IOP Conference Series: Earth and Environmental Science

Impact Evaluation of Riparian Vegetation on Aquatic Habitat Quality of Rivers

Impact Evaluation of Riparian Vegetation on Aquatic Habitat Quality of Rivers

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Abstract. The knowledge about the natural potential vegetation is important to ensure the ecological stability of the area in terms of the restoration of riparian vegetation. The natural generic and spatial arrangement of riparian vegetation helps to maintain aesthetic appeal and has a high biological value in the country. Therefore, this work analyses the qualitative stream characteristics. To classify the qualitative parameters of the stream the method of indexes was used. The following hydromorphological methods were used to assess the condition of the biotope: QBR method (Qualitat del Bosc de Ribera) that is based on qualitative analysis of riparian vegetation, the HMS method (Habitat Modification Score) that allows to examine the anthropogenic changes in the river, BEHI method (Bank Erosion Hazard Index) that is used to determine the vulnerability to erosion, RGA method (Rapid Geomorphic Assessments) that is used for assessing the stability and sensitivity of the stream in relation to sedimentation processes, and RCE method (Inventory of River, Channel and Environment) that is used to assess the physical and biological state of small currents. The above-mentioned methodologies reliably identify the extremes concerning the riparian and the accompanying vegetation of the rivers. The vegetation is an important parameter for assessing the quality of the stream and it point out the areas that should be restored as a priority. As expected, the qualitative and quantitative characteristics of riparian vegetation have shown better results in rural areas than in urban areas. The quality of the stream is degraded by anthropogenic interventions in urban areas as well as in rural areas, so the focus on the vegetation of the whole stream is substantial. The individual methods allow the restoration of data in case of more significant changes that could be caused, for example, by floods or more significant anthropogenic impacts. The importance of this issue is growing as the riparian vegetation represent a valuable element of ecological stability with multiple functions. The riparian vegetation care is set by the actual legislation at national and transnational level, regarding the admitted European strategic objectives and documents. The application of the methodologies reliably identifies extremes in riparian vegetation, which significantly affect the overall characteristics of the flow quality, and they should be the subject of the restoration. The biological, morphological and water state of ten representative parts of Slatina and Drietomica rivers were evaluated. The results show that these methodologies present an appropriate tool for assessing the quality of riparian vegetation and can be used for restoration measures.

IOP Conf. Series: Earth and Environmental Science 221 (2019) 012111 doi:10.1088/1755-1315/221/1/012111

1. Introduction

The knowledge of natural potential vegetation is important to ensure the ecological stability of the area in terms of the restoration of riparian vegetation. The natural generic and spatial arrangement of riparian vegetation helps to maintain aesthetic appeal and has a high biological value in the country. Vegetation cover is one of the main component of the landscape and has a significant role in water regime. During the period of high precipitation or melting the snow, it supports the hydrological balance by retaining the water; the water drainage is slower what helps to regulate the accurate water circulation in the country. Vegetable cover retains a certain amount of water in the mountains, thus avoiding the flooding of the lower areas. It fulfills the function of erosion protection and stabilizes the channel, which has a direct impact on the quality of the aquatic habitat of the streams. It is an important factor in the formation of the habitat of ichthyofauna, creates shelters and contributes to the channel morphology, which is reflected by increased depths of water in the area of the root system in the riparian area [1,2].

Ecological approaches to the evaluation of aquatic ecosystems and the issue of their assessment are solved in Zumbroich et al. [3]. Lampert and Sommer are dealing with the problem of evaluation of the ecosystems on the basis of the ecological principles, because their value is undefined. The possibility of assessment is achieved by assigning the anthropogenic changes that are induced in the ecosystems; these changes then can be measured, classified and evaluated according to certain assessment criteria [4]. However, the basic prerequisite for the possible assessment is the creation of the reference state that represents the comparison element. The definition of such a state is very difficult and is related to the issue of distinguishing natural, near nature and the remote nature state. Some artificial anthropogenic systems may have a higher value than the natural systems according to some evaluation characteristics; for example, according to the species richness.

