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Editorial: Advances in Biomonitoring for the Sustainability of Vulnerable African Riverine Ecosystems

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Editorial on the Research Topic

Advances in Biomonitoring for the Sustainability of Vulnerable African Riverine Ecosystems

INTRODUCTION

Since recorded time, rivers have facilitated the establishment of human civilizations because of the myriad ecosystem goods and services they offer (Macklin and Lewin, 2015). Rivers provide transportation corridors, supply food in form of fisheries, and are major sources of water for irrigation, domestic use, renewable energy, and industrial development (Ripl, 2003). However, these benefits have come at a great cost to the structural and functional integrity of rivers and linked ecosystems (Dudgeon et al., 2006; Vörösmarty et al., 2010).

The capacity of rivers to sustainably meet human needs for water and ecosystem services is premised on maintaining their ecological integrity, which encompasses the gamut of biological diversity and ecosystem processes that maintain them (Karr, 1993). In river networks, ecological integrity is spatiotemporally dynamic, largely driven by the natural flow regime (Poff et al., 1997), which provides a template for ecological processes and species to thrive. River managers have the challenge of reconciling human needs with the ecological requirements of healthy ecosystems. This requires innovative decision-support tools for assessing and monitoring the ecological status of rivers to guide management and conservation efforts.

This Research Topic presents selected original research articles and reviews on some of the tools used to assess the ecological status of rivers in Africa. The objectives of the special issue are to:

i. contribute to the development of biomonitoring tools (e.g., biotic indices, multimeric indices, models, etc.), that are affordable, rapid and easy to use for enhanced understanding of human impacts on rivers.
ii. give novel insights into the effects of multiple stressors in rivers arising from human activities, such as land-use change, water pollution and excessive water withdrawals,
iii. address methodological challenges related to the use of existing tools used for biomonitoring, and
iv. encourage knowledge sharing and standardization of tools used for biomonitoring rivers in Africa, and promote interdisciplinary collaborations.

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ECOLOGICAL STATUS OF AFRICAN RIVERS

Africa is a continent of immense natural heritage, including iconic rivers that fostered the earliest civilizations and continue to be integral to the continent's socio-economic development. Major rivers, such as the Nile, Niger, Orange, Tana, and Zambezi, drain Afromontane headwaters but downstream their flows quench semi-arid and arid lands that grace their journeys to the sea. Although Africa's rivers are amongst the least developed in the world (Grill et al., 2019), there have been ambitious plans to expand water use for irrigation, industry and hydropower (UN-Water Africa, 2003). These developments come with complex social, economic, governance or political challenges that exert multiple demands and stressors on river ecosystems at different spatial and temporal scales (Zeitoun et al., 2013; Fouchy et al., 2019; Birk et al., 2020).

Although data is limited, the status of African freshwater resources is one of a general decline (Darwall et al., 2011; UNEP-WCMC, 2016). Major concerns have been raised on the effects of pollution, urbanization, land-use change, overexploitation of biological resources, agriculture and invasive species on water quality and quantity, aquatic biodiversity, nutrient cycling, and energy sources supporting food webs (e.g., Masese et al., 2017; Fugère et al., 2018; Sayer et al., 2018; Matomela et al., 2021). These impacts are reducing ecosystem services offered by rivers and their floodplains, and undermining human well-being across the continent (IPBES, 2018).

ADVANCES IN BIOMONITORING VULNERABLE AFRICAN RIVERS

To address threats posed by multiple stressors in rivers, a determination of the present ecological condition is needed to guide decisions on management and conservation. For this reason, the development and use of bioassessment and biomonitoring tools is an integral part of integrated water resources management. While efforts have been made to develop indices or models to assess and monitor the status of rivers in Africa (Dallas, 2013; Masese et al., 2013), most countries, except South Africa, lack these tools and expertise on their use.

As a contribution to the use of biotic indices in Africa, Dallas, 2013 has presented a review on important methodological considerations for developing new or adapting existing macroinvertebrate-based biotic indices for bioassessment. Similarly, Achieng et al. and Tampo et al. present the application of multimetric indices in rivers based on fishes and macroinvertebrates, respectively. Other interesting biomonitoring approaches covered in this Special Topic include the use of macroinvertebrate traits as indicators of ecological health (Edegbene et al.) and the use of host-parasite dynamics as bioindicators of heavy metal pollution in rivers (Keke et al.). Considering that identification of reference conditions is a prerequisite for biomonitoring programs (Dallas, 2013), Agboola et al. demonstrate the use of the multivariate approach in the selection of reference sites, and in their second paper, they show how to conduct an ecological risk assessment of stressors in rivers in KwaZulu Natal, South Africa.

The use of citizen science as an environmental monitoring approach in many African countries is quite limited (Requier et al., 2020). To address this need, Aura et al. used indigenous knowledge to develop a multimeric index, called the "Citizen Index of Ecological Integrity (CIEI)," for bioassessment of rivers. Further, Ndiritu et al. developed a biomonitoring framework based on the United States Environmental Protection Agency's Biological Condition Gradient (BCG; USEPA, 2016) to support the rehabilitation of the upper Tana River basin in Kenya.

WAY FORWARD

Innovative approaches and management solutions are required to achieve water-related sustainable development of African economies. The governments, research institutions, private sector, and civil society need to be involved in addressing the inherent problems. Below we highlight three areas of action that should be prioritized for improved conservation and management of rivers in Africa.

1. Plans to develop water resources should espouse principles of integrated water resources management (IWRM) (Dirwai et al., 2021). IWRM seeks to develop and manage water in a manner that maximizes economic and social benefits for multiple water users without degrading ecosystems (Meran et al., 2021).
2. While striving to supply water to millions of people in sub-Saharan Africa who lack access to safe drinking water and sanitation (Armah et al., 2018), the effects of water withdrawals on the ecological condition of rivers should be monitored. This calls for water allocation planning, water accounting and environmental flows assessments to apportion available water for river ecosystems and abstractive uses.
3. The complex mix of multiple stressors acting on rivers in Africa calls for multidisciplinary, multi-institutional, and transboundary (where necessary) collaborations and stakeholder participation to develop decision-support tools to guide the conservation and management of river ecosystems at multiple scales.

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All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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