ACTA HYDROBIOL.	28	1/2	111—119	KRAKÓW 1986

Microbiological characteristics of the River Dunajec waters in the sector between Nowy Targ and Nowy Sącz (Southern Poland)

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Manuscript submitted July 16, 1985, accepted September 25, 1985

Abstract — The microbiological description of the waters of the River Dunajec in a sector of nearly a hundred kilometre, was based on an investigation which was carried out during one year and included analysis of the number of selected groups of bacteria and their biomass. The obtained results showed that the fertility of the water increased along the river course in spite of the self-purification processes occurring there. A continuous inflow of wastes closely connected with towns lying on the river is evident.

Key words: river, microbiological characteristics, self-purification.

1. Introduction

The aim of the work was to describe the microbiological characteristics of the water of the River Dunajec in the sector from Nowy Targ to Nowy Sącz. The description is based on the analysis of numbers of selected groups of bacteria whose growth and development in surface waters are limited by the concentration of easily accessible nutrient substances, concentration of oxygen, and temperature (Daubner 1969, Allen 1969, Overbeck 1974, Jones 1977). Not only the numbers but also the composition of microbiological populations depend to a marked degree upon the quality of these factors, this being associated with the trophy of waters (Kuzniecov 1952, Godlewska-Lipowa 1974, Donderski 1977).

The River Dunajec has been investigated by many specialists. Their works were concerned with the problems of hydrochemistry (Maultz 1972), algology (Chudyba 1965), fauna (Dratnal, Szczęsny 1965, Dratnal et al. 1979, Sowa 1979), ichthyobiology (Bieniarz, Epler 1972, Starmach 1983/84), or approached the problems in a wider environmental aspect (Starmach 1965, Zarzycki 1982, Kawecka, Szczęsny 1984). However, among these works no microbiological investigations which would contribute to a more comprehensive description of changes occurring in the water of the examined river sector have been carried out so far.

2. Study area, material and method

The microbiological investigation was carried out in an almost 100 km long sector of the middle course of the River Dunajec. In this sector, which begins from the confluens of the Rivers Biały and Czarny Dunajec, the River Dunajec flows across the Nowy Targ valley to the east as far as the Pieniny Range, and across the area of the future dam reservoir at Czorsztyn and Sromowce Wyżne, receiving the waters of the streams Białka Tatrzańska and Potok Niedzicki. It then flows in a deep gorge through the Pieniny National Park and the spa and recreational complex of Krościenko and Szczawnica. At Szczawnica the Grajcarek stream which drains the Małe Pieniny (Little Pieniny) range, flows into the River Dunajec. From this place the river flows northwards and receives two left-side tributaries, the streams Ochotnica and Kamienica Łącka, and then two right-side affluents, the River Poprad, the largest of all affluents of the River Dunajec, and, a few kilometres further, the Kamienica Nawojowska stream to which sewage from the town of Nowy Sącz is fed. Below, at Knurów, the Rożnów dam reservoir begins. This is 20 km in length and 1 km in width.

The basin of the River Dunajec covers 706 km² at Nowy Targ (580 m above sea level) and 4300 km² at Nowy Sącz (290 m above sea level) and lies in the region of the Tatra Highlands, the Beskid Range, and the Nowy Sącz Valley (Punzet 1975).

The climate of the basin is characterized by a great variability resulting from considerable differences in the configuration of the area and the varied position of valleys in relation to the prevailing winds, this favouring the formation of local climatic conditions. In most parts of the basin the average annual temperature is around 5—6°C (Figuła 1956).

