Ecoregions Delineation for the Territory of Serbia

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Abstract

The aim of this paper is to more precisely define the borders of ecoregions shared on the territory of Serbia, in regard to the original concept provided by Illies (1978) and accepted by the EU Water Framework Directive (WFD 2000). The borders of Illies's ecoregions are defined rather coarsely and could not be used as a basis for water typology. According to data on the macroinvertebrate communities, as well as based on general natural characteristics of the area and selected bio-geographical works, the territory of Serbia is a part of 5 ecoregions: ecoregion 5 – Dinaric Western Balkan; ecoregion 6 – Hellenic Western Balkan; ecoregion 7 – Eastern Balkan; ecoregion 10 – Carpathian; and 11 – Pannonian Lowland. Four of these ecoregions (5, 6, 7, and 11) comprise wide areas within the country, while ecoregion 10 comprises only a restricted area in Northeast Serbia. Although ecoregion 10 is restricted to a narrow area, the influence of the Carpathians is evident in Northeast Serbia. A detailed discussion on the position of ecoregion boundaries is provided in the paper.

Keywords: ecoregion borders, macroinvertebrate communities, spatial distribution, bio-geography, Serbia

Introduction

The ecoregion concept defined by Illies (1978) and accepted by the EU Water Framework Directive (WFD, 2000), is frequently used as the basis for stream typologies. Illies (1978) defined 25 European ecoregions (ER) and provided the map and description of ecoregion boundaries.

The ecoregional approach is a widely used basis for spatial classification of waters, according to areas that represent entities in regard to distribution of aquatic biota. However, the borders of Illies's ecoregions are defined rather coarsely. The aim of this study is to more precisely set up the ecoregion boundaries shared by Serbia according to the concept proposed by Illies (1978). Namely, the bordering zones of ecoregions shared on the territory of the country are situated along the course of the area's largest rivers. Thus, the left and right tributaries of rivers such as the Danube, Sava, Velika and Južna Morava belong to different ecoregions, according to Illies (1978), which is not supported by biogeographical discussions (Matvejev and Puncer, 1989; Lopatin and Matvejev, 1995; Stevanović, 1995) on the recent and historical distribution of the biota. Therefore, our attempt was to use the data on aquatic macroinvertebrates to more precisely define these ecoregion boundaries.

The territory of Serbia is subdivided into 5 ecoregions, according to Illies (1978) (Figure 1): ecoregion 5 – Dinaric Western Balkan; ecoregion 6 – Helenic Western Balkan; ecoregion 7 – Eastern Balkan; ecoregion 10 – Carpathians; and 11 – Panonnian Lowland. Four of these ecoregions (5, 6, 7, and 11) include wide areas within the country, while No. 10 comprises only a restricted area in Northeast Serbia. Although, ecoregion 10 is restricted to a narrow area, the influence of the Carpathians is evident in the Northeast Serbia. Also, the influence of Southern areas is apparent, especially in East Serbia.

Serbia could be clearly divided in two regions – the Pannonian plain and the hilly/mountainous region situated south of the Danube and Sava River. The mountainous region is especially abundant in factors influencing the distribution of flora and fauna. The Pannonian basin is more homogenous in environmental factors in relation to the mountainous area. In an orographic and geological sense, the mountainous complex is composed of five systems:

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1) The Rhodope Mountains, situated in Northern, Central and Southern Serbia; 2) the Carpathian, located in the northeastern part of the country; 3) the Balkan mountain range that spreads across east and south parts of Serbia; 4) the Dinaric mountains in Metohija and Montenegro; and 5) the Skardo-Pind mountains comprising several mountains in Kosovo and Metohija.

The diversity of inland surface waters is enormous. When one considers hill and mountain streams, large rivers, lakes and wetlands, the diversity of these ecosystems is clearly apparent. Additionally, area-specific environmental factors greatly contribute to the uniqueness of each aquatic ecosystem. Thus, attempts to classify/group these waters, mostly for applied purposes, are understandable.

The territory of Serbia is heterogeneous concerning overall environmental conditions (climate, geological substratum, relief, historical factors, hydrology, etc.) and consequently, the distribution of plants and animals is a complex issue (Stevanović and Vasić, 1995). Furthermore, the area is characterised by specific and diverse flora and fauna and represents one of Europe's and Western Palearctic biodiversity centres (Stevanović and Vasić, 1995). Therefore, the characterisation of the aquatic ecosystems for the territory of Serbia is a serious assignment.

Thanks to its geographic position, diverse climate, petrographic and pedological types, orographic characteristics, and historical factors, that strongly influenced the recent biota, the territory of Serbia is one of the most complex regions in Europe concerning the distribution of plants and animals.

The distribution of aquatic biota in the region is also a complex issue (Stanković, 1962; Lopatin and Matvejev, 1995). The diverse climate and pedological characteristics contribute to the complexity of the mountainous region. The types of climate zones and the variations within zones, as well as the geological and pedological nature of the area are discussed in Stevanović and Stevanović (1995).

Figure 1: Ecoregion borders within territory of Serbia according to the original subdivision of Illies (1978)

