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Hydrolink

The role of citizen science in the campaign to designate UK's first official river bathing water

By Rick Battarbee

This article describes the citizen science project that helped establish a stretch of the River Wharfe in Yorkshire as the first running water site in the United Kingdom (UK) to be designated as a bathing water. The objective was to raise local awareness about the impact of sewage discharges on faecal bacteria concentrations in the river as it flows through the small town of Ilkley. With funds from local councils and charities we conducted surveys of *Escherichia coli* abundance along the river. It was shown that high faecal bacteria concentrations were not only caused by discharges of untreated sewage but also by treated effluents and by runoff from agricultural land. As a designated bathing water, the Environment Agency is now required to monitor the site, identify specific pollution sources, and ensure control measures are put in place.

Discharging untreated or partially treated sewage into rivers to prevent sewage treatment works (STW) becoming overloaded is standard practice in the water industry. In the UK such discharges are allowed under "consent to discharge" licences issued by the Environment Agency (EA). The relevant legislation implicit assumption is that untreated discharges would occur very infrequently, only during or directly after exceptionally heavy rainfall. In recent years, however, there has been an upsurge in pollution incidents reported by members of the public and data from event detection monitors, now fitted to combined sewer overflows (CSOs) throughout the UK, show that untreated sewage spills occur not exceptionally but very frequently and in many cases over 100 times per year.

The residents of Ilkley, a small town in West Yorkshire, have been in the forefront of the campaign to halt sewage spills. Initially complaints made to the EA and to the local water company (Yorkshire Water) about spills from the local STW into the local river, the River Wharfe, fell on deaf ears. Both organisations sheltered behind the site's "consent to discharge" licence held by the company.

Figure 1 | Untreated sewage discharge from the Ilkley sewage treatment works. Photo credit: Karen Shackleton.

Enter citizen science

Some of the initial anger in Ilkley centred on the unsightly nature of the untreated sewage discharges especially those that occurred in summer when river flow was too low to wash away solid matter. But the key concern was the health risk to river users from waterborne faecal pathogens. The local campaign group consequently went in search of data on pathogen concentrations. However, requests for information revealed that monitoring faecal bacteria concentrations on rivers did not occur. Faecal bacteria are only monitored at designated bathing water sites, which in Yorkshire only occurred on the coast.

We consequently devised our own protocols and set up a citizen science project to monitor faecal bacteria *(Escherichia coli* and Intestinal enterococci) both above and below the Ilkley STW and along the full length of the River Wharfe. We raised funds from a multiplicity of local councils, charities, and other organisations including crowdfunding and trained local citizens to collect samples. The samples were analysed by a fully accredited commercial laboratory.

Our objective was to raise awareness about the issue, locally and nationally, and provide our own advice to residents and visitors about the dangers of swimming in the river, especially at sites downstream of storm overflows.

Our data showed that high concentrations of *E. coli* not only occurred downstream of the storm overflow during spills, but also downstream of the final (treated) effluent outfall on occasions when the storm overflow was not spilling. For example, the *E. coli* concentration on the 10 July 2019 was 35,000 cfu/100 ml in the river at Beanlands Island, a site downstream of the final effluent outfall, compared with just 350 cfu/100 ml between the storm overflow and the treated outfall (**Figure 2**).

As treated effluent flows into the river continuously, day and night, we could conclude that *E. coli* concentrations downstream of the STW would always exceed safe limits for bathing, whatever the weather, and these concentrations would be further boosted in wet weather by discharges from the storm overflow.

The UK's first designated river bathing water site

Despite the strength of local opinion and despite the clarity of our data the campaign to clean up the river made little headway. Things changed when it was decided at a town meeting to apply to the UK Government for the stretch of River Wharfe in Ilkley to be designated as an official bathing water site under the EU Bathing Water Directive, now, post-Brexit, absorbed into UK legislation. If successful, such designation would require the EA to begin a monitoring programme and conduct a site investigation.

The frequency of storm overflows was not a barrier for the application as the principal criterion for designation depended on the visitor popularity of the proposed bathing water site (**Figure 3**) rather than water quality. In December 2020, after long delays due to the covid pandemic and an extensive consultation process, the site was awarded bathing water status, the first of its kind for a running water in the UK.