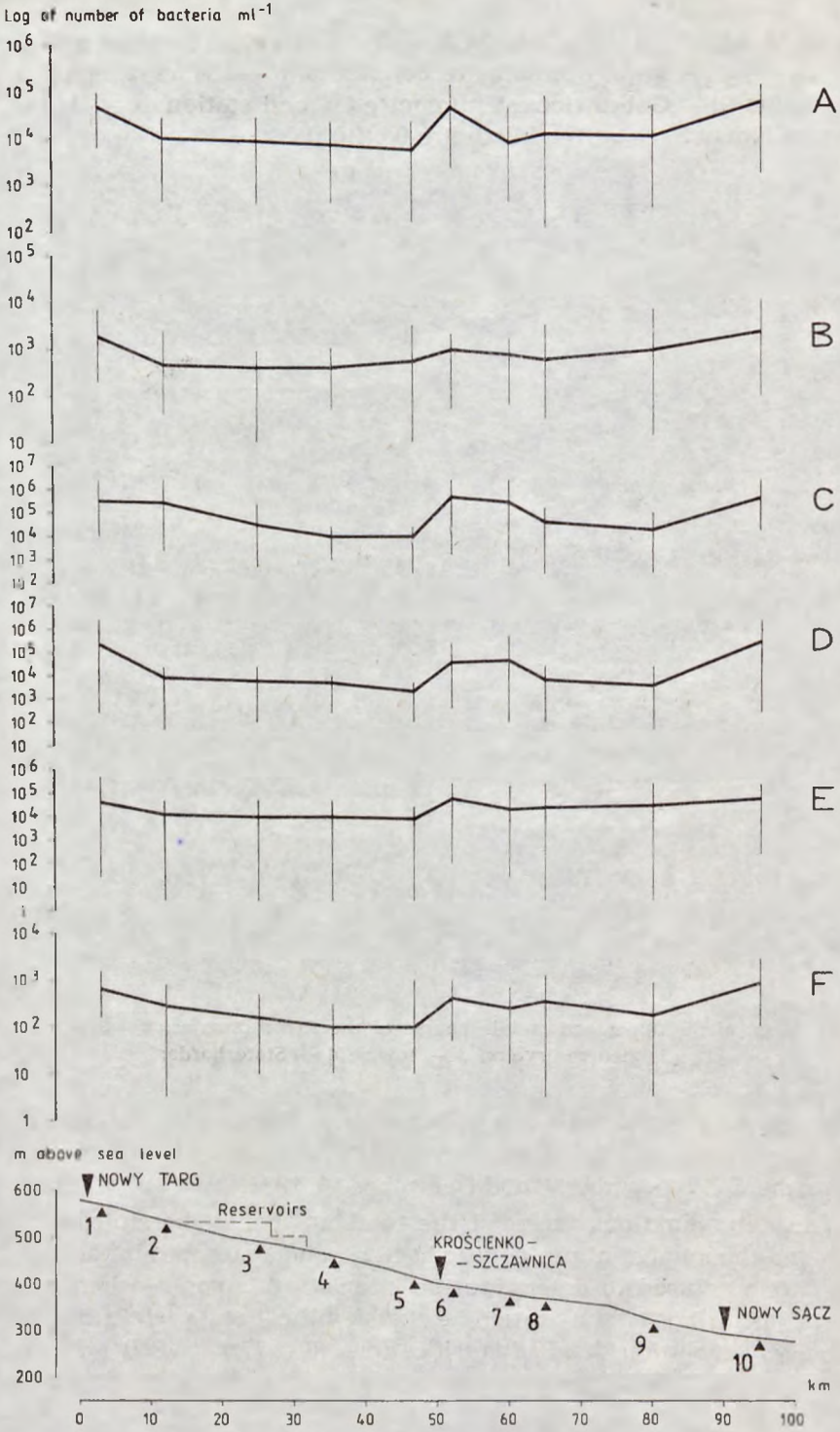
Taking the confluence of the Rivers Biały Dunajec and Czarny Dunajec as the beginning of the investigated sector, 10 stations were established: station 1 — Waksmund, at kilometre 3; station 2 — Knurów, at kilometre 12; station 3 — Czorsztyn, at kilometre 25; station 4 — Sromowce

Niżne, at kilometre 35.5; station 5 — Szczawnica, at kilometre 46.5; station 7 — Tylmanowa, et kilometre 60; station 8 — Zabrzeź, at kilometre 65; station 9 — Gołkowice, at kilometre 80; and station 10 — below the town of Nowy Sącz, at the kilometre 95 (fig. 1).

Fig. 1. Basin of the upper and middle course of the River Dunajec. 1 — stations; 2 — planned reservoirs; 3 — towns; 4 — State border

Samples of the water were collected from the current on January 14, February 13, March 17, April 9, May 19, June 25, July 24, August 24, September 22, November 2, and December 10, 1981.

The determinations included the total number of heterotrophic bacteria and the number of proteolytic bacteria and anaerobes in the samples. The titre was used to determine the intensity of some biochemical processes occurring in the water, i.e., ammonification, protein hydrolysis with H_2S evolution, and denitrification (Rodina 1968, Collins, Lynn 1970). The bacterial biomass was calculated according to Romanenko 1964.



