DEPENDENCES BETWEEN THE RIVER FLOW AND SOME PARAMETERS OF MACROZOOBENTHIC COMMUNITIES IN THE BLAGOEVGRADSKA BISTRITSA RIVER, SOUTH-WEST BULGARIA

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Abstract The Blagoevgradska Bistritsa River is the basic water source of the town of Blagoevgrad, the biggest one in south-west Bulgaria. The river and its basin were studied in 2002 and 2003. The results from the hydrometric research showed that the river flow regime differed in the two years. Its effect on macroinvertebrate benthic communities was analyzed. The flow decreased downstream during the summer – autumn low flow period in 2003 – a phenomenon contrary to the natural one. The minimal discharge in the lower part of the river was very low and determined extremely unfavourable living conditions for the aquatic species. The flow influenced greatly some communities' parameters – the number of taxa (species), the dominant composition, and the total abundance. The higher flow led to an increase (up to some limit) in the number of taxa and individuals and vice versa – the prolonged low flow led to loss of species, a considerable decrease in the number of individuals, and degradation of communities. The number of constant species decreased considerably and the number of dominant and subdominant species increased in periods of very low river discharge. The biotic response was observed after a certain delay.
Keywords Dominant composition; macrozoobenthos; number of species (taxa); river flow; total abundance

INTRODUCTION

The biodiversity and the normal functioning of the lotic (running-water) ecosystems depend first of all on the natural flow regime and the characteristics of the stream flow quantity and timing (Poff and Allan, 1997). Different human activities modify the natural flow regime, especially the low flow, and the biggest risk of disturbance of the river ecosystem integrity occurs during the low water phase (Evans, 1997). The conditions then affect to the greatest extent the composition of macroinvertebrate benthic communities (Barton and Farmer, 1997), the most important ones in the lotic ecosystems. Water withdraws from the rivers for water supply or other purposes can cause serious changes in the river habitats including temperature ones, can lead to population decline and species extinction or ecosystem degradation (Fitzhugh and Richter, 2004).

The Blagoevgradska Bistritsa River and its basin were studied in 2002 and 2003 in order to make a contemporary assessment of the river ecological condition. Hydrometric, physicochemical

(Sakelarieva and Janeva, 2006) and hydrobiological research – macroinvertebrate benthic communities (Sakelarieva and Janeva, 2005, 2007, 2009; Sakelarieva et al., 2008), of the river were carried out. The anthropogenic impact (Michailov, 2005; Sakelarieva, 2005) and the stream conditions (Michailov and Sakelarieva, 2005) within the river basin were also analyzed. The results from the hydrometric research and the river flow influence on macrozoobenthic communities are presented and commented in this paper.

METHODS

The Blagoevgradska Bistritsa River rises from the south slopes of Golyam Mechy vruh (2618 m) in the South-western part of Rila Mountain (42°03′30″ N and 23°26′30″ E), flows to the west, and after it runs through the town of Blagoevgrad, empties into the trans-boundary Struma River (41°59′20″ N and 23°04′30″ E). Its length is 41 km. The catchment area is 234 km^2, with average altitude 1370 m, and average inclination – 0,442. The river flow regime is distinguished for its spring high flow (from snowmelt and rainfalls) and summer-autumn low flow periods (Hydrological guide, 1957, 1958, 1981). The average annual discharge at its mouth of about 3 m^3/s, has been decreasing since 1980 – 1982 as a result mainly of direct anthropogenic impacts – water withdraws for water supply (Michailov, 2005; Sakelarieva, 2005).

Seven river sites were studied in 2002 and 2003 (Fig. 1). The last site, located at the river mouth, was influenced by the sewage waters of the town of Blagoevgrad. Sixty three hydrobiological samples (macrozoobenthos) were gathered according to ISO 7828-1985(E) – 42 in 2002 (each month from May to October) and 21 in 2003 (in May, August and October). The species frequency of occurrence (pF) was estimated after De Vries (1937) and the degree of dominance (DT) – after Kojova (1970). Species with pF > 50% were assumed as constant, the ones with pF = 25 – 50% - as accompanying, and species with pF < 25% - as casual.

