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Design of Restoration of Regulated Rivers Based on Bioindication

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Abstract

Streambeds of rivers and brooks should form the dominant features in the urbanized areas. However, the current river regulations were unilaterally focused on flood protection and riverbeds have generally the character of prismatic channel. This solution inhibits the aesthetic function of the watercourses and has the negative impacts on instream biota. Based on the results of the research that was carried out on the mountain streams of Slovakia the authors introduce the implementation of river restorations that maintain the flood protection of the area while retaining the landscaping features of the stream. The paper describes the procedure for restoring the regulated streams based on bioindication and documents the quality of aquatic habitat of regulated and natural streams in particular examples.

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Keywords: river restoration; bioindication; morphology of river channels; instream habitat; quality;

1. Introduction

Every form of water in nature is irreplaceable, but humans in urbanized areas most intensively perceive the environment of watercourses that form the frame of the landscape structure. It can be said that the water streams represent the dominant features of the urban space. Besides the aesthetic features, additional functions of watercourses are important, such as urban function, creation of the relaxation areas in the park arrangements but also the function of ecosystem of aquatic habitat [6]. Water and care for it may be regarded as evaluating criterion for the development of the country.

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Natural development of watercourses and the development of civilization are in contrast, for an area that is flooded (inundation area) can be regarded as inappropriate for habitation, or building any constructions. However, historical development of mankind has been associated with the river and building in the inundation areas [2]. Most of the settlements and cities are built near watercourses, what requires costly engineering measures to protect them against floods, which in turn causes destabilization of river activity [1]. River regulation measures oriented towards flood protection excluded inundation areas from flow profile. The flow was concentrated into the area between levees, thereby increasing the water flow velocity. This effect resulted in intensive bed erosion, which can be regarded as critical at multiple streams in Slovakia. This phenomenon can be documented on a number of objects, especially on the bridges where bed erosion threatens the stability of bridge piers [4].

Erosion activity of the flow has a particularly negative effect on the stability of slopes. Therefore, the feet of the slopes are usually additionally fortified by rip-rap. While flexibly responding to changes in vertical alignment of the riverbed, the rip-rap also negatively affects the instream biota, because it eliminates the variability of channel complexity. Effective method of restoration must be based on an assessment of the current state of watercourses and their adaptation to the changed conditions. This erudite method also requires increased attention of all stakeholders and is required by the Water Framework Directive 2000/60/EC [7] establishing a framework for Community action in the field of water policy.

2. Material and methods

When evaluating the hydroecological quality of watercourses, the authors focused on the assessment of the habitat quality in the summer period of minimum flows, which is the most stress phase for the stream biota. The Riverine Habitat Simulation System (RHABSIM) [5] was used for evaluation. It is an interdisciplinary decision-making system, which is based on the recognition that most fish species prefer certain combinations of water depths, flow velocities, water temperature and bottom material. If these values for fish species in the affected reach are known, it is possible to determine the prognosis for influence of any changes in abiotic factors on the biological environment of the stream.

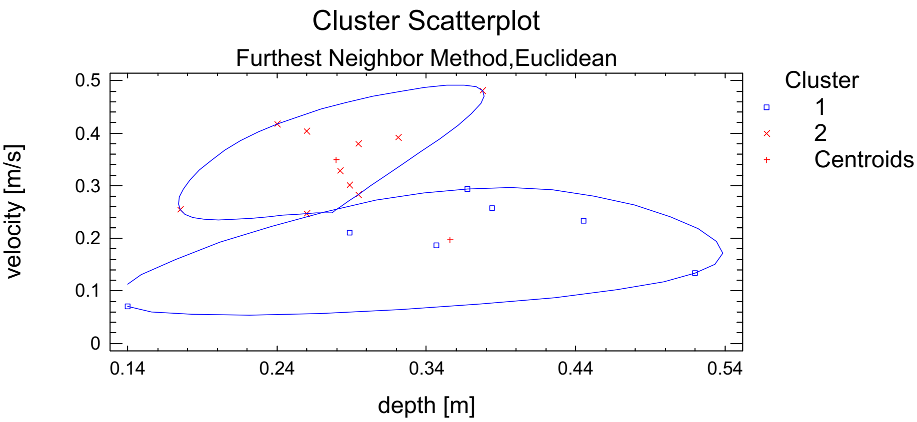

Fig. 1. Cluster scatterplot of the habitat preferences by brown trout.

In our study, two types of the flow environment were compared: natural streams and regulated reaches. Nine streams were selected in the basin of the river Váh, where ichthyological survey, topographic and hydrometric measurements were implemented, focused on the preferences of ichthyofauna. Selection of a suitable representative fish species was an important factor. The brown trout (*Salmo trutta m. fario*) was selected, for it occurred in all monitored rivers and was the most numerously represented. The cluster analysis along with other multivariate statistical methods was used to define the relationship between preferences of the brown trout and habitat parameters in the natural and regulated reaches. Electrofishing was used for the ichthyological survey. Water depths and flow velocities were measured in localities of capture of each particular individual. Thus the statistic file was obtained that has been subjected to cluster analysis. To verify the results of this analysis a file has been divided into two clusters – natural streams and regulated reaches. Data on water depth, flow velocity and number of individual species were used as variables. Two clusters were formed (Fig. 1) that are almost exactly identical to the original distribution of the file on natural streams and regulated reaches.

