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Rainfall-induced soil aggregate breakdown in field experiments at different rainfall intensities and initial soil moisture conditions

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Soil aggregate breakdown under rainfall impact is an important process in interrill erosion, but is not represented explicitly in water erosion models. Aggregate breakdown not only reduces infiltration through surface sealing during rainfall, but also determines the size distribution of the disintegrated fragments and thus their availability for size-selective sediment transport and re-deposition. An adequate representation of the temporal evolution of fragment mass size distribution (FSD) during rainfall events and the dependence of this dynamics on factors such as rainfall intensity and soil moisture content may help improve mechanistic erosion models. Yet, little is known about the role of those factors in the dynamics of aggregate breakdown under field conditions.

In this study, we conducted a series of artificial rainfall experiments on a field silt loam soil to investigate aggregate breakdown dynamics at different rainfall intensity (RI) and initial soil water content (IWC). We found that the evolution of FSD in the course of a rainfall event followed a consistent two-stage pattern in all treatments. The fragment mean weight diameter (MWD) drastically decreased in an approximately exponential way at the beginning of a rainfall event, followed by a further slow linear decrease in the second stage. We proposed an empirical model that describes this temporal pattern of MWD decrease during a rainfall event and accounts for the effects of RI and IWC on the rate parameters. The model was successfully tested using an independent dataset, showing its potential to be used in erosion models for the prediction of aggregate breakdown.

The FSD at the end of the experimental rainfall events differed significantly among treatments, indicating that different aggregate breakdown mechanisms responded differently to the variation in initial soil moisture and rainfall intensity. These results provide evidence that aggregate breakdown dynamics needs to be considered in a case-specific manner in modelling sediment mobilization and transport during water erosion events.