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The potential for freshwater citizen science to engage and empower: a case study of the Rivers Trusts, United Kingdom

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Rivers Trusts in the United Kingdom work to protect and restore freshwater ecosystems. This includes the provision of citizen science opportunities that encompass water quality monitoring, assessment of polluting outfalls, surveying riverine plastic pollution, mapping and control of freshwater invasive species and assessment of the biological health of rivers. In some cases, citizen science data has led directly to action being taken to address a pollution source and, in one example, indirectly influenced policy focus. Online platforms play an increasingly important role in capturing and portraying citizen science data. A large multi-stakeholder initiative aims to achieve a step-change in the contribution of citizen science to the assessment of river health including development of a standardised national framework. There is potential for citizen science to widen the monitoring of freshwater to encompass toxic chemicals.

KEYWORDS

freshwater citizen science, Rivers Trusts, water quality, pollution, online data platforms

1 Introduction

Numerous examples of freshwater citizen science can be found, globally, including the monitoring of: bacteria as an indicator of sewage (Farnham et al., 2017), urban water quality (Ho et al., 2020; Hegarty et al., 2021), phytoplankton blooms (Castilla et al., 2015), organic micropollutants in lakes (Wang et al., 2020), riverine microplastics (Forrest et al., 2019), and hydrological parameters (Starkey et al., 2017; Weeser et al., 2018). Whilst several citizen science typologies are recognised, ranging from a basic collection of data through to co-created involvement in research design (Shirk et al., 2012; Haklay, 2021), the dominant approach within freshwater citizen science projects lies disproportionately at the lowest level of participation and more significant involvement remains uncommon (Njue et al., 2019; Schölvinck et al., 2022). Additional challenges of data quality (Aceves-Bueno et al., 2017), and lack of subsequent action by decision-makers (Conrad and Hilchey, 2011) are also documented.

The value of citizen science in supporting the monitoring and tracking of progress of the United Nations Sustainable Development Goals, has been demonstrated (Fritz et al., 2019), highlighting its potential to improve the reporting process. In the United Kingdom, freshwater citizen science has been given recent impetus through growing media and public awareness (Consumer Council for Water, 2021) of the poor quality of United Kingdom rivers, stimulating national debate and, anecdotal evidence suggests, promoting a rise in freshwater citizen science as civil society seeks to have greater ownership in addressing the issue. Moreover, a recent Parliamentary Inquiry into Water Quality (EAC, 2021) included several recommendations supportive of citizen science.

The Rivers Trust (RT) is a registered independent environmental charity and the umbrella body for 65 member trusts across Britain, Northern Ireland and Ireland. RT and its member trusts undertake river catchment management, with the goal of healthy freshwater ecosystems. This includes the provision of volunteering and citizen science opportunities to enhance the local evidence base and improve understanding of river health.

Varied freshwater citizen science activities are overseen by the Rivers Trusts, and a primary objective of this paper is to highlight several techniques, and the value of online platforms to capture the data arising. Secondly, evidence is provided of how data derived from this citizen science has stimulated some form of action to address a particular issue. Thirdly, a new, innovative approach is introduced that aims to create a step-change in the contribution of citizen science to integrated catchment management. The potential for citizen science to address chemical pollution is also explored.

2 Case studies

2.1 Monitoring freshwater quality

Several Rivers Trusts oversee citizen science monitoring of river water quality, recognizing its value in raising awareness in local communities and contributing to the evaluation of river health. Initially, these initiatives may be designed as one-off “waterblitz” approaches whereby several volunteers each use, for example, nutrient test strips across a river network, on the same day. Such approaches only provide a snapshot of river health, however, with pollutant sources and concentrations being strongly dictated by river flow at the time of monitoring. Nevertheless, the approach has merit with respect to attracting wide community engagement with an objective to initiate interest with a view to retaining some volunteers for more sustained citizen science activities.

More commonly, citizen science under Rivers Trusts aims to undertake repeat monitoring at a regular interval over a prolonged period, to gain a more robust picture of ecosystem health. Westcountry Rivers Trust’s citizen science investigation initiative (Westcountry Rivers Trust, 2023b), for example, aims to create a network of river catchment communities invested in their local river environment. Water quality monitoring kits are provided to participants, together with guidance on sampling locality, protocol and safety. Monthly sampling is encouraged, with data being captured on a dedicated online platform and downloadable for analysis. Where 12 or more samples have been collected over a year for a particular waterbody, a scorecard is generated based on measurement of dissolved and suspended solids, phosphate, evidence of recent pollution and pollution sources, and ecology (Westcountry Rivers Trust, 2023a).

