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Evaluation of the hydro-ecological quality of the aquatic habitat of the Váh River

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Abstract

There is a cascade of hydroelectric power plants built on the Váh River. From a water-management point of view, the natural channel is used to drain extreme discharges. During most of the year, discharges are regulated by water-management structures. These discharges are not used for energy-related purposes; therefore, it is important to determine the optimal discharge that will not negatively affect the ecosystem of the stream. The minimum balance discharge (hydro-ecological discharge) was determined based on the instream flow incremental methodology (IFIM) using the riverine habitat simulation system (RHABSIM). Input data were obtained from direct measurements on three reference reaches in the area between the cities Piešťany and Nové Mesto nad Váhom. Hydraulic flow characteristics were derived from three measurements at different water levels. Habitat quality was represented by ichthyofauna. Data to determine the habitat suitability curves of fish were obtained using a diving technique to collect video footage. The modelling resulted in the quantification of the effect of discharge on ichthyofauna as a bio-indicator of habitat quality, which implied the need of 20 $m^3 \cdot s^{-1}$ for a minimum balance discharge in summer.

Key words: *bioindication, habitat suitability curves, ichthyofauna, IFIM methodology, mountain streams*

INTRODUCTION

Understanding the influence of the anthropogenic effects on the structure of aquatic habitat within a stream remains one of the most neglected areas of research in the field of water management. Evaluation and assessment of the habitat quality is the necessary information for various water-management decisions and planning; for example, in determining minimum (hydro-ecological) discharge rates. Such evaluations were conducted on the lower section of the Váh River. There is a cascade of hydroelectric water-management structures built on the Váh River. From a water-management point of view, the natural channel is used to drain extreme discharge. During most of the year, discharges are regulated by the water-management structures. These discharges are not used for energy-related purposes; therefore, it is important to determine the optimal discharge that will not negatively affect the ecosystem of the stream. In particular, the goal of this study was the determination of the minimum discharge rate under the weir in Trenčianské Biskupice. The minimum balance discharge was determined based on the IFIM using the riverine habitat simulation model (RHABSIM) [PAYNE 1998]. Input data were obtained by direct measurement from three reference reaches in the area between Piešťany and Nové Mesto nad Váhom. Hydraulic flow characteristics were derived from three measurements at different water levels. Habitat quality was represented by ichthyofauna. Data for the determination of habitat suitability curves of fish were obtained using a diving technique to obtain video footage. The modelling resulted in the quantification of the effects of discharge on ichthyofauna as a bio-indicator of habitat quality, which implies the need for a minimum balance discharge in the summer. The results showed that the relationship between the fish population and the habitat characteristics reflected well the changes induced by the discharge and riverbed structure of the stream. The main advantage of the IFIM-based models is that they quantify biological changes in the stream, based on the discharge. The habitat suitability curves of the individual fish species represented evidence that they tended to dwell in similar habitat. Therefore, it was possible to use a cumulative suitability curve. The results of the minimum discharge rate simulations indicated an optimal water level interval suitable for the conservation of biota in the stream. Specifically, it is necessary to ensure the supply of water from the weir of Trenčianské Biskupice to the old channel of the Váh River with a discharge rate of 20 $m^3 \cdot s^{-1}$. Even at the discharge rate of 10 $m^3 \cdot s^{-1}$ there was no significant deterioration in the quality of the aquatic habitat. By increasing the discharge to above 20 $m^3 \cdot s^{-1}$, the velocity rates were higher, and the fish population could be washed away. This phenomenon occurred because the riverbed was not sufficiently rugged and did not provide enough hiding places for the fish. Therefore, it would be expedient to improve the quality of the aquatic habitat not only by increasing the discharge but by channel revitalisation to support its morphological structure.

Anthropogenic activity has altered the morphology but also the flow regime [MUÑOZ-MAS *et al*. 2016]. For example, the river regulation, significantly change the bed morphology, which has a negative effect on the habitat of the rivers. Regulated rivers changed the rugged morphology to monotone. This also affects the diversity of habitats in rivers. Natural habitat is formed by a suitable combination of flow velocity and water depth [BREWER *et al*. 2018; MAŽEIKA *et al*. 2006]. The construction of water reservoirs on the stream cause even more significant changes. The tanks radically change the entire spectrum of aquatic biota including the flow regime of the stream.

