Research Article

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Water Quality of the Rivers in the Prespa Region in 2014

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Abstract: The aim of this study was to determine water quality of the following tributaries of Lake Prespa: Golema, Istocka, Kranska and Brajcinska. For this purpose, the following physical and chemical parameters were monitored in 2014: concentration of dissolved oxygen, biochemical oxygen demand for five days, chemical oxygen demand through $KMnO_4$ consumption, concentration of total nitrogen, and concentration of total phosphorus with bimonthly dynamics. Additionally, microbiological parameters such as heterotrophic bacteria and total number of coliform bacteria, including their seasonal dynamics, were studied. The highest organic and nutrient loading was registered in the Golema River. The results from microbiology indicated organic and faecal pollution of the water in the investigated rivers.

Key words: Rivers, anthropogenic, water quality, total nitrogen, total phosphorus, bacteria

Introduction

Many areas in the world are facing water shortages due to the scarcity of water resources in addition to the increase in the population (Gleick 1993). Rivers are very important freshwater ecosystems with essential importance for life maintenance. They provide numerous benefits for the people, some of which are irreplaceable, such as: water supply for households, industry and agricultural purposes, hydropower, navigation, recreation and spiritual fulfillment (Allan & Castillo 2007). Due to the fact that water quality and human health are tightly interconnected, the analysis of water before its usage has primary importance. There are some physical, chemical and microbiological parameters, which are used as standards for determination of the quality of water.

Lake Prespa together with Lake Ohrid has been considered as a hotspot of biodiversity and of great ecological, economic and social importance. The quality of water in the lake depends to a great extent on its tributaries, such as the rivers Golema, Istocka, Kranska, and Brajcinska. Therefore, physical, chemical and microbiological analyses of water in the rivers of the Prespa Region were conducted in order to determine their water quality. Previous studies indicate that the tributaries of Lake Prespa are under anthropogenic influence and they have negative impact on water quality of the lake littoral (Jordanoski & Sarafiloska 2001, 2002, Lokoska 2006, 2010, Sarafiloska et al. 2006, Shemo et al. 2008, Novevska & Lokoska 2009, Jordanoski 2012). The aim of this study was to determine the water quality of the following tributaries of Lake Prespa: Golema, Istocka, Kranska, and Brajcinska, based on physical, chemical and microbiological parameters and compare the results with those from the previous studies.

Materials and Methods

Lake Prespa is shared between the Republic of Albania, the Republic of Macedonia and Greece. It comprises two lakes, the Big and Small Prespa lakes. Lake Big Prespa is the second largest natural lake in the Republic of Macedonia situated in the Prespa Valley, which is isolated, enclosed and rounded by massive and high mountains. Lake Big Prespa is inflowing into Lake Ohrid through an underground flow (Cvijic 1911, Stanković 1960, Anovski et al. 1980, Sibinovik 1987).

The water samples were taken at five locations in the following tributaries of Lake Big Prespa: the rivers Golema, Istocka, Kranska, and Brajcinska (Fig. 1). The Golema River is the largest tributary of Lake Big Prespa. The other two tributaries, Kranska and Brajcinska, are draining forested and agricultural areas in the eastern shores of the lake. The Istocka River is small and dries out during the summer period.

The water samples were collected in 2014 with bimonthly dynamics. The following physical, chemical and microbiological parameters were studied: concentration of dissolved oxygen, biochemical oxygen demand for five days (BOD_5), chemical oxygen demand (COD) by potassium permanganate ($KMnO_4$), concentration of total nitrogen, concentration of total phosphorus, number of heterotrophic bacteria and total number of coliform bacteria.

The samples were collected in appropriate reagent bottles according to the standards for treatment of individual samples and transported in field-work cool boxes. The concentration of dissolved oxygen was determined in accordance to the method of Winkler (Bether 1953, APHA 1980). The biochemical oxygen demand for five days (BOD_5), which gives information about the oxygen required for chemical degradation of the organic constituents in the water in association with microorganisms, over a period of five days, at 20°C, in the dark, was determined according to standard methods. The chemical oxygen demand (COD) was determined by titrimetric analyses through the potassium permanganate ($KMnO_4$) consuming capacity (Bether 1953, APHA 1980). The concentration of total nitrogen in the water was estimated according to the Kjeldahl digestion, by which the nitrogen is transformed into a form of ammonia, and thereafter, it was determined spectrophotometrically at 640 nm wavelength with a Spectrophotometer UV/VIS, model SP–8001 (Solórzano 1969, APHA 1980). The concentration of total phosphorus was determined by the method of persulfate oxidation (Strickland & Parsons 1972, APHA 1980). The results for absorption of total phosphorus were analysed spectrophotometrically at

