



British  
Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

# Gateway to the Earth



## Real-time indication of faecally contaminated drinking water with fluorescence spectroscopy: towards understanding the causation

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# The driver

- 2 billion people consume drinking water contaminated with faeces (WHO, 2018)



- A more rapid monitoring approach is needed to improve this
  - currently culturing requires >18h to provide a result

# Tryptophan-like fluorescence (TLF)

- What is TLF?
- Tryptophan – essential amino acid
- Quantified using field fluorimeters



Instant results

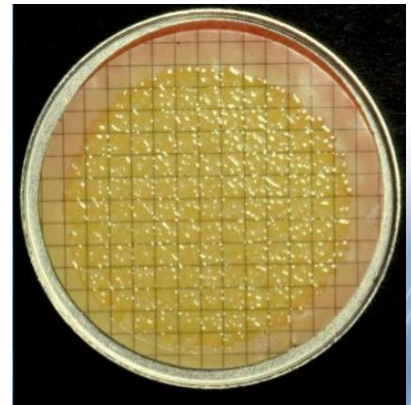


# Real-time indicator of faecal contamination

- Significant predictor of thermotolerant coliforms (TTC) presence/absence and enumeration
  - 2015 - Zambia
  - 2016 - India
- Superior to others predictors, e.g. turbidity, sanitary risk scores



Instant



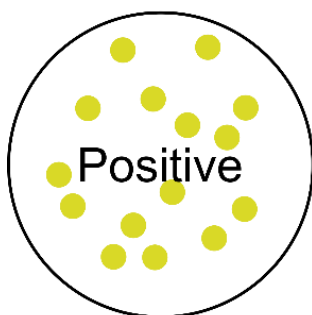
>18hr



# Predicting presence/absence of TTCs

- Combined India, Malawi, South Africa, Zambia (n = 564)

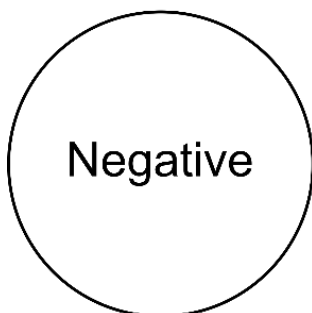
Plate counts  
(>18 h)



Predicting plate  
counts (real-time)