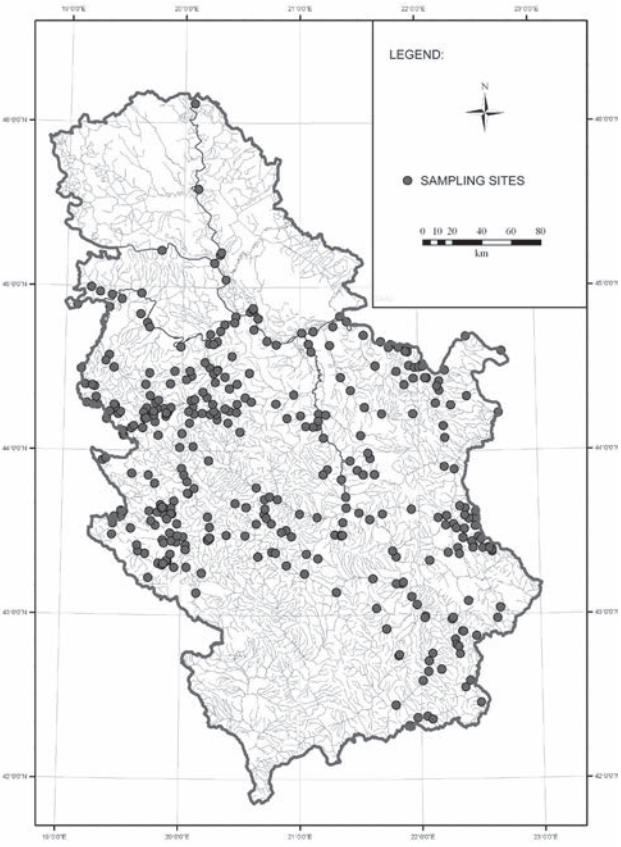

Figure 2: Sampling sites for aquatic macroinvertebrates

Study Design, Material and Methods

As the starting point, the borders of ecoregions shared by Serbia, as proposed by Illies (1978), were used (Figure 1). The borders of Illies's ecoregions are defined rather coarsely. Thus, our attempt was to use the data on aquatic macroinvertebrates and biogeographical discussions to present the ecoregions boundaries more precisely (Matvejev and Puncer, 1989; Lopatin and Matvejev, 1995; Stevanović, 1995).

The data on macroinvertebrate communities derived from 351 sampling sites (Figure 2), on 159 watercourses in Serbia, during the 2003-2009 period, were used for precise delineation of ecoregions. The dataset included 520 samples and 452 identified taxa.

The following site data were collected: elevation, geographical coordinates (x, y), substrate type, width (minimal, mean and maximal) and depth (mean and maximal) of the watercourses. The assessment of hydromorphological (HYMO) degradation of the sampling sites was performed according to the criteria presented in Table 1.

Table 1: Criteria for the assessment of HYMO degradation at sampling sites

HYMO degradation:		
1	No degradation	No changes of natural flow regime, no modification of banks and bottom.
2	Slight degradation	Slight changes of natural flow regime; the influence of flow regime changes is of local character (only few tenths of a meter); bank and bottom modification of local character (only few tenths of a meter); no evident changes of macroinvertebrate communities at investigated sector (minimum 100 meters covered).
3	Moderate degradation	Slight changes in flow regime; the influence of those changes evident at considerable stretch (more than 50 m for small rivers, more than 200 m for medium sized rivers, and more than 500 m for large rivers); bank or bottom modification evident in considerable stretch (more than 50 m for small rivers, more than 200 m for medium sized rivers, and more than 500 m for large rivers).
4	Significant degradation	Significant changes in flow regime at considerable part of the stretch; intensive sedimentation due to the changes of flow regime evident; serious modification of banks and/or bottom in considerable stretch.

The size classes of the rivers used in the following text corresponds to those used in the typology of running waters in Serbia (Paunovic *et al.*, 2007). Therefore, large rivers are considered to be those having a catchment area greater than 4.000 km^2, while very large rivers are those with a catchment area greater than 10.000 km^2.

Analyses of the selected parameters were performed taking into consideration the relation of faunistic composition (rough data, relative abundance of the taxa in samples, as well as qualitative composition of the community - presence/absence of the taxa). In principle, the analyses were done in regard to geo-morphological entities and large basins (spatial data subsets), which attempted to investigate the validity of the ecoregional approach (overtaken by the WFD from Illies (1978)).

In the first step of the analyses, samples from sites that are under considerable anthropogenic influence were excluded. The relevant filtering of the data was performed based on the field data (notes on hydro-morphological degradation and data on physico-chemical parameters measured *in situ* - oxygen concentration, oxygen saturation, nitrates, nitrites, orthophosphates, pH and electrical conductivity), as well as based on the data derived from routine water quality monitoring of Serbian waters during the 2000-2007 period (Republic Hydrometeorological Service of Serbia and Serbian Environmental Protection Agency). For the preliminary status assessment based on the data from routine monitoring, basic physico-chemical parameters (oxygen concentration, oxygen saturation, nitrates, nitrites, amonium ion, orthophosphates, pH and electrical conductivity), and saprobic index values (Pantle and Buck, 1955) were taken into consideration.

Table 2: The criteria used for preliminary assessment of the status of sites covered by the study

Site quality		
0	Unknown	No enough data to assess the status
1	Reference sites	No evident disturbance; no hydromorphological changes recorded on site, or upstream the site; organic or nutrient pollution not recorded based on data available; if the data from routine monitoring available, the assessed water quality status does not exceed the threshold values for the first class.
2	Near natural sites	The site is under slight anthropogenic influence and it is evaluated that this disturbance does not influence macroinvertebrate community; if the data from routine monitoring available, the assessed water quality status does not exceed the threshold values for the first class for majority of the parameters.
3	Good status	Although the anthropogenic influence is evident (hydromorphological degradation and/or nutrient and organic pollution), the deviation of macroinvertebrate community from reference one is slight; the values of relevant metrics do not exceed threshold values for second water quality/status class.
4	Moderately degraded habitats	Moderate anthropogenic influence evident; aquatic macroinvertebrate community moderately changed; recorded values of physico-chemical parameters mostly within the third water quality class; values of saprobic index mostly within third class.
5	Degraded habitats	High anthropogenic influence evident; macroinvertebrate community changed in regards to expected one; one or several taxa groups tolerant to organic and nutrient pollution dominates in majority of the samples; recorded values of physico-chemical parameters within the third and fourth water quality class; values of saprobic index mostly within third and fourth class.

The criteria used for the preliminary assessment of site status covered by the study are described in Table 2.

The data derived from sites that are assessed as 5 (Degraded), 4 (Moderately degraded) or 0 (No data available) are excluded from all analyses. Furthermore, in the selected analyses, the data derived from sites characterised as reference, or near natural, are taken into consideration only in order to eliminate the influence of anthropogenic stress on the results. It was impossible to use only the data from reference and near natural sites in all analyses, due to the lack of reference and near natural sites for some water types.

