SLOVAK DANUBE RIVER ASSESSMENT BASED ON INTERCALIBRATED BIOLOGICAL METHOD FOR MACROINVERTEBRATES

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With respect to the international and transboundary character of the Danube River, its water quality has been regularly monitored for a long time period. Several studies have dealt with macroinvertebrates of its Slovak reach. In connection with the EU WFD multimetric approach was adopted within ecological status (ES) assessment in natural water bodies. Its main principle is a comparison with reference conditions. Slovak Republic developed WFD compliant classification schemes for ES assessment, based on selected stressor specific metrics depending on Slovak river typology. The Danube River, categorized as special subtype of Very large river within Pannonian Lowland ecoregion, was subdivided to four water bodies – two natural and two heavily modified. This new approach was applied since 2007. The first Slovak river basin management plan (2009) comprised evaluated data of years 2007 and 2008, which were used in Intercalibration exercise of Very large rivers starting from 2009. It was a process of intercomparison of the biological assessment methods for macroinvertebrates within relevant rivers and water bodies. The upper section of the Danube River Slovak river reach fell into good status while the most of it was evaluated within moderate status.

Key words: Danube River, intercalibration, macroinvertebrates, ecological status, WFD

INTRODUCTION

Due to the Danube River international importance a high interest is focused on its water quality which has been monitored on its Slovak river reach since half of nineties. More detailed monitoring has been carried out since 1992, due to the Gabčíkovo Water Structure construction with the main purpose of energy production, flood protection and navigation. As the biomonitoring of European aquatic ecosystems was substantially influenced by the European Water Framework Directive (WFD) since 2000, the Slovak 172 km long river reach has been regularly monitored to obtain reliable data for the development of type-specific assessment method of the ecological status/potential. Status assessment is defined through the response of the biota at the level of the water body as the classification and management unit. The Danube River main channel was subdivided into four water bodies: two natural with free-flowing zones and two heavily modified influenced by Gabčíkovo Water Structure. Macroinvertebrates as a good indicative biological quality element were commonly used for the Danube River assessment because of their good responses to different environmental factors. In order to define main environmental objective - good ecological status, WFD provides also the procedure of intercalibration exercise (IC) ensuring the comparability of the Member States' biological monitoring results and thus classification systems in each ecoregion of EU. Member States are organized in Geographical Intercalibration Groups (GIGs), sharing particular surface water body types. The intercalibration was carried out for each biological element and for each common surface water body. Within *Cross-GIG Very Large Rivers Intercalibration* starting from 2009 Slovak Republic provided data on macroinvertebrates and related ecological status from the Danubian localities sampled in 2007 and 2008, included also in the first Slovak River basin management plan (RBMP 2009). EU Commission propose to include the successfully

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intercalibrated boundaries to the official national classification systems and to implement them for the ecological status assessment.

