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BACTERIOLOGICAL CONTAMINATION OF BABIA GÓRA MASSIF STREAMS

The main aim of this research was to present bacteriological contamination of Babia Góra Massif streams, especially with mesophilic bacteria, psychrophilic bacteria, proteolytic bacteria and also coliforms and thermotolerant coliforms. The analysis is entirely based on comparing total bacteria numbers in different streams in Babia Góra Massif (in side and outside the Babia Góra National Park). The authors discovered also the main reasons for bacterial expansion. They also assessed the impact of the natural conditions (season, weather) and human activity on bacteriological conatmination of streams. This research allows the identification of the main sources of pollution and evaluation of purity of streams in Babia Góra Massif.

1. INTRODUCTION

In Poland, there are 23 national parks. One of the oldest is the Babia Góra National Park (BGNP). It was established in 1954 around Babia Góra Massif, which is called "the Queen of the Beskidy Mountains", because Babia Góra is the highest summit of Beskidy Mountains (1725 m). In 1977, UNESCO incorporated BGNP into the Worldwide Biosphere Nature Reserve Net due to its environment, which is characteristic of Beskidy Mountains, and its geographical position [1], [2]. The borders of the BGNP do not enclose the whole Babia Góra Massif. This fact makes BGNP a useful source of information about natural environment and undesirable changes this environment caused by human activity.

Expansion of bacteria in water depends on many different factors (physical, biological, chemical). The factors affecting total number of bacteria and taken into account in this research can be itemized as follows:

• Temperature; it depends on season, weather conditions, topography (shade given by natural or artificial object).

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• Chemical compounds (organic and inorganic) which occur in water (natural chemical constitution) and are introduced into water in natural way (earth flow, shedding of leaves) or as a result of human activity.

• Concentration of oxygen in water.

Temperature is one of the most important factors, which have a great impact on bacterial expansion in water. If the temperature of environment is taken into account, bacteria can be classified as follows: psychrophiles (low), mesophiles (temperate) and thermophiles (high) [3], [4], [9], [11]. This leads to the conclusion that the higher the temperature (as a result of, e.g., season or weather conditions), the higher the total number of mesophilic bacteria and the lower the total number of psychrophilic bacteria. When this regularity is disturbed, other factors influence bacterial reproduction.

The changes in river level are equally important. This level depends on temperature and weather conditions (precipitation). When temperature is high and precipitation does not occur, the level of river water is low, hence the concentration of bacteria is higher.

Taking into account the source of energy used by bacteria, they can be divided into: phototrophs or chemotrophs. Bacteria use both inorganic and organic matter. Chemical composition of water affects bacteria occurring in aquatic ecosystems. Surface water is permanently enriched with chemical compounds formed as a result of natural processes (earth flow, shedding of leaves, decaying aquatic organisms) and human activity (economic and municipal). In this research, the authors assume that the increasing number of bacteria (excluding this caused by natural factors) is due to human activity.

In every ecosystem, including aquatic ecosystems, we can find proteolytic bacteria which break down proteins in dead organic matter. In surface water, there are many sources of dead organic matter. Dead aquatic organisms and dead organic matter from the outside (e.g., shedding of leaves) are natural sources of organic matter. Proteolytic bacteria break down also proteins associated with human activity (sewage, wastewater). A total number of proteolytic bacteria changes, depending on the season. In pure surface water, the number of bacteria reaches its maximum in autumn, when many aquatic organisms die (living conditions are worsened) and there is a flow of organic matter from the outside (shedding of leaves). Another maximum in the total number of proteolytic bacteria is observed also in spring or in early summer (depending on weather conditions). In this period, living conditions are conducive to all organisms, including proteolytic bacteria, and the water is rich in nutrients accumulated during the winter, when the activity of organisms is reduced (not all nutrients are consumed) and some of aquatic organisms die. If nutrients are consumed, a total number of proteolytic bacteria decreases. Proteolytic bacteria break down only the organisms, which die in natural way. If a total number of proteolytic bacteria increases (after elimination of natural factors, which could affect bacterial expansion), this can be related to pollution of water due to human activity.

In terms of the requirement for oxygen, bacteria are divided into (facultative and obligate) aerobes and anaerobes. The concentration of oxygen is the next factor affecting a total number of bacteria in water.

The concentration of oxygen in water changes, depending on the distance from the river spring. Springwater is poor in oxygen because it is often underground water, which does not contain oxygen. Oxygen shortage disappears very quickly, especially in high-mountain streams, due to high turbulence of water, which causes its quick oxygenation. In rivers, water oxygenation changes, depending on the distance from the spring source. In the middle of a river lenght, production of biomass and consumption of oxygen are high, and oxygenation and turbulence – low.

Concentration of the oxygen might change also as a result of human activity. Earth flow of biogenic compounds from fertilized fields and the inflow of sewage to the rivers and streams are responsible for their eutrophication. This process could be the reason of a deficit (serious or partial) of oxygen in water. Oxygen deficit causes unbalance between aerobes and anaerobes.

Facultative anaerobes being examined are coliforms and thermotolerant coliforms. Both are indicator species of the presence of sewage in water. Natural environment of these bacteria is alimentary tract (human and animal). Although they are able to live in water, they cannot reproduce there, which means that every single coliform or thermotolerant coliform becomes from sewage or animal droppings.

Bacterial contamination of water allows us to show the impact of human activity on environment. Due to the occurrence of mesophilic bacteria, psychrophilic bacteria, proteolytic bacteria, coliforms and thermotolerant coliforms a human impact on Babia Góra Massif environment could be verified. Aquatic environment is a natural habitat for mesophilic bacteria, psychrophilic bacteria and proteolytic bacteria. Their presence and number depend on season and weather conditions. If their total number is high, it is possible that people polluted the water. On the other hand, for coliforms and thermotolerant coliforms natural habitat is alimentary tract, so their presence testifies to human activity [3]–[6].

2. MATERIALS AND METHODS

2.1. THE AREA AND SITES STUDIED

Babia Góra Massif is situated in Żywiecki Beskid Mountains, which are the east part of High Beskidy Mountains. Babia Góra Massif (1725 m) stretches between the Jałowiecka Pass and the Lipnicka Pass [2], [7]. Our studies are based on comparing bacterial contamination of streams inside and outside Babia Góra National Park. Other factors taken into account are climate, season and topography of Babia Góra Massif.

All streams are situated on the north side of Babia Góra Massif because its north and south sides are exposed to different weather conditions.

The streams under examination situated in Babia Góra National Park are as follows:

- the Jaworzynka Stream (station 1),
- the Markowy Potok (station 4).

