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Sediment connectivity in a small catchment with badlands: Testing connectivity indices using fallout radionuclide tracers at the Vallcebre Research Catchments.

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At the Vallcebre Research Catchments (South Eastern Pyrenees), results obtained during over 20 years showed that badlands are the primary sources of sediments to the drainage network. Parent lutitic rocks are weathered during winter producing regoliths, which are eroded from badland surfaces mainly during summer intense rainstorms. Even if the produced sediments are mainly fine, due to the ephemeral nature of summer runoff events most of them are deposited on the stream beds, where may remain during some time (months to years).
Within the MEDhyCON project, a fallout radionuclides (FRNs) tracing experiment (i.e. excess lead 210 (Pbx-210) and beryllium 7 (Be-7)) is being carried out in order to investigate sediment connectivity. A simplified Pbx-210 balance model on badland surfaces suggested a seasonal sawtooth-like activity pattern: FRN would be accumulated in regoliths from October to June and depleted in summer. Early summer erosion events would produce the sediments with the highest activity whereas late summer events would produce sediments with the least activity coming from the deeper regolith horizons.
These findings lead us to intend two sediment connectivity indices analysing respectively the temporal and spatial variability of the Pb-210 activities within the fine sediments:
(1) The temporal variability of activities in suspended sediments at the gauging stations, being a measure of sediment transfer, ergo connectivity; a high variability mimicking regolith activity temporal pattern would represent high connectivity, whereas a low variability would involve that the sediments were pooled in a large and slowly moving stock.
(2) The ratio between fine sediment activities at the sources and fine stream sediment activities downstream; fine stream sediment activities higher than those at their sources and increasing downstream (ratio lower than the unity) may indicate long-term permanence (low connectivity) of sediments in the stream beds, because once deposited on stream beds, the fine sediments would have an increasing downstream time to receive radionuclide fallout.
Results to date showed that Pbx-210 activities of fine bed and suspended sediments were usually below detectable levels or with large uncertainty bounds, confirming that they come mainly from fresh rocks but making difficult the hypotheses testing. A relevant decrease in Pbx-210 activity was observed in suspended sediments during summer 2013, confirming the temporal accumulation of FRN on badland regoliths and the subsequent depletion of FRN-rich horizons, along with a significant connectivity of sediment.
Shorter-lived Be-7 activity was detectable only on badland regoliths and suspended sediments, with activities increasing downstream; this cannot be attributed to the accumulation of FRN in old sediments, because of the short life of Be-7. Instead, fine bed sediments might be brought into suspension by raindrop impacts, and most of the FRN content of these raindrops would be flushed with the suspended sediment, in partial conflict with the hypothesis supporting the second index.