3. Results

The average annual numbers of the examined bacteria and the ranges of variation found in the river course are presented in fig. 2.

The number of the whole group of heterotrophic bacteria in the water of the River Dunajec varied from 1.4×10^2 — 1.4×10^5 cells ml^{-1}. In the aspect of the entire investigation period the highest and most uniform values were noted at the stations in Nowy Sącz (an average of 5.7×10^4 cells ml^{-1}), Waksmund (an average of 5.6×10^4 cells ml^{-1}), and Krościenko (an average of 5.5×10^4 cells ml^{-1}), and the lowest ones in Szczawnica (an average of 5.9×10^3 cells ml^{-1}) and Sromowce Niżne (an average of 7.2×10^3 cells ml^{-1}). At Knurów, Czorsztyn, Sromowce Niżne, and Szczawnica the number of heterotrophic bacteria was maintained at the same level and was usually smaller by one order of magnitude than the number of those found at Waksmund. Similar relations were observed in the case of stations lying below Krościenko, though the number of these bacteria at the stations in Tylmanowa, Zabrzeź, and Gołkowice was on average lower only by half on order of magnitude.

The group of proteolytic bacteria, as compared with heterotrophs, was usually less numerous, on average by one order of magnitude.

The greatest differences between the stations were found among the groups of bacteria which were responsible for the desamination of proteins and the decomposition of protein with H_2S evolution. The ammonifying bacteria formed the most numerous group of organisms. Their largest numbers were found at the stations in Waksmund, Krościenko, Tylmanowa, and Nowy Sącz, while at the stations in Sromowce Niżne and Szczawnica their smallest numbers were observed in the water.

In the case of the group of bacteria which decompose protein compounds containing sulphur, the pattern of changes was very similar.

As in the other groups, large numbers of denitrifying bacteria characterized the stations below the towns, while the stations between Krościenko and Nowy Sącz were also classified among them by reason of the pronounced number of anaerobic bacteria.

Changes in the average bacterial biomass in the different seasons is shown in fig. 3.

At almost all stations the greatest bacterial biomass was observed in summer. Only at the station at Gołkowice did a maximum occur in the spring. In the summer the largest biomass was found at the stations below Nowy Sącz (5.68 $\mu g\ dm^{-3}$ on the average), Krościenko (4.803 $\mu g\ dm^{-3}$ on the average), and Waksmund (4.154 $\mu g\ dm^{-3}$ on the average). At these

Fig. 2. Average annual number and range of variations of the determined groups of bacteria in the course of the River Dunajec. A — heterotrophic bacteria; B — proteolytic bacteria; C — ammonifying bacteria; D — bacteria producing H_2S; E — denitrifying bacteria; F — anaerobic bacteria

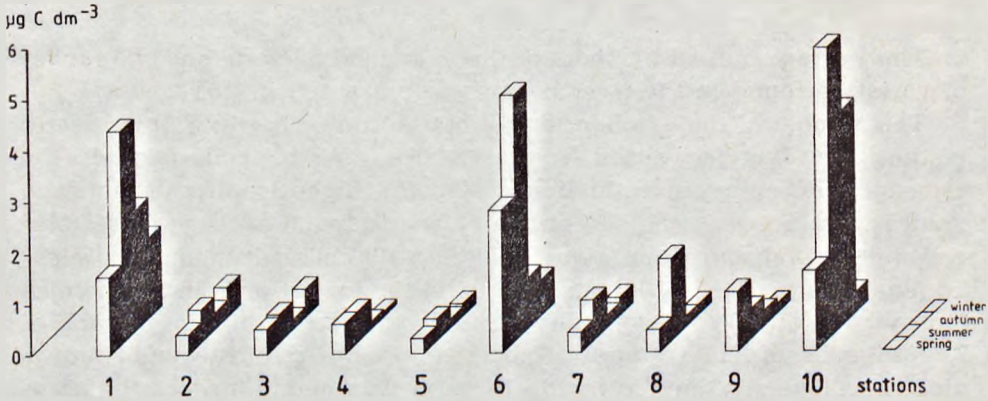


Fig. 3. Seasonal changes in the mean biomass of bacteria in the water of the River Dunajec from Nowy Targ to Nowy Sącz

stations the value of the biomass was higher than the average values found at the remaining stations in all seasons of the year. The water from the stations at Sromowce Niżne at Szczawnica showed the minimum values of the bacterial biomass. At Sromowce Niżne the minima occurred in the autumn and winter, while at Szczawnica they were noted in the spring and summer.