The streams outside of Babia Góra National Park are:

- the Jaworzyna Stream (station 2),
- the Skawica Stream (station 5), upstream part,
- the Skawica Stream (station 6), middle part.

Station 3, the Czatożanka Stream, is situated on the border of Babia Góra National Park.

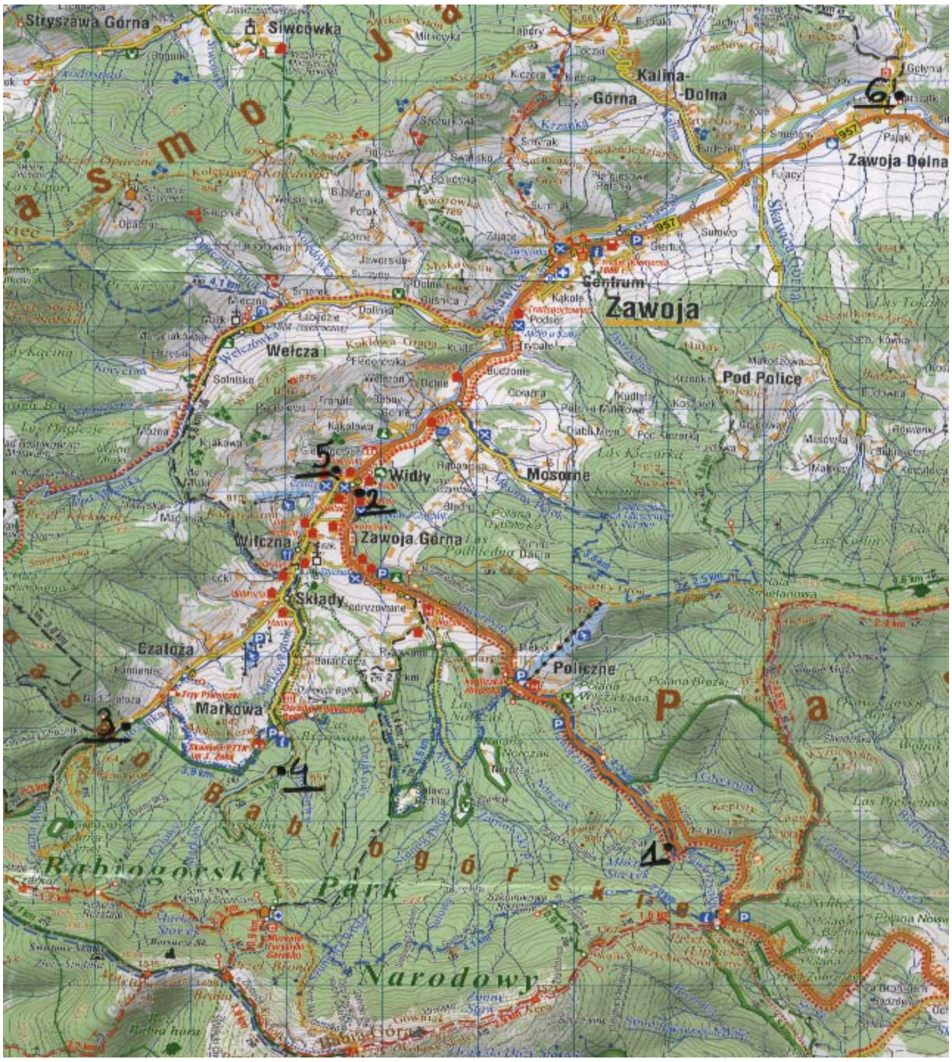

Fig. 1. Location of the stations

All stream bottoms are covered with stones and gravel, which is typical of this area. Stations 1 and 3 are situated in steep, V-shaped valleys, stations 1 and 4 – in the middle of forest, station 3 between forest and pasture and stations 2 and 5 are situated in town. Station 6 lies between meadows, but not far away from fields and town. Due to such location of the streams it is possible to specify the sources of the bacterial contamination.

In all the streams, water is continuously mixed which is typical of mountainous streams and rivers. As a result, the oxygen concentration and temperature are the same in all cross-sections of the streams. The streams differ in flow velocity due to their different width and depth which are dependent on weather conditions [8]–[10]. It is impossible to eliminate these factors because of the topography of the Park.

2.2. METHODS

Bacterial contamination is assessed based on:

- Total mesophilic bacterial count in 1 cm^3 of water.
- Total psychrophilic bacterial count in 1 cm^3 of water.
- Total proteolytic bacterial count in 1 cm^3 of water.
- Total coliform count in 100 cm^3 of water.
- Total thermotolerant coliform count in 100 cm^3 of water.

All the analyses were carried out in the Chair of Microbiology at the Academy of Agriculture in Cracow in May, July, August, September, November and December 2004 and consisted in defining total count of:

- mesophilic bacteria in 1 cm^3 of water cultured on agar medium at 37 °C for 24 hours,
- psychrophilic bacteria in 1 cm^3 of water cultured on agar medium at 22 °C for 48 hours,
- proteolytic bacteria in 1 cm^3 of water cultured on gelatine medium at 22 °C for 48 hours,
- coliforms in 100 cm^3 of water cultured on Endo medium at 37 °C for 48 hours,
- thermotolerant coliforms in100 cm^3 of water cultured on Endo medium at 44 °C for 48 hours.

Quantitative analyses of mesophilic, psychrophilic and proteolytic bacteria were based on Koch's plate method of dilutions. Using 1 cm^3 pipettes and 9 cm^3 test tubes containing physiological solution (0.85% solution of NaCl) we prepared the dilutions according to the scheme shown in the table.

Quantitative analyses of coliforms and thermotolerant coliforms were based on the method of membrane filtration. 100 cm^3 of water was percolated through two membrane filters (the size of pores ranges from 0.2 to 0.4 μm): one for coliforms and one for thermotolerant coliforms. All filters were placed in Petri dishes with Endo medium.

Table

Scheme of Koch's plate method of dilutions

Culture	Dilution				
	N	1/10	1/100	1/1000	1/10000
Agar (M)	–	+	+	+	+
Agar (P)	–	+	+	+	+
Gelatine culture	+	+	+	+	–

M – mesophilic bacteria.
P – psychrophilic bacteria.

3. DISCUSSION

A total number of mesophilic bacteria at the first and second stations is similar, but at the second station it is higher, probably due to station location. The first station is situated in a higher part of the massif, near the river source and inside the BGNP. On the other hand, the second station is situated in Zawoja-Widły, between buildings. For this reason the environment is highly polluted because of human activity (sewage, roads, trout breeding), which has also the influence on a total number of bacteria, but not on their distribution. This means that at both stations the season, weather conditions, temperature and natural processes have, to a high degree, the influence on bacterial expansion. At both stations the size of bacteria population reaches its maximum in July (summer) and in September and November (autumn).

