



British  
Geological Survey

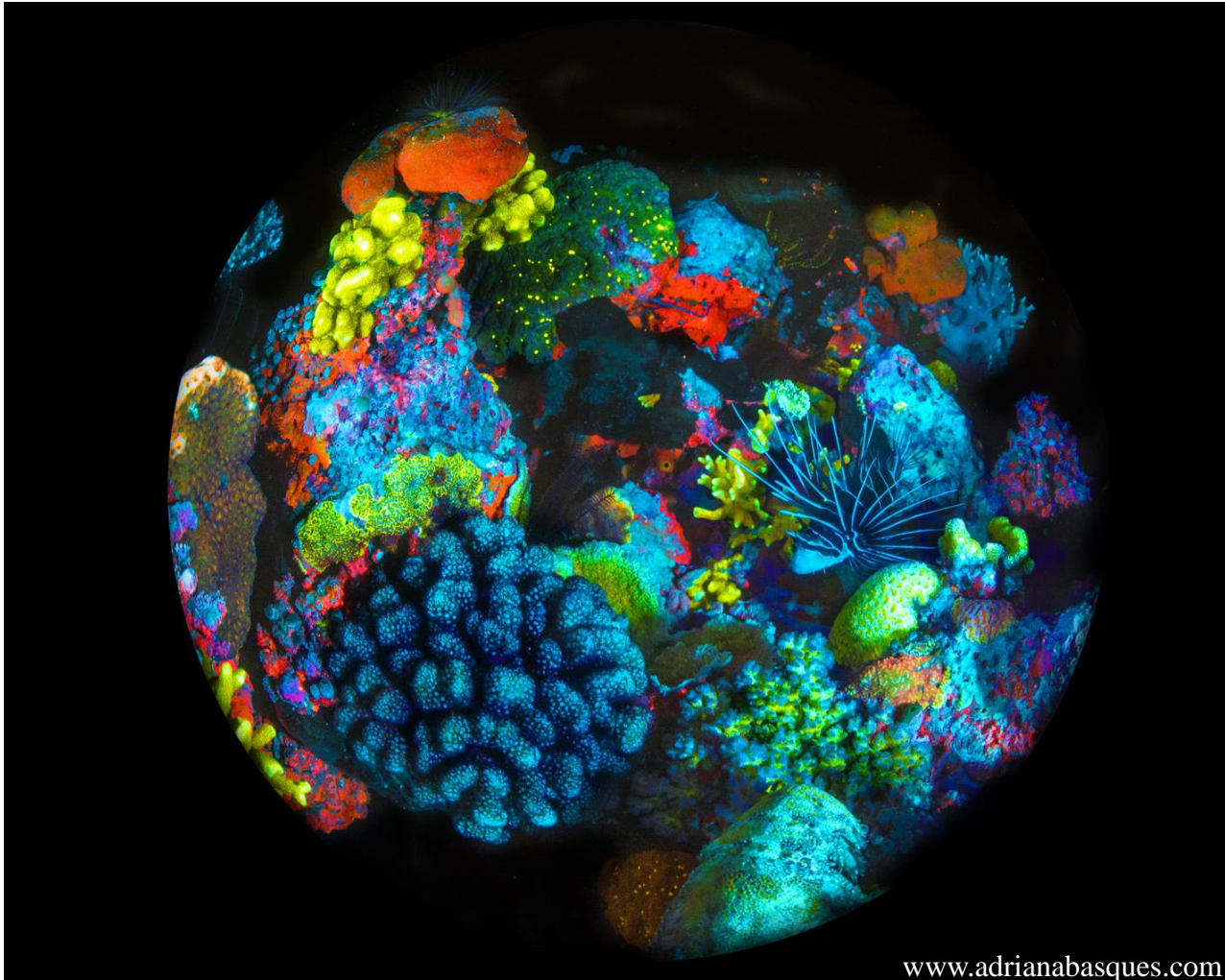
NATURAL ENVIRONMENT RESEARCH COUNCIL

Gateway to the Earth

# Fluorescence for monitoring the microbial quality of drinking water

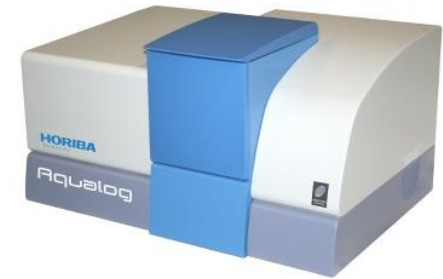
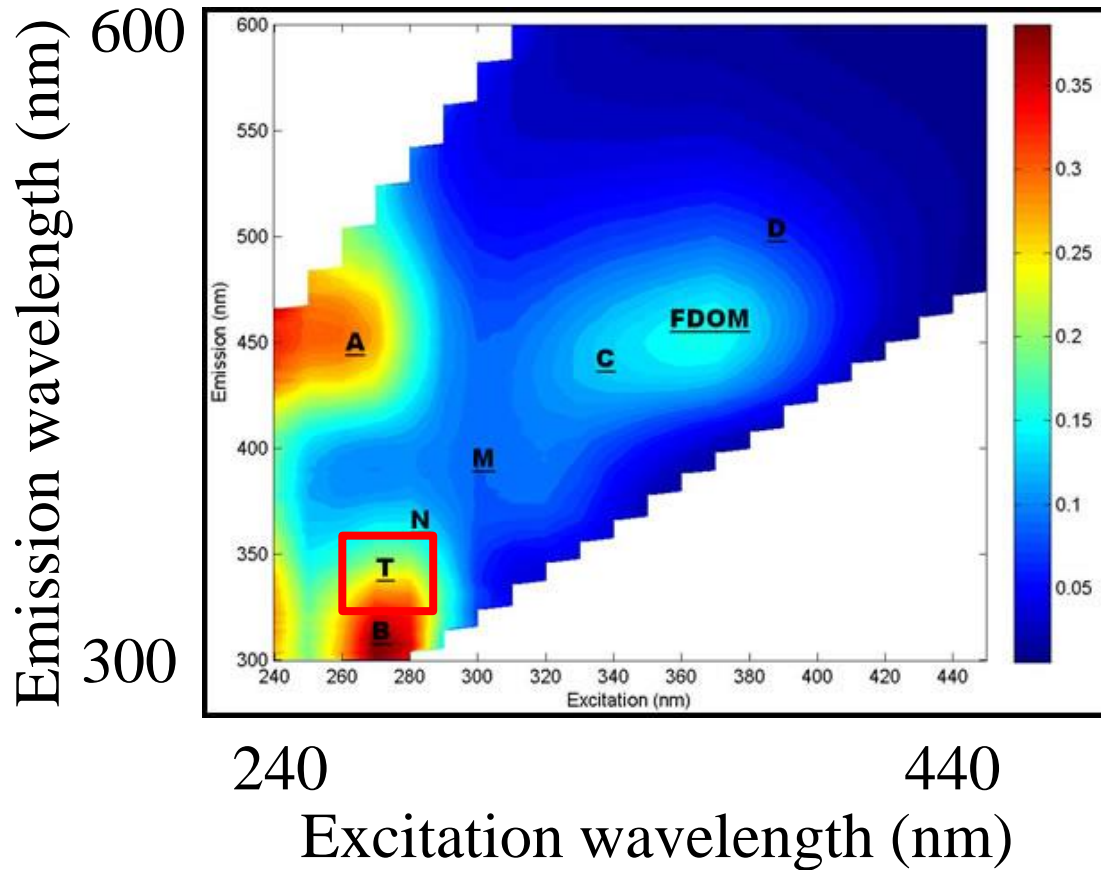
James Sorensen  
British Geological Survey

# What is fluorescence?



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# Fluorescence of dissolved organic matter (FDOM) in water



Tryptophan-like  
fluorescence (TLF)

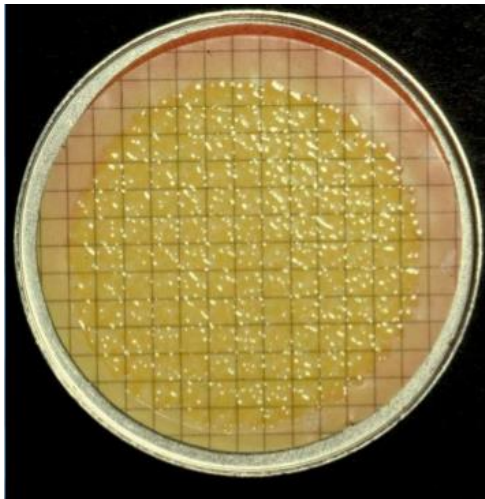
# Linking TLF & *E. coli*

- Multiple studies have shown *E. coli* cells directly produce tryptophan-like fluorescence (TLF) in the lab
- For example, Fox *et al.* 2017 demonstrated a very strong correlation between TLF and *E. coli* ( $r^2 = 0.98$ )
- *E. coli* cells are used for the industrial production of tryptophan

1. Can tryptophan-like fluorescence (TLF) assess the microbial quality of drinking water...?

# Assessing microbial quality of drinking water

- Roaming survey of drinking water sources in Africa/India ( $n = 564$ )



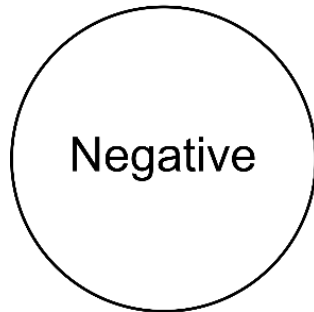
Result within >18hr



Result within 10 secs

# Predicting presence of thermotolerant coliforms

Plate counts  
(>18 h)



Predicting plate counts (real-time)

False negatives  
4%



Fluorescence > 1.3 ppb?