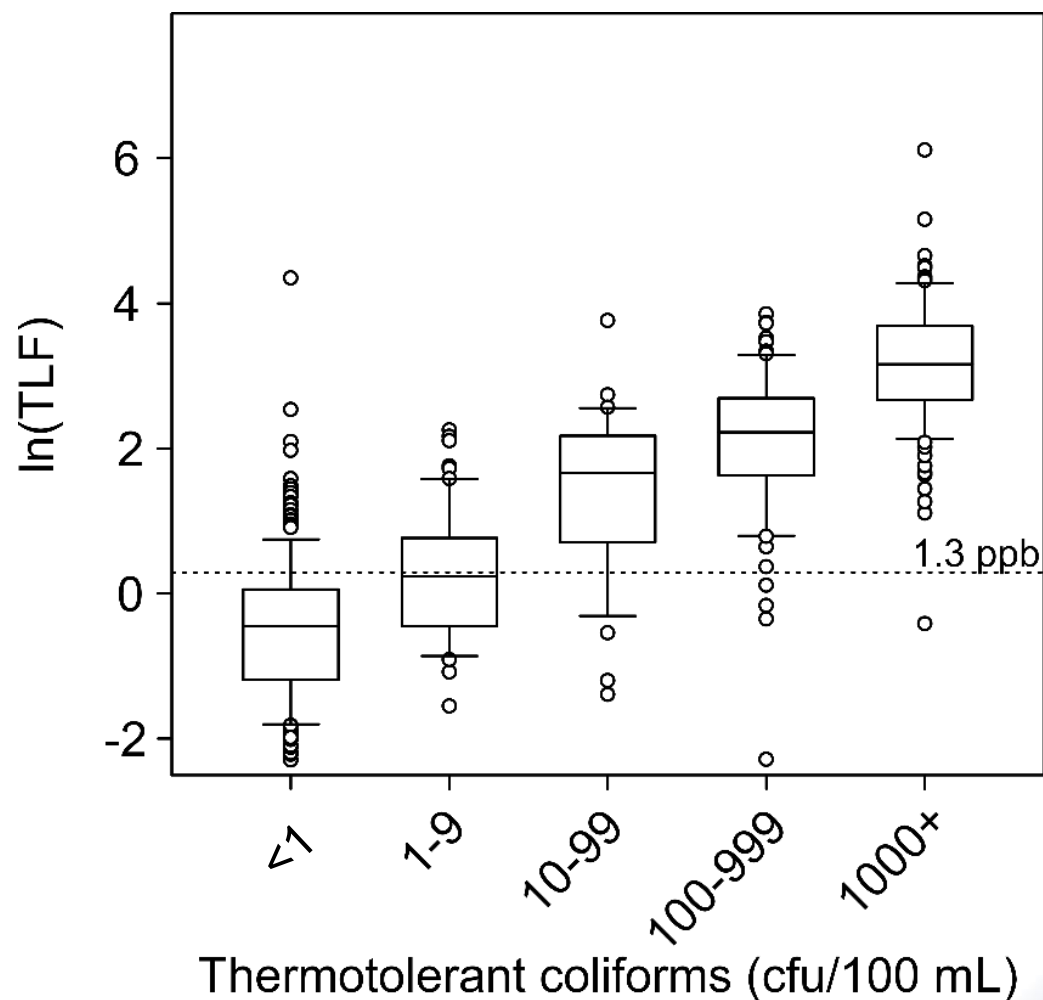
Limit of detection  
~10 cfu/100mL

Fluorescence > 1.3 ppb?



# Extent of faecal contamination

- Very strong correlation ( $\rho = 0.80$ ,  $p < 0.001$ ,  $n = 564$ )



# Online assessment of faecal contamination

- Online TLF (2 min resolution)
  - Strongly correlated with *E. coli*
  - Superior to turbidity



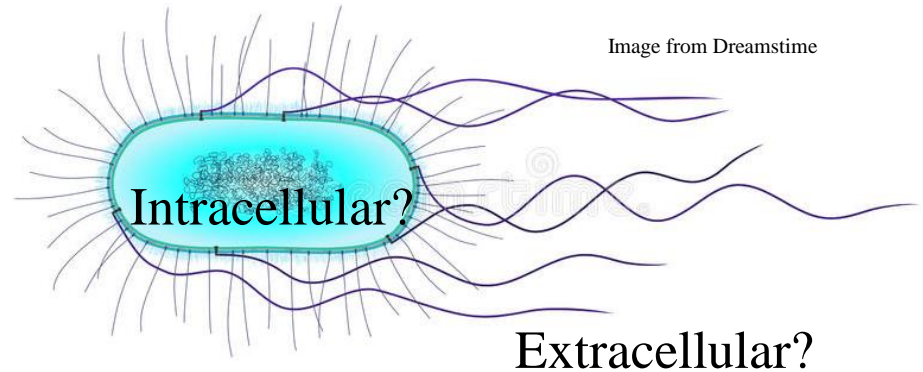
# Causation...