The results of the research show that the river regulation is most pronounced in mountain streams. Elimination of rugged morphology is mainly manifested at low flow rates. The depth of the water is low and there are no habitats in the river that would be suitable for ichthyofauna at low flow [MACURA *et al.* 2012]. Since fish are sensitive to morphological changes they are suitable bio-indicator [CHEEK, TAYLOR 2016; RONI *et al*. 2014]. They are also sensitive to changes in temperature and flow [AVERY-GOMM *et al*. 2014; COWX, WELCOMME 1998; SCHLOSSER 1990]. Because of their longevity, mobility, and sensitivity to biotope changes, they are suitable for assessing ecological river integrity [AARTS, NIENHUIS 2003; KEELEY *et al*. 2015; WELCOMME *et al*. 2006].

In mountain streams, the most appropriate bio-indicator is brown trout (*Salmo trutta* m. *fario*), which is of ecological and socioeconomic importance worldwide [CARLSON *et al*. 2016]. For research, it is also important, that *Salmo trutta* m. *fario* is planted in streams, thereby a higher abundance is maintained, which is favourable for the ichthyological research aimed at bio-indication of habitat quality. In the middle sections of the streams there is a greater range of fish species that are sensitive to morphological and hydrological changes. The aim of current research is to quantify the design characteristics of suitable habitats for river fillings [DÖLL, ZHANG 2010]. Taking into account this trend, the results in this study focus on the effect of objectification of the discharge from the Váh River under the weir in Trenčianske Biskupice.

The reach of interest of the Váh River was situated between the cities of Piešťany and Nové Mesto nad Váhom near the Horná Streda village under the highway bridge. It consisted of a regulated channel with a track composed of regular arches, between which there was a straight section. From the tracking point of view, this section can be characterised as an excellent example of a curved track created according to Fargue's thesis. From the habitat point of view, this section is relatively homogeneous. It contained primarily only two types of habitat, which were modelled by river activity. As a result of the velocity field transformation in the curved track from the convex to the concave bank, a characteristic triangular cross-sectional shape was formed. In the convex section of the profile, the water depth and flow velocity increased steadily. The concave part was characterised by a steep bank and higher velocity rates. The transition area between the curved sections could be called a current section from the perspective of the aquatic biota.

The topography of the reference reaches was characterised by cross-sections that were measured by levelling. In areas of greater water depth and flow velocity, topography was measured by a diver.

MATERIALS AND METHODS

GENERAL INFORMATION

The relationship between the physical and biological components of a stream represents a key aspect for assessing the quality of the aquatic habitat of a stream [CARNIE *et al*. 2016]. The models that are based on the instream flow incremental methodology (IFIM) [BOVEE *et al*. 1998] are suitable for such analysis. The basis of IFIM is the system of environmental flow analysis (SEFA), as well as a physical habitat simulation system (PHABSIM), that was developed in the United States. SEFA is used to analyse the relationship between the flow and the biotic environmental components; this relationship is a continuous flow function [LOPES *et al*. 2004]. The FIM methodology has traditionally been considered as a modern and objective method, despite the persistent criticism [ROSENFELD, PTOLEMY 2012]. This methodology is based on habitat preference by ichthyofauna [AYLLÓN *et al*. 2009]. IFIM can provide reliable assessments of river quality when sufficient data are available [CASPER *et al*. 2011].

The model contains data from the biotic and abiotic areas. The abiotic parameters are the width, depth and surface area of the channel, the velocity of the flow, and the hydraulic characteristics in relation to the flow and morphology of the channel. The biotic information is mainly represented by bio-indicators (fish) in the form of habitat suitability curves.

The summer period with minimum flows was selected as the project period due to the low water depth, limited shelter options and low oxygen content in heated water. The main purpose of this study was to design minimum flow rates. The paper presents a methodology of creating a habitat suitability curve, which is derived from ichthyological and hydrometric measurements. Understanding the impact of different parameters on the shape of the habitat suitability curve was necessary so that this information could be used for other similar discharges. A detailed description of the methodology of deriving suitability curves is peresented by the authors of this article in ŠTEFUNKOVÁ *et al*. [2018].