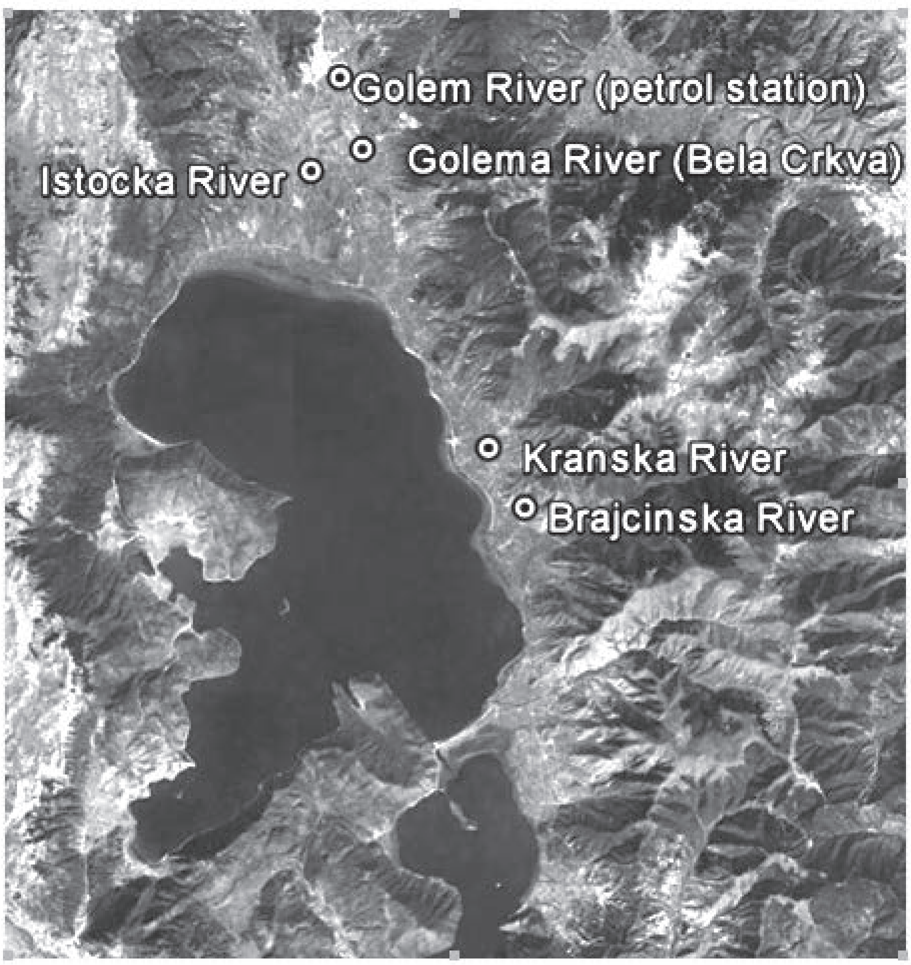

Fig. 1. Sampling locations at the studied rivers in the Prespa Region, in 2014

885 nm wavelength, with a Spectrophotometer UV/VIS, model SPECORD 10 (Zeiss).

The microbiological analyses were conducted according to the standard limnological methods (Rodina 1972, APHA 2005). The number of heterotrophic bacteria was determined on mesopeptone agar (MPA), while the total number of coliforms was determined on selective chromogen substrate (COLI ID) (Kohl 1975, Kavka et al. 2008).

The categorisation of water was made in five classes (I–V: little, moderate, critical, strong and excessive) pollution in accordance to the Decree on classification of waters of the Republic of Macedonia (Official Gazette 1999) and Kavka et al. (2008).

Results and Discussion

The highest value of dissolved oxygen (12.75 mg/L) was registered in the water from the Istocka River in March 2014, when the flow of the river was also the highest (Fig. 2). In the studied period, high values of dissolved oxygen were recorded in the mountain rivers Kranska and Brajcinska. In summer, the concentration of dissolved oxygen was generally lower, which corresponded to the increased temperature of the water. The lowest value of 1.21 mg/L for this parameter was registered in the Golema River in July 2014. Such a state of water in the rivers Golema, Kranska and Brajcinska was reported in the previous surveys carried out between 2000 and 2001 (Jordanoski & Sarafiloska 2002).