According to Langhammer [5], the assessment using the indexation methodology is based on the principle of scoring the individual parameters determined from the point of view of their impact on the hydromorphological and hydroecological flow quality. The primary results of field monitoring are used as input data. For most indicators the scoring is based on the frequency or range of the occurrence of the different forms of regulation of river environment and inundation environment. The evaluation reflects the hierarchical principle; the basic assessment is carried out for the individual mapped sections, of which the overall value for a given water body is derived. The selection of the sections is based on the examination of the monitored river in the existing background and the field survey. During the survey the representative sections that reflects changes in the quality of the aquatic and terrestrial habitat, the morphology of the flow and the relation to the surrounding environment are selected.

Bennett and Simon [6] report that riparian vegetation can play a critical role in assessing the physical, biological and hydraulic functions of watercourses and rivers. They point to the importance of relations between riparian vegetation on the one hand and fluvial processes and channel morphology on the other. Riparian vegetation is the most important element of natural protection of watercourses against the erosion, which makes this harmful process significantly eliminated. In general, the influence of the erosion protection of the forest ecosystem is known. Riparian vegetation is the last form of forest in the basin, using which we can reduce the erosion processes in the watercourses and thus significantly limit sedimentation processes. The problem of riparian vegetation can occur when invasive plant species, such as Fallopia japonica, occur. The invasive species distorts the original balance in the original riparian vegetation and thus weakens their function [7].

Properly maintained riparian vegetation also plays an important role in improving flow rates in the event of floods. The effectiveness of grass-herbaceous vegetation in mitigating the negative impacts during the flood is high; the trees and shrubs have smaller effectiveness. The vegetation is divided into areas of natural streamflow with the altered species composition and the vegetation of the regulated streamflow with the proposed species composition. The basic functions of vegetation are divided into hydrological and water management (protection of the waterside from erosion, protection of water from pollution, slowing of flow, etc.); biological and ecological (water level shielding, biodiversity, animal refuge for animals, bio-corridors, etc.) and economic function with a secondary interest (mining of riparian vegetation).

Ivan et al. [8, 9] assess the quality of the aquatic habitat based on bioindications, including the riparian vegetation. Timothy et al. [10] investigated forest riparian ecosystems and wood residues from the riparian vegetation accumulated in the channel and their impact on the morphology of the flow, including the stability of the channel. They have demonstrated that individual trees without vegetation bordering the banks have a significant function in the formation of morphology of the channel and its ground plan, where the tree's pitch and vegetation density are relevant.

The importance of the connection of the river – river bank – riparian vegetation has been highlighted by many authors [11, 12, 13, 14, 15]. The problem of root systems of riparian vegetation in relation to river banks stability has been dealt by Abernethy and Rutherfurd [16].

2. Materials and methods

2.1. Characteristics of Slatina River and Drietomica River

The choice of streams was focused on smaller flows of submountain and mountain character, which have a high rate of preserved natural riparian vegetation and their ecological value is significant. The main factors of the choice of these flows were also the hydromorphological changes and various degrees of anthropogenic influence. Two submountain streams were selected: Drietomica River located in the Váh River basin, and Slatina River that is in the Hron River basin (Figure 1); they have been topographically measured in the years 2016 and 2017. Slatina is a river in central Slovakia that runs through the districts of Detva and Zvolen. It is 55.2 km long and the catchment area is 793 km^2. It has the character of a submountain river with a specific morphology of the river bed. It is one of the last naturally meandering streams in Slovakia and together with the riparian vegetation it represents a biocorridor of a regional importance. Drietomica is a river in the middle part of the Považie with the spring in the Czech Republic under the main ridge of the Lopenická Vrchovina in the Biele Karpaty at an altitude of about 520 m above sea level. It is the right tributary of the Váh River, with a length of 22.5 km (of which 13.5 km is in Slovakia and 9 km in Czech Republic) and the catchment area is 116 km^2. Stream section from the state border to the village of Drietoma is a protected area - Drietomica Nature Reserve. In the lower section of Drietomica River there is a sedimentation of cavities in the channel and bifurcation activity.