The number of sites and relevant taxa included in each step of the analyses, following above described filtering, is presented at each resulting graph.

The taxonomical fitting of the biological data was also performed. Thus, the rare taxa that could be characterised as accidental findings and/or that are not identified to the satisfactory taxonomical level (species/genus) taxa were eliminated from the analyses (Bryozoa, Porifera, Nematoda, Polychaeta, Arachnida, Megaloptera and Collembola).

For the analyses of the basic spatial data subsets (division of lowland part of the territory from the hilly/mountainous region), the distribution (relative abundance per sample) of the most important (in regard to abundance, number of recorded taxa among the group and frequency of occurrence in samples) faunistic groups were analyzed, which comprised: Turbellaria (Platyhelminthes), Oligochaeta, Hirudinea (Annelida), Gastropoda, Bivalvia (Mollusca), Gammaridae (Crustacea), Ephemeroptera, Trichoptera, Plecoptera, Coleoptera, Odonata, and Diptera (Insecta). This was performed due to the fact that analyses on the species level did not provide the visible separation of samples in regards to spatial gradient.

Non-metric Multidimensional Scaling (NMS) and Correspondence Analyses (CA) were used to detect and visualise differences in sites/samples in regards to spatial position and to identify the relevant community patterns, as effective statistical procedure for the analyses of ecological datasets (Mc-Cune and Mefford, 1999; Karadžić and Marinković, 2009). The following software packages were used for statistical analyses: “Flora” (Karadžić, 1998) and Statistica for Windows for CA "PC-Ord 4.2" (Mc-Cune and Mefford, 1999) for NMS.

As the bases for delineation of ecoregion borders, the boundaries of larger basins were taken into consideration, as the distribution of aquatic biota is closely related to characteristics of catchments that represent natural entities.

Results and Discussion

As the bases for consideration of spatial distribution of macroinvertebrate fauna and ecoregions delineation, the following prerequisites were taken into consideration:

- The territory of Serbia could be clearly divided in two regions – Pannonian Plain and the hilly/ mountainous region to the south of the Danube and Sava River;
- The influence of the Pannonian region is evident in the area situated northward of the Danube-Sava line, through larger River valleys, e.g. Velika Morava, Drina and Kolubara valleys;
- The border between ecoregion 5 and 7 should be moved more to the east, since there is no clear evidence of significant differences between the left and right tributaries of the Južna Morava;
- The western boundary of the Timok River Basin could be considered as a border between ecoregions 5 and 7, since the area is under the influence of the Balkan Mountains. Faunistic specificity of the Timok catchments was underlined in the investigation of Simić (1993). Fukarek (1977), in the discussion on the faunistic and floristic (biogeographical) division of former Yugoslavia, considers the Timok catchment part of the Moesian Balkan and the bordering zone between the Sub-Carpathian and the Moesian Balkan;
- In addition, the area of Stara Planina Mountain (partially within the Timok catchment) is a part of the Balkan Massif and the region is characterised by high biological diversity of insects (Radović *et al.*, 1995), algae belonging to Charophyta (Blaženčić *et al*., 1995), as well as higher plants (Stevanović *et al*., 1995). The area is also characterised by high diversity of aquatic macroinvertebrates (Simić 1995; Živić *et al.*, 2005). Simić (1995) considers the catchment of Beli Timok a separate hydro-faunistic region;
- The area in North-East Serbia in the region of the “Đerdap“ National Park is specific in general natural characteristics, that was confirmed by the discussion of Fukarek (1977), as well as by the investigation of Simić (1993). The region is in the bordering zone of ecoregions 10 and 11. Fukarek (1977) considers the area as Sub-Carpathian, which reveals the influence of the Carpathian Mountains on the region;
- The area of the Timok catchments and “Đerdap“ National Park (comprised of mostly smaller direct tributaries of the Danube River, having the characteristics of hilly watercourses, but at small elevations) is additionally specific since it is a narrow area where a mosaic of different biomes is represented (Matvejev and Puncer, 1989) - Sub-Mediterranean Oak Woodlands,

South European mostly deciduous foothill and mountain woodlands, (Oro) Mediterranean mountains and forests in gorges (on slopes and on the peaks, especially in areas not influenced by the last glaciation).

The distribution pattern of the macroinvertebrate fauna was used to further analyze the spatial model and to propose the ecoregion boundaries for Serbia.

In the first step, the analysis was performed on 292 samples (after filtering in regards to the preliminary status assessment as described in Materials and Methods) from belonging to all river types covered by the study (large, medium sized and small rivers), taking into consideration the distribution (quantitative data) of 12 taxa groups that were found to be the principle component of the macroinvertebrate communities in the analysed dataset - Turbellaria (Platyhelminthes), Oligochaeta, Hirudinea (Annelida), Gastropoda, Bivalvia (Mollusca), Gammaridae (Crustacea), Ephemeroptera, Trichoptera, Plecoptera, Coleoptera, Odonata, Diptera and Diptera (Insecta). The sites characterised as Moderately degraded (4) and Degraded (5 according to criteria presented in Table 2) were excluded from the analyses.

Based on the performed CA (Figure 3), two basic spatial data subsets were identified in our results – data originated from sites located in the lowland part of Serbia, in the Pannonian region, situated northward to the Danube and the Sava Rivers, as well as data originated from the sites located to the south of the above mentioned rivers, situated in the hilly/mountainous region of Serbia. According to the results graph, the lower section of the Velika Morava River, Mlava River and watercourses belonging to the lower part of the Kolubara catchment area, are less different in regards to potamon type rivers in the region (the Danube, the Sava and the Tisa Rivers) in comparison to other watercourses. The data presented, therefore, indicates that the sites situated northward to the Danube and Sava (including those rivers), namely, the lower stretch of the Velika Morava, Kolubara and Mlava River, belong to ecoregion 11.

