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Estimation of quality of some surface waters near the Upper Silesia using the algal growth test*

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Abstract — By applying the bioassay technique using *Chlorella pyrenoidosa* Chick. in the period 1977—1979, the pollution of waters belonging to the catchment area of the Rivers Mała Panew and Brynica was estimated. Pollution of waters of the Mała Panew catchment area with zinc, lead, and cadmium was shown. The zinc and lead concentrations exceeded those toxic for *Chlorella*. In the waters of the Brynica catchment area no great pollution was found, although they were found to have a varying nutrient level.

Key words: rivers, reservoirs, *Chlorella pyrenoidosa*, bioassay, heavy metals, pollution.

1. Introduction

The aim of the present work was to determine the pollution level of surface waters in the catchment area of the Rivers Brynica and Mała Panew with industrial and agricultural wastes and with industrial dusts from zinc and lead foundries located in this area.

The application of bioassay technique permits the acquirement of knowledge concerning the trophic value of water and its pollution. The results of the growth test are influenced by factors about whose activity

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the chemical analysis of the water alone cannot supply information. It covers the aspect of availability of biogens, the effect of other substances (e.g. trace elements), growth substances in a general sense of the word, or even the presence of organic sources of carbon in the water (Forsberg 1972, Marvan 1979).

2. Material and methods

Seven stations located in the catchment basin of the Rivers Brynica and Mała Panew were subjected to bioassay estimation in the period 1977—1979 (fig 1); they are marked "T" on the map. A detailed description of the investigated area is given by Żurek and his work (1985).

The bioassay estimation of the water was performed in laboratory conditions. The test alga, *Chlorella pyrenoidosa* Chick., strain No 366, was obtained from the collection of the Institute of Zootechnics in Zator (Bednarz, Nowak 1971). The water samples taken on successive dates underwent sedimentation for 24 hours in darkness, at a temperature of 0—1°C and were then inoculated with *Chlorella pyrenoidosa* cells in the amount 10^5 cells cm^{-3}. The alga was cultivated for 12 days in 100 cm^3 conical flasks, containing 50 cm^3 of water each, at a 20°C and in the light of day-light type fluorescent lamps of 2600 lux/diel. During the cultivation cultures were aerated with air. Cultivation was carried out with 3 repetitions.

Each experimental series was accompanied by a control cultivation on L_5m medium (Jankowski 1964). Every second day culture increments were checked by the cell counting method in a Bürker's cell. On conclusion of the cultivation the cultures were harvested and the obtained dry weight yield (dried to a constant weight at 105°C) was revaluated with reference to the control yield assumed as 100%.

3. Results

In the water of the stations located on the Rivers Graniczna Woda near Tworóg (station 10), Mała Panew (station 12), and Stoła near Tworóg (station 11, fig. 1) pollution having an inhibiting and toxic effect on the growth of *Chlorella pyrenoidosa* was found. This was particularly distinct when the water level was low, for example on June 14, 1977. Toxicity of the water from the three mentioned stations was determined several times during the investigation (figs 2, 3). The water from the River Stoła (station 11) was distinguished by greatly differentiated results of the growth test. When the water level was high (on August 30, 1977) a slightly better yield of *Chlorella* than that of the control was obtained at this station (fig. 2).

