Investigating the effect a wastewater treatment plant has on local river water quality

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Introduction

Rivers serve many, as both areas for recreational activities and habitats for wildlife. In the UK, the Environmental Agency has implemented a number of rules to regulate the quality of the processed discharge water prior to its reintroduction into a watercourse. Though raw wastewater undergoes a number of treatment processes before it is discharged, it may not be sufficient to protect users of the river. Incompletely or incorrectly treated water from a treatment plant released into a watercourse could contain unsafe levels of bacteria and high levels of nutrients that could be harmful to the environment. High levels of *E. coli* can cause endemics such as cholera, and environmental crises such as eutrophication occur when there are high levels of nutrients in a body of water. This project aims to determine whether or not discharged water from a wastewater treatment plant is safe, and further, if the downstream water quality is affected. In this investigation, levels of *E. coli*, phosphate and nitrate concentration, as well as algae count were calculated using samples taken from a certain river in the North of England.

Safe levels for bathing[1] :

- *E.coli* - **500** colony-forming units (CFU) per 100ml
- *Intestinal enterococci* - **185 CFU** per 100ml
- Nitrate and phosphate levels have **no specified threshold** (but are not considered a primary concern for human health when swimming)

Hypotheses

-We hypothesised that concentrations of bacteria (including *E. coli*) will not exceed the safety thresholds.

-We also believe that concentrations of bacteria, algae, nitrates and phosphates will be highest at the discharge point, followed by downstream and at the lowest levels upstream.

Methods

Three data points were chosen from around the wastewater treatment plant: **25m** upstream, at the discharge point and **25m** downstream. Using these samples we tested for:

- Algae, using a **haemocytometer** and **microscope**
- Phosphate and nitrate levels, using a **spectrophotometer**
- Total bacteria, using a **non-selective spread plate**
- *E. coli* colonies, on a **Eosin Methylene Blue plate**

Limitations

- Algal counts did not distinguish between different varieties of algae
- Does not give an overall look at wastewater treatment across the UK
- Nitrate and phosphate levels tell us little about how safe the water is for bathing, as there is no clear threshold.
- Tests were performed within a limited timescale and do not account for algal blooms' formation over time. **Fig. 5** shows that algal counts increased downstream, potentially due to algae blooming in the presence of elevated concentrations of nitrates and phosphates.

References

[1] Department for Environment Food & Rural Affairs (2021). *Bathing Water Quality*. [online] environment.data.gov.uk. Available at: https://environment.data.gov.uk/bwq/profiles/help-understanding-data.html [Accessed 4 Dec. 2024].

Results

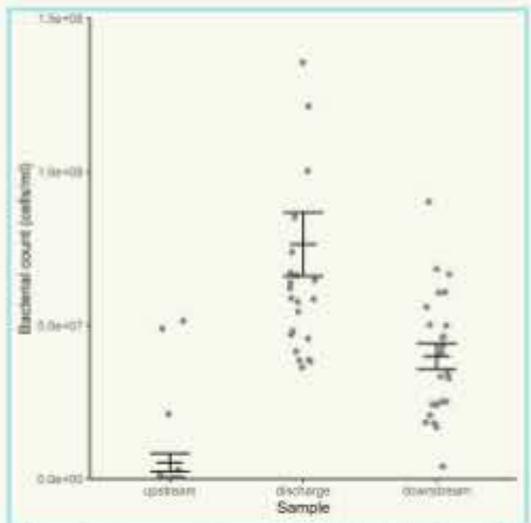

Fig. 1: Bacterial count (CFU/ml) with 2 anomalous data points removed, T=3.065, significant to $p < 0.005$