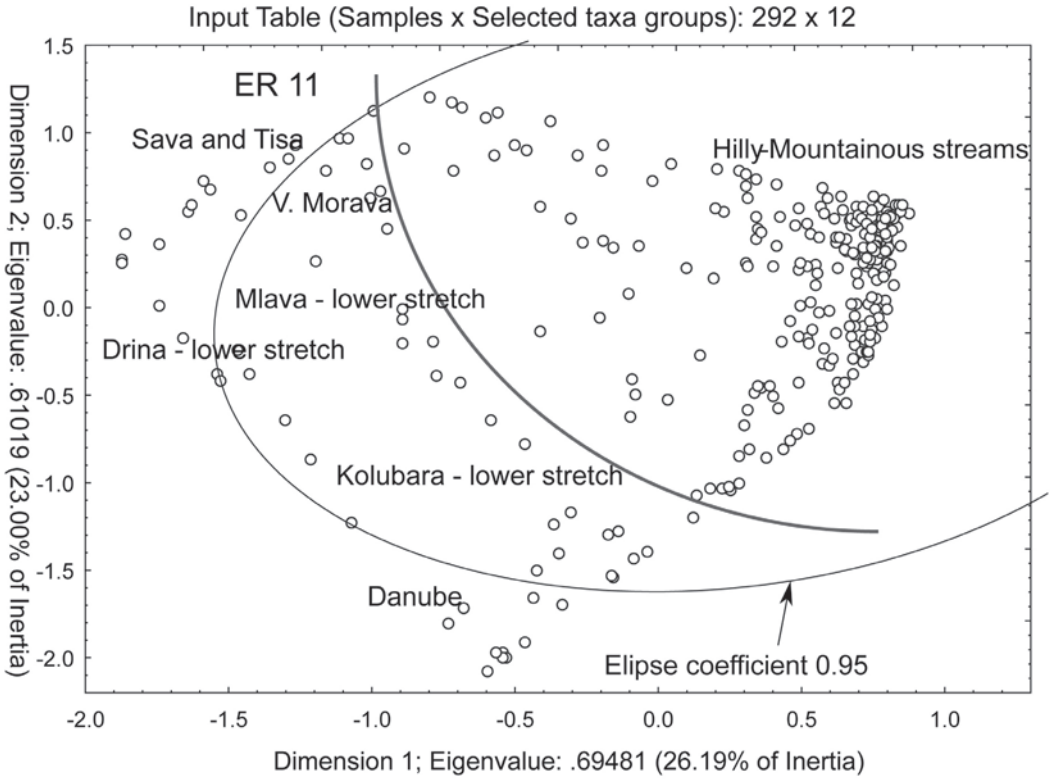

Figure 3: Resulting graph of CA based on the data from 292 sampling sites and density of selected taxa groups

The resulting graph of CA that contains data of the large and very large rivers only, (rivers with catchments larger than 4,000 km^2) (Figure 4) described a similar pattern in the sites distribution as CA performed on the whole dataset (Figure 3). The data only, from large and very large rivers, are taken into consideration in order to eliminate the differences in the community that are a consequence of the river size.

In order to eliminate misinterpretation of the data, due to analyses on the level of principal taxa groups, the NMS on the genus level was also performed. (Figure 5). In addition, very large rivers (the Danube, Sava and the Tisa) were excluded from the analysis, in order to minimise the specificity of the fauna of potamon type rivers that was confirmed by the previous investigations, as well as by the analyses presented in Figures 3 and 4.

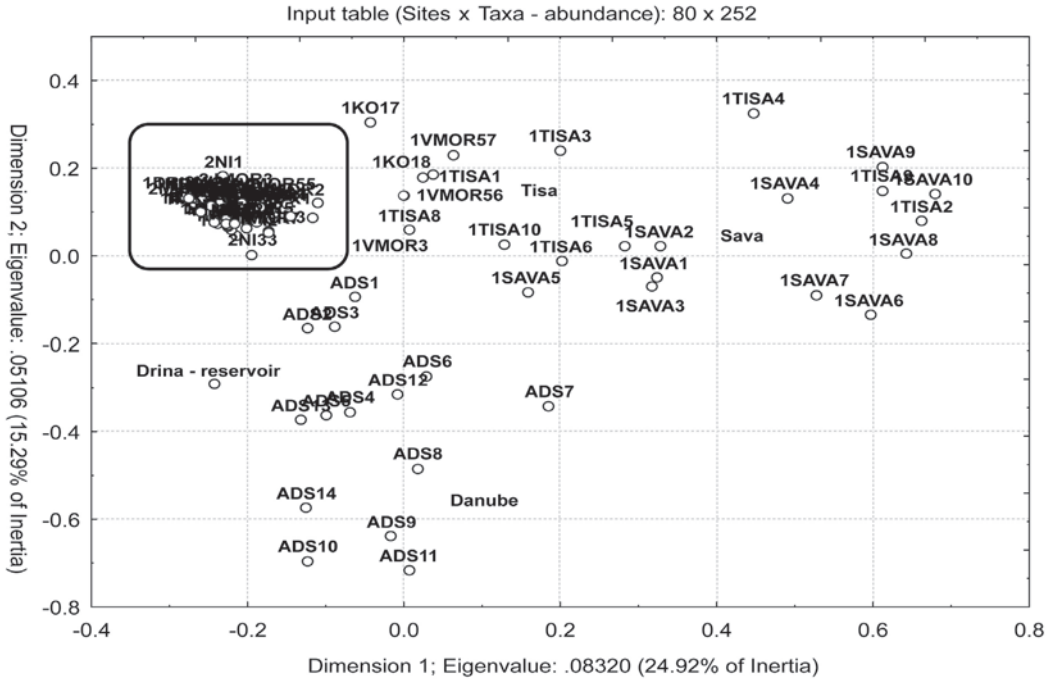

Figure 4: Resulting graph of CA based on the data from large and very large rivers (catchments area larger than 4,000 km^2) and species abundance

