High resolution mapping of fine sediment and pollutants throughout large river cross sections with innovative uncrewed survey boats; supporting improved flux estimation, habitat assessment and bathing water safety

Lead Supervisor: Ponnambalam Rameshwaran, UK Centre for Ecology & Hydrology (UKCEH)
Email: ponr@ceh.ac.uk

Co-supervisors: Andrew Wade, Geography and Environmental Science, University of Reading; Nick Everard, UK Centre for Ecology & Hydrology (UKCEH); Gareth Old, UK Centre for Ecology & Hydrology (UKCEH)

All but 14% of UK rivers fail to meet the Environment Agency definition of Good Ecological Status, and none are rated good for Chemical Status[1]. Therefore the amount and transportation of fine sediment (sand particles and finer) and other pollutants through river systems remains of major interest to researchers and catchment stakeholders because of the fundamental importance for the process-understanding and quantification of contaminant and nutrient transfer. Sediment transport and deposition is a key to in-stream geomorphology and the resultant habitat which in turn determines biodiversity. Furthermore, knowledge of sediment fluxes is important in determining infrastructure sustainability (hydropower, flood defences), flood risk, agricultural soil loss and bathing water safety.

The ARCboat and (inset) ARCboatlite uncrewed river survey boats

Traditionally, the most robust fine sediment flux estimates and pollutant measurements have been from continuous bank-side monitoring or spot sampling. However, in rivers with large cross sections and/or complex and dynamic

hydromorphology, fluxes will vary greatly over cross sections. Although fine particles are often assumed to be relatively evenly distributed throughout flowing cross sections the aggregation of these particles can mean that significant variations in sediment concentration can occur. Given that these variations are challenging to quantify, poorly understood and are likely to be important in the estimation of sediment and pollutant fluxes this represents a priority research area. The aim of this project is to resolve, for the first time, these cross-sectional variations in fine sediment and pollutants transport, to enable a step-change in sediment budget estimation, habitat suitability assessment, and implications for flood risk.

The proposed project focusses on the use of novel instrumentation to resolve sediment and other pollutant fluxes at previously unprecedented resolution. Firstly, simultaneous, co-located measurements of river hydraulics, suspended sediment and pollutants will be obtained using advanced uncrewed survey boats. Secondly, observed variations will be investigated to elucidate cross-sectional changes in sediment/pollutants transport and their controls. Knowledge will be gained by making observations in a variety of catchment settings and across a range of flow conditions. A state of the art ADCP (Acoustic Doppler Current Profiler) instrument and multi-parameter water quality sensors will be used to make streamflow, river hydraulics, fine sediment and other pollutants measurements. The instruments will be deployed remotely using Differential GPS equipped, radio-controlled boats (ARCboat and ARCboatlite) to allow the safe survey of large and often inaccessible river and floodplain flows (see photo). The ADCP backscatter data will be evaluated against in situ physical water samples (particle size and mass) and independent direct measurements (turbidity and particle size) to provide robust calibration. This sophisticated calibration procedure is particularly well suited to a research project and will contribute to the delivery of an optimised techniques protocol. The multi-frequency ADCP sensor should allow new insights into sediment particle sizes and their spatial distribution, while the high-resolution river hydraulics data will help illustrate the settings, processes and conditions in which sediments are mobilised and deposited.

Measurements undertaken with the uncrewed boats at a range of locations and times will help inform understanding of the spatial and temporal factors influencing water quality across a range of flow conditions. This will provide a more accurate quantification of downstream fluxes, enabling improved understanding of the factors and processes that control sediment and other contaminant transport, and hence chemical, biological and ecological status and bathing water safety.

Training opportunities:

The training will be split between UKCEH and the University of Reading, giving exposure to research institute and HEI environments. Training will be given in field-based instrumentation deployment and maintenance (e.g. use of Acoustic Doppler Current Profiler (ADCP) including radio-controlled boat operation and Malvern Panalytical Mastersizer 3000), data analysis, and statistical and process-based modelling allowing development of numerical modelling skills and data visualization methods to view and disseminate the measurements. At UKCEH, the student will gain experience of working at the science-policy interface in a team that commissions, conducts and translates research for policy-makers and will have opportunities to be involved in meetings with catchment stakeholders. The student will be embedded within a larger network of scientists working on hydrology, water quality and ecology at UKCEH and Reading, and will be exposed to the latest water quality monitoring and modelling techniques with access to national and catchment-scale datasets from long-term monitoring programmes and at high-resolution (20 minute data for 2 years in the Kennet) to support their own observations. The student will have access to advanced computer facilities, research seminars, general scientific training through the Reading Researcher Development Programme/UKCEH Postgraduate Training Scheme and opportunity to attend project meetings, and national and international conferences and workshops.

Student profile:

Candidates for this project should have a minimum of an Upper Second Class Honours degree or equivalent in engineering, environmental science, physics, geography, mathematics, ecology or a similar discipline, and an interest in both instream hydraulics and catchment hydrology. The candidate will be required to have an interest in catchment management, be willing to undertake field work and have good numerical and computing skills. Good communication skills will be essential to engage with stakeholders (including citizen scientists). The student will be based at UKCEH Wallingford.

References: (optional)

[1]https://www.theguardian.com/environment/2020/sep/17/rivers-in-england-fail-pollution-tests-due-to-sewage-and-chemicals

https://research.reading.ac.uk/scenario/