4. Discussion

The presented differences in the numbers of the groups of examined bacteria illustrate the changes which occur in the water of the River Dunajec between Nowy Targ and Nowy Sącz. This attempt at characterization of the waters also confirms the variability of conditions occurring in the investigated sector of the river and in its basin (Starzecka 1977, Pasternak, Starzecka 1979, Starzecka 1979).

On the basis of all average numbers of the investigated groups of bacteria and their biomass throughout the period of study the stations at Waksmund, Krościenko, and Nowy Sącz should be distinguished. At these stations, lying below towns, the highest values of the described parameters were observed, while whatever the season of the year the numbers and biomass of all groups of microorganisms decreased at stations lying further away from towns. The lowest values were found in the region of the Pieniny Mts (Pieniny National Park).

According to the classification of water purity developed for the lowland River Nida (Starzecka et al. 1979), the average numbers of heterotrophic bacteria, ammonifiers, denitrifiers, and bacteria releasing H_2S found in the water of the River Dunajec belong to the classes of re-

latively pure to very strongly polluted waters (Waksmund, Krościenko, and Nowy Sącz). This shows the very strong pressure of domestic sewage on the waters of this submontane river which, however, has a much greater potential of reaction to the inflow of pollution.

In relation to previous hydrobiological studies carried out in the River Dunajec (Chudyba 1965, Dratnal, Szczęsny 1965, Bieniarz, Epler 1972, Dratnal et al. 1979, Sowa 1979, Starmach 1983/84), the present results show the rapid degradation of the Dunajec waters. According to the obtained results the highest level of eutrophication is noted below Nowy Targ and Nowy Sącz. At the same time a distinct increase in trophy occurs in the river below Krościenko.

It can be said that the investigated part of the river to preserved to a marked degree its self-purification potential, as manifested in the sectors between Knurów and Szczawnica, and between Tylmanowa and Gołkowice. However, after successive discharges of wastes from the spa and recreational complex of Krościenko-Szczawnica the processes of self-purification in the sector between Tylmanowa and Gołkowice are less intensive.

The filling of the future reservoir at Czorsztyn and Sromowce Wyżne will eliminate this part of the River Dunajec where the number of bacteria in the water is distinctly reduced.

5. Polish summary

Charakterystyka mikrobiologiczna wód Dunajca na odcinku od Nowego Targu do Nowego Sącza (Polska Południowa)

Na podstawie jednorocznych badań opartych na analizie liczebności wybranych grup bakterii i biomasy, przeprowadzono charakterystykę mikrobiologiczną wód Dunajca na blisko stukilometrowym odcinku rzeki (ryc. 1).

Biorąc pod uwagę wszystkie średnie liczby badanych grup bakterii i biomasę za cały okres badań można wyróżnić stanowiska Waksmund, Krościenko i Nowy Sącz, a więc stanowiska poniżej miast, gdzie stwierdzono jednoznacznie najwyższe średnie wartości badanych parametrów, natomiast niezależnie od pory roku, na stanowiskach bardziej oddalonych od miast, biomasa i liczebność wszystkich badanych grup mikroorganizmów spada, osiągając najniższe wartości w okolicach Pienin (ryc. 2, 3). Wyniki te wskazują, że badany odcinek rzeki najsilniej zeutrofizowany jest poniżej Nowego Targu i Nowego Sącza, równocześnie obserwuje się wyraźny wzrost trofii wód poniżej Krościenka.

Badany odcinek Dunajca w znacznym stopniu zachował zdolność samooczyszczania; jest to widoczne na odcinku Knurów — Szczawnica i Tylmanowa — Gołkowice. Jednak na odcinku Tylmanowa — Gołkowice po kolejnej porcji zanieczyszczeń nie oczyszcza się tak intensywnie.

Zalew przyszłych zbiorników w Czorsztynie i Sromowcach Wyżnych wyeliminuje odcinek Dunajca, na którym stwierdzono wyraźny spadek liczebności bakterii w wodzie.

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