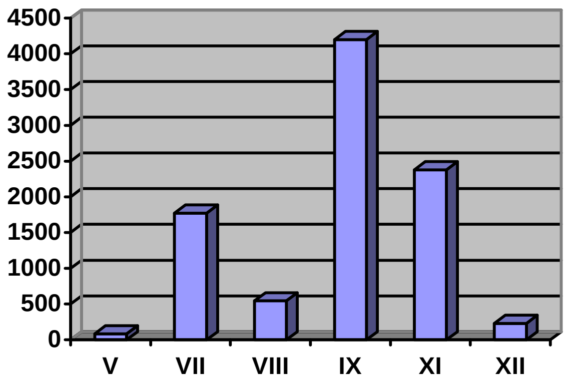

Fig. 2. A total number of mesophilic bacteria in 1 cm³ of water from station 1

A total number of mesophilic bacteria at the third station (the Czatożanka Stream) does not depend on weather conditions. Its maximum is reached only in autumn (November). This allows the conclusion that another factors affect a total number of mesophilic bacteria. The third station is situated on the border of the BGNP, above buildings and near water conditioning station. Earth flow of biogenic compounds from pastures has the influence on both total number and distribution of bacteria. This station is located between pasture and thick forest. A total number of bacteria reaches its maximum in autumn as a result of the constant inflow of organic matter from forest and earth flow of biogenic compounds from pasture.

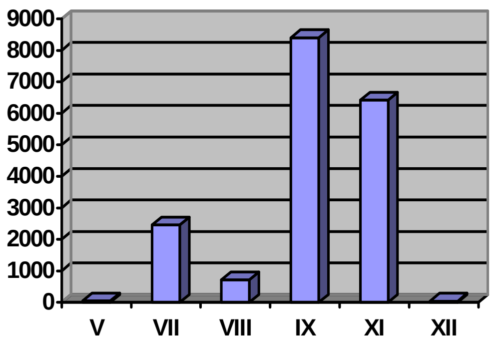

Fig. 3. A total number of mesophilic bacteria in 1 cm³ of water from station 2

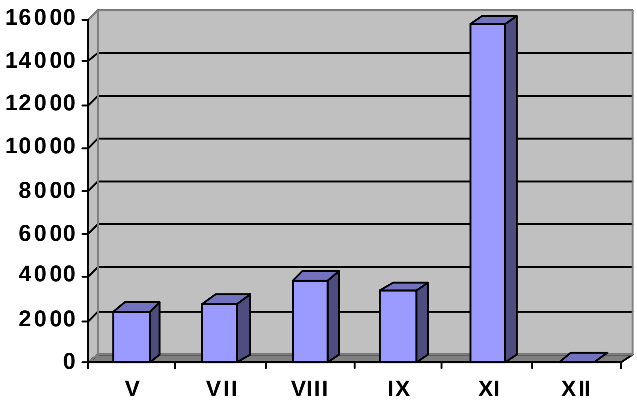

Fig. 4. A total number of mesophilic bacteria in 1 cm³ of water from station 3

A total number of mesophilic bacteria and their distribution at the fourth station (the Markowy Stream) is similar to that at the first station and depends mainly on the season and weather conditions. This station is situated in the BGNP. A higher total number of bacteria in November and its smaller diversification during all analyses are due to the station location (thick forest).

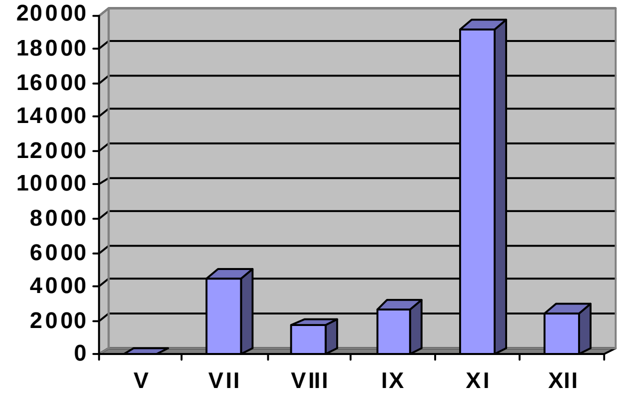

Fig. 5. A total number of mesophilic bacteria in 1 cm³ of water from station 4

At the fifth and sixth stations (both on the Skawica River) it is hard to find the maximum. In the whole period of investigation, a total number of mesophilic bacteria is much higher than at previous stations. It is possible only to point the minimum. Quantitative analyses show that the sixth station is more polluted than the fifth one because of their location. The fifth station lies in the middle of Zawoja, and the sixth station at the end of Zawoja (here the Skawica collects water from the whole Zawoja). Human activity has the greatest influence on so serious bacteriological contamination of water: sewage (high amount especially in tourist seasons), wastewaters (industrial plants, animal farms and fish breeding) and inflow of biogenic compounds (from fields, pastures and nursery). The minima occur in August and December. Minimum in winter might be a result of low temperature.

