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Editorial: Freshwater science in the tropical anthropocene

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Editorial on the Research Topic
Freshwater science in the tropical anthropocene

Freshwater ecosystems comprise only 0.01% of the volume of water on Earth (Dudgeon et al., 2006) and 0.8% of its surface (Mittermeier et al., 2010), while harboring approximately 10% of the global diversity (Strayer and Dudgeon, 2010; Winemiller, 2018). Waterways, wetlands, lakes, and other freshwater ecosystems provide many ecosystem services, for example, provisioning, supporting, and cultural or nonmaterial benefits (Millennium Ecosystem Assessment, 2003; Millennium Ecosystem Assessment, 2005).

Tropical freshwater globally harbors most species with high genetic and phylogenetic diversity, and high endemism (e.g., Willig et al., 2003; Lomolino et al., 2010). Nevertheless, the tropics include areas still unknown or poorly studied (Irvine et al., 2016; Rico-Sánchez et al., 2020). Additionally, there is high human diversity with numerous cultures and languages (Collard and Foley, 2002), and developing countries in the tropics generally have high population density and industrial growth while lacking funds for environmental research, monitoring, and policy-making (Irvine et al., 2016; Kwok et al., 2007).

Despite the fundamental and irreplaceable role of freshwater ecosystems in sustaining life on Earth, these ecosystems are considered among the most threatened (Dudgeon, 2019). In the Anthropocene, freshwater environments are subjected to multiple stressors and cumulative impacts from the interactions of these stressors (Garcia-Moreno et al., 2014; Reid et al., 2019). These impacts are particularly evident in tropical freshwater ecosystems, which have been described as endangered hotspots (Dudgeon et al., 2006; Darwall et al., 2009; Mittermeier et al., 2010), in large part because of the ability to balance supply water for a large human population, the full range of ecosystem services and conservation of freshwater ecosystems and aquatic biodiversity is especially challenged in the region where research funding and environmental regulation and policy are limited.

The research topic *"Freshwater Science in the Tropical Anthropocene"* aimed to provide a critical overview of the current state of the gaps in our understanding of Freshwater Science in the Tropical Anthropocene, its challenges, and its major developments.

One of the consequences of the Anthropocene is the so-called sixth massive biodiversity extinction (Kolbert, 2014). Freshwater biodiversity does not escape this trend (Collins, 2010; Winemiller, 2018; Cowie et al., 2022). An emergency recovery plan to bending the curve of global freshwater biodiversity loss (BCGFBL) has been proposed by Tickner et al. (2020),

delineating priority actions including, restoring critical habitats, and managing the exploitation of freshwater ecosystem resources, especially species and riverine aggregates. In addition, Bozelli (2019) taking into account the conditions in Brazil propose protection of ecosystem as a first step to restoration.

In our topic issue, a proposal for a Theory of Change to reverse the current Mexican freshwater fish extinction crisis is presented by Contreras-McBeath et al. The authors analyze the particular conditions of Mexico and suggest key intervention areas including restoration and reintroduction, conservation management prioritizing critically endangered species, exploration to find possibly extinct species, and communication and outreach to gain support for conservation interventions. These important findings by Contreras-McBeath et al., align with at least two priority actions presented by Tickner et al. (2020) to BCGFBL.

In addition, Keke et al. described the importance of analyzing ß- and γ-diversity to identify priority sites for conservation in Afrotropical lotic ecosystems where land-use alterations is a key driver of biodiversity loss. Consistent with Bozelli (2019), protection of ecosystems is the primary recommended action for restoring tropical freshwater ecosystems.

Biomonitoring is a key tool that provides a cost-effective and reliable way of assessing these changes in freshwater systems in response to cumulative impacts from multiple stressors, and for developing management strategies. However, in tropical freshwater ecosystems, impacts to freshwater ecosystems and aquatic biodiversity are often poorly understood because biomonitoring is not widely implemented. In this this topic, a characterization of an Andean river using physicochemical water parameters and biotic quality indices (including aquatic macroinvertebrates) is presented by Carrasco-Badajoz et al. their findings demonstrate that aquatic macroinvertebrates are suitable monitoring parameters for assessing water quality and that biomonitoring is a reliable, effective, and affordable assessment tool in developing countries, which was also a proposal by Bozelli (2019).

The effect of introduced fish and seasonality on aquatic ecosystem condition was assessed by Bellingan et al. using aquatic macroinvertebrates in the Keiskamma River system, South Africa. Macroinvertebrates patterns were driven primarily by seasonal flow patterns, although the presence of introduced fish also influenced macroinvertebrates. Thus, macroinvertebrates are sensitive indicators of the effects of non-native fish, and have potential to be an important biomonitoring tool to assess the impact of exotic species in tropical systems.

The DNA barcode (COI gene) was used for monitoring freshwater biodiversity and detecting changes in communities following perturbations to aquatic ecosystem in Mexico by Elías-Gutiérrez and Valdes-Moreno. Environmental DNA (eDNA) is a proving to be promising tool for assessing freshwater biodiversity and environmental change in the megadiverse Neotropics, and as valuable biomonitoring approach as also shown by Reid et al. (2019), although eDNA studies should be supported by a well-documented DNA baseline.

Pollution of freshwater ecosystems has long been a major issue, which has been exacerbated in the Anthropocene by the production and use of novel chemicals known as emerging pollutants (EP) and other pollutants of emerging concern (Tavengwa and Dalu, 2022). Among these new classes of pollutant, microplastics have emerged as a considerable a global issue. However, studies in tropical freshwater ecosystems are scarce, and there is a pressing need to strengthen scientific knowledge (Yardy et al., 2022). In this volume, Moyo present a meta-analysis of microplastics and to assess their impacts on functional traits of tropical freshwater fish and invertebrates. Bacterivores, omnivores, predators, and filter feeders were the guilds most affected by microplastic pollution of freshwaters compared to shredders, with filter feeders particularly susceptible as they are passive consumers. It was recommended that future studies assess chronic and long-term physiological and behavioral effects of microplastics on freshwater organisms. A second paper in this topic (Lopez et al.) highlighted the limitations around studying the chemical nature of microplastic pollution of tropical freshwater systems, and as a first step assessed the occurrence, concentration and distribution of suspected suspended microplastics (SSMP) in Ecuador. The authors used the SSMP/zooplankton ratio to evaluate the risk to filter and suspension feeders, which are potentially predisposed to consume SSMP at the expense of natural food items.

The topic of *"Freshwater science in the tropical anthropocene"* has emerged as a major area of research interest, and will continue to be a key focus area of pure and applied research. Indeed, further research is needed to increase understanding of the resilience of tropical freshwater systems to the cumulative impacts of multiple stressors, support management to better balance competing demands on tropical freshwater ecosystems, and support the development of biomonitoring programs and more robust policy frameworks to facilitate effective conservation of tropical freshwater ecosystem health and biodiversity.

Author contributions

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

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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