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Impacts of rainfall on rill erosion evolution processes and flow hydrodynamics on steep hillslopes

Pei Tian (1,2), Xinyi Xu (1), and Chengzhong Pan (1)

(1) Beijing Normal University, College of Water Sciences, Key Laboratory for Water and Sediment Sciences, Beijing, China (tianpei@mail.bnu.edu.cn), (2) Department of Civil and Environmental Engineering, University of California, Irvine, California, USA (ptian2@uci.edu)

There is limited information concerning the mechanism of rainfall impact on flow-driven erosion processes on steep hillslopes. Field experiments under six different inflow rates (q: 6-36 L/min/m) with and without simulated rainfall(60 mm/h) were conducted on a steep slope (26°) to investigate the impacts of rainfall on erosion, rill development and runoff hydraulics. Results showed that rainfall significantly decreased soil infiltration rate and increased soil loss, but this effect of rainfall became weaker with increasing q. The relative contribution of rainfall to rill and interrill erosion, and the interaction between rainfall and overland flow on soil loss both depended on q. When q was 6 L/min/m, the contribution to rill erosion was greater than interrill erosion, and the interaction was negative; while with increasing q, the contribution to interrill erosion was greater, and the interaction became positive. The rainfall strengthened rill development especially for relatively low q conditions, which was mainly reflected in the increase of rill width and length. Rainfall significantly altered runoff hydraulics, but this effect decreased with increasing q. Rainfall decreased interrill flow velocity and enhanced the spatial uniformity of mean flow velocity (V) distribution. Rainfall significantly increased shear stress and stream power, which is positively related to soil loss. Due to rainfall, the critical hydrodynamic parameters of mean flow velocity, stream power, and unit stream power decreased. These results can help to understand erosion evolution processes on steep hillslopes.