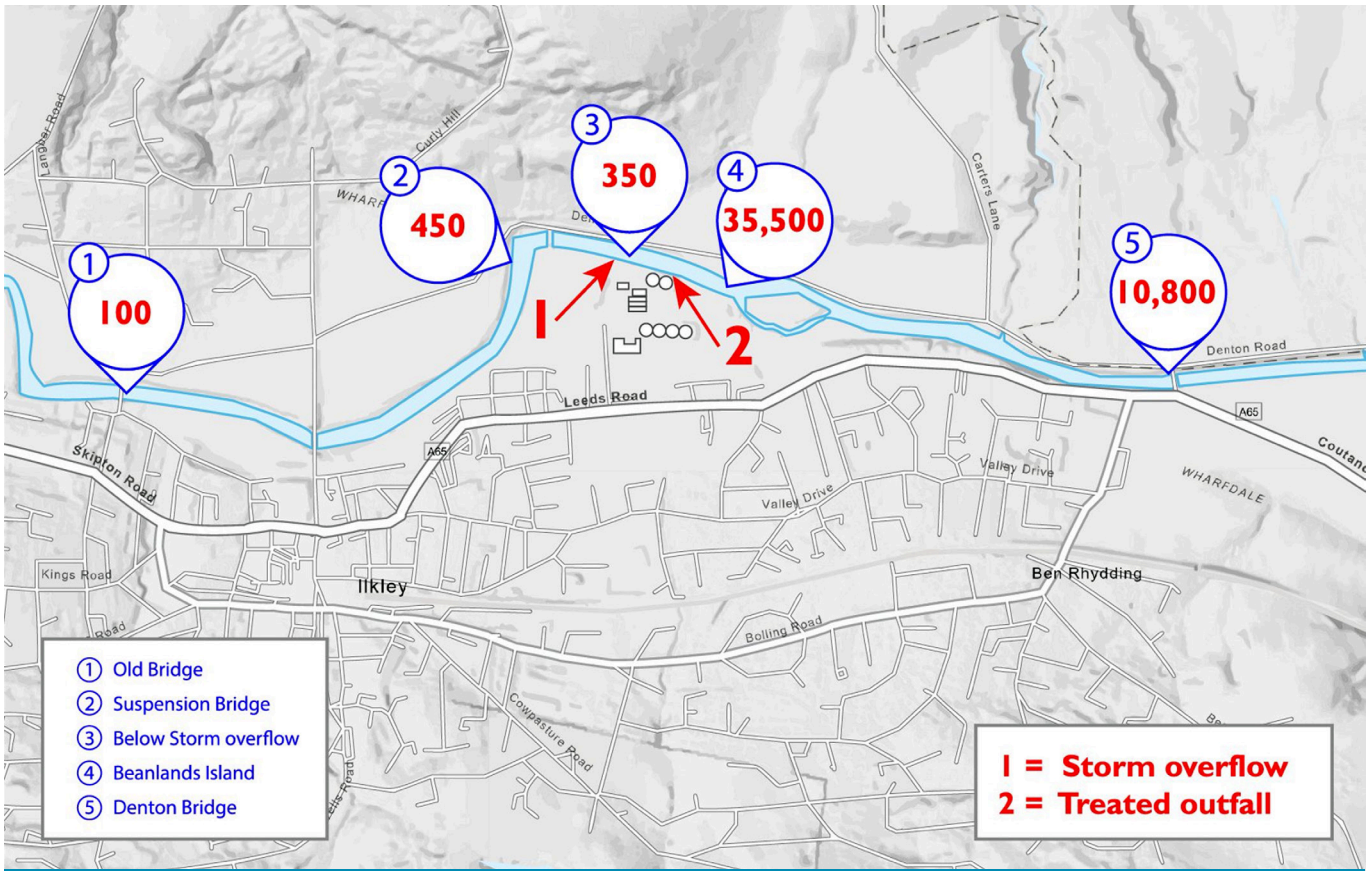

Figure 2 | *Escherichia coli* concentrations (cfu/100 ml) for sites on the River Wharfe upstream and downstream of Ilkley sewage treatment works on 10 July 2019. Drawing: Bruno Vincent.

Figure 3 | Visitors at the designated bathing water site on the River Wharfe in Ilkley.