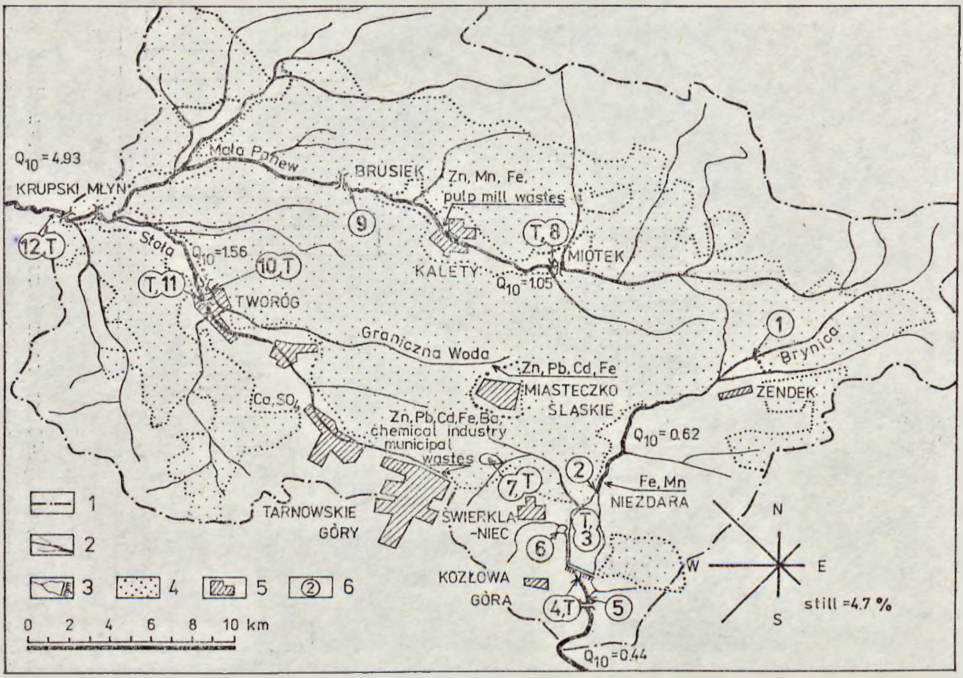

Fig. 1. Location of stations in the upper parts of the catchment area of the Rivers Brynica and Mała Panew, chief pollution, and wind rose. 1 — catchment area borders; 2 — rivers; 3 — dam reservoir; 4 — woods; 5 — inhabited area; 6 — station numbers. T — stations where water taken for algae tests

A quite high dry weight yield and the smallest differentiation of cultivation results was found in samples taken from the reservoir of potable water at Kozłowa Góra (station 3, fig. 2).

The growth test carried out on water from the remaining stations (ground outflow from the reservoir at Kozłowa Góra — station 4, the Lake Chechło-Nakło — station 7, the River Mała Panew near Miotek — station 8) showed various and changing resources of nutrients but no toxicity was established in the examined water (figs 2, 3).

From the seasonal aspect it may be stated that better growth of algae was obtained in water taken in the autumn-winter period than in the spring-summer one (fig. 2). This regularity was clearly distinguishable at both stations on the rivers Mała Panew (stations 8, 12), on the Graniczna Woda (station 10), and in the dam reservoir at Kozłowa Góra (station 3).

During the analysis of the process of culture growth from inoculation to the end of cultivation it could be seen that in highly polluted stations the toxic effect of water components appeared from the sixth day (fig. 3) preceded only by a small rise in the population density of *Chlorella py-*

