**Project Title**

Investigating nutrient cycling, retention and bioavailability of effluents discharged from constructed wetlands: optimising wetland management to reduce emerging risks to freshwaters

**Lead Supervisor Name**

Professor Penny Johnes

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**Lead Supervisor Location/Student Home Institution**

Institution: Bristol

School: School of Geographical Sciences

**Full Project Description**

This project will focus on understanding processes controlling the bioavailability and impact of C, N and P exported from treatment wetlands, focusing on nutrient uptake and metabolism by primary producers, and developing evidence to optimise wetland operational management to minimise emerging risks for adjacent freshwaters. The studentship tackles 3 objectives: (1) To understand the cycling of C, N and P in a constructed wetland system, the rates of C and N exchange with the atmosphere and P exchange with the sediments over an operational year. This will involve 1 year of in situ monitoring using novel telemetered sensor monitoring of key physico-chemical variables together with sample collection daily, and hourly over 24-hour periods, to investigate how the quantity and fractionation of the C, N and P load changes relative to diurnal cycling, season, and operational management of the wetland. In parallel, to collect gas, sediment, plant, biofilm and phytoplankton samples to determine the rates of nutrient exchange between cells within the wetland ecosystem, while POCIS discs will be deployed to trap unstable organic compounds generated by the wetland, to determine their nature and occurrence. (2) To identify the pathways by which C, N and P compounds enter the biota within the treatment cells of the wetland, using novel isotopic approaches. In year 2, the student will use compound specific stable isotope probing and bulk isotope analysis approaches using δ13C, δ18O, δ2H, δ15N labelled compounds to trace nutrient cycling pathways within the wetland. With additional financial support provided by Wessex Water (£15k), the student will add isotopically labelled, commonly occurring compounds to the effluent flowing into the wetland. Sampling of plant, biofilm, sediment, phytoplankton, water and gaseous emissions from the wetland over a 3 month period will allow investigation of the rates and pathways of nutrient cycling, and uptake and export through the wetland, identifying the dominant processes controlling nutrient ‘removal’ in the system, and key cells where this could be enhanced through optimisation of cell design/function. (3) To determine the bioavailablity of C, N and P chemistry of the final treated effluent on riverine phytoplankton, periphyton and plant communities via biological uptake activity assessment of selected chemicals using bioassays. In Year 3, using information from Objectives 1 and 2, the student will undertake laboratory-based bioassays to determine the relative bioavailablity and removal efficiency for commonly occurring compound groups within the wetland. The information will be used to identify ‘highest risk’ nutrient fractions generated by the wetland, relative to likely biotic impacts in receiving freshwaters. Wetland cells/processes suppressing the production of these fractions will be identified and advice will be generated on optimisation of wetland design to reduce emerging risks to freshwaters. The student will receive training in cutting-edge analytical chemistry, bioassay techniques, and monitoring and experimental strategies for field-scale investigations. Working with the leading water utility company in the UK, he/she will join the FRESH CDT community, and wider research teams of the supervisors, with access to world class expertise and facilities. Experience of working with the industrial partner will provide an exciting opportunity for further professional development.

**Real Life challenges this project will address**

Diatoms are used as bioindicators for water quality because species tolerate characteristic ranges of pH, concentrations of oxygen and dissolved organic matter, and many other important ecological parameters. Key species are typically identified by morphology (physical appearance), but this classification may be mislead by hidden genetic diversity, with important implications for management of freshwater environments. The project will help to improve identification by establishing the congruence (level of agreement) between genomic diversity and morphological classification and proposing revisions to bioindicator classification where needed.

**What you should know about this project**

Some of the most basic questions in evolution and ecology - where do organisms originate, how are they distributed in the environment, and how does their biodiversity contribute to ecosystem function - are unsolved for microbes, particularly those that are difficult to grow in the lab. This is a huge problem because microorganisms - particularly photosynthesisers such as diatoms - drive primary productivity and ecosystem function in many settings, including freshwater environments. To understand and protect the system, we need to understand its microbial component. This project aims to answer several very basic questions about freshwater diatoms: what factors determine their abundance and distribution; are there genome-level differences between endemic (localised) and cosmopolitan forms; and to what degree do the usual techniques used to identify and classify diatoms actually reflect their evolutionary history and ecosystem function - an important consideration for attempts to use particular species as hallmarks of healthy or damaged habitats? The project team is highly multidisciplinary and ideally placed to support the research. It brings together skills in bioinformatics, genomics and evolutionary biology (Dr. Tom Williams, Bristol) with expertise in microbial fieldwork and sampling (Dr. Bryony Williams, Exeter; Dr. Ingrid Juttner, National Museum of Wales), biogeochemistry and ecology (Dr. Patricia Sanchez-Baracaldo, Bristol) and diatom biology and taxonomy (Prof. Wim Vyverman, Ghent University). This range of skills will provide a very broad training base to equip the student for success both within academia and beyond.

**What expertise you will develop**

The student will develop a very broad range of skills in bioinformatics (genome assembly, analysis, phylogenetics and population genetics), protistology fieldwork (organism sampling, isolation), and molecular biology labwork (culturing and microscopy, genome sequencing).

**Why this project is novel**

While the bulk ‘removal’ of N and P via constructed wetlands has been assessed previously, we lack an understanding of how carbon (C), N and P are cycled simultaneously within these ecosystems. We also lack an understanding of which processes control the balance between plant or algal uptake, microbial metabolism and biosynthesis, sediment associated nutrient storage and sorption-desorption kinetics under different management regimes, and the rates at which new organic compounds are biosynthesised within the wetland via the biotic loop, prior to their release into adjacent freshwaters. This studentship will investigate both the rates, and processes controlling this cycling, retention and export, and the biotic impact of the final treated effluent discharged to the adjacent ecosystem, as this varies in relation to operational wetland management. The project will take advantage of the first full size constructed wetland in the UK to provide tertiary treatment for phosphorus removal from a sewage treatment works effluent. This wetland has been included in the Wessex Water Business Plan and recognised as the solution to phosphorus removal by the Environment Agency within the National Environment Programme. The project findings will inform water industry design principles and Environment Agency permitting policy on the use of wetlands within the sewage treatment system. The research undertaken by the student will advance our understanding of organic nutrient uptake and metabolism in the plant, algal and microbial communities in constructed wetlands, and feed into the development of national guidance on their optimal design and operation to manage the emerging risks associated with wastewater effluent treatment and discharge to adjacent waters.

**Rest of Supervisory Team:**

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