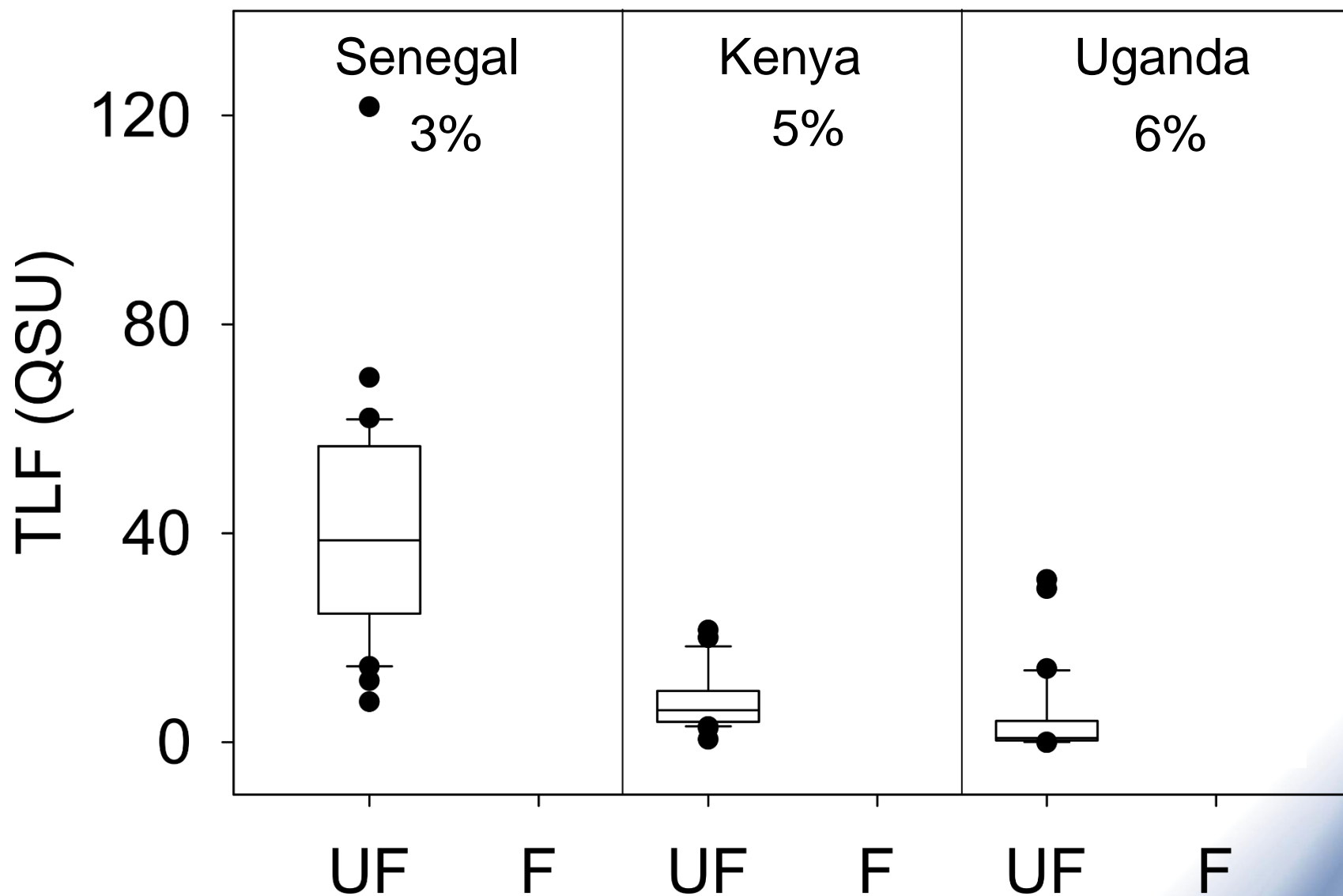
- *E. coli* cells directly emit TLF in lab studies
- *E. coli* cells used for the industrial production of tryptophan
- Many other bacteria fluoresce at TLF wavelengths or also excrete compounds



# 1. TLF Intra/extracellular?

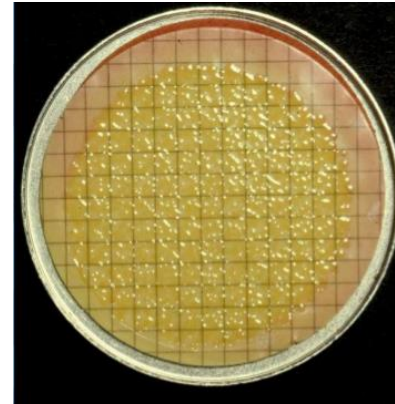
- Groundwater sources selected in Kenya, Senegal, Uganda ( $n \sim 100$ )
- Measuring TLF
- Filter sample ( $0.22 \mu\text{m}$ )
- Re-measure TLF