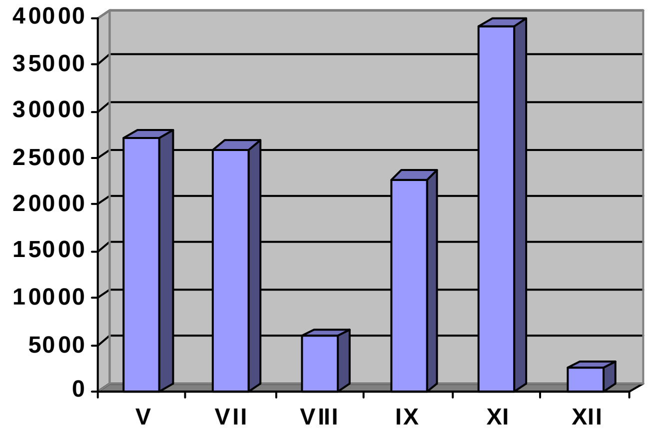

Fig. 6. A total number of mesophilic bacteria in 1 cm³ of water from station 5

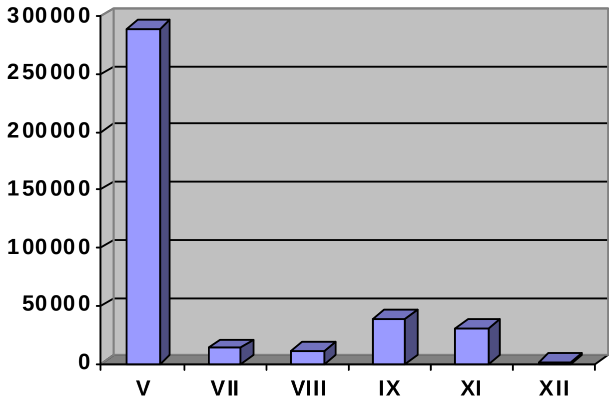

Fig. 7. A total number of mesophilic bacteria in 1 cm³ of water from station 6

The distribution of a total number of psychrophilic bacteria in all stations shows that season and weather conditions have greater influence on expansion of psychrophilic bacteria than on the expansion of mesophilic bacteria. Maximum and minimum occur at all stations in the same analyses. The main maximum in November is a result of lower temperature (season) and better living conditions for psychrophilic bacteria. On the other hand, a total number of bacteria is different at each station. The stations inside (1 and 4) and on the border of the BGNP (3) are less polluted with psychrophilic bacteria than the stations outside the BGNP (5 and 6). Compounds, which stimulate expansion of psychrophilic bacteria, are the same as compounds stimulating expansion of mesophilic bacteria (at these stations). A total number of psychrophilic bacteria is lower than that of mesophilic bacteria, which shows that in the streams examined and in the Skawica flowing down Babia Góra Massif living conditions (especially temperature) are better for mesophilic bacteria than for psychrophilic bacteria.

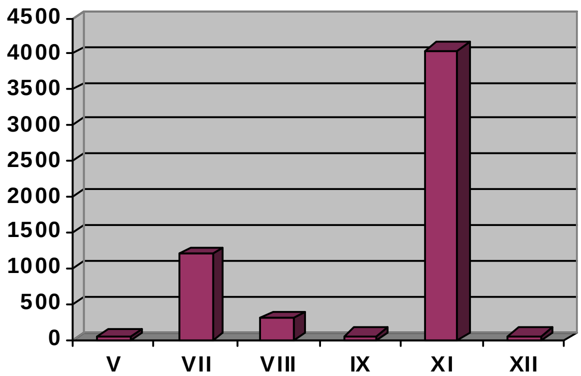

Fig. 8. A total number of psychrophilic bacteria in 1 cm³ of water from station 1

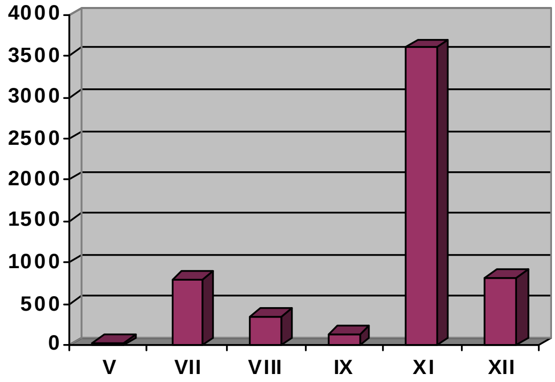

Fig. 9. A total number of psychrophilic bacteria in 1 cm³ of water from station 2

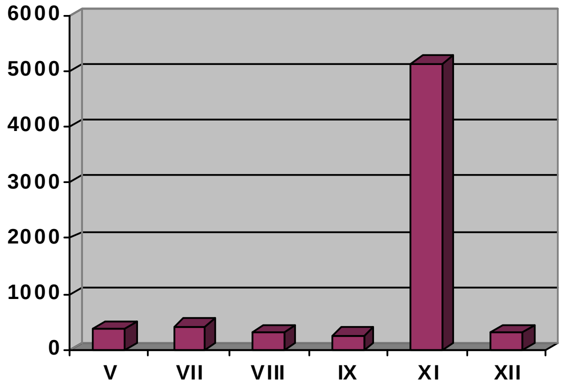

Fig. 10. A total number of psychrophilic bacteria in 1 cm³ of water from station 3

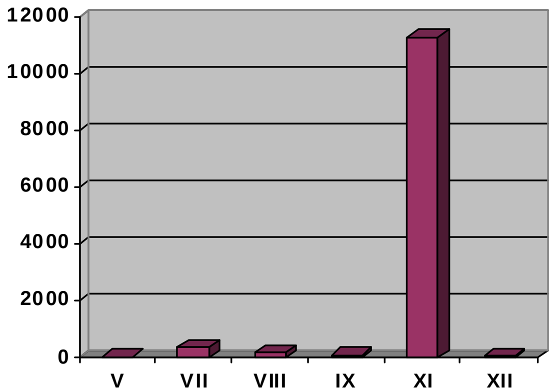

Fig. 11. A total number of psychrophilic bacteria in 1 cm³ of water from station 4

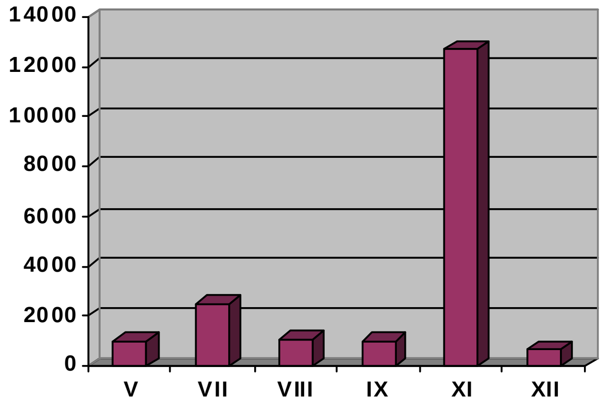

Fig. 12. A total number of psychrophilic bacteria in 1 cm³ of water from station 5

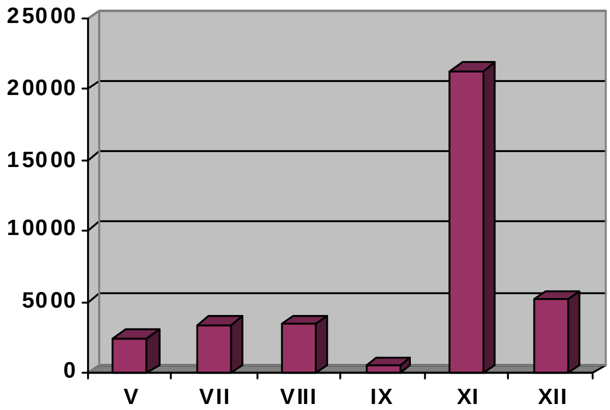

Fig. 13. A total number of psychrophilic bacteria in 1 cm³ of water from station 6

Similar research was carried out for Wigry Lake (the Wigry National Park (WNP)) by KORZENIEWSKA and NIEWOLAK [12]. They found that a total number of psychrophilic bacteria in the lake is higher than a total number of mesophilic bacteria. So the living conditions in the Wigry Lake (WNP) are different from these in streams and Skawica (BGNP).

