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ASSESSMENT OF THE RIVER HABITAT QUALITY IN UNDEVELOPED AREAS OF SERBIA APPLYING THE RHS (RIVER HABITAT SURVEY) METHOD

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Abstract: Paper's main goal is to establish "RHS reference site", which will be the basis for future classification of river habitat quality in other regions of Serbia. River habitats in Golijska Moravica and Jerma basin have been assessed and classified by RHS method, and reference values are determined (which would serve for the next research of river habitats in Serbia). In Golijska Moravica and Jerma basin semi–natural and predominantly unmodified habitats with high diversity are dominant. If we compare HQA index of Moravica and Jerma with HQA indexes in some European countries (Austria, Germany) of same river type (small, shallow mountain rivers) we can conclude that sites in Moravica and Jerma basin have higher habitat diversity. Within river basins there are spatial differences of HQA index value. River sites in Moravica and Jerma basin have lower values of HMS index than sites in European countries. The impact of individual characteristics on total HQA and HMS score is also determined in this paper.
Results of this paper are important for conservation of natural habitats, for river basin management plans and to estimate environmental impact of future water management activities in these basins.

Key words: RHS method, HQA index, HMS index, Golijska Moravica, Jerma

Introduction

The foundation for sustainable water management is the access to the good quality data and expert assessment based on scientific knowledge. The methods that characterize physical structure of water flows and establish the quality of river habitats are becoming more and more important in the decision–making process for the needs of planning the environmental protection, and especially as the components of impact assessment on the environment (Raven et al, 2002).

The Water Framework Directive of the European Union represents the turning point in water management in Europe. Although Serbia is not the member of European Union, intensive activities on implementation of this Directive under the coordination of the Ministry of Agriculture, Forestry and Waterpower Engineering–Republican Water Department have been carried out in Serbia for a long time considering the fact that almost all its territory is in the Danube River

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Basin, and that it is signatory country of The Danube River Protection Convention in Sofia –(The Convention on Protection and Sustainable Use of the River Danube), as well as the fact that it is has been rightful member of ICPDR since the year 2003. The General Directive of European Union on Waters, (Directive 2000/60/EC, 2000), or the WFD, has for the first time introduced necessary hydromorphologic element in the assessment of the ecologic status of the water flow. The goals of the WFD are: prevention of degradation of aquatic ecosystems; promotion of sustainable use of water resources; reduction of pollution of groundwater and surface waters. The WFD is geographically universal (for all members of the EU) and covers all surface waters and groundwater, as well as transitional waters and coastal waters. The Directive demands from the Member States to protect, enhance and revitalize water bodies (apart from those artificial ones or those classified as "significantly modified", for which good ecological potential is foreseen), to maintain or achieve "good status" by 31st December 2015. This is realized when ecological (including hydro morphologic elements) and chemical conditions of water flows are at least "good", in the classification that has five categories from "excellent to very poor". (Directive 2000/60/EC, 2000). On the basis of all of these mentioned it can be concluded that physical (hydro morphologic) element is very important in ecological classification of rivers.

Some European countries already have well developed national programmes for determining hydro morphological qualities of rivers which are suitable for operative monitoring under the demands of the WFD, although survey methods differ from state to state (Raven et al, 2002). The STAR Project (Standardization of River Classification) was initialized in order to find common method for the whole Europe. The River Habitat Survey (RHS) was chosen as the most advanced method, which can be translated as the method for surveying river habitats (Szoszkiewicz et al, 2006).

Several European countries (Austria, Switzerland, Denmark, Italy, and Spain) developed systems for determining hydro morphologic features of rivers. However, three systems stand out with their development and accompanying documentation: the LAWA–vor–Ort from Germany, the SEQ–MP and the RHS from the Great Britain. The RHS methodology enables collecting, on several different levels, well systematized data on river hydromorphology, geomorphology, habitats and methods for the land use. The collected data are very suitable for statistic analysis and index measurement, and useful for determining quality and degradation of river ecosystem. Some of these indexes are the Habitat Quality Assessment (HQA) and the Habitat Modification Score

(HMS) which quantify physical quality of habitat and its abundance that is, the degree of morphological degradation (Szoszkiewicz et al, 2006).

More than 17 000 RHS studies have been completed since 1994. In the Great Britain the RHS method has been used in the reports of the water flow condition on the national and regional levels, as the part of the analysis of the impact on the environment and in characterization of hydromorphological conditions and influences on the water flows under the demands of the WFD of the European Union. The method was also tested on small rivers in other states of Europe: Finland, France, Austria, Portugal, Italy and Slovenia, with adaptation to local conditions.

The central network of 5600 stratified randomly chosen localities assessed in the Great Britain in the period from 1994–1996, represents essential foundation for the statistically based comparisons of different water flows and the analysis trend.

In Italy a study was made with the objective to research the application of different methods of the river habitat assessment on the representative locations. Apart from the RHS method with the HQA and the HMS indexes, which are developed in the Great Britain, three more indexes were added: the Index of Fluvial Functioning, the Buffer Strip Index and the Wild State Index. These indexes were studied at 33 locations with 3 different types of river flows, in order to establish hydromorphological features of the chosen Italian rivers. (Balestrini et al, 2004).

In Germany the RHS method was for the first time applied in 1999. Each federal unit made its chart of sustainable river habitats applying the RHS method, and the first chart was printed in 2002. The charts which contain 33000 km of river length show the diversity of river flows according to the quality, from the unmodified (1st class) to the completely modified (7th class). The largest number of river habitats (about 77% of the studied river habitats) are moderately modified (4th class) or they are in rather higher class. It has been worked on the standardization of parameters which were used in national methods of habitat sustainability in order to ensure comparison of the results of sustainable river habitats among the Member States of the European Union. (Kamp et al, 2007).

