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Multi-scale investigation of fine-sediment ingress in gravel-bed rivers using experiments and numerical modelling

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Increased suspended sediment loads in gravel-bed rivers, potentially leading to clogging of the pores in the river bed, is a problem acknowledged since at least the 1980s. Early research was concerned with declining salmonid production along the North American Pacific coast due to siltation processes. Since then, research has expanded and includes a wider geographical and ecological coverage. Despite this long history of research into gravel-clogging by fine sediment, the relationship between enhanced suspended sediment loads and sediment ingress is still poorly quantified.

The research presented here seeks to address this gap and has a two scale approach to improve the quantification of fine-sediment ingress into river gravels under a range of flow, fine sediment and gravel framework conditions. Laboratory scale flume experiments mimicking natural conditions were used to measure flow and the character of fine sediment both above and ingressing into custom-made basket traps. At a larger scale, the same basket traps were installed in a field setting (the gravel-bed River Culm in South-West England) in three river reaches, in conjunction with continuous monitoring of suspended sediment concentration and flow discharge (to estimate sediment loads).

The data were evaluated with regards to the Krone formulation for deposition (Krone, 1962), an equation generally believed to include the main physical determinants driving fine-sediment deposition. The formulation states that rise in suspended sediment concentration, settling velocity and also decline of flow velocity or bed shear stress all lead to an increase in suspended sediment deposition. This evaluation was achieved by setting up a numerical model, which was initially applied to the flume experiments and subsequently up-scaled to the field scale.

Data generated by both the flume and the field experiments do not agree well with the predictions of the Krone formulations. This agreement was especially weak for fine silt to clay size particles. For example raised bed shear stress and raised velocities did not generally lead to a decline in fine sediment deposition. These discrepancies potentially reflect the control of fine-sediment ingress by small scale processes, including sealing, re-suspension, aggregation and flocculation, which might not be captured by ‘standard′ predictive equations.