

LONG-TERM CARBON SEQUESTRATION USING CHARCOAL

INTRODUCTION

Long term carbon sequestration is highly dependent on the recalcitrance of organic matter in soils.

If the carbon to be sequestered is not recalcitrant in the soil, microbial decomposition of the organic matter will reintroduce the carbon into the atmosphere as carbon dioxide.

Thus, a molecular level examination of the contribution of newly formed organic carbon into soils, in terms of recalcitrance, and the mechanism and potential for their sequestration is required.

We examined the potential for charcoal, a very recalcitrant substance in soils, to complex with newly formed organic substances, like compost, and sequester a fraction of non-recalcitrant materials on a long term basis and produce a new recalcitrant substance suitable for carbon sequestration (Figure 1).

MATERIALS AND METHODS

Different amounts of compost (24% C) were reacted with a constant amount of charcoal collected from the Lake Tahoe watershed at 100°C for 24 hours under reflux. The dissolved organic matter was measured for all compost-charcoal complexes following the reactions. Solid state ¹³C nuclear magnetic resonance (NMR) was also used to examine the compost and charcoal contributions to the overall reaction.

Compost and charcoal (Figure 1) have very different chemical group distributions as shown by their ¹³C solid-state NMR spectra (Braida et al., 2003). Charcoal has a highly aromatic structure configuration (shaded region of 110-150 ppm in Figure 1) whereas compost has a more heterogeneous mixture of chemical components, but dominated by aliphatic, N-alkyl, saccharide, alcohol, and ether groups (unshaded region from 0 to 65 ppm in Figure 1). The complexation (Figure 2) of these two materials is expected to produce a more recalcitrant substance compared to compost alone. Sorption studies have shown that there are physical sites (Braida et al., 2003) into which organic compounds can complex, making charcoal a potentially good nucleation site contributor for the stabilization of compost.

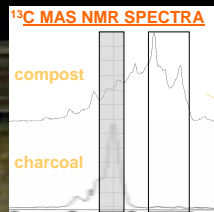


Figure 1. Hypothetical example

RECALCITRANT
Complexation reaction = PRODUCT

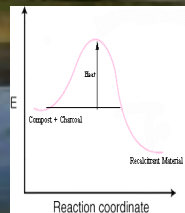


Figure 2. Hypothetical reaction coordinate diagram

THEORY

RESULTS

The major contribution from charcoal was recalcitrant aromatic or conjugated moieties (blue shaded region in Figure 3) while from compost a wide range of nonrecalcitrant moieties (aliphatic, sugar, and carboxyl-C containing structures) were present (yellow shaded region in Figure 3).

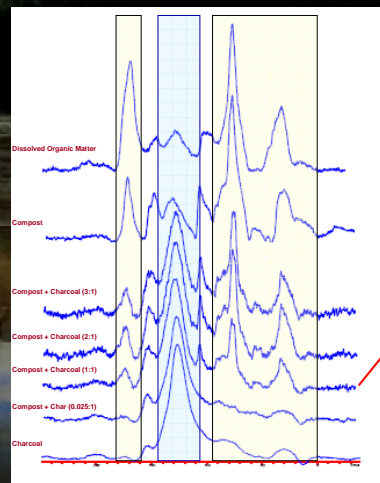


Figure 3. ¹³C MAS NMR spectra for compost-charcoal

RESULTS

The dissolved organic matter (DOM) results (Figure 4) showed that charcoal can retain a fraction (~18% at 2.6:1 compost:charcoal) of the total dissolved component released by nonrecalcitrant organics introduced to soils (i.e., compost). We are currently involved in determining if the complexation can be intermolecular or a surface sorption process similar to activated carbon. An internal complexation model is possible since charcoal can swell in the presence of organic solvents (Braida et al., 2003).

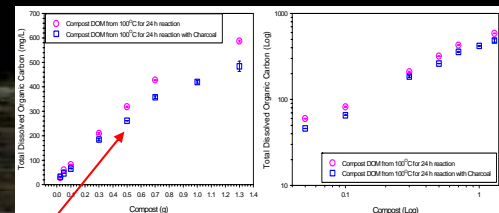


Figure 4. DOM from compost alone and compost + charcoal reactions.

ACKNOWLEDGMENTS and REFERENCES

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Braida, W. J., Pignatello, J. J., Yuefeng, L., Ravikovitch, P. I., Neimark, A. V., and Xing, B. 2003. Sorption hysteresis of benzene in charcoal particles. *Environ. Sci. Technol.* 37: 409-417.

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