The process for developing the suitability curves involved the following steps:

– topographic measurements in the reference reaches;
– an ichthyological survey and hydrometric measurements;
– evaluation of the probability distribution functions and return period curves in the reference reaches of the streams;
– the evaluation of the effect of velocity and water depths on the suitability rating of habitat;
– the evaluation of the weighted usable area (WUA).

TOPOGRAPHIC AND HYDROMETRIC MEASUREMENT OF REFERENCE REACHES

At each reference reach, bed topography was measured, and the discharge rate was determined by hydrometric measurement. Stationary points were fixed for repeated measurements, from which it was possible to measure the water level regime at various stages to verify the hydraulic model. The measurements were conducted during the summer period when flow rates were low and air temperatures higher.

Discharge measurements were performed simultaneously with an ichthyological survey. Hydrometry was in accordance with ISO 748. At the beginning of the measurement, the appropriate cross-sections for hydrometry were selected. The riverbed of the measured cross-section was regular, without any large stones or other obstacles to the flow, as reported by HERSCHY [2008]. A set of three hydrometric propellers were placed on one rod and used to measure flow velocity. All hydrometric propellers were calibrated according to ISO 3455-1976.

ICHTHYOFAUNA OF THE REFERENCE REACH

The determination and evaluation of ichthyofauna in reference reaches was conducted under the guidance of Professor Ing. Ivan Straňaj, SUA Nitra.

Sampling was conducted using an electrofishing method on 11–12.07.2017 by a thyristor type of electric aggregate that is adapted for fishing in larger streams (2A, 100–300 V) with a choice of electrical parameters. The fishing anode was operated by a fishing crew consisting of 10 persons. The efficiency of the electrode was acceptable up to a depth of 0.5–1.5 m. With increasing depth and water current strength, the efficiency decreased, and at depths below 1.5 m, the fishing became highly selective. The fish had a wide variety of escape locations at the bottom, and around the edge of the electric field.

The catch per unit of effort (CPUE) was defined as the catch in the number of fish and kilograms, calculated per 1 ha of area and 1 hour of electrofishing, using one electric aggregate with one fishing electrode. Simultaneously, the data were used to determine the abundance and weight of the species caught for each site, using the CPUE.

HABITAT SUITABILITY CURVES

Habitat suitability curves, as the basic biotic input to the model, are a graphical representation of the preference of the major abiotic components of the microhabitat (velocity rate, water depth, and shelters). There were several field measurement methodologies aimed at determining habitat suitability curves. However, the size of the flow significantly complicated this task. For the size of the selected flow, the method of electric aggregation proved to be unsuitable; therefore, a methodology using video recordings of the aquatic area using a diving technique was developed for the first time. According to the so-called Method B [THOMAS, BOVEE 1993], individual fish and habitat parameters were identified. Field measurements were mostly conducted by a team of divers to identify each site where individual fish were located. Abiotic factors of habitat (water depth, flow velocity, type of shelter, type of substrate) were measured at all sites after the ichthyological observations were conducted. These results were subsequently combined and suitability curves were determined. The main problem with the methodology based on the photography of the aquatic area of flow was the difficult localisation of the image. Each location of fish habitat needed basic hydraulic data. Therefore, the derivation of habitat suitability curves was verified from the video recording of the stationary camera (the camera was fixed at a location at the bottom of the flow for 20–30 min). Verification measurements showed that this methodology had several advantages:

– fish were not affected by a moving diver;
– the position of the stationary camera was precisely defined as a point of a cross-section profile; determination of the hydraulic characteristics was therefore significantly easier.

The disadvantage of this method was, in particular, the very limited possibility of identifying the fish species (visibility conditions in 2017 were not ideal). This disadvantage was not decisive in the selected river, because the distinctly dominant species were the barbell (*Barbus barbus*), chub (*Leuciscus cephalus*), and common nase (*Chondrostoma nasus*). Because the *Chondrostoma nasus* occurred only in the natural reach, only two suitability curves for the dominant species (*Barbus barbus* and *Leuciscus cephalus*) were determined. Habitat suitability curves for velocity (Fig. 1) and habitat suitability curves for depth (Fig. 2) are shown in the chapter "Habitat suitability curves".

