IMPROVING WATER QUALITY ON THE RIVER WHARFE FROM OUGHTERSHAW TO THE OUSE:

A CITIZEN SCIENCE PROJECT

Faecal bacteria data from tributary becks between Bolton Abbey and Ilkley on the 23rd August 2021

iWHARFE

Improving water quality on the River Wharfe from Oughtershaw to the Ouse: a citizen science project

Faecal bacteria data from tributary becks between Bolton Abbey and Ilkley on the 23rd August 2021

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Summary

E. coli concentrations in water samples collected from tributary becks of the River Wharfe immediately upstream of Ilkley on the 23rd August 2021 were unusually high. Samples taken from the main river also had relatively high concentrations. Sampling took place following persistent rain on the previous day but the data cannot be explained by discharges from Sewage Treatment Plants (STWs) or Combined Sewer Outfalls (CSOs). We assume that the high values are caused primarily by enhanced transport of *E. coli* into watercourses from agricultural land and argue that diffuse sources of faecal bacteria, as well as point sources upstream, may need to be controlled if the newly designated bathing water site in Ilkley is to meet the minimum standard for safe swimming.

Introduction

The iWharfe project is a citizen science project concerned with water quality in the River Wharfe. It was designed in 2020 by the Ilkley Clean River Group, Yorkshire Dales Rivers Trust and Addingham Environment Group. Two surveys of the river, in August 2020 and August 2021, have now taken place [1, 2].

Although the primary focus of the iWharfe survey in both years was on the main river, water samples for faecal bacteria in 2020 were also taken for analysis from a number of the principal tributaries, such as the River Skirfare and the River Washburn.

In the 2021 survey special attention was paid to smaller tributaries, specifically those flowing into the R. Wharfe between Draughton and Ilkley, centering on Addingham. These becks have each been sampled on several occasions previously[3,4]. They are of particular interest as they drain catchments immediately upstream of the stretch of river in Ilkley newly designated as a bathing water.

A central question in the bid to reduce the concentration of faecal bacteria in the river is the extent to which these diffuse catchment sources contribute to the overall contamination at the bathing water site.

Our previous work on this stretch of the river[4] has shown that the highest concentrations of faecal bacteria in the main river upstream of Ilkley are best explained by direct discharges from Combined Sewer Overflows (CSOs), principally from the Addingham Pumping Station.

However, in August 2021, we recorded relatively high levels of *E. coli* in the main river at a time when the Addingham CSO was not spilling indicating that under certain weather patterns the input of *E. coli* from diffuse sources within these tributary catchments can be sufficient to raise faecal bacteria concentrations in the river. Consequently, it is possible that the minimum standard of safety under the Bathing Water legislation cannot be achieved without controlling diffuse discharges from agricultural and other non-CSO related catchment sources.

Here we present *E. coli* data for becks upstream of the designated bathing beach in Ilkley in comparison to concentrations in the main river. Sampling took place on Monday 23rd August, a dry day, but occurring after a period of sustained rainfall the day before. This day was itself preceded by a long spell of dry weather with associated low river levels until the 21st of August (Fig.1).

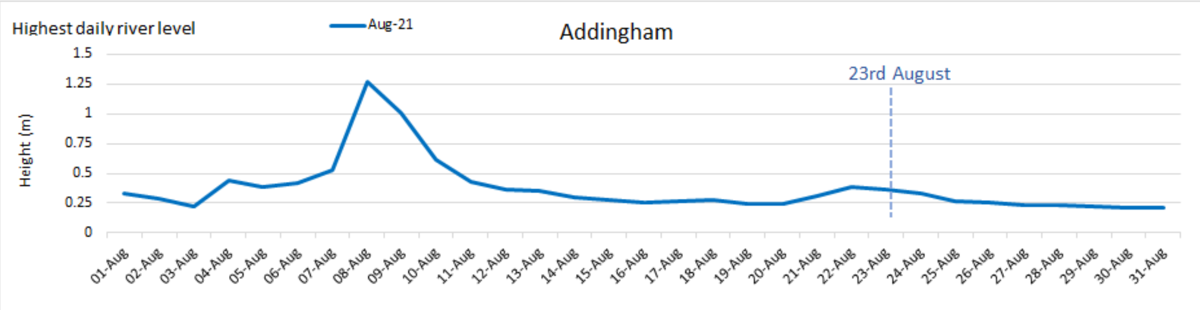


Figure 1: Addingham river levels August 2021, showing 23rd August, the day of sampling