The lowest total number of proteolytic bacteria occurs at the third and fourth stations situated in thick forest. Location and season are the main reasons for the occurrence of a maximum total number of proteolytic bacteria in autumn. Other analyses show constant but low level of proteolytic bacteria. Bacteria of this type decompose the organisms, which died in natural way. The analysis carried out in December at the fourth station is the exception to the above trend. A high number of proteolytic bacteria might be caused by water pollution with sewage. However, the Markowy Stream flows out of strictly protected part of the BGNP. For the sake of strict protection, fallen tree trunks and branches are left in place, provided that they are not infected with diseases. So the area in the vicinity of the fourth station must be more fertile than that in the third station, and temperature in December in 2004 was not as low as usual in this season and did not make living conditions much worse for proteolytic bacteria.

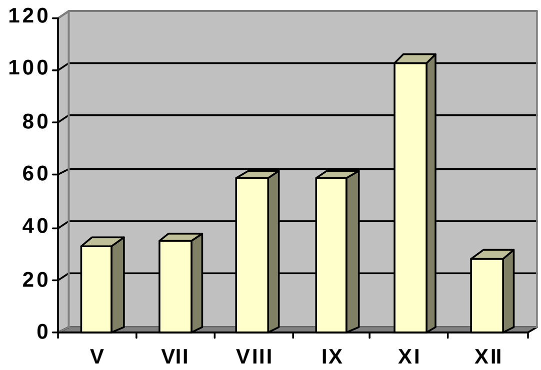

Fig. 14. A total number of proteolytic bacteria in 1 cm³ of water from station 3

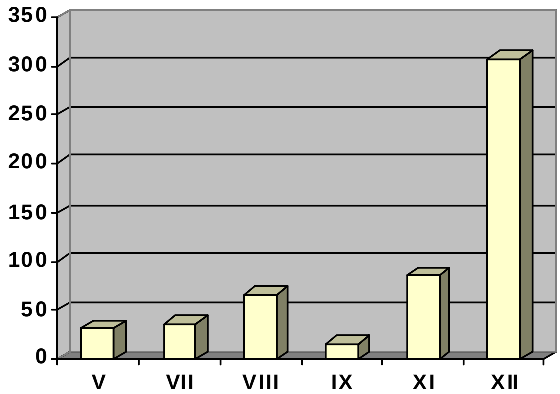

Fig. 15. A total number of proteolytic bacteria in 1 cm³ of water from station 4

A total number of proteolytic bacteria at the first and second stations is also low, but higher than that at the third and fourth stations. At the second station, the water is not so polluted as at the fifth and sixth stations, although it is also situated between buildings. However, a higher number of proteolytic bacteria might be caused by the inflow of sewage. This might be the reason of a high number of proteolytic bacteria in December, when their total number should decrease at non-polluted stations (e.g., the first station). On the other hand, a total number of proteolytic bacteria at the first station is higher than at other stations situated inside the BGNP (pure stations), which might be explained by the valley shape resembling the letter V. Rain water causes earth flow with different nutrients (including proteins), which are indispensable for bacteria. The highest number of proteolytic bacteria at both stations occurs in May and November, which means that (like at other non-polluted stations) expansion of these bacteria depends on natural processes.

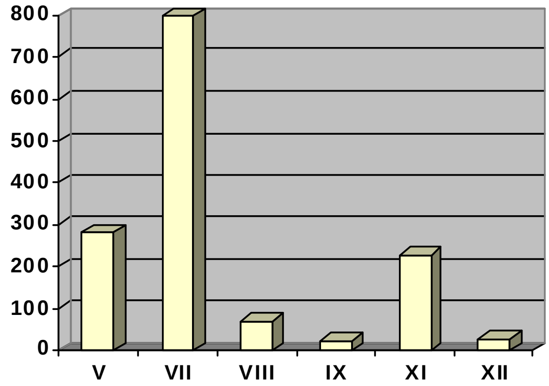

Fig. 16. A total number of proteolytic bacteria in 1 cm³ of water from station 1

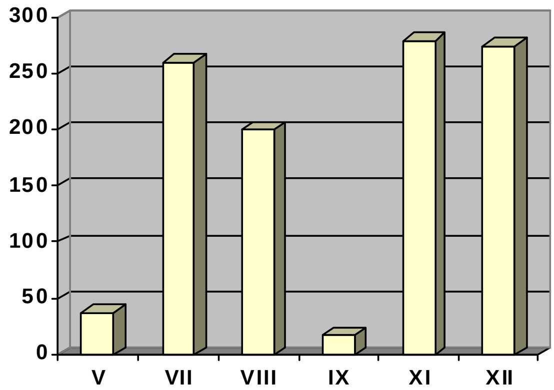

Fig. 17. A total number of proteolytic bacteria in 1 cm³ of water from station 2

The fifth and sixth stations are abundant in proteolytic bacteria. Their occurrence cannot be explained by seasons. Although in November the size of the population of these bacteria is high, they do not reach their maximum, which occurs in May. A total number of proteolytic bacteria changes irregularly. The only explanation can be sewage discharge and other sources of proteins in water.

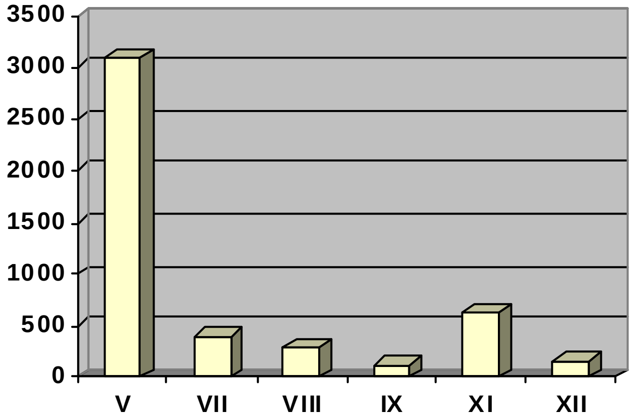

Fig. 18. A total number of proteolytic bacteria in 1 cm³ of water from station 5

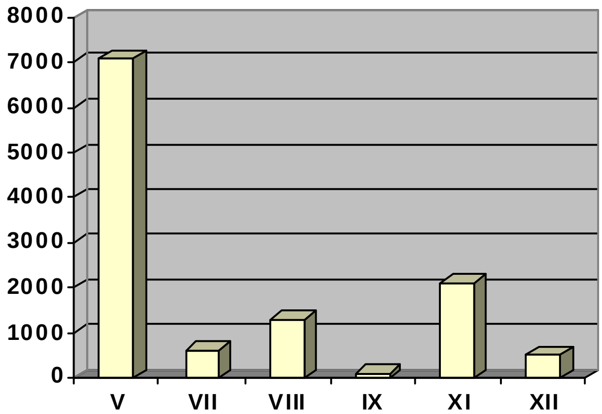

Fig. 19. A total number of proteolytic bacteria in 1 cm³ of water from station 6

Proteolytic bacteria were investigated in the Dobczycki reservoir by scientists from Polish Academy of Sciences in Cracow, Poland. Authors compared a total number of proteolytic bacteria from the Dobczycki reservoir and its tributary – the Wolnica Stream. Experiments revealed that it was higher in the Dobczycki reservoir than in the Wolnica, where it was on a constant low level, like in the streams of Babia Góra Massif [13].

