Ecological Indicators 76 (2017) 170–177

Contents lists available at ScienceDirect

Ecological Indicators

journal homepage: www.elsevier.com/locate/ecolind

Original Article

Robustness of the biotic indicators used for classification of ecological status of lotic water bodies: A testing method when the data series are short

Geta Rîşnoveanu [a,*], Gabriel Chiriac [b], Marinela Moldoveanu [a,c]

[a] University of Bucharest, Department of Systems Ecology and Sustainability, Doctoral School of Ecology, Spl. Independenţei 91-95, 050095 Bucharest, Romania
[b] National Administration "Apele Romane", Edgar Quinet 6, Bucharest, Romania
[c] National Institute of Hydrology and Water Management, Şos. Bucureşti-Ploieşti 97, Bucharest, Romania

ARTICLE INFO

Article history:
Received 1 June 2016
Received in revised form
24 November 2016
Accepted 28 November 2016
Available online 27 January 2017

Keywords:
Biotic indices
Lotic systems
Short data series
Small scale water basins
Distribution patterns

ABSTRACT

Successful implementation of the Water Framework Directive and achieving its objective of good ecological status of all water bodies depend on the power of the set of monitoring indicators to capture the change in the ecological status of aquatic systems. In this context, testing the robustness and sensitivity of ecological indicators currently used for assessing the status of lotic water bodies is instrumental for the adaptation and further development of assessment methods. This is also a prerequisite for an effective, context-based monitoring system and for improving the quality of the decision making for water bodies. This is particularly challenging in regions where the sets of indicators are under development, the data series are relatively short and data which addresses the individual error sources are lacking. Here we show that hierarchical clusters and ordination analysis provide appropriate tools with which the validity of the ecological status of water bodies set up based on biological multimetric monitoring indices in a small water basin could be tested. We hypothesize that robust and informative monitoring methods classify all water bodies belonging to a single ordination grouping in the same quality class (high, good, moderate, poor or bad). In our case study multimetric biological indicators failed to discriminate between the good and moderate ecological status. Community structure as well as water conductivity and nitrate load were primarily responsible for the observed difference between ordination groupings. Inconsistencies shown in our case study are likely to be induced by insufficient refinement of monitoring schemes and by the constraints existing in the data series and available metadata. We show that multiplication of indicators leads to discrepant interpretation and problematic application. Proposed ordination analysis proves to be a simple and useful tool to detect such discrepancies and support further progress in indicator development. Integrated and longer data and metadata series are needed to refine context-based monitoring methods.

1. Introduction

Degradation of rivers and biodiversity loss at different spatial and temporal scales occurs through multiple stressors whose effects are difficult to separate and identify (Kail and Wolter, 2013). Efficient management of water bodies depends on the development and selection of robust, sensitive, informative and easily applicable tools that allow to reveal and prioritise the pressures and stressors that act in a basin and mitigate their effects (Birk et al., 2013; Cao and Hawkins, 2011). This imposes substantial challenges for scientists in requiring complex and dynamic biological communities to be quantified into a single metrics with the aim of detecting temporal and spatial changes in the quality of water bodies (Mascaró et al., 2013) which seems to be more complex than anticipated when the Water Framework Directive (WFD) was adopted. One major obstacle was the fact that no consistent biological datasets were available for lakes, rivers and coastal waters (Hering et al., 2010). This is of special relevance especially in the new member states, where the entire process of re-organization of water management by hydrological catchments, and harmonisation of classification and monitoring methods with other states across Europe started later. In those states traditional biological monitoring methods do not provide data for the water quality assessment compliant with

* Corresponding author.
E-mail addresses: geta.risnoveanu@g.unibuc.ro, risnoveanugeta@yahoo.ca (G. Rîşnoveanu), gabriel.chiriac@rowater.ro (G. Chiriac), marinela.moldoveanu@hidro.ro (M. Moldoveanu).

http://dx.doi.org/10.1016/j.ecolind.2016.11.044
1470-160X/

the directive requirements and standardised data series are generally short, with limited reliability and accessibility (Jackson et al., 2016; EU, 2012). Besides, the assessment schemes are not entirely implemented and the reference conditions from which the degree of change is measured do not cover all typologies and encounters serious limitations.

Significant differences in the development and implementation of assessment methods exist across Europe (Pardo et al., 2012). Compared to Northern and Western Europe, biological indicators for Eastern European lotic systems are less developed, even though, increasing attention has been paid to implement EU directives for aquatic conservation and management employing different biological quality elements (BQEs). For example, in Romania, until 2009, only the Saprobe Index (SI) of macroinvertebrates and phytoplankton has been officially applied to indicate the biological quality of rivers. Assessment methods were not completely available before the first river basin management plan had to be drafted in 2009 and currently they are either in the testing phase (i.e. phytoplankton, macroinvertebrates and fishes) or still under development, as it is the case for macrophytes and benthic algae. Assessment of ecological status have been based on single metrics (i.e. category A indices in Table 1) or combination of metrics including multimetric indices generally developed on metrics from one BQE for different types of water bodies (i.e. category B indices in Table 1).

