What improvement does a river need? New insight about the application of invertebrate-based index in river health assessment

Quelles améliorations sont nécessaires pour garantir la qualité des eaux de nos rivières ? Nouveau regard sur l'utilisation d'indices biotiques dans l'évaluation de la santé des cours d'eau

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RÉSUMÉ

Les indices biotiques qui s'appuient sur la faune benthique sont fréquemment utilisés comme témoins de la santé des cours d'eau, notamment dans l'évaluation de la qualité de l'eau. L'indice BMWP-PL (équivalent polonais du système britannique « Biological Monitoring Working Party ») a été calculé pour 20 sections transversales non aménagées et chenalisées de la rivière Biała et les résultats ont été comparés avec les paramètres physiques et qualitatifs de l'eau des habitats des sections transversales. Les deux types de sections transversales se distinguent nettement par leurs conditions physiques d'habitat, tandis que les paramètres physico-chimiques changent essentiellement d'amont en aval. Le nombre de taxons prélevés est compris entre 3 et 26 et, d'après les indices BMWP-PL respectifs, la qualité de l'eau varierait de bonne à mauvaise. Cependant, comme la qualité de l'eau analysée était excellente à chaque fois, il en a été conclu que les résultats du calcul de l'indice n'étaient pas liés aux paramètres physico-chimiques de l'eau, mais à ceux de l'habitat physique et que c'était le nombre de chenaux à faible débit qui permettait d'expliquer en grande partie les écarts de valeurs d'indice. Au vu de la relation ténue entre les paramètres physico-chimiques et les résultats obtenus, l'indice BMWP-PL constitue davantage un indicateur de l'intégrité écologique des cours d'eau en fonction de leurs caractéristiques hydromorphologiques et physico-chimiques qu'un véritable indicateur de qualité de l'eau.

ABSTRACT

Benthic invertebrate-based indexes are commonly used as proxies for river health, especially river water quality. Scores of BMWP-PL index (a Polish equivalent of the British Biological Monitoring Working Party score system) were determined for 20 unmanaged and channelized cross-sections of the Biała River and compared with water quality and physical habitat parameters in the cross-sections. The two types of cross-sections clearly differed in the physical habitat conditions, whereas physico-chemical parameters of the river water mostly varied in the downstream direction. The number of recorded taxa ranged from 3 to 26 and the respective scores of the BMWP-PL index indicated the water to vary between high and poor quality. Since the analysed water quality was consistently high, the BMWP-PL scores were not related to physico-chemical parameters of the water but to physical habitat parameters, with the number of low-flow channels explaining the largest proportion of the variance in the index values. The lacking dependence on physico-chemical water parameters renders the BMWP-PL as indicator of the ecological integrity of rivers, related to their hydromorphological and physico-chemical characteristics, rather than of water quality.

KEYWORDS

Benthic invertebrates, BMWP-PL index, ecological river integrity, physical habitat, water quality.

1 INTRODUCTION

To restore good ecological status of the rivers, it is essential to recognise whether ecosystem degradation has mainly resulted from a decrease in water quality or physical habitat degradation. Benthic macroinvertebrates are frequently used to monitor the ecological integrity of rivers but to date the monitoring has been concentrated on changes in riverine biocoenoses caused by the degradation of water quality. A Polish index BMWP-PL and its British prototype, the Biological Monitoring Working Party score system (Hawkes, 1998), based on the composition of benthic macroinvertebrate families recorded at a monitoring site, are commonly considered indicators of water quality because the composition is sensitive to water pollution (e.g. Fleituch et al., 2002; Kownacki et al., 2006). However, hydromorphological degradation may be an important stressor affecting the composition of benthic invertebrate communities. This paper examines the applicability of BMWP-PL index as an indicator of river health in a study of the gravel-bed Biała River, Polish Carpathians. The study was conducted in two reaches that are typified by the alternation of relatively long, unmanaged channel sections with short channelized sections at bridge crossings. The contrasting hydromorphological conditions in the sections provide an opportunity to relate the variability in taxa richness of benthic invertebrate communities and BMWP-PL scores not only to the variation in water quality but also in physical habitat conditions.

2 STUDY METHODS

Benthic macroinvertebrates were surveyed in July and September 2010 in 20 channelized and unmanaged cross-sections of the Biała River, and the resultant taxa richness and scores of the BMWP-PL index were compared with water quality and physical habitat parameters in the cross-sections. Water was sampled in the cross-sections immediately before the invertebrate surveys to determine pH, conductivity, dissolved oxygen, BOD_5, COD_{Mn}, and the concentrations of: phosphate, total P, nitrite, nitrate, ammonium, sulphate, chloride, calcium and magnesium. Physical habitat parameters in the cross-sections were determined during baseflow conditions, with active channel and low-flow channel widths determined at each cross-section, followed by measurement of water depth, near-bed and depth-averaged velocity, and mean grain size of surface bed material at equal intervals across the low-flow channels. The pattern of variation in the environmental conditions (i.e. physical habitat and water quality parameters) among the surveyed cross-sections was examined using a principal component analysis. Patterns in the taxa richness of invertebrate assemblages and in BMWP-PL scores in the Biała were compared to the variability in water quality and physical habitat conditions along the longitudinal and channel management-related gradients.

3 RESULTS AND DISCUSSION

Analysis of the spatial patterns of environmental variables clearly differentiated channelized and unmanaged cross-sections by their distinct physical habitat conditions, whereas physico-chemical parameters of the river water mostly varied in the downstream direction. Particular cross-sections hosted between 3 and 26 invertebrate taxa, with the respective scores of the BMWP-PL index indicating the water in the surveyed cross-sections to vary between high and poor quality. However, taxa richness and the BMWP-PL scores were unrelated to physico-chemical parameters of the river water, which consistently pointed to high water quality. Instead, they were significantly related to several physical habitat parameters, with the number of low-flow channels in a cross-section and the coefficient of cross-sectional variation in depth-averaged velocity explaining the largest proportion of the variance in both the taxa richness and the values of BMWP-PL index.

The relationship of the index scores with the complexity of flow pattern in the river and a lack of their dependence on physico-chemical water parameters indicate that if the index is to be considered an indicator of the ecological integrity of rivers, it should be recognized that it is dependent both on their hydromorphological and physico-chemical characteristics. Although the BMWP-PL has been documented to indicate water quality in polluted rivers with similar, mostly degraded hydromorphological status, its interpretation as such an indicator can be questionable in rivers where deterioration of ecological state stems mostly from degraded physical habitat conditions.

4 CONCLUSIONS

The identified dependence of the taxonomic richness of invertebrate communities on the physical habitat complexity shows that simplification of the flow pattern and river morphology of mountain rivers due to human impacts must be considered a very important cause of the subsequent degradation of their biocenoses. Restoration projects aimed at an overall improvement of river health, involve its assessment using indices based on aquatic organisms. The study of the Biała River shows that the interpretation of such indices may not be unequivocal and should be tested against all factors potentially affecting the ecological status of a watercourse. A re-evaluation of the meaning of such commonly used indices in the context of a particular river that is to be restored may allow to pin-point the underlying cause of river health degradation and precisely address the needs for improvement in river restoration plans.

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