During the year 2005, fourteen studies of the RHS on 8 rivers were carried out in Slovenia. The results confirm that the RHS method is suitable for assessment of physical features of small and middle rivers (the river channel width < 100m), but several changes were made which included some objects and occurrences that do not appear on the rivers of the Great Britain (Raven et al, 2005).

The assessment of the ecological status is based on calibration in relation to the "reference" conditions for the given river type. Physical features of these reference conditions, which represent "excellent" status, can be directly received from establishment of river site network from the rivers which are considered "completely or almost completely untouched". If this kind of network does not exist for the certain river type, physical features can be received indirectly– through modeling or expert opinion. By definition, if the rivers with unmodified physical structure, or in other words, with excellent hydro morphological status have good water quality, they should support aquatic communities with excellent ecological status (Raven et al, 2002). These reference river sites with the best quality river habitats and waters are situated in undeveloped areas of our country, since water flows in the undeveloped areas are in small extent modified, that is they are almost untouched. Also, the rivers in these regions have the best water quality and those rivers mostly belong to the first class. For these reasons, in the scope of the project "Modality of Valorization of Geopotential of the Undeveloped Regions in Serbia", the RHS method was used for the first time in undeveloped areas of south–western and south–eastern Serbia.

Study methods

The River Habitat Survey (RHS) is the method used to determine the quality of river habitats based on their physical features. The method has four components: standardized field protocol; computer database for entering the results of surveyed river sites and their comparison with other sites of the same river type; methods for establishing the habitat quality; and the system for establishing artificial modifications of river sites (Raven et al, 1998).

Before we come to the description of the RHS it is necessary to define the following terms: *"site"is* 500 m long river part that is used in the RHS; "RHS reference site" are those sites which are specifically chosen for study in order to establish the RHS reference site network; "river type" is descriptive term for rivers with similar physical characteristics, "feature" is well recognized object or form which is registered in the RHS survey.

The river habitat quality is determined by the appearance and diversity of different features which are known to have great importance for the integrity of ecosystem. It is received by comparison of surveyed features at the river site with those which were surveyed on other rivers of similar type. River habitats of high quality are mainly situated at the unmodified sites (Raven et al, 1998).

The bank features and features of river channels are surveyed at 10 equally distant *spot–checks* at 50 m intervals. Physical characteristics are noted down at each spot–check (the flow type, channel substrates, channel and bank features, the bank modifications and river channel alteration, etc) as well as the land use and in–stream channel vegetation. Extensive additional list of characteristics is noted down along the 500 m long site. These data are called "*sweep–up information*". The main categories of sweep–up information are: land use, bank profile, presence of trees, presence of occurrences and objects in river channel (pools, rifles, middle bars), river channel size, objects of specific importance and the evidence of recent water management activities. All of these pieces of information, including photos of localities, cartographic data (altitude, distance from the mouth of the river and other) and geology are entered in the database, from which several different reports can be made. Taking into account all of these data, together with historical influences and geomorphologic processes, some information can be gathered which would be of great importance for protection and revitalization of river flows (Raven et al, 2000).

The Habitat Quality Assessment ***HQA*** is an indicator of global diversity of habitat, conditioned by site natural characteristics. The HQA index has a lot of habitat quality indicators such as number of different flow types, channel floor and deposition features in the channel and on the banks. It is presented with scores that are given to each individual characteristic, so that sites with numerous different natural characteristic have the best result. The comparison of the HQA indexes is only possible among sites with similar river flows. The values of HQA indexes often move from 10–80 scores, where 10 scores indicate that river has very small number of features characteristic for natural rivers and 80 scores indicate a large degree of natural characteristics.

The *Habitat Modification Class (**HMC**)* is established according to the ***HMS index*** (*Habitat Modification Score)* which presents indicator of anthropogenic influence on water flows. The HMS quantifies the presence and the influence of anthropogenic modifications such as bank reinforcement, modified bank profile, piping and number of weirs. The modifications are scored according to their presence, as well as according to their influence, that is the pressure on the given site. The values of HMS index often move from 0–100 scores, where 0 score shows the absence of artificial modifications, while 100 scores show large number of features caused by artificial modifications (Szoszkiewicz et al, 2006).

It is important to emphasize that the HQA index has to be calibrated first , that is compared to the HQA index of “reference river site”, that represent the best possible quality of river habitat and the quality of water in one country. After that, the values of the HQA index are expressed in quintiles calibrated in relation to reference values (upper 20%, upper 40%, 40%–60%, lower 40%, lower 20%). Combining the HQA and HMS indexes we come to the final qualification of the river habitat quality, in which 5 classes stand out: excellent, good, fair, poor, extremely poor (Raven et al, 2002). The connections between the HQA and HMS indexes are represented in the figure 1.

The main demand for establishing the impact on the environment is determining the current condition at the site and estimation of ecologic modifications that would be caused by proposed works. Three main types of physical alterations of river channels are: *reinforcement (*concrete support of banks, steel pillars, gabion (large pebbles in wired baskets)), *the profile modification* (deepening of river channels and banks) and *regulation* of river flow with dam objects in river channels. The HQA and HMS indexes can be used as a help in assessment of habitat condition before and after physical modifications of river channels and riparian land. It is important to note that RHS cannot replace specific methods, but it can make it easier to choose among thorough studies which are necessary for establishing the pressure on the environment (such as geomorphologic and botanic studies).

The advantage of the RHS is in the fact that it gives conceptual frame for other, specific studies of aquatic macrofits, floor fauna (macroinvertebrate) and fish. For example the data collected by the RHS method and charts made according to it are applied on the development of serial of models for prediction of crab *Austropotamobius pallipes* (Lereboullet) appearance on the rivers in the Great Britain and Ireland (Naura, Robinson, 1998). In the scope of the RHS, on the basis of numerous studies carried out by now, it can be concluded that the HQA index probably plays the most important role in organization of biologic communities (Erba et al, 2006).

