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Soil internal forces initiate aggregate breakdown and splash erosion

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Abstract: Soil erosion is a severe ecological and environmental problem and the main cause of land degradation in many places worldwide. Soil aggregate breakdown is the first key step of splash erosion and is strongly influenced by soil internal forces, including electrostatic, hydration, and van der Waals forces. However, little is known about the effects of soil internal forces on splash erosion. In this study, we demonstrated that both splash erosion rate (SER) and soil aggregate breaking strength (ABS) were significantly affected by soil internal forces. The SER and ABS increased first (from 1 to 10^{-2} mol L^{-1}), then became stable (from 10^{-2} to 10^{-4} mol L^{-1}) with decreasing electrolyte concentration of bulk solution. The electrolyte concentration of 10^{-2} mol L^{-1} in bulk solution was the critical point for both soils in splash erosion and soil aggregate stability. The experimental results could be well interpreted by the theoretical analyses of soil internal forces. The surface potentials around soil particles increased with decreasing electrolyte concentration, thereby increasing the electrostatic repulsive force among soil particles. This phenomenon led to soil aggregate breakdown and release of fine soil particles. Soil SER and aggregate stability showed a linear relationship (R^2 = 0.83). Our results suggested that soil internal forces induced soil aggregate breakdown and then release of fine soil particles when the soil was wetted, supplying the original material for splash erosion. Furthermore, the raindrop impact force was the driving mechanism causing soil particle movement. In summary, splash erosion was caused by the coupling effects of soil internal forces and the raindrop impact force. Our study provides a possible internal controlling method for reducing splash erosion by adjusting soil internal forces between soil particles.

Keywords: aggregate stability; surface potential; electrostatic force; slaking effect; splash erosion.