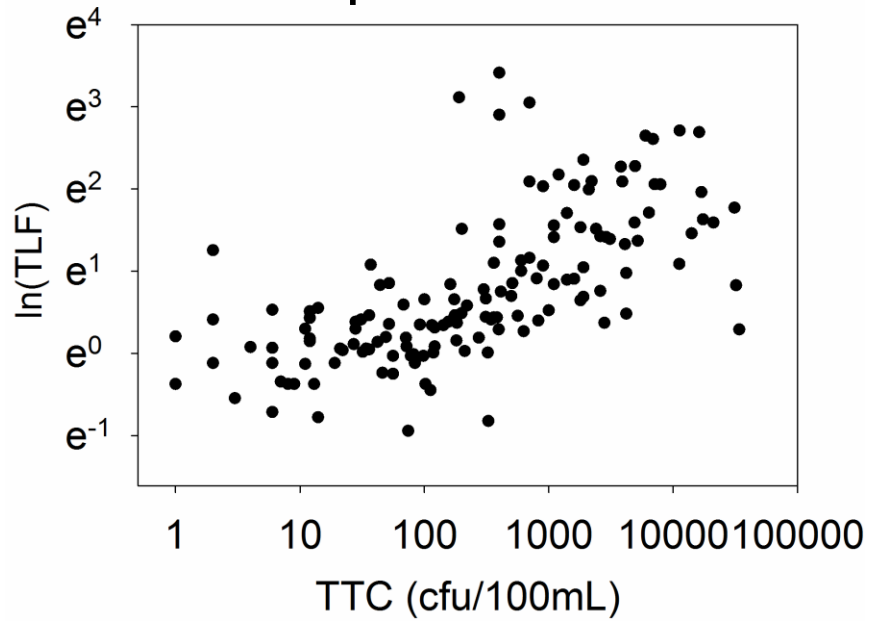
## 2. TLF specific to TTCs?

- Sampling of 40 sources in Lukaya, Uganda on 4 occasions through wet-dry season transition

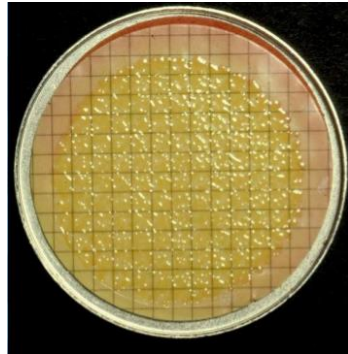




$\rho$  0.74



TLF



TTCs

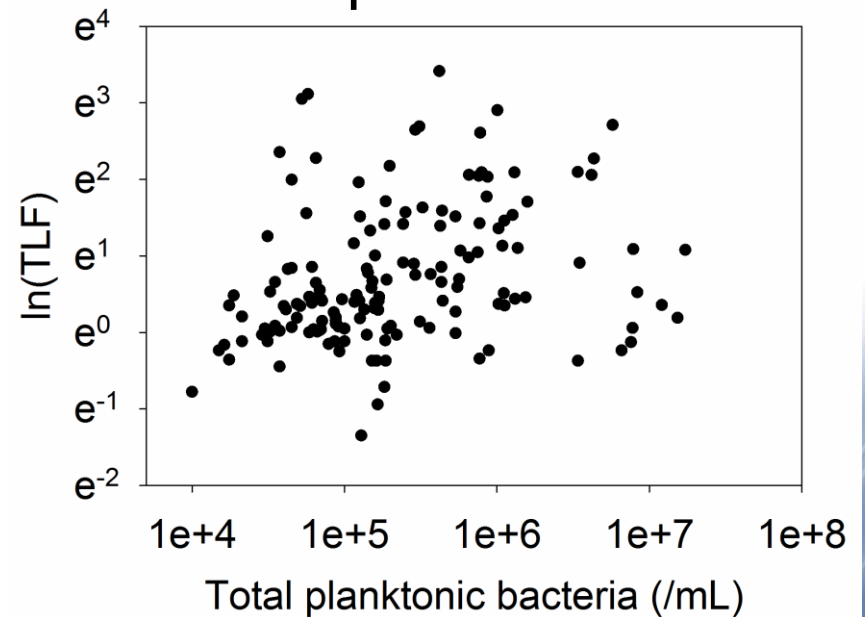
TLF



All bacteria



$\rho$  0.34





# Conclusions

- Tryptophan-like fluorescence (TLF) is:
  - A real-time indicator of faecal contamination
  - Extracellular in groundwater
  - More related to faecal indicator bacteria than total bacteria