For the needs of analysis of rivers in urban environment –Urban River Survey (URS) is developed which represents a modification of the RHS method. The connection between anthropogenic influences on the stretch of river flow and the characteristics of their habitats can be seen thanks to the URS methods and data. Also, some conclusions can be brought about the habitat quality rehabilitation of urban river flow potentials based on the analysis of this method (Boitsidis et al, 2006).

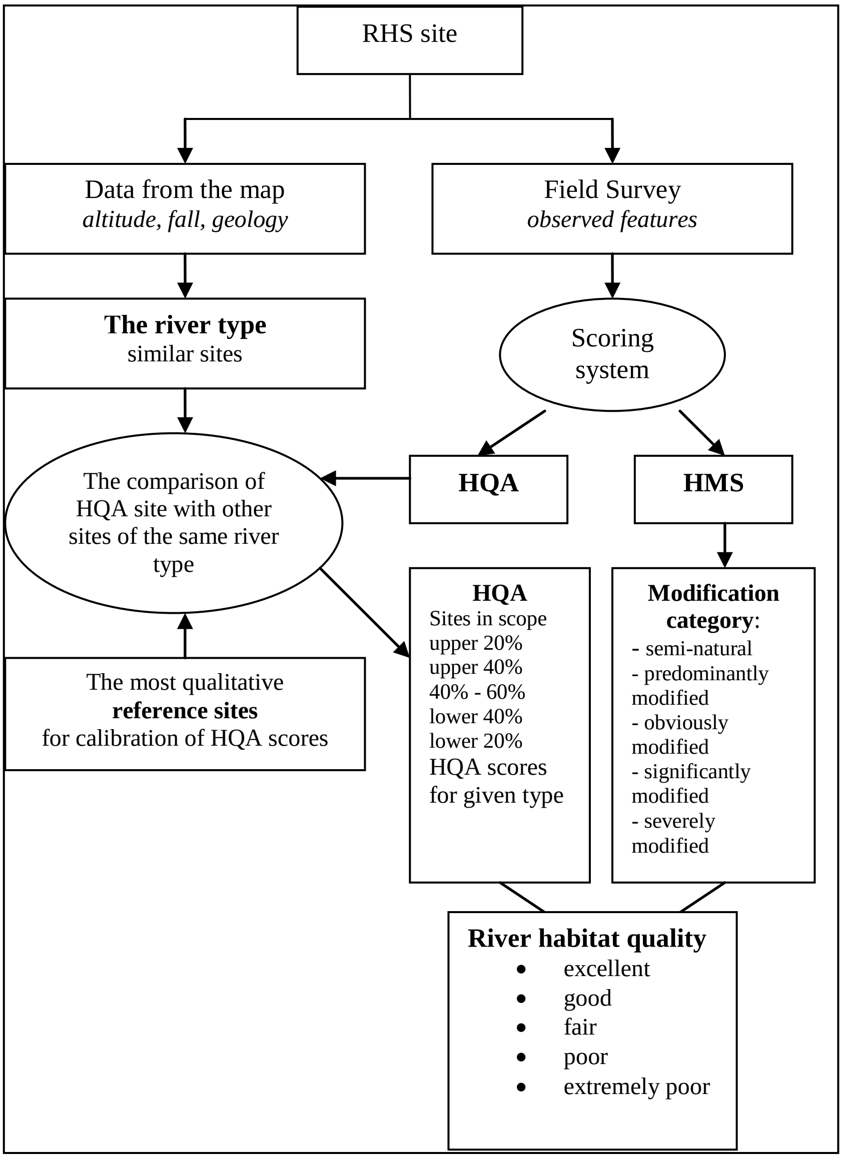

Figure 1. The connections between the RHS site, river types, HQA and HMS indexes (Raven et al, 1998, modified)

Tasks and objectives

According to the presented content by now, it can be concluded that the application of the RHS method is possible on small and middle rivers in Serbia. The researchers of the Geographical Institute "Jovan Cvijić" SASA (Serbian Academy of Science and Art) have applied the RHS method on river flows in Serbia since 2006 (Milanović et al, 2008). During the summers 2006 and 2008 field researches were carried out at 19 river sites in the Golijska Moravica Basin (Milanović et al, 2006) and the Jerma River Basin. One of the tasks of this field work was to apply RHS method for the first time in our country in order to receive reference values which would be used for calibration, or in other words, for establishing the quality of river habitat in other parts of Serbia. Apart from this, the results of the study should be used for establishing the ecologic condition of the above mentioned river flows. These localities would be visited after certain period in order to see any changes that may happen.

On ten selected locations in Golijska Moravica Basin, the RHS field protocols were filled in, photos of locations were made as well as digital map in Microstation (Milanović et al, 2006). Topographic maps 1:50 000 were used for the field research and for creating maps of locations. All the collected data helped forming electronic database. We have to stress that the terrain on most of locations was hardly accessible, which in certain extent influenced the quality of survey. The second research with the same method was carried out in July 2008 on nine selected locations in the Jerma Basin.

At the end, it should be emphasized that a lot more field surveys should be carried out throughout Serbia for classification of the river habitat quality, and that the received results from these basins can be used for establishing the so called "RHS reference sites".

Research area

The Golijska Moravica Basin is situated in the south–western part of Serbia, between 43º19' and 43º51' N latitude and 19º45' and 20º22' E longitude. The Golijska Moravica River, 86.9 km long, sprang on wooded mountain Golija (the highest peak Jankov kamen 1833 m altitude) and flows towards north to Požeška valley , where it flows into the Đetinja River. It presents right component of the Zapadna Morava River, with meridian flow direction and basin area of 1518 km^2. The Golijska Moravica Basin is asymmetrical (the left side covers 72% of its total area) and the main tributaries come from its left side (Urošev, 2006).

