Microbiological analysis of private water supplies in Scotland

The impact of risk factors and seasonal variation on water quality

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Introduction

- 3.6% of the Scottish population uses around 22,000 private water supplies (PWSs), largely in rural areas
- The majority (89%) of these are small, non-commercial water supplies (Type B supplies) which are unregulated and not routinely tested

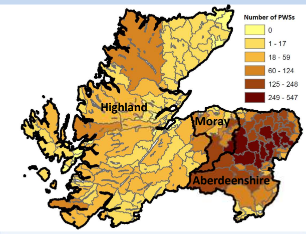

Figure 1: Numbers of PWSs per postcode sector in the study areas

- The water quality of PWSs is variable, posing associated health risks such as waterborne illness
- The study regions are in the northern regions of Scotland, where **12% of the population** are reliant on these PWSs

Methods

- April 2015 - March 2019: **5,922 water quality tests** performed by local authorities to detect *E. coli* in water samples from private water supplies in the study region
- ***E. coli* was detected in 10.8% of samples** (638 samples) - concentrations of *E. coli* ranged between 0 to 2,010 cfu/100 ml
- A test failure is classified as any *E. coli* concentration above 0 cfu/100 ml
- The fail rate differed between Regulated **(9.7%)** and Type B supplies **(15.9%)**
- Water sample test data was matched with a private water supply register to reveal additional characteristics of the supplies associated with each test
- These characteristics were analysed to explore potential associations with *E. coli* detection
- Environmental factors such as the density of nearby livestock (Fig. 2 & 3) and the month that the sample was collected in (Fig. 5) were also examined

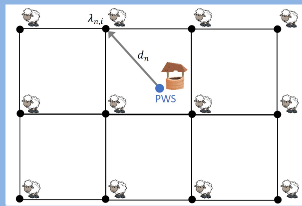

Figure 2: Livestock density for Scotland was retrieved from the EDINA agricultural census 2015.

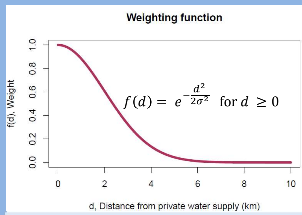

Figure 3: A Gaussian random walk Dispersal Kernel was developed to estimate the density of livestock in the surrounding area for each supply.

Results

- Key findings from this analysis of *E. coli* water sample failures show potential associations with seasonality, density of sheep in the surrounding area, whether the supply is groundwater fed or surface water sourced, and whether treatment systems were installed
- These potential associations are shown in the subsequent figures, each with respect to the *E. coli* test fail rate

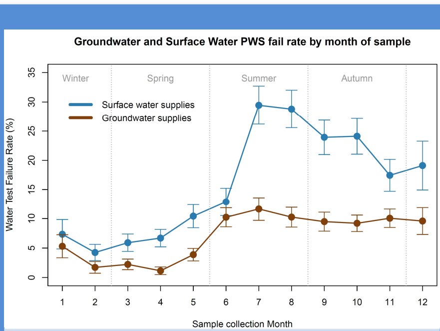

Figure 5: *E. coli* fail rate for surface water sourced (watercourses, lochs and rainwater) and groundwater fed supplies (wells, springs and boreholes), by month of sample

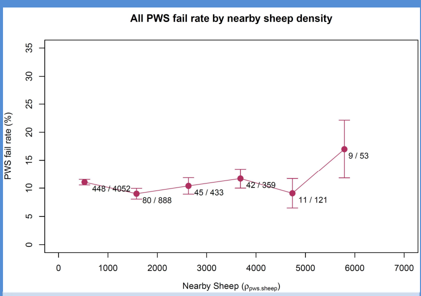

Figure 4: *E. coli* fail rate by nearby sheep density to the PWS. There does not appear to be a strong dependence of the nearby sheep density on the fail rate

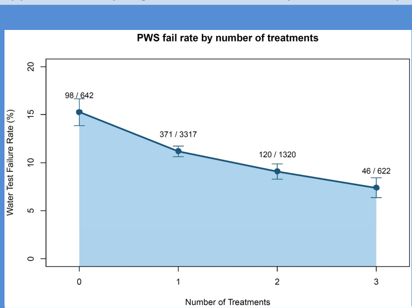

Figure 6: *E. coli* fail rate by number of installed treatment systems for a supply, e.g. physical filter, disinfection, chemical filter and chloramination

Factors increasing the likelihood of *E. coli* presence

- In general, surface water supplies have a higher fail rate, this is heightened from July to October (Fig. 5).
- For each additional treatment installed on a supply, the fail rate tends to decrease (Fig. 6)
- Analysing these two factors together, it can be seen that the sharp rise in fail rates beginning in July (Fig. 5) is biased towards supplies without any installed treatments (Fig. 7)

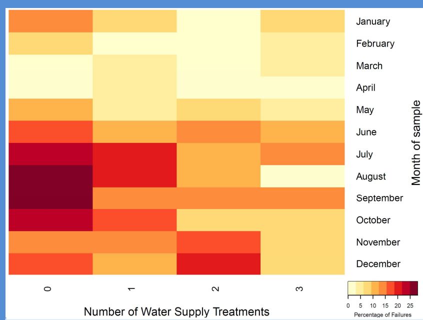

Figure 7: Heatmap of *E. coli* fail rates for the number of installed treatment systems and the month of sample

Future

- Further examination of the effectiveness of individual treatments either single or combined
- Develop a numerical model to estimate the expected test result for a PWS, given the risk factors described above such as month of sample, supply type, livestock density, and the presence of any protective measures such as installed treatments

PWS users and engagement

A postal questionnaire will be sent to 1000 Type B PWS users. Early results from Aberdeenshire have highlighted a number of behaviours and insights, such as potential factors that would **encourage users to increase testing of their supply** (Fig. 8)

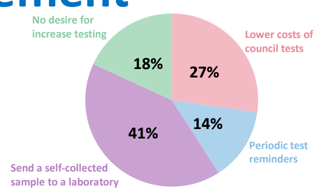

Figure 8: Responses from questionnaire

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