2.2 Monitoring surface water outfalls

One of the major threats to water quality in urban rivers is misconnections, whereby incorrect plumbing means that untreated, foul water from homes discharges into rivers via the surface water drainage system rather than to the sewage treatment works. Misconnections, therefore, detrimentally impact the freshwater ecosystem, often markedly (Revitt and Ellis, 2016). The Zoological Society of London has led the development of a citizen science method, known as Outfall Safari, for locating, assessing the impact of, and reporting on polluted surface water outfalls (Pecorelli and Walker, 2019). In dry weather, trained volunteers walk the riverbanks with a mobile app that allows them to geolocate, photograph and assess outfalls for evidence of pollution. Data is sent directly to a database for analysis and reporting to the regulator and water company. Several Rivers Trusts have adopted the Outfall Safari (Catchment based approach, 2023a; Catchment based approach, 2023b; South East Rivers Trust, 2023), training citizen scientists to support the survey and assessment of outfalls. In the case of South East Rivers Trust, for example, subsequent investigations by Thames Water have helped homeowners to rectify more than 400 misconnected appliances (South East Rivers Trust, 2023).

2.3 Bathing water quality

The United Kingdom has over 600 designated coastal bathing water sites, 406 of them in England (GOV.UK, 2021) which each require monitoring for microbial water quality. Unlike most other European countries, however, the United Kingdom, until very recently, had not a single river bathing water designation, with river water quality standards historically being set to protect aquatic life rather than public health, through implementation of the European Union’s Water Framework Directive (European Commission, 2023).

Numerous local community groups nationwide continue to campaign for bathing water status for their river bathing site. This process includes the mobilisation of community support to undertake bacterial water quality monitoring to evaluate the threat to public health. The data arising from such citizen science has helped to support the successful designation of the United Kingdom’s first two river bathing water sites at Ilkley (Ilkley Clean River Campaign, 2023; Yorkshire Dales Rivers Trust, 2023) and Oxford (Thames21, 2023), respectively, and several other ongoing campaigns. In this respect, citizen science can be viewed as influencing, indirectly at least, the focus of an existing government policy. Successful designation at a site requires action to address all sources of microbial pollution to ensure water quality standards to protect public health are met.

Since 2020, RT has mapped and made freely available online, the location and spill frequency of storm overflows and the location of wastewater treatment plants nationwide (The Rivers Trust, 2023b), extracting the information from an Environment Agency (the public body with responsibilities relating to the protection and enhancement of the environment in England) database. The map has been widely referenced in local, regional, and national media (with 55,779 unique views in 2022) and used to support local community investigations into microbial water quality, particularly with respect to applications to Government to designate inland bathing water status at several river locations nationwide.

2.4 River habitat restoration—fish and eel passage

The Thames Rivers Trust, the hub for rivers trusts across the Thames River basin, has worked with the Zoological Society of London, the Thames Estuary Partnership and fellow Rivers Trusts, Action for the River Kennet, South East Rivers Trust and Thames21, to co-develop a standardised methodology, known as ObstacEELS, for citizen scientists to use to identify and assess obstacles preventing the migration of eels (Thames Rivers Trust, 2023). Local members of the community trained in the approach surveyed rivers in the Thames catchment during 2021, assessing the "passability" of each man-made structure in the river channel, ground truthing old data and collecting supporting imagery using the River Obstacles app (River Obstacles, 2023). The app records the route the citizen scientists take when surveying, enabling future work to focus on un-surveyed reaches of the river. It also enables review of data and the removal of duplicates, and the clean data is fed into the Thames Estuary Partnership's fish migration roadmap. The mapping enables prioritisation of projects to open fish passage. All data is shared with the Environment Agency to inform the Thames River Basin Eel Management Plan.