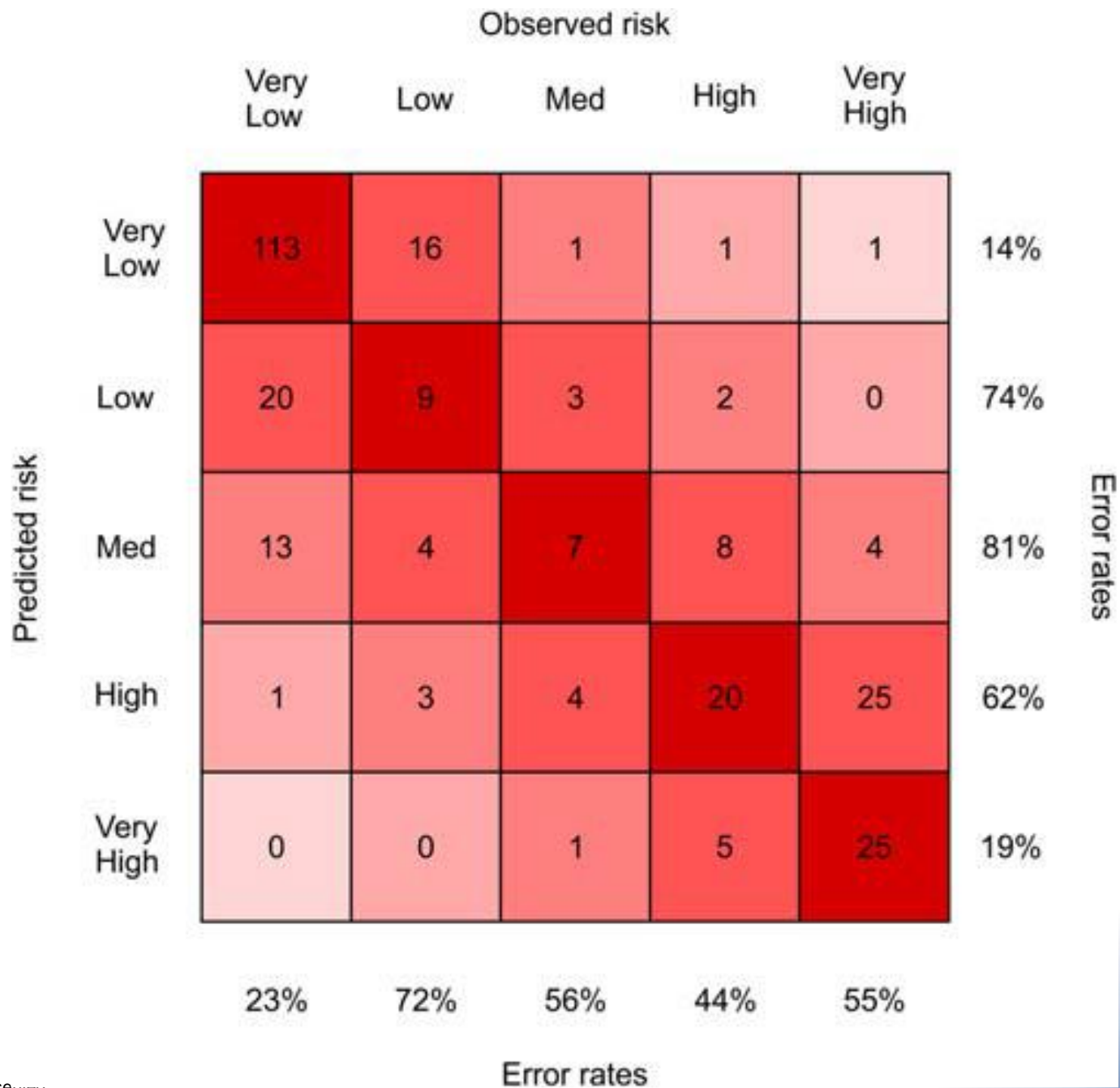
Instant result

# References

- **Sorensen, J.P.R.**, Lapworth, D., Marchant, B., *et al.* (2015). In-situ tryptophan-like fluorescence: a real-time indicator of faecal contamination in drinking water supplies. *Water Research*, 81, 38-46.
- **Sorensen, J.P.R.**, Sadhu, A., Sampath, G., *et al.* (2016). Are sanitation interventions a threat to drinking water supplies in rural India? An application of tryptophan-like fluorescence. *Water Research*, 88, 923-932.
- **Sorensen, J.P.R.**, Baker, A., Cumberland, S., *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.
- **Sorensen, J.P.R.**, Vivanco, A., Ascott, M.J., *et al.* (2018). Online fluorescence spectroscopy for the real-time evaluation of the microbial quality of drinking water. *Water Research*, 137, 301-309.

