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RFID tags as a direct tracer for water and sediment dynamics

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RFID (Radio Frequency IDentification) is a wireless automatic identification system to track objects with widespread application in industrial operations, but also selected applications in ecological research (animal tracking) and for hydro-sedimentological studies (sediment transport with RFID tags embedded in bedload material). In this study, for the first time, we test and apply RFID tags as a direct tracer to track water pathways, erosion patterns and sediment transport on the surface at the hillslope and headwater scale. The RFID system used here consists of tags with a size of 12 x 2 mm and a combination of mobile and stationary antennas. The transport pathways and velocities of the RFID tags can be individually assessed due to their unique identification numbers.

The study area is a badland of easily erodible marls and carbonates located in the Villacarli catchment (42 km^2) in the Central Spanish Pyrenees. The badlands have been identified as one of the main sediment sources for siltation of the downstream Barasona Reservoir.
More than 700 tags were placed in different terrain units using three experimental setups, including lab experiments:
(i) intensive feasibility tests ranging from laboratory flume experiments to tracer studies under natural channel and slope conditions to compare the transport of RFID tags relative to colored particles of the natural sediment;
(ii) several transects across the badland to investigate sediment transfer characteristics on different morphological units (i.e. channel, rills, slopes);
(iii) a raster of 99 RFID tags covering a slope flank with vegetated and unvegetated parts to reveal the influence of vegetation to erosion and transport processes.

The detection of transported tags was carried out with a mobile antenna system to map the spatial distribution of tags after selected rainfall events and with two stationary antennas in channel cross-sections for time-continuous observation of tag passage. From the observations, we derived transport distances and velocities for a one year period. The transport behavior of the RFID tags was similar to the micrite limestone material of the badland. These results indicate the important role of terrain position and vegetation patches for erosion patterns, sediment transfer and the associated time scales along the catchment. We assess the potentials and limitations of the RFID technique as a direct tracer for assessing water and sediment connectivity along hillslopes to first order channels.