Hysteretic sediment fluxes in rainfall-driven soil erosion

Mohsen Cheraghi[1], Seifeddine Jomaa[2], Graham C. Sander[3] and D. Andrew Barry[1]

[1]Ecological Engineering Laboratory, School of Architecture, Civil and Environmental Engineering, ÃĽcole Polytechnique FÃľdÃľrale de Lausanne, CH-1015 Lausanne, Switzerland.

[2]Laboratory of Ecohydrology, School of Architecture, Civil and Environmental Engineering, ÃĽcole Polytechnique FÃľdÃľrale de Lausanne, CH-1015 Lausanne, Switzerland.

[3]Department of Civil and Building Engineering, Loughborough University, Loughborough LE11 3TU United Kingdom.

Abstract

Hysteresis patterns of different sediment particle sizes were studied via a detailed laboratory study and modelling. Seven continuous rainfall events with stepwise- varying rainfall intensities (15, 30, 45, 60, 45, 30 and 15 $mm\,h^{-1}$, each 20 min duration) were conducted using a 5-m $\times$ 2-m erosion flume. Flow rates and sediment concentration data were measured using flume discharge samples, and interpreted using the Hairsine and Rose (HR) soil erosion model. The total sediment concentration and concentrations of

seven particle size classes (< 2, 2-20, 20-50, 50-100, 100-315, 315-1000 and > 1000 μm) were measured. For the total eroded soil and the finer particle sizes (< 2, 2-20 and 20-50 μm), there was a clockwise pattern in the sediment concentration versus discharge curves. However, as the particle size increased, concentrations tended to vary linearly with discharge. The HR model predictions for the total eroded soil and the finer particle size classes (up to 100 μm) were in good agreement with the experimental results. For the larger particles, the model provided qualitative agreement with the measurements but concentration values were different. In agreement with previous investigations using the HR model, these differences were attributed to the HR model's assumption of suspended sediment flow, which does not account for saltation and rolling motions.

Keywords:

Hysteresis effects, Sediment transport, Flume experiment, Splash soil erosion, Hairsine and Rose model, Particle Swarm Optimization.