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Small changes in wetting angle cause major changes in hydrological characteristics of subcritically water repellent agricultural soils

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Soil water repellency: origin, assessment and geomorphological consequences,

Small changes in wetting angle cause major changes in hydrological characteristics of subcritically water repellent agricultural soils

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Soil organic matter (SOM) is a key component of all soils, which influences their fertility and hydrological properties. Even a small SOM content can change soil hydrological properties from a wettable to a water repellent status. Many agricultural mineral soils have a water drop penetration time (WDPT) of < 5 s, which indicates that rainfall or irrigation readily penetrates the soil surface. A seemingly wettable status, however, does not mean that the soil wetting angle is zero, but only that it is lower than a critical value. In this case, soils exhibit subcritical water repellency. Water movement and soil water retention in the unsaturated zone are highly dependent on the wetting angle, which in turn can be affected by SOM. The hydrological properties of 5 agricultural soils from the Lublin region (SE Poland) in a natural, subcritically water repellent, state and after SOM removal were compared to quantify the impact of SOM and wetting angle. The investigated soils covered a wide range of textures from coarse sand to heavy clay and ranged in organic carbon content from 9.8 to 12.3 g kg-1. Water and methanol sorptivity, water diffusivity vs moisture content, and soil retention were measured for these 5 soils in natural and SOM-free states. The results from natural soils were supplemented by measurements carried out on model 'soils' consisting of quartz particles (50-200 [U+F06D] m) with 4 different hydrophobization levels.
It was found that SOM removal caused an increase in water sorptivity for all soils ranging from ca 60% for the coarse sandy (Haplic Arenosol) to ca 290% for the heavy clay (Haplic Leptosol). The calculated apparent wetting angle decreased in all cases after SOM removal by 25-30°, except for the Haplic Arenosol where it remained unchanged. If the wetting angles are calculated from water sorptivity for the natural state and methanol sorptivity for the SOM-free state their values are larger, but their range for the investigated soils is smaller (ca 7° only). The above wetting angle values concern the apparent values, which are approximately 2 times larger then the true Young wetting angle. Application a the wavy pore model (Czachor et al., 2010) to the obtained results suggests that the wetting angle changes due to SOM removal can be ca. 10 times smaller than the change of apparent values. This means that relatively small changes in Young's wetting angle, caused by SOM removal, may result in major changes in soil hydrological characteristics. The above hypothesis was confirmed, by the water diffusivity vs. moisture content characteristics. Generally the water diffusivity values for the SOM-free state are 1 to 2 orders of magnitudes larger than those of the natural soils.
The drying branch of water retention of all soils was practically independent of SOM content, while the wetting one was highly SOM dependent for one of the soils (Haplic Cambisol). For the remaining soils, the effect was smaller or beyond the measurement capabilities. These implications of these findings for soil hydrological behavior are discussed on the basis of a model that considers the effect of non-cylindrical (wavy) pores (Czachor

et al., 2010).

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