EGU21-345, updated on 27 Jan 2022
https://doi.org/10.5194/egusphere-egu21-345
EGU General Assembly 2021

The HydroEcoSedimentary Tool: an integrated approach to characterise interstitial processes in freshwater systems

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Increased deposition of fine sediments in streams affects a range of key ecosystem processes across the sediment-water interface, and it is a critical aspect of river habitat degradation and restoration. Understanding the mechanisms leading to fine sediment accumulation along and across streambeds, and their affectation to ecological processes is therefore essential for comprehending human impacts on river ecosystems and inform river restoration. Here, we introduce the HydroEcoSedimentary Tool (HEST) as an integrated approach to assess hydro-sedimentary and ecologically relevant processes together. The HEST integrates the estimation of a range of processes occurring in the interstitial zone, including sedimentary (fine sediment accumulation and fine sediment loss upon retrieval), hydraulic (hydraulic conductivity), geochemical (water quality and temperature) and ecological (with a focus on brown trout early life stages).

We tested the HEST application in two rivers with different degrees of morphological degradation in Germany. The HEST was successful in recording the set of key hydrosedimentary and ecologically relevant factors, and in providing a mechanistic linkage between and biological effect in a site-specific context. The HEST data confirmed that salmonid embryo mortality could be linked to high fine deposition in gravel beds. In addition, the HEST illustrated that such mortality could be linked explicitly to interstitial depths and to different infiltration pathways for fines (e.g. vertical vs. horizontal). Although interstitial water quality and temperature were within ecological thresholds and did not show significant differences with surface water, it was still useful to monitor such variables and to rule out any effect on mortality. Water temperature, for example, could be extremely important to detect local groundwater inputs, which has been demonstrated to have a significant effect on embryo salmonids elsewhere. The HEST also allowed accounting for the loss of fines during retrieval failure and estimating hydrological factors with the HEST illustrates its additional usefulness and reliability.

Compared to other methods, the HEST expands the possibilities to monitor and quantify fine sediment deposition in streambeds by differentiating between vertical, lateral and longitudinal infiltration pathways, and distinguishing between the depth (upper vs. lower layers) at which interstitial processes occur along the streambed column.