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Organic compounds characteristics associated with heat-induced increases of water repellency in Australian eucalypt forest soils

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Ground surface heating during wildfires often leads to increased water repellency in soils. The effect of elevated soil temperature on water repellency has been investigated in many laboratory-based studies and temperature thresholds for increases in, and destruction of, water repellency have been established. However, little is known about the changes in organic compounds patterns and their chemical structure that associated with these changes.
Here we report on the characterisation of the chemical changes of organic compounds associated with heat-induced increases in water repellency in Eucalypt soils of different repellency levels. Fires are very common in eucalypt forest environments and soils under eucalypt species exhibit one of the most severe repellency levels, providing an ideal study case. Three SE Australian eucalypt forest soils from different locations (two sands and one sandy loam) were heated in the laboratory for 10 min at 300° C. Laboratory heating resulted in extreme repellency in the three soils studied. Heated and unheated control samples were then extracted by accelerated solvent extraction (ASE) with iso-propanol/ammonia mixture (IPA/NH3 95:5). Extraction led to the elimination of any water repellency present both in the original (heated) and the control samples. Organic compounds in the IPA/NH3 solvent were measured in extracts of increasing polarity in order to solubilise the residue. Before heating, the total solvent extracts from the soils with sandy texture were dominated by n-alkanols, terpenoids, C16 acid, C29 alkane, β-sitosterol and polar compounds such as glycerol, monosaccharides and glycosides. Fatty acids with chain length over C20 were detected in the sandy soils, while the soil of heavier texture (sandy loam) lacked longer than C20 fatty acids and had lower concentrations of alkanols (exceeding C26 chain lenght) and alkanes (C29, C31). Alkane patterns were characterized by the predominance of C21 – C31 homologues with a maximum at C29.
A profound change in lipid patterns occurred in the soils following heating. The major compounds in the extracts of the burnt soils were benzenecarboxylic acids, levoglucosan, simple sugars and glycosides. Heat-induced changes resulted in: a) sharp decrease in total amounts (normalised to total organic carbon) of fatty acids, alkanes and alkanols; b) change of fatty acid signatures and shift to homologous series of shorter than C16 with a maximum at C12; c) increase in the relative yields of aromatic compounds (mainly benzenecarboxylic acids) in the samples after burning.
Our data demonstrate that some compounds detected in the originally unheated and repellent soils were lost after heating at 300°C. The increased water repellency in the heated soils was associated with extraction of compounds of aromatic structure and polar compounds such as saccharides and short chain low molecular weight organic acids. Heating has also caused production of complex high molecular weight compounds detected in the more polar fractionated extracts.
We speculate that aromatic compounds and polar compounds such as saccharides are involved in interactions, which play a crucial role in repellency expression in the soils after heating. Benzenecarboxylic acids may be useful as a proxy of the impact of heat on soil organic matter characteristics in soils.