Geophysical Research Abstracts
Vol. 16, EGU2014-12472-3, 2014
EGU General Assembly 2014

Factors influencing biochar hydrophobicity and the influence of biochar content on the hydrological and erosional response of a silt loam under simulated rainfall

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The production of biochar and its application to soil has the potential to make a significant contribution to climate change mitigation while simultaneously improving soil quality. Several authors have reported that biochar is hydrophobic. Few studies to date have investigated the effects of biochar on soil hydrology and erosion during rainfall.

Hydrophobicity was assessed by using a goniometer to measure water-droplet contact-angles on the surfaces of biochar particles. Biochars were produced from *Salix viminalis, Miscanthus giganteus* and *Picea sitchensis* feedstocks that were pyrolyzed at 350, 500, 600 and 800˚C in a nitrogen-purged tube furnace. The influence of biochar on soil hydrology was investigated using hydrophobic biochar produced from hardwoods pyrolysed in a ring kiln at ∼400˚C. The biochar was ground and sieved to < 2 mm then added to a silt loam at rates of 0, 5, 25 and 50 g kg^{-1}. Water (30% of the water-holding capacity of the unamended soil) was thoroughly stirred into each sample. Samples were stored at 21˚C in sealed containers in a dark room without natural light for 250 days. Aggregate stability and the hydrological and erosional response of the soils were then assessed using a laboratory rainfall-simulator. The organic matter content of soils and eroded sediments was measured by loss-on-ignition.

The hydrophobicity of biochar was influenced both by the initial material (biomass type and particle size) and the pyrolysis temperature. For each biomass type, hydrophobicity was reduced with increasing pyrolysis temperature. This can be attributed both to the destruction of alkyl functionalities and shrinkage of particles during pyrolysis, smoothing their surfaces. A biochar content of 5g kg^{-1} did not affect the aggregate stability of a silt loam, but biochar contents of 25 and 50 g kg^{-1} reduced aggregate stability by 11 and 23% respectively. Lower aggregate stability accelerated formation of surface seals in soils with high biochar content, so rainwater infiltration was reduced, meaning runoff coefficients increased with increasing biochar content. Sub-surface flow was reduced with increasing biochar content. Biochar content did not affect the total amounts of sediment eroded by runoff and splashing from soils of differing biochar content. However, correlations between rainfall duration and erosion became weaker with increasing biochar content. The differences between the organic matter content of eroded sediments and that of the plots from which they were eroded tended to increase with increasing biochar content, suggesting that biochar was increasingly preferentially eroded as its prevalence in the soil increased.