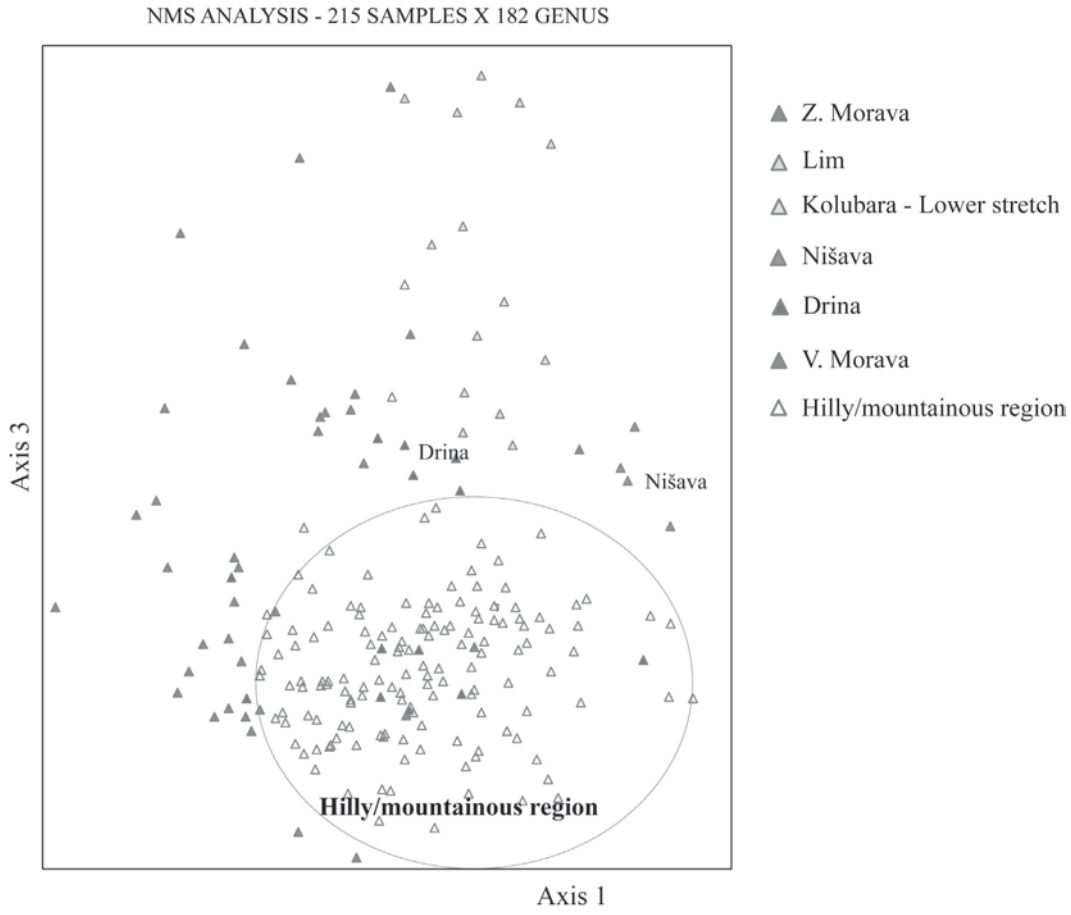

Figure 5: Resulting graph of NMS analysis on the data from sites belonging to large rivers (the Danube, Sava and Tisa Rivers excluded from the analysis) - the genus level.

Additionally, the samples from lowland parts (ecoregion 11) were excluded from the analyses. The analysis was performed on 94 samples, taking into account only sites assessed as 1 and 2 according to criteria presented in Table 2. According to the CA resulting graph (Figure 6), the samples from the Timok River catchment area were found to be separated from the rest of the sites, as well as samples from the Zapadna Morava Basin.

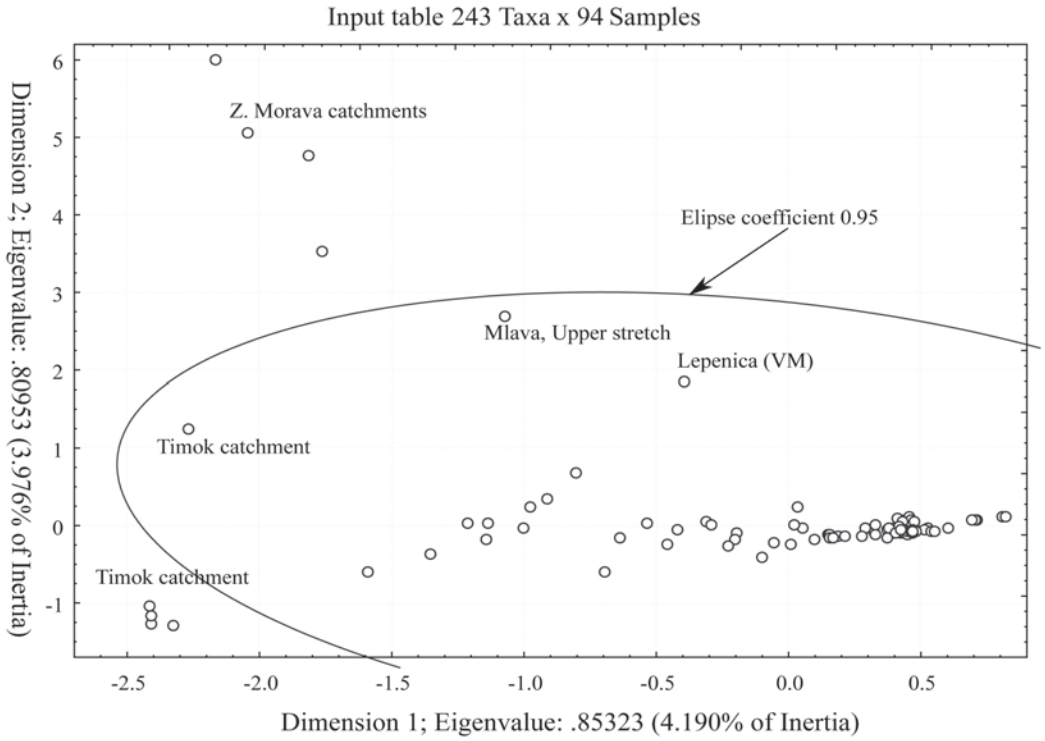

Figure 6: Resulting graph of CA based on the results from reference or near natural sites belonging to hilly mountainous watercourses (lowland rivers excluded from the analysis).