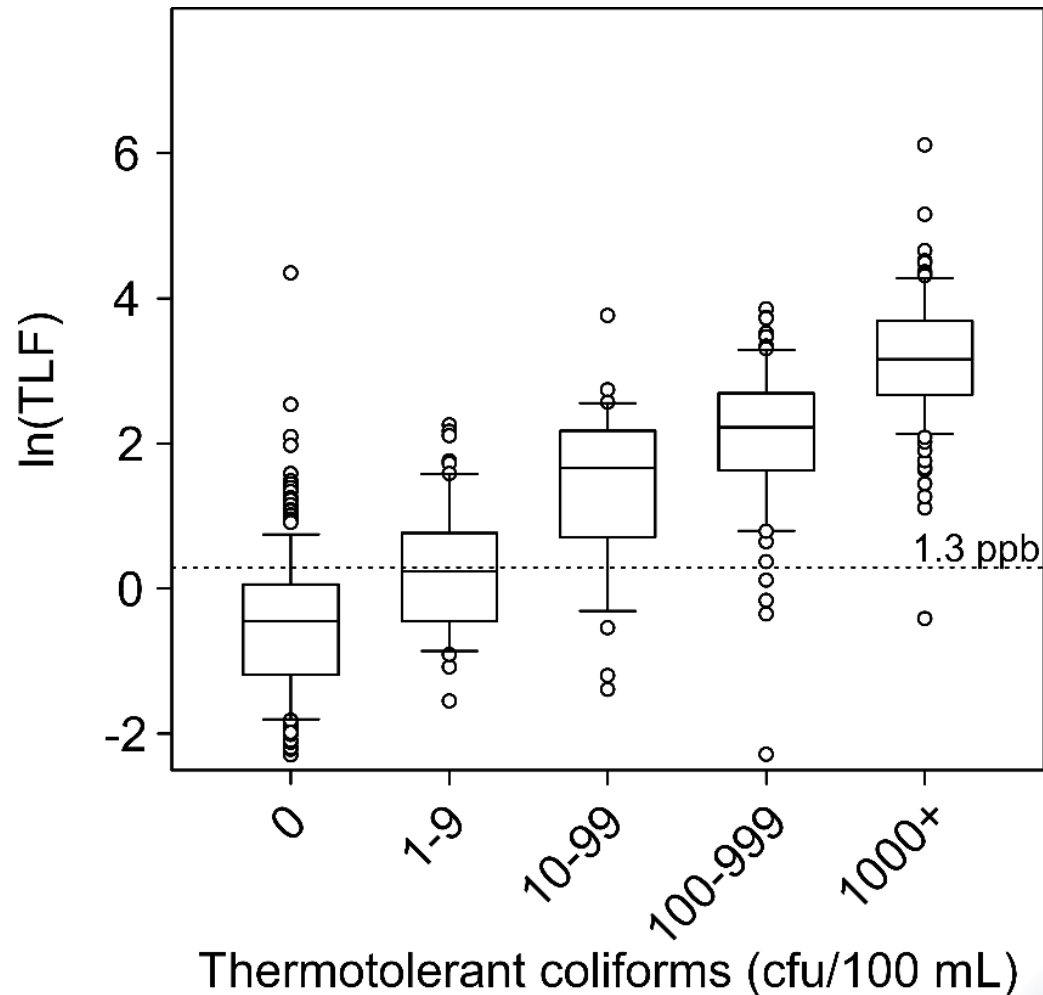


False positives  
18%

Limit of detection  
~10 cfu/100mL

# Correlation with thermotolerant coliforms

- Very strong correlation ( $\rho = 0.80$ ,  $p$ -value  $< 0.001$ )





1. Can tryptophan-like fluorescence (TLF) assess the microbial quality of drinking water...?

Yes!

- Can predict presence/absence of thermotolerant coliforms
- Is positively correlated with the number of thermotolerant coliforms

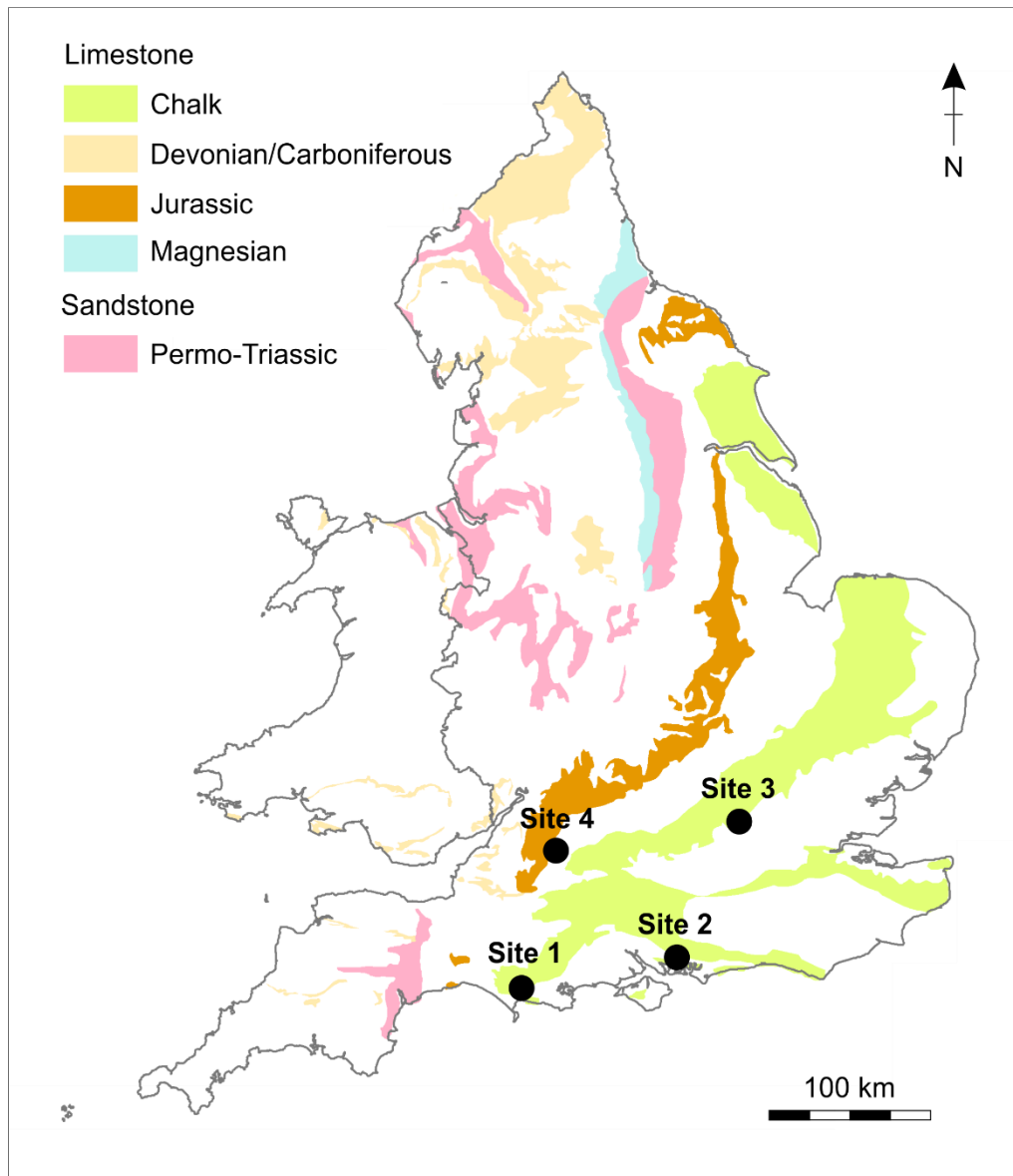
## 2. Does it work in the UK?

