

Testing the Limits. Can Nitrate Levels be Used to Safeguard the Health of UK Rivers? The Critical Reflection of an Undergraduate's Introduction to Independent Research

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Abstract

The novelty of independent research is always a memorable experience, although never for the reasons expected. The responsibility of designing and executing an original project; the uncertainty of having to cope with issues as and when they arise. While I can attest to this being a positively enriching experience, it was certainly not without its drawbacks. Since the majority of these were a product of my shifting priorities, this came to define my project. Akin to a trial by fire at times, I thus attained a better understanding of the realistic expectations that ought to come with carrying out research, at any level, alongside the strengthening of my resilience to setbacks – although it did not feel as such at the time. Met with unfavourable circumstances, I nevertheless produced a comprehensive academic poster that has since allowed me to present at multiple conferences. Furthermore, I have taken my experience here and the desire to undertake research onto the next project and will continue to do so going forward.

Keywords: Nitrate pollution, riverfly abundance, safeguarding UK rivers, UK river health.

Introduction

During the summer of 2024, I undertook a research project to investigate the influence of **nitrates** on the **health** of UK rivers, with a focus on examining the need for introducing environmentally focused nitrate limits to safeguard river biodiversity. Funded through the University of Warwick's Undergraduate Research Support Scheme (URSS), this study was my introduction to the satisfaction and struggles that come with carrying out original research (University of Warwick, 2025). This critical reflection will therefore, in the style of Gibbs' Reflective Cycle, review my candid experience of the project: from the initial unfamiliarity of my academic independence to grappling with issues I could feasibly address and recognising those I could not (Gibbs, 1988). Although I could identify a plethora of strengths and limitations with how I approached and executed this project, it would be more fitting to summarise this evaluation as a recognition of the 'shifting priorities' that come with navigating independent research.

Plotting of pollution

To better understand the scale of the issue I hoped to investigate, I set about mapping the major sources of pollution affecting each of my sample rivers: the River Wye, Great Ouse and Dart. These rivers were categorised by **intensive farming units**, sewage treatment works and settlements with populations exceeding 2000 people, the latter signifying risk of **urban diffuse pollution**. This would enable the characterisation and assessment of pollution at each site I sampled, which I planned on incorporating with a water quality index (WQI) – which uses several **physicochemical** parameters of water quality to evaluate surface water quality, including nitrate (Uddin *et al.*, 2021).

The mapping stage of my study took place prior to doing any of my own sampling, and hence became the first drawback. Firstly, I planned on using ArcGIS Pro as my preferred mapping software, due to being able to overlap multiple layers of data with both spatial and temporal properties, helping to produce a comprehensive output (Esri, 2025a). Unfortunately, given that I work on a Mac, I soon learnt ArcGIS Pro does not natively support MacOS and required running the programme within a Windows environment on my Mac

(Esri, 2025b). Despite the help of the University of Warwick's IT Services team to overcome this issue, I soon came across a worse problem.

Further reading into WQIs led me to discover the minimum number of physicochemical parameters I required would be four, not the two I was investigating, while most widely used models utilised between eight and eleven of these parameters (Uddin *et al.*, 2021). To adhere to my budget and still produce a sufficient body of data from across my sample rivers, I realised the importance of my mapping work would have to be sidelined. Given the number of hours I had committed to mapping, I was frustrated to say the least. Fortunately, my work was not completely wasted, as it remained effective in illustrating the magnitude of **anthropogenic pressures** facing our rivers when presenting my final output, while elsewhere in the study, I could support this with statistical outputs. The balance between qualitative and quantitative analysis proved most effective in disseminating my findings to interdisciplinary audiences.

This experience certainly helped me identify a disconnect between the planning and budgeting aspects of my research and what is analytically achievable. As such, I hope to be more realistic, in terms of project constraints, whether budget, timing or otherwise, when planning and executing future research projects.

Grappling with government data

While I continued with mapping, my preparations also involved studying the Environment Agency's (EA) Ecology & Fish Data Explorer and Water Quality Data Archive, and where data was unavailable, having to submit several Environmental Information Regulations (EIR) requests to both the EA and Natural Resource Wales (NRW) (Environment Agency, 2025a; Environment Agency, 2025b).

The aim of this was to obtain historical ecological and physicochemical data for each of my sample rivers to compare my to-be-collected data to long-term trends in pollution and determine if my data was expected or noticeably

different to historical figures. Although the process felt cumbersome at times – only helping confirm my prior concerns regarding engagements with government organisations – the few individuals I did speak with were fortunately very accommodating in processing my EIRs and forwarding them to the relevant offices for my sample rivers.

