

Environmental Analysis & Electrochemistry

The power of citizen science for transformative change

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As the global scientific community grapples with the intertwined challenges of climate change, biodiversity loss, and rising pollution levels, new tools and methodologies are needed to scale environmental monitoring and public engagement. One such tool - citizen science - is proving to be transformative, not only for data collection, but for community empowerment and policy impact.



Citizen science is the active involvement of non-scientists in the scientific research process. From co-creating the hypothesis and developing the methods, through data collection and analysis, to dissemination of the results, citizen scientists can play a hands-on role in research. In addition to this core research component, citizen science incorporates elements of **engagement** – raising awareness and creating nature connection – **education** – developing knowledge and honing skills – and **empowerment** – facilitating behaviour change and action.

At the environmental charity, Earthwatch Europe, we use citizen science to connect people with nature and provide them with the tools they need to take action for the planet. By working with people, nature and science, we address climate change, biodiversity loss and pollution by focusing on three key areas: soil health, urban biodiversity and water quality.

Soil health for climate resistance

Healthy soils are fundamental to sustaining agricultural productivity, and mitigating and adapting to climate change; yet degradation processes affect at least 63% of soils in the European Union. In an effort to empower farmers to become citizen scientists of their own land and help them transition to more sustainable agricultural practises, we have developed an easy-to-use soil health toolkit which assesses simple factors as proxies for more complex parameters of soil health: soil texture and infiltration rate give an indication of soil structure, while colour provides a suggestion of carbon content; vegetation cover and root depth is a proxy of how well the soil is protected against erosion, and earthworm counts are a proxy for biodiversity.

The toolkit has been used as part of the EU-funded project, Benchmarks - which aims to develop a monitoring framework and clear soil health index for benchmarking – where it was used to test soils across twenty-six allotments across the city of Brno in the Czech Republic, creating a snapshot of soil health in the region. Of the soil samples collected, 77% were greyish brown, suggesting lower levels of carbon stored within the soil; and most earthworms were found in intermediate soil conditions, as opposed to very wet or very dry. This information was provided back to the participants so that they might better connect with their soils and modify their gardening practises to improve soil quality; a clear example of **citizen science for community engagement and education**.



Determining soil colour using the soil health toolkit

Tiny Forests for urban biodiversity

Community engagement and education is also critical in our approach to addressing biodiversity loss. The World Wide Fund for Nature's Living Planet Report 2024 documents a 73% average loss in the abundance of vertebrate species since 1970. Land use change is the biggest direct driver of biodiversity loss, often leading to the destruction and fragmentation of natural spaces.



Tiny Forest planting - Bloomberg Tiny Forest. Credit Lateral North

Our Nature in Cities work aims to improve access to and connection with nature in urban areas which typically lack green space and evidence the socio-environmental benefits of nature-based solutions like Tiny Forests: small areas of urban woodland, planted using the **Miyawaki method** which involve soil preparation methods and dense planting of native tree species to encourage rapid growth.

Tiny Forests – co-designed and planted with communities - can mitigate against many of the impacts of climate change. We have shown that people feel **more thermally comfortable** in Tiny Forests as they age, with older forests having smaller temperature swings between day and night than outside of them. During the day, air temperatures are up to 6 degrees cooler inside a three-year-old Tiny Forest than they are outside of the forest. Hugely important after one of the hottest Junes on record. Tiny Forests also provide **flood mitigation**; with average infiltration rates inside a Tiny Forest 32% faster compared to the surrounding area.

Crucially, Tiny Forests also provide spaces to support urban wildlife, with the average number of ground dwellers per Tiny Forest increasing as they age. Which is reassuring, and perhaps what one might expect. But the citizen science efforts behind these data are more impressive: in 2024, our citizen scientists conducted **89 ground dweller surveys** across **68 forests**, **158 pollinator surveys** across **63 forests** and **72 butterfly surveys** across **53 forests**, equating to an incredible **108 hours of biodiversity monitoring** in one year.

Moreover, our data show that participating in Tiny Forest events significantly benefitted participants self-reported feelings of connection to nature, on average **moving from D to E on the inclusion of nature in self-scale** – which is particularly striking when you acknowledge that over 50% of UK Tiny Forests are planted in areas that score four or below on the **Index of Multiple Deprivation**.

These data – which you can explore in our latest *Tiny Forest Monitoring Report* -

demonstrate this powerful two-way street between researchers and citizen scientists; yes, researchers can gain in incredible amount of data through citizen scientists, but equally as important are the improved understanding of biodiversity, the skills to monitor it and the improved connection towards it that citizen scientists can gain.

