Geophysical Research Abstracts
Vol. 12, EGU2010-12665, 2010
EGU General Assembly 2010

The effect of heterogeneity and surface roughness on soil hydrophobicity

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Soil water repellency, or hydrophobicity, can develop under both natural and anthropogenic conditions. Forest fires, vegetation decomposition, microbial activity and oil spills can all promote hydrophobic behaviour in surrounding soils. Hydrophobicity can stabilize soil organic matter pools and decrease evapotranspiration, but there are many negative impacts of hydrophobicity as well: increased erosion of topsoil, an increasingly scarce resource; increased runoff, which can lead to flooding; and decreased infiltration, which directly affects plant health. The degree of hydrophobicity expressed by soil can vary greatly within a small area, depending partly on the type and severity of the disturbance as well as on temporal factors such as water content and microbial activity.

To date, many laboratory investigations into soil hydrophobicity have focused on smooth particle surfaces. As a result, our understanding of how hydrophobicity develops on rough surfaces of macro, micro and nano-particulates is limited; we are unable to predict with certainty how these soil particles will behave on contact with water. Surface chemistry is the main consideration when predicting hydrophobic behaviour of smooth solids, but for particles with rough surfaces, hydrophobicity is believed to develop as a combination of surface chemistry and topography. Topography may reflect both the arrangement (aggregation) of soil particles and the distribution of materials adsorbed on particulate surfaces. Patch-wise or complete coverage of rough soil particles by hydrophobic material may result in solid/water contact angles $\geq 150^{\circ}$, at which point the soil may be classified as super-hydrophobic.

Here we present a critical review of the research to date on the effects of heterogeneity and surface roughness on soil hydrophobicity in which we discuss recent advances, current trends, and future research areas.

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