Difficulty instead came from the archived data often containing missing entries, at times across several years; this effectively prevented me from accurately charting trends in river health. Although a useful experience, and one that ought to be beneficial for any future projects, if at least to temper my expectations of EIR requests, this forced me to alter the emphasis of my project. Initially designed to consider both spatial and temporal analytical directions, the emphasis was streamlined to a purely spatial comparison. While I did not recognise this at the time – I suppose that as the issue of river pollution and its management has, in recent years, only become more pertinent to the interests of the public – it may have been more appropriate to begin as a spatial analysis.

Hereafter, I ought to better scrutinise the aims of my projects, to identify the most appropriate means of answering my objectives without needlessly wasting time and other resources on less effective strategies.

Sample selection and access

Much of my data collection consisted of nitrate testing, a determinant of water quality measured using a **photometer**, and invertebrate sampling with a focus on **riverfly** abundance – a useful indicator of environmental health. While selecting possible sample sites along each river, I thus prioritised sampling depth as the main factor governing my decision, with site depths above what would allow for kick sampling – the disturbance of substrate from the riverbed to collect dislodged invertebrates (Field Studies Council, *nd*).

Although I primarily relied on resources such as River Levels UK, I initially remained determined to not waste the data I had obtained through my EIR requests and compare my results to government data for the years available

(River Levels, 2025). Attempts to align my proposed sample sites with locations historically used by the EA and NRW nevertheless proved fruitless, with too many sites not adhering to my pre-existing requirements. At least I did not commit too much time to this endeavour. Having navigated the issue of selecting what I considered to be appropriate sample sites, I was subsequently met with some challenges in the field.

Unbeknownst to me, and not evident when mapped, several of my sample sites were only accessible via private land, forcing several last-minute changes as I located alternative sites along my sample rivers – up to a few miles away – that could be reached on public land. Although I could have done without the stress of this, acutely aware of my daily workload required to remain on schedule and within budget, I will look back at this as an effective lesson in proper, prior, planning, with it prudent to have prepared a backup plan. This experience has helped me recognise that research projects can go awry in many unexpected ways and has made me more resilient in coping with and addressing such changes.

Phantom phosphate

I have thus far exclusively referred to my examination of water quality through the analysis of nitrate. This was not always the case; I had intended on sampling for both nitrate and **phosphate** concentrations, due to their strong association with sewage effluent and agricultural runoff into UK waterways (Meixian *et al.*, 2022; Rankl, 2023). While onsite, these measurements were to be completed as and when I had collected and prepared my river samples. However, after finishing sampling at my first location along the River Dart – a several-hour venture when including riverfly sampling – I realised this would prove too time-consuming, with approximately one week to complete my sampling from across the UK and remain within budget. Furthermore, the photometers' reagents used in my chemical analyses are designated as highly toxic to the environment with long-lasting effects. Besides the appropriate PPE to handle safely, this would have required a high level of care and precision I had not the time to afford. I resolved instead to

keep my samples chilled in a cool box, therefore, until the running of my tests was feasible. Although a bothersome setback, at the time I felt assured in this compromise.

As appears to be a recurring theme underscoring this project, upon later running the measurements of my samples for nitrate and phosphate, I was met with the final complication to shape my study's focus: phosphate was essentially absent from my samples. Since I had obtained a range of nitrate readings, I realised something was wrong. My prior understanding had been that nitrate and phosphate were considered stable in solution, with the samples kept cool to minimise microbial activity (Agency for Toxic Substances and Disease Registry, 2017; Comber *et al.*, 2015; Lloyd *et al.*, 2022). Further review of the literature led me to discover that, for phosphate analysis, this ought to be completed within 24 hours of sampling, after storage at 4°C in the dark (Lloyd *et al.*, 2022). This came as a great surprise, having believed I previously acted on reliable evidence. I also surmised that due to the specifications of the equipment I used, physicochemical parameters including iron and copper concentrations, and sample **turbidity**, may have unduly influenced my phosphate readings (Hanna Instruments, 2025).

Regardless of the cause, I was left with little choice but to discard phosphate from my write-up. Although unlikely to have ultimately altered my conclusions, this will teach me the danger of assuming the reliability of a couple of corroborated sources, while learning the importance of thorough literature reviews to ensure no contradictions arise to later undermine any aspect of my research.