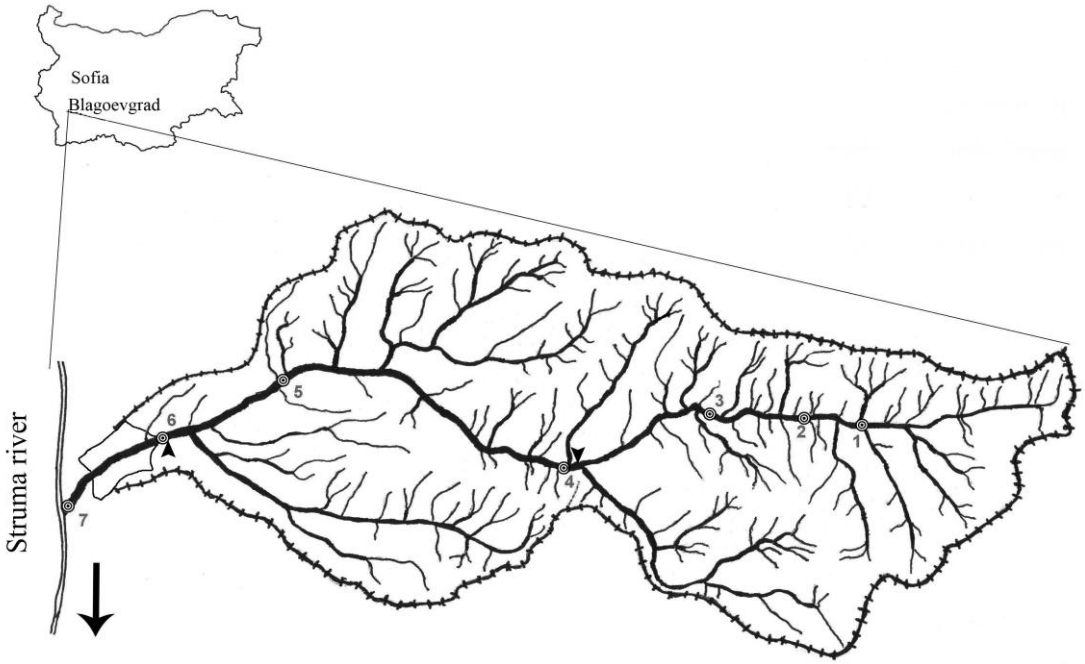

Fig.1. The Blagoevgradska Bistritsa River basin: ◎ - sites under research ▼ - gauge stations.

The water stages (stream depths) were recorded daily or once in two (three) days at the Blagoevgrad gauge station located closely to the sixth studied site in the period February 2002 – December 2003 (Fig.1). A standard hydrometric method was applied to determine the stream flow quantities. The flow velocity was measured by means of a flow meter at verticals in intervals of 1 meter or by floats

at some sites with large rock fragments in the river bed (depending on the specific geological characteristics of the river). A rating curve was established by using the graphic method. The curve was used to determine the stream flow at the sixth site in the days when the hydrobiological samples were collected.

RESULTS AND DISCUSSION

Hydrometric research

The analysis of the hydrograph at the Blagoevgrad gauge station showed that the river flow regime differed essentially in 2002 and 2003 mainly in respect to the basic flow characteristics in summer and autumn (Fig. 2). Because of the frequent and considerable in amount rainfalls a steady state of the water stages and the flow discharge respectively did not occur in 2002. The summer-autumn low flow period was not observed clearly – the values of the minimal flow, the average daily (about 1.100 м^3/s) and monthly (about and more than 2 м^3/s) were too high. However the average monthly discharge in February was very little (about 0.050 м^3/s). The low flow period in summer and autumn of 2003 was well manifested. Its duration was about 4 months and the values of the minimal average daily (about 0.020 м^3/s) and monthly (between 0.160 and 0.050 м^3/s) discharge were very low.

