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Using modeling to manage organic residues and maximize soil carbon benefits

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Problem

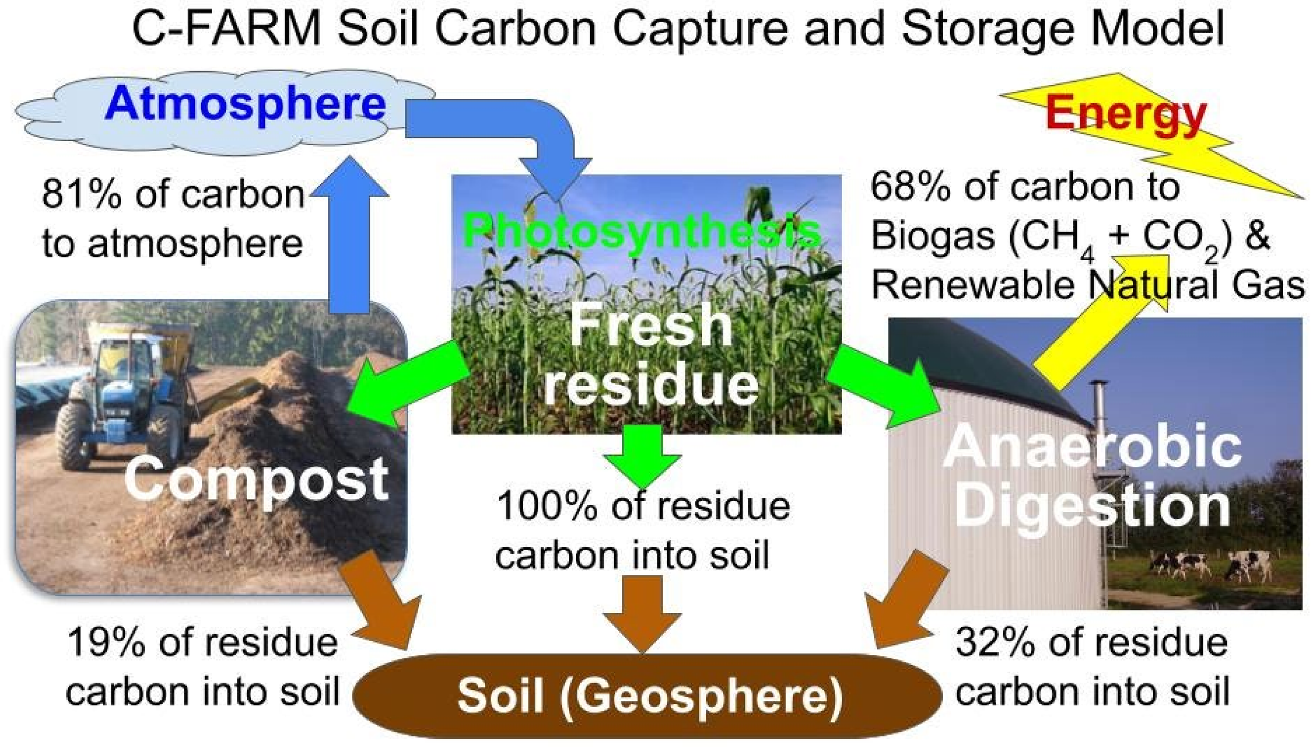
Globally there is a need for renewable energy biomass feedstock that does not compete with food production. In order to assure food supply sufficiency in the future, and to also get more biomass energy from the land, this study evaluates strategies to extract energy from crop residues and still achieve strong soil carbon benefits through engineering and design.

Rationale

Farming practices include soil agriculture, growing crops, and animal and manure storage/management. They also represent sources of green house gas (GHG) emissions. Renewable energy can reduce GHG emissions but there is a need to remove atmospheric carbon and sequester it in stable forms. Agroecosystems such as farms can serve as a portal for carbon sources and sinks. There is a need to measure the carbon retention in the soil due to farming practices as well as microbial respiration. Increasing soil carbon levels can be a strong sink and represent sustainability. Crop residues are the most dominant input of organic residues to the soil ecosystem. There is a need to measure the retention of carbon in the soil through modeling to maximize soil carbon benefits.

C-FARM Simple Soil Carbon Capture and Storage Model
Carbon that enters the soil organic carbon pool is the "humified" fraction of carbon inputs (Ci) from residues (microbial respiration or energy for the microbes). Microbial biomass also feeds on the stable organic matter. Therefore, there is a loss from the soil organic carbon pool.

