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Effect of sediments generated by rill erosion on soil hydrology at small spatial scale

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After formation, a rill may remain in the field for weeks or months contributing to a large percentage of the sediment production downstream. Recent findings show that the rill flow transport capacity of soil clods can be much different from that in overland flow depending on the prevailing discharges. It is then hypothesized that within the sedimentation area of a rill network, rill erosion is able to generate a layer of sediments whose granulometric characteristic should be different than that produced by interill erosion (i.e., by overland flow). To what extent these granulometric differences also lead to local disparities in the hydrological behaviour of the soil (e.g., infiltration rate), is uncertain. The aim of this work is (i) to determine the incidence of the sediments generated by rill erosion on the hydrological properties of the sedimentation area, and (ii) to evaluate the granulometric characteristic of these sediments.

In a region strongly affected by rill erosion, a 25 m x 15 m plot containing well-defined eroded and sedimentation areas was selected to carry out experiments. Rills were obliterated by tillage and the plot was then protected by a fence during ca. one year until a noticeable rill network was again clearly developed within the experimental site. Detailed topographic surveys were made at different stages of rill system formation using a robotic-surveying, no-prism total station. In addition, rainfall and soil moisture content at different depths were monitored using a pluviograph and TDR probes, respectively. Four contrasting treatments were defined within the rill network: (i) A the top of the plot only affected by splash erosion; (ii) in the eroding area affected mainly by interrill erosion, (iii) in the sedimentation area of rills, and (iv) in the same location of (i) but removing the soil crust. In each of these sites, in-situ hydraulic conductivities, K, made at several tension, (Φ = 2, 5, 12 17 cm of water) were determined using a disk infiltrometer. In addition, soil samples for granulometric and sediment size analysis were also taken at the depths of 0-1, 0-5 and 0-10 cm.

For all the experimental treatments and for $\Phi > 12$ cm, K values converge to a steady value of ca. 0.08 mm/h. Instead, from $\Phi < 12$ onwards, K value increases exponentially but at a clearly different rate depending on the treatments. The lowest infiltration rate was determined in treatment (iii), i.e. under the area affected by sediment from rill erosion. For example, $K_{(\Phi=2)}$ at treatment (iii) equals 0.19 mm/h which was around one order or magnitude less than the corresponding value at treatment (iv), and 5 times less than that at treatment (i). However, more than 50% of the soil mass in treatment (iii) are arranged as large (>10 mm) soil clods, while only 25% of those clods are present in the soil mass of treatments (ii) and (iii). Therefore, the minimal infiltration rate under the sediments from rill erosion is mainly a matter of continuity of soil porosity rather than a limiting amount of macro aggregates in the soil material.

Rill erosion and deposition processes can dramatically affect the hydrological behaviour of soils due to the local granulometric characteristics of the depositional materials. This occurs mainly in a range of tension whose active porous and soil moisture content are critical for direct penetration of raindrops and for irrigation planning, respectively.