Architecture versus sewage

The application for bathing water status shifted the emphasis of our citizen science project. Whereas sewage effluent, both untreated and treated, was indisputably responsible for the high concentration of faecal bacteria downstream of Ilkley STW (Figure 2), we needed to identify the sources of faecal bacteria arriving at the proposed bathing water site from sources upstream. These sources potentially included outfalls from small village STWs, a sewage pumping station storm overflow serving the village of Addingham, septic tanks, urban surface water runoff and agricultural livestock in tributary catchments.

For dry weather conditions, the data showed that *E. coli* concentrations in the main river were relatively low. In wet weather, however, we identified two scenarios that elevated *E. coli* concentrations in the main river and at the designated bathing site.

First, on two occasions after heavy rainfall the capacity of the storm tanks at Addingham Pumping Station was exceeded and untreated effluent was discharged into the local stream (Mill Stream) and thence into the main river. Despite the dilution provided by the main river in spate, the injection of *E. coli* in such high amounts increased its concentration in the Wharfe from 300 to 2,800 cfu/100 ml (Battarbee & Secrett 2020).

And second, on 23 August 2021, the day after a long spell of dry weather followed by a prolonged rainfall event, we observed *E. coli* concentrations in the main river rising to over 2000 cfu/100 ml (Figure 4) but at a time when the storm overflow at Addingham Pumping Station was not operating.