The values of the BOD_5 parameter in the collected samples of water from the studied rivers are depicted on Fig. 3. The highest value was registered in the Golema River and it was 9.63 mg/L in January 2014, while the lowest one was recorded in the Brajcinska River in January 2014, and it was 0.89 mg/L. The highest values of this parameter for all the studied period were registered in the samples from the Golema River.

The results for chemical oxygen demand (COD) showing the quantity of the organic matter through the consumption of $KMnO_4$ in the water from the rivers of Prespa Region are depicted on Fig. 4. As it can be seen from the graph, the maximum value of this parameter (129.85 mg/L) was recorded in the Golema River in November 2014, while the lowest value (3.35 mg/L) was measured in the Istocka River in December 2014. High organic loading of the water in the Golema River was reported for 2000 as well (Jordanoski & Sarafiloska 2001).

The concentrations of total phosphorus in the water from the rivers Golema, Istocka, Kranska, and Brajcinska are presented on Fig. 5. The highest phosphorous loading of water was observed in the Golema River, where the maximum value (219.39 µg/L) was recorded in September 2014. The minimum value of 9.16 µg/L was recorded in the water from the Istocka River in December 2014. During the studied period, high values of this parameter – within the range of 21.61 µg/L (May) and 119.74 µg/L (March) – were also registered in the water from the Kranska River. High phosphorus loading of the water in the rivers Golema and Kranska was reported for 2004–2005 as well (Sarafiloska et al. 2006). According to the Decree on classification of waters of the Republic of Macedonia (Official

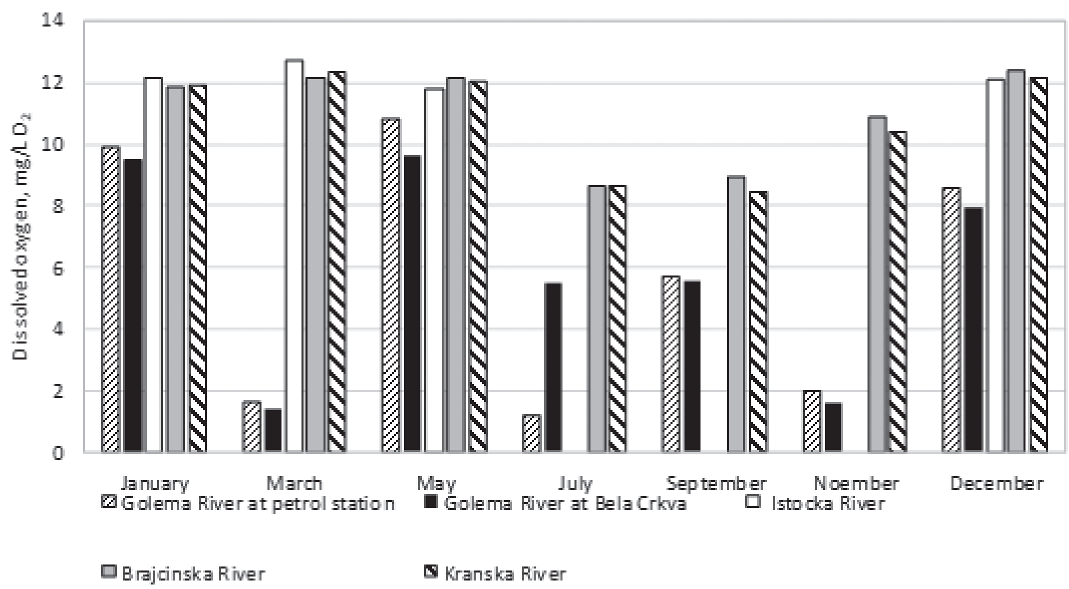

Fig. 2. Concentrations of dissolved oxygen in the studied rivers in the Prespa Region, in 2014

Gazette 1999), based on the concentrations of total phosphorus during the studied period, the water quality of the Golema River was classified under fifth class, except in May 2014, when it was classified under fourth class. The water quality of the rivers Istocka and Brajcinska were assessed under fourth class, while this of the Kranska River varied between fourth and fifth classes.