Sites

Tributaries selected for sampling on the 23rd August 2021 were Hambleton Beck, Addingham Wine Beck, Addingham Town Beck, Addingham Lumb Beck and Ilkley Spicey Beck (Fig. 2). They all have different characteristics. Hambleton Beck has a largely agricultural catchment and contains the small village of Draughton which is served by its own STW. Wine Beck has an agricultural catchment but has in the past been contaminated by wastewater from a poorly performing private septic tank serving a small caravan site. Town Beck also has an agricultural catchment but the lower reaches of the beck flow through Addingham, a village with a population of over 3,500. Lumb Beck rises on Rombalds Moor but its catchment below the moor consists almost entirely of agricultural grassland. Finally, Spicey Beck also rises on Rombalds Moor but runs directly from the edge of the moor into and through the built-up urban area of Ilkley meeting the Wharfe at the Riverside Hotel close to the Old Bridge. Overall, but with the exception of Spicey Beck, the principal land-use within these upstream tributary catchments is livestock farming.

Samples were taken from each site close to their confluence with the main river (Fig. 2). In the case of Addingham Town Beck the sample was taken in Church Field downstream from the junction of Town Beck and Back Beck. For Spicey Beck the sample was taken in the grounds of the Riverside Hotel upstream of the Spicey Beck CSO.

Samples were also taken on the main river from Bolton Bridge to Denton Bridge (Fig. 2) as part of the iWharfe21 campaign on the same day[2].

Methods

Field sampling

Samples were collected from the main river and the tributaries using sterile sample bottles provided by ALS Ltd. Cool bags with bags of crushed ice were used to keep the temperature of the samples between 2 and 8° C before and during delivery to the laboratory in Wakefield. Sampling began in the early morning and was completed within a period of four hours during which no change in weather or flow conditions were observed.

Laboratory analysis

Samples were transported overnight from Wakefield to Coventry and microbiological analysis to detect *E. coli* concentrations was carried out by ALS Coventry within 24 hours of sample collection. Plates are incubated at 30°C for 4 hours and at 37°C for a further 14 hours after which colonies characteristic of coliforms and *Escherichia coli* are counted.

Results

Data from samples taken on 23rd August 2021 from both the main river and from selected tributary becks are shown in both Fig. 2 (map) and Fig. 3 (histograms). Table 1 also shows the data from the tributaries from the 23rd August in comparison to data from the same sites sampled on different occasions in 2019, 2020 and 2021.