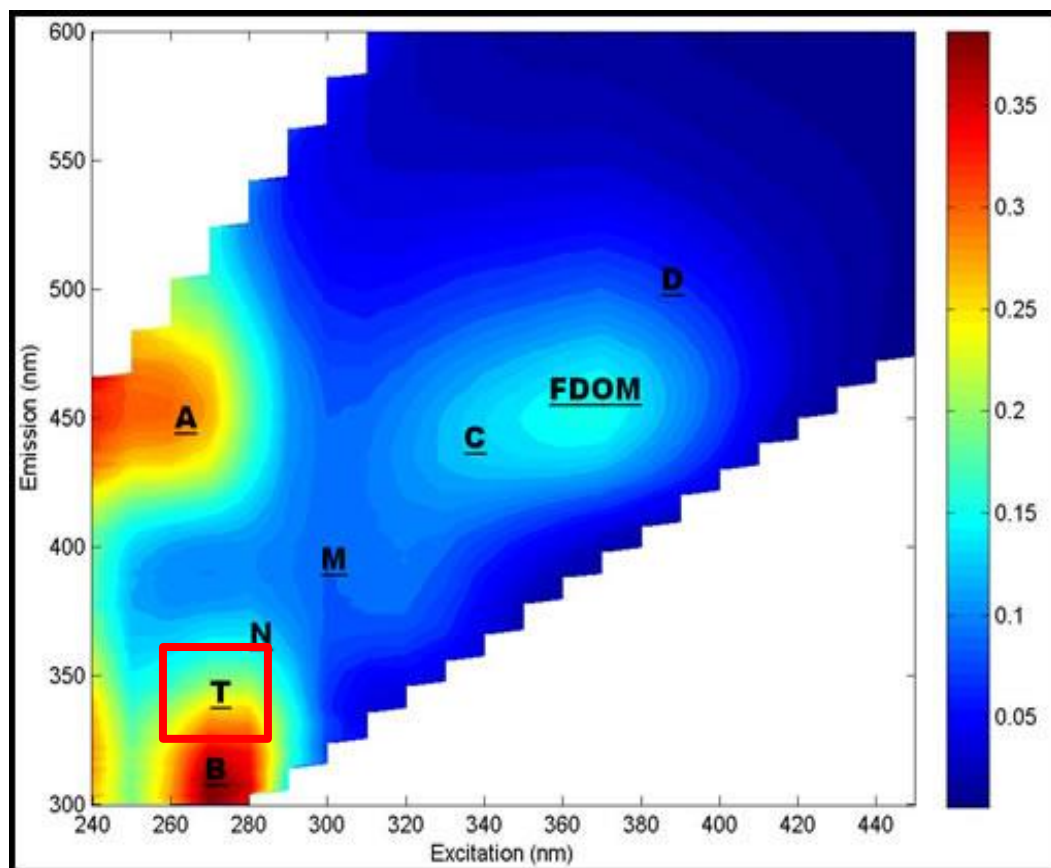
# Limitations – can be overcome

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



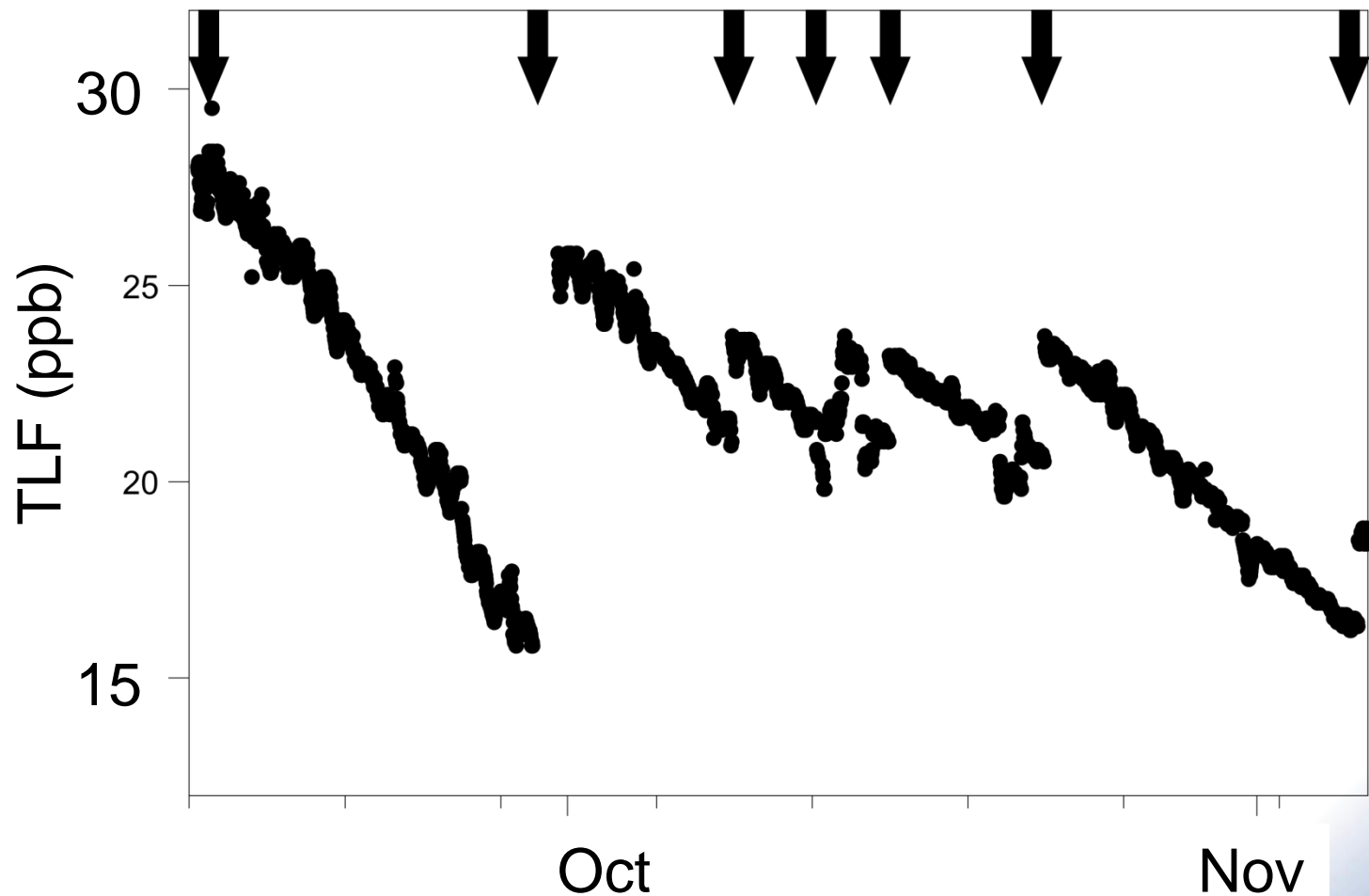


# Overlapping fluorescent peaks



- 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?

# Quantifying fluorescence - fluorimeter

