Hi-res modelling & monitoring of pollutants in a Dorset chalk stream

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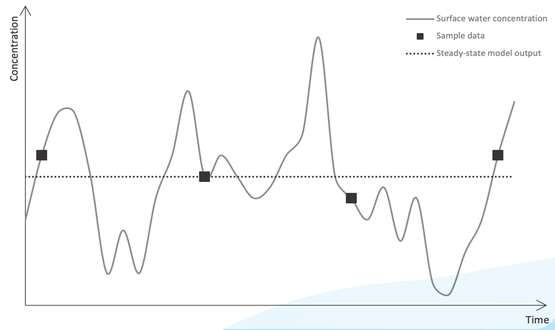
CONTEXT

Emerging pollutants in aquatic ecosystems

- Emerging contaminants (ECs), such as pharmaceuticals and illicit drugs, have become ubiquitous in the aquatic environment and their presence has been detected up to several tens of micrograms per litre.
- These compounds are subtly changing the ecological fabric of our rivers through a combination of lethal and sub-lethal effects. But they also threaten human health and the security of our drinking water supply.
- Despite significant research and practical expertise, there remain major knowledge gaps about the sources, transport and fate of contaminants in waterways.
- The risks posed from these compounds is poorly understood as river monitoring and models lack fine-scale space and time resolutions to describe their fluvial fate and transport.
- Figure 1 to the right shows how both low resolution models & grab sampling may fail to represent the high-resolution variation that could be occurring.
- High-resolution models are thus needed to better quantify the risks, but this is challenging due to sparse monitoring data on ECs to support model development.



RESEARCH QUESTIONS

- How do surface/groundwater interactions modulate water-quality and how can these interactions be represented in the model?
- What is the temporal variation at point source effluents and how do the discharges impact downstream water-quality, during baseflow conditions?
- What are the key controls and sensitivities on in-stream variation at different timescales?
- What are the key data requirements to consider to develop a high-resolution model for emerging contaminants?

RESEARCH IMPACT

- Improved understanding of source-pathway-receptor linkages for this river system, leading to more targeted management decisions.
- New tools and approach to evaluate the risk of emerging contaminant pollution from wastewater discharges.
- Understand what the implications are for future river monitoring and determination of river health under the Water Framework Directive environmental quality standards.

AIMS & OBJECTIVES

This project develops a novel approach to this problem. High-resolution monitoring data are combined with river profiles, and local hydrologic and hydrogeologic information, to construct high-resolution models in space and time. This is used to interrogate observations and provide perceptual models of how wastewater discharges impact nutrient water-quality under various reference conditions. The perceptual models are then used to provide new approaches to assess the potential impacts of emergent contaminants on UK freshwaters.

This research draws on extensive work in a lowland chalk catchment and uses this as an exemplar case study for this new approach. This is due to their unique position as sites of high ecological value, but also as acute focal points of human activity and water management pressures

RESEARCH APPROACH

MODEL DEVELOPMENT

Building a hydrodynamic model using the DHI MIKE river modelling software suite.

MODEL VALIDATION USING SENSORS

A high-resolution water-quality monitoring campaign was conducted in August 2022 to validate the model results. Multi-parameter sensors were deployed in-situ at strategic locations, including sewage treatment effluents.

ADAPTING THE MODEL FOR ECs

Inferences gained, particularly on dynamics of pollutant loading and hydrology, will help me assess the potential risks of emergent contaminant pollution

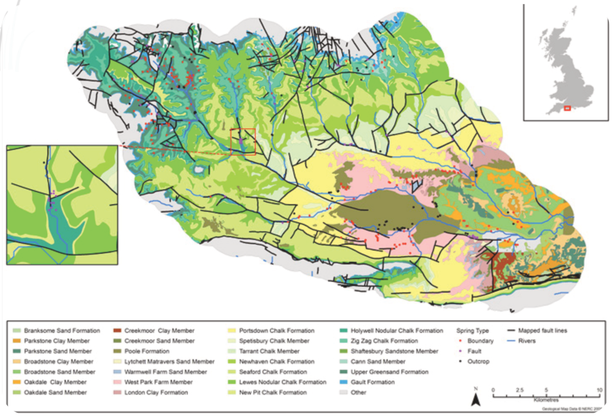
RISK ASSESSMENT

Predicted concentrations will be compared to no-effect concentrations and the river network will be colour coded based on risk quantification. A slider widget will provide a means of illustrating the temporal risk profile.

DISCHARGE & DEPTH PROFILING

Spot gauging river discharge and deploying pressure transducers (VanEssen divers) to provide a flow accretion analysis of the Frome, as well as to provide data to calibrate the hydrological model.

RESEARCH CATCHMENT LOCATION



Solid bedrock geology and spring discharges of the Frome & Piddle catchment[1]

[1] Howden, N.J.K.,2004.Hydrogeological controls on surface/groundwater interactions in a lowland permeable Chalk catchment: Implications for water quality and numerical modelling. (Thesis),Imperial College London.

UNDERSTANDING CHALK HYRDOGEOLOGY

- The catchment is groundwater dominated with most of the baseflow coming from the chalk aquifer.
- The chalk is a complex dual-porosity aquifer and there are a number of key hydrogeological controls that give rise to a heterogeneous mosaic of surface/groundwater interactions in the river valley corridor.
- These surface/groundwater interactions play a key role in influencing the spatial distribution of surface water-quality.
- Thus, a crucial first step of my research has been to derive a hydrogeological perceptual model for the River Frome. We focus on the occurrence of surface/groundwater interactions in the catchment and how they maintain baseflow and influence water-quality.
- This has helped support the collection of required field data, and the application of the new base model.

THOMAS HOMAN

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Thomas Homan, PhD candidate | University of Bath

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