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Dynamic soil water repellency during infiltration of water, ethanol, and aqueous ethanol solutions in post wildfire soils

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Contact angle dynamics, the temporal dependence of repellency, and the persistence of repellency are all terms used to describe dynamic changes in soil water repellency with time. Studied over varied spatial and temporal scales, much remains to be known about dynamic soil water repellency and its role during infiltration. Of those approaches used to characterize dynamic soil water repellency and develop mechanistic insight, tension infiltration has become an important one. Removing positive pore water pressures through tension infiltration facilitates the observation of infiltration initiated by capillary pull and experimentally eliminates one of the competing mechanisms that generates non-uniqueness. This makes tension infiltrometers and the data they generate uniquely sensitive to (primary) changes in contact angles and fractional wettability. Changes, which are subsumed when positive pore water pressures are the primary drivers of infiltration, as is the case during ponded infiltration in water repellent soils. One pressing challenge, however, is that analytical approaches, based on idealized wettable-system principles (e.g. 0^0 and/or static contact angles), yield suspect results in non-wetting / fractionally wettable / dynamic systems. Consequently, complex infiltration behaviours, and linkages between fundamental process oriented understanding and real-world problems, remain poorly understood. This persistently impedes our ability to accurately describe, model, and predict flow in water repellent systems. To help address this knowledge gap, this work presents suites of in situ field (3D) and laboratory (1D) experimental data collected in naturally repellent post wildfire soils using tension infiltrometers (4.4cm and 8cm, respectively) and different infiltrating fluids. In the field, 49 infiltration tests using water, ethanol (95%), and Molarity of Ethanol Drop (MED)-derived aqueous ethanol solutions indicated that early- and late-time infiltration behaviours were not well related in organic-mineral layered heterogeneous systems over a few cm's. However, in combination, they did provide readily interpretable differences in repellency across materials and across different sites. Further trends in wettable and non-wettable fluid behaviours and porous media characteristics were well expressed in late-time average infiltration rates. These relational results were more reliable and generated greater insights than calculations of Ks and S. Calculations of Ks and S resulted in a large number of negative values, and introduced more uncertainty in all calculated results, including those that were positive. Evaluated in the laboratory in an analogous capacity, homogenized soil materials were used in 20 column experiments to isolate individual material characteristics and evaluate these relationships when within-layer heterogeneity was removed/minimized. Real promise exists in examining differences in wettable and non-wettable infiltration data sets, the governing mechanisms driving these systems at different points in time, and the utility of traditional numerical approaches when base assumptions/conditions are not well met.