ICG2022-128
https://doi.org/10.5194/icg2022-128
10th International Conference on Geomorphology

Mountain managed streams as highways for reduced bedload transport

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Many mountain streams across Europe are managed by grade-control structures (e.g., check dams or boulder ramps) and embankments with the aim to increase the lateral and vertical stability of the channels and to reduce bedload transport rates. We conducted a field experiment in the flysch Carpathians, Czechia, to assess sediment fluxes in a managed and untreated pool-riffle stream of similar characteristics (channel width ≤5 m, bed slope ~2 %) to evaluate the impact of rigid stream management on coarse sediment connectivity. The fieldwork included the tracking of PIT-tagged gravels and cobbles (four-year monitoring between 3/2018 and 2/2022), the analysis of the grain size of the surface and subsurface bed sediments, and geomorphic mapping. After three bankfull flow pulses, we found large disproportions in bedload transport activity between the managed and the untreated stream, when much longer travel distances of the PIT-tagged particles up to 500 m by skipping of seven consolidation check dams were recorded in the first case, whereas the most PIT-tagged particles were deposited in gravel bars and riffles relatively close to the release site in the latter case. Lateral sediment supply and vertical bed material exchange were markedly reduced by the presence of artificial bank stabilisations and a forced bed armour layer (d50surf / d50sub ~ 4) without noticeable development of gravel bars in the managed stream. This also led to overall degradation of the channel and loss of geomorphic complexity, when uniform plane beds without variable bedforms were separated by individual check dams. On the contrary, the frequent presence of bank failures on the outer banks of bends and the low difference between the grain sizes of the surface and subsurface sediments (d50surf / d50sub ~ 1.5) suggested strong interactions in the vertical and lateral dimensions of the sediment (dis)connectivity in the untreated pool-riffle stream. These findings have implications for sediment-transport processes and sustainable management of wider gravel-bed channelized rivers, when one may expect rapid flushing (relatively low incoming rates) of bedload particles and intensification of bed armouring processes accompanied by a loss of habitat heterogeneity.