RESULTS AND DISCUSSION

ABUNDANCE AND ICHTHYOMASS

Tabulated data on fish abundance and ichthyomass in the monitored reaches are presented in Table 1. The high-

Table 1. Abundance, ichthyomass, and average weight on the reference reaches of the River Váh

Parameter	Fish species																
	brown trout (*Salmo trutta m. fario*)	barbel (*Barbus barbus*)	common bream (*Ambramis brama*)	Schneider (*Alburnoides bipunctatus*)	common bream (*Abramis brama*)	common bleak (*Alburnus alburnus*)	chub (*Leuciscus cephalus*)	common dace (*Leuciscus leuciscus*)	gudgeon (*Gobio gobio*)	common nase (*Chondrostoma nasus*)	vimba bream (*Vimba vimba*)	roach (*Rutilus rutilus*)	stone loach (*Barbatula barbatula*)	pike (*Esoxlucius*)	european perch (*Perca fluviatilis*)	common minnow (*Phoxinus phoxinus*)	sum
No. 1: Váh – regulated reach																	
Abundance (pcs)	6.00	347.0	4.0	0.0	1.0	81.0	143.0	2.0	80.0	0.0	10.0	20.0	0.0	0.0	7.0	90.0	791.0
Biomass (kg)	1.09	20.5	1.5	0.0	1.1	2.5	21.9	0.2	1.5	0.0	0.4	2.6	0.0	0.0	0.8	0.2	54.1
CPUE ($pcs \cdot ha^{-1} \cdot h^{-1}$)	17.15	991.8	11.4	0.0	2.9	231.5	408.7	5.7	228.7	0.0	28.6	57.2	0.0	0.0	20.0	257.3	2260.9
CPUE ($kg \cdot ha^{-1} \cdot h^{-1}$)	3.12	58.7	4.2	0.0	3.0	7.1	62.6	0.5	4.2	0.0	1.0	7.3	0.0	0.0	2.3	0.6	154.7
Average weight (g)	182.00	59.2	369.8	0.0	1050.0	30.5	153.3	80.0	18.3	0.0	35.0	128.2	0.0	0.0	117.1	2.5	68.4
No. 2: Váh – natural reach																	
Abundance (pcs)	1.00	138.0	0.0	7.0	0.0	48.0	52.0	1.0	12.0	45.0	0.0	0.0	3.0	2.0	1.0	27.0	337.0
Biomass (kg)	0.19	132.5	0.0	0.2	0.0	1.1	28.7	0.0	0.1	49.8	0.0	0.0	0.0	0.0	0.0	0.1	212.7
CPUE ($pcs \cdot ha^{-1} \cdot h^{-1}$)	2.79	385.5	0.0	19.6	0.0	134.1	145.3	2.8	33.5	125.7	0.0	0.0	8.4	5.6	2.8	75.4	941.5
CPUE ($kg \cdot ha^{-1} \cdot h^{-1}$)	0.53	370.1	0.0	0.5	0.0	3.1	80.2	0.1	0.2	139.2	0.0	0.0	0.1	0.0	0.1	0.2	594.4
Average weight (g)	190.00	960.0	0.0	26.1	0.0	23.1	552.0	42.0	6.9	1107.0	0.0	0.0	6.0	3.5	31.0	3.0	631.3

Explanations: CPUE = catch per unit of effort.
Source: own study.

