Certain biochar may stimulate greenhouse gas emissions

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Introduction

A substantial amount of greenhouse gas (GHG) emissions is from agriculture practices. Biochar has shown to provide great benefits for agriculture regarding pH, porosity, and water/nutrient retention of soil. It is also one way that carbon can be sequestered to reduce the amount of carbon being released to the atmosphere. Figure 1 illustrates how biochar can help with carbon sequestration within the carbon cycle. With the increasing popularity of using biochar as a soil amendment, the question arises as to whether the application of biochar will mitigate or stimulate greenhouse gas emissions in agricultural fields.

This ongoing study aims to synthesize recent research data on biochar's effects on soil greenhouse gas (GHG) emissions, particularly CO_2, CH_4 and N_2O. There have been a select number of papers done on this topic, but they are not recent and data from individual studies have been merely discussed using statistical methods. This study aims to provide updated information.

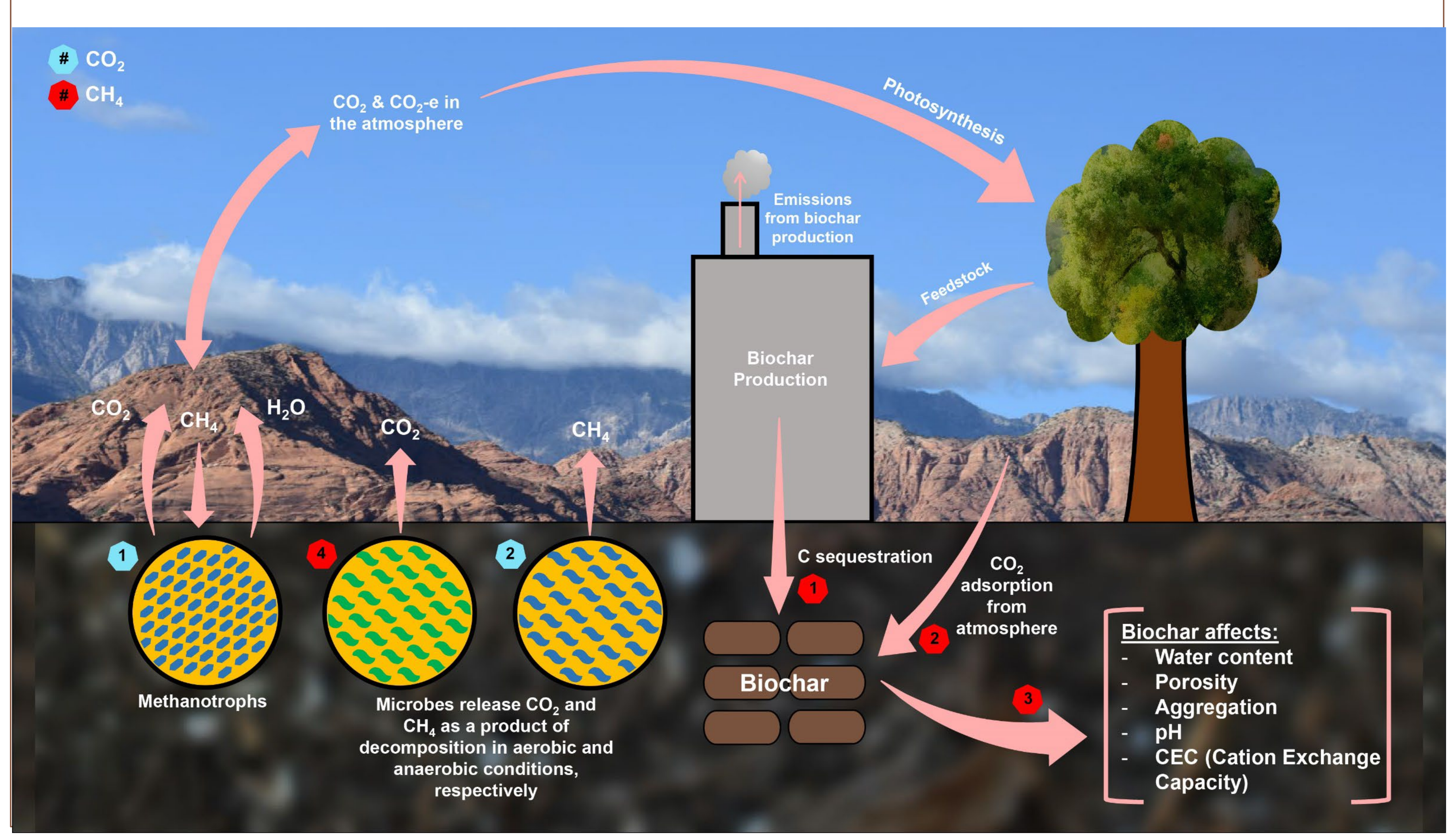

Figure 1. Effects of biochar on the C cycle, highlighting the mechanisms that affect CO_2 and CH_4 emissions