DEVELOPMENT OF THE SLOVAK METHOD OF ASSESSMENT

During the preparation of the first RBMP four water bodies were designated on the main channel of the Danube River Slovak section: SKD0016 (rkm 1880,2 – 1869) natural common Slovak-Austrian section; SKD0019 (rkm 1869 – 1851,6) heavily modified Slovak stretch, SKD0017 (rkm 1851,6 – 1807,0) heavily modified common Slovak-Hungarian section and SKD0018 (1807,0 – 1708,2) natural common Slovak-Hungarian section. All water bodies of the Slovak Danube stretch were categorized according to the Slovak river typology (RBMP 2009) as a special subtype of Very large river (catchment area >10000 km^2) within Pannonian Lowland ecoregion (<200 m). Data from national surface water quality monitoring in Slovakia were used to derive the Danube-specific classification schemes (ŠPORKA et al. 2009). They were based on WFD compliant methods of sampling and evaluation performed in 2002 – 2004. A robust database for analyses consisted of all available monitoring sites on the Slovak Danube section. The key issue was a selection of suitable metrics sufficiently descriptive and reflecting the given environmental conditions. The outputs of international EU project AQEM (AQEM CONSORTIUM 2002) focused on macroinvertebrates were used to derive the assessment system which would meet all WFD criteria. Quantitative samplings of macroinvertebrates from the monitored Danube localities were carried out according EN 16150 (2012). Samples were processed and more than 200 metrics, grouped to 4 groups - richness/diversity, composition/abundance, sensitivity/tolerance and functional metrics, were calculated using the program ASTERICS, developed within AQEM project. The further attempt was to select the ideal metrics that should be according to HERING et al. (2006) responsive to a stressor, with low natu -ral variability, and provide a distinct interpretable response. Such set of candidate metrics was reduced by excluding some metrics as e. g. redundant, developed for other specific countries or other river types. An ability to detect different types of stressor (organic pollution, morphological and overall degradation) was considered as well. The following step was setting of threshold values of the five ecological quality classes ranging from high status to bad status for all selected suitable metrics. Based on methodological guidelines for implementation of WFD, the individual metrics values expressed on different scales, were transformed into the so-called EQR (ecological quality ratio) unified values between 0 and 1. Such transformation enables a comparison of results obtained by different metrics and to integrate different metrics into a multimetric index (MMI). The classification schemes developed according the above described procedure (ŠPORKA et al. 2009) were later updated on the basis of more robust database and of the validation of assessment results (MIŠÍKOVÁ ELEXOVÁ et al. 2009). Finalized schemes comprising 6 metrics (Saprobic index, Oligo taxa (%), BMWP score, Index of Biocoenotic Region, Akal+Lital+Psamal (%)) for the Danube River water bodies, defining five classes of ecological quality based on macroinvertebrates assemblage, are included in WATER ACT 269 (2010).

PROCESS OF INTERCALIBRATION

For the purpose of ecological status intercalibration, data on national assessment methods were collated from 19 participating countries. Methods used in national WFD monitoring programs were delivered in questionnaire within official reporting to leaders of the Cross-GIG Very Large Rivers intercalibration group. Altogether 770 macroinvertebrates samples with supporting information from 297 sampling sites of very large rivers across Europe were collected for the following data processing (BIRK et al. 2016). The biological data included the taxa composition with abundance of macroinvertebrates sampled and processed according to the national official methodologies. The values of ecological quality ratio (EQR) and *descriptive environmental data* related to each sample were delivered as well. Slovak Republic provided the macroinvertebrates and supporting environmental data during the second IC phase in 2009. These data were based on 35 samples from 18 sampling sites of the Slovak Danube River reach monitored in 2007 and 2008. Besides heavily modified water bodies they covered also two natural water bodies, which were subject to intercalibration procedure. Hence upper section - water body SKD0016 with input representative locality Bratislava (rkm 1869) and lower section - water body SKD0018 with output representative monitoring site Szob (rkm 1707) were covered. Both mentioned localities were established as the representative sampling sites for the ecological status assessment in related natural water bodies (**Fig. 1**). Samplings carried out both in