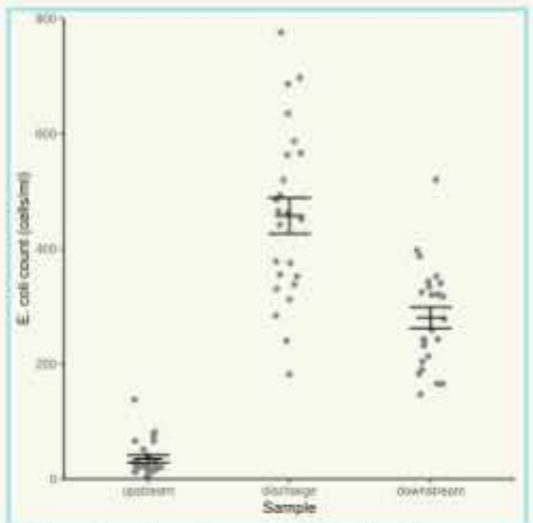

Fig. 2: *E. coli* count (CFU/ml), T=7.4598, significant to $p<0.001$

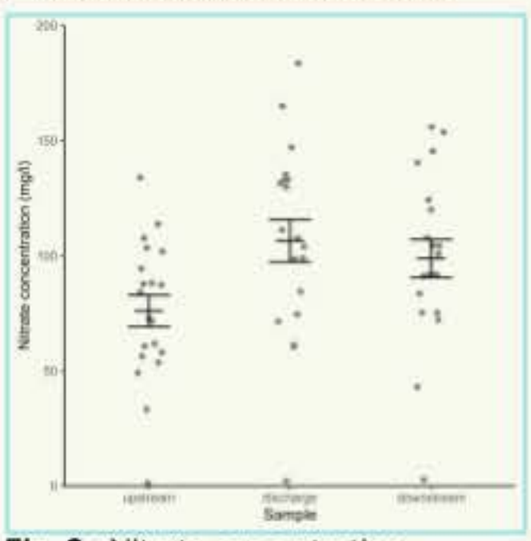

Fig. 3: Nitrate concentration (mg/l), T = 2.1839 Significant to $p < 0.025$

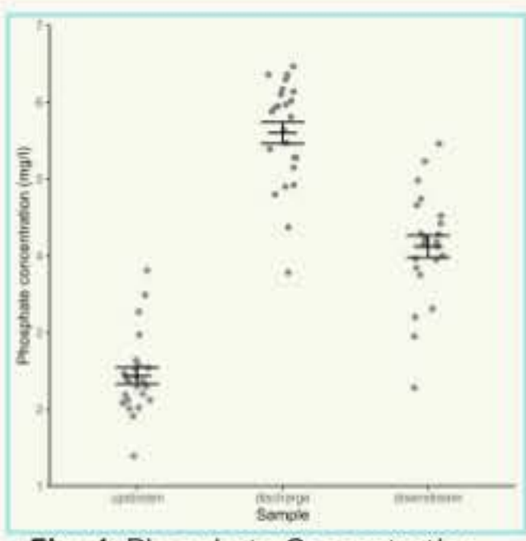

Fig. 4: Phosphate Concentration (mg/l), T = 10.1336, Significant to $p < 0.001$

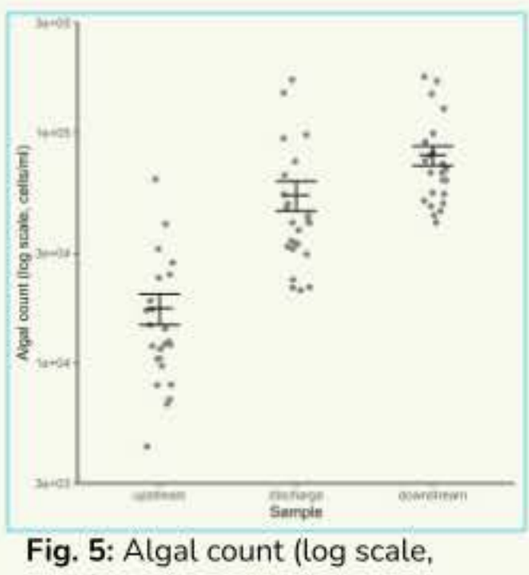

Fig. 5: Algal count (log scale, CFU/ml), T=6.7109, significant to $p<0.001$

An unrelated t-test was carried out on the results from the upstream and downstream samples. In all cases it was found that there was a statistical difference at p=0.025 or below. This means that the null hypothesis can be rejected in all scenarios and there is a statistical difference between the upstream and downstream sections. This suggests that the water being discharged from the wastewater treatment plant is having an effect on the environmental conditions of the river further downstream.

Conclusion

In conclusion, it is clear from our results that discharge from the wastewater treatment plant had a **considerably negative effect** on the water quality of the river. Graphical and statistical analysis provides evidence for **significantly higher** bacterial, algae, phosphate and nitrate levels when comparing samples upstream and downstream of the discharge pipe, however across all samples, levels of these factors were **considered unsafe**. This has negative implications on the environment, where high phosphate and nitrate concentrations can cause **eutrophication**, leading to harmful algal blooms and a high pH. As a result of these unfavourable conditions, many aquatic organisms will struggle to survive. This has further ill effects on humans, where water is deemed unsafe for recreational activities and **dangerous for health** due to the risk of diseases such as cholera, diarrhoea and cancer. To combat this nationwide issue, required immediately to prevent further harm to our ecosystems, there should be further regulations and restrictions put in place to prevent the release of this unsafe discharge, as well as closer monitoring and testing. Further research is also needed to identify the ideal levels of phosphate and nitrate, and to distinguish between concentrations of safe and unsafe algal species.