Methods and Materials

Data were extracted from **independent individual studies** and then **statistically processed** for analysis. This synthesis focuses on biochar made from **woody feedstocks** through **fast pyrolysis**. Possible impacting factors like

- *Biochar feedstock type*
- *Pyrolysis temperature*
- *Residence time*
- *Soil type and soil properties*

were considered for comparisons. To exclude influences of fertilizer nutrients (e.g., N and P), research that applied fertilizers during the observation periods were not selected. All the emission data collected from different sources were converted into their respective **cumulative emissions over 30 days**, and the **percentage changes in GHG emissions** were calculated between the control and experimental values.

Results

Data from biochar created from wood sources with different pyrolysis temperatures. Figures 2-8 show results of that data.

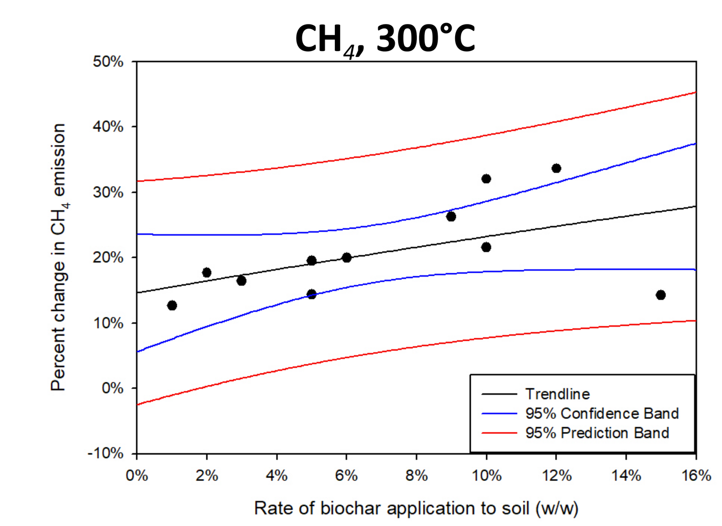

Figure 2. Change in CH_4 emission vs. Rate of Biochar Application, Pyrolysis Temp of 300°C

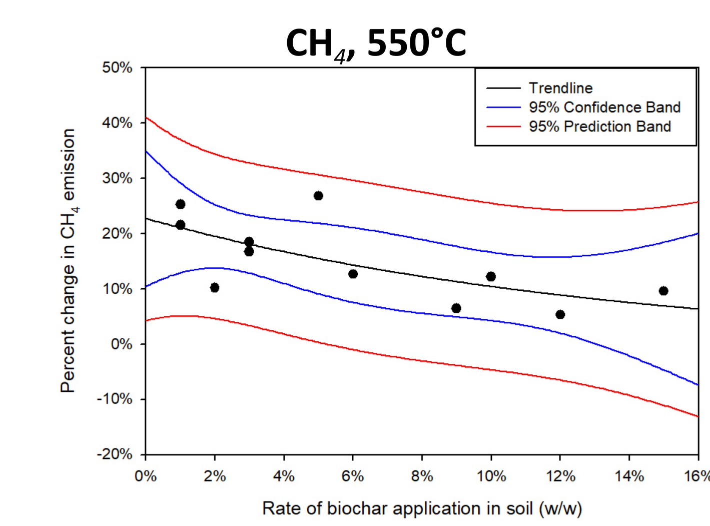

Figure 3. Change in CH_4 emission vs. Rate of Biochar Application, Pyrolysis Temp of 550°C