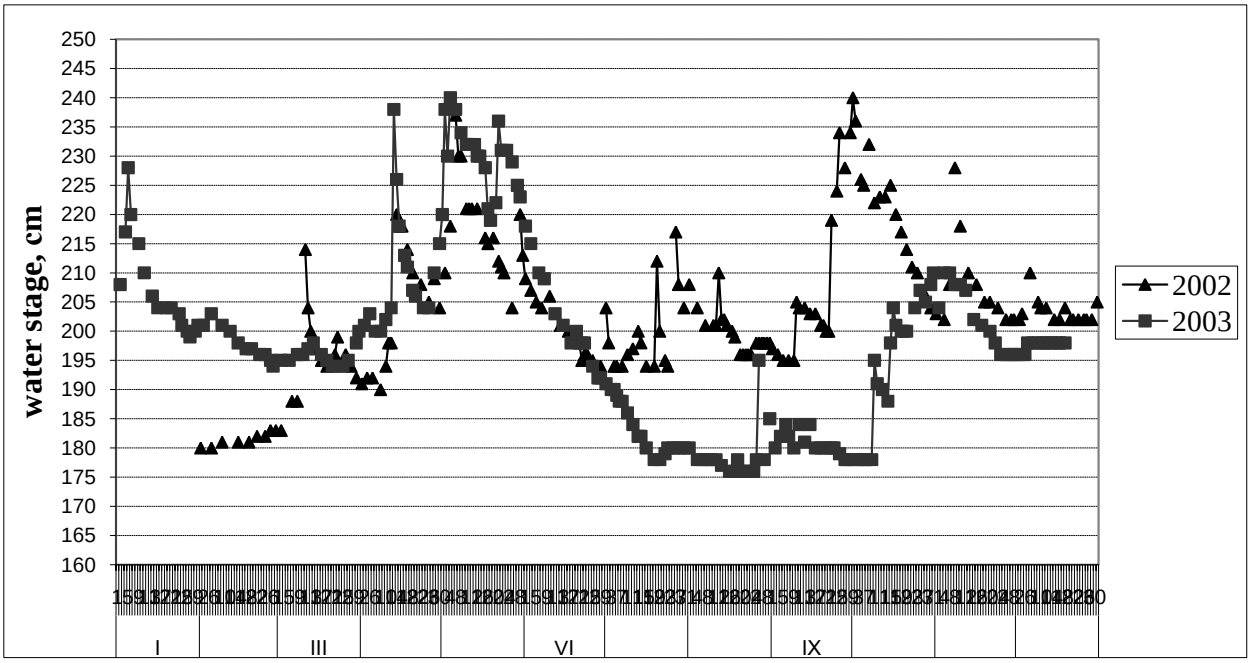

Fig. 2. Hydrograph at the Blagoevgrad gauge station in 2002 and 2003.

Despite the direct anthropogenic impacts – water withdraws from the river and its main tributaries, the stream flow increased naturally downstream (from the first to the sixth studied site) in summer and autumn of 2002. A contrary tendency was observed in 2003. The highest flow was registered in the upper part of the river (first site) and the lowest one at the city of Blagoevgrad, which showed that the natural flow regime had been disturbed. The river flow at the last studied site then consisted extremely of returned sewage waters from the town of Blagoevgrad.

The tendency of flow decreasing along the river length in summer and autumn months has been observed since 1982 (Michailov, 2005). In comparison with years up to 1982, the low flow period in summer and autumn 2003 at the town of Blagoevgrad had longer duration and much lower average daily and monthly values of the stream flow (Sakelarieva, 2005). The river even dried up in

its lower part in 1993 and 2000. In all cases the considerably reduced stream flow has led to extremely unfavourable living conditions for the aquatic species – quite limited living space, unusually low flow velocity, high temperature etc.

The river flow effect on macrozoobenthos

The differences in the river flow in 2002 and 2003, mainly in the summer and autumn months, allowed analyzing its influence on some parameters of macroinvertebrate benthic communities – the number of species (taxa) - S, the dominant composition (species frequency of occurrence - pF and degree of dominance – DT), the relative total abundance (N).

The total number of taxa found in the river was practically the same in 2002 and 2003 (175 and 174). However, the number of taxa varied in the different seasons - it was smaller in spring 2002 (107 compared to 123 in 2003) and larger in summer (130) and especially in autumn (122) 2002 (in comparison with 122 and 99 respectively in 2003). The same was relevant to the studied sites too – differences were registered again in the different seasons. In spring 2002 compared to 2003 the number of species was smaller at all sites except for sites 2 and 5, while in summer 2002 it was larger at all sites without the first two. In autumn the differences were still greater at six of the sites, except for site 5, where the species number was equal. Most probably these differences were due to the different discharge in the previous months – low flow in the period August 2001 – February 2002, almost constant high flow after March 2002, and very low flow in July – October 2003.