Unlocking the Severn (2023a) is a large-scale conservation and river engagement project focused on restoring the connectivity of the River Severn. The creation of fish passage at 6 barriers (weirs and dams) has opened up 158 miles of river habitat (Unlocking the Severn, 2023b), supporting both eel and salmon migration but also one of the United Kingdom's rarest fish, the twaite shad. As part of this, the Severn Rivers Trust has developed a citizen science and community engagement program (Unlocking the Severn, 2023a) that collects data to support estimation of shad population run size, through counting of fish over specified time periods swimming through a notch in a weir. This included online monitoring by citizen scientists during the COVID pandemic through use of a video feed.

2.5 Freshwater biota—Riverfly monitoring

The Anglers' Riverfly Monitoring Initiative was launched in 2007 (The Riverfly Partnership, 2023b) to record the presence and abundance of pollution-sensitive invertebrate groups as an indicator of river pollution and change in local environmental conditions. The focus of the monitoring is on "riverflies"–mayflies, stoneflies and caddisflies, identified through kick sampling of the riverbed, using a simple standardised technique (The Riverfly Partnership, 2023a). A training programme enables any interested party, including anglers and local community groups, to carry out Riverfly monitoring, and the initiative is widespread across a network of organisations in the United Kingdom, meaning that monitoring of invertebrates is undertaken at a greater spatial and temporal scale than would be possible through regulatory monitoring alone. Data nationwide is stored in an open-access database hosted by the Freshwater Biological Association and accessible through the Riverfly Partnership website. The verified data is freely available to view and download under the terms of the Open Government Licence.

If invertebrate scores drop below a "trigger level" of expected population abundances at a given locality, the appropriate regulatory authority is notified so that the problem can be identified, and action taken. There are several documented occurrences of successful action being taken based on Riverfly data, including that collected by volunteers trained by Action for the River Kennet and Tyne Rivers Trust (Thompson et al., 2015; Brooks et al., 2019). The citizen science underpinning the initiative is, therefore, considered to be sufficiently accurate and robust to drive subsequent action. Several Rivers Trusts both undertake Riverfly monitoring themselves and train volunteers. Ribble Rivers Trust (2023) and Bristol Avon Rivers Trust (2023) for example, both have a comprehensive network of monitored sites and map the resultant data across their respective catchments.

2.6 Freshwater invasive non-native species

Despite the environmental threats (IUCN, 2023) and economic burden (Oreska and Aldridge, 2011) posed by Freshwater Invasive Non-Native Species (FINNS), resources to tackle the problem in the United Kingdom remain very limited, with the need to take a coordinated approach at a river catchment scale and a requirement to engage with numerous different riparian landowners to access land, providing additional challenges. To address these, several Rivers Trusts work with local volunteers to undertake citizen science to map and provide direct support to the control and/or eradication of, primarily, plant FINNS.

Norfolk Rivers Trust and the Norfolk Non-Native Species Initiative are collaborating to remove and, where possible, eradicate Himalayan balsam (*Impatiens glandulifera*) from the Wensum catchment (Norfolk Rivers Trust, 2022). The Wensum River is a chalk stream and hence recognised as a globally important freshwater ecosystem. However, the balsam grows up to 2 m in dense stands on the riverbank, competing with native plants for light, space and nutrients. The project, funded by the local water company, Anglian Water, brings together several stakeholders across the Wensum area to report sightings of balsam via a dedicated web and mobile phone app and to support events to undertake direct removal of the plant. A similar approach is adopted by Tees Rivers Trust to the tackling of Giant Hogweed (*Heracleum mantegazzianum*), a riparian plant whose sap can cause blistering and irritation to the skin. Mapped sightings, including by volunteers, are captured online and used by Tees Rivers Trust to coordinate and target action across several stakeholders and to monitor progress in removal of the plant (Tees Rivers Trust, 2021).

2.7 Plastics

It is estimated that around 80% of marine litter in Europe comes from land-based sources and approximately 85% of this is made up of plastic waste (EEA, 2023). To date, however, monitoring of litter in the environment has been focused primarily on beaches, with initiatives such as the "Beachwatch" campaign (Marine Conservation Society, 2022), but less data has been collected in upstream river catchments.