The average discharge of the Golijska Moravica River at Arilje is 10.6 m^3/s, minimal average annual discharge is 5.18 m^3/s, and maximal is 16.9 m^3/s. In absolute values, the average maximal discharge is 125 m^3/s, and the average minimal is 1.72 m^3/s (Urosev, 2007). The Golijska Moravica Basin is very profuse (12.2 l/s/km^2), and the water quality is very good. The Golijska Moravica River belongs to the first class of river quality up to Ivanjica, and from Ivanjica through Gradina till the river mouth it is in the 2nd \ 3rd class(2nd b), eg. the water quality is in transition from the 2nd to the 3rd class. The Veliki Rzav River is almost in its whole flow length in the 1st class of river quality (except after the Mali Rzav River mouth, on the entry into Arilje town, where it belongs to the 2nd class). The tributaries of the Golijska Moravica River–the Lučka River and the Grabovica River belong to the 1st class of river quality or they are in transition from the 1st class to the 2nd class (Urošev, 2006). From this reason the major part of the Golijska Moravica Basin is proclaimed catchment of surface water for the needs of water–supply of settlements in the future (Group of authors, 1996). The regional water–supply system "Rzav" currently functions and it supplies 5 cities: Arilje, Požega, Lučane, Čačak and Gornji Milanovac. Apart from this, the waters of the Golijska Moravica Basin can be used for other purposes as well: hydraulic engineering, recreation and irrigation.

The Jerma River basin is situated in the southeastern part of Serbia, between 42º41' and 43º04' N latitude and 22º21' and 22º49' E longitude and it includes, according to the measurements of Microstation software–815 km^2. The Jerma River Basin was first put in the georef system, and then digitalized in the program surroundings of Microstation. That enabled faster and more precise collecting of basic morphometric data on water flows in the basin. The Jerma River arises from the river Vučja and the river Grubina which meet at village Klisura on the east of Vlasinsko Lake on the mildly curved mountainous surface above which peak Cvetkov grab rises 1 489 m high (Stanković, 1997) The length of this river, counting from longer component–the Vučja River is 73,2 km. It arises on 1420 m altitude and it empties on 410 m altitude. The spring water branches of the Jerma River have gorge–like valleys which are totally opposite to Žne polje. Jerma gorge, between Vlaška mountain and Greben, that is downstream from Zvonacka Spa to Belo Polje, is specially important. Jerma gorge is on some parts 5–10 m wide and 200–300 m deep (Stanković,1997). It leaves the territory of our country at Strezimirovci village and goes into Zne polje in Bulgaria. It enters Serbia again after 27 km flow–length through Bulgaria not far away from village Petačinci. After 28 km from the entry into Serbian territory it empties into the Nišava River as its left tributary (Gavrilović, Dukić, 2002).

Although the flow length in Bulgaria is considerably shorter, 50% (400 km^2) of the total surface of the basin belong to Bulgaria because of the asymmetric Jerma Basin (Manojlović et al, 2003). Longer tributaries flow from the right side, which makes the right side surface slightly longer (484 km^2).

The river Jerma brings about 3.9 m^3/s, so the specific runoff is 4.4 $l/s/km^2$ at the mouth. The minimal average annual discharge is 2.2 m^3/s, and the maximal is 11.5 m^3/s. In absolute values the average maximal discharge is 38.1 m^3/s, and the average minimal is 0.9 m^3/s (RHMZ, 1998–2007). The water quality on the Jerma River has been tested on Trnski Odorovci profile since 1993. According to the researches in the period from 2004–2007, the Jerma River in its spring water part belongs to the 1st class of water quality, and from Trnski Odorovci up to the river mouth it is in the 2nd class (which is at the same time the demanded class). For this reason there is possibility to use the waters of this basin for the needs of water supply. Only local water supplies have been built from the spring by now. The water from this river can be used for different forms of recreation, irrigation, and since this region is a of great beauty there are also conditions for tourism development.

The description of river sites

The RHS method was applied on 19 river sites in the basins of the Golijska Moravica River and the Jerma River, and they are put into the following groups:

- River sectors in mountainous region (MOR 5 (the mouth of the Golijska River), MOR 6 (the Golijska Moravica River at Rimski Most), JER 1 (the Jerma River at village Klisura), JER 2 (the Kostroševska River at village Kostroševci) and JER 9 (the Jerma River at village Strezimirovci));
- River sectors in high hills (MOR 2 (the mouth of the river Panjice), MOR 3 (the river Golijska Moravica in Gradina Gorge), MOR 7 (the mouth of the river Nosnice), MOR 8 (the Veliki Rzav River at Radobuđe village, upstream from the mouth of the Mali Rzav), JER 3 (the Zvonacka River at village Zvonci), JER 4 (the Jerma River at Trnski Odorovci village), JER 5 (the Jerma River in gorge), JER 8 (the Poganovska River at village Poganovo));
- River sectors in low hills (JER 7 (the Jerma River at village Gornje Držine) and JER6 (at the mouth of the Jerma River));
- River sectors in settlements (MOR 1 (the Golijska Moravica River in Ivanjica), MOR 4 (the Golijska Moravica River in Prilike) and MOR 9 (the Veliki Rzav River in Arilje));

– River sites in lowland region (MOR 10 (at the mouth of the Golijska Moravica River)).

The basic morphometric data of the chosen river sites for the Golijska Moravica River and the Jerma River are presented in the tables 1. and 2., and their location in the basins on the figures 2. and 3.

For the purpose of easier identification in the future RHS database–the abbreviation "MOR" is added next to the number of river sites which represents all the spot–checks in the Golijska Moravica Basin, and the abbreviation "JER" for all the spot–checks in the Jerma Basin.