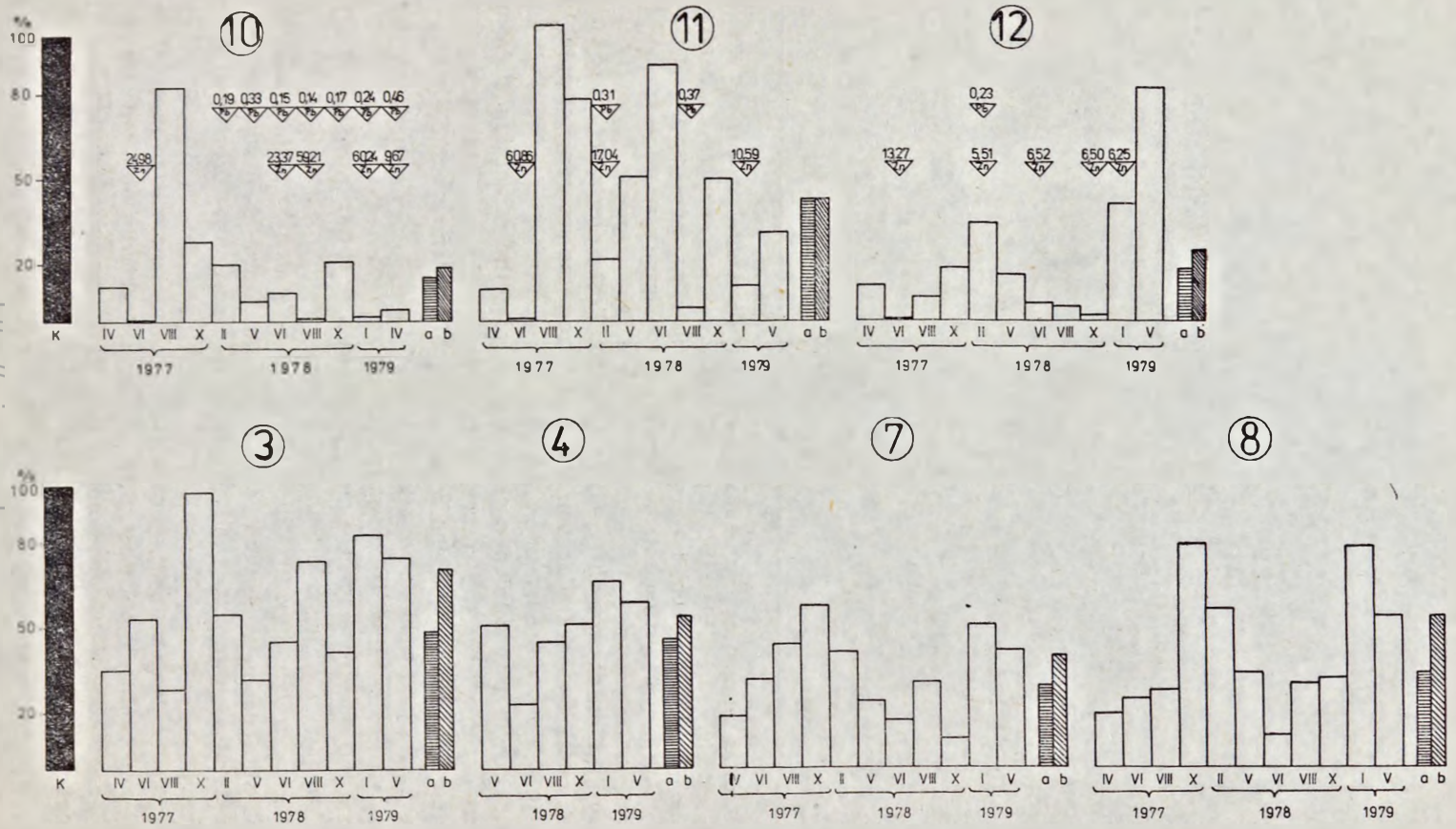

Fig. 2. Dry mass yield of 12-day old cultures of *Chlorella pyrenoidosa* (expressed in % of yield of control culture), cultivated in waters taken from 3—12 stations (see fig. 1). Control culture — K. Mean yield of cultures at spring-summer — a, autumn-winter — b. Concentration of Zn and Pb in water in mg dm^{-3} (according to Reczyńska-Dutka, unpubl.) exceeding toxic concentrations for *Chlorella* — triangle graphs