According to STARZECKA and BEDNARZ [13], a total number of bacteria (mesophilic, prychrophilic and proteolytic bacteria) in the Raba River was greatly affected by their biodiversity with time and in space, the differences in the availability of nutrients, physiology of bacteria and physical and chemical factors, which affect living conditions in water. Some of the factors have also the influence on living conditios in streams and the Skawica River in Babia Góra Massif.

A total number of coliforms and a total number of thermotolerant coliforms at the fifth and sixth stations were much higher than at other stations during the whole period of investigation. This may be attributed to the discharge of improperly treated sewage, illegal inflow of domestic sewage and untight septic tanks. At the sixth station a total number of both bacteria is higher than that at the fifth station, which can be explained by the location of both stations. The fifth station is situated in the middle of Zawoja, and the sixth one at the end of this village. The highest number is observed in July and August, after long period of drought with high temperature which lowered the level of the river.

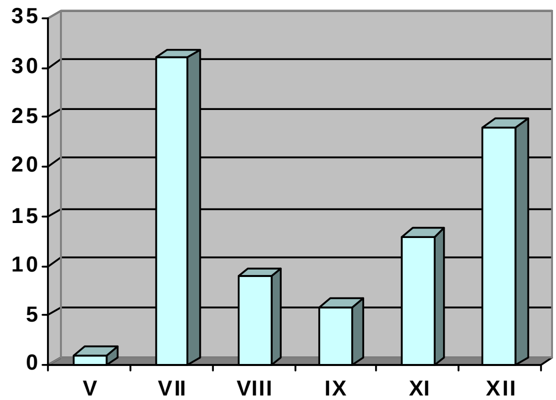

Fig. 20. A total number of coliforms in 100 cm^3 of water from station 5

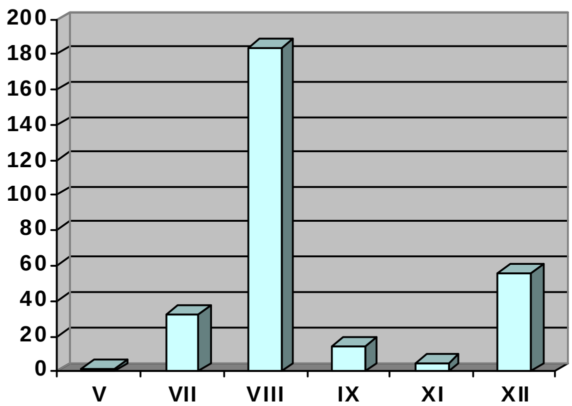

Fig. 21. A total number of coliforms in 100 cm^3 of water from station 6

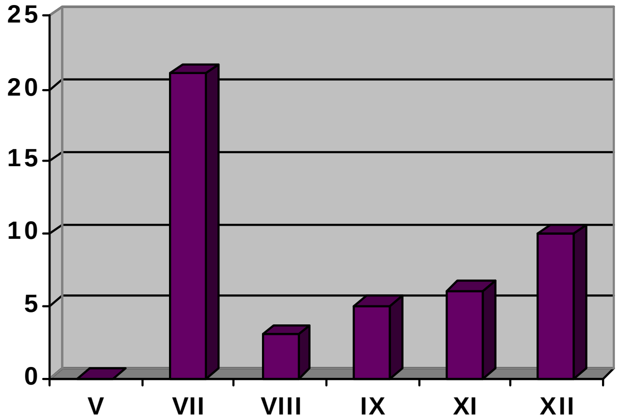

Fig. 22. A total number of thermotolerant coliforms in 100 cm^3 of water from station 5

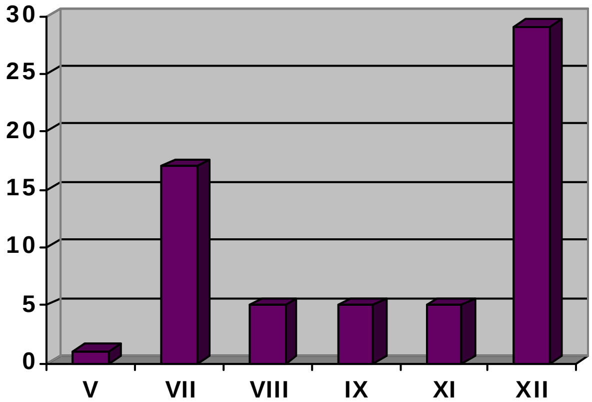

Fig. 23. A total number of thermotolerant coliforms in 100 cm^3 of water from station 6

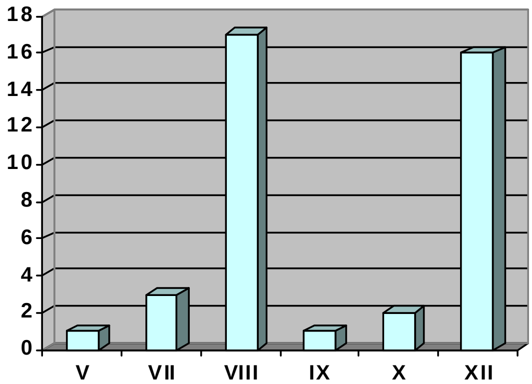

Fig. 24. A total number of coliforms in 100 cm^3 of water from station 2

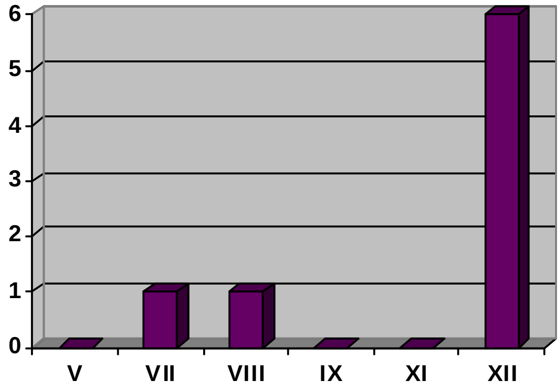

Fig. 25. A total number of thermotolerant coliforms in 100 cm^3 of water from station 2

The maxima in coliforms and thermotolerant coliforms at the second station are reached also in July and August, but they are much lower than these at the fifth and sixth stations because of lower density or better treatment of sewage. The first reason seems to be more genuine.