Table 1. Morphometric river site data in the Moravica Basin

Site	River	Place	Site altitude. (m)	Average fall (m/km)	Spring altitude (m)	The distance from the spring (km)	Maximal depth (m)	The width of water mirror (m)	The bank top width (m)
MOR 1	Moravica	Ivanjica	465	10	1350	38.7	0.65	8.5	25.0
MOR 2	Panjica	Gradina	390	24	1050	13.6	0.23	4.2	7.3
MOR 3	Moravica	Gradina	387	4	1350	56.5	–	8.0	14.0
MOR 4	Moravica	Prilike	403	3	1350	50.7	–	10.0	13.5
MOR 5	Golijska r.	mouth	667	20	1670	15.5	0.35	4.7	8.1
MOR 6	Moravica	Rimski Most	638	14	1350	19.8	0.75	5.0	9.5
MOR 7	Nošnica	Međurečje	533	7	1380	34.0	0.40	3.0	7.0
MOR 8	Veliki Rzav	Radobuđa	360	4	1360	58.9	0.45	13.6	18.6
MOR 9	Veliki Rzav	Arilje	330	3	1360	64.2	0.40	14.5	20.5
MOR10	Moravica	mouth	299	< 1	1350	86.6	–	10.0	13.0

In the basins of the river Golijska Moravica and the river Jerma there are similar physical–geographic conditions. Moderate continental climate is mainly spread, only in the upper parts of the basin (sites MOR 5, MOR 6, JER 1, JER 2 and

JER 9) sub mountainous climate is present. All the rivers in the studied basins have pluvial–nival hydrologic regime.

Morphometric data on studied river sites in the basins of the Moravica River and the Jerma River are given in the tables 1. and 2. and these surveys refer to the period of small waters.

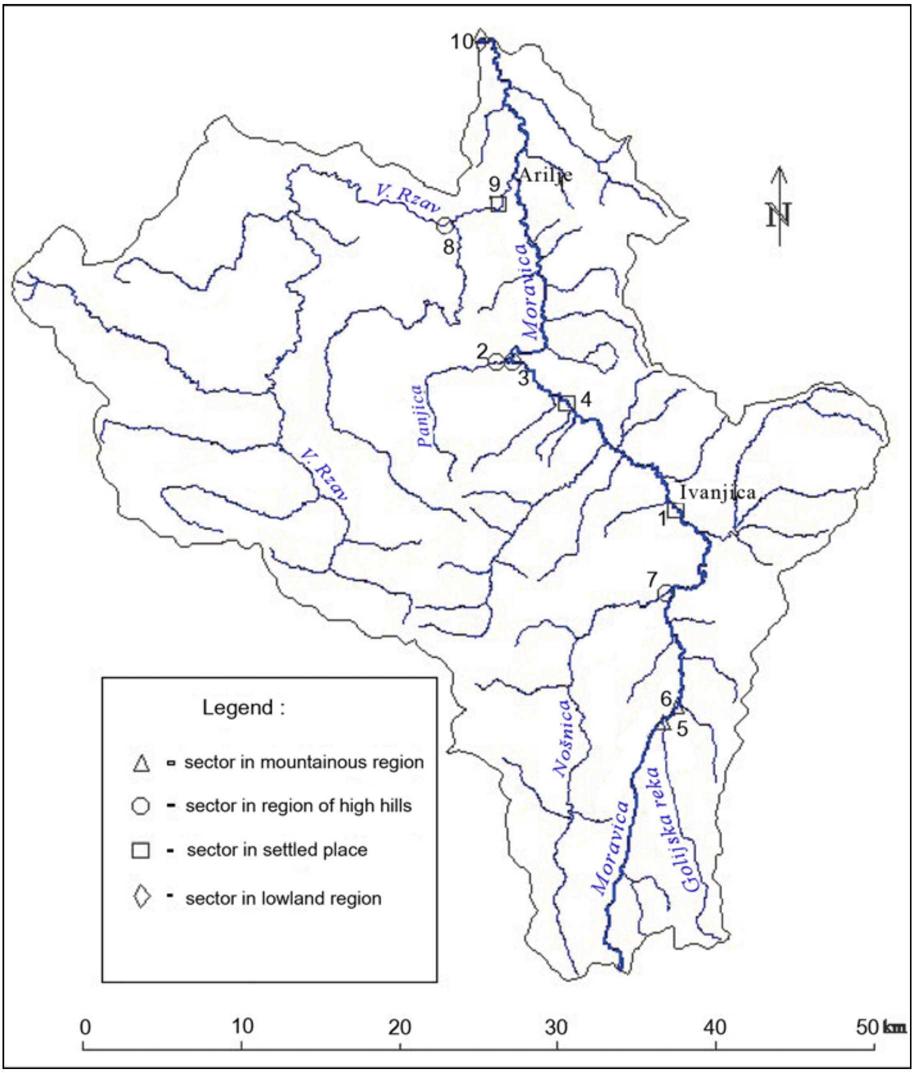

Figure 2. The location of studied river sites in the Moravica Basin

The geological structure of the Golijska Moravica River, depending on location, consists of phyllites, sericitic schists, triassic massive and bedded limestones, jurrasic limestone, porphyrite, carboniferous metamorphic rocks and alluvium. The valleys in the studied sectors are mainly in the V shape. River channels are composed of cobbles, boulders and bedrock, except for the floor of the mouth at the MOR 10 site which consists of slime and larger gravels. The dominant flow type at these sites is rippled and broken wave, and in some places water floods even in the forms of rapids and cascades. There are moss and immersive broadleaved plants at certain sites in the river channel.

The vegetation structure of the bank sides is diverse, depending on the location of the site. Broadleaved mixed forest take turn with coniferous forests (MOR 5), natural meadows and high grass, cultivated pastures and cultivable soil. The river sites in inhabited places (MOR 1, MOR 4 and MOR 9) are significantly modified with urban influence. Urban zones, parks, gardens, cultivated pastures are dominant in this region. Weirs (composed of big rock blocks), pedestrian bridge and city strand at MOR 9 site have big influence as well.

