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Soil Hydrophobicity Effects on Soil Erosion: Interplay between Hydrological and Mechanical Effects

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Soil erosion poses a significant threat to agricultural and natural resources. Soil water repellency (SWR), namely the resistance to wetting due to hydrophobicity, has become widespread due to variety of processes including droughts, wildfires, pollution and greywater irrigation. Recent studies showed that that SWR exerts a strong effect on soil erosion by its hydrological impact: reduction in infiltration implies increase in overland flow, the driving force for erosion. Another, much less explored and more complex effect of SWR on erosion is through its impact on soil cohesion and strength, the resisting force for erosion. Here, we focus on the combined effects of SWR on erosion. We compile the published experimental data of erosion in hydrophobic soils, which provides contradictory evidence of both increase and decrease of erosion with increasing SWR. We find that while drought- and fire-induced SWR predominantly increases erosion, there is no clear trend for pollution-induced SWR, suggesting that pollution can improve the soil's resistance to erosion, and that this mechanical effect of SWR is stronger than the hydrological effect of increased overland flow. We establish a rational connection between the SWR and its hydrological and mechanical effects on erosion through a simple 1D numerical model. The results of the model indicate that the net erosional impacts of SWR depends on the balance between the soil hydrological and soil mechanical effects of SWR. The key insights obtained from literature and this straightforward model enhanced our understanding of the dual nature of SWR's influence on soil erosion dynamics.

Keywords: Cohesion, Erodibility, Hydrophobicity, Hydrology, Runoff, Soil Erosion