Coliforms and thermotolerant coliforms at the fourth station reach their maxima in August, which testifies to the influence of lower stream level on a higher number of these bacteria. Other analyses at this station reveal only single colonies or they do not occur at all. Wild animals from the BGNP are probably responsible for the presence of single colonies in stream water.

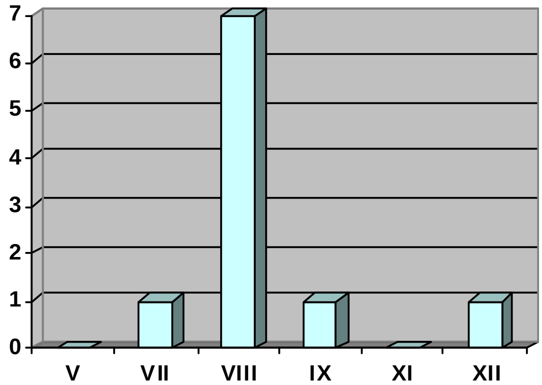

Fig. 26. A total number of coliforms in 100 cm^3 of water from station 4

At the first station conditions are similar to these at the fourth station. The bacteria investigated reach their maxima in November, and in other seasons they are absent or form single colonies only. Their occurrence can be attributed to the presence of wild animals. Good weather conditions (as at the second, fifth and sixth stations) are probably responsible for the maxima of coliforms and thermotolerant coliforms in November.

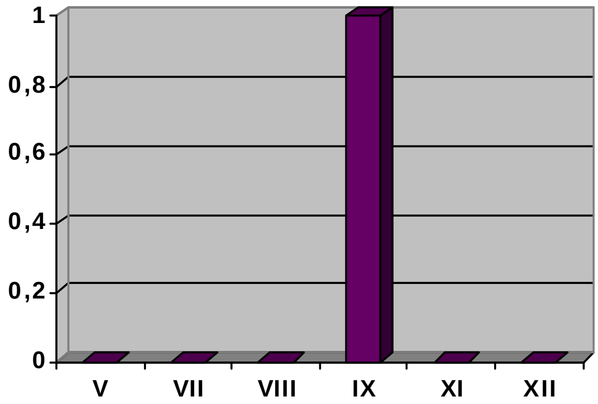

Fig. 27. A total number of thermotolerant coliforms in 100 cm^3 of water from station 4

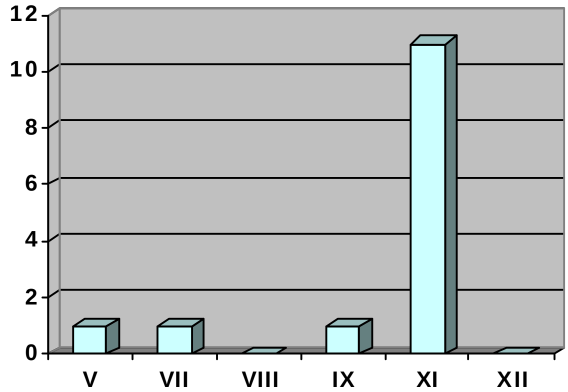

Fig. 28. A total number of coliforms in 100 cm^3 of water from station 1

At the third station coliforms and thermotolerant coliforms occur only in July and August. In these months, rains fall rarely and temperature is high which promotes high number of bacteria. The occurrence of coliforms and thermotolerant coliforms is also affected by wild and farm animals (the third station is situated near pastures).

NIEWOLAK and KORZENIEWSKA [12] studied also coliforms and thermotolerant coliforms in Lake Wigry. They found out why these bacteria occur in this lake. Their single colonies in the samples of water can be attributed to the presence of water fowls and wild animals.

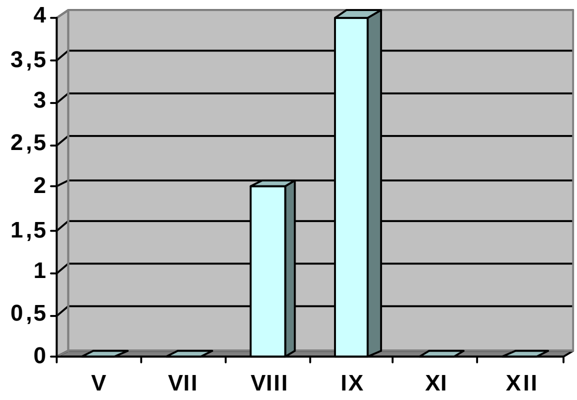

Fig. 29. A total number of coliforms in 100 cm^3 of water from station 3

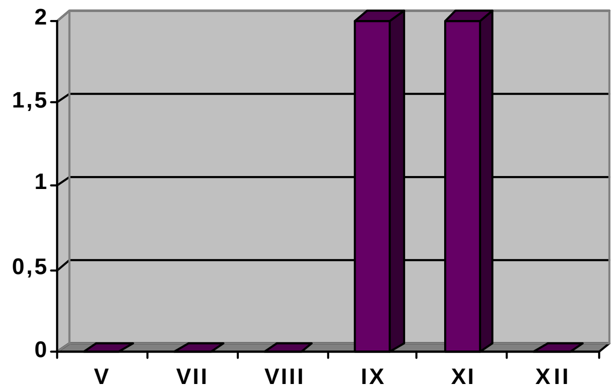

Fig. 30. A total number of thermotolerant coliforms in 100 cm^3 of water from station 3

The village of Zawoja belongs to the Sucha Beskidzka district, where the project "Alternative sources of drinkable water in the Sucha Beskidzka district in emergency" [14] is implemented. The Sucha Beskidzka district is faced with the necessity of being prepared for drought or flood, which occur more and more often. According to the report, 20 thousand people (1/4 people lived in the Sucha Beskidzka district) are supplied with drinkable water which is surface water (local rivers and streams). The purity of surface water in the Sucha Beskidzka district was tested and it turned out that the water was contaminated with bacteria both in rainy and in dry periods. In rainy periods, bacterial contamination is a result of washing pollutants out of fields, places where animals droppings are stored, septic tanks (often without tight bottom). In dry periods, when a river level is lower, the concentration of sewage from households and animal stocks in surface water increases. In the Sucha Beskidzka district, illegal inflow of sewage to rivers is still a serious problem.

4. RESULTS

The streams inside the Babia Góra National Park are less contaminated with bacteria than these outside the Park. At the same time, the streams situated on the border of the BGNP are threatened with unwise human activity. The farther from the border of the Babia Góra National Park, the higher the concentration of bacteria.