The above results indicate that brown trout is a sensitive bioindicator for the morphological changes in the river channel. It can therefore be assumed that the habitat quality modelling using the brown trout as a bioindicator will reliably represent the changes in the river morphology induced by river training measures.

2.1. Example of the quality assessment of the Myjava River

Using the example of the Myjava River in the village of Turá Lúka it can be documented the impact of the morphological changes caused by the river training on the quality of an aquatic habitat that have been indicated by brown trout. There are significantly smaller water depths in the flat riverbed after river regulation than the pools and shelters of natural streams. Also, the flow velocities in the regulated stream are lower than the ones in the riffle areas of the natural reach. Small water depths create favourable conditions for development of the algal biomass resulting in eutrophication, which is often accompanied by distinctive odour. During small water discharges accompanied by large quantities of algae there are known cases of death loss of fish due to a lack of oxygen.

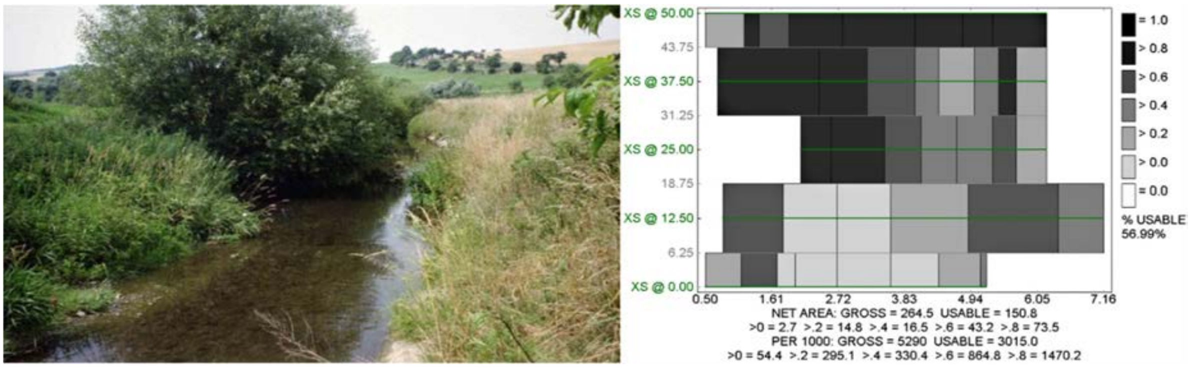

Fig. 2. Natural reach of the Myjava River and evaluation of the environmental quality (vertical axis is the stream chainage, horizontal axis is the width of the channel). A value of 0 (light colour) is the worst level of environmental quality, 1 (black) is the highest environmental quality.

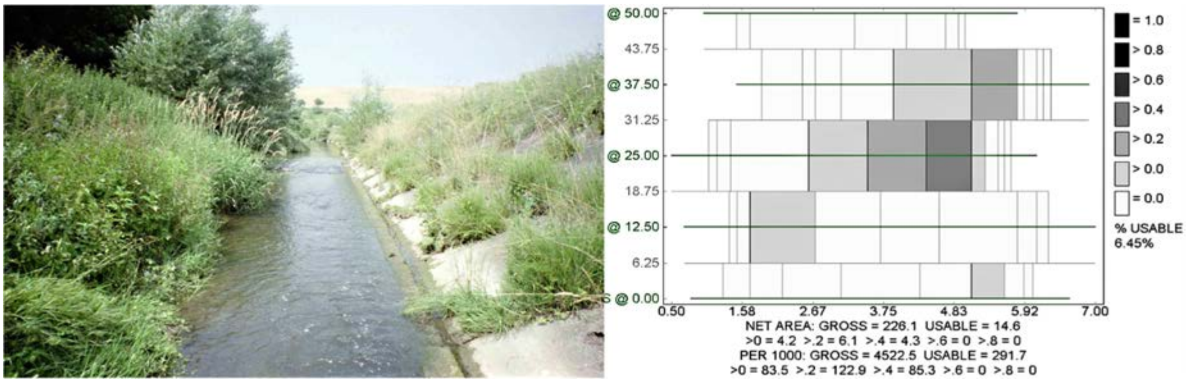

Fig. 3. Regulated reach of the Myjava River and evaluation of environmental quality (vertical axis is the stream chainage, horizontal axis is the width of the channel). A value of 0 (light colour) is the worst level of environmental quality, 1 (black) is the highest environmental quality.

