Participatory Research to Quantify Microbes in River Water

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SUMMARY
A community lab near Lausanne, Switzerland, Hackuarium, has a long record of developing open science hardware. From 'DIY' fluorescence detectors for bacterial biosensor studies, to a reliable spectrophotometer, a bioreactor, and other tools, Hackuarium members have made and continue to aim to make low cost and reliable research instruments. Hackuarium work around quantitative microbiological measures of water quality began in 2016. For the Panama GOSH in 2022, a special mini-incubator was developed for a workshop around water quality. Now, results will be presented on the latest season of such work, when the opportunity arose for a participatory research project around river water quality, which had always been a concern. With 15 rivers assessed, the mini-incubator was built also as a 3D-printed variant, for more convenient incubations by five of the teams. Finally, 10 years after starting these water quality efforts, microbial pollution levels of local rivers can be reported.

KEYWORDS
Microbiological pollution; mini-incubator; 3D-printed; R-cards; bioindicator

1 INTRODUCTION

The Swiss public service laboratory association, Hackuarium, began in 2013, and one of the first big events it participated in was a Water Hackathon (Hackteria, 2014). Using quantitative microbial methods to assess water pollution began a couple years later, with the Hackuarium project "Micro to macro water pollution" (Hackuarium, 2016), after lifeguards in Montreux shared their worries about recurring health issues (e.g., itchy skin and stomach bugs) every summer. The project over its first two consecutive years revealed peaks of pollution into the bay during the two weeks of the Montreux Jazz Festival. After communication with local authorities was ineffective, sampling during the pandemic year summer season, when everything was different, allowed publication of the open-access article (Aronoff et al, 2021). Ultimately, the team even collaborated with the Montreux Jazz Festival for two seasons, with a tiny lab set up beneath the main venue for the concerts. Two years later, an improvement in water quality was observed, but not guaranteed (because one year, in 2022, there was virtually no rain, although the following year, 2023, was the cleanest seen). However, a concrete result (potentially unrelated to the team's studies) is that there is now a shower on the 'beach' where many children swim. Additionally, a slight peak of pollution linked to the music festival was observed in 2025.

Throughout all this work, river water was only used as the 'positive control' for these microbial analyses, because it reliably contained indicators of raw sewage contamination, in particular *E. coli* from the human intestine. While these bacteria indicate the presence of fecal contamination, however, a host of other pollutants that are harder to detect also end up in waterways, and are the main reason for closing swimming beaches if levels for these 'bioindicator' bacteria exceed a public health limit (in Switzerland, set at 100 *E. coli* per 100ml). Other bacteria (e.g. general coliforms and potentially dangerous enterococci) enter calculations to determine official limits for public health reasons, that differ between countries. Additional analyses are needed to precisely determine the origin or nature of the types of pollution of most concern. Why rivers are reliably contaminated with *E. coli* was always a mystery, as these bacteria were not generally believed to grow well in such water. Interestingly, a classic

'open science' study (Rey et al., 2015) assessing bacterial water quality of the Bagmati River, near where GOSH 2026 will be held, helped inspire some of the current work.

2 METHODS

The microbial method used for this study is based on the identification of bacterial colony species by color, due to inclusion of substrates in the growth media that are metabolically activated, depending on the enzymes in particular bacteria, for so-called 'chromogenic' assays. In the initial paper, only ordinary petri dishes were used, but already in the 2nd season (2017) Hackuarium participants 'beta-tested' a new support for quantitation, the R-Card (Roth, et al. 2026). These have grids printed on them to facilitate counting and just a little flap of plastic, taking up a much smaller volume than traditional petris. The small incubators were developed with Harald Tay (Tay, 2022) for the water quality workshop held during the Panama GOSH in 2022, especially for these small cards, with stacks of cards capable of being incubated easily, for a very low cost. A 3D-printed enclosure was developed for this work at Hackuarium.

3 RESULTS

The results of this sampling season were not surprising, given the fact that previous studies by Hackuarium only used river water as its positive control. More analyses will be presented.

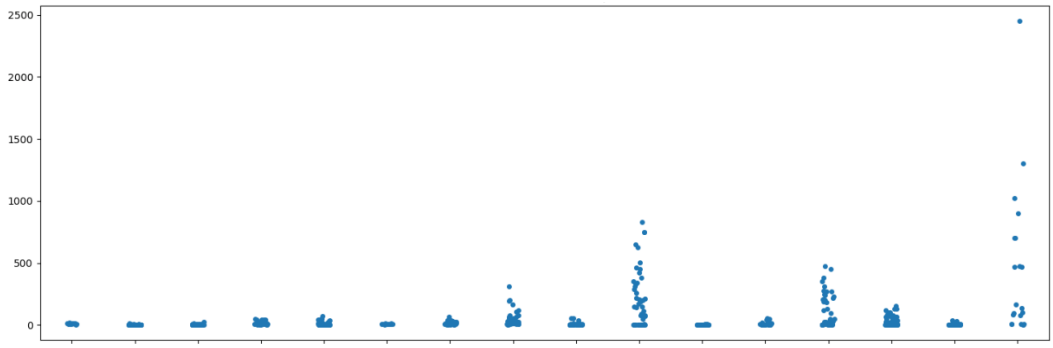

Figure 1. A graphical representation of quantitative data from the summer sampling season, with numbers of *E. coli* colonies counted on the R-Cards (x-axis) for each river studied (along the y-axis, including one contaminated pipe, far right). To note, **one blue colony on an R-Card was already at the Swiss limit for recreational water**, and at least four of the rivers were very highly contaminated.

4 DISCUSSION and CONCLUSIONS

The results of this sampling season were eye-opening, also for members of the public. We hope a more general public will be sensitized to the issue of river water that is not for recreational use, except in particular instances.

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