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Habitat structure changes of the Wisłoka river as a result of channel restoration

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ABSTRACT

The economic use of rivers in many cases has led to the degradation of their beds, the interruption of ecological continuity, and its defragmentation. The action opposite to the above-described process is restoration. Rarely in Poland, we can analyze the effect of restoration activities in the mountain riverbed.

On the studied sections of the Wisłoka river, restoration activities were carried out as a result of which, it is assumed that the habitats of the lithophyll fish species will be restored and anadromous fish such as salmon, trout, zarte, and sturgeon will potentially be spawning. The diversity of habitat conditions in the riverbed was obtained by laying oversized boulders, supplementing the bottom substrate washed out in the process of bed erosion, and forcing the change of the horizontal river system. Because a monitoring is crucial point in a restoration process after completion of the channel restoration, the hydraulic habitat conditions of ichthyofauna were assessed in the areas of habitats created on the basis of the hydromorphological assessment of river quality for the Wisłoka river from the weir in Mokrzyce to Pustków one year after reconstruction of the bed.

The Wisłoka river is a right-bank tributary of the Vistula river with a length of approximately 164 km and a catchment area of over 4.1 thousand km^2. The section covered by the study, from the weir in Mokrziec to Pustków, has a length of about 30 km (km 43 ÷ 73). In this section, ten locations for restoration were selected and one reference section. Wisłoka's sandy-gravel bottom decreased in the second half of the 20th century to the 1990s at a rate of 5–9 cm/year. Restoration involving diversification of water flow conditions was achieved by placing boulders, depositing bed material in the river channel, and forcing the change of the horizontal river system through controlled lateral erosion of the banks. The impact of individual boulders on the bottom and the streamlines is increased by grouping them together, and several variants are used: openwork arrangement over the entire width of the trough, grouped arrangement of boulders differentiates local flow conditions, and openwork cluster directs the mainstream line and generates conditions for creating the bends. The hydromorphological valorization of the river was made by identifying hydromorphological units in the channel and carrying out hydromorphological assessment of the sections. Identification of hydromorphological units before and after restoration was made on the basis of the types identified in the Mesohabitat Evaluation Model.

As a result of the restoration process, the differentiation of water flow conditions, gravelbars movement, and the change of the horizontal layout of the river were obtained. Changes in the riverbed resulted in the diversification of the distribution of habitats. Often, the homogeneous riverbed turned into a system of various habitat types that change with the flow. In many sections, the part of individual habitat types in the total surface area of the riverbed has changed. Prior to restoration, the distribution of habitats on all sections was on average as follows: riffie – 0.2% of the water area at decade, fast run –7.4%, run – 55.6%, shallow water – 25.0%, and backwater – 11.9%. The structure of habitats completely lacked structures described as pool. After restoration, all types are represented in the habitat structure and on average are as follows: riffie –0.8% of the water area, fast run –18.1%, run –33.2%, pool –23.5%, shallow water – 13.9%, and backwater –10.5%. There is a noticeable decrease in the contribution of low energy

habitats (i.e. shallow water and backwater) from 36.9% to 24.4%, increase in areas with fast flow from 9.6% to 18.9% and the appearance of areas with medium energy (pool). Fig. 1 shows the spatial distribution of habitats on the tenth section of the Wisłoka river as an example of changes on all ten sections covered by restoration activities. There was a large diversity of habitat distribution: the dominant normal flow - run was partly replaced with shallow water, and pool behind the boulders. The presence of the deflector caused the formation of a backwater directly behind the deflector and concentrated the flow in the right part of the channel, where the fast run dominates.

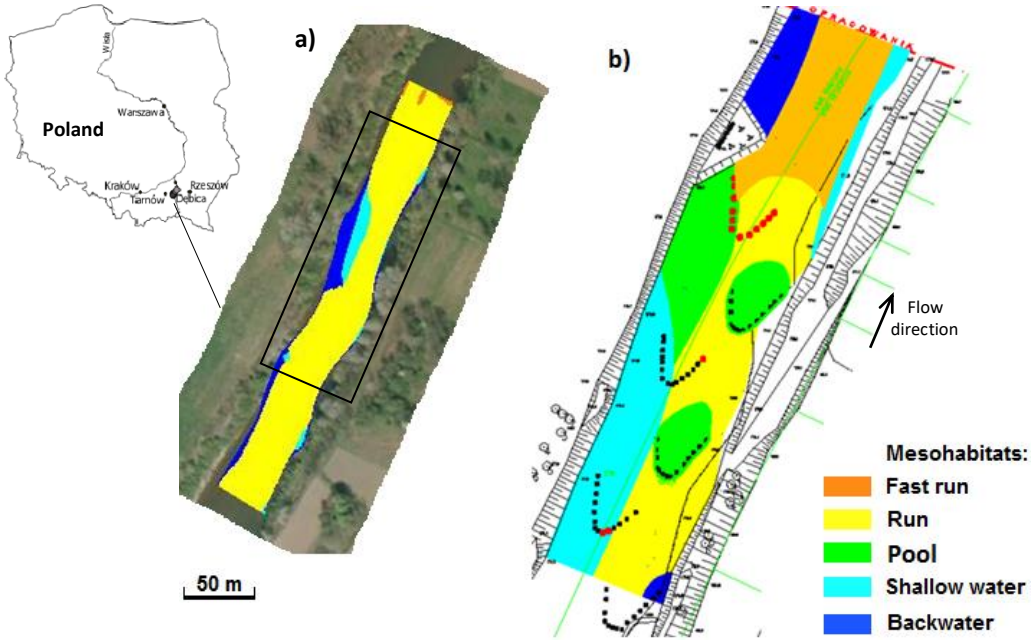

Fig. 1 Mesohabitats structure in the section number 10 of the Wisłoka river; a) before restoration, the 2D model for discharge Q=7.95 m^3s^{-1}, b) after restoration, discharge Q=13.6 m^3s^{-1}; black and red symbols - restoration design

After completing the work, the structure of hydromorphological units has been changed by diversifying the spatial velocity distribution, caused by the breakdown of the high-velocity zone into smaller areas, between them the pool and backwater units were created. This can also be seen in a better assessment of parameters describing the condition of the main channel.

Restoration did not include changes of bank protection. Within the channel, restoration activities improved the morphological quality of the channel but did not cause a significant change of the all river valley. The assessment of naturalness includes ten categories of features, six of which concern the main channel and the remaining flood plains. Since the restoration covered only the main channel, the changes in the hydromorphological quality are the highest in locations 06, 07, and 08 – the quality decreased by approximately 0.9 points, which translates to an increase in the grade by one class. In seven locations increased their channel grade by one class. The average assessment of the main channel in 2011 was 3.02, and in 2014 was 2.60 (with flood terraces 3.25 and 3.00, respectively).

As a result of restoration, the channel hydromorphological quality in the studied sections have been improved. Changes in the riverbed caused by the depositing of gravel, the arrangement of individual boulders and clusters, and the construction of the deflector have caused a diversification of the distribution of habitats. The homogeneous channel in sections 02, 03, 07, 09, and 10 has evolved into a system of various habitat types. The presence of different hydromorphic units help an increase the number of species and amount of fish individuals. Restitution of biodiversity depends on physical habitats variability as well as support the restoration of the ecological continuity of the Wisłoka river for fish and other organisms. An interdisciplinary approach will allow a full assessment of the effects of restoration in the future.