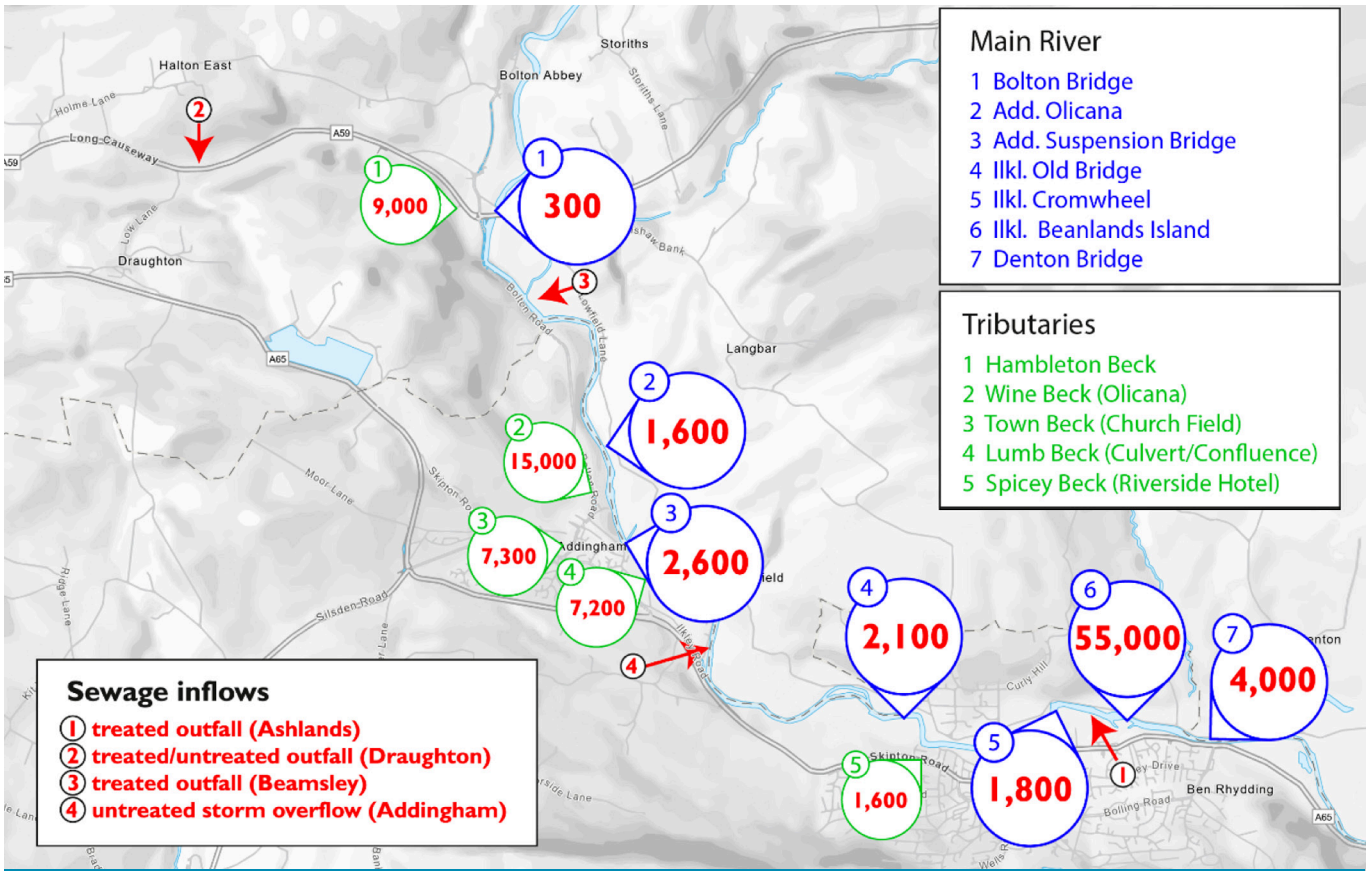

Figure 4 | *Escherichia coli* concentrations (cfu/100 ml) for sites on the River Wharfe (red numbers in blue circles) and tributary streams (red numbers in green circles) on 23rd August 2021. Drawing: Bruno Vincent.

The concentrations of *E. coli* in the tributary streams on that day were the highest recorded, indicating that the high concentrations in the main river were mainly of agricultural origin. We surmised that increased flow following the earlier rainfall had resuspended faecal bacteria from streambed and riverbed sediments and caused soil contaminated with livestock faeces to be inwashed from the banks (**Figure 5**).

Control measures

Following its designation as a bathing water site, the EA began monitoring faecal bacteria in Ilkley in 2021. Based on results for the 2021 bathing water season (May to September), the site has been classified as "poor", i.e. a 90 percentile value for *E. coli* greater than 900 cfu/100 ml.

Lifting the Wharfe from "poor" to "sufficient" status as defined by the legislation will require control of a number of different sources of faecal bacteria. Reducing spills of untreated sewage from CSOs is a priority not just in Ilkley but nationally in the UK —a priority now enshrined in the 2021 Environment Act. The solutions, however, although easy to identify will be slow to implement. For Ilkley, reducing groundwater infiltration into the sewer network, de-combining foul and surface water sewers and retrofitting sustainable urban drainage systems in the catchment are all needed but will take decades to complete.

Moreover, in the Wharfe catchment and other areas with extensive livestock farming, diffuse sources of faecal bacteria require control by better land and animal management, especially in riparian zones (Kay *et al.* 2018).

Although some of these solutions inevitably require hard engineering, for example the de-combination of old combined sewer networks, others are nature-based solutions that provide multiple environmental benefits. Constructed farm ponds and wetlands can be used for effluent treatment, rain gardens in urban areas reduce surface water runoff into sewers and fenced riparian buffer zones in agricultural catchments limit livestock access to river banks. Each of these solutions reduces both faecal bacteria contamination and nutrient pollution in watercourses, creates wildlife habitat and mitigates carbon emissions. Such co-benefits need to be taken into account when considering the cost of cleaning up.

The future

Following the Ilkley designation, a second river site (on the River Thames at Port Meadow) has now also been designated. Many more such designations are likely in coming years as campaign groups spring up throughout the UK and as the 2021 Environment Act, which requires water companies to reduce discharges from CSOs, takes effect. However, investment by water companies will materialise only slowly, diffuse pollution from agricultural land may be difficult to control and if climate change causes more frequent and intense rainfall events, the problem may well become much worse before it improves.

Citizen scientists have a major role to play in local monitoring schemes, raising public awareness and holding polluters, regulators and politicians to account.

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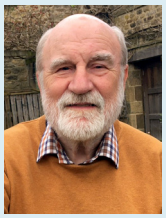
Figure 5 | Cows on the River Wharfe at Bolton Abbey. Photo credit: Jonathan White.



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He is a Fellow of the Royal Society and the recipient of numerous awards including the Ruth Patrick Award from the American Society of Limnology and Oceanography, the Victoria Medal from the Royal Geographical Society and a Lifetime Achievement Award from the International Paleolimnology Association. He is also a Foreign Member of the Norwegian Academy of Science and Letters, an Einstein Professor of the Chinese Academy of Sciences and a Fellow of the Freshwater Biological Association. He holds honorary doctorates from the University of Ulster and Queens University, Kingston, Canada and is the former Editor-in-Chief of the Royal Society Journal, *Biology Letters.*

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