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Effects of moisture conditions on potential soil water repellency in a tropical forest regenerated after fire

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ABSTRACT

Potential water repellency (PWR) is a common index to indicate the degree to which soils repel water. Soil organic matter (SOM) is a requisite substance for the water repellency but many studies have shown that SOM content alone could not fully account for the observed variation in PWR. We investigated potential factors responsible for PWR of soils in a tropical forest in East Kalimantan, Indonesia. In addition to the well-investigated soil properties (e.g., total SOM content, pH, and the amount of iron or aluminum oxides), we also focused on soil moisture content at the time of sampling and water-extractable organic matter (WEOM) content based on the hypothesis that PWR may depend on amphiphilic fractions, including WEOM, in the outermost layer of SOM adsorbed on soil particles — soil water may change the amount and/or the conformation of the amphiphilic fractions. Results showed that the degree of PWR had the highest correlation with the amount of WEOM, not with SOM, among the factors investigated ($R^2 = 0.29$). The WEOM content ($R^2 = 0.65$) better explained the variation in water repellency than SOM content ($R^2 = 0.47$) even after soils were soaked in *n*-hexane (a non-polar solvent) and expected to have uniform SOM conformation (hydrophobic components dominant on the surfaces). The combination of soil moisture and SOM contents better explained the PWR than SOM content alone. These results suggest that soil water content can have substantial effects on PWR by changing the availability and/or conformation of the amphiphilic SOM, including WEOM.

1. Introduction

Soil water repellency affects water movement and associated nutrient cycles. High soil water repellency reduces the water storage capacity of the soil and enhances the spatial heterogeneity of water and of nutrient movements (Bundt et al., 2001; Doerr et al., 2000; Kobayashi and Shimizu, 2007). Potential water repellency (PWR), i.e., the water repellency when the soil is dry, has been commonly used to compare the degree to which different soils repel water.

PWR has been reported to increase with increasing soil organic matter (SOM) content if the other soil physicochemical properties are similar (Chenu et al., 2000; Mataix-Solera and Doerr, 2004; McKissock et al., 1998). Soil water repellency results from the coating of hydrophilic mineral particles with SOM, which is fairly hydrophobic (Doerr et al., 2000). Soil with a high SOM content has a larger proportion of SOM-covered particle surfaces and is therefore more capable of repelling water.

In addition to the amount of SOM, the conformation of the outermost layer of SOM can significantly influence the PWR. Amphiphilic compounds may be present in the outermost layer of SOM and play a key role in water repellency (Kleber et al., 2007). Amphiphilic compounds can easily change their conformation if soaked in solution, depending on the solution polarity. Soil water repellency has been found to decrease when the soil is dried after soaking in polar solvents, but it increases when soaked in nonpolar solvents (Ma'shum and Farmer, 1985; Ma'shum et al., 1988; Roy and McGill, 2000). Nonpolar solvents may change the conformation of the amphiphilic SOM by causing the hydrophobic components to be reoriented outward or stretched on the surface of the soil particles (Doerr et al., 2005; Ma'shum and Farmer, 1985; Ma'shum et al., 1988). In addition, nonpolar solvents may reorient hydrophilic functional groups inward toward mineral surfaces or toward the inner hydrophilic parts of the adsorbed SOM.

The very high polarity of water may reduce PWR by changing the conformation of the outermost layer of SOM (Ma'shum and Farmer, 1985; Ma'shum et al., 1988). Furthermore, soil moisture conditions may affect PWR by changing the quantity and quality of the SOM, especially water-extractable (soluble) organic matter (WEOM),

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