The values of the concentrations of total nitrogen (organic and inorganic) in the studied period are presented on Fig. 6. The maximum nitrogen loading was found at both sampling locations in the Golema River. The highest value of 3,740.79 µg/L was registered in July 2014 at the sampling location near the petrol station in the Golema River, where the level of the water was the lowest. The minimum value of 217.06 µg/L was registered in the Brajcinska River, in November 2014. During the studied period, the values of this parameter at all sampling locations followed low variations. High nutrient loading of water in the Golema River was reported in previous investigations from 2007 (Shemo et al. 2008). Based on the obtained results for the concentration of total nitrogen in our study, the quality of water in the Golema River was classified under fifth class (Official Gazette 1999). The quality of water in

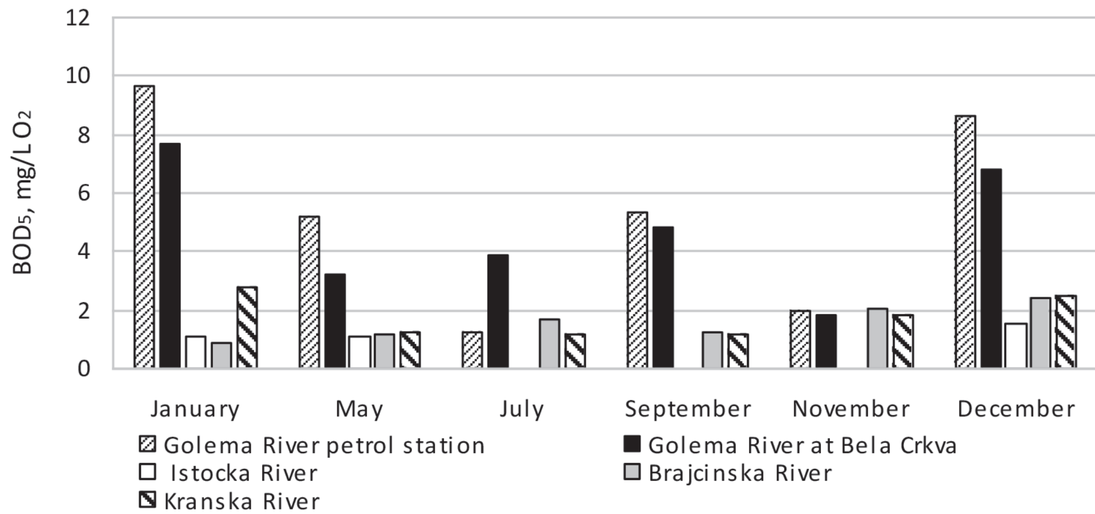

Fig. 3. Values of biochemical oxygen demand for five days (BOD_5) in the water samples from the studied rivers in the Prespa Region, in 2014

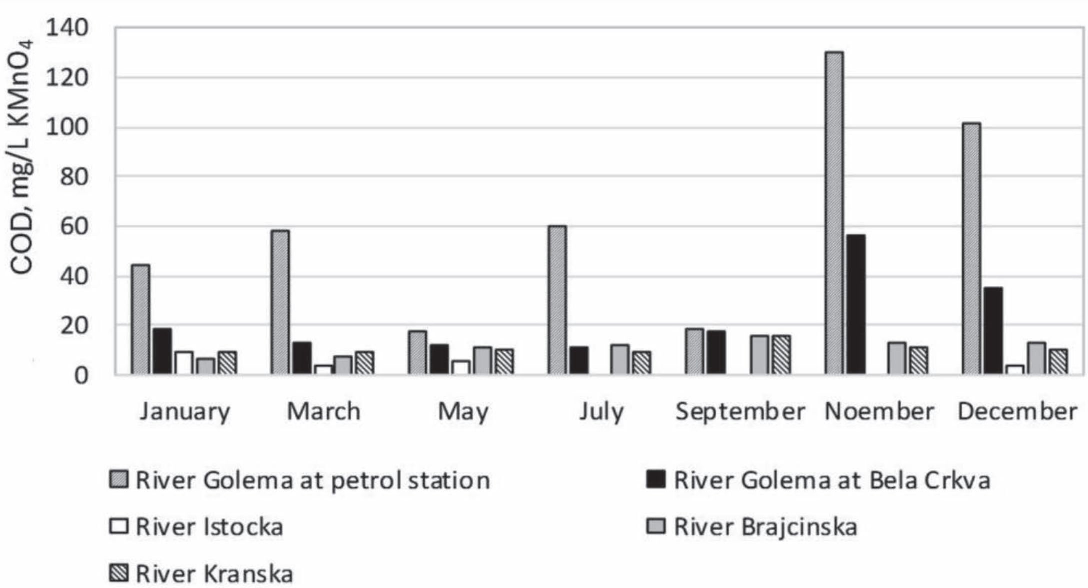

Fig. 4. Chemical oxygen demand (COD) by $KMnO_4$ in water samples from the studied rivers in the Prespa Region, in 2014