Table 2. Morphometric river site data in the Jerma River Basin

Site	River	Place	Site altitude (m)	Average fall (m/km)	Spring altitude (m)	The distance from the spring(km)	Maximal depth. (m)	The width of water mirror (m)	The bank-top width (m)
JER 1	Jerma	Gorge	860	21	1420	9.2	0.17	3.9	8.4
JER 2	Kostroševska r..	Kostroševci	855	19	1580	7.4	0.15	3.5	11.1
JER3	Zvonacka r	Zvonce	610	30	920	7.1	0.30	5.2	11.9
JER 4	Jerma	Trnski Odorovci	550	25	1420	52.8	0.50	13.0	18.0
JER 5	Jerma	In the gorge along the road	510	20	1420	58.2	–	7.0	12.5
JER 6	Jerma	River mouth	414	2	1420	72.3	–	–	–
JER 7	Jerma	Gornja Držina	445	5	1420	66.0	0.50	13.0	23.0
JER 8	Poganovska r.	Poganovo	545	28	920	8.2	0.16	3.5	7.5
JER 9	Jerma	Strezimirovci	803	16	1420	15.1	0.45	4.5	9.0

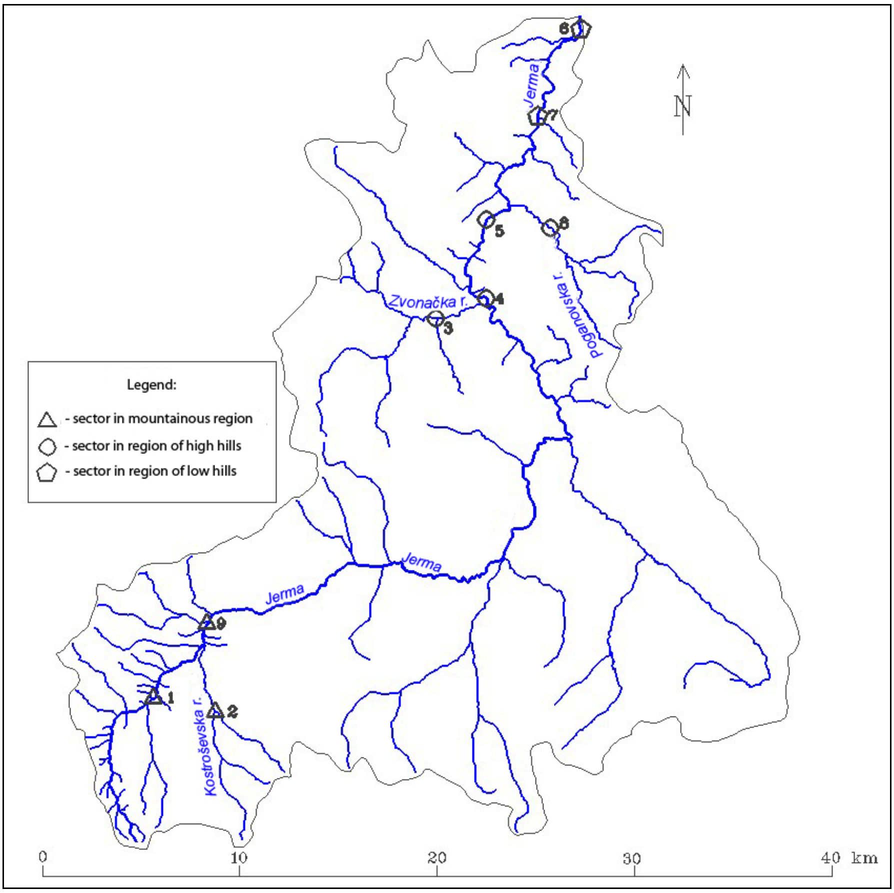

Figure 3. The location of the studied river sites in the Jerma

Alluvium dominates in the geological structure of the studied sites in the Jerma Basin, slates were only registered at JER 1 site and conglomerates, sandstones and triassic limestone at JER 3 site. As in the case of the Golijska Moravica Basin the valleys in the Jerma Basin are mostly in the V shape at the studied sites, only in some places gorges and asymmetric and concave valleys appear. The river channels in the Jerma Basin are also composed of cobbles and boulders, or somewhere even of bedrock and only at the JER 9 site the floor is composed of larger gravels. In the channel at some sites large quantity of refuse can be seen. The dominant type of river flow is the same as in the Golijska Moravica–rippled, and in some places rapids appear. On the basis of analysis of both basins it can be concluded that vegetation in the river channels is more presented in the Jerma Basin in relation to the Golijska Moravica Basin. In the river channels of the Jerma Basin vegetation is registered on 7 out of 9 sites, and most of all, large quantities of moss and somewhat smaller immersive narrowleaved and broadleaved plants.

In the vegetation structure of the bank sides broadleaved mixed forests, natural meadows and high grass are dominant, while cultivable soil is noted only at JER 8 site. Contrary to the Golijska Moravica Basin there are no sites in settlements. Objects were registered on most of the sites, which have influence on the features of river habitat – pedestrian bridges and fords, road bridge at JER 3 site, and weirs at JER 8 site.

The Results

The HQA index is calculated by adding scores for the presence of natural objects (such as point bars, side bars, channel substrate, flow type, vegetation type in channel, presence of trees and natural riparian land use etc.) The scores for these features, as well as for features needed for calculating HMS index are given in the work of Raven et al from 1998.

Higher value of the HQA shows that the river site is better ranked, that is it has better habitat diversity. In the tables 3. and 4. scores are given according to the categories and total HQA index for all 19 sites in the basins of the Golijska Moravica and the Jerma.

