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Effect of biochar on the fate of volatile petroleum hydrocarbons and soil microbiology in an aerobic sandy soil

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Biochar addition to soil is currently being investigated as a novel technology to remediate polluted sites. A critical consideration is the impact of biochar on the intrinsic microbial pollutant degradation. Adding biochar to soil will reduce the soil porewater concentration of hydrophobic organic compounds (HOCs) and their leaching risks. Pollutants bound in the micropores of biochar become less accessible for bio-uptake by soil-dwelling organisms and plants. Biochar amendment may thereby reduce the transfer of HOCs from the soil matrix into the terrestrial food-chain. By the same mechanisms, strong binding may, however, further reduce the availability of HOCs to microorganisms with the ability to metabolize these compounds. On the other hand, biochar addition to degraded soil has been shown to improve the soil structure and fertility, and hence often also microbial cell numbers.
Because of these antagonistic effects it is not straight-forward to predict the impact of biochar on the biodegradation of pollutants. We therefore studied the impact of a wood-derived biochar (2% on dry weight basis) produced by fast pyrolysis on the fate of volatile petroleum hydrocarbons and soil microbiology in an aerobic sandy soil with batch and column studies. The soil-water partitioning coefficient, Kd, was enhanced in the biochar-amended soil up to a factor 36, and petroleum hydrocarbon vapor migration was retarded accordingly. The effect of biochar on sorption was most remarkable for aromatic hydrocarbons. Despite of increased sorption the overall microbial respiration was comparable in the biochar-amended and unamended soil. This was due to more rapid biodegradation of linear, cyclic and branched alkanes in the biochar amended soil. Despite of similar respiration, total microbial cell numbers were a factor 1.8 lower in biochar amended soil, indicating microbial growth with a lower biomass yield. Both, petroleum vapour and biochar addition led to distinct shifts in the microbial community structure derived from denaturing gradient gel electrophoresis (DGGE). Biochar itself contained little extractable bacterial DNA. Nutrient addition demonstrated that the biodegradation of all petroleum hydrocarbons was nutrient limited except for toluene biodegradation in biochar amended soil. We conclude that the total petroleum hydrocarbon degradation rate was controlled by nutrient availability and the reduced availability of aromatic hydrocarbons in the biochar amended soil led to greater biodegradation of the other petroleum compounds.