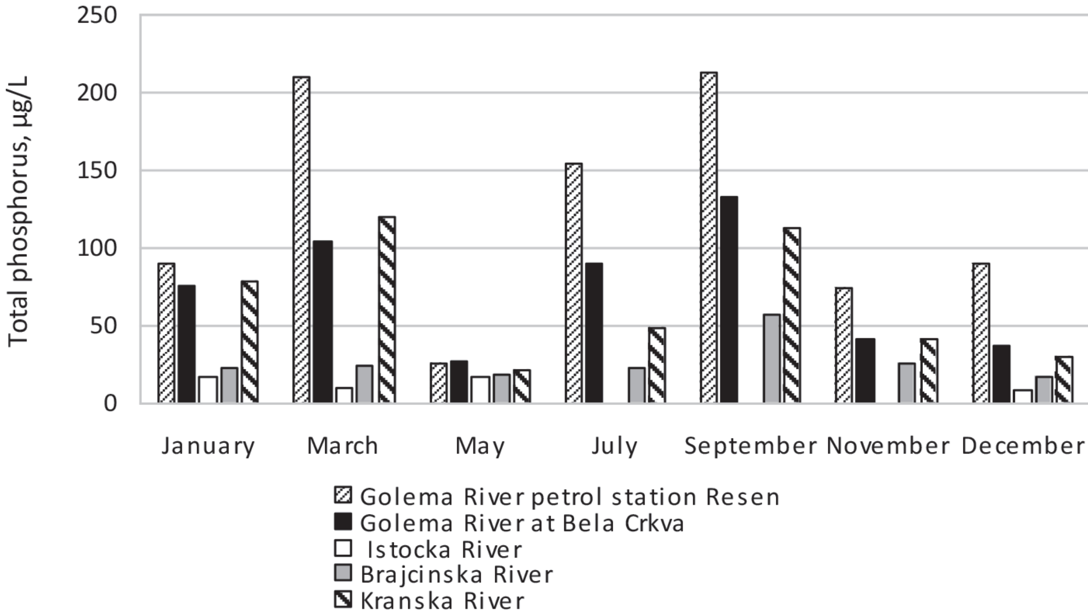

Fig. 5. Concentration of total phosphorus in the water samples from the studied rivers in the Prespa Region, in 2014

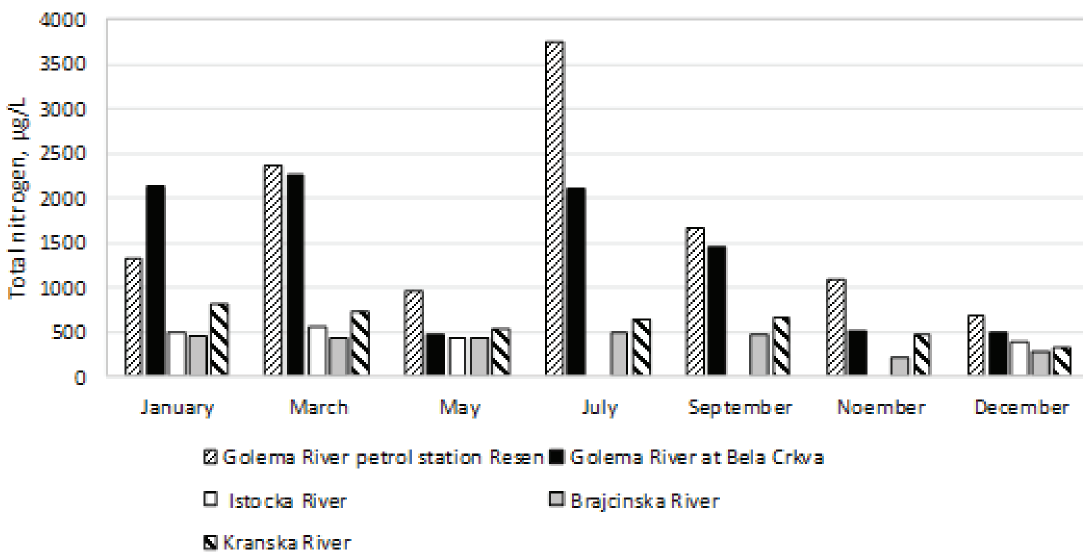

Fig. 6. Concentration of total nitrogen in the water samples from the studied rivers in the Prespa Region, in 2014