C-FARM Soil Carbon Capture and Storage Model



Methodology

Mathematical Model

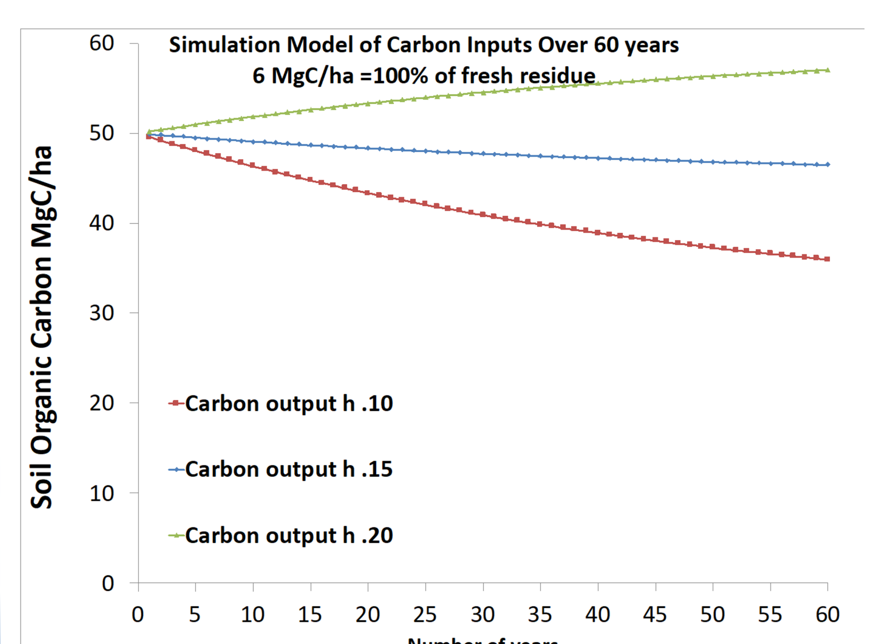
Simple Soil Carbon Model
dCs/dt=h*Ci-k*Cs
Cs-→ soil organic carbon
t→ time
h→ humification (representing fraction of carbon input from residues
Ci→ input of fresh residues
k– decay rate of soil organic carbon
Cs(t) = h*Ci/k + (Co - h*Ci/k)*exp(-k*t)

Common Testing Conditions for Maryland and Southern Pennsylvania

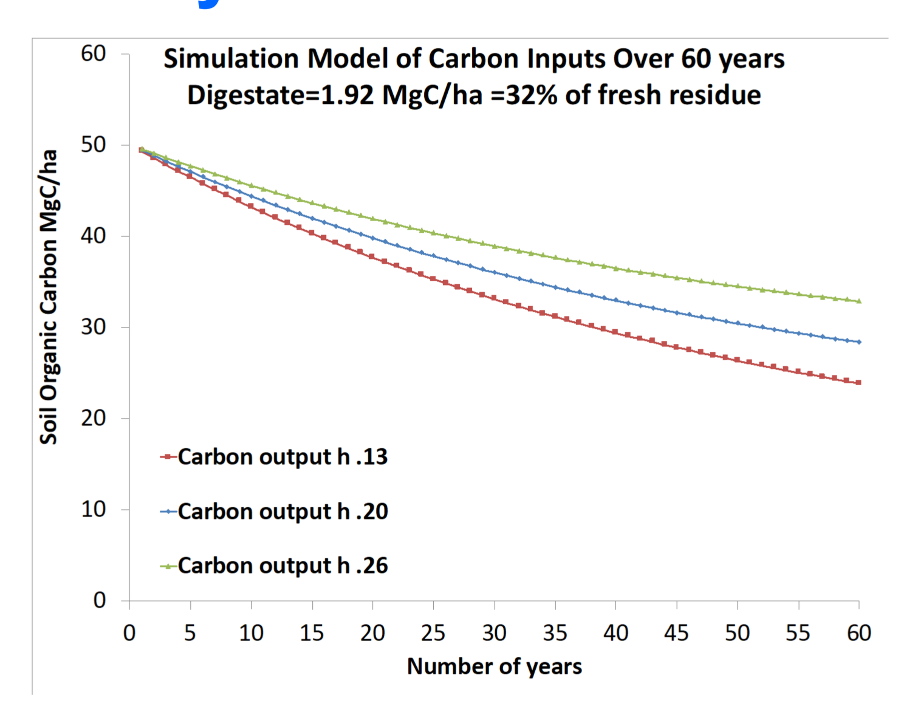
Cs=50 MgC/ha, k=0.02 and t=60 years

Treatment	Testing conditions
Fresh residue	Ci = 100% carbon input h = 0.10, 0.15, 0.20 humification
Digestate	Ci = 32% carbon input h = 0.13, 0.20, 0.26 humification
Compost	Ci = 19% carbon input h = 0.15, 0.23, 0.30 humification

