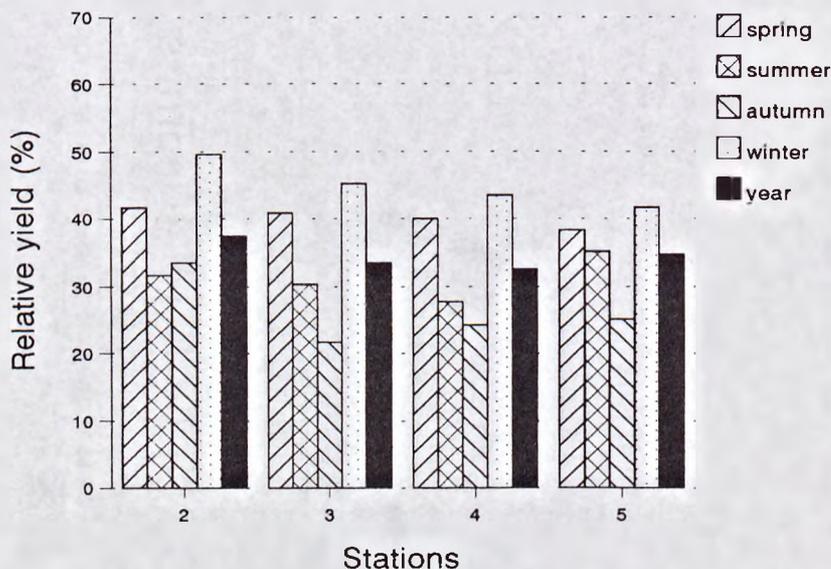


Fig. 4. Mean relative yield of dry mass of *Chlorella pyrenoidosa* Chick. cultures cultivated in water from affluents of the Dobczyce Reservoir from April 1992 to May 1993: 2 — River Raba above the reservoir, 3 — River Raba below the reservoir, 4 — Brzezówka stream, 5 — Trzemesnia stream.

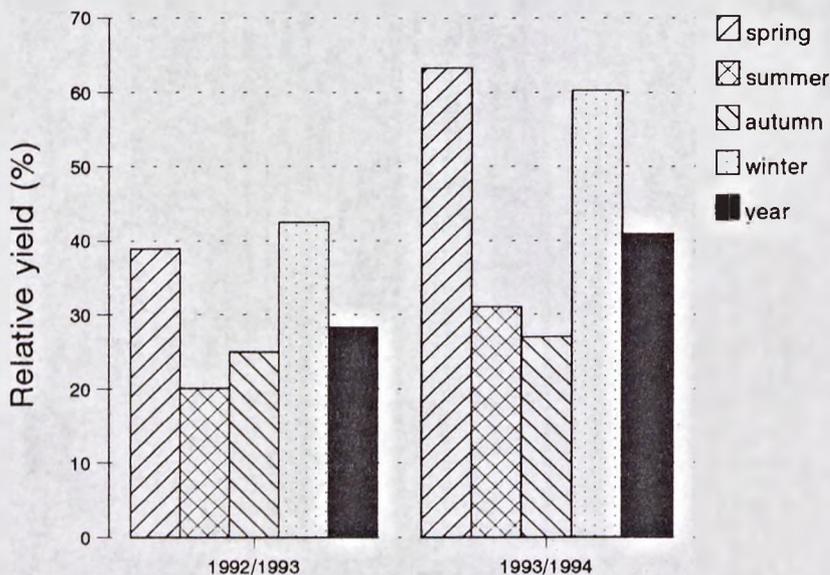


Fig. 5. Mean relative yield of dry mass of *Chlorella pyrenoidosa* Chick. cultures cultivated in water from the Dobczyce Reservoir in two years of investigations (from April 1992 to May 1993, and from May 1993 to June 1994).

significant correlation between the yield of *C. pyrenoidosa* cultures and the N/P relation was obtained only in the case of the Trzemeśnia stream ($r = 0.55$, $p < 0.04$).

The trophic level of the Goczałkowice Reservoir waters, determined three times in the period from January to June 1994, was distinctly higher than that of the Dobczyce Reservoir, estimated at the same time. This was evidenced by the dry mass yield of *C. pyrenoidosa*, amounting to 42.5–81.5% of the control culture yield, obtained from the waters of the Goczałkowice Reservoir, whereas the corresponding value obtained from the Dobczyce Reservoir waters was only 30.8–65.2% of the control culture yield (fig. 6).