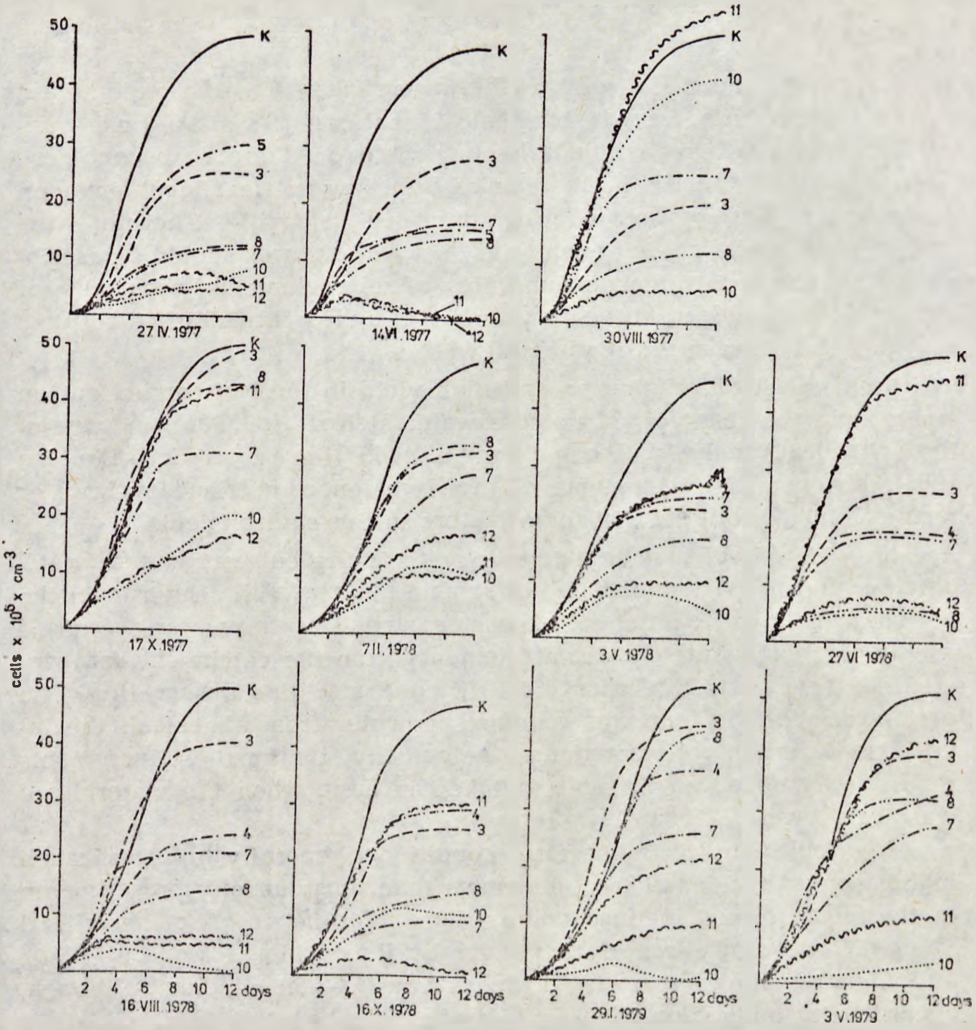

Fig. 3. Growth dynamic of *Chlorella pyrenoidosa* cultures in water from stations 3—12, where water taken for algae tests (see fig. 1). K — control culture

renoidosa. The growth rate of cultures established in the examined water was usually slower than that of control cultivations. The samples taken from the River Stoła (station 11) on August 30, 1977 were exceptional, a slightly higher growth rate than the control being observed on the date. Cultures cultivated on water from the investigated stations usually also acquired the stationary phase of growth earlier than control (which was expected), although increments in culture density sometimes occurred to the end of cultivation (fig. 3).

4. Discussion and conclusions

The investigations showed that the waters of the Tworóg region were highly polluted (fig. 1). Macrochemical analysis (Bombówna, unpublished results) showed that the low yield of *Chlorella pyrenoidosa* cultivated in them could not be caused by a low nutrient level since, on the contrary, these waters may be described as fertile. Therefore the limited growth of alga and even total decay of cultures should be ascribed to the presence of large quantities of microelements, especially of zinc, cadmium, and lead (Reczyńska-Dutka, unpublished results), reaching the water as with industrial wastes.

The smallest differentiation and high yield in the test carried out on water from the reservoir of potable water at Kozłowa Góra, in view of the chemical analysis (Bombówna 1985, Reczyńska-Dutka 1985), demonstrate the existence of a fairly balanced nutrient level, water fertility, and the absence of toxic factors in the environment.

The water level also undoubtedly affects the cultivation test yield, obtained on the particular dates of sample taking. With a high level the inhibiting or even toxic effect of wastes carried by the water decreased and the washing out of nutrient elements from the catchment area increased. The test of October 17, 1977 confirmed this observation. The best increment in algae was obtained in water from almost all the investigated stations on that date. Analogically, the smallest increments in *Chlorella* appeared in samples taken in June when the water level was at its lowest.