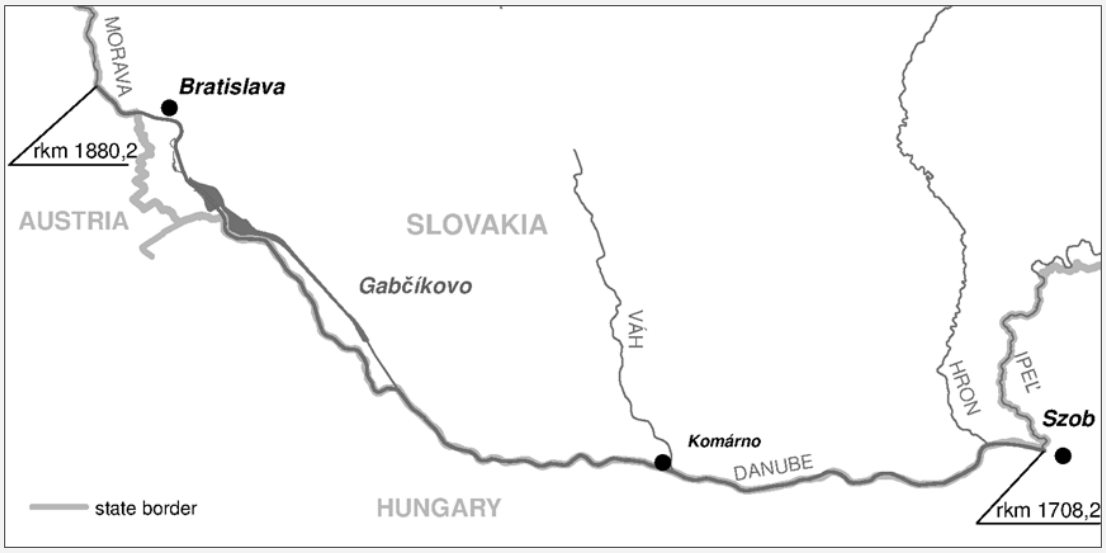

Fig. 1 Map of the investigated reach of the Danube River; rkm indicate input and output of the Danube River to the Slovak territory.

spring and autumn seasons of 2007 – 2008 and also during the Joint Danube Survey expedition (JDS 2) in summer 2007 were processed and analyzed as above described (ŠPORKA et al., 2009). These data were processed and used for the inter-comparison within the Cross-GIG Very Large Rivers intercalibration group in its second phase (years 2008 – 2011, finalized in 2013) and relaunched within the third phase (since 2013, finalized in 2018). As the compliance of national methodologies with WFD-criteria had to be checked to ensure intercalibration feasibility, countries also demonstrated the pressure-impact relationship of their assessment system and its strength by correlation coefficient was declared as well. This was considered as a proof of methods′ sufficient sensibility to the cumulative effect of the various anhropogenic impacts (BIRK et al. 2016). Slovakia together with Austria provided this proof showing significant correlation (Spearman Correlation Coefficient = -0.73) and linear regression (R^2 = 0.52) between BOD and the national EQR values. Also pressure *impoundment* – impact relationship in common SK/AT method was proved by clear distinction between impounded and non -impounded sites. *Anthropogenic pressures* contained 8 hydromorphological parameters (damming, upstream dams′ influence, hydropeaking, channelization, impoundment, water abstraction, riparian vegetation alteration, navigation intensity) and 2 physico-chemical parameters (annual average concentrations of Nitrate-N and orthophosphate-P), categorized by national participants into 2 to 4 levels.

DATA ANALYSIS

The sampling data on taxa composition and abundance from all participating countries were used to calculate the biological metrics covering WFD requirements. The principle of inter-comparison process was based on using Intercalibration Common Multimetric index ICMi and Combined Abiotic Pressure index CAPi to compare biological information and anthropogenic stressors across different countries. Statistical methods as benchmark standardization and normalization were used (BIRK et al. 2013, POIKANE et al. 2015). Standardization removed the differences among national biological data caused by different methodologies, typologies, biogeography etc. Normalization transformed the used metrics values into 0-1 scale. Correlation analyses of national EQRs, ICMi and pressure parameters were performed based on both national datasets and combined dataset of all countries.

National delegates were actively involved in the process of testing CAPi and ICMi variants by working with dynamic *excel spreadsheets*. After correlating of all biological metrics with national EQRs and the various pressure parameters, 13 candidate metrics were selected to compose ICMi. The first priority at the selection process was the highest metrics correlation with national EQRs and the second one – correlation with pressures. 30 preliminary ICMi variants were correlated against different CAPi variants (various combinations of the individual pressure

Metric name	Description	Taxonomic composition	Abundance	Sensitive taxa	Diversity	Major taxonomic
EPT_HK%	Percentage of EPT (Ephemeroptera + Plecoptera + Trichoptera as % abundance classes)	*X*	*X*	*X*		
no_EPTCBO	Number of EPTCBO taxa (Ephemeroptera + Plecoptera + Trichoptera + Coleoptera + Bivalvia + Odonata)	*X*		*X*	*X*	*X*
no_Tricho	Number of Trichoptera taxa	*X*		*X*	*X*	
potamal_ges%	Preference for zonation type potamal (% individuals)		*X*	*X*		
AKA_HK%	Preference for microhabitat akal (% abundance classes)		*X*	*X*		
pfil%	Percentage of passive filter feeders (% individuals)		*X*			

Tab. 1 Single common metrics composing the Intercalibration Common Multimeric index ICMi.

