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Variety of the guiding image of rivers – defined for ecologically relevant habitat features at the meeting of the alpine, mediterranean, lowland and karst regions

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ABSTRACT

Due to a long history of human intervention in river ecosystems, pristine conditions hardly exist nowadays and therefore a concept of a 'guiding image' defines the present-day potential natural state. Since regional physiographic factors influence the natural habitat features and biota on local level, also guiding images are expected to differ regionally. In this study, the guiding images of rivers of four major regions were defined: alpine, lowland, mediterranean and karst. The habitat features of rivers were studied in four major European regions: the Alps, the Pannonian Lowland, the Submediterranean region and the Dinaric region. For the analysis only those river habitat quality features were used that were proven to be ecologically important. The results showed differences among habitat features of rivers of all investigated regions. On the whole dataset the major gradient among reference sites was observed for habitat features that are in tight relation to water flow and sediment dynamics. For these features the major differences were found between the alpine and the lowland rivers, and on the other hand the similarities were observed between the Mediterranean and the Alpine rivers and between the karst and the lowland rivers. Another important gradient was observed on account of habitat features of riparian and channel vegetation. The highest values of these features were observed for the alpine and the mediterranean rivers and lower in the karst or the lowland rivers. However, the simpler riparian vegetation structure suggested by our results might not be the representative picture of natural vegetation, so the values of these features for a guiding image should be used with caution.

In the present study the first step to the guiding images of the rivers in four major regions is proposed. Since the results showed considerable variability of some river habitat features present within regions, we suggest further investigation on even smaller groups. Nevertheless, the recognized differences and similarities among four regions in river habitat features that are ecologically relevant might serve as guidance for more sustainable and cost-effective river management.

1. Introduction

The management of riverine environment in Europe has reached an important turning-point with the implementation of the Water Framework Directive (WFD, European Commission, 2000). The main goals of the WFD require from Member States the assessment of ecological condition of rivers and the achievement or maintaining of good ecological status. A novel part included in the WFD is the assessment of hydromorphological pressures, acknowledged as one of the main pressures of our time (Richter et al., 1997; Schinegger et al., 2012). In the light of the WFD requirements river restoration is gaining increased attention. Many projects are being realized but with little desired outcomes (Jähnig et al., 2010; Palmer et al., 2010; Haase et al., 2012; Wolter et al., 2013). The fundamental part for definition of cost-effective measures and consequently achieving the desired WFD goals is the understanding of river ecosystem functioning and the connections between aquatic assemblages and their natural or anthropogenically disturbed environment. A substantial number of studies establish the links of river habitat quality and degradation to predominantly benthic invertebrate assemblages (Lammert and Allan, 1999; Sandin and Johnson, 2004; Erba et al., 2006; Feld and

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Hering, 2007; Larsen and Ormerod, 2010; Petkovska and Urbanič, 2015), but also fish (Smiley and Dibble, 2008; Wyżga et al., 2009), and other animal groups bound to river environment (Hering et al., 2006; O'Hare et al., 2006; Bona et al., 2008; Manenti et al., 2009). Due to the WFD requirements several aquatic assemblages-based assessment methods addressing hydromorphological pressure have been recently developed in different European countries (Birk et al., 2012; Rinaldi et al., 2013a).

These aquatic assemblages-based assessment methods enable the simultaneous evaluation of all hydromorphological pressures, but for river management defining the core factors causing the degradation is of equal importance. The program of measures for river basin management plans should be designed cost- effectively aiming at desired ecological status improvement. Therefore, it is essential to define the river habitat quality and modification factors that need to be managed. A large amount of methods have been developed for summarizing heterogeneous nature of riverine physical habitat characteristics and modifications (Muhar et al., 1996, 1998; Raven et al., 1998, 2003; LAWA, 2000; Rinaldi et al., 2013a). The methods differ mainly with respect to the objectives for which they were designed, the time required for their application and whether they measure physical characteristics or evaluate them (Fernández et al., 2011). Several of these methods were adopted for the WFD implementation in European countries (Rinaldi et al., 2013a), but only for a few of these methods the links with aquatic assemblages have been studied (e.g. Urbanič, 2014), mostly considering features of the UK River Habitat Survey method (RHS; Raven et al., 1998, 2003). RHS method represents one of the most comprehensive methods and is probably the most tested method in European countries (Balestrini et al., 2004; Szoszkiewicz et al., 2006; Tavzes et al., 2006; Bona et al., 2008; Urošev et al., 2009; Raven et al., 2010). The RHS method was adapted for use in Southern Europe (Buffagni and Kemp, 2002) and served also as a basis for the Slovenian hydromorphological (SIHM) assessment method development (Tavzes and Urbanič, 2009).