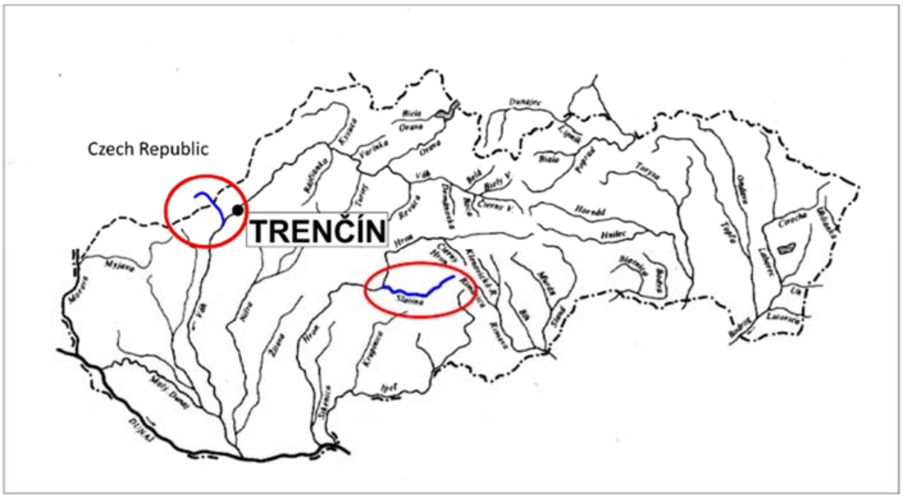

Figure 1. Map of Slovakia and localization of Drietomica River and Slatina River; source: www.kanoistika.sk

2.2. Hydromorphological survey

Slatina and Drietomica rivers were divided into 10 characteristic areas according to the morphological characteristics of the stream and riparian vegetation. The vegetation was recorded on both banks of the rivers in case that the width of the river did not exceed 50 m. These areas were characterized by the representative segments that are shown in Table 1 and Table 2.

Table 1. Representative sections for the Staltina River.

No.	Representative section	Localization of the section
1	Before the water reservoir Hriňová in the mountain area	RURAL AREAS
2	Hriňová – after the water reservoir Hriňová	URBAN AREAS
3	Hriňová village, after the tibutary Bystrô, close to fish path and bed drop	URBAN AREAS
4	Close to the Korytárky village	RURAL AREAS
5	Close to village Kriváň	RURAL AREAS
6	Detva	URBAN AREAS
7	Close to village Zvolenská Slatina (reference stream)	RURAL AREAS
8	Village Slatinka – post-flood condition (reference stream)	URBAN AREAS
9	Close to villageVígľaš - near the bridge	RURAL AREAS
10	In the village Vígľaš - near the railway track	URBAN AREAS

Table 2. Representative sections for the Drietomica River.

No.	Representative section	Localization of the section
1	Spring area - North of the village Vyškovec	RURAL AREAS
2	Restoration section in the village Vápenice	URBAN AREAS
3	Section in the village Rovné (connection to the pond)	URBAN AREAS
4	Slovak rep. – Czech rep.- Border on the Sloavk side	RURAL AREAS
5	Reference section for shelters, behind the village Drietoma; above the bridge	RURAL AREAS
6	Section behind the village Drietoma; below the bridge	RURAL AREAS
7	Regulated section in the centre of Drietoma village	URBAN AREAS
8	Regulated section near Drietoma; above the bridge	URBAN AREAS
9	Section near Drietoma, below the bridge	URBAN AREAS
10	Regulated section in the Kostolné-Záriečie; before mouth to the Váh River	URBAN AREAS

2.3. Methodology QBR

QBR ("Qualitat del Bosc de Ribera") is a simple method for assessing the quality of riparian forest habitat (accompanying and riparian flow vegetation). The QBR index was designed and developed for use on the Mediterranean flows in Spain. It can also be useful as a tool for defining "very good ecological status" for the needs of the EC Water Framework Directive. The QBR index is based on four components of riparian habitats: the total occurrence of accompanying and riparian vegetation, its quality, structure, and record of changes in the flow. It also considers the differences in flow geomorphology. The classification scale for the QBR method is in Table 3. The QBR index is expected to be suitable for use in mild and semi-dry geographical areas without any changes in the assessment. Taxonomical knowledge is not necessary, the knowledge of local plants is sufficient, and it is necessary to distinguish between native and introduced species [17, 18].