parameters) to choose the best correlating ICMi. Final CAPi consisting of 7 hydromorphological (excluding *damming*) and 2 physico-chemical parameters was composed to exact formula of so -called Hymo7_P_N index (BIRK et al. 2016). Then different 30 ICMi variants were again tested for the best correlation with the national EQRs (priority 1) and the next priority for selection was the good correlation with final CAPi. Also here national delegates participated in the process of selection and composing the candidate metrics into a multi-metric index ICMi. The final ICMi consisted of 6 biological metrics listed in **Tab. 1.**

BOUNDARIES COMPARISON

Intercalibration Excel Template Sheets with data related to 727 macroinverebrates samplings of 16 participating countries were used for the analyses to compare the national class boundaries of ecological status via EQR values. Relationships between ICMi, national EQRs and pressures – using stressor index CAPi were analyzed (BIRK et al. 2016). Comparison of both high/good and good/moderate national boundaries was expressed displaying the bias from the given intercalibration boundaries (**Fig. 2** and **Fig. 3**).

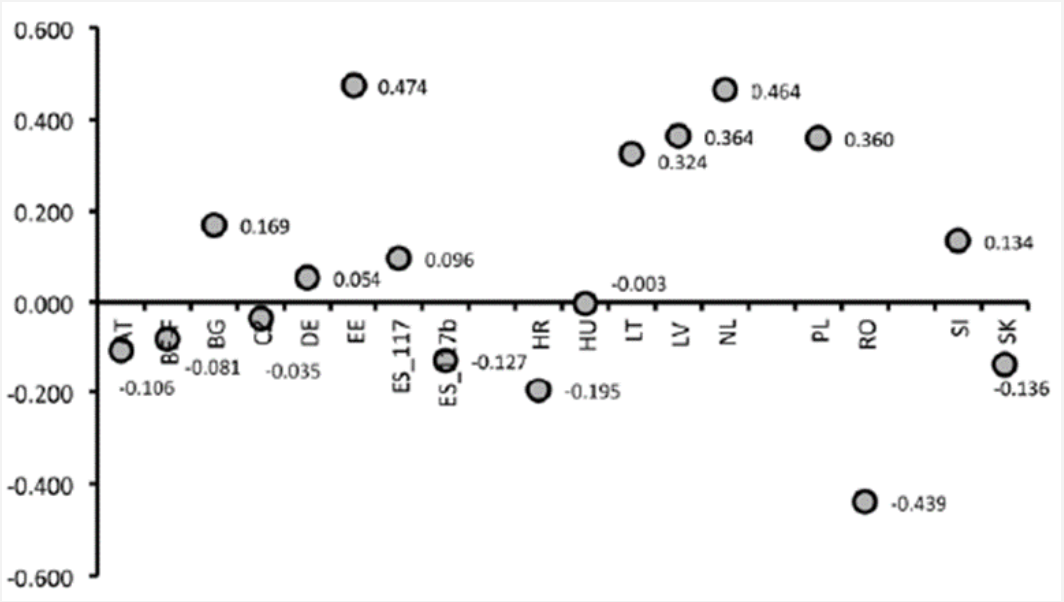

Fig. 2 High/good boundary bias (SK – Slovak result).

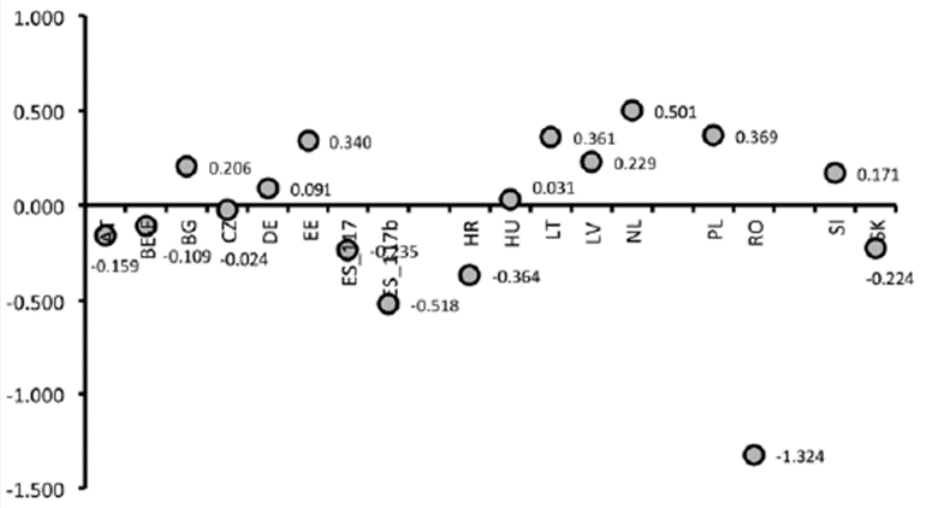

Fig. 3 Good/moderate boundary bias (SK – Slovak result).

