**Understanding the ecological role of organic matter (OM) in urban freshwaters**

**Lead Supervisor Name**

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**Full Project Description**

Organic matter (OM) is an essential component of freshwater ecosystems, fuelling the microbial food-web and primary production, influencing rates of greenhouse gas exchange with the atmosphere and changing water quality and ecosystem health through light attenuation. In contrast to upland rivers, lowland catchments are relatively understudied with regards to OM cycling, despite having highly modified inputs from intensive agricultural activity and growing urban populations, particularly via sewage effluent. For example, previous research has identified that there has been a long-term rise in the concentration of dissolved organic carbon (DOC) in the River Thames over the last 100 years, largely attributable to the population driven increase in the volume of sewage effluent entering the catchment (Noacco et al. 2017), in tandem with increases in both nitrogen (N) and phosphorus (P) from intensive agricultural production and sewage discharges to waters. C, N and P all contribute to the OM pool in these systems. However, there are significant knowledge gaps with regards to the composition of effluent OM and how it interacts with the microbial community and existing OM pool in freshwaters. This is important, as rivers, as well as supporting high levels of biodiversity and providing numerous ecosystem services, are responsible for processing approximately 2.8 Pg of terrestrial organic carbon annually, roughly equivalent to terrestrial net production, and therefore play an important role in the global carbon cycle. Modification of the natural processes controlling OM cycling in freshwater may therefore have widespread consequences. This project aims to address this by investigating the role of urbanisation (particularly sewage effluent) on the dynamics and biological processes that are responsible for the biological turnover and fate of dissolved organic matter (OM) in lowland rivers and streams. This project will address three key questions:

1. What is the molecular composition of sewage effluent OM and how does it differ from riverine OM influenced by natural and agricultural sources?
2. How does effluent OM interact with the microbiologically driven processes that determine the fate of OM in the freshwater environment?
3. What are the wider impacts of effluent OM on the health of freshwater ecosystems in urban rivers? The student will work closely with the project partner, Thames 21, a charitable organisation set up with the aim of enhancing waterway environments in the Thames catchment. Using their data and knowledge from their existing monitoring programmes, exemplar rivers will be selected within the Thames catchment, covering a range of impacted rivers, from highly urban headwaters characterised by sewage misconnections, to sites where a clear impact of sewage effluent can be seen by comparing upstream sites with receiving waters.

The student will receive training in the use of state-of-the-art techniques available at the Centre for Ecology & Hydrology and the University of Bristol to address these questions. These include high-resolution mass spectrometry (at Bristol) to characterise the chemodiversity of OM using novel techniques developed in recent NERC funded research, and high throughput DNA sequencing, flow cytometry and enzyme assays to explore the microbiological controls determining the turnover and fate of OM from sewage effluent in receiving rivers. Surveys will be conducted, applying these techniques, to understand the patterns in OM diversity in three urban river sites representing contrasting conditions. Laboratory bioassays and stable isotope labelling experiments will be used to perform controlled experiments to determine the fate and microbiological turnover of specific OM compounds identified from the field sampling and analysis programme at the three urban river sites, allowing the student to link specific compounds to specific biotic responses for the first time.

**Real Life challenges this project will address**

The River Thames is one of the longest studied rivers in the world, and a recent analysis has indicated that dissolved organic carbon (DOC) concentrations have risen over the past 100 years, alongside increasing nitrogen and phosphorus loading primarily attributable to urban population increases. However, we lack an understanding of what the implications of these increases are for urban rivers both to the microbial food web and the wider freshwater ecosystem, and of the knock-on consequences of any changes these might drive in urban rivers for the human population experiencing these changes through their work, leisure and amenity use of urban riverscapes. This project will provide new knowledge and understanding of a key, and poorly understood driver of ecosystem and associated amenity degradation in urban rivers, supporting the targeted development of policy and management strategies for urban rivers. Thames21 and others are working to address this issue and these efforts would be significantly enhanced through the application of this PhD.

**What you should know about this project**

The expansion of urban areas and changing ways in which we live and work in these environments means that understanding the impact of human activity on freshwater ecosystems is increasingly important. This project will seek to address the impact and role that urban derived organic matter (OM) has on freshwater ecosystems by applying a range of cutting edge molecular techniques for analysing both microbiological and organic matter composition. You will be supervised by a cross-disciplinary team of academic and stakeholder supervisors at the Centre for Ecology & Hydrology (CEH), Wallingford and the University of Bristol.

**What expertise you will develop**

Working at both CEH and the University of Bristol, you will receive training in state-of-the-art techniques to characterise the chemodiversity of organic matter (OM) from urban sources and to understand its microbial interactions within freshwater ecosystems. At CEH you will receive training in high throughput DNA sequencing, bioinformatics, flow cytometry and extracellular enzyme assays, and in a 12-month secondment at the University of Bristol, you will receive training in the use of high-resolution mass spectrometry for compound-specific analysis of OM in urban rivers.

**Why this project is novel**

The dynamics of organic matter (OM) cycling in lowland rivers is understudied relative to upland rivers, despite the high degree of modification and anthropogenic inputs of OM that lowland rivers receive, and in particular, understanding of its behaviour and ecosystem functional role in urban rivers is poorly understood. This PhD studentship aims to make significant gains in our understanding of the processing and impacts of OM in urban rivers through the application of state-of-the-art tools for the high-resolution chemical and biological characterisation of freshwater ecosystems recently developed by the project supervisors. The application of these techniques and the integration of these highly multidimensional datasets will provide novel insights into not just the patterns of OM flux and its composition in urban freshwaters, but the biological processes that determine its turnover and fate, and its impact and significance in driving ecosystem structure and function.

**Rest of Supervisory Team:**

**Stakeholder Organisation** Thames21

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