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Vertical redistribution of organic matter causing water repellency in soil following simulated wildfire

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Ground heating during wildfires often leads to redistribution of organic matter and associated changes in wettability within the top few centimetres of soil. These changes vary with the characteristics of the soil, heat flux and heating duration, and oxygen availability. Here we report on a series of experiments examining the effects of a simulated, slow-moving wildfire of 0.5 h duration on soil wettability for various substrates under controlled laboratory conditions.

Forest soil (carbonate free sandy loam, total carbon ˜8 wt%) was obtained from a Eucalyptus globules forest in northern Portugal. The fraction $<$ 2 mm with a water droplet penetration time (WDPT) of ˜10s was used throughout. In addition, clean acid washed sand (AWS; ˜ 0.4 mm particle size, WDPT $<$ 1 s) was used as wettable coarse model material. Following surface heating of homogeneous soil columns (48 mm diameter, 120 mm depth, mounted in a stack of 10  12 mm segments) with naked flames it was found that soil WDPT close to the surface (0-12 mm depth) was destroyed, whereas that 12-24 mm commonly showed a highly significant increase in WDPT (˜ +12000s) and soil at 24-36 mm commonly showed a similar increase. Total carbon (TC) analysis of soil from various depths indicated significant loss of organic material from 0-12 mm). At other depths significant random variability in TC prevented unequivocal detection of transfer or loss of any volatilised organic material down the column.

When a thick layer (24 mm) of soil were placed above wettable AWS, the effect of the simulated fire was to render AWS water repellent to varying extents (WDPT 10-

10000 s) with a similar effect on the lower half of the layer of soil (12-24 mm, WDPT ˜ 12000 s). When thinner soil layer of 12 mm was used, the WDPT of underlying AWS (12-24 mm) increased in the range 300-10000 s. When the top soil was further reduced to a layer 6 mm thick, the underlying AWS (6-12 mm) showed no significant change in WDPT but the layer at 12-24 mm experienced a change of ˜300 s with a barely detectable change in the layers below ($>$ 24 mm). When the column was prepared in a sandwich structure with soil placed between layers of AWS, the thickness and location of the soil layer affected the subsequent wettability. The WDPT of a thick layer of soil (12-24 mm) underneath a thick layer of AWS (0-12 mm) increased to ˜700 s with no change in WDPT of the AWS underneath ($>$ 24 mm). A thin layer of soil (6-12 mm) underneath a thin layer of AWS (0-6 mm) became completely wettable (WDPT ˜0s), however, the WDPT of AWS beneath the soil (12-24) became significantly more water repellent (WDPT ˜ 4500s). It appears that a thin surface layer of material (possibly rendered wettable and organic free by fire) is not sufficient to prevent development of water repellency in deeper layers. These preliminary findings suggest that clean mineral surfaces such as sand may be rendered more water repellent than a typical soil at the same depth possibly due to differences in the quantity and nature of adsorption sites available to capture material affected and mobilised by fire and migrating down the resulting temperature gradient in the column. Where such material may be accommodated within a pre-existing micro- or nano-porous organic soil component its influence on wettability may be attenuated, whereas coarser, clean mineral surfaces offer no such refuge. These findings also support the long-held notion that coarse textured soils are more susceptible to fire-induced water repellency. It appears that the structure of a soil column may influence the distribution of post-fire soil wettability in a complex manner.