Is TLF a superior online indicator of the microbial quality of drinking water than turbidity?

# Online fluorescence to assess microbial water quality

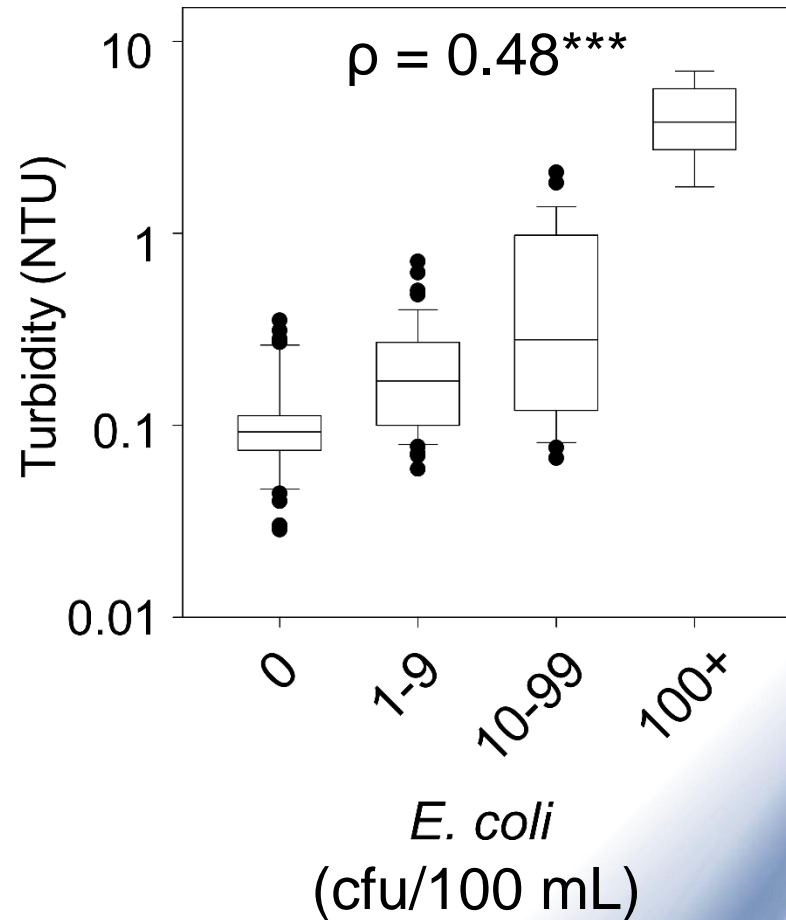
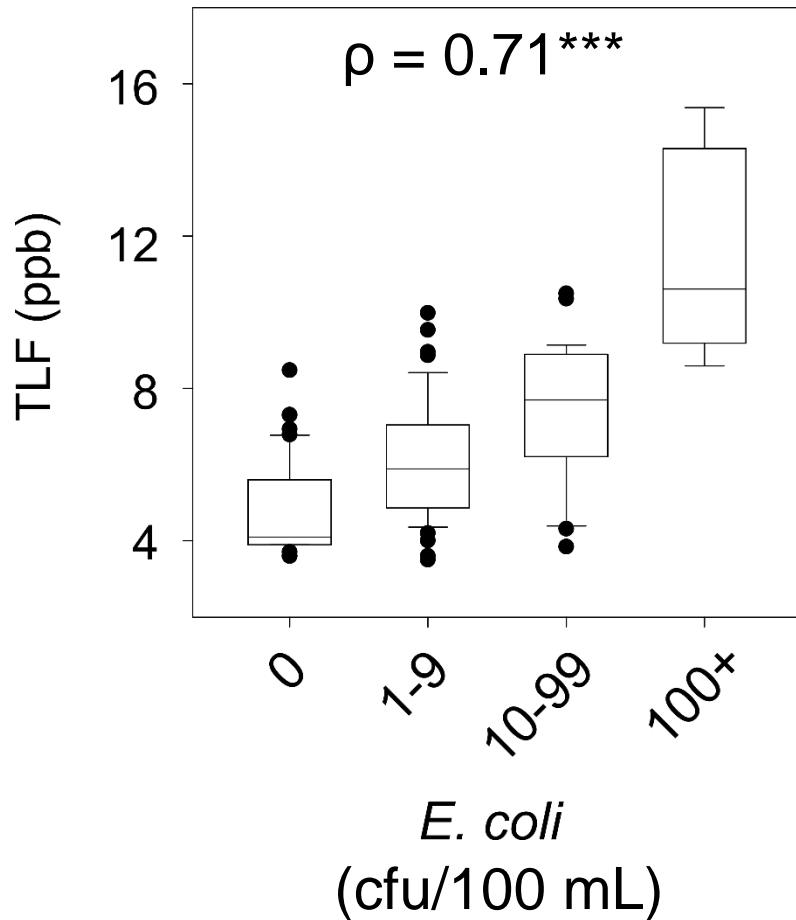
- Online fluorescence (2 min) comparison with
  - online turbidity
  - *E. coli*
  - total bacterial cell counts by flow cytometry