Table 3. Classification scale of QBR for the assessment of the quality of the riparian and bank vegetation of the flow (excellent quality – vegetation close to nature, good quality of vegetation – slight damage, average quality – damage of vegetation is significant, slightly degraded vegetation – very poor quality and function, extreme degradation - vegetation of very low quality) [17].

Riparian habitat quality class.	QBR	Colour
Riparian habitat in natural condition	>=95	blue
Small disturbance of vegetation, good quality	75-90	Green
Slightly disturbed vegetation, average quality	55-70	Yellow
Damaged vegetation, bad quality	30-50	Orange
Extreme degradation, very bad quality	<=25	red

2.4. Methodology RCE
The Riparian, Channel and Environmental Inventory (RCE) method is used for assessing the physical and biological condition and the quality of small flows in the lowland, valley and farmland. The form contains of 16 circuits that define the quality of riparian and aquatic vegetation, the morphology of the river and river banks, the way of using the landscape in the vicinity of the flow and its biological condition [19]. The biological condition is aimed at assessing the condition of ichthyofauna and macrozoobenthos as well as the state of non-living organic material. There are several methods of sampling of macrozoobenthos in the field. We chose a method for collecting the data on smaller streams called "kick /sweep sampling method" using a triangular landing net with a stitch size of 1 mm.

2.5. Methodology BEHI
This is a method of determining the degree of threat of water banks by "Bank Erosion Hazard Index" – BEHI. The method was compile by Rosgen [20, 21] and it is based on the quantification of the degree of soil threat by erosion on the banks of rivers. The method was verified and used by several authors in their work: [22, 23, 24, 25].

2.6. Methodology HMS
HMS (Habitat Modification Score, a tool of River Habitat Survey - RHS) is a methodology for assessing the habitat changes made by human being and evaluating the physical state of the flow. It is a partial tool of the RHS methodology and can be used without changes and needs of RHS database data. River Habitat Survey is a method developed and used since 1994 in England and in other EU countries. It is used to evaluate hydromorphological characteristics of flowing waters.

2.7. Methodology RGA
RGA (Rapid Geomorphic Assessments) is a methodology for assessing the stability and sensitivity of flow in relation to sedimentation processes in the flow. It was created in America [26].

3. Results

3.1. Methodology QBR
According to QBR methodology the average quality score of the habitat of accompanying and riparian vegetation for ten representative sections of the Drietomica River equals 60 (Table 4), which means it is an average quality and mild disturbance. The result of the average score does not have a real verifiable value, because the Drietomica River has some sections with extremely degraded accompanying and riparian vegetation as well as sections of high quality vegetation that are close to natural one. Extreme degradation of vegetation can be found on regulated sections in the village of Drietoma (D7, D8) and in the village of Kostolná - Záriečie (D10), where there is no bush and tree vegetation and the banks are fortified with stones or grass. The best valuation of accompanying and riparian vegetation is achieved in sections in rural areas (D1, D4, D5 and D6), where the composition is related to natural vegetation in terms of phytogeographical fragmentation of Slovak Republic.

Table 4. Evaluation of the QBR score for 10 representative sections on the Drietomica River.

Riparian habitat quality class.	QBR	Colour	Section number	Sum
Riparian habitat in natural condition	>=95	blue	1,4,5,6	4
Small disturbance of vegetation, good quality	75-90	Green	9	1
Slightly disturbed vegetation, average quality	55-70	Yellow	-	-
Damaged vegetation, bad quality	30-50	Orange	2,3	2
Extreme degradation, very bad quality	<=25	red	7,8,10	3
Average value				Average quality

The average quality of the habitat of riparian and accompanying vegetation (Table 5) for ten representative sections of the Slatina river was affected mainly by:

- The presence of waste in the vicinity of the flow (municipal waste, construction rubble, landfills),
- deaf places without growing stands,
- mowing of lawns banks,
- presence of interfering objects and infrastructure near the flow (cooperatives, arable land, railroad),
- low number of domestic plant species and their quality and quantity,
- longer flow segments with no shadows,
- regulated flow sections in the urban areas.