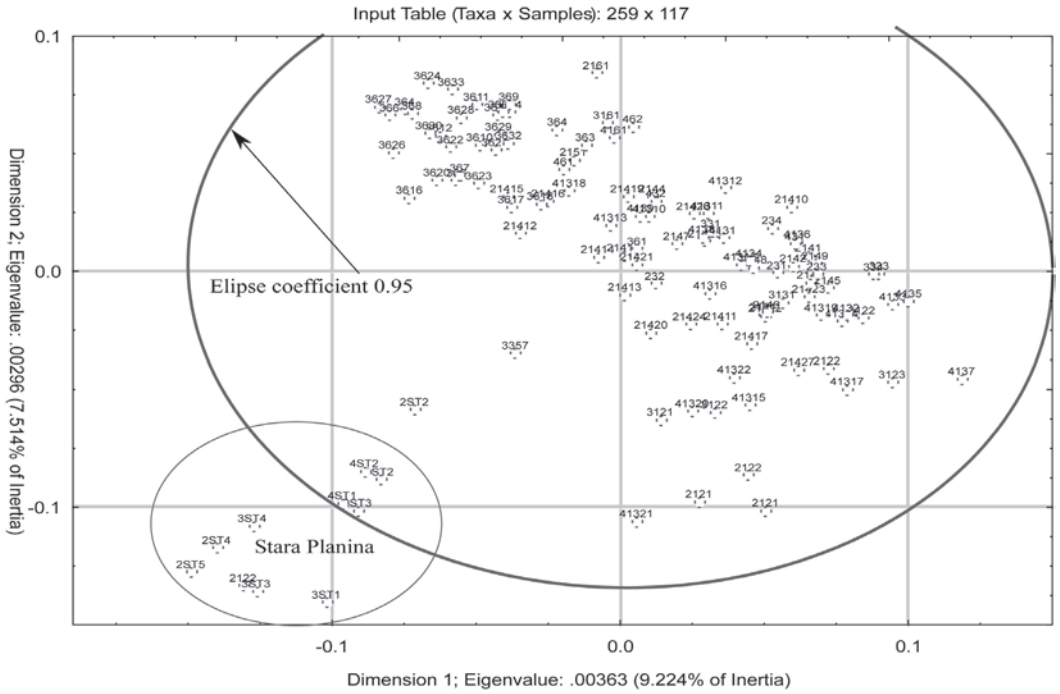

Figure 7: Resulting graph of CA based on the results from sites characterized as good or above (class 1, 2 and 3 according to criteria listed in Table 2) belonging to hilly mountainous watercourses (lowland rivers excluded from the analysis).

The resulting graph of CA (Figure 7) showed that sites from the Stara Planina Mountain are separated from the rest of the samples. The analysis was performed on the input table containing the larger dataset, since the sites characterised as having good status (label 3 in Table 2) were taken into consideration.

Based on the qualifications described at the beginning of the Results and Discussion section, as well as results on spatial distribution of macroinvertebrate fauna that were presented above, the boundaries of the ecoregions are proposed, as presented in Figure 8.

According to the more precise delineation of the ecoregions boundaries presented in Figure 8, ecoregion 11 (ER 11) within the territory of Serbia covers an area of 29,185.7 km^2 and is located in the northern lowland area of the country. This area is more

