Geophysical Research Abstracts,
Vol. 10, EGU2008-A-08186, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-08186
EGU General Assembly 2008

Changes in organic compounds characteristics associated with heat-induced increases and elimination of water repellency in soils

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Ground surface heating during wildfires often leads to an increase or, above a critical threshold, elimination of water repellency in soils. The temperature thresholds for these changes are well established, however, very little is known about the changes in organic compounds characteristics that are responsible for these hydrologically important soil transformations. Here we report on the characterisation of the chemical changes of organic compounds associated with heat-induced increases and elimination of water repellency. Three Australian eucalypt forest soils of different origin (two sands and one sandy loam) and water repellency characteristics were heated in the laboratory for 10 minutes at temperatures between 320-330˚ C. Laboratory heating in this temperature range resulted in elimination of repellency in both sandy loam soils, with the exception of one replicate, in which repellency increased. Soil organic compounds were extracted by accelerated solvent extraction (ASE) with an isopropanol/ammonia mixture (IPA/NH_3 95/5), which led to the elimination of any water repellency present, and analysed by gas chromatography-mass spectrometry. Organic compounds in the IPA/NH_3 solvent extracts were measured in solvent/solvent mixtures of increasing polarity in order to solubilise the residue. Before heat treatments patterns of lipid compounds and compound classes varied between the three soils. The total lipid extracts from the soils with sandy texture were dominated by terpenoids from the lupane, ursane and oleanane groups, palmitic acid, C_{29} alkane, β-sitosterol and polar compounds

such as glycerol, monosaccharides and glycosides. The fatty acid signature ($C_6 - C_{26}$) in the sandy soils was dominated by $< C_{20}$ n-alkanoic acids. Alkane patterns were characterized by the predominance of $C_{21} - C_{31}$ homologues, with a maximium at C_{29}. The monoterpene α, β- phellandrene was found in all soils. A range of shorter chain length fatty acids $C_6 - C_{19}$ was observed in heavier textured (sandy loam) soil, which also had and higher organic carbon content.

A profound change in lipid patterns occurred in all the extracts following heating irrespective of whether or not repellency was destroyed. Heat- induced changes resulted in: a) the loss of main lipid signatures and b) a high abundance of benzene carboxylic acids, as well as levoglucosan, simple sugars and glycosides, compared to the unburned soils. This suggests that alkanes, fatty acids and terpenoids are not the sole cause of repellency expression in the soils studied.

Our data demonstrate that many of the compounds detected in the originally unheated, repellent soils were lost after heating in the temperature range 320 – 330 ˚C. The increased hydrophobicity in the heated soils is associated with compounds of different chemical properties and mode of adsorption on soil particles. This suggests that the commonly observed increase in water repellency during wildfires in this temperature rage is not due to redistribution or increased bonding of existing compounds, as suggested in some previous studies. Instead, substantial changes in the chemical composition of the organic compounds present in the soils appear to be responsible. We suspect that saccharides and aromatic acids can play a role in repellency expression in soils after heating.