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Formation of Soil Water Repellency by Laboratory Burning and Its Effect on Soil Evaporation

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Fire-induced soil water repellency can vary with burning conditions, and may lead to significant changes in soil hydraulic properties. However, isolation of the effects of soil water repellency from other factors is difficult, particularly under field conditions. This study was conducted to (i) investigate the effects of burning using different plant leaf materials and (ii) of different burning conditions on the formation of soil water repellency, and (iii) isolate the effects of the resulting soil water repellency on soil evaporation from other factors. Burning treatments were performed on the surface of homogeneous fully wettable sand soil contained in a steel frame (60 x 60 cm; 40 cm depth). As controls a sample without a heat treatment, and a heated sample without fuel, were also used. Ignition and heat treatments were carried out with a gas torch. For comparing the effects of different burning conditions, fuel types included oven-dried pine needles (fresh needles of *Pinus densiflora*), pine needle litter (litter on a coniferous forest floor, *P. densiflora* + *P. rigida*), and broad-leaf litter (*Quercus mongolica* + *Q. aliena* + *Prunus serrulata var. spontanea* + other species); fuel loads were 200 g, 300 g, and 500 g; and heating duration was 40 s, 90 s and 180 s. The heating duration was adjusted to control the temperature, based on previous experiments. The temperature was measured continuously at 3-second intervals and logged with two thermometers. After burning, undisturbed soil columns were sampled for subsequent experiments. Water Drop Penetration Time (WDPT) test was performed at every 1 mm depth of the soil columns to measure the severity of soil water repellency and its vertical extent.

Soil water repellency was detected following all treatments. As the duration of heating increased, the thickness of the water repellent layer increased, whilst the severity of soil water repellency decreased. As regards fuel amount, the most severe soil water repellency was formed at a fuel load of 300 g. Pine needle litter formed the most severe soil water repellency and fresh pine needle formed the thickest water repellent layer, whilst broad-leaf litter did only cause water repellency on the surface of the sand.

The soil evaporation rate was measured by a gravitational method at an isothermal condition. Undisturbed soil columns were sealed after adding 50 ml of tap water through the bottom. After twelve hours of stabilization, the columns were opened and covered with filter paper. The rate of soil evaporation through the soil surface was measured by the hourly weight change at 45°C. The initial 65 hours' evaporation rate was analyzed, while the slope of cumulative evaporation over time maintained its linearity. It was found that as the thickness of the water repellent layer increased, the evaporation rate tended to decrease. These two variables showed a good correlation (Pearson's correlation coefficient =-0.8916, p=0.0170) and a large coefficient of determination (R^2=0.795) in the linear regression. This suggests that a layer of water repellent soil can affect water evaporation rate and that the rate is negatively correlated with the thickness of the repellent layer.