As was mentioned above the lowest river flow was registered at the sixth site so it is interesting to study the species number dynamics there. Opposite tendencies were observed in 2002 and 2003 – an increase in the number of species from spring (37) to autumn (43) in 2002 and a decrease (from 45 to 31) in 2003. The comparatively small number of benthic groups and species in summer (11 and 30 respectively) and autumn (10 and 31) 2003 reflected considerably worsened environmental conditions – loss of habitats, extremely low flow velocity and high water temperature (24° C in August) determined by the very low flow, amassed in the middle of the river bed.

The species number dynamics at river mouth reflected the effect of the stream flow in the previous months on the macrozoobentic communities, functioning and developing under conditions of pollution (Fig. 3). The higher flow had a wholesome effect improving the conditions at the bottom – the number of species increased to 34 in May 2003 (after 12 month high flow), whereas the very limited flow during the summer and autumn months of 2003 led to a substantial reduction in the number of species in August and October.

The casual taxa (species) in both years were over twice as many as the constant and the accompanying ones put together. The number of taxa from the three groups was almost equal in 2002 and in 2003. However, essential differences were observed in May, August and October. Most probably the small number of constant species in May 2002 (17) reflected the summer low flow period in the previous year and the winter low flow period in 2002 (Fig. 4). On one hand, the number of constant taxa was practically the same in October 2003 (16) and was due to the well presented summer low flow period in that year – the more sensitive species had dropped out of the communities because of the extreme conditions at some of the studied sites. On the other hand, the number of constant taxa in October 2002 (31) and in May 2003 (29) was also almost equal, i.e. it could be assumed that at the end of one and the beginning of the other vegetative period the number of constant species remains the same (in the absence of considerable external impacts). The number of species with frequency of occurrence more than 50% was quite close in August 2002 and 2003 (27 and 29 respectively) and commensurable with that registered in May 2002. It shows that in this respect the macroinvertebrate benthic communities react with a delay to the variations in the

environmental conditions – the biotic response (an alteration in the composition) manifests itself after a certain period of time – in the case in October 2003 after the end of the low flow period.

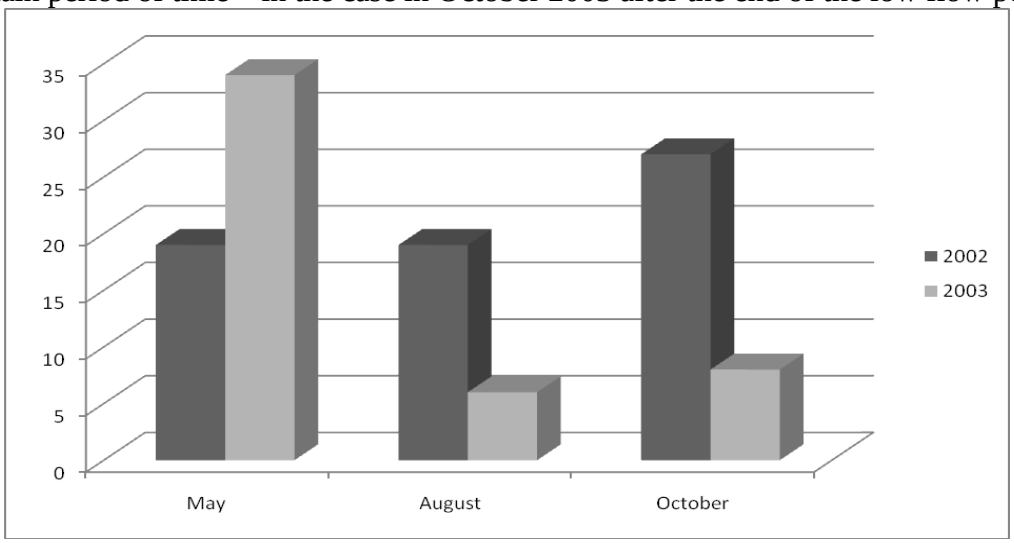

Fig. 3. The number of taxa found at the river mouth in 2002 and 2003.