Table 2. Abundance and biomass of fish species in natural and regulated channels

Fish species	No. 1: Váh – regulated reach				No. 2: Váh – natural reach			
	abund.		biomass		abund.		biomass	
	%	C	%	C	%	C	%	C
Brown trout (*Salmo trutta* m. *fario*)	0.75	V	2.02	III	0.30	V	0.09	V
Golden loach (*Sabanejewia aurata*)	0.00		0.00		0.59	V	0.00	V
Common nase (*Chondrostoma nasus*)	0.00		0.00		13.35	I	23.42	I
Barbel (*Barbus barbus*)	43.86	I	37.94	I	40.95	I	62.27	I
Vimba bream (*Vimba vimba*)	1.26	IV	0.65	V	0.00		0.00	
Chub (*Leuciscus cephalus*)	18.07	I	40.49	I	15.43	I	13.49	I
Common dace (*Leuciscus leuciscus*)	0.25	V	0.30	V	0.30	V	0.02	V
Common bream (*Ambramis brama*)	0.51	V	2.73	III	0.00		0.00	
Common bleak (*Alburnus alburnus*)	10.24	I	4.56	III	14.24	I	0.52	V
Gudgeon (*Gobio gobio*)	10.11	I	2.71	III	3.56	III	0.04	V
Roach (*Rutilus rutilus*)	2.53	III	4.74	III	0.00		0.00	
Schneider (*Alburnoides bipunctatus*)	0.00		0.00		2.08	III	0.09	V
Stone loach (*Barbatula barbatula*)	0.00		0.00		0.89	V	0.01	V
European perch (*Perca fluviatilis*)	0.88	V	1.51	IV	0.30	V	0.01	V
Common carp *(Cyprinus carpio)*	0.13	V	1.94	IV	0.00		0.00	
Common minnow (*Phoxinus phoxinus*)	11.38	I	0.41	V	8.01	II	0.04	V

Explanations: abund. = domination in number, biomass = weight domination, C = class of domination; I = eudominant (>10%); II = dominant (5–10%); III = subdominant (2–5%); IV = recedent (1–2%), V = less than 1%.
Source: own study.

est count was identified in locality no. 1 (regulated reach), with 2261 fishes, compared to locality no. 2 (natural reach), with 942 pcs (CPUE). On the contrary, the highest biomass was identified for locality no. 2 (natural reach), with 594 kg (CPUE), compared to locality no. 1 (regulated reach), with 155 kg (CPUE). The biomass at location no. 2 was almost four times higher than that at location no. 1.

This session also coincided with an average weight of fish caught that was nine times greater in the natural reach (631.3 g) compared to that in the regulated reach (68.4 g). Furthermore, the average weight of the dominant species was much higher in the natural reach than in the regulated reach. For example, the average weight of *Barbus barbus* was 960 g in the natural reach and 59 g in the regulated reach, and the average weight of *Leuciscus cephalus* was 552 g in natural reach and 153.26 g in regulated reach.

It follows, that measurements that are focused on fish habitat preference are decisive for modelling the quality of aquatic habitat. The preference is determined based on a more detailed description of the location where the fish was caught. The water depth, flow velocity and site characteristics are measured at this location. The evaluated data are represented by suitability curves. Further data from the ichthyological survey given in chapter 3.5 and in Tables 1 and 2 represent the basic overview of the current state of ichthyofauna in the stream section. These data are important in assessing the development of ichthyofauna in the conditions of a change flow in the stream.

DOMINANT SPECIES

Table 2 shows the count and weight dominance of species found at the monitored sites, divided into relevant classes. The most significant abundance of species in the ichthyofauna of the natural reach of the Váh River was ranked as follows: *Barbus barbus*: 40.9% abundans 62.3% biomass, *Chondrostoma nasus*: 13.4% abundans 23.4% biomass, and *Leuciscus cephalus*: 15.4% abundans, 13.5% biomass. In the regulated reach, the dominant species include *Barbus barbus* (43.8% abundans, 37.9% biomass) and *Leuciscus cephalus* (18.1% abundans, 40.5% biomass). In both localities, common dace and European perch (*Perca fluviatilis*) were subrecedent species.

HABITAT SUITABILITY CURVES

According to the methodology described in the chapter "Materials and methods" ("Habitat suitability curves") the habitat suitability curves for velocity (Fig. 1) and habitat suitability curves for depth (Fig. 2) were conducted for two dominant species (*Barbus barbus* and *Leuciscus cephalus*).

