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Editorial: Environmental citizen studies in freshwater science

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Editorial on the Research Topic

Environmental citizen studies in freshwater science

Traditional freshwater research, which aims to address and investigate the ecology and management of aquatic environments, has typically been a costly and time-consuming activity (Njue et al., 2019). Water quality monitoring and data gathering methods can add substantial costs to institutions and government agencies engaged in monitoring. These costs include personnel resources in the field and laboratory, technical equipment and maintenance, supplies, and overall logistics in data collection and coordination. Large watershed areas can exacerbate complexities and costs by limiting access or creating constraints for timely or event driven site visits, thus limiting opportunities for temporal or episodic surveillance of these systems. This can lead to infrequent data collection efforts, creating data gaps that diminish the utility and meaningfulness of the data.

Observing and monitoring freshwater systems through citizen science programs has increased dramatically in recent times through public engagement via social media campaigns and online activities (Walker et al., 2020). Citizen science can help to fill observational gaps where traditional scientific observations are limited (Walker et al., 2020) or under reported (Hadj-Hammou et al., 2017). Citizen scientists have the advantage of being place-based, making it more logistically feasible to capture episodic events or increase the temporal frequency in monitoring efforts. This provides an enhanced resolution of resource conditions and dynamics. Data collection efforts by citizen scientists also create additional benefits by heightening local awareness and knowledge of local issues, engaging people in active resource management and advocacy, and promoting sound resource stewardship backed by credible scientific data.

Engaging diverse participants in freshwater research and resource management can take many forms, but the common thread of paramount importance is the generation of useable data. High-quality citizen science data is vital, and with appropriate training and protocols developed to guide organisations and participants, citizen science data can demonstrate quality assurance and control, matching the quality of data collected by paid experts, particularly for standard aquatic measurements. When implemented correctly, these measures address many concerns about citizen science data accuracy or suitability, allowing the integration of citizen science data with traditionally collected data. Buytaert et al. (2016) suggest that the development of low-cost technologies is facilitating a shift from centralised monitoring to a more diverse, decentralised approach. This new methodology

integrates multiple data sources including remote sensing, *in situ* sensing and citizen science, providing a more comprehensive understanding of freshwater systems. Understanding the challenges for all citizen scientists in freshwater research, in terms of leading projects, producing reliable data, and retaining participants, is pivotal for successful programs.

The goal of this Research Topic is to share insightful and inspiring information about how to effectively collaborate and communicate with communities in ways that advance freshwater research and its application in diverse contexts. The articles frame challenges and opportunities for citizen science, and provide relevant case studies in regional, national, and global contexts.

Kirschke et al., present the outcomes from a global survey aimed at understanding the comparative effects of citizen science projects in water quality. Findings suggest that most citizen science projects in the field are successful in delivering positive results particularly relating to data outputs and societal outcomes. The authors stress the importance of project design and funding to derive impact from such initiatives. Collins et al. profile a range of citizen science opportunities specific to the freshwater environment across the United Kingdom. They provide examples of new approaches for consideration to increase the contribution of communities in understanding and addressing pollution of aquatic environments. Wu et al. examine citizen science and water quality monitoring across China. Their findings suggest that training requires enhancement (particularly in certain regions) and that the term “citizen science” may serve as a barrier to more widespread engagement. Dickson et al. provide a case study of a regional water quality program in Australia. They examine methods and results to assess the accuracy of citizen science data against paid expert data collection efforts. Findings suggest that when the program is properly supported and integrated with professional scientific data, the results are generally accurate and representative, thereby better informing management. Additionally, community contributions to scientific research have many other benefits, such as fostering environmental stewardship and increasing the spatial and temporal coverage of monitoring programs. O'Reilly and Starrs provide insights into how to tailor an existing citizen science program to meet new funding requirements. As a result, the program has become an integral part of catchment health and local land management policy, with improvements to data quality assurance and control processes. Starkey et al. detail barriers to community water quality monitoring across both Taiwan and the United Kingdom. They expose important technical barriers that still exist, preventing many communities from taking the lead in water quality monitoring schemes.

We hope that these articles will inspire increased engagement and interest in citizen science and freshwater research, re-engaging communities with freshwater ecosystems globally. As editors of this Research Topic, we encouraged and aimed to include manuscripts

covering a range of geographies and scales of interaction, spanning from the local and regional to national and global levels. Unfortunately, we are missing articles referencing the Americas, Africa, and Indigenous groups around the world. We had hoped to attract a more comprehensive and geographically diverse Research Topic to serve as a reference point for communities and researchers alike. The absence of contributions from these continents and Indigenous groups creates a gap in the narrative, hindering a complete understanding of the challenges and opportunities faced by communities in these regions.

Recognising this gap, we understand that while citizen science activities are operating, they may not be well connected to the global community. There are also far fewer citizen science initiatives operating in some of these regions due to insufficient incentives, lack of awareness and economic pressures (see Ferraro and Kiss (2002) for a discussion on incentivising biodiversity conservation). Freshwater ecosystem issues are universal, and a more inclusive representation in research is crucial for crafting effective, context-specific solutions. Our call to action is for additional investment in identifying the most efficient and useful monitoring systems to ensure both researchers and communities are benefitting from this important area for citizen science globally.

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ER: Writing—original draft, Writing—review and editing. JA: Writing—review and editing. IO: Writing—review and editing. HS: Writing—review and editing.

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