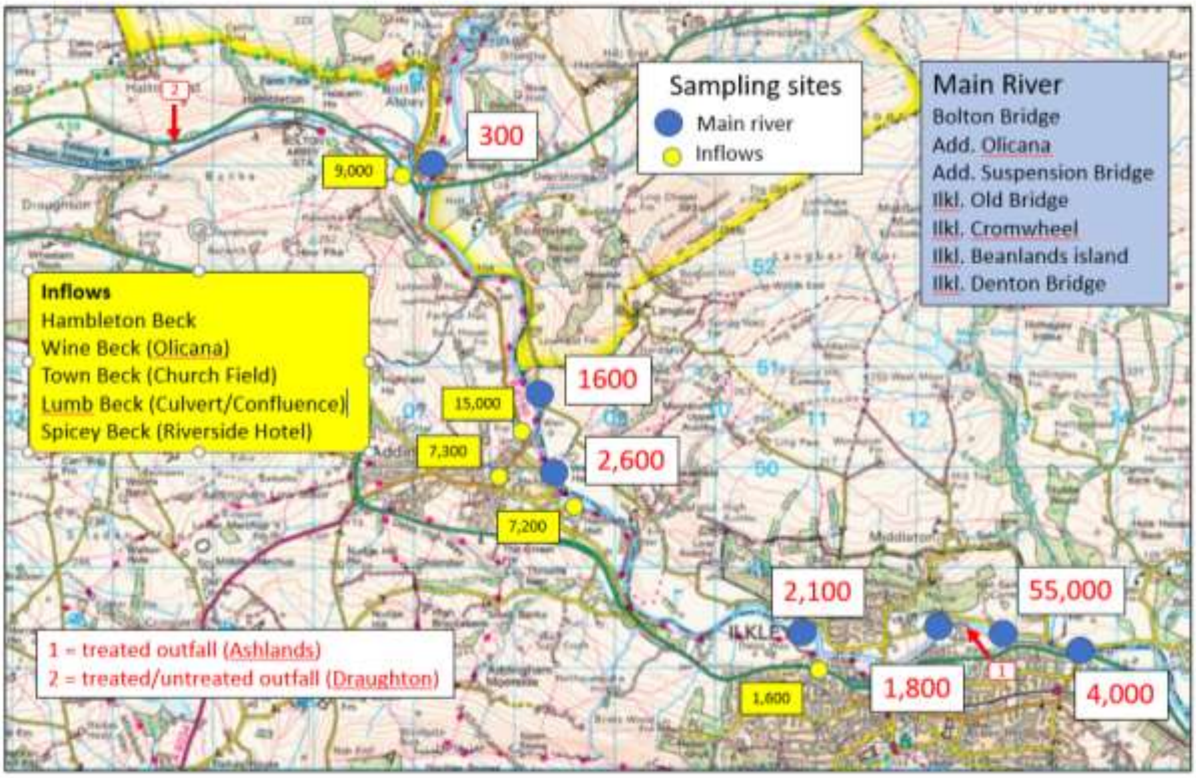


Figure 2: Map of the River Wharfe and its catchment between Bolton Abbey and Ilkley showing sampling sites on the main river (red on white) and on tributary becks (black on yellow). Site names are listed in downstream sequence. The positions of the treated effluent outfalls from Ashlands STW (1) in Ilkley and from the Draughton STW (2) are shown by a red arrow.

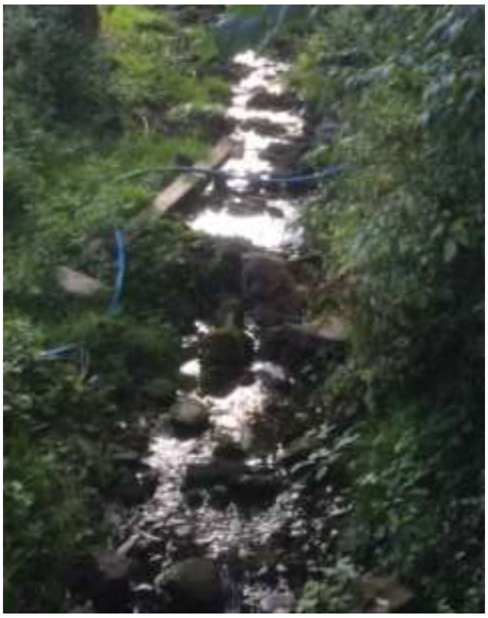
Hambleton Beck

Hambleton Beck has been sampled on three previous occasions with concentrations varying from 800 to 2200 (Table 1). The concentration on 23rd August of 9000 cfu/100 ml, contrasts sharply with these previous results. Although it is a small tributary in relation to the Wharfe, the Wharfe typically at Bolton Bridge has low concentrations of *E. coli* [1,4]. On this occasion the concentration was 300 cfu/100 ml (Fig. 2). The high concentration in the tributary although diluted by the volume of water in the main river appears to be responsible at least in part for the increase in concentration in the river downstream from 300 at Bolton Bridge to 1,600 cfu/100 ml at Olicana (Figs. 2, 3). The source of the *E. coli* on this occasion is unclear as the beck receives both faecal contaminants from agricultural land and from the Draughton STW.