Table 3. HQA scores of the sites in the Moravica Basin

Categories	MOR 1	MOR 2	MOR 3	MOR 4	MOR 5	MOR 6	MOR 7	MOR 8	MOR 9	MOR 10
Flow types	10	6	5	5	8	8	9	8	8	6
Channel substrates	5	4	1	4	6	6	7	6	4	3
Channel features	4	8	4	3	6	7	7	6	2	1
Bank features	5	1	1	5	2	3	2	1	2	2
Bank vegetation structure	6	3	7	7	7	9	6	9	7	9
Point bars	0	0	0	0	0	0	0	0	0	0
In–stream channel vegetation	0	3	0	0	2	2	1	2	2	0
Land–use within 50 m	2	4	3	2	10	2	1	4	0	0
Trees and associated features	9	14	12	16	18	17	13	15	11	15
Objects of the special importance	5	5	5	5	5	5	5	5	5	5
HQA	**46**	**48**	**38**	**47**	**64**	**59**	**51**	**56**	**41**	**41**

The comparison of the HQA index for the studied river sites in the Moravica Basin and the Jerma Basin is possible because these sites belong to the same river type. Altitude, geologic structure of the basin, climate and hydrologic regime of these sites are very similar. According to the European classification of the river types (Szoszkiewicz et al, 2006), river sites in the basins of the Moravica and the Jerma belong to the mountainous river type, or to be more precise, to the subtype of small, shallow mountainous river.

Table 4. HQA scores of the river sites in the Jerma Basin

Categories	JER 1	JER 2	JER 3	JER 4	JER 5	JER 6	JER 7	JER 8	JER 9
Flow types	8	7	10	8	8	4	8	7	7
Channel substrates	5	4	6	6	4	4	4	3	5
Channel features	3	5	7	7	6	4	5	4	2
Bank features	3	7	8	6	8	1	5	5	8
Bank vegetation structure	13	12	12	10	7	8	10	11	11
Point bars	1	1	0	0	0	0	1	1	1
In–stream channel vegetation	0	1	1	2	3	2	2	5	0
Land–use within 50 m	4	3	2	3	4	0	3	0	1
Trees and associated features	10	17	12	10	6	18	10	12	17
Objects of the special importance	5	5	5	5	5	5	5	5	5
HQA	**52**	**62**	**63**	**57**	**51**	**46**	**53**	**53**	**57**

According to the results from tables 3. and 4. we can conclude that sites in Jerma Basin have higher values of HQA index than sites in Moravica Basin. HQA values in Jerma Basin vary between 46 and 63 scores, while average score is 54.8 points. On the other side in Moravica basin slightly lower HQA values are observed between 38 and 64, while average score is 49.1 points. This could be explained by presence of big towns in Moravica Basin (Ivanjica, Arilje), higher population density and higher infrastructure development. All this brings to higher anthropogenic impact on the environment, and therefore has influence on quality of river sites. On the other hand Jerma Basin is less accessible, there are no major towns and road infrastructure isn’t so developed, so sites in this basin have more natural characteristics.

If we compare the HQA indexes for the Moravica River and the Jerma River with the HQA indexes in some European countries (Austria, Germany) for the same river type (small, shallow mountainous rivers) we can conclude that the sites in the basins of the Moravica River and the Jerma River have better habitat diversity. The values of the HQA index of small, shallow mountainous rivers in Austria start from 18 to 54 scores, and in Germany from 27 to 59 scores (Erba et al, 2006), which is considerably less than the above stated values in the basins of the Moravica River and the Jerma River.

Inside the basins some differences in the values of the HQA index can be recorded. Thus, in the Moravica Basin the highest values of the HQA index (64–56) were received for the river site in the upper parts of the basin, where the population density is lower, river falls are bigger and river vegetation is conserved (the mouth of the Golijska River (MOR5), the Moravica at Rimski Most (MOR 6) and the Veliki Rzav at Radobuđe (MOR8)). The lowest values of the HQA (38–41) have the river sites situated in lower part of the basin: they have small falls, they pass through agricultural land, inhabited places (the river Moravica at Gradine (MOR3), the Veliki Rzav–Arilje (MOR 9), the Moravica mouth (MOR 10)). In the Jerma Basin the differences in the HQA values for certain sites are to a great extent smaller. The largest habitat diversity have the Jerma tributaries–the Kostroševska River (JER 2) 62 scores and Zvonačka River (JER 3) 63 scores. Both sites have big channel falls and they are situated in forests and natural meadows. The minimal value of the HQA index in the Jerma Basin is registered at the Jerma mouth (JER 6) – 46 scores. Such a low value at the mouth of the Jerma River and the Moravica River is also caused by inaccessibility of this site, which influenced lower number of surveyed features.

Four river types are evident in Europe: lowland type, mountainous type, South–European type, the Alpine type. Szoszkiewicz et al established hydromorphologic differences based on 216 surveyed sites using the RHS method in four separate geographic regions. Also, they found which RHS features mostly influence the size of the HQA and HMS indexes (Szoszkiewicz et al, 2006).

In all four European river types none individual feature did not take part with more than 14% in the HQA index. The common feature for all four types was *the bank vegetation structure*, which contributed with about 10% of total HQA results (Szoszkiewicz et al, 2006). The share of this category on the river sites in the Moravica Basin and the Jerma Basin was 16.6%. Similar shares in our country and in Europe had categories: *channel substrate* (8.8%) and *flow type at spot–checks* (14.2%). The most important category of the HQA index in Europe on the mountainous rivers was *bank features recorded at spot–checks*, which participated with 13.2% of the total result (Szoszkiewicz et al, 2006). However, the share of this category on the mountainous rivers in our country was only 7.6%. The biggest share in the HQA result on the mountainous rivers in our country had *trees and associated features* category with 25.6 %.