Evaluation of the robustness and sensitivity of biological indicators currently used for assessing the current status of lotic water bodies is instrumental for the adaptation and further development of assessment methods and represents a prerequisite to lay the foundation of an effective, context-based monitoring system. This is particularly challenging in regions where the sets of indicators are under development, the data series are relatively short and data which address the individual sources of error as variability in sampling and laboratory analysis, seasonal and geographical variability are lacking (Clarke and Hering, 2006; Hering et al., 2010; Gobeyn et al., 2016). As many sampling and analysis procedures have been standardised across Europe and training programmes have been implemented in connection with the WFD in different East European countries (including Romania), effects of different field and lab procedures are supposed to be relatively minor (Borja et al., 2007; Kahlert et al., 2012). Handling the spatial and temporal variability, defining biological reference status and index combination rules continues to represent major challenges as it is also across all Europe (Baattrup-Pedersen et al., 2013; Moe et al., 2015). Solving these issues has serious practical implications as they may assist managers to decide whether or not current trends in the dynamics of water bodies call for policy changes and investments to achieve good ecological status (Birk et al., 2013; Sergeant et al., 2012).

The aim of our research is to use hierarchical clusters and ordination analysis to test the extent to which the quality classification of running waters made by biotic multimetric indices currently used by the monitoring system reflects the similarity of their physical, chemical and biotic structure. We particularly address the following questions: i) Are there any consistent patterns in distribution of lotic systems structure?; and ii) Are those patterns consistent with the ecological status of water bodies set up based on biological multimetric monitoring indices? To answer these questions the Litoral water basin in Romania was used as a case study.

2. Methods

2.1. Study area

The Litoral water basin is a small water basin (5480 Km^2), located in the southeast part of the country and it is under the influence of the Black Sea (Fig. 1). It has a temperate continental climate with low rainfall values (200–400 mm/year) and average altitude below 200 m.

All water courses in the area are lowland rivers of low order. The registered flow rates are very low (multiannual mean flow ranges between 0.064–0.690 cm/s) and frequently they become drained. Besides, according to the National Management Plan (2009) these littoral rivers present some particularities regarding the structure of biological communities (i.e. lacking fish fauna in natural conditions). All of these distinguish the rivers in the Litoral basin from the other lowland rivers across the country. They were classified as special lowland typologies: RO06* and RO08*. Water quality assessment methods established for lowland water bodies (RO06 and RO08) were modified accordingly to meet the distinct features of these uncommon typologies. The National Monitoring Programme established 14 monitoring sections in the basin. Only 9 of them for which the data sets were complete are included in the study.

2.2. Assessment of the ecological status

The analyses were based on the data sets obtained by the national monitoring system (ANAR) in 9 monitoring sections (Fig. 1) belonging to 7 water bodies identified along 5 rivers. The data were collected seasonally, from spring to autumn 2009 and 2010, after the first European Intercalibration Exercise performed in 2008 whose objective was to ensure comparable results of the large number of monitoring methods used in different Member States and to provide a uniform assessment at continental and national scales of the ecological status of lotic systems (Birk et al., 2013). Physical, chemical and biological data were collected according to international standards (i.e. Knoben et al., 1995). At each sampling moment, 5 replicate samples of benthic macroinvertebrates were randomly collected with a 625 cm^2 surber sampler, washed through a sieve (mesh size 250 μm) and preserved in 4% formaldehyde. All of the faunal specimens were hand sorted from sediments under a stereomicroscope and subsequently identified to species level in the laboratory. Minimum 5 replicates of benthic algae, each covering 5 cm^2 of representative microhabitats, were randomly sampled by scraping. All individuals present in samples were counted (Birk et al., 2010).

Quantitative numerical row data concerning the structure of benthic invertebrate communities and benthic algae were used to calculate a wide range of biotic indices (Table 1) that are currently in the testing phase in Romania. They served to calculate the values of the multimetric indices for macrozoobenthos and benthic algae using the formulas provided by the Romanian National River Basin Management Plan (RNRBMP, 2009) (Table 1). The worst status of the two multimetric indices of a water body determines its final ecological status.

2.3. Distributional patterns of communities

Physical and chemical parameters and biological raw data (Table 2) were used for multivariate analyses. Non parametric hierarchical paired clustering (based on Bray-Curtis distances) was deemed appropriate to identify clearly differentiated hierarchical groupings of monitoring sections.

Complementary, non-metric Multi-Dimensional-Scaling (nMDS) served for viewing the group patterns and confirmation of the results accuracy (Clarke and Warwick, 1994). This method is particularly appropriate for analysis of spatial and temporal distributional patterns of non-parametric data with different numerical scales and units of measurement. The validity of the results is reflected by the stress factor value, which expresses the discrepancy between the multidimensionality of the data and the final, low-dimensional ordination. Stress values between 0.1 and 0.2 represent acceptable results, values between 0.1 and