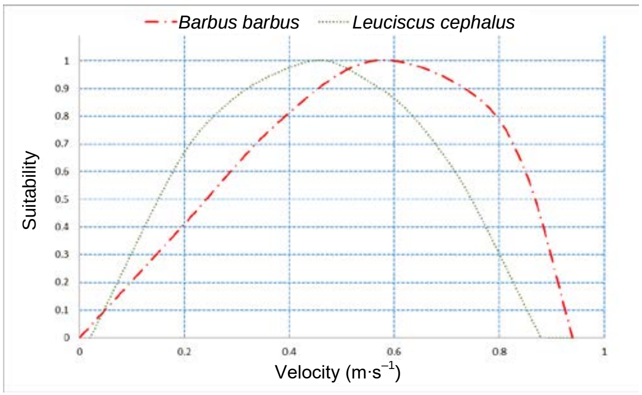

Fig. 1. Habitat suitability curves for individual fish species for the velocity rate of the Váh River in the city of Piešťany; source: own study

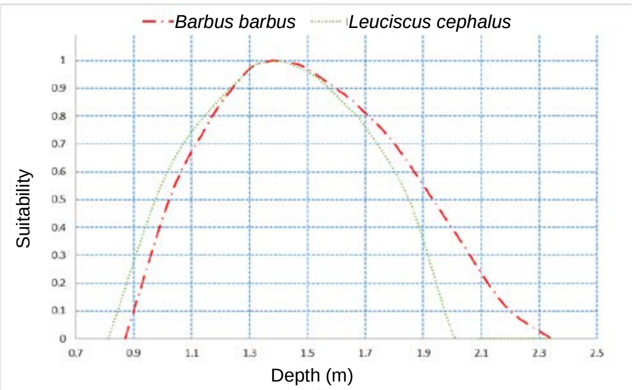

Fig. 2. Habitat suitability curves for individual fish species for depth of the Váh River in the city of Piešťany; source: own study

WEIGHTED USABLE AREA

The WUA was the final output of the IFIM. It was a direct function of discharge and represented the suitability of the entire modelled reach divided at the microhabitat level. In this reach, two species were primarily represented, namely the *Barbus barbus* and *Leuciscus cephalus.* The *Chondrostoma nasus* was in a larger proportion in only one locality; therefore, the habitat suitability curve for the *Chondrostoma nasus* was not representative. Based on the above, we present an analysis of the weighted usable area only for the other two species (Fig. 3).

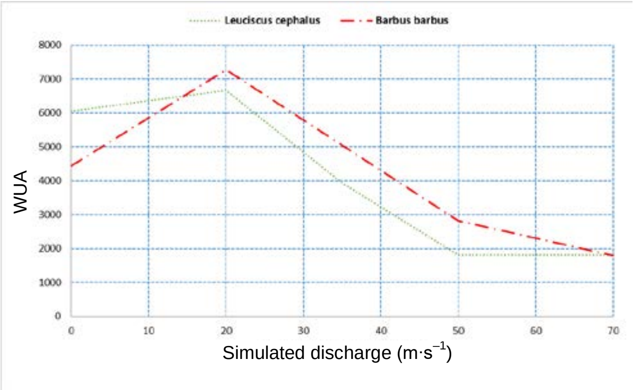

Fig. 3. Weighted usable area (WUA) for individual fish species of the Váh River at different discharge rates

RHABSIM modelling of aquatic habitat quality required a velocity field simulation that was verified for at least two water levels. The velocity field was measured by hydrometry in individual cross-sections (08.07.2017) at a discharge rate of 19.5 $m^3 \cdot s^{-1}$. Verification of the velocity field was conducted on 21.07.2017 at a velocity rate of 16.7 $m^3 \cdot s^{-1}$ and 14.10.2017 at a discharge rate of 70 $m^3 \cdot s^{-1}$.

Habitat suitability curves for both species had a similar course of measured hydraulic parameters, which corresponded to a similar optimal habitat for both species. The species were therefore analysed together. The rate of suitability for flow velocity within the simulated flow rates decreased with increasing discharge and conversely, the rate of suitability for water depth increased with increasing discharge. The most suitable discharge rate was 20 $m^3 \cdot s^{-1}$ (Fig. 3), which corresponded to the biological discharge rate in the Váh River at this locality. Thus, with increasing flow rates, the suitability rate for water depth increased, but at the same time, the suitability rate for flow velocity significantly decreased. Hence, the resulting combined suitability curve, and consequently, the WUA, decreased from discharge equal to 20 $m^3 \cdot s^{-1}$ with increasing discharge (Fig. 3).

