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PREFACE

Aquatic biomonitoring: Lessons from the past, challenges for the future

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ABSTRACT

This special issue stems from an increasing awareness on the key contribution made by biometrics and biological indices in the quality classification of aquatic ecosystems. This theme has been the subject of passionate debate during the 13th European Ecological Federation (EEF) and 25th Italian Society of Ecology's (S.It.E.) joined congresses held in Rome in September 2015. In this frame, on the margins of the special *symposium* named "*Biomonitoring: Lessons from the past, challenges for the future*", it was launched the idea of a special issue of the Journal of Limnology on the "aquatic" contributions presented at the conference. The present volume mainly reports these studies, enriched by few invited papers. Among the other things, the main message is the need of a better integration between sector knowledges and legislative instruments. This is even truer given the on-going climate change, and the necessity to record rapid changes in ecosystems and to elaborate effective/adaptive responses to them.

Key word: Bioindication; aquatic ecosystems; macroinvertebrates; diatoms; macrophytes; fish; ostracods; remote sensing.

INTRODUCTION

In recent decades, the traditional approaches used to characterize and monitor ecosystems (*e.g.*, physical and chemical, taxonomic) have been integrated and partially replaced by species- and community-based indices. For example, at the European level, the enactment of the EU Water Framework Directive (WFD, Directive 2000/60/EC; European Union, 2000) has overcome the limits imposed by a mere physical and/or chemical investigation of waters by integrating biological communities in the monitoring programs. In particular, the use of bioindicators contributes to the ecological classification of colonized habitats – in this case of colonized water bodies – thus making it possible to evaluate, if present, the deviation from the "reference conditions". This transition has the potential, among other things, to produce multi-spatial interpretations of the relationships between organisms, biogeochemistry and the physical environment. The biological communities and/or biomarkers are able to reflect the real-time quality of the system under consideration, but also to integrate in time the perturbations exerted on ecosystems. In this context, the possibility of building an integrated and intercalibrated view of the ecosystem represents an important innovation in the field of the environmental monitoring (Poikane *et al.*, 2011).

This approach appears, thus, more robust and less subjected to errors associated with transient phenomena. However, its uncritical use and the insufficient knowledge of species and communities autoecology can lead to wrong evaluations. Along with the lack of knowledge about biology and ecology at several organization levels, methodological issues such as sampling effort and imperfect detection of species, or the difficulty to exactly define the reference conditions if not properly taken into account can severely bias the results of biomonitoring (Bouleau and Pont, 2015; Baattrup-Pedersen *et al.*, 2017). Additionally, for example, the strong capability of primary producers to modulate the physical and chemical conditions in which they live can explain in part: i) the non-linear responses of many aquatic macrophyte communities to external perturbations, or ii) the clear space- and time-dependence of the evaluations provided by some macrophyte multi-metric indices (Demars *et al.*, 2012; Bolpagni *et al.*, 2016). Furthermore, the increasing spread of exotic species on a global scale is another critical factor that can alter the responses of biological communities to the rising impairment of ecosystems. In this context, basic research should be implemented to support limits and opportunities offered by biomonitoring for proper management actions.

SPECIAL ISSUE CONTENTS PRESENTATION

These critical issues have been debated in a special symposium (*Biomonitoring: Lessons from the past, challenges for the future*) of the 13th European Ecological Federation (EEF) and 25th Italian Society of Ecology's (S.It.E.) joint conference – *Ecology at the Interface: science-based solutions for human well-being* – held in Rome (Italy), September 21st - 25th September 2015. The

mission of this symposium was the knowledge exchange between international groups that work with biomonitoring, also through the implementation and the support of basic discussion. In this context, our main goal was the sharing of methodological approaches to support the development of robust indicators, providing tools for their calibration and a proper use. This special issue is the symposium outcome, based on a selection of 13 peer-reviewed papers dealing with all the main biotic components of freshwater ecosystems, with special emphasis to the responses of the aquatic biological community to the main environmental and human drivers.

Four papers address the focal issue of the running water biomonitoring based on macroinvertebrates (Bo *et al.,* 2017; Burgazzi *et al.,* 2017; Guareschi *et al.*, 2017; Merritt *et al.*, 2017). They focus on multiple themes, as well as the importance of adopting functional approaches in river monitoring programs (Merritt *et al.*, 2017), or the contribution of rare *taxa* to the classification of water bodies (Guareschi *et al.*, 2017). Bo and colleagues (2017) review the history and development of macroinvertebrate indices in use in Italy, providing suggestion to improve the current biomonitoring approach. Another key aspect addressed in the present special issue is the role of mesohabitat mosaic in driving macroinvertebrate diversity and variability in braided rivers (Burgazzi *et al.*, 2017). These systems are general poorly studied, and their intrinsic structural high complexity is often neglected in biomonitoring protocols. As a major result, the summer flow reduction as a homogenizing force leads to a general loss of the most sensitive *taxa*.

