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Erosion by shallow concentrated flow – experimental model deconstruction

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The force of the flowing water is considered to be the main determinant factor for soil particle detachment and transport. The flow of water is described with flow velocity and discharge, and is often summarised in different composite parameters such as shear stress, stream power etc. The entrainment and transport of soil particles is then expressed as a threshold problem, where a soil specific critical value of shear stress, stream power etc. has to be trespassed. Thereafter, the increase of erosion is considered to be lineal.
Despite considerable efforts, the process based model concepts have not been able to produce more reliable and accurate reproduction and forecast of soil erosion than "simple" empirical models such as the USLE and its derivates. Therefore, there still remain some unanswered fundamental questions about soil erosion modelling:
1. What are the main parameters of soils and flowing water influencing soil erosion?
2. What relationship do these parameters have with the intensity and different types of soil erosion?
3. Are the present concepts suitable to describe and quantify soil erosion accurately?
For approaching these questions, laboratory flume and field experiments were set up.
The aim of the laboratory experiments was to elucidate the influence of basic parameters as grain size, slope, flow and flow velocity on sediment transport by shallow flowing water. Therefore, variable flow was applied under different slopes on moveable beds of non-coherent sands of different grain sizes. The field experiments were designed to quantify the hydraulic and erosive functionality of small rills in the field. Here, small existing rills were flushed with defined flows, and flow velocity, flow depth, discharge at the end of the rill as well as transported sediments were quantified.
The laboratory flume experiments clearly show a strong influence of flow velocity on sediment transport, depending this at the same time on the size of the transported grains, and the sediment concentration. It is also shown that hydraulic parameters are not able to predict the combination of sediment detachment and transport. Moreover, the relationship between flowing water and sediment transport is shown to be complex, depending on the morphological evolution of the bed. The field experiments confirm these results, and also show that under variable conditions higher transport rates than those predicted by different model concepts are possible.
Soil erosion by flowing water is much more complex than reflected in model concepts: they neither reflect the process variability nor the interaction between the different dynamic parameters of flow and soils. We conclude that mechanistic concepts, in which simple or composite predictors define the dynamics of soil erosion, can not succeed in soil erosion modelling.