These results represent standard results that are based on a combined degree of suitability. From a more detailed analysis of the effect of the flow velocity and the water depth on the quality of the aquatic habitat, we obtain a more specific impact of the change in flow on the quality of the aquatic habitat. Flow velocity is an important parameter that has a significant impact on the river bed morphology and thus on the quality of microhabitats. At a higher flow rates, there are increased flow velocities that force the fish to look for shelters so that the fish are not washed out.

There were several articles devoted to the issue of the effect of flow velocity and water depth on the quality of aquatic habitat but they were mainly focused on mountain and sub mountain streams and trout preference [HOOPER 1973; MACURA *et al*. 2012]. The basic principle of the influence of flow velocities on the quality of the aquatic habitat was also maintained for the Váh River; at a certain flow velocity the fish leaves the original habitats and seeks for shelters. Based on the results it follows that at the flow rate of 8 $m^3 \cdot s^{-1}$, 73% of the flow surface area has a suitability rate of 0.6 or more. At a flow rate of 19.5 $m^3 \cdot s^{-1}$ it was 61%, and at a flow rate of 50 $m^3 \cdot s^{-1}$ it was only 19%. From the point of view of flow velocity it follows that by increasing the flow rate from 10 to 20 $m^3 \cdot s^{-1}$ there is an insignificant change in the suitability of habitat; further increasing the flow rate reduces the suitability of habitat significantly.

Water depth of flow is also an important factor in assessing the quality of aquatic habitat [APARICIO *et al*. 2011; FLADUNG *et al*. 2003; LASNE *et al.* 2007; MACURA *et al*. 2018; MAGALHÃES *et al*. 2002; PATTON, HUBERT 2000; SLAVÍK *et al.* 2005]. In the case of the Váh River, the suitability of habitat for water depth varied to the contrary of that of flow velocity; the suitability rate increases with flow rate. At a flow rate of 8 $m^3 \cdot s^{-1}$, 17% of the surface area of the flow has a rate of suitability of 0.6 or more, at a flow rate of 19.5 $m^3 \cdot s^{-1}$ it was 26% and at a flow rate of 50 $m^3 \cdot s^{-1}$ it was 38%. This analysis shows that the change in flow rate of the Váh River is dominated by the change in velocity. When we analyse the entire data set from the RHABSIM model, we get logical connections. By varying the flow rate, the flow level changes slightly. Specifically, by changing the flow rate from 10 to 50 $m^3 \cdot s^{-1}$, the flow level changes by 54 cm. Such a change of water depth affects the habitat's suitability positively. The flow velocity at flow Q_{50} reaches in several sections the velocity of 1.6 $m^3 \cdot s^{-1}$. This velocity is inappropriate also for the trout. REISER and WESCHE [1977] have determined a range of velocities that are critical for *Salmo trutta* m. *fario*; the maximum critical flow velocity at which the trout will withstand a long term in shelter is $v_k = 0.90$ $m \cdot s^{-1}$. It can be assumed that for *Leuciscus cephalus* and *Barbus barbus* this flow velocity will be significantly lower. It follows that by increasing the flow rate, the change in flow velocity will have a significant impact on the quality of the habitat in the Váh River.

CONCLUSIONS

From the course of the weighted usable area (WUA) in the simulated flow intervals, it can be concluded that the hydro-ecological limit in the selected section of the Váh River is 20 $m^3 \cdot s^{-1}$. Increasing the discharge would not improve the quality of habitat during the summer period. The improvement would be possible through increased segmentation of the channel, i.e. the creation of more shelter, the construction of side-arms, and other river restoration measures, which would lead to a greater diversification of the velocity field and channel morphology.

Regarding the definition of the hydro-ecological limit, it should be noted that this method was determined by the instream flow incremental methodology (IFIM) decision-making method (the title "decision-making" is derived from the procedure; the results obtained were discussed by the decision-making committee, which consisted of a wider array of abiotic and biotic experts. The commission decides on changes, in this case, the ecological flow. The flow is further monitored, and the design parameters could be corrected based on the monitoring). In this specific case, the procedure is important because increasing the discharge will be at the expense of electricity production, which has a significant effect on the economy of the hydroelectric power plant.

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