In both cases 25 % (±0.25) bias was accepted and in case of too relaxed national boundary (if bias fell below -0.25) its adjustment was proposed. Slovak Republic which was successfully intercalibrated within the type R-L2: *Very large medium to high alkalinity rivers* (alkalinity >0.5 meq/l) fell into the accepted range of bias. Hence according the final Commission Decision 2018/229 (EUROPEAN COMMISSION 2018) the Slovakian boundaries for high/good and good/moderate ES were fully justified and accepted for the ecological status assessment in natural water bodies of the Slovak Danube River stretch.

ECOLOGICAL ASSESSMENT IN TWO DANUBIAN NATURAL WATER BODIES

Using successfully intercalibrated Slovak method of the Danube River classification, the ecological status of two Danubian natural water bodies was evaluated in its representative sampling sites. The *upper* water body SKD0016 – in

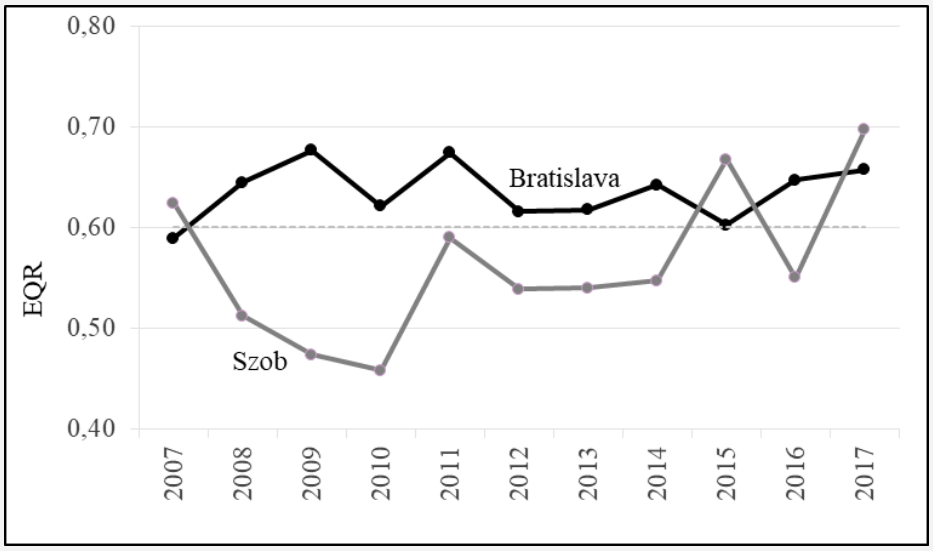

Fig. 4 Course of EQR values in input (Bratislava) and output (Szob) representative sampling sites of the Danube River Slovak stretch.

Bratislava (right) and the *lower* SKD0018 – in Szob (left). This evaluation was performed on the basis of macroinvertebrates data sampled during the spring 2007-2017.

The upper water body that represents the input section of the Danube River Slovak river reach was evaluated almost in entire surveyed period within good status, with EQR values between 0.6 and 0.7. Although the EQR classifying values are more fluctuating in output water body in its representative sampling site Szob, the most of them fell into moderate status (bellow 0.6; **Fig. 4**).

CONCLUSION

Water quality in the Slovak Danube output water body has a tendency to improve and approach good ecological status last three years. This is a positive message for the upcoming RBMP concerning to the main WFD objective. The following step within WFD European activities is a Common understanding and harmonizing of methods for ecological potential assessment in heavily modified water bodies. As the Slovak reach of the Danube River is highly impacted by Gabčíkovo Water Structure this is the next important issue regarding two related heavily modified water bodies.

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