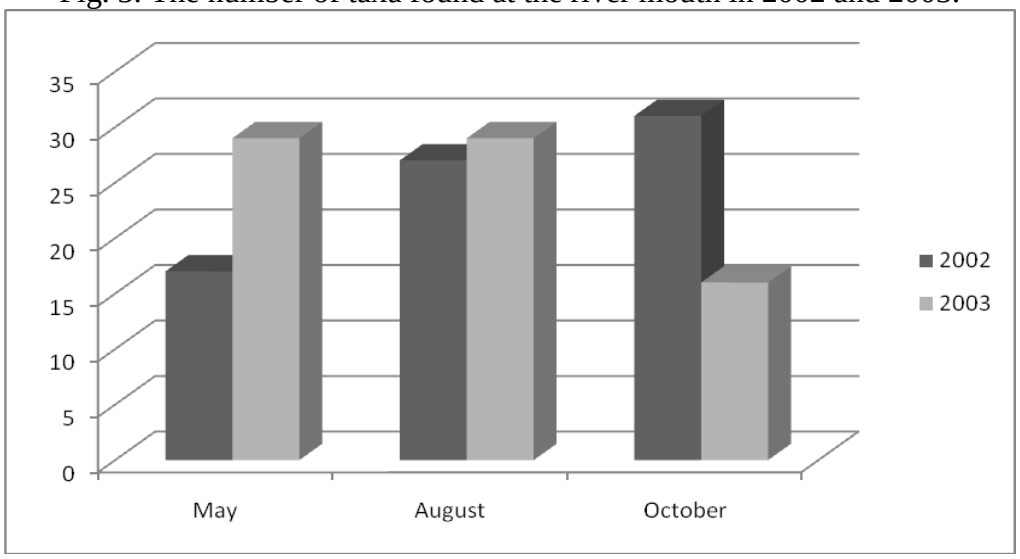

Fig. 4. The number of constant taxa in 2002 and 2003.

In regard to the number of dominant and subdominant species, a considerable increase was observed in autumn 2003. The number of taxa with maximum value of the degree of dominance index also increased, which pointed to the fact that essential variations in the local conditions had occurred at each site and downstream in comparison with the previous seasons (Fig.5). A contrary tendency was registered in 2002 (Fig. 5), when the high river flow led to equalization in conditions and the number of dominant species in the macrozoobenthic communities decreased in October.

Considerable differences in the values of the total abundance were observed in 2002 and 2003 (Fig. 6). The total number of individuals in 2002 was almost twice as much as that in 2003. The macrozoobenthos number in August 2002 was more than twice as much as that in August 2003, and the one in October 2002 – 4.6 times higher in comparison with 2003. The unfavourable environmental conditions during the low flow period in 2003 determined the low values of this parameter in summer and autumn. The twice smaller number of individuals in May 2002 compared to 2003 most probably reflected the winter low flow period in 2002 - 2003, and perhaps the summer-autumn low flow period in 2001.

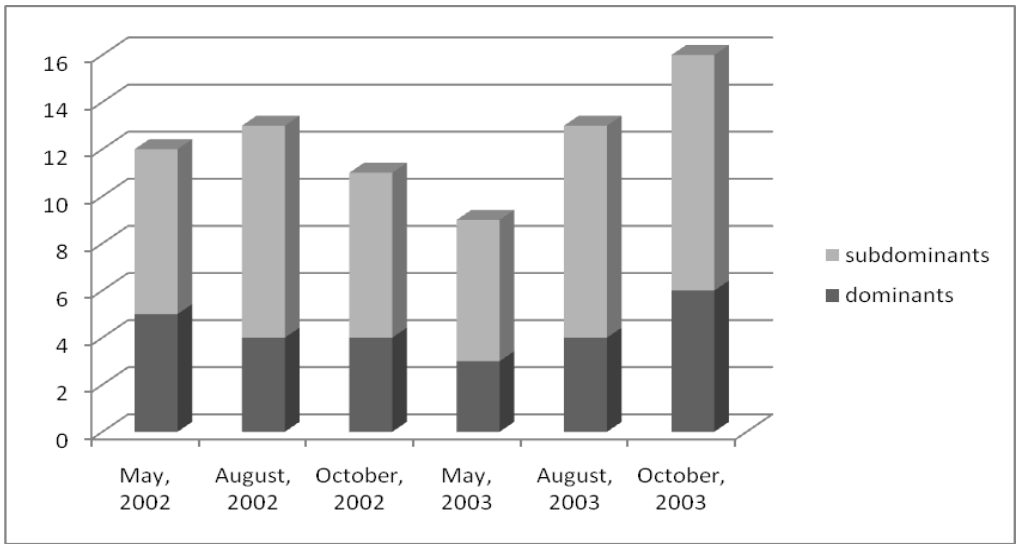

Fig. 5. The number of dominant and subdominant species in 2002 and 2003.