The results of the QBR methodology for the Slatina River are in table 5.

Table 5. Evaluation of the QBR score for 10 representative sections on the Slatina River.

Riparian habitat quality class.	QBR	Colour	Section number	Sum
Riparian habitat in natural condition	>=95	blue	-	-
Small disturbance of vegetation, good quality	75-90	Green	1,5,7	3
Slightly disturbed vegetation, average quality	55-70	Yellow	6,8	2
Damaged vegetation, bad quality	30-50	Orange	3,4,9,10	4
Extreme degradation, very bad quality	<=25	red	2	1
Average value				Average quality

3.2. Methodology RCE

The assessment of the physical and biological condition and the quality of small flows shows a very good score for five representative sections of Drietomica River; average score for the Drietomica River is also very good. The evaluation for Slatina River shows an average value for seven representative sections and a very good value for three sections. Regarding the morphology of the riverbed, there is mainly the negative influence of regulated straightened sections (especially in urban areas communities) and artificial interventions such as the construction of bridges, the presence of infrastructure and objects in the protection zone of the flow. The biological condition is in excellent or very good condition. This confirms the character of macrozoobenthos in all ten representative sections, but also the quantitative and qualitative characteristics of ichthyofauna on the reference sections of Drietomica River in the urban areas and rural areas [27, 28].

3.3. Methodology BEHI

Using the BEHI methodology the susceptibility to erosion has been evaluated as very low or medium throughout the Drietomica River; Drietomica is predominantly a river with a low erosion-sensitivity. Similarly, for the whole Slatina River the susceptibility to erosion was evaluated as very low to medium. The results are influenced by the flood activity, which left the sections more eroded. This factor has also influenced the quality of the habitat of the accompanying vegetation.

3.4. Methodology HMS

There are significant morphological changes across the Drietomica River. The unmodified nature, close to the natural one, is predominant, especially in the spring area (sections D1, D2 and D3) and in the protected landscape area of Drietomica (sections D4, D5 and D6). According to the HMS methodology, the sections D7, D8 and D9 are partially or majority modified. In spite of hard regulations from the past, the flow has adapted in an artificially channel and creates meanders (high grass islands) and rapids areas. The physical state can be characterized as semi-natural (near nature) for most sections of Slatina River. The reason for occurrence of lower scores is mainly the presence of infrastructure (especially bridges) in some sections.

3.5. Methodology RGA

The Drietomica and Slatina Rivers can be characterized as stable to moderately stable rivers. The reason for such a situation can be found mainly in the diversity of morphology of the channel, the presence of river regulation and interventions in the immediate vicinity of the channel as well as in wider contexts, which also result in extreme floods.

Figures 2 and 3 show the results of the QBR, RCE, BEHI and HMS indexing method for the representative sections of Drietomica and Slatina rivers represented by the given color scale: blue - very good condition (close to natural one), green - good condition, yellow – average condition, orange - bad condition and red - very bad condition).

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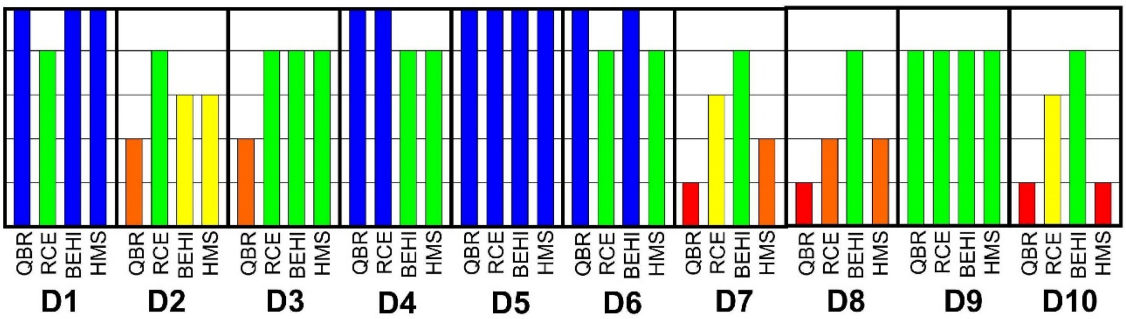

