

High resolution modelling of fate and transport of organic micropollutants and their effect on ecosystems in small rivers

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This project is one of a number that are in competition for funding from the NERC Centre for Doctoral Training in Freshwater Biosciences and Sustainability (GW4 FRESH CDT) which is offering 12 studentships for entry in September/October 2019.

In the recent years, the presence of organic micropollutants in river waters, including pharmaceuticals and personal care products (PPCPs), their trans-formation products and many pesticides, has been confirmed up to several tens of micrograms per litre. Although it is believed that presence of pharmaceuticals is not directly harmful for humans, there is strong evidence that these concentrations are harmful for aquatic life. For the UK, a national comprehensive source apportionment model has been developed (SAGIS), but the fate and behaviour in small dynamic river systems has never been accurately described.

PPCPs are mainly discharged into the surface water via sewage treat-ment works. Pesticides, like metaldehyde, and nutrients will reach the river water via diffuse pathways. During river transport, concentrations generally will reduce further by dilution and other attenuation effects, e.g. adsorption to sediments, biodegradation, and photochemical degradation by sunlight. Most water quality models apply simple first order decay kinetics in a steady state approximation aiming at larger river systems such as the Rhine, but inadequate for small rivers. In our approach, we will develop a river model that couples hydrological and water quality modelling at high spatial and temporal resolution.

The model will be used to perform a time and location dependant risk assess-ment of different functions of the surface water and its riparian areas. This will enable new risk evaluation methodologies for specific functions along the river. The model will also enable scenario studies to predict the effects of abatement options, like additional treatment steps for removal of pharmaceuticals at STWs.

The student experience will comprise a combination of cutting edge modelling of hydrological and (bio)chemical processes in rivers. The project will include fieldwork for advanced sampling required to validate the models. Furthermore, the student will be working in close collaboration with Wessex Water and the Environment Agency.

The studentship has the following objectives:

1. To deliver a time-dependent hydrological and water quality model for a small-scale river

The model will be based on dynamic hydrological models that will be expanded with a water quality model, incorporating (bio)chemical degradation and adsorption processes. In collaboration with Wessex Water, a small river will be selected as a case study to develop the model. Also, integration of the model in the SAGIS-SIMCAT modelling systems will be investigated.

2. To calibrate and validate the model for key PPCPs and pesticides

A monitoring campaign will be setup to collect biological and chemical data for calibrating and validating the model. Model compounds will be selected for independent validation of the different (bio)degradation and attenuation pathways.

3. Develop a risk assessment methodology

This objective will use the model to setup a risk assessment methodology and identify risks for aquatic life and specific ecosystem functions such as supporting habitats, waste treatment and assimilation, biological control, and water supply. The applicability of the model as a decision support tool will be tested.

Real Life challenges this project will address

This project addresses the presence of micropollutants and chemicals and their effects for the ecological water quality in river waters. PPCPs and pesticides in river waters are a threat to aquatic life and biota. Furthermore, their presence may lead to additional treatment needs for producing safe drinking water and comply with water quality regulations. The model will give decision makers insight in pollution risks in rivers, effects on ecosystems and aquatic life, and test different scenarios and abatement options for pharmaceuticals and other micropollutants. It will also enable to setup a time dependent risk profile for water quality related issues in a river.

What you should know about this project

The PhD project aims at creating a better understanding of the dynamics of concentrations, fate and transport of organic micropollutants and their effects on biology and ecosystems in small rivers. In the UK, much effort has been put by the Environment Agency and the water industry in developing a comprehensive source apportionment model for chemicals emissions (SAGIS-SIMCAT) on a national scale. In this project, we will focus on a next step of mathematical modelling of hydrological and environmental processes in the small rivers and predict micro-pollutant concentrations at a high resolution.

Small rivers are highly dynamic systems in which water flows and emission loads can change orders of magnitude in a very short time. The effect of these dynamics on the aquatic life and biology are unknown. Current water quality models are based on simple dilution and first order decay models to describe environmental processes in a steady state approximation. Therefore, existing models are inadequate for small rivers. Building on the accurate emissions and source apportionment data, we will – for the first time – develop a water quality model for small rivers to describe pollutant concentrations and loads in a high spatial and temporal resolution. The model will be used to quantify environmental risks, the effects for aquatic life in ecosystems, and help decision makers in prioritising abatement options.

The supervisory team are academic and industrial experts in water quality and hydrology:

Jan Hofman (University of Bath), water science and engineering, lead-supervisor

Nicholas Howden (University of Bristol), hydrologic modelling, co-supervisor

Ruth Barden (Wessex Water), environmental management, industrial supervisor

Barbara Kasprzyk-Hordern (University of Bath), environmental chemistry and analytics, co-supervisor

The wider collaborators (local co-supervisor) include: Thomas Kjeldsen (University of Bath), hydrologic modelling, Jannis Wenk (University of Bath), water science and engineering. The project will also seek collaboration with the Environment Agency.

What expertise you will develop

- A strong expertise in aquatic environmental (bio)chemical processes in small rivers, more specifically around the dynamics of fate and degradation of organic micropollutants
- Cutting edge modelling skills that describe the biochemical processes in a high spatial and temporal resolution and integrate these models into hydrological models
- Risk assessment methodologies to identify risks for aquatic life and specific ecosystem functions such as supporting habitats, waste treatment and assimilation, biological control, and water supply.
- Understanding of international regulatory frameworks
- Understanding of the UK water sector

Why this project is novel

Water quality modelling in river systems is not new. Models exist for source apportionment (SAGIS-SIMCAT) and water quality (GREAT-ER, LF2000-WQX, QUAL2K, MIKE). Most water quality models only include simplified transport and decay equations, based on dilution and first order decay. In this project, for the first time, a specific and accurate model to predict concentrations of micropollutants (PCPPs, pesticides) and transformation products at a high spatial and temporal resolution in small rivers will be developed. Also, connecting the model outcomes to the effects on the river ecosystems and the aquatic biology, the effects of the dynamics for different end-points and a functional risk assessment along the river is a novel methodology. This risk assessment will be used to predict the effects of different abatement options for river pollutions and prioritise the potential measures to prevent pollution.

The project involves different disciplines: environmental chemistry to describe the (bio)chemical degradation processes for micropollutants, advanced chemical analysis, hydrological modelling, mathematical modelling skills, chemical engineering (mass balances in the modelling), ecotoxicology and risk assessment methods.

Funding

Studentships cover Home tuition fees, training support grant and stipend (£14,777 p/a, 2018/19 rate) for a period of 3.5 years and are open to UK/EU applicants who have been resident in the UK since September 2016.

Applications

Applicants must have obtained, or be about to obtain, a First or Upper Second Class Honours degree, or the equivalent qualifications gained outside the UK, in an area appropriate to the skills requirements of the project.

Applications should be made direct to the CDT using their online application form. See <http://www.gw4fresh.co.uk/how-to-apply/doctoral-students/>.

APPLICATIONS CLOSE AT 09:00 ON 17 DECEMBER 2018.

You do NOT need to apply to the University of Bath at this stage – only those applicants who are successful in obtaining an offer of funding from the CDT will be required to submit an application to study at Bath.