The hydromorphological assessment methods either measure characteristics or evaluate them, but in both cases the assessment depends on the reference conditions. The definition of reference conditions has long been a subject of discussion (Fryirs and Brierley, 2009; Pardo et al., 2012; Wyżga et al., 2012; Feio et al., 2014; Rinaldi et al., 2013b). Since river systems have been affected by human activities for a very long time (Marsh, 1864), the present state of rivers is the result of a long interplay between natural and human induced factors and finding the 'pristine' conditions nowadays is hardly feasible. Also the naturalness of the past river conditions is questionable (e.g. in previous centuries more intense land degradation from agricultural activities was present; Williams, 2000). In last decades, a largely accepted has become a concept of a 'leitbild' (Kern, 1992, 1994) or a 'guiding image' (Palmer et al., 2005) with the reference conditions defined as the present-day potential natural state under the omission of all uses and the removal of all reversible pressures, which are reached after redevelopment without socio- economic restrictions (Gellert et al., 2014). According to WFD the reference conditions are only characterized by no or minimal changes in their hydromorphological and physico-chemical characteristics so long as these do not have a significant effect on the ecosystem (Wallin et al., 2003).

It is recognized that regional physiographic factors influence the natural hydromorphological characteristics and biota on local level (Frissell et al., 1986; Sandin and Johnson, 2004), hence, affect guiding images. In various parts of the world numerous classification schemes suggest regional differences of river channels based on their physical characteristics (Kondolf et al., 2003; Repnik Mah et al., 2010; Splinter et al., 2010). On the other side, ecoregions were delineated based on similar associations of climate, soils, topography and other characteristics in Europe and America (Illies, 1978; Omernik, 1987) in order to define regional goals for water quality and management. Since the desired goal is sustainable water management, the priorities should be based on the links with aquatic biota. The parameters of applied hydromorphological assessment methods for the WFD purposes have rarely been related to aquatic assemblages, or only on the basis of expert judgement and not empirically. The relationships between single habitat features and benthic invertebrates have been investigated mostly for the RHS features (Erba et al., 2006; Cortes et al., 2009; Dunbar et al., 2010), and also for parameters of the SIHM method (Petkovska and Urbanič, 2015). Our study therefore focused on two main objectives:

i) to test the difference among some main European regions on the basis of the SIHM morphological parameters, which are in good relation with benthic invertebrate assemblages (Petkovska and Urbanič, 2015) and/or are important in morphological assessment (Tavzes and Urbanič, 2009), and
ii) to develop the guiding images for rivers of each of the investigated regions on the basis of the relevant SIHM morphological parameters.

The developed guiding images may then be used as a tool for sustainable river management in different regions.

2. Methods

2.1. Study area

Slovenia covers a total area of 20,273 km^2 and has no less than 4573 km of river channels within catchments larger than 10 km^2 and even more when counting all smaller streams. Moreover, there is a wide ecological variety of the area, resulting in very different hydromorphological, physico- chemical, and consequently biotic river types. One of the main possible descriptors for classification of river types in the European Water Framework Directive (Directive 2000/60/EC) are ecoregions, which were defined in Europe by Illies (1978). Since Illies (1978) did not consider all local characteristics, for Slovenian area a redelineation of the ecoregions was made (Urbanič, 2008). Four inland water ecoregions were defined, using abiotic factors (tectonic map, geology map, geographical maps, map of karstified area, terrain slope, landscape regions, and river regimes) and biological data (benthic invertebrate assemblages): the Alps (Ecoregion 4), Dinaric western Balkan (Ecoregion 5), Pannonian Lowland (Ecoregion 11), and Po Lowland (Ecoregion 3). The rivers of the area are also shared among two river basins that influence fish communities (Danube river basin, Adriatic river basin; Urbanič, 2011), dividing the ecoregions the Alps and the Dinaric western Balkan into two sub-ecoregions (Fig. 1).

2.2. Hydromorphological data and study sites

Hydromorphological characteristics were surveyed and calculated using Slovenian hydromorphological (SIHM) assessment method (Tavzes and Urbanič, 2009; Urbanič, 2014). Data on morphological features using the SIHM method are gathered along a 500 m long stretch of the river using an adapted version of the UK River Habitat Survey (RHS) method (Raven et al., 2003; Tavzes and Urbanič, 2009). At 10 spot-checks, spaced every 50 m, bank and channel features (predominant substrate, physical features of channel and banks, flow-type, channel vegetation type, land use, vegetation structure of banks and adjacent land) are recorded. Additionally, the sweep-up part of the survey along the whole stretch covers land use in the 50 m stretch from the channel, bank profile, extent of trees, extent of bank and channel features,