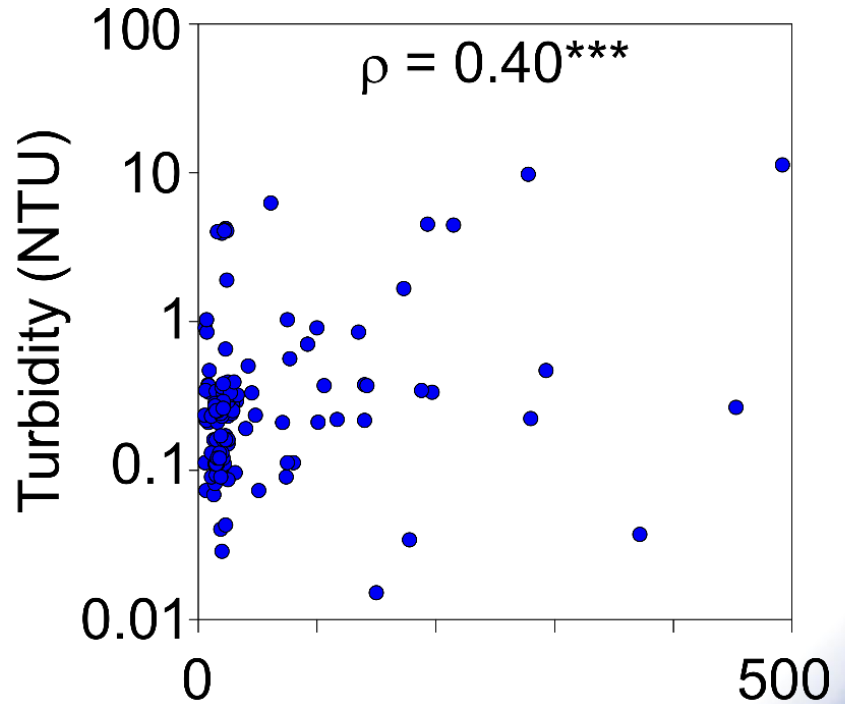
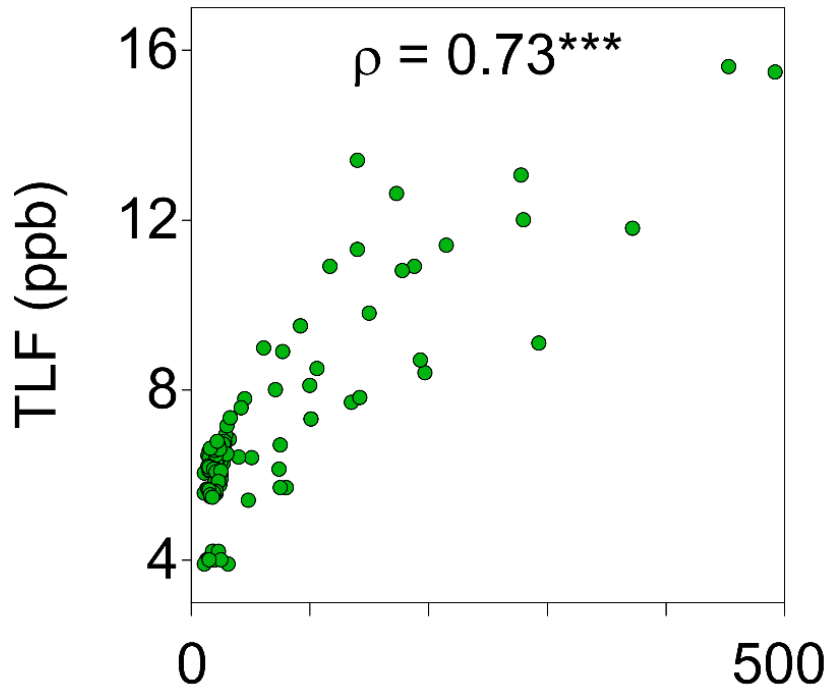


