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Physical and chemical effects of biochar on natural and artificial water repellent soils

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Water repellency (WR) affects soils worldwide. Hydrophobic compounds accumulate in soil through organic matter decomposition, microbial activity, condensation of organic compounds during vegetation fires, or through anthropogenic impacts such as oil spills. WR hinders vegetation establishment, which can lead to soil erosion and increased runoff.

Biochar is currently being evaluated for its potential to increase soil carbon and as a soil amendment. To date, the effect of biochar on water repellent soils has remained largely undetermined. This study considered the potential of biochar as both a physical and chemical amendment for water repellent soils by asking two questions: does adding biochar reduce the observed degree of soil water repellency; and does biochar remove hydrophobic compounds from soil?

The potential of biochar as a physical amendment to water repellent soils was evaluated by mixing 5, 10, 25 and 40% (by weight) each of coarse and fine ground biochar with two naturally water repellent soils and measuring the water drop penetration time (WDPT) for each mixture. Biochar particles beyond the range of existing soil particle diameters increased WDPT variability, which could be explained by increased surface roughness and the resulting enhancement of water repellency effects through Cassie-Baxter interactions. Overall, fine biochar was more effective at reducing water repellency: 25% w/w rendered both soils studied wettable.

Removal of hydrophobic compounds by biochar was tested by mixing 1, 5, 10, 25 and 40% biochar with acid washed sand (AWS) coated with 1.2×10^{-5} mol octadecane and octadecanoic acid (per gram AWS, which corresponds to approximately 50 monolayers hydrophobic compound per gram AWS). Each mix stood for 1 to 30 days in a solution of pH 3, 6 or 9 before the AWS was extracted and the quantity of hydrophobic compound remaining determined by infrared spectroscopy and/or gas chromatography.

Biochar successfully removed the hydrophobic compounds, even in dry conditions and independent of pH and exposure time. Results varied with the quantity of biochar added: some removal was evident with 1% and 5% biochar additions, approximately 50% of material initially deposited onto AWS was removed by 10% biochar, and $\geq$ 25% biochar removed 100% of the material present.

These results suggest that biochar can reduce WR effects in soils by creating wettable pathways through water repellent soil and by removing hydrophobic compounds from soil particles.