Conclusion

Returning to the concept of 'shifting priorities' that has come to define my study, I believe that, despite my struggles, this will ultimately benefit me in all aspects of independent research. From appreciating the constraints of budgeting and time on analytical power, to the recognition of realistic aims, supported by contingency planning in case of malign circumstances, and

ensuring this is corroborated by the academic literature, I feel I have grown more resilient to the volatility that can come with executing research. The sense of uncertainty and foreboding, however, that comes with recognising and attempting to respond to failure is often worse than the actual issue at hand, as evidenced by the academic poster that I produced from my study and later presented at both the British and International Conferences of Undergraduate Research. To summarise, while this was a decidedly enjoyable, fulfilling experience, and one which ought to benefit my undertaking of future projects, I realise now how executing independent research is rarely without its difficulties. Since beginning a new study in the summer of 2025, I feel I have, so far, improved my adaptability to problematic circumstances, avoiding the pitfalls of past errors and oversights. I am currently writing up this project and am applying to present at an academic conference later this year.

Acknowledgements

I would like to acknowledge and thank my supervisor, Robert Lillywhite, for all his support with this project. The countless Teams meetings, providing invaluable advice – without limiting my freedom to figure out issues independently – and unyielding patience in helping keep me grounded in what was feasible with my budget and time constraints. Without Rob, my project would never have turned out the way that it did, nor open so many doors for me going forwards.

Appendix

Website: <https://www.uk-river-report.org.uk/>

Poster:

Testing the limits. Can nitrate levels be used to safeguard the health of UK rivers?

Federico Fidel White

Aim of study:

To investigate the influence of **nitrate** levels on the **health of UK rivers**. This will consider the relative **importance** of the different **sources** and the **consequences** of **nitrate pollution**, and the need to impose **limits** to **safeguard water quality** and **environmental health**.

Introduction:

- As of 2024, **only 14%** of English rivers achieved **good ecological health**.
- The **top three sources** preventing waterbodies achieving good ecological status are: **agricultural pollution** (40%), **sewage and wastewater** (36%) and **urban diffuse pollution** (18%).

Materials and methods:

- Nitrate testing: conducted using a **Hanna HI-97728 Nitrate Photometer** to obtain an average for the **upper, middle and lower courses** of each sample river.
- Invertebrate sampling: **Environment Agency** standard **three-minute kick sample** and **one-minute manual search** along each sample river, as for the testing of nitrate concentrations.

Conclusions:

- There are **several chemical parameters** used in the determination of **water quality**. This study has focused on nitrate as a **proxy**. **Riverfly abundance** is a useful **indicator** and can be used to demonstrate how **environmental health** varies across the length of a river and between rivers.

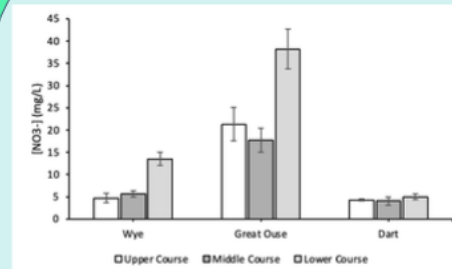
- The results suggest that **higher nitrate concentrations** favour **tolerant species**, over intermediate and intolerant riverfly.

- By **mapping the major sources of pollution** affecting each sample river (QR code below), this further highlights the need to limit nitrate levels. However, this also presents an interesting consideration of whether **addressing these inputs directly** or focusing on implementing legislation to **tackle the consequences** of these activities, is of greater importance.

- The changes in riverfly diversity may be in part attributed to the **sharing of ecological niches**, on top of **tolerance to nutrient enrichment**, as with rising nitrate concentrations, intolerant species are unable to as readily compete with more tolerant riverfly.

- The results for the Wye and Great Ouse suggests that **limits for nitrate concentrations** could **benefit overall species abundance** and should be introduced for UK rivers, as there already exists for reactive phosphorus. However, with **contrasting thresholds** across these rivers, any legislation should go beyond **generalised standards** and be **tailored specifically** to each UK river, using a **holistic assessment approach**.

Results: nitrate concentration and river fly abundance



Nitrate concentrations along the **lower course** of the Wye were **significantly higher** compared to the **upper and middle courses**; the same was true for the Great Ouse. However, **no significant difference** was recorded along the Dart.

Nitrate levels **across the three rivers** were **significantly different**, with the Great Ouse being the highest.