FreshWater Watch for pollution monitoring

Nature connection is as important for our blue spaces as they are our green; not least because we are living in a global freshwater crisis, with consumption six times higher than it was a hundred years ago, and renewable freshwater resources declining across many countries.



FreshWater Watch testing in Zambia. Credit Enock Mwangilwa, WECSZ

In the UK, our rivers are polluted by many sources: sewage discharges, agricultural runoff and urban runoff. At Earthwatch, while we predominantly focus on sewage and agriculture, our citizen scientists explore all sources.

In collaboration with the Evenlode Catchment Partnership and Emissions Analytics, we investigated tyre pollution in the Evenlode catchment – a tributary of the Thames. Citizen scientists took water samples from puddles on roads, outfalls, and from rivers beneath outfalls for analysis using solid-phase microextraction with two-dimensional Gas Chromatography-Mass Spectrometry. Almost 1000 unique organic chemical compounds were detected; with 11 novel tyre compounds – never clearly evidenced before in the literature as coming from tyres – detected across all locations. We were particularly concerned by the levels of two toxic chemicals - methylene chloride and n-hexane - running from roads to rivers across this catchment.

On a wider scale, our FreshWater Watch programme allows anyone across the globe to measure nitrate and phosphate nutrient pollution in their local freshwater body. Nitrates and phosphates are found in both sewage discharges and agricultural runoff and are important indicators of ecological health; underpinning the process of eutrophication. They are detected using a simple testing kit, with the concentration of nutrient pollution demonstrated by a colour change. Participants upload these readings to an open-access platform, where datasets are updated in real time.

FreshWater Watch community groups monitor waterbodies of interest at monthly intervals; generating a temporal record of water quality at specific sites. In the United Kingdom, the biannual **Great UK WaterBlitz** creates snapshots of freshwater health across the nation. Over four days, citizen scientists assess their local rivers, lakes, ponds and streams for nutrient pollution; pinpointing pollution hotspots across the UK. In September 2024, 4500 participants investigated 2300 sites, and in April 2025 8000 citizen scientists analysed 4000 sites; **66% of which had unacceptable levels of nutrient pollution.**

In September Earthwatch partnered with researchers at Imperial College London to investigate additional chemicals present in the water; many of which - venlafaxine, trimethoprim, diclofenac, tebuconazole and acetamiprid - have appeared on EU Water

Framework Directive watch lists. In April, we partnered with *Water Rangers* and *Surfers Against Sewage* to investigate the presence of *Escherichia coli*. Bathing water classifications are based on bacterial counts which are described in Colony Forming Units, or CFU, in 100 millilitres of river or lake water. Inland waters are considered Sufficient if they contain less than 900cfu/100ml of *E. coli*; above this threshold, bathing waters are considered Poor. Our data show that **24% of sites tested** across the UK had poor water quality in terms of *E. coli* levels.

Citizen scientists used **R-Cards** and/or one of three different laboratories. R-Card and lab results had a strong positive correlation ($\rho = 0.66$, $p < 0.0001$), showing that **R-Cards are a useful citizen science tool that can compare well with laboratory testing.** Phosphate concentrations and *E. coli* levels also had a positive correlation ($\rho = 0.40$, $p = 0.006$), very likely in relation to discharges from sewage treatment works.

Much like engaging in Tiny Forest monitoring, taking part in a WaterBlitz has a positive impact on participants: our latest survey shows that **67% improved their understanding** of water quality issues, while **22% reported a positive shift** in their relationship with nature.



Great UK WaterBlitz participant

People power for policy

Citizen science is great for data collection, public engagement and education, but what about empowerment; can it really create an impact? Absolutely.

As part of our freshwater work in Sierra Leone, Earthwatch are empowering communities to monitor progress towards a Sustainable Development Goal (SDG), 6.3.2, "*Proportion of bodies of water with good ambient water quality*".

Working with UN Gems water and the National Water Resources Management Agency, we have equipped citizen scientists with the tools they need to increase monitoring cover from 18 to 34 water bodies. Importantly, the data citizen scientists generated was incorporated into official monitoring towards SDG6 by the National Water Resources Management Agency; demonstrating the potential for citizen science to contribute to monitoring or even shaping environmental policy.

Earthwatch Europe believes in the power of data for change, and in citizen science as a catalyst for environmental action. As our work demonstrates, well-designed citizen science initiatives can deliver credible datasets, engage underserved communities, and inform both local action and national policy. For researchers considering this approach, the evidence is clear: people are willing, capable, and ready to contribute to the science that shapes our planet's future.