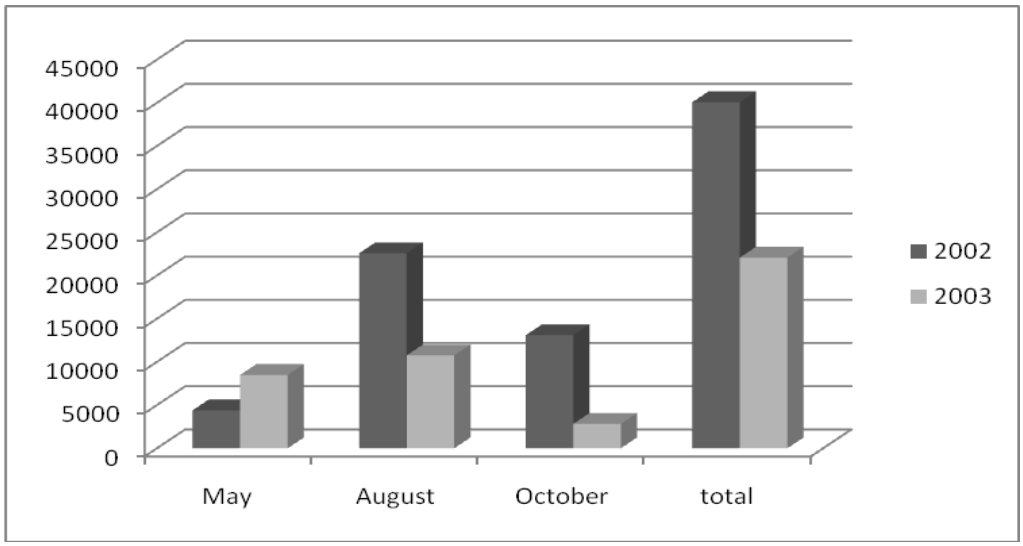

Fig. 6. Total number of individuals in 2002 and 2003

The differences in the number of individuals were still greater at the last 3 studied sites in summer and autumn 2002 and 2003, where the distinctions in the discharge were also bigger. The differences were markedly greater at the river mouth where the pollution from the town of Blagoevgrad sewage waters also had its negative effect. The total number of individuals there was larger in 2002 compared to 2003 – 74.7 times in summer, and 20.6 times in autumn.

The comparison of the most abundant macrozoobenthic groups showed that their number was larger in 2002, from 1.3 times for family Chironomidae (Diptera) to 4 times for class Oligochaeta. Excluding the river mouth, five benthic groups – orders Ephemeroptera, Plecoptera and Trichoptera and families Simuliidae and Chironomidae (Diptera), were most abundant. Order Ephemeroptera dominated in 2002, followed by Trichoptera and Plecoptera, families Chironomidae and Simuliidae and class Oligochaeta. Order Ephemeroptera was the most abundant in 2003 too but with fewer individuals, and was followed by Chironomidae, Trichoptera, Plecoptera, Simuliidae and Oligochaeta. Assuming that the low flow period was the primary cause for the lower abundance of the main benthic groups in 2003 it should be noticed that the passive filtrators from family Simuliidae and the requiring high flow velocity and low temperature species from order Plecoptera were the most sensitive in this respect, followed by class Oligochaeta, orders Ephemeroptera and

Trichoptera.The detritivores and requiring lower flow velocity taxa from family Chironomidae were the most tolerant.