Sample site	Ashlands 07.10.19	Ashlands 10.12.19	iW 20 24.8.20	iW Upp 2.6.21	iW Upp 26.7.21	iW 21 23.8.21	AEG 20.9.21
Hambleton Beck	2200		1900	800		9000	
Wine Beck (Olicana)	11000		4200			15000	
Town Beck (Church Field)		800	3300			7300	
Lumb Beck (Culvert/Confluence)	2300	1100	2800	600	1700	7200	
Spicey Beck (Riverside Hotel)		18000	8100		36000	1600	5500

Table 1. E. coli (cfu/100 ml) for selected tributary becks between Bolton Abbey and Ilkley sampled between October 2019 and October 2021 for different projects. iW 20 = iWharfe 2020; iW Upp = iWharfe Upper; iW 21 = iWharfe2021; and AEG = Addingham Environment Group.

Wine Beck



Wine Beck was first sampled at the Olicana site on 7th October 2019 (Table 1). The sample had a very high *E.coli* concentration of 11,000 cfu/100 ml, suggesting the presence of a significant pollution source. Local research established that the probable source of the contamination was a septic tank serving the Paddock, a fixed caravan site of approximately 15 households, just upstream from the point of sampling. From a conversation with the Environment Agency we believed sewage from the Paddock was diverted away from the septic tank and into the main sewer following the construction of a small pumping station on Bolton Road in 2020. A sample taken in the iWharfe 2020 campaign, however, gave a relatively high value of 4,200 cfu/100 ml suggesting a continuing source of contamination. The very high value of 15,000 cfu/100 ml on the 23rd August 2021 (Figs. 2, 3) supports that conclusion, especially since the *E. coli* concentration of a sample taken on the same morning upstream of the Paddock was 2,400 cfu/100 ml (Leah Humphries, pers. comm.).