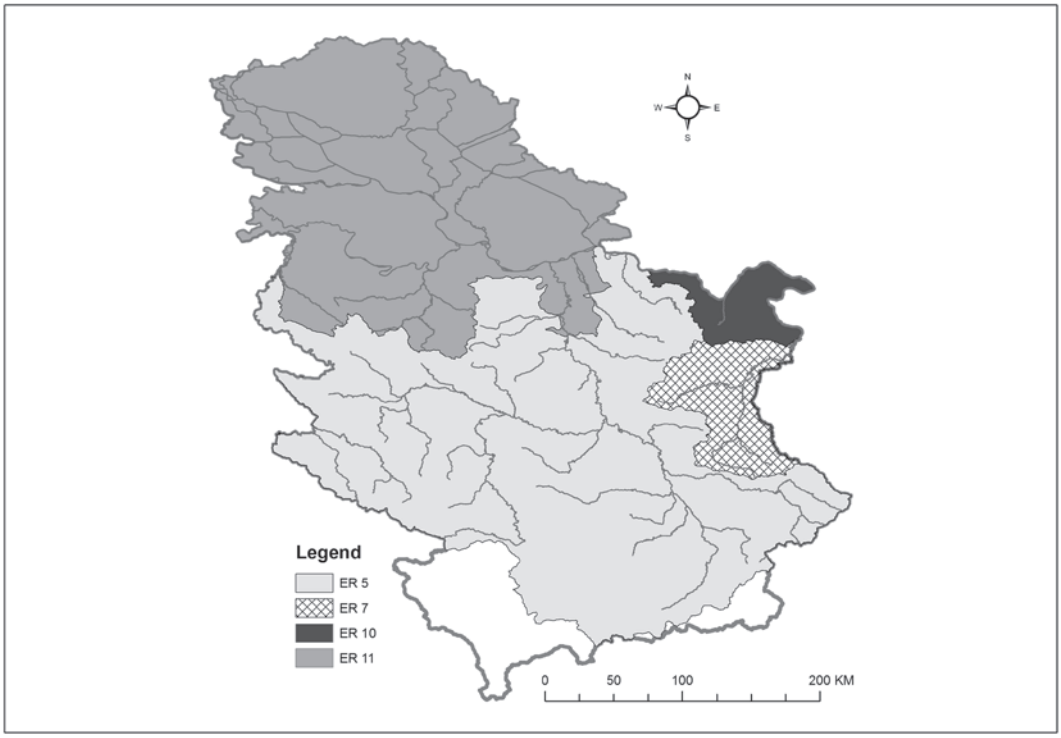

Figure 8: Revised boundaries of ecoregions in Serbia

homogenous regarding general natural conditions than hilly/mountainous areas. Part of the Sava catchment belongs to ER 11, part of the Kolubara basin (lower Kolubara), as well as the main course of the Sava River and its tributaries. Additionally, ER 11 in Serbia includes the direct tributaries of the Danube and basins of the Tisza, Begej, Tamiš, lower parts of the Velika Morava and Mlava Rivers, as well as small-sized watercourses of the Vojvodina Province. The area surrounding the lower stretch of the Drina River (up to the Lešnica tributary) was also considered as a part of the ER 11. According to our research, the region is characterised by the fauna of aquatic macroinvertebrates, as well as fish fauna (Simonović, 2003) characteristic for lowland areas of Europe.

Ecoregion 5 (ER 5) in the area of Serbia covers an area of 45.692,0 km^2. According to our results, ER 5 covers part of the Kolubara basin (sub-catchments of the rivers Gradac, Jablanica, Obnica, Ribnica incl. the Lepenica), a larger part of the Drina basin (except the most downstream part – see explanation bellow) and the basins of the Lim and the Uvac Rivers. Additionally, ER 5 includes part of the Velika Morava, catchments of the rivers Zapadna and Južna Morava, and the Ibar basin. The streams of the "Upper" Kolubara catchments are characterised by fauna of aquatic macroinvertebrates which is significantly different from that recorded in other tributaries of the Kolubara ("Lower" Kolubara) and, according to the characteristics of the community, is more similar to rivers at the catchment of the Zapadna Morava and tributaries of the Drina, excluding the rivers Jadar and Lešnica.

The area is heterogeneous regarding general natural conditions (Simić, 1995; Simić and Simić, 1999), but due to distribution of mountain massifs, as well as to historical factors, fauna of aquatic macroinvertebrates consisted mainly of widely spread forms, but also recorded the taxonomy of narrow spreading and forms of different levels of endemic characteristics (Filipović, 1979; Marinković-Gospodnetić, 1980; Radović *et al.*, 1995). Heterogeneity has caused certain differences in communities of water macro-invertebrates, hence, the area is divided into hydro-faunistical subregions (Paunović, 2007).

The border between the Danube and Adriatic Basins was considered to be the southern boundary of ecoregion 5. The part of the Danube basin shared by Serbia and the Adriatic Basins are distinguished enough to be separated as different ecoregions in regard to overall natural characteristics, as well as in regard to distribution of aquatic biota (Banaresku, 1991).

The boundary of the ecoregion 5 and 7 is situated at the border of the Timok Basin (western border) in its northern part, while in its southern part the division is positioned on the border between the Danube and Aegean Basin. Based on macroinvertebrate fauna data from the Timok basin (mostly sites from the upper part of the basin), the area is significantly different in comparison to other basins.

The boundary of ecoregions 5 and 10 is positioned on the east boundary of the Pek River and next to the massifs of Homolj and Deli Jovan Mountains.

Ecoregion 7 (ER 7) in the area of Serbia covers an area of 4,497.8 km^2 and comprises the Timok River Basin. As it was previously emphasised, the area is specific according to overall natural characteristics, and consequently in regard to its macroinvertebrate community.

Ecoregion 10 (ER 10) covers the direct tributaries of the Danube in the Iron Gate Sector ("Đerdap" National Park Area) in the southeastern part of Serbia and comprises an area of 2,501.6 km^2. We are of the opinion that the influence of the Carpathian Mountains is significant in the area which was confirmed by investigation of aquatic macroinvertebrate fauna, as well as by the above presented bio-geographical discussions (Fukarek, 1977; Matvejev and Puncar, 1989). The massif of Homolj and Deli Jovan Mountains partially separates the area from the region situated in southern direction (the Timok, Mlava and Velika Morava catchments).

The part of Serbia that belongs to the Adriatic Basin belongs to ecoregion 6 (ER 6), with an area of 5,425.4 km^2. Although we do not have recent data to confirm this division, the separation of the two large basins is a reasonable solution and general differences in aquatic biota distribution are confirmed by Starobogatov (1970).

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References

Banarescu, P. (1991). Zoogeography of Fresh Waters. Distribution and Dispersal of Freshwater Animals in North America and Eurasia. Vol. 2, AULA- Verlag Wiesbaden. 519-1091.

Blaženčić, J., Cvijan, M. and R. Laušević (1995). Diverzitet slatkovodnih algi Jugoslavije sa pregledom vrsta od međunarodnog značaja, 159-182, in: Biodiverzitet Jugoslavije sa pregledom vrsta od međunarodnog značaja,Stevanović, V. and V. Vasić (eds.). Biološki fakultet i Ecolibri, Beograd. [Diversity of freshwater algae of Yugoslavia with review of internationally important species]

Filipović, D. (1979). Biogeografical and faunistical nortes on mayflies (Ephemeroptera) of SR Serbia. Proceedings of the 2nd International Conference on Ephemeroptera, 211-219.

Fukarek, O. (1977). Zum Gliderung der illzrischen Pfanzenprovinz in naturliche Vegetationsgebeite mit hilfe der Waldgesellschaften. Centralblatt fur des gesamte Fortwesen 94, 3, 154-162. [The classification the Illyrian province to natural vegetation areas based on forest communities]

Illies, J. (1978): Limnofauna Europaea. Gustav Fisher Verlag, 1-532.

Karadžić, B., Sašo-Jovanović, V., Jovanović, Z., and R. Popović (1998). "FLORA" a database and software for floristic and vegetation analyzes, 69-72, in: Progress in Botanical Research, Tsekos I. and M. Moustakas (eds.). Kluwer Academic Press, Dodrecht.