Algae cultivated in laboratory conditions generally tolerate much higher concentrations of trace elements than those usually present even in the most polluted natural waters. For *Chlorella vulgaris* the critical value (LC_{50}) of zinc concentration, given by Rachlin, Farran (1974), and Rosko, Rachlin (1977) ranges from 2.4—5.1 mg dm^{-3}, although, according to other data (De Filippis, Pallaghy 1976), *Chlorella* is resistant to the activity of zinc ions, tolerating without any great effect a concentration of 65 mg dm^{-3}.

It was also found that cadmium toxicity decreased in the presence of zinc (Rosko, Rachlin 1977) and is also connected with the level of nutrients in the cultivation environment (Stockes et al. 1973). Lead usually had a toxic effect on algae at a concentration of 0.1 mg dm^{-3}, while for particular species the lethal threshold could be slightly lower or higher (Christensen et al. 1979, Hessler 1974, Jørgensen 1979).

In bioassays carried out in polluted waters it seems that the observed toxic effects should be reffered to heavy metals, dominating in this environment (Wang et al. 1978), although the toxicity of single metals

and their mixtures varies. It is generally accepted that mixtures are more toxic than single components.

In the examined waters (fig. 1) of the Rivers Stoła, Graniczna Woda, and Mała Panew (stations 10, 11, 12) the amounts of zinc and lead (Reczyńska-Dutka, unpublished results) were often greater than the concentrations described in literature as toxic for *Chlorella*. In the case of cadmium, the quantities occurring in these waters were also very large, although slightly smaller than toxic concentrations. However, all three were greater than in the mixtures of metals applied by Wong and Beaver (1980) and considered by these authors as toxic.

Despite of the above-mentioned quite considerable tolerance of *Chlorella* for heavy metal mixtures the growth test gave small increments. Toxic effects were also frequent. These results demonstrate how very strong is the water contamination in this area.

The much less polluted waters of the River Brynica (Reczyńska-Dutka 1985) did not inhibit the growth of *Chlorella pyrenoidosa* in the reservoir of potable water at Kozłowa Góra (station 3) and its ground outflow (station 4) and only slightly modified the growth of the alga in the Mała Panew water at the upper station (station 8). Similarly, the Lake Chechło-Nakło (station 7), located in the area of atmospheric pollution alone, did not contain in its waters enough trace elements to have any great effect on the growth of *Chlorella*. Thus, the growth test permitted only the estimation of its water fertility. The water of the Lake Chechło-Nakło (station 7) was estimated as poorer than that in the Kozłowa Góra reservoir (station 3) but still fairly fertile.

Thus, the waters belonging to the Brynica catchment area may be considered, despite of a certain heavy metal pollution, as relatively pure.

5. Polish summary

Ocena jakości niektórych wód powierzchniowych w pobliżu Górnego Śląska za pomocą glonowego testu wzrostowego

Przy zastosowaniu glonowego testu wzrostowego, prowadzonego na *Chlorella pyrenoidosa* Chick., szczep nr 366 z kolekcji Instytutu Zootechniki w Zatorze, dokonano oceny wód: zbiornika zaporowego na rzece Brynicy w Kozłowej Górze (st. 3), wypływu wody ze zbiornika (st. 4), jeziora Chechło-Nakło (st. 7), rzek Graniczna Woda (st. 10), Stoła (st. 11) i dwóch stanowisk na rzece Mała Panew (st. 8 i 12) (ryc. 1). Stwierdzono obecność silnych zanieczyszczeń metalami ciężkimi w wodach rzek: Stoły, Granicznej Wody i Małej Panwi w niższym jej odcinku (ryc. 2, 3). W niektórych terminach wody te były toksyczne dla glonu. Toksyczność występowała szczególnie wyraźnie przy niskich stanach wód. Dla pozostałych stanowisk większych zanieczyszczeń nie stwierdzono, wykazano tylko różną i zmienną zasobność wód w składniki pokarmowe (ryc. 2, 3). Najmniej zróżnicowane i przeważnie najlepsze wyniki testu wzrostowego w wodach zbiornika w Kozłowej Górze (st. 3) świadczą o braku toksycznych zanieczyszczeń, lecz dość dużej żyzności jego wód.

6. References

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