THE STABILITY OF FINE-GRAINED SEDIMENTS IN LOWLAND STREAMS

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1) Background

Lowland streams in England are experiencing increased fine-grained sediment loads, most likely caused by changes in land-use practices, reduced flow due to groundwater abstraction and modification of stream profiles and morphology. The fine particles accumulate within the gravel bed, under macrophytes and in margins (Cotton et al. 2006). These stores can correspond to large proportions of the annual suspended sediment flux, e.g. 57% for the River Piddle (Collins & Walling 2007).

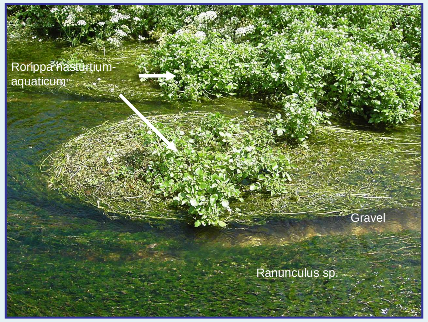
Fine-grained sediment is commonly associated with high levels of organic carbon, nutrients and contaminants. Therefore, the deposition and retention of fine particles can have serious impacts on the local hydrology (e.g. reduced groundwater exchange) and ecology (e.g. deteriorated trout spawning grounds). Although, recent research has been conducted into fine sediment transport in rivers, little emphasis has been placed on the stability of the sediment deposits (but see Gerbersdorf et al. 2005).

To date, no study has investigated how macrophytes, microbes and invertebrates interact to influence riverine sediment stability.

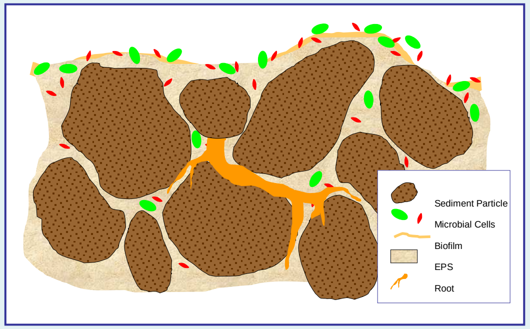
2) Research Objectives

I. **To investigate the spatial and temporal variability of fine-grained sediment stability within lowland streams**.

II. **To examine the physical, chemical and biological factors that impart sediment stability.**



Representative macrophyte community in a chalk stream. Sediment accumulates within the macrophyte beds and along the margins. (Bere Stream, Frome-Piddle Catchment, Dorset). Photo courtesy of G. Davies.



Conceptual diagram of fine-grained riverine sediment. The microbial community and associated extracellular polymeric sustances (EPS) are divided into a surficial component (i.e. biofilm) and infaunal component. The EPS and plant roots act as a matrix to find the sediment grains.

3) Sediment Characteristics Affecting Stability

Research on marine/estuarine sediments suggests that physical, chemical and biological attributes interact to determine sediment stability (e.g. Lundkvist et al. 2007).

<u>Physico-chemical</u>

The physical characteristics of the sediment, notably particle size and bulk density, have a significant impact on fine-grained sediment stability. Consolidated clays and silts are inherently more stable than fine sands because of their higher organic content and strong electro-chemical bonding. Even in low quantities (3-15% by weight), clay/silt particles can form a matrix that causes predominately fine sand sediment to behave cohesively (Mitchener & Torfs 1996). The cohesiveness of clay particles is positively correlated with cation concentrations, so marine muds will pull off a Welly better than lacustine or riverine muds.

<u>Biological</u>

Carbohydrates and proteins (EPS) released by bacteria and diatoms can form a gelatinous matrix that binds the microbes and sediment grains. When produced on the sediment surface, these mats can increase the erosion threshold, and when produced within the sediment, by infaunal microbial communities, they can decrease erosion rates.

Invertebrates can have a stabilising or destabilising effect on the sediment depending on their feeding mode, behaviour, and biogenic structures (e.g. tubes, nets, burrows)

Macrophyte beds tend to have a stabilising effect on sediment. In dense stands, the leaves and stems dampen free-stream velocity and turbulence, while the roots and rhizomes bind the sediment. However, when annual plants die back in the autumn, decomposing roots can decrease stability.

4) Proposed Methods

I. I propose an 18-month sediment sampling programme within lowland streams in Dorset. Sediment cores and *in situ* cohesive strength measurements (CSM) will be taken in areas of sediment accumulation (e.g. macrophyte beds and margins). Sediment characteristics will be measured in the lab.

II. I propose a combination of statistical analysis of core and CSM data, as well as experiments conducted in microcosms and an annular flume. The microcosm experiments will investigate stability in natural riverine sediment and its associated flora/fauna. The annular flume experiments will use representative sediment and introduced flora and fauna to minimise complicating factors. Antibiotics and light/dark conditions will be used to control bacterial and algal growth. Sediment characteristics and cohesive strength will be measured after varying periods of incubation.

5) Predicted Results

I. Sediment stability will have a baseline dictated by its physico-chemical characteristics, and should be enhanced by microbial activity and the presence of dense macrophyte stands.

II. Spatial and temporal variability will likely be tied to seasonal variations in sediment load characteristics and microbial and macrophyte community dynamics.

Fine sediment accumulating beneath a macrophyte bed in a chalk stream (Frome-Piddle Catchment). Photos courtesy of L. Baldock.

Acknowledgements

I would like to thank my supervisors Dr. Geraldene Wharton, Prof. Roger Wotton (UCL), Dr. Jenny Schmid-Arraya (QMUL), Dr. Ian Droppo (Environment Canada), as well as Jon Bass and Grieg Davies for advice and support. Funding provided by the University of London (University Research Studentship), Queen Mary College, and the QM Department of Geography.

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