- Four public water supply sites (raw water)
- All groundwater
- 6-10 months

# Online indicators and *E. coli*

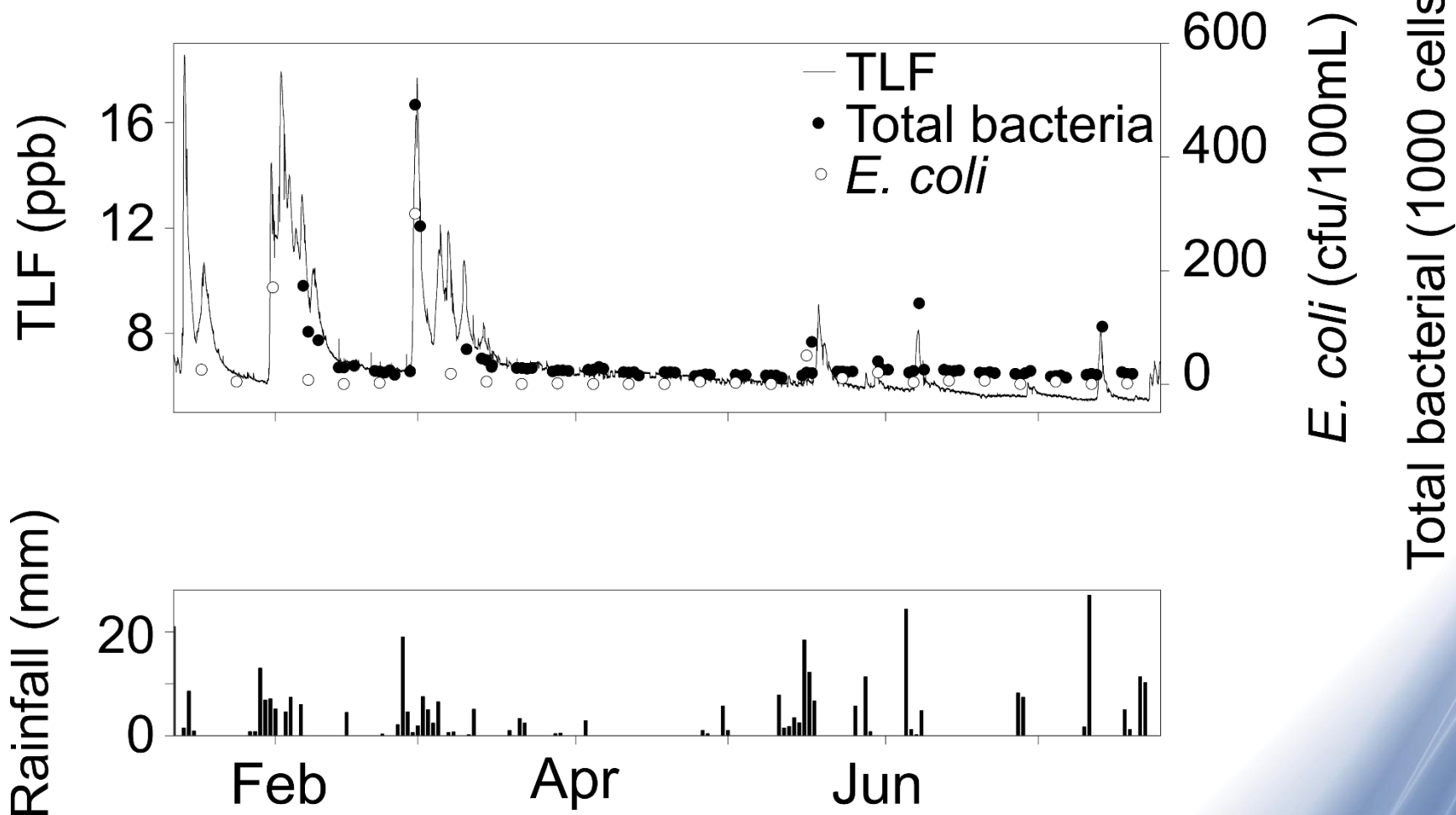


# Online indicators and total bacteria



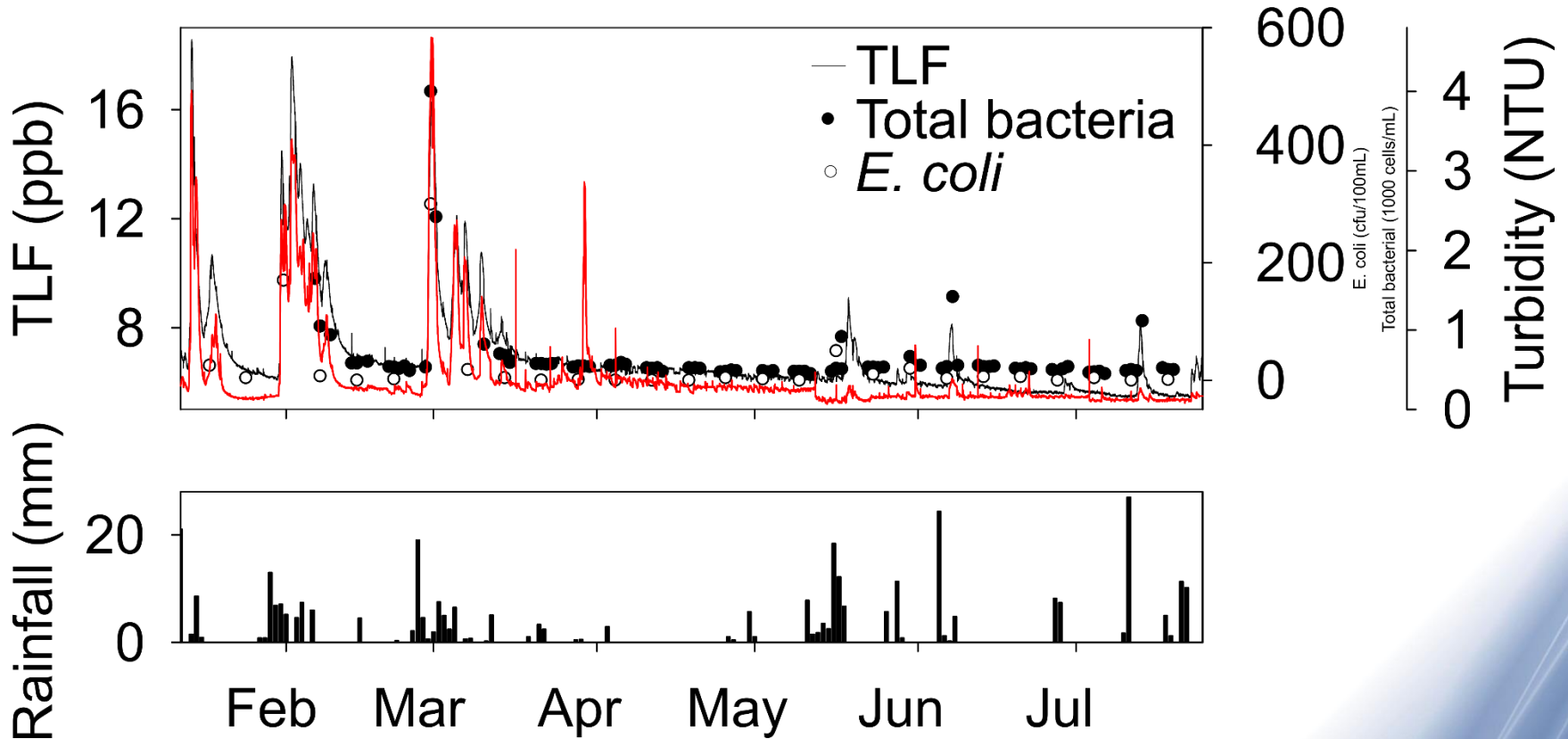
Total bacterial cell counts (1000 cells/mL)

