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Consistency of Rain Splash Soil Erosion under Controlled Laboratory Flume Conditions

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Prediction of soil erosion is challenging due to the wide range of factors that can affect it. At the catchment scale, for instance, inconsistent soil erosion yields have been reported in numerous studies. Explanations involve nonlinearities in these contributing factors and their interactions (such as soil surface properties, precipitation characteristic, topography and land cover). Controlled laboratory flume experiments provide a means to improve our process physical understanding. Here, we report on experiments wherein the dependence of rain-splash soil erosion on the precipitation rate, area of soil exposed and initial soil conditions was investigated using laboratory flume experiments. The role of these factors on predicting experimental results was examined based on a prototype experiment and area-based approach. That is, we hypothesised that flume erosion can be predicted by a simple linear scaling of the different factors. Fourteen experiments were carried out in which we varied the precipitation rate (28, 60 and 74 mm/h), the fraction of surface rock fragments (20, 30, and 40%) and initial soil conditions (dry hand-cultivated, wet sealed-compacted and dry compacted). In addition, the influence of time was investigated by considering different experiment durations (2-5 h). In all experiments, we measured the discharge rate, the total sediment concentration and the sediment concentrations of the individual size classes at the flume exit.

The presence of surface rock fragments on the soil surface prevents surface sealing and reduces the cross-sectional area available for flow, thereby affecting the development of steady-state equilibrium. Results revealed that, generally, estimates of the individual size classes' sediment concentrations, taking the exposed area into account, reproduce satisfactorily the measured data at steady state, independent of the initial conditions and rainfall intensity. Before steady state, however, the main feature in most sediment size classes is an early concentration peak, which was found not to be proportional to the area exposed and effective rainfall. Rather, results showed that the short time behaviour is mainly controlled by the soil antecedent and initial conditions, such as surface sealing, surface compaction and soil moisture. In addition, findings suggested that the larger size classes are more sensitive to prior soil conditions than the finer size classes. It was found, also, that this proportionality of erosion to area of exposed soil can be obtained for the entire erosive event under carefully controlled conditions.

Steady state erosion rates, based on a prototype precipitation, were within a factor two of measured rates, for total and individual size classes. However, at short times, erosion due to raindrop splash is not proportionally controlled by the precipitation rate. Overall, the results thus indicate that, for a given soil, experimental data based on a given rainfall rate can be used as a rough estimator of the steady rate of erosion for a different rainfall rates.