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Editorial: Biomonitoring freshwater ecosystems health in a changing world: the significance of socio-ecological approaches

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Editorial on the Research Topic
Biomonitoring freshwater ecosystems health in a changing world: the significance of socio-ecological approaches

Water is undoubtedly the main source of life on earth, providing essential elements needed by all living beings to maintain vital functions. It is estimated that approximately 70% of the human body consists of water, which is needed for many physiological and metabolic activities (Jéquier and Constant, 2010; Munteanu et al., 2021). The availability of clean water is essential for maintaining a healthy ecosystem, and socio-economic development (United Nations Environment Programme, 2016; United Nations, 2020). Freshwater ecosystems, particularly, are used for waste treatment, fisheries, drinking water, and support cultural and recreation activities (e.g., boating and swimming; Dudgeon et al., 2006).

Although water covers a large part of the world, only approximately 0.74% is available for drinking (Rost et al., 2008; Yilmaz, 2013). At the same time, overexploitation and anthropogenic pollution from rapid population growth, unplanned urban and industrial development, as well as climatic change and war outcomes present critical threats to the ecological health of freshwater ecosystems (Edegbene and Akamagwuna, 2022; Priya et al., 2023). As a result, freshwater ecosystems are considered among the most threatened; experiencing large biodiversity declines and are at high risk of global collapses (Dudgeon et al., 2006; Dudgeon, 2019). Moreover, recent studies have demonstrated recovery of freshwater biodiversity, especially in developed nations with water management activities (e.g. Europe; Haase et al., 2023). The threat posed by the aforementioned anthropogenic activities on freshwater ecosystems have drastically reduced the quality of water and the services they provide (Dudgeon et al., 2006).

Biological monitoring studies are becoming increasingly important worldwide to improve and prevent water pollution, and research on the subject continues unabated. Biomonitoring of ecosystem health is rooted in the principle of comparing the assemblages

of organisms at an impacted site with those at a minimally impacted, control or reference site (Reece and Richardson, 2000; Bonada et al., 2006; Edegbene et al., 2023). The difference in assemblages between impacted and control sites provides information on the health status of riverine ecosystems at the impacted site (Akamagwuna et al., 2022; Edegbene et al., 2023). Even though studies on biomonitoring of freshwater ecosystems have made significant strides, yielding invaluable information into how natural systems respond to stressors and provide a basis for effective environmental management, the pressures facing water resources are multi-faceted and complex, cutting across ecological, societal, and economic boundaries (Olatunji et al., 2023). Additionally, various methods and indicators have been established to characterize and assess these multi-layered challenges but often through a narrow disciplinary lens (e.g., hydrology, ecology, or economics; Vogel et al., 2015). This silo-approach de-emphasises the interconnectedness and interactions between these challenges in a complex social-ecological system, thereby contributing to the continued threats on freshwater ecosystems globally.

Our present Research Topic, "*Biomonitoring Freshwater Ecosystems Health in a Changing World: the Significance of Socio-Ecological Approaches*," provides insights on employing a multi-dimensional approach that integrates ecology, society, and economic parameters as indicators for determining the health of freshwater ecosystems in a complex and dynamic world. Such approaches and issues are at the heart of Integrated Water Resource Management (IWRM) and Socio-Ecological Systems (SES) research (Berkes et al., 2003). Our Research Topic aims to describe the state of using socio-ecological approaches to biological monitoring of freshwater ecosystems, unpacking knowledge gaps regarding the role of the links between ecology, society, and practice in strengthening biomonitoring of freshwater ecosystems.

In our Research Topic, the benefits of using socio-ecological indicators were emphasized by Sewunet et al. The authors, in their approach, applied both quantitative and qualitative methods, leveraging local-community-based knowledge to improve the ecosystem health of lakes-impacted by water hyacinths. The findings of the study demonstrate the willingness of community stakeholders to contribute their labour and finance to preventing water hyacinths infestation; a key finding that is needed for policy formation and resource allocation for intervention management.

Aside the use of socio-ecological indicators, the development of biomonitoring tools using a taxonomic-based approach has been widely explored globally, especially in the global south. On the other hand, the use of trait-based approach in developing biomonitoring tools have been lightly explored. Traits are physiological, morphological, behavioural, and ecological characteristics and preferences of organisms (Edegbene et al., 2021). In this Research Topic, the impact of illegal gold mining (panning) and other anthropogenic activities on macroinvertebrate traits distribution pattern in an Afrotropic river ecosystem were explored by Edegbene et al. Their findings revealed that several trait combinations respond differentially to illegal gold mining (panning) and other anthropogenic activities. They also identified vulnerable and tolerant traits that can be used as a utility for assessing the ecological health conditions of freshwater ecosystems subjected to similar impacts.

Kloskowski and Nieoczym investigated the behavioural effects of omnivorous fish on amphibian spawning habitat selection. They compared the oviposition patterns of anurans larval densities as well as phytoplankton and zooplankton abundance in ponds where *Cyprinus carpio* (carp) breeds and ponds where carps were absent. They discovered that amphibians (e.g., anurans) strive more in ponds free of fish compared to ponds with a high density of fish species. Further, oviposition was reduced or absent in amphibians in ponds with high fish density. The scarcity of amphibians in ponds with a high density of fish was discovered to be caused by the predatory prowess of the carp fish.

Ngor et al. outlined the importance of physico-chemical, geo-hydrological and climatic indicators for the management of river ecosystems, especially with regard to fisheries studies globally. They used these parameters in predicting fish species richness and abundance in the Lower Mekong Basin (LMB). Six predictive models were compared regarding their performance to predict the richness and abundance of fish species. They found that the Random Forest model out-performed the remaining models. Variables such as alkalinity, distance from the sea and water level were the major predictors that explained the variation in the fish species richness and abundance in LMB.

The effects of temperature on exercise metabolism, hypoxia tolerance, and RNA sequence analysis in *Sinilabeo rendahli* from the Yangtz River in China were investigated by Li et al. The metabolic and physiological characteristics, as well as hypoxia, and changes in tolerance levels in *S. rendahli* at different temperatures, were examined for 14 days. After the 14-day window, parameters such as individual metabolic rate, temperature quotient, routine metabolic rate, critical oxygen tension and loss of equilibrium were measured while transcriptome-RNA sequencing was performed on the juvenile *S. rendahli* muscle tissue after 28 days. The study highlighted that *S. rendahli* strives more in cold water compared to relatively high temperatures.

We are confident that all the studies in our Research Topic will make a valuable contribution to future biological monitoring research using the multi-faceted approach outlined here. Further, the scientific data they provide will enable water research managers to effectively manage freshwater ecosystem, and we are happy to present our special issue to you.

Author contributions

AE: Conceptualization, Supervision, Writing – original draft, Writing – review & editing. NY: Writing – original draft, Writing – review & editing. FA: Writing – original draft, Writing – review & editing.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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