In Mediterranean rivers, the strong seasonality with drought during the hot season and extreme flows in autumn-winter greatly drives the primary production and the trophic chain (Barthés *et al.*, 2015). The on-going climate change is expected to exacerbate the weather extremes with dramatic effects on river biofilm species diversity, growing rates or photosynthetic pigments (Tornés and Ruhì, 2013). In this context, Piano *et al*. (2017) investigate by regression modelling analysis the responses of benthic chlorophyll *a* concentration – assumed as a proxy of the algal biomass – to hydrological variability, including river intermittency. Specifically, they have tested the usefulness of using an *in situ* fluorimetric probe (BenthoTorch®) to discriminate between the main algal groups (*i.e.*, diatoms, cyanobacteria, and green algae) composing autotrophic biofilm. Della Bella *et al.* (2017), instead, apply a classical approach to explore the diatom diversity across the different river macrotypes recorded in the Umbria region (Central Italy). They focus on the Intercalibration Common Metric Index (ICMi; Mancini and Sollazzo, 2009), suggesting the existence of strong differences between diatomic diversity metrics comparing different Mediterranean river types, an aspect that should be taken into account in comparative studies.

Macrophytes are a further key element in monitoring programs, however additional investigations are needed to refine their use in biomonitoring because the complex interactions between aquatic primary producers and ecological drivers (Demars *et al.*, 2012; Bolpagni and Laini, 2016; Bolpagni *et al.*, 2016). In addition, alien plants may be considered one of the most critical causes of the functionality loss of aquatic ecosystems. The available knowledge needs to be improved to better manage control and mitigation programs. For this purpose, Bertrin *et al*. (2017) investigate the distribution patterns of alien species in the Aquitaine lakes, considering the influence of hydromorphology on plants morphological plasticity. All this information is fundamental to support effective actions. Similarly, to monitor and to counteract the worldwide aquatic environments decline, Sender *et al.* (2017) propose a new multi-criteria method of evaluation and assessment of the ecological status of lakes based mainly on macrophytes. Among other things, this method allows to point out a zonal evaluation of the lacustrine environment, identifying the most critic zones in terms of ecological status. In this way, it becomes easier and immediate to identify the most effective recovery actions. Additionally, with the aim of making monitoring procedures leaner and more effective, Bolpagni *et al.* (2017) explore the potential integration between the Habitat Directive (HD, European Union, 1992) and the WFD. A better integration between these two directives turned out to be a win-win strategy to obtain reliable information on the ranges occupied by macrophytes and aquatic habitats *sensu* HD, and to examine their status of conservation (Bolpagni *et al.*, 2013; Azzella *et al.*, 2014). In the general context of the macrophyte-environment relationships, another key question is the responses of the co-occurrence patterns of species to environmental gradients. This issue is investigated by Azzella *et al.* (2017) focusing on the depth distribution patterns of macrophytes in a series of volcanic lakes in Central Italy by using a null model analysis approach. Their main efforts confirm the not random co-occurrence patterns of macrophyte' communities in deep lakes. As a rule, it is fundamental to evaluate the local effects of lake trophy or human perturbations on plant dynamics before inquiring the arrangement of species.

In the last decades, remote sensing techniques have proved to be an extraordinary effective tool for monitoring ecosystems at multiple scales, especially for the aquatic ones. Bresciani *et al*. (2017) test their usefulness in the analysis of cyanobacterial blooms in the frame of the BLASCO project (CARIPLO Rif. 2014-1249). These authors verified the highly effectiveness of remote sensing for mapping cyanobacterial blooms and highlighted their main advantages, including the generation of synoptic and dynamic views. Additionally, Villa *et al*. (2017) explore the potential of airborne and spaceborne imaging sensors

for mapping aquatic vegetation based on the spectral responses of its morphological and physiological features. They focused on macrophyte morphological traits (*i.e.*, fractional cover, leaf area index and above-water biomass) to discuss on the pivotal contribution offered by remote sensing to support macrophyte monitoring and management (Villa *et al.*, 2015).

Finally, one contribution addresses the role of physical and chemical drivers, as well as the functional complexity of riparian contexts in structuring the population of one of the most threatened target animal group: inland water fish. The paper by Piccoli *et al.* (2017) is finalized to assess the contribution of a complex of *Natura 2000* sites to support fish communities, with special emphasis to two endemic and one alien *Barbus* species, implementing the current data on their local spatial distribution.

Generally, all these studies stimulate a new awareness on the pivotal contribution of the biomonitoring approaches in the recovery of ecosystems and their functions, emphasizing the need of a better integration between sector knowledges and legislative instruments. This is a fundamental objective in a fast changing world, in order to improve our capability to record rapid changes in ecosystems, and then be ready to elaborate effective/adaptive responses to them.

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