Karadžić, B. and S. Marinković (2009). Kvantitativna ekologija. Institut za biološka istraživanja "Siniša Stanković", Beograd, 1-489. [Quantitative ecology]

Lopatin, I. K. and S. D. Matvejev (1995). Kratka zoogeografija sa osnovama biogeografije i ekologije bioma Balkanskog poluostrva. Knjiga 1, Univerzitetski udžbenik, Ljubljana, 1-166. [Zoogeoraphy, principles og biogeography and ecology of Balkan Peninsula (distribution of biomes, distribution laws, elements of flora and fauna)]

Marinković-Gospodnetić, M. (1980). Fauna Trichoptera SR Srbije. SANU, Odeljenje prirodnih nauka, Zbornik radova o fauni SR Srbije, 1, 71-84. [Trichoptera fauna of Serbia]

Matvejev, S. D. and I. J. Puncer (1989). Karta bioma, predeli Jugoslavije i njihova zaštita. Posebna izdanja Prirodnjačkog muzeja u Beogradu, 36, 1-76. [Map of biomes of Yugoslavia and their protection]

McCune, B. and M.J. Mefford (1999). PC-ORD. Multivariate Analysis of Ecological Data, Version 4. MjM Software Design, Gleneden Beach, Oregon, USA, 1-237.

Pantle, R. and H. Buck (1955). Die biologische uberwachung der Gewasser und die Darstellung der Ergebnisse, Gas. u Wasserfach 96, 1-604.

Paunović, M. (2007). Struktura zajednica makroinvertebrata kao indikator tipova tekućih voda Srbije. Doktorska disertacija, Univerzitet u Beogradu, Biološki fakultet, 1-218. [Composition of macro-invertebrate communities as indicator of running waters types in Serbia]

Paunovic, M., Jakovcev-Todorovic, D., Simic, V., Stojanovic, B., Cakic, P. (2007). Macroinvertebrates along the Serbian section of the Danube River (stream km 1429-925). Biologia, Bratislava 62, 2, 1-9.

Radović, I., Mesaroš, G., Pavićević, Mihajlović, Lj., Protić, Lj. and A. Ćetković (1995). Diverzitet entomofaune (Insecta) Jugoslavije sa pregledom vrsta od međunarodnog značaja, 371-424, in: Stevanović, V. and V. Vasić, (eds.). Biodiverzitet Jugoslavije sa pregledom vrsta od međunarodnog značaja. Biološki fakultet i Ecolibri, Beograd, 1-562. [Diversity of insect fauna (Insecta) of Yugoslavia with review of internationally important species]

Simić, V. (1995). Mogućnosti ekološkog monitoringa rečnih sistema Srbije na osnovu makrozoobentosa. Doktorska disertacija, Biološki fakultet Univerziteta u Beogradu, 1-248. [Possibilities of ecological monitoring of running waters in Serbia]

Simić, V. and S. Simić (1999). Use of the river macrozoobenthos of Serbia to formulate a biotic index. Hydrobiologia, 416, 51-64.

Simić, V. (1993). Saprobiološka valorizacija Svrljiškog i Trgoviškog Timoka na osnovu sastava makrozoobentosa. Magistarski rad, Biološki fakultet Univerziteta u Beogradu, 1-263. [Saprobiological valorisation of the Svljiški and Trgoviški Timok based on the structure of macrozoobenthos]

Simonović, P. (2006). Ribe Srbije. NNK Internacional Beograd, Biološki fakultet Univerziteta u Beogradu, 1-246. [Fish of Serbia]

Stanković, S. (1962). Ekologija životinja. Univerzitet u Beogradu i Zavod za izdavanje udžbenika SR Srbije, Beograd, 1-432. [Animal ecology]

Starobogatov, Y.I. (1970). Fauna Mollyuskov i zoogeografucheskoe rajoniranie kontinentalnih vodsemov. Nauka, Leningrad, 1-372. [Mollusks fauna and zoo-geographycal reonisation of inland waters]

Stevanović, V. (1995). Biogeografska podela teritorije Jugoslavije, 117-128, in: Stevanović, V. and V. Vasić (eds.). Biodiverzitet Jugoslavije sa pregledom vrsta od međunarodnog značaja. Biološki fakultet i Ecolibri, Beograd. [Biogeographic division of the territory of Yugoslavia]

Stevanović, V. and B. Stevanović (1995). Osnovni klimatski, geološki i pedološki činioci diverziteta kopnenih ekosistema Jugoslavije, 75-96, in: Stevanović, V. and V. Vasić (eds.).Biodiverzitet Jugoslavije sa pregledom vrsta od međunarodnog značaja. Biološki fakultet i Ecolibri, Beograd. [Basic climatic, geological and pedological factors of the diversity of terrestrial ecosystems in Yugoslavia]

Stevanović, V., Jovanović, S., Lakušić, D. and M. Nikolić (1995). Diverzitet vaskularne flore Jugoslavije sa pregledom vrsta od međunarodnog značaja, 182-216, in: Stevanović, V. and V. Vasić (eds.). Biodiverzitet Jugoslavije sa pregledom vrsta od međunarodnog značaja. Biološki fakultet i Ecolibri, Beograd [Diversity of vascular flora of Yugoslavia with review of internationally important species].

Stevanović, V. and V. Vasić (1995). Biodiverzitet Jugoslavije sa pregledom vrsta od međunarodnog značaja. Biološki fakultet i Ecolibri, Beograd, 1-562. [Biodiversity of Yugoslavia with review of internationally important species]

WFD (2000). Water Framework Directive - Directive of European Parlament and of the Council 2000/60/EC – Establishing a Framework for Community Action in the Field of Water Policy.

Živić, I., Marković, Z. and J. Ilić. (2005). Composition, structure and seasonal dynamics of macrozoobenthos in the Temska and Visočica Rivers (Serbia). Arch. Biol. Sci., 57, 2, 107-118.