The following features have minimal influence on the value of the HQA index: *channel features only found in sweep–up, flow type only found in sweep–up, bank features only found in sweep–up.* The mistakes in recording these features will not have larger influence on the total value of the HQA index. On the other hand, the mistakes in recording the features with big influence would significantly alter the value of the HQA index. These are: *flow types at spot–checks, channel substrates type at spot–checks, vegetation types in the channel.*

The scores for measuring the HMS index are given for the presence of the artificial objects (pipelines, weirs, bridges, flow deflectors, dams, fords and other). Also, these scores are given for the modifications in the river channel, such as modified bank profile, reinforced banks, embankments and poached banks. The higher degree of the modification of the river site, the higher HMS values are. In the tables 5. and 6. scores are given according to the categories and the total HMS index. Also, the modification class for all 19 monitored sites in the basins of the Moravica River and the Jerma River are seen.

Comparing the tables 5. and 6. it can be recorded that the Moravica Basin is more exposed to anthropogenic influences because it has higher values of the HMS index–the maximal (42 scores) and the average value (10 scores). The sites in the Jerma Basin have considerably lower values of the HMS index: the maximal 16 and the average – 4.8 scores.

Table 5. The HMS scores and HMS classes of the river sites in the Moravica Basin

Categories	MOR 1	MOR 2	MOR 3	MOR 4	MOR 5	MOR 6	MOR 7	MOR 8	MOR 9	MOR 10
Modifications at the spot–checks	27	0	0	2	0	0	8	2	9	0
The modifications which were not recorded at the spot–checks	2	2	0	1	0	0	4	0	11	2
Scores for the artificial objects for the whole site	13	1	0	0	1	0	3	0	12	0
HMS	**42**	**3**	**0**	**3**	**1**	**0**	**15**	**2**	**32**	**2**
Class	**4**	**2**	**1**	**2**	**1**	**1**	**3**	**1**	**4**	**1**

In general, river sites in the Moravica Basin and the Jerma Basin have lower values in comparison to the river sites in Europe, where the HMS goes to 100 scores. The explanation for this is that our sites were surveyed in undeveloped regions, while the river sites in Europe were surveyed also in developed urban regions.

Contrary to the HQA values, the highest HMS values (42–32) were received for the river sites which go through inhabited places, with high population density (the Moravica River–Ivanjica (MOR1), the Veliki Rzav River – Arilje(MOR 9)). Considerably low values (16–15) have two sites which are situated in settlements with lower population density, but with some economic activity expressed (Nošnica–Međurečje (MOR 7), the Poganovska River–Poganovo (JER 8)). The lowest HMS values (0–1) have the river sites situated in the upper parts of the basin (the mouth of the Golijska River (MOR 5)), Moravica at Rimski Most (MOR 6), or untouched sites in the middle parts of the basin (the Moravica River– Gradina (MOR 3), the Jerma River– Gornja Držina (JER 7)).

Table 6. The HMS scores and HMC classes of the river sites in the Jerma Basin

Categories	JER 1	JER 2	JER 3	JER 4	JER 5	JER 6	JER 7	JER 8	JER 9
Modifications at the spot–checks	2	1	2	0	8	2	0	3	0
The modifications which were not recorded at the spot–checks	2	2	0	2	0	0	0	12	2
Scores for the artificial objects for the whole site	0	1	1	0	0	2	1	1	0
HMS	**4**	**4**	**3**	**2**	**8**	**4**	**1**	**16**	**2**
Class	**2**	**2**	**2**	**1**	**2**	**2**	**1**	**3**	**1**

As said before, Szoszkiewicz et al analyzed which RHS features mostly affect the HMS index values (Szoszkiewicz et al, 2006). The structure of HMS index is very different from the HQA index because each category inside the HMS index contains large number of features that are scored differently. The category *modifications at spot–checks* often gives most scores to the HMS index in Europe, between 61% and 78%, Alpine rivers even more (Szoszkiewicz et al, 2006). The share of this category at the surveyed sites in the Moravica Basin and the Jerma Basin is 44.4%. That means that mistakes in recording of *the modifications at spot–checks* have large influence on the HMS index value.

Contrary to the HQA index, where it is not possible to establish classes of the habitat diversity, and where the comparison of the HQA values can only be performed inside the same river type, the HMS index can be classified in the classes of habitat modifications (HMC), and then compare with different river types. The classification of the habitat modification is given in the work paper of Raven et al, 1998.

Table 7. Classes of the modification of the river sites in the basins of the Moravica and the Jerma River

Modification of the site	HMC	HMS	Number of sites
semi–natural	1	0 – 2	8
predominantly unmodified	2	3 – 8	7
obviously modified	3	9 – 20	2
significantly modified	4	21 – 44	2
severely modified	5	> 45	0

Most of the river sites in the studied basins are situated in semi–natural and predominantly unmodified condition (table 7.). Two river sites are in obviously modified and two sites are in significantly modified condition.

The fact that the most of the sites are situated in semi–natural and predominantly unmodified condition, as well as that these sites have high diversity of habitat, that is high values of HQA index, confirms our hypothesis that the river sites in the undeveloped regions of Serbia can be ”reference RHS sites”, according to which calibration and classification of future RHS studies would be performed.

Conclusion

The results of this study made it possible to determine hydromorphologic river features in the Moravica Basin and the Jerma Basin, as well as natural and anthropogenic influences on them, which present one of the preconditions for establishing ecologic conditions of these rivers under the demands of the WFD. In the Moravica Basin and the Jerma Basin semi–natural and predominantly unmodified habitats with high diversity are dominant. However, for the further development of the river habitat classification in Serbia it is necessary to carry out lot more field surveys throughout the country using these two mentioned basins as samples. The objective of this study is accomplished to establish ”reference RHS sites” which present the foundation for future classification of the river habitat quality in other regions of Serbia.

Also, this study points out the possibility for application of the RHS method in the undeveloped areas of Serbia. The received results are important for conservation of natural habitats, for making river basin management plans and assessment of the impact of the future water management activities on the environment in the undeveloped regions of Serbia.

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