# Continuous TLF data



# Adding turbidity data

— Turbidity





## 2. Does it work in the UK?

Is TLF a superior online indicator of the microbial quality of water than turbidity?

Yes!

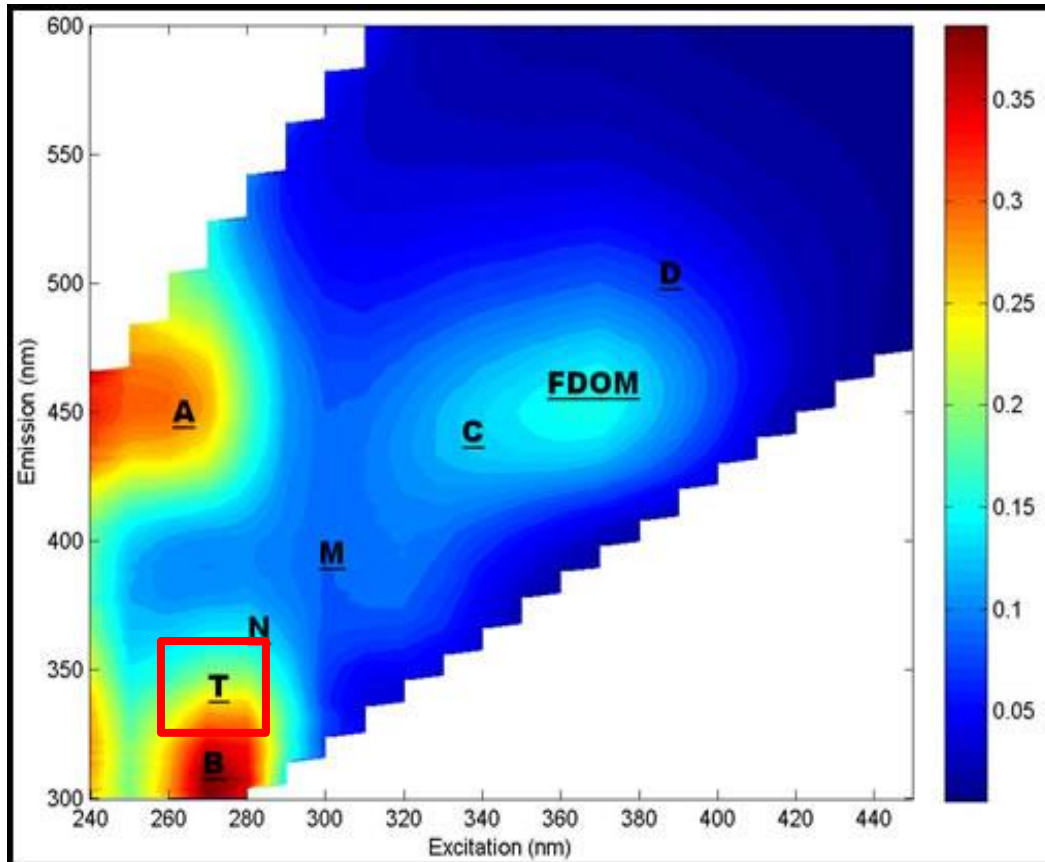
- TLF is better correlated with both *E. coli* and total bacterial counts