The analysis of mesophilic bacteria shows that their total number depends greatly on station location. The stations situated inside the Babia Góra National Park (1 and 4) were less contaminated than the stations outside the park. Both season and weather conditions are considered to be the main causes of the changes in the number of mesophilic bacteria. A total number of mesophilic bacteria at the stations outside the BGNP (5, 6) is constant, but on a high level, and does not depend on weather conditions and season. At these stations only minima are reached. The main impact on a total number of mesophilic bacteria has human activity: communal sewage (tourists must be taken into acount), industrial sewage, biogenic matter flows from fields, pastures and nurseries.

The distribution of a total number of psychrophilic bacteria in particular analyses and stations is to a greater extent dependent on the season and weather condition than that of mesophilic bacteria. However, the more polluted the station, the higher the number of psychrophilic bacteria. Minima and maxima at all the stations are reached in the same months. The highest number of psychrophilic bacteria occurs in November at all the stations. The stations inside the Babia Góra National Park (1 and 4) and on its border (3) are less contaminated by psychrophilic bacteria than the stations outside the BGNP (5 and 6). The factors stimulating an increase in psychrophilic bacteria are the same as the factors stimulating an increase in mesophilic bacteria. Generally, a total number of psychrophilic bacteria is smaller than a total number of mesophilic bacteria, which shows that better conditions for mesophilic bacteria are encountered in Babia Góra streams.

Expansion of proteolytic and mesophilic bacteria is affected by the same factors. Expansion of the former bacteria depends on season and the processes that proceed in nature. Inflow of organic matter in autumn (shedding of leaves) is responsible for maximum levels of bacteria in November and December. Our results do not corroborate this finding at every station. It might be a result of human activity, because it is noticed especially at the stations with polluted water (sewage of different origin). This conclusions may be supported by the fact that in May a total number of proteolytic bacteria is much higher than in November (contrary to less polluted stations).

The total numbers of both coliforms and thermotolerant coliforms at the second, fifth and sixth stations (stations between buildings) are much higher than at other stations (inside the BGNP). Sewage of different origin is responsible for high levels of coliforms and thermotolerant coliforms:

- Illegal inflow of sewage (in Poland it is still serious problem).
- Leaky septic tanks (especially during rainstorm).
- Run-off from fertilized fields.

The highest numbers of coliforms and thermotolerant coliforms are observed in July and August after the period of long-lasting drought and high temperature, which lowered the level of rivers, being a reason of high concentration of coliforms and thermotolerant coliforms and other contaminants. There are two main reasons for different numbers of coliforms and thermotolerant coliforms at the second, fifth and sixth stations: different density of their populations or different degree of sewage purity. In other cases, coliforms and thermotolerant coliforms are not found or occur in single colonies (this might be attributed to the activity of wild animals).

The water in the streams of Babia Góra Massif is first of all contaminated with coliforms and thermotolerant coliforms contained in sewage. At the same time, expansion of mesophilic, psychrophilic and proteolytic bacteria depends on season and weather conditions only at the stations with the cleanest water (inside the BGNP). In other cases, a total number of bacteria depends on human activity.

LITERATURE

[1] FUJAK K., FUJAK J., *Babiogórski Park Narodowy*, Wydawnictwo Multico, Warszawa, 2000.

[2] ROTTER A., FICEK Z., *Babia Góra – Babiogórski Park Narodowy*, Wydawnictwo Karpaty, Kraków, 1995.

[3] PAWLACZYK-SZPILOWA M., *Mikrobiologia wody i ścieków*, Wydawnictwo Naukowe PWN, Warszawa, 1978.

[4] RHEINHEIMER G., *Mikrobiologia wód*, Państwowe Wydawnictwo Rolnicze i Leśne, Warszawa, 1987.

[5] SOBCZAK E., *Teoria i ćwiczenia z mikrobiologii ogólnej i technicznej*, Wydawnictwo SGGW i AR, Warszawa, 1991.

[6] SZEMBER A., *Zarys mikrobiologii rolniczej*, Wydawnictwo AR, Lublin, 1995.

[7] PTASZYCKA-JACKOWSKA D., *Światy Babiej Góry*, Wydawnictwo Grafikon, Wadowice, 2002.

[8] KAJAK Z., *Hydrologia – limnologia. Ekosystemy wód lądowych*.

[9] LIBUDZISZ Z., KOWAL K., *Mikrobiologia techniczna*, Wydawnictwo Politechniki Łódzkiej, Łódź, 2000.

[10] LAMPERT W., SOMMER U., *Ekologia wód śródlądowych*, Wydawnictwo Naukowe PWN, Warszawa, 2001.

[11] NOWAK A., *Mikrobiologia dla kierunków rolnictwo, ogrodnictwo i ochrona środowiska*, Wydawnictwo AR, Szczecin, 2000.

[12] KORZENIEWSKA E., NIEWOLAK S., *Ocena sanitarno-bakteriologiczna wód przybrzeżnych jeziora Wigry. Problemy aktywnej ochrony ekosystemów wodnych i torfowisk w polskich parkach narodowych*, S. Radwan, R. Kornijow (editors), Lublin, 1999, 232–236.

[13] *Zbiornik Dobczycki – ekologia, eutrofizacja, ochrona*, J. Starmach, G. Mazurkiewicz-Boroń (editors), Kraków, 2000.
[14] GOŁUSZKA J., KWAŚNY W., *Raport z realizacji programu: Alternatywne źródła zaopatrzenia w wodę pitną ludności powiatu suskiego w warunkach specjalnych*, Sucha Beskidzka, 2004.

ZANIECZYSZCZENIE BAKTERIOLOGICZNE POTOKÓW MASYWU BABIEJ GÓRY

Określono zanieczyszczenie bakteriologiczne potoków położonych w masywie Babiej Góry na podstawie ilościowej analizy bakterii mezofilnych, psychrofilnych, proteolitycznych oraz bakterii grupy *coli* i grupy *coli* typu kałowego. Przeprowadzone badania mają charakter porównawczy. Ich celem, oprócz wykazania stopnia zanieczyszczenia bakteriologicznego, było przede wszystkim wskazanie powodów i źródeł zanieczyszczenia bakteriami wód potoków położonych w masywie Babiej Góry zarówno w granicach, jak i poza granicami Babiogórskiego Parku Narodowego oraz określenie wpływu czynników pogodowych. Otrzymane wyniki i ich interpretacja pozwolą ograniczyć źródła zanieczyszczające wodę, a także mogą służyć do określenia jakości wód powierzchniowych pod kątem bakteriologicznym.