To address the lack of data in river catchments and amplify the efforts of existing litter picking groups, the Preventing Plastic Pollution (PPP) project created an initiative to pick and monitor litter from source to sea (Preventing Plastic Pollution, 2023b). The project was funded by the Interreg France (Channel) England Programme (Interreg, 2023) and was supported by several stakeholder organisations. The project brought together local community groups and organisations, including Rivers Trusts, to mobilise citizen scientists in several river catchments across England. Volunteers were asked to use standardised survey methods, aligned to the OSPAR Commission's guidelines for monitoring marine litter (OSPAR Commission, 2010) to ensure data comparability.

RT has developed an open access plastics data platform (Preventing Plastic Pollution, 2023a), enabling community groups to access guidance and resources, upload survey findings, visualise results and export data in a variety of formats. The aim is to populate the database with similar survey initiatives nationwide to provide a comprehensive and quantitative overview of the issue. To that end, the platform is designed with a tiered approach to account for the varying levels of time and rigour applied to data collection, ranging from a single overview survey event, through basic to advanced litter counts and brand audits, whereby polymer types and the company associated with the plastic are identified. The user is both able to search for an existing community initiative, thereby helping with volunteer recruitment and to add a new group. The data can be downloaded in a variety of formats, as well as accessed via an openly accessible Application Programming Interface (IBM, 2023).

3 Discussion and conclusion

Rivers Trusts and their partner organisations provide a range of citizen science opportunities with respect to the freshwater environment, reflecting an appetite for engagement by the public and a perceived value to participating. In common with citizen science reported elsewhere (Thornhill et al., 2019), the techniques and approaches have evolved rapidly in recent years, but whilst these enhance the local evidence base, there remain few examples of harmonised approaches being adopted at a national scale in the United Kingdom. To begin to address this, protocols have been established, e.g., with respect to monitoring plastic pollution, that are recognised as a key element of successful citizen science (Rambonnet et al., 2019). Additionally, online platforms are increasingly developed enabling the portrayal and analysis of data, targeting of action and communication with key stakeholders; publishing data in a publicly available open-access format is recognised as one of the ten principles of citizen science (Robinson et al., 2018).

Whilst examples of citizen science data directly triggering action are emerging (e.g., via Riverfly and Outfall Safari), they remain limited and wider data acceptance remains a challenge. Moreover, direct participation of citizen scientists within the research design process remains limited. To attempt to address these challenges, RT leads a new, large-scale project—Catchment Systems Thinking Cooperative (CaSTCo)—that aims to create a step-change in the contribution of citizen science and community monitoring to the assessment of river health and enhance the evidence base to support decision-making (The Rivers Trust, 2023a). Funded by OFWAT, the water services regulation authority in England, CaSTCo encompasses numerous partners including water companies, communities, local catchment partnerships, technical experts, academics, government, environmental NGOs and the private sector. Collectively, the partners will co-design a standardised national framework for monitoring of rivers and develop a platform that will integrate and openly share river catchment data from multiple sources, including citizen science. Additionally, through enabling direct participation of the citizen scientists within the research design process, it is anticipated that the project will build a sense of ownership for them, helping to address issues of retention and continuity of engagement (Land-Zandstra et al., 2021; Schölvinck et al., 2022).

Much of United Kingdom freshwater citizen science to date has focused on a relatively narrow range of determinands, primarily addressing nutrients and selected physico-chemical parameters. Chemical pollution of United Kingdom rivers is, however, ubiquitous, (EAC, 2021). To date, simple field kits for chemical analysis have not, typically, been available, precluding the monitoring of hazardous chemicals in citizen science programs. Relatively new approaches that enable on-site extraction of a chemical from a water sample (e.g., Waterkeeper Alliance, 2022) may, however, help to address these limitations. Similarly, passive samplers, which are now commercially available, can be deployed to determine time-weighted and/or flow weighted mean concentration of chemical contaminants by adsorption to media in the sampler itself followed by analysis in the laboratory. The approach has been used to monitor several contaminant types including herbicides (Farrow et al., 2022), pharmaceuticals and industrial chemicals (Moschet et al., 2015). With suitable training and sufficient resource, these new approaches provide the potential for freshwater citizen science to make a greater contribution towards addressing chemical pollution of aquatic environments.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author.

Author contributions

RC wrote the manuscript in consultation with AF, MW, and SB who made substantial contributions to its structure and scope. All authors contributed to the article and approved the submitted version.

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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.

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