Geophysical Research Abstracts
Vol. 12, EGU2010-15432, 2010
EGU General Assembly 2010

Proteomic profiling: a novel approach to understanding the biological causes of soil water repellency

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Soil water repellency is a common phenomenon affecting a wide range of soil and land use types in different climates and is considered "the norm rather than the exception with its degree being variable". In all but the most severe cases, soil water repellency is transient with soils wetting eventually after prolonged wet weather and returning, when soil moisture content falls below the critical value. Despite the far-reaching environmental and (agro-)economic consequences, the fundamental biological causes of soil water repellency and its transient behaviour remain poorly understood.

It is widely accepted that soil water repellency is caused by organic compounds coating soil particle surfaces. This reduces the particle's surface tension to values lower than that of water, which, as a net effect, inhibits the intrusion of liquid water into the soil pore space. Microbial as well as plant-derived substances have been implicated as sources of these organic materials, while some microbes have also been identified as degraders and/or emulsifiers of hydrophobic compounds. Common hydrophobic compounds and metabolites (e.g.
alkanes and fatty acids) have been isolated from both wettable and water repellent soils in similar amounts indicating that their relevance is ambiguous.

Even greater uncertainty exists about the role of soil micro-organisms in the development, reduction and temporal variability of soil water repellency. Importantly, certain filamentous fungi and actinomycete bacteria are able to render their hydrophilic cell surface hydrophobic, for example, during spore formation and hyphal foraging through air-containing pores in soil, by producing extracellular hydrophobic proteins. Beyond their own cell surface, the extracellular proteins can form highly recalcitrant hydrophobic surfaces on the hydrophilic side of amphiphilic, i.e. air-water or soil particle, interfaces. Remarkably, the proteins from fungi can also adhere to hydrophobic surfaces under drying conditions rendering them hydrophilic. The dynamics of production of these proteins and the formation of these hydrophobic protein surfaces in soils are not known. Other, yet unknown, proteins may also contribute to development, reduction and temporal variability of soil water repellency.

Here we present the first steps of a new NERC funded project aimed at exploring the relationship between the presence and/or absence of (hydrophobic) protein and soil water repellency. It involves isolation and characterisation of hydrophobic protein and the temporal metaproteomic profiles in UK grassland and dune soils with varying degrees of water repellency. This contributes to identifying the proteomic dynamics, which may influence soil hydrology and structure, and ultimately the ability of soils to absorb water, support biomass growth, store carbon, and to capture and degrade pollutants.