**Using in situ sensors to monitor ecosystem health in freshwater catchments**

**Lead Supervisor Name**

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**Lead Supervisor Location/Student Home Institution**

Institution: Cardiff

School: EARTH

**Full Project Description**

The project will assess different methods for measuring nutrient fractions in surface water bodies. The student will work with the diverse, multi-disciplinary supervisory team to develop a range of skills to address a real-world problem. The project will begin with the analysis of historic datasets from the field site and complementary sites in the UK (including Hampshire Avon, Wyle, Nadder, Conwy) to determine how geosmin production responds to water quality, microbiological and biogeochemical parameters. Statistical analysis of these data will determine the key parameters to be measured, and how frequently data returned in order to predict ecosystem change and associated taste and odour problems. The results of these analyses will be used to design and implement a program of in situ monitoring at the field site.In situ monitoring technologies ] will be co-installed at the field site to allow cross-validation of the different methods. These will be complemented by measurement of physical and geochemical parameters (EC, T, pH, DO) and the existing water monitoring program run by our stakeholder at DCWW. This includes sample collection and lab analysis for nutrients, major ions and microbiological indicators, alongside local meteorological conditions and water levels. The student will then explore the most useful methods for returning data from the field in a useable format within useful timescales (near real-time) via satellite or GSM telemetry. The student will also test how the sensors represent nutrient dynamics by comparing water samples analysed in the labs with the sensor data. In parallel with the field monitoring, the student will develop a series of laboratory experiments to determine the impact of different nutrient phases on the freshwater ecosystem microbiota responsible for the majority of taste and odour issues. Cyanobacteria will be incubated in the laboratories at Cardiff and dosed with different nitrogen compounds. Ammonia is a known trigger (Perkins et al. 2019), but reliable in situ methods for field measurement are as yet unavailable. We will therefore explore how ammonia triggers changes in the laboratory experiments to understand how and when variables that can be sensed automatically can be used to signpost potential taste and odour issues.

Once the first datasets are assembled, the student will explore them with the supervisory team and stakeholders to determine

1. which sensors are most appropriate for assessing water quality,
2. how nutrient dynamics influence water quality, particularly those factors which influence taste and odour,
3. on what timescales data need to be collected and returned from the site in odour to predict water quality conditions that impact taste and odour, and that could result in eutrophication
4. how sensor data can be used to represent the complex biogeochemical cycles occurring at the field site. The field site can then be used as a model for efficient monitoring of ecosystem status and water quality for other UK catchments.

**Real Life challenges this project will address**

Freshwater eutrophication costs water companies approximately £54-96m annually in England and Wales. £1.5k per day per water treatment works. An excess of nutrients fertilises algal blooms that have negative impacts on ecosystem health, water quality, and eventually taste and odour. Treating the water after blooms have occurred is expensive, typically occurs after the problem has occurred, and risks longer term damage to the ecosystem. If treatment can be responsive, rather than predictive, then treatment costs may be reduced and ecosystem health improved. Predictive treatment, however, requires real-time monitoring of nutrient status of water bodies. Nutrients are typically assessed by water sampling and return to the laboratory for analysis, which even in the best case scenario may take several days. Technologies are now available for in situ monitoring of some nutrient species, notably nitrate and DOM, but their suitability for UK freshwater systems rather the ocean waters for which they were designed is poorly known. This project will assess several in situ sensing methods, to aid our project partners in developing the best predictive tools to control risks of eutrophication , taste and odour problems associated with geosmin production, and reducing associated water treatment costs and improving supply catchment ecosystem health.

**What you should know about this project**

This project will combine biological, biogeochemical, statistical and engineering methods to collect and analyse data on the ecological status of freshwaters destined for human consumption. The supervisory team includes river monitoring specialists, biogeochemists, sensor engineers and experts in statistical techniques, alongside stakeholders in the water industry.

**What expertise you will develop**

The student will utilise cutting edge sensor technologies to measure the response of algal communities to nitrogen enrichment in surface water catchments. They will develop cross-disciplinary field, laboratory and analytical skills, learning to deploy a variety of sensing systems in the field, trouble-shooting, validating (including laboratory analysis), handling large datasets and quantifying errors. They will conduct lab experiments to assess the impact of different forms of nitrogen on microbiota known to influence taste and odour in DCWW catchments. They will explore large datasets to understand the links between biogeochemical and microbial parameters in freshwater ecosystems. They will engage with stakeholders at Welsh Water, learning how the water industry presently monitors nitrate and other water quality parameters, and work closely with catchment teams to develop future effective monitoring regimes and early warning systems.

**Why this project is novel**

The development of in situ chemical monitoring technologies has the potential to revolutionise water quality monitoring, particularly when data can be returned from the field via telemetry enabling real-time measurement of parameters such as nitrate, CDOM, chlorophyll a and light availability. However, sensors are a significant expenditure, and few water monitoring organisations have the capacity to assess the efficacy of the different options available. Here we have the unique opportunity to assess state-of-the-art methods for in situ measurement of water quality parameters likely to affect the production of geosmin by the algal community in catchments and water supply reservoirs, to understand how technologies can be used most efficiently to understand biological responses and associated taste and odour problems . The field data will be generated in association with samples collected to determine a wider range of water quality variables which influence microbiological response and geosmin production in these sytems. The field data will be compared with historic datasets to determine the key controlling variables, and specifically to elucidate the role of nitrogen compounds and dissolved organic matter (DOM). The student will also run a series of parallel laboratory experiments to explore the impact of nutrient phases on the ecosystem and the consequence of N enrichment on the production of geosmin in freshwaters at the catchment scale.

**Rest of Supervisory Team:**

**Stakeholder Organisation** Welsh Water

**Stakeholder Supervisor** Roo Perkins

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