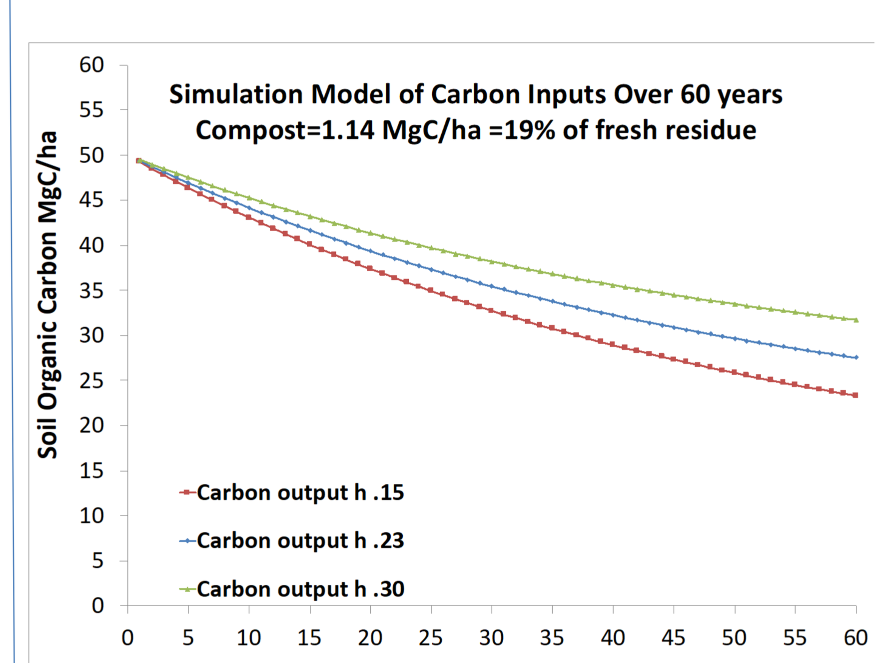
Data & Analysis



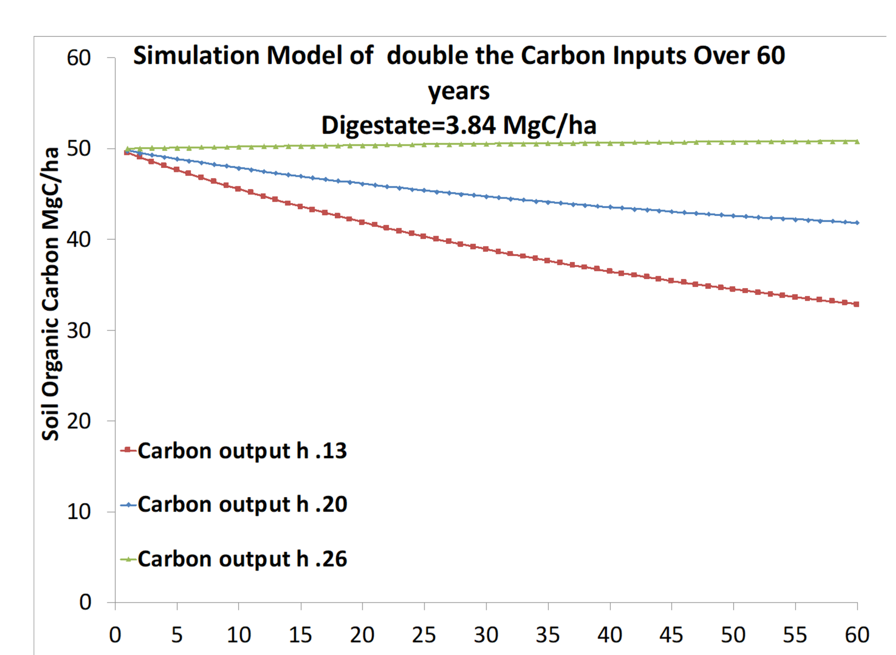
Graph Analysis: h values of 0.20 are achieving carbon quasi-steady state for the fresh residue