The river flow effect on the abundance of the main benthic groups was still stronger during the summer and autumn months when the flow characteristics differed greatly in 2002 and 2003. The number of individuals at sites 2 to 6 was higher in 2002 from 1.9 times for family Chironomidae to 16.1 times for family Simuliidae (2.2 times for Trichoptera, 2.5 - for Oligochaeta, 3.3 - for Ephemeroptera, 4 times for Plecoptera). The abundance at sites 5 and 6 only was still higher in summer and autumn 2002 – 3.4 times for Chironomidae, 4.1 and 4 times for Oligochaeta and Plecoptera, 5.6 and 5.7 times for Ephemeroptera and Trichoptera, 92.5 times for Simuliidae (Fig. 7). Class Crustacea only (found mainly at those two sites and presented mostly by *Gammarus balcanicus* Schaeferna, 1922) was more abundant in 2003 because of the species preferences for lower flow velocity.

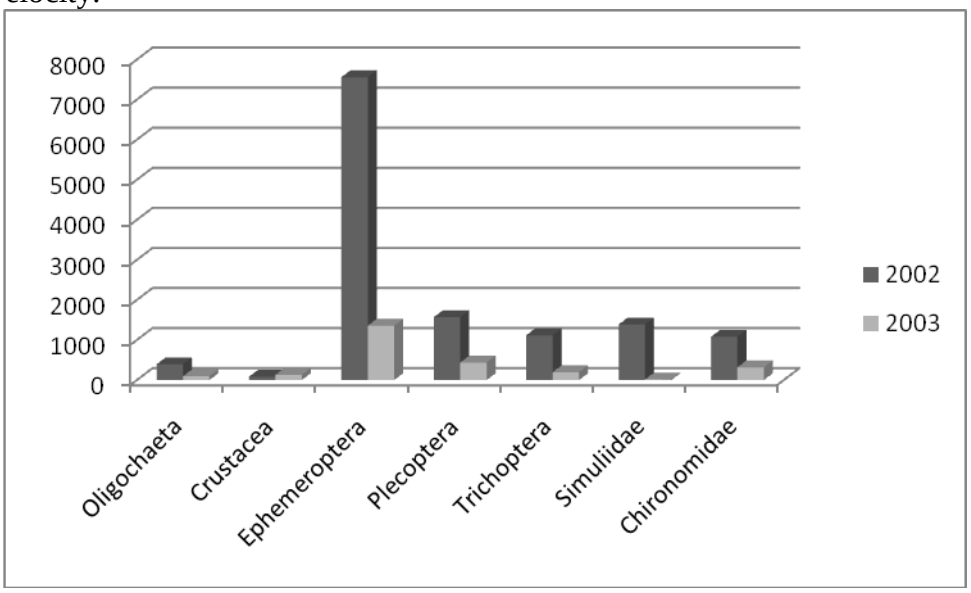

Fig. 7. Total number of individuals from the main macrozoobenthic groups at sites 5 and 6 in August and October 2002 and 2003.

It was determined that the average number of individuals of benthic groups that dominated in number at the first six sites of the river in 2002 (Ephemeroptera, Trichoptera, Plecoptera, Chironomidae и Simuliidae) depends on the average depth and the average flow temperature. The correlation is valid for depths from 0.15 to 1 m, temperatures from 4 to 15 C˚ for rivers with mountain character and conditionally undisturbed flow.

CONCLUSIONS

In cases of summer – autumn low flow periods the river flow decreases downstream – a phenomenon contrary to the natural one. The minimal discharge in the lower part of the river is very low and determines extremely unfavourable living conditions for the aquatic species.

The volume of the river flow in the previous months influences greatly the number of taxa (species) and the dominant structure of macrozoobenthos especially when the communities function and develop under conditions of pollution. The higher discharge leads to increase in the number of taxa (up to some limit) and vice versa – the prolonged low flow leads to loss of species and communities' degradation. The number of constant species decreases considerably as a result of the very low discharge and the number of dominant and subdominant species increases. The number of taxa with maximum value of the degree of dominance index also increases.

The total (relative) number of individuals of macrozoobenthos is influenced comparatively fast and very strongly by the river flow. The sensibility of the main benthic groups is connected to their biological requirements in relation to their way of living and particularly to their way of feeding. The passive filtrators from family Simuliidae, as well as the requiring high flow velocity and low temperature species from order Plecoptera are the most sensitive in this respect. The detritivores and requiring lower flow velocity taxa from family Chironomidae are the most tolerant. Under conditions of undisturbed flow the average number of individuals depends on the average depth and the average flow temperature.

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