Figure 2. Evaluation of the QBR, RCE, BEHI and HMS methodologies for the Drietomice River sections (Rural areas - D1, D4, D5, D6, Urban areas - D2, D3, D7, D8, D9, D10).

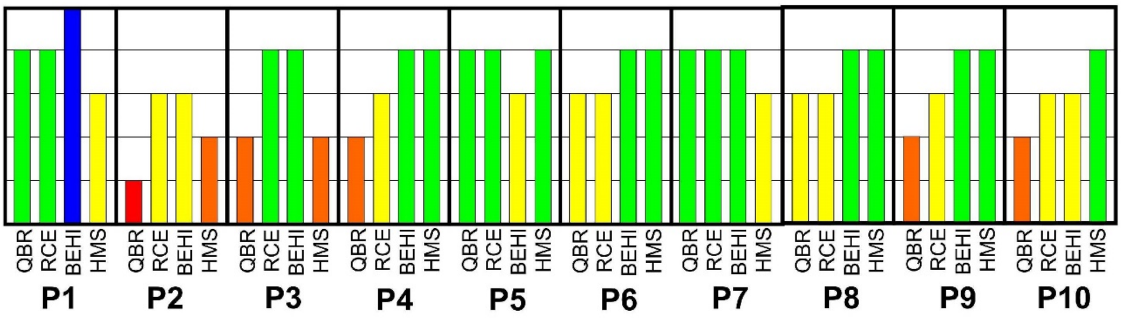

Figure 3. Evaluation of the QBR, RCE, BEHI and HMS methodologies for the Slatina River sections (Rural areas – P1, P4, P5, P7, P9, Urban areas – P2, P3, P6, P8, P10).

In addition to these methodologies, Drietomica River was monitored in detail from the year 1995 until present, at four reference sections. Two of them represent a modified flow area and are located only at the lower part of the river in the Drietomica village. The remaining two represent the natural section of the flow. The qualitative characteristics of the flow, macrozoobenthos, ichthyofauna and the morphological changes of the flow were monitored. These results were evaluated and modeled and more detailed research results can be found in Macura et al. [28, 29].

4. Conclusion

Riparian vegetation is an important stabilizing element in the planning of restoration measures in the catchment area. The article provides a summary document of the analysis of morphological processes in the flow, conditions and parameters for the assessment, including the assessment of the riparian and accompanying flow vegetation. The use of hydromorphological indexing methodologies for different flow characteristics makes the process of assessment the state of flow for the decision-making process of restoration measures or for the definition of significantly altered water bodies faster.

These methodologies identify the extremes concerning the riparian and accompanying vegetation reliably. These extremes significantly affect the overall qualitative flow characteristics and should be the subject of restoration measures. As expected, the qualitative assessment and the quantity of the riparian vegetation was on average better in the rural areas than in the urban areas. Last year floods were most signalized at the current deteriorated state of river banks and riparian vegetation of the Slatina River compared to the state in the past years. Also, anthropogenic interventions do not degrade the flow quality only in urban areas but also in rural areas, so the attention to the vegetation of the whole stream is justified. These methods are less time-consuming so it allows data to be renewed after an occurrence of a more pronounced events, such as floods, but also more pronounced anthropogenic impacts. The importance of the problematic is growing from a number of perspectives; as riparian vegetation represents a valuable ecostabilizing element with multiple functions. Riparian vegetation care is provided by current legislation at national and transnational level, regarding the adopted European strategic targets and documents.

Acknowledgment

This study has been jointly supported by the Slovak Research and Development Agency under Contract No. APVV-16-0253; and by the Scientific Grant Agency under Contract No. VEGA 1/0625/15.

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