# Consider some of the limitations

# Limitations – can be overcome

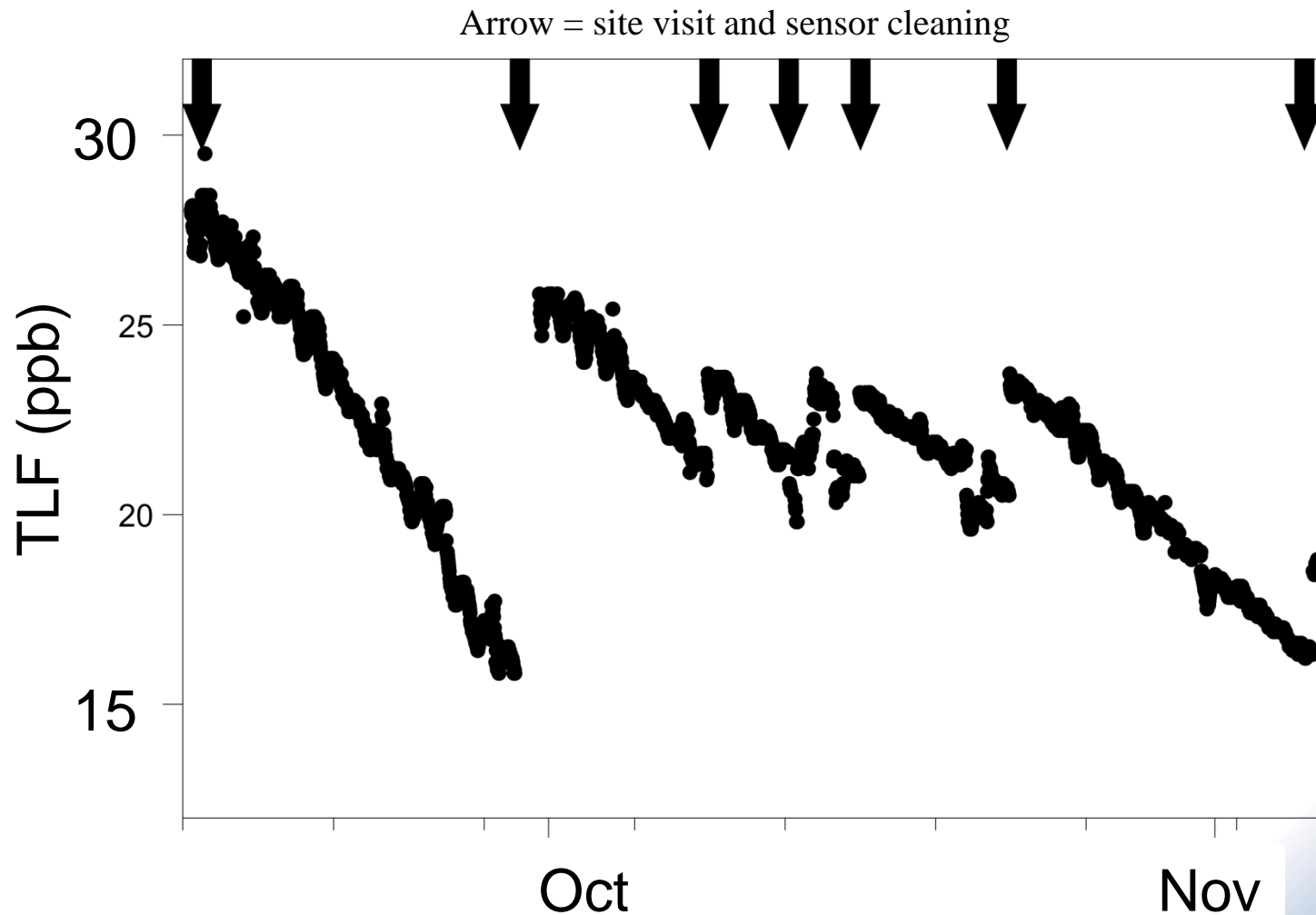
- Temperature – linearly related, possibility to autocorrect
- Turbidity – corrections have been proposed
- Inner-filtering – future sensors could autocorrect

# Overlapping fluorescent peaks



- Overlapping of fluorescent peaks
- Multiple sensors?

# Sensor fouling



# Future work

- What are we actually measuring with TLF?
- TLF is a selective indicator of *E. coli*?
- Current false-positive rate (18%) is too high
- Applicability for treated drinking water?

# Conclusions

- Portable, commercially available fluorimeters targeting tryptophan-like fluorescence (TLF) are:
  - Indicative of the presence/absence and number of *E. coli* in drinking water (threshold of 1.3 ppb, LOD ~10 cfu/100mL)
  - Superior to turbidity as an online indicator of microbial water quality

# References

- **Sorensen, J.P.R.**, Lapworth, D.J., Marchant, B.P., et al. (2015). In-situ tryptophan-like fluorescence: a real-time indicator of faecal contamination in drinking water supplies. *Water Research*, 81, 38-46.
- Baker, A., Cumberland, S.A., Bradley, C., et al. (2015). To what extent can portable fluorescence spectroscopy be used in the real-time assessment of microbial water quality?. *Science of the Total Environment*, 532, 14-19.
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- Fox, B.G., Thorn, R.M.S., Anesio, A.M., et al. (2017). The in situ bacterial production of fluorescent organic matter; an investigation at a species level. *Water Research*, 125, 350-359.
- **Sorensen, J.P.R.**, Baker, A., Cumberland, S. A., et al. (2018). Real-time detection of faecally contaminated drinking water with tryptophan-like fluorescence: defining threshold values. *Science of the Total Environment*, 622, 1250-1257.