Geophysical Research Abstracts
Vol. 19, EGU2017-13293, 2017
EGU General Assembly 2017

Measuring and understanding soil water repellency through novel interdisciplinary approaches

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Food security and production is one of the key global issues faced by society. It has become evermore essential to work the land efficiently, through better soil management and agronomy whilst protecting the environment from air and water pollution. The failure of soil to absorb water – soil water repellency – can lead to major environmental problems such as increased overland flow and soil erosion, poor uptake of agricultural chemicals and increased risk of groundwater pollution due to the rapid transfer of contaminants and nutrient leaching through uneven wetting and preferential flow pathways. Understanding the causes of soil hydrophobicity is essential for the development of effective methods for its amelioration, supporting environmental stability and food security.
Organic compounds deposited on soil mineral or aggregate surfaces have long been recognised as a major factor in causing soil water repellency. It is widely accepted that the main groups of compounds responsible are long-chain acids, alkanes and other organic compounds with hydrophobic properties. However, when reapplied to sands and soils, the degree of water repellency induced by these compounds and mixtures varied widely with compound type, amount and mixture, in a seemingly unpredictable way.

Our research to date involves two new approaches for studying soil wetting.
1) We challenge the theoretical basis of current ideas on the measured water/soil contact angle measurements. Much past and current discussion involves Wenzel and Cassie-Baxter models to explain anomalously high contact angles for organics on soils, however here we propose that these anomalously high measured contact angles are a consequence of the measurement of a water drop on an irregular non-planar surface rather than the thermodynamic factors of the Cassie-Baxter and Wenzel models. In our analysis we have successfully used a much simpler geometric approach for non-flat surfaces such as soil.

2) Fluorescent and phosphorescent probes are widely used in chemistry and biochemistry due to their sensitive response to their physical and chemical environment, such as polarity, and viscosity. However to date they have not been used to study soil water repellency. Here in collaboration with photochemistry groups in Swansea University and the University of Coimbra, we are examining the use of fluorescent probes to measure the polarity and viscosity of the soil/organic interface for both model and natural soils and how this changes in real time during wetting.