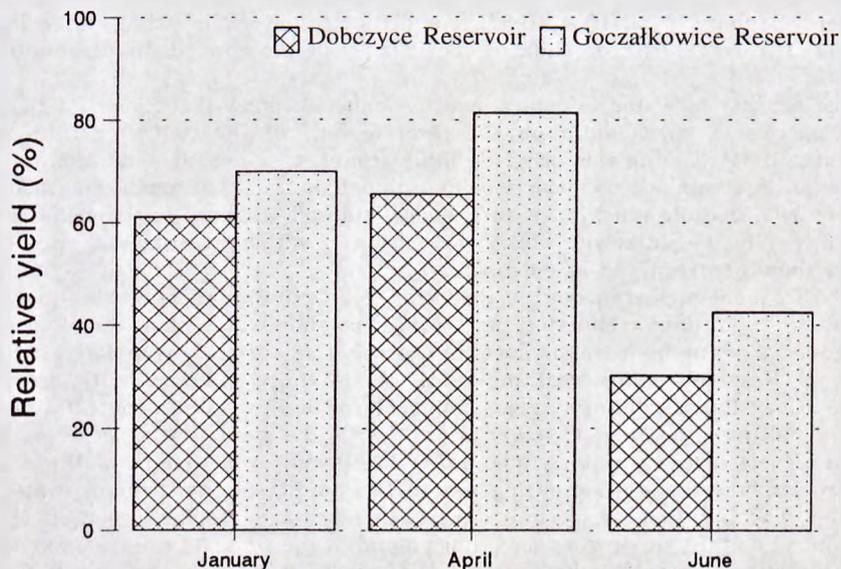


Fig. 6. Comparison of relative yields of *Chlorella pyrenoidosa* Chick. cultures cultivated in waters from the Dobczyce Reservoir and Goczałkowice Reservoir in 1994.

4. Discussion

The River Raba above the Dobczyce Reservoir is a receiver of municipal waste waters from Myślenice. In spite of the existence of a sewage treatment plant, the input of pollution discharged to the river is quite large. Besides, in the short (under 10 km) section between the point of waste discharge and the reservoir, complete mineralization and selfpurification of the river cannot take place, this resulting in the fact that selfpurification processes take place directly in the reservoir. Nevertheless, in comparison with the trophic state of the River Raba above the reservoir, the water in the reservoir showed lower fertility, and the processes taking place in the reservoir caused a fall in trophic level of the water in the River Raba below the reservoir. The direct catchment of the reservoir is formed by streams from areas of different land use. This is reflected in the lower trophic level of the Brzezówka stream (a forest-agricultural catchment) than that of the Trzemeśnia stream (an agricultural-forest catchment).

When comparing the mean trophic level of the water, covering the whole investigation period, in the Dobczyce Reservoir, the River Raba and the Brzezówka and Trzemeśnia streams with the fertility of other dam reservoirs and water courses investigated by means of the growth test with the application of *C. pyrenoidosa*, it may be seen that the trophic level of the Dobczyce Reservoir waters was distinctly lower than that of the Goczałkowice Reservoir ones although it was higher than that of the Kozłowa Góra Reservoir (Bednarz 1985). Similarly, the waters of the River Raba and the investigated streams of the direct Dobczyce Reservoir catchment had a clearly higher trophic level than was evidenced in the investigations of other rivers and streams, e.g. the Rivers Brynica (Bednarz 1985) and Nida (Starzecka et al. 1988) and the Traczówka, Baczków, and Drwinka streams (Bednarz et al. 1984, 1987), but distinctly lower than that of the Rivers Vistula (Bednarz 1988), or Nida in the vicinity of Pińczów (Bednarz and Bucka 1995).

The fertility of water is determined as high (eutrophic) at a yield of the test algal species *C. pyrenoidosa* on the level of 50% of the control culture yield (Bednarz 1984). Taking this criterion into account, the investigated waters of the Dobczyce Reservoir catchment may be determined as waters of temperate (medium) trophic level (mesotrophic) but with a clearly marked tendency to changes towards eutrophy. The Goczałkowice Reservoir, however, although analysed only three times, should be regarded as eutrophic.

The frequent appearance of algal blooms, unfavourably affecting the quality of the water and often rendering its use as potable water impossible, are the consequence of the high trophic level of the water. The rise in trophic level of the Dobczyce Reservoir water, reaching 88.6% of the entire inflow of water from the fertile River Raba tributary (mean trophic level of the water about 40% of the control culture growth of *C. pyrenoidosa*), with the periodically occurring high trophic levels of these waters, amounting to 60 and even to 90% of the control culture growth, poses a serious threat to the quality of the drinking water for Kraków. The situation is especially dangerous, since high trophic levels (60–65% of the control culture yield) were sometimes found in the water of the reservoir itself. It is therefore imperative that effective measures be taken to limit the inflow of highly trophic waters to the reservoir. This above all concerns the River Raba itself and also the waters of the direct catchment of the Dobczyce Reservoir.

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