the rivers Kranska and Istocka was classified under fourth class, while this in the Brajcinska River varied from second to third classes.

The heterotrophic bacteria were presented with relatively high values in all the rivers, ranging from 14,900 colony forming units (CFU)/ml in the Brajcinska River (winter) to 281,600 CFU/ml in the Golema River (summer) (Fig. 7). According to the numeric presence of the bacteria, the water in the Golema River was mainly of third class, except in summer, when the water was classified under fourth class. The rivers Istocka and Brajcinska in winter and spring were of second class, while in autumn of third class. The Brajcinska River in summer was of third class and the Istocka River in summer dried up. The Kranska River was classified under third class in all the studied period. These results show the relatively high (moderate to critical) organic pollution of all the rivers in the region. However, it should be noted that the water in the Golema River had the highest (strong) organic pollution throughout the whole year. Similar results were reported for the periods 2001–2006 (Novevska & Lokoska 2009) and 2008–2009 (Lokoska 2010).

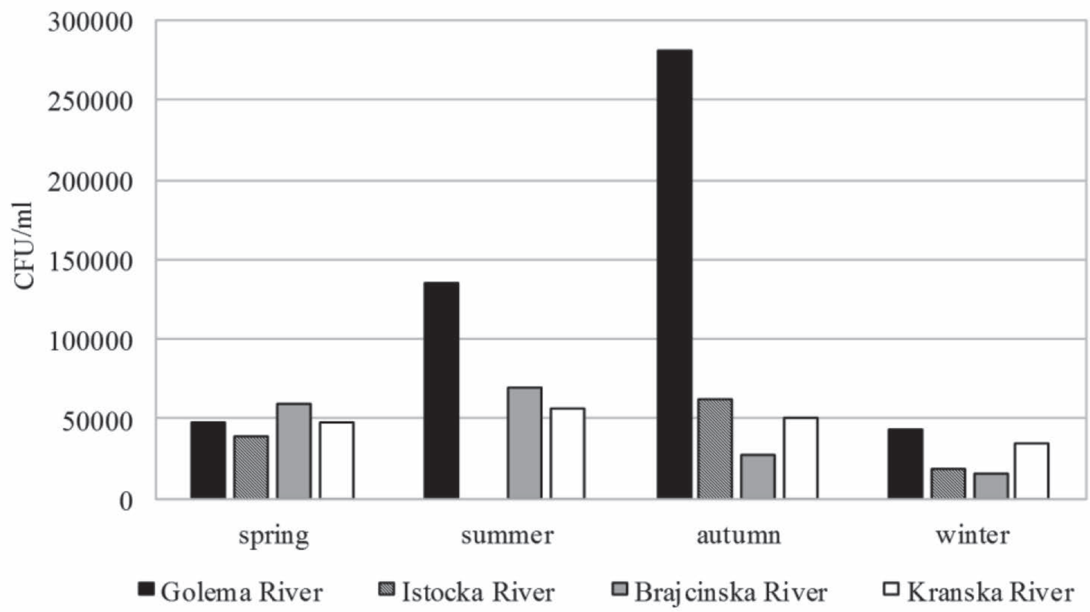

Fig. 7. Heterotrophic bacteria (colony forming units [CFU]/ml) in the water samples from the studied rivers in the Prespa Region, in 2014