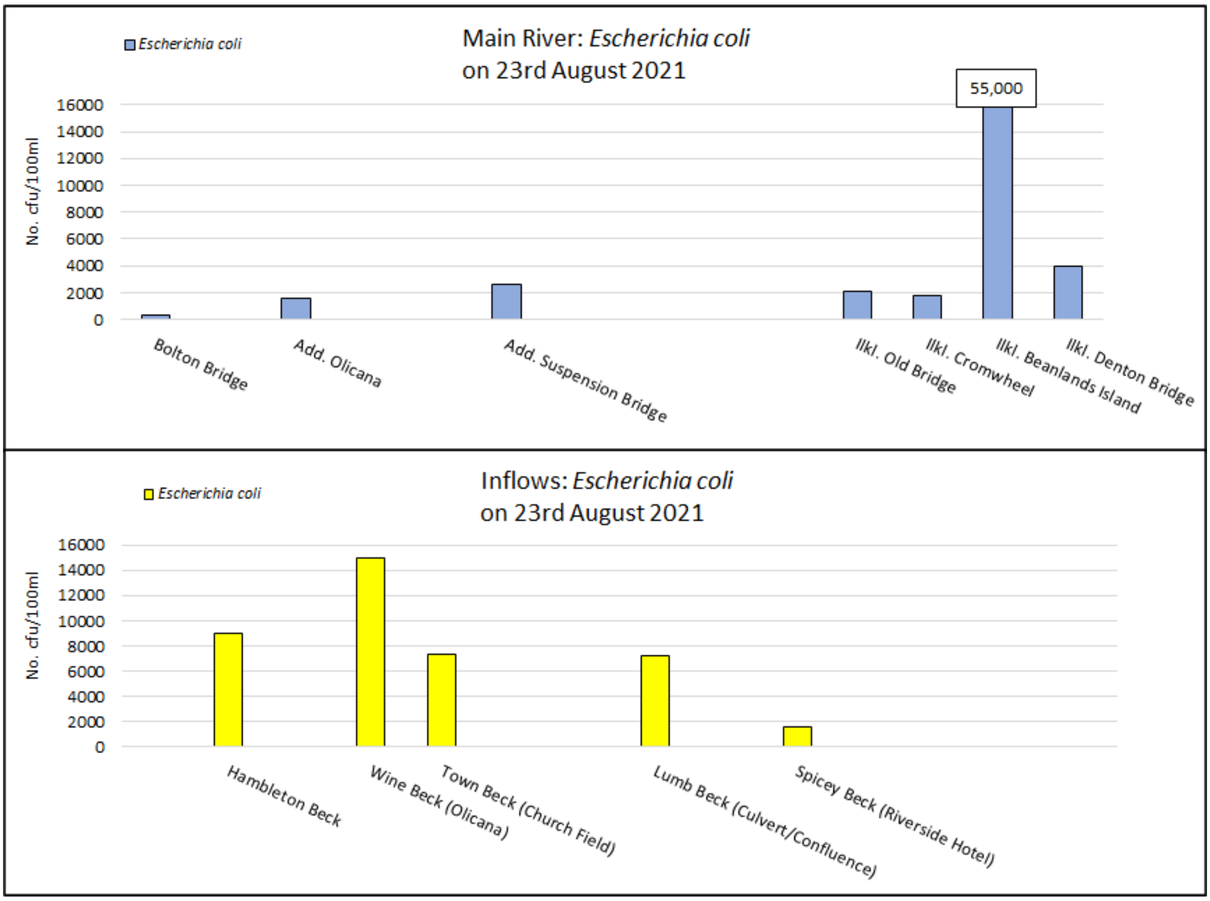


Figure 3. E. coli (cfu/100 ml) for the River Wharfe (upper panel) and selected tributary becks (lower panel) sampled on the 23rd August 2021.

Town Beck

Samples from Town Beck (Church Field) in Addingham have been taken on two previous occasions, giving values of 800 and 3,300 cfu/100 ml (Table 1). As for other sites sampled on 23rd August 2021 the value of 7,000 cfu/100 ml for *E. coli* observed for this site on that day is by far the highest recorded. There are no CSOs or STWs upstream of the sampling site. This value does not therefore reflect the input of sewage effluent, either treated or untreated. However, Addingham has a population of over 3,500 and the village itself comprises a significant part of the Town Beck catchment. Some surface water from houses, gardens and road surfaces is directed into the combined sewer but a significant fraction of the runoff, especially from the newer housing estates, is discharged into the beck. It is uncertain therefore from a single sample located close to the confluence with the Wharfe whether the dominant source of faecal bacteria in the beck is derived from the village or from upstream agricultural land. It is likely that both sources are

important. Previous work on nutrient pollution[5] has shown clearly how phosphorus concentration increases as Town Beck (called Marchup Beck in its upper reach) flows through the improved and semi-improved grasslands in the upper catchment but doubles as the beck receives runoff from new housing estates within the village. Further work is needed to quantify the relative roles of these different pollution sources.

Lumb Beck

Of the five tributaries sampled on the 23rd August Lumb Beck is the one with a catchment most dominated by agricultural land with livestock husbandry for both sheep and cattle being the most common farm business. As for other sites, samples for *E. coli* analysis have been taken on several previous sampling occasions with values varying between 600 and 2,800 cfu/100 ml (Table 1). The value on the 23rd August 2021 is the highest recorded to date. It is unlikely that this high value can be accounted for by septic tank discharges (although we do not know what arrangements are in place to process waste from a caravan site in the catchment at School Farm). The most likely contamination is from farm livestock. A detailed survey of the headwaters of Lumb Beck on a farm by farm basis is needed to identify the principal sources of contamination within the catchment.

Spicey Beck

Spicey Beck enters the Wharfe close to the Riverside Hotel where a CSO is located. The sampling site for this survey, however, was located upstream where the beck enters the grounds of the hotel as it emerges from the culvert under Bridge Lane. The site was first sampled on the 10th December 2019 when it had an exceptionally high concentration of 18,000 cfu/100 ml (Table 1) reflecting serious contamination from an unknown upstream source. Subsequent samples from this site also showed very high values to the extent that we carried out a more detailed survey of the beck in order to identify the pollution source or sources (unpublished data). On the 23rd August 2021, however, the value was considerably lower than on previous occasions (cf. Figs. 2, 3) in contrast to values from the becks on the same day described above. There is no agricultural land in the Spicey Beck catchment. The upper catchment is dominated by heather moorland and the lower catchment is part of the built-up urban area of Ilkley. This relatively low value on the 23rd August supports our inference that the high values in the catchments of the becks meeting the Wharfe upstream of Ilkley are strongly influenced by agricultural sources of *E. coli*.

