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Physical Modelling of Rainfall-induced Landslides in Wettable/Water Repellent Sand Mixtures

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1 Introduction

First time rainfall events in dry slopes frequently produce large volume, short-time spaced debris flows; this has recently been linked to reduced infiltration due to an extreme dry soil condition. However, water content alone may not explain the reduced infiltration (e.g. pour water in dry beach sand). Dry soils are likely to interact differently with water at the particle level i.e. water-particle contact angles are higher than 0 degrees; if >90 degrees, as in water repellent soils, no infiltration occurs. Here, we tested the hypothesis that debris flows are infiltration-initiated for predominantly wettable soils and runoff-initiated for predominantly water repellent soils.

2 Materials and Methods

By means of physical model tests in a side-glassed flume, we induced failure (landslides and surface runoff) by artificial rainfall in slopes made of soil mixtures ranging from fully wettable to fully water repellent. To mimic soils subjected to wildfires, and some forest and agricultural soils where the water repellent condition is likely, soil water repellency was induced in the laboratory and samples prepared to various wettability ratios. We instrumented the physical model with pore pressure transducers to monitor positive pore water pressure in saturated conditions, and TDR probes to monitor soil water content in unsaturated conditions. Sediment and water discharge was monitored. Snapshots were taken from the side of the flume side to identify and track the failure model.

3 Results

We found that the infiltration and failure behaviour was strongly dependent on soil particle wettability (Fig. 1). In predominantly wettable soils, infiltration was by preferential flow, and the failure mode dominated by retrogressive sliding. For predominantly water repellent soils, the soil surface was impermeable, and the failure mode dominated by surface erosion.

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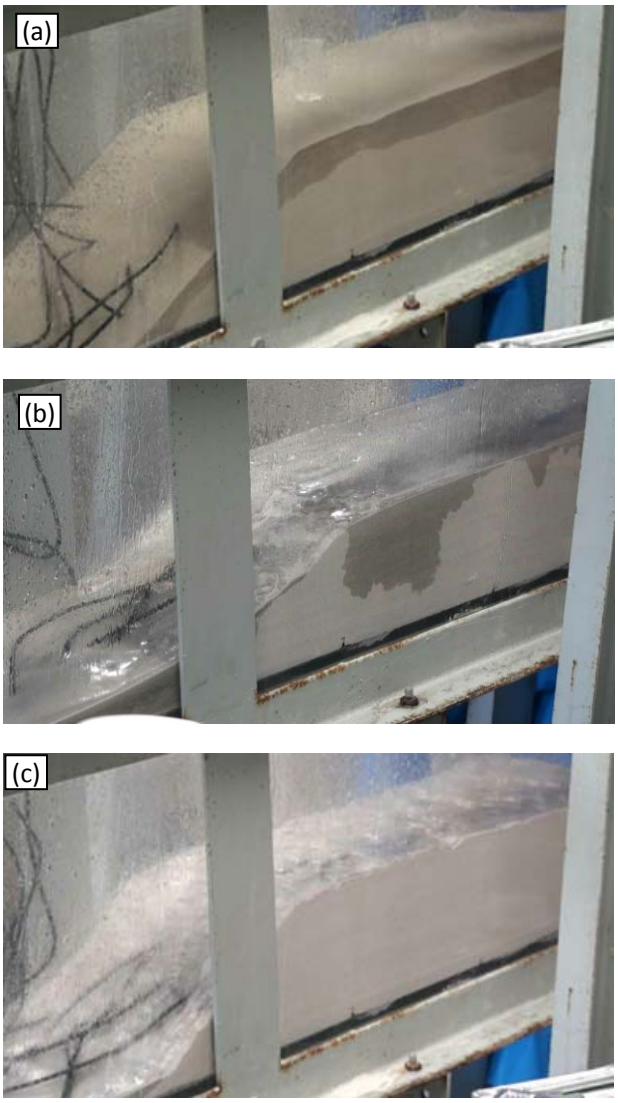

Fig. 1: Photographs of the physical models after 10 minutes of rainfall in (a) wettable sand, (b) mixture wettable/water repellent and (c) water repellent sand.