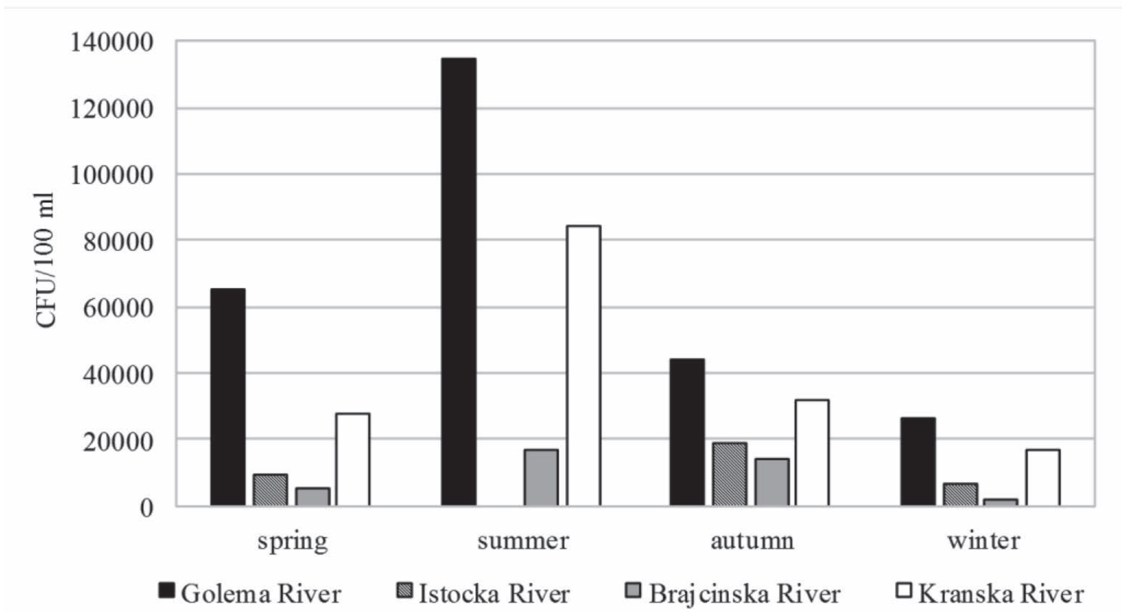

Fig. 8. Total number of coliform bacteria (colony forming units [CFU]/100 ml) in the water samples from the studied rivers in the Prespa Region, in 2014

The highest total number of coliform bacteria in water from the Golema River was estimated at 135,000 CFU/100 ml, in the summer period, while the same indicator in the Brajcinska River had a value of 1,500 CFU/100 ml, in the winter period (Fig. 8). The total number of coliform bacteria in the Kranska River was between 17,000 and 84,000 CFU/100 ml, depending on the season. The studied rivers were highly faecally polluted, which was also confirmed by the results for the coliform bacteria. According to the classification of Kavka et al. (2008) and the presence of these bacteria in the waters from all the rivers and seasons, the studied rivers were classified under third class (critical pollution), except for the Golema River in summer and autumn, when it was of fourth class (strong pollution).

The results for organic loading of the water from the Golema River showed the occurrence of an intensive process of mineralisation, which has caused a reduction in the quantity of dissolved oxygen in the water. The low concentrations of dissolved oxygen in the summer period are a result of the increased temperatures of water, which on the other hand, create conditions for faster growth and development of bacteria that use the dissolved oxygen for degradation of organic matter. During the winter period, the concentration of dissolved oxygen in the water increases as a result of the inflow of fresh waters, originating in rainfalls and snowfalls, which in turn increase the river flow, hence the degree of aeration of water also increases, while the lower water temperatures decrease the activity of the bacteria. The Golema River is a direct recipient of industrial water, municipal waste water and drainage water from the arable areas in the surroundings, and in the summer period, when the water level drops, the share of the communal and waste waters increases. Therefore, we assume that the nutrient loading of the Golema River is due to the inflow of vast quantity of water originating in the snow melting, rainfalls, municipal and industrial waste waters and the washout of the surrounding agricultural areas treated by organic and artificial fertilisers. The increased concentrations of total phosphorus in the waters from the Kranska River are presumably also due to water inflows from rainfalls, washout of the agricultural surroundings and waste water.

Conclusions

The obtained results from the physical, chemical and microbiological analyses indicate that water from the tributaries of Lake Prespa is organically and faecally polluted throughout the studied period. Most alarming is the deterioration of water quality in the Golema River as a result of the anthropogenic impact. Organic and nutrient loading is evident for the Kranska River as well. Our results show the necessity of preventive measures towards improvement of water quality of the rivers in the Prespa Region, especially considering their huge importance for the population living in this area, for the nature as a whole, and for the protection of Lake Prespa, which is a habitat of numerous plant and animal species.

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