Graph Analysis: none of the h values are achieving carbon steady state rates, more Ci (Carbon input) is needed then the initial 1.92 MgC/ha



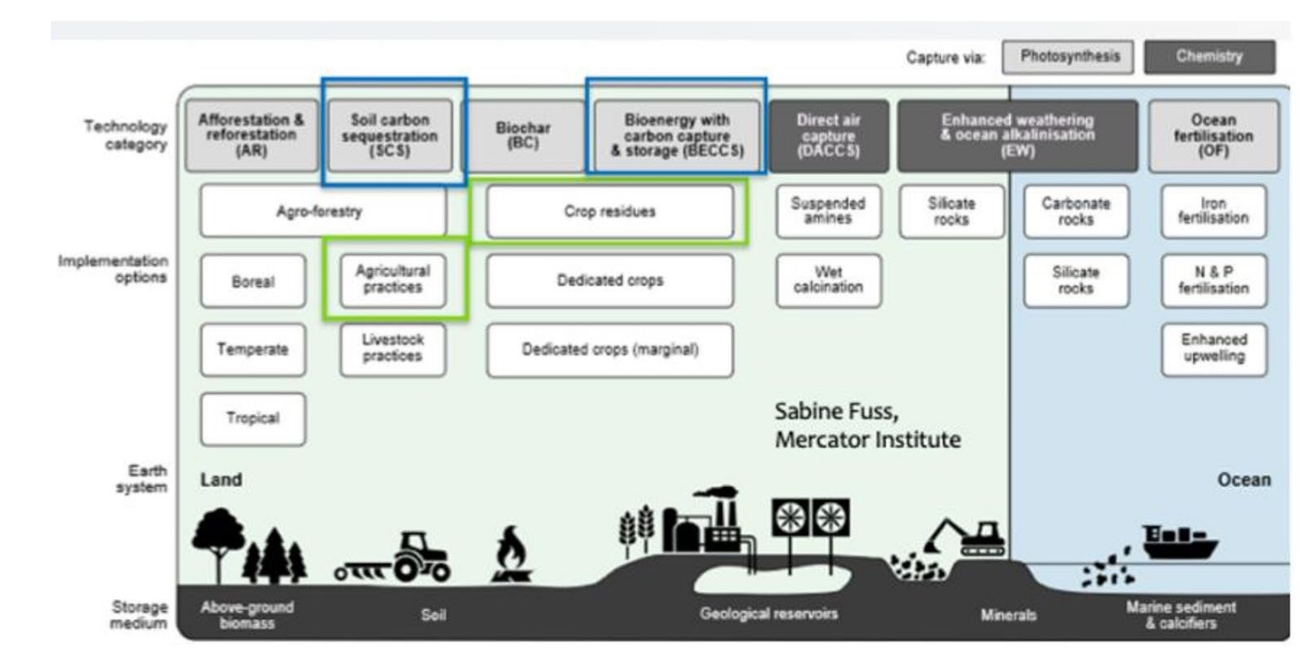
Graph Analysis: All of the h values are showing carbon loss over time for the compost



Graph Analysis: Quasi-steady state rate of carbon is achieved for the h values of .26 and .20 when the Carbon input is doubled to 3.84 MgC/ha

Future Implications

Grass to Gas
Anaerobic digestion provides biogas and the recycled nutrients stabilize carbon for building soil organic matter. It represents low-cost technology, sustainability, and high energy yields.



Technological: (SCS) Soil Carbon Sequestration (BECCS) Bioenergy with Carbon Capture and Storage
Implementation: Crop residues and agricultural practices

Conclusion

There is a need globally to create negative emissions of carbon dioxide. Carbon levels are rising so the use of modeling to predict future patterns and trends is paramount. Bioenergy with carbon capture and storage (BECCS) has the potential to be a negative emissions technology when it is implemented well. Supporting sustainable biomass production serves as an alternate to fossil fuels and can not be depleted; nonetheless, the sustainable crop and livestock systems must be continually studied globally in order to understand more about the role of nutrient cycling and greenhouse gas emissions.

Acknowledgements

Dr. Tom Richard, Dr. Armen Kemanian, Brooke Goggins, Renee Sollenberger, Center for Science and the Schools, Penn State University

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The RET for Teachers is funded by the USDA-NIFA Award No. 2020-68012-31824, Consortium for Cultivating Human and Naturally regenerative Enterprises.