River Wharfe

E. coli concentrations for samples taken from the main river along the stretch from Bolton Bridge to the Cromwheel corner are consistently high varying from 1,600 to 2.600 cfu/100 ml (Figs. 2, 3). The concentration at Bolton Bridge itself is quite low at 300 cfu/100 ml and the value below the Cromwheel at Beanlands Island is very high at 55,000 cfu/100 ml. The low value at Bolton Bridge is expected. We have eleven data points for samples taken in the Bolton Abbey stretch of the river, none greater than 1000 cfu/100 ml[6] . Equally the high value downstream of the Cromwheel is also expected. We have 16 data points for the Beanlands Island site varying from 4,000 to 150,000 cfu/100 ml reflecting the influence of the effluent discharge from Ashlands STW[6]. The unusually high values for the river between these two sites appear to be caused by the high concentration of faecal bacteria entering the river from the tributary becks.

Conclusions

Although the data presented here are derived from a snapshot survey of the river on a single day it is possible, given the amount and nature of prior data to hand from these tributary becks and from the main river[6], to make several conclusions:

- The high values of *E. coli* in the main river from Bolton Bridge to Ilkley are not the result of discharges from storm overflow tanks or CSOs as none was spilling on the 23rd August;
- With the exception of Spicey Beck, the concentrations of *E. coli* in all the tributary becks sampled from Bolton Bridge to Ilkley are significantly higher than for samples taken on any previous occasion from these sites, indicating that the high concentrations in the river on the 23rd August are strongly influenced by diffuse catchment sources and not by point sources from STWs or CSOs;
- *E. coli* concentrations in Hambleton Beck may be strongly influenced by the STW serving Draughton village discharging into the beck, high concentrations in Wine Beck may be the result of a poorly functioning septic tank and the high concentrations in Town Beck could be influenced by surface runoff from the built-up area of Addingham. However, each of these catchments contain large areas of agricultural land and Lumb Beck has a predominantly agricultural catchment. The Spicey Beck catchment lacks agricultural land. Taken together these data strongly suggest that the dominant source of *E. coli* on this day was from agricultural land;
- The values observed on the 23rd August for Hambleton Beck, Town Beck and Lumb Beck are all much higher than observed on previous sampling occasions. It is probable that these high values are related to the unusual weather and flow conditions occurring at, or leading up to, the date and time of sampling;

- As the previous day was extremely wet and followed a long period of very dry weather with low beck and river flows we surmise that the high concentrations in the becks were the consequence of faecal bacteria being mobilised within or washed into the becks from riparian soil contaminated by livestock faeces. We also surmise that the high concentration in the river was not only due to the high concentration in the becks but also to the relatively low dilution effect of the main river on that day. The volume of flow in the main river on the 23rd was only slightly elevated by the rainfall on the previous day (Fig. 1).

If these inferences are correct, it is apparent that there are occasions during the bathing water season when weather patterns and riverflow behaviour can combine to generate faecal bacteria concentrations in the main river that are unsafe for bathing independently of discharges from STWs and CSOs.

Whilst the main high-level source of faecal bacteria upstream of the newly designated bathing water site remains the storm overflow from the Addingham pumping station[4] and spills from Ilkley CSOs, agricultural and other diffuse sources of faecal bacteria in tributary beck catchments may also need to be controlled if the bathing site is to meet the minimum standard for compliance under bathing water legislation. A study by Kay *et al.*[7] demonstrated that riparian fencing to restrict cattle access to streams and within-catchment attenuation methods such as ponds and wetlands can be effective in reducing the concentration of faecal bacteria in watercourses.

The beck data presented here are from a small number of samples taken in the lower reaches of the becks close to their confluence with the main river. Much finer-scale sampling is needed to identify the specific sources of faecal bacteria within each of these beck catchments. Were such sampling to take place in future, value could be added by using DNA as a method of microbial source tracking to differentiate human and agricultural livestock sources of contamination.

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