Course Comparison	River Wye ($\bar{x}$)	River Great Ouse ($\bar{x}$)	River Dart ($\bar{x}$)
Upper vs Middle	NS (4.70/5.70)	NS (21.3/17.7)	NS (4.30/4.03)
Upper vs Lower	*** (4.70/13.5)	*** (21.3/38.2)	NS (4.30/4.97)
Middle vs Lower	*** (5.70/13.5)	*** (17.7/38.2)	NS (4.03/4.97)

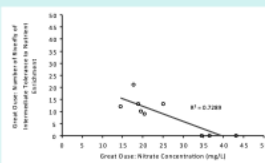
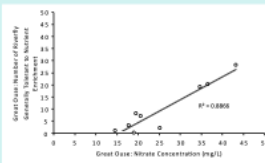
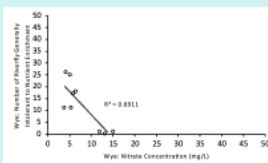
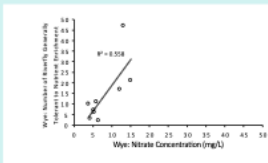
Correlation between nitrate concentration and riverfly abundance:

Riverfly Tolerance	Wye: [Nitrate] (Pearson C.C)	Great Ouse: [Nitrate] (Pearson C.C)	Dart: [Nitrate] (Pearson C.C)
Generally Tolerant	*** (0.747)	*** (0.942)	NS (-0.457)
Intermediate Tolerance	NS (-0.181)	*** (-0.854)	NS (0.277)
Generally Intolerant	*** (-0.831)	NS (-0.542)	NS (0.572)

$\bar{x}$ = mean (mg/L), NS = not significant, *** = significant ($p \leq 0.05$)

Nitrate concentrations on the **lower Wye** were greater than **12.1 mg/L** which favoured **tolerant riverfly**.

Oppositely, **intolerant species**, were only abundant **upstream**, between **3.9 - 6.5 mg/L**.



Nitrate levels along the **lower Great Ouse** were higher than **34.7 mg/L**, favouring **tolerant riverfly**.

However, **intermediate tolerance riverfly** were only recorded further **upstream**, at a range of **14.6 - 25.2 mg/L**.

Important links:



References



Sampling map



Website/blog

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Glossary

Anthropogenic pressures: Refers to the various human-induced factors that create environmental stress, significantly impacting ecosystems and biodiversity.

Health: The characterisation of an ecosystem's condition and functionality derived from a range of physicochemical and ecological parameters.

Intensive farming units: Farms that practice the high density rearing of livestock, often associated with issues around animal welfare, and which produce large quantities and concentrations of animal waste. If improperly recycled, the latter, rich in nitrate and phosphate, risks contamination of waterways and groundwater from resulting runoff.

Nitrate: A compound of nitrogen and oxygen, found naturally at low levels in freshwater environments. Also, a component of fertilisers and raw sewage effluence – occurrence at higher concentrations is indicative of agricultural runoff or sewage discharge, causing eutrophication. Concentration measurements were conducted in the study using a Hanna HI-97728 Nitrate Photometer.

Physicochemical: Relating to the combined physical and chemical parameters that define and influence environmental conditions, such as the concentration of pollutants in a river, and the river's turbidity.

Phosphate: A compound of phosphorous and oxygen, found naturally at low levels in freshwater environments. A component of fertilisers and sewage effluence, phosphate runoff similarly causes eutrophication. Concentration measurements were conducted in the study using a Hanna HI-713 Phosphate Checker.

Photometer: An instrument used to measure the concentration of chemical substances, such as nitrate and phosphate, in a solution. This relies on measuring the transmission or absorption of light at a certain wavelength,

often using a reagent to react with the substance of interest, colouring the solution proportionally to its concentration. In this instance, the reagents used for the nitrate photometer and phosphate photometer are both toxic and harmful to the environment.

Riverfly: A family of invertebrates, most of whose life cycle is spent in freshwater ecosystems such as lakes and rivers. Consisting of 33 invertebrate groups, these are used as a standardised monitoring technique, often in conjunction with several physicochemical parameters, to determine the health of rivers and other freshwater systems.

Turbidity: A key test of water quality concerning the cloudiness, or opacity, of a water sample. Caused by the presence of suspended particles such as algae and silt, this can negatively influence pollutant readings due to the scattering and absorbance of light otherwise detected by measuring equipment.

Urban diffuse pollution: Environmental contamination originating from dispersed, non-point sources within the urban landscape, such as from street runoff and poorly managed storm overflow systems.

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