Another danger from low flows arrives in winter, when water in the flat riverbed freezes. This kind of stream has a negative impact on urbanized areas and requires acute restoration based on the harmony relationships of the natural flow. Figures 2 and 3 show the regulated and natural reference reaches of the Myjava River divided into cells by RHABSIM. The quality of the environment in individual cells is evaluated from 0 to 1 (0 - the lowest environmental quality - light cells; 1 - the highest environmental quality – black cells). From a comparison of the images it can be stated that the natural reach produces a significantly better environment than the regulated channel.

3. Results and Discussion

River regulation produces monotonous morphology of the river channel, which does not provide suitable habitat for instream biota. River restoration should therefore be focused primarily on supporting the complexity of the channel [3]. Design of the elements forming the variable morphology of the channel should be derived from the results of modelling the quality of an aquatic habitat, as shown in the example of the Myjava River.

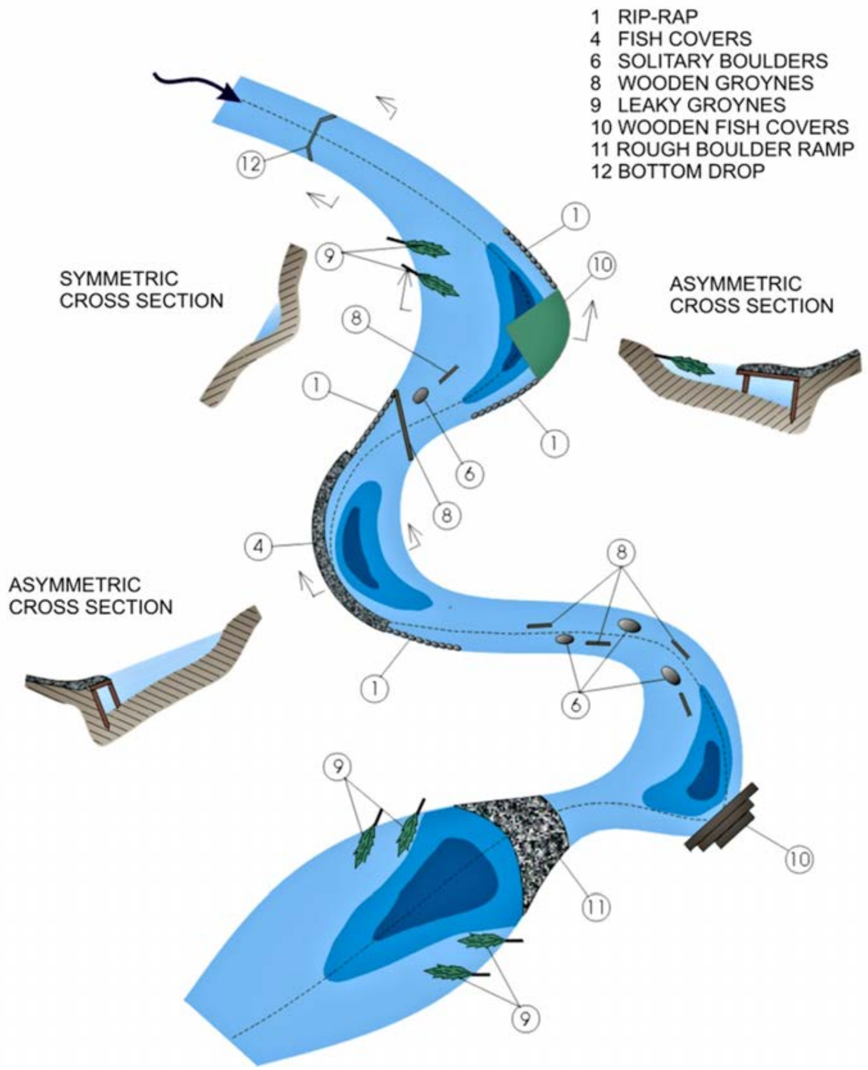

Fig. 4. Schematic example of a restored stream.

Restoration measures are of a major importance in the period of minimum flows, as is apparent from the definition of river restoration - using the kinetic energy of the stream to support the complexity of the channel. Design of the channel complexity does not have to become monotonous; therefore, it is necessary to use a wider range of technical elements that support the diversity of the riverbed, creating a harmonious complex of shaded and unshaded areas. The outer appearance of the stream should remind a natural state with inconsistent bank lines and significant differences in fords and riffle reaches. A schematic example of the setup of a restored stream is shown in Fig. 4.

4. Conclusions

Every natural bed of the watercourse, as a unique unrepeatable individuality in the landscape area requires an individual approach to the design of its restoration. Some schematization in past river regulation projects allows for outlining the certain types of approaches to address the restoration of watercourses. Unilateral solutions in sensitive areas of rivers always bring negative response. Therefore, a knowledgeable and sensitive approach in river training and improving is required. It is important to emphasize that the configuration of the urban areas in Slovakia requires intensive care of regulated streams. Morphology of the landscape and characteristic settlements near watercourses do not provide any other alternative of effective flood protection and use of the stream for the improvement of the urban areas.

Acknowledgements

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