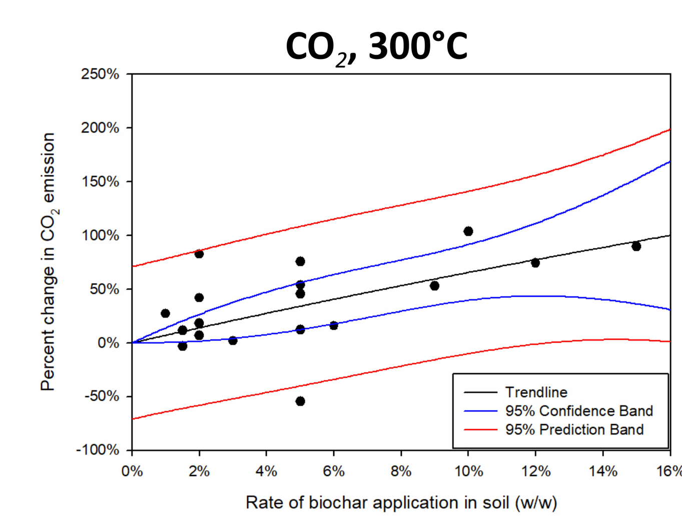

Figure 4. Change in CO_2 emission vs. Rate of Biochar Application, Pyrolysis Temp of 300°C

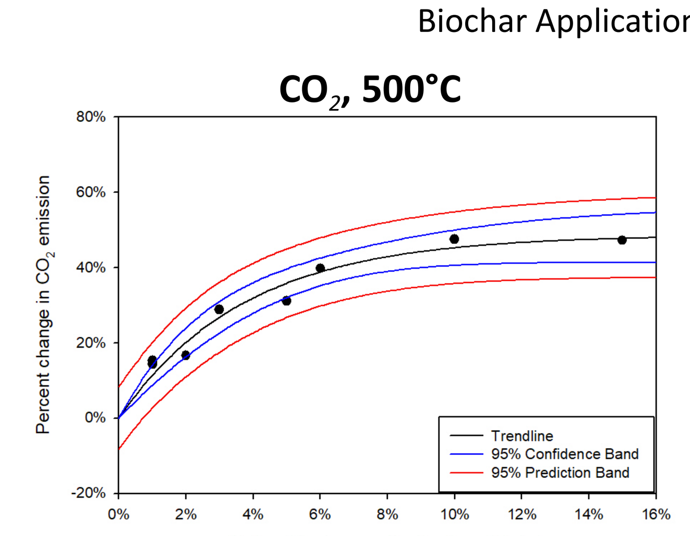

Figure 5. Change in CO_2 emission vs. Rate of Biochar Application, Pyrolysis Temp of 500°C

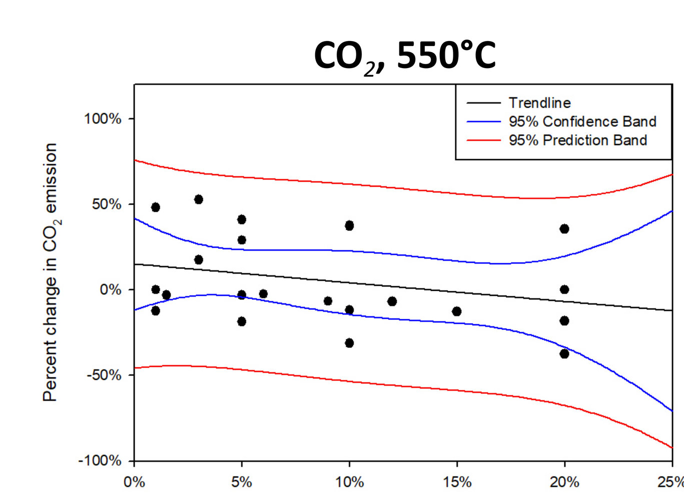

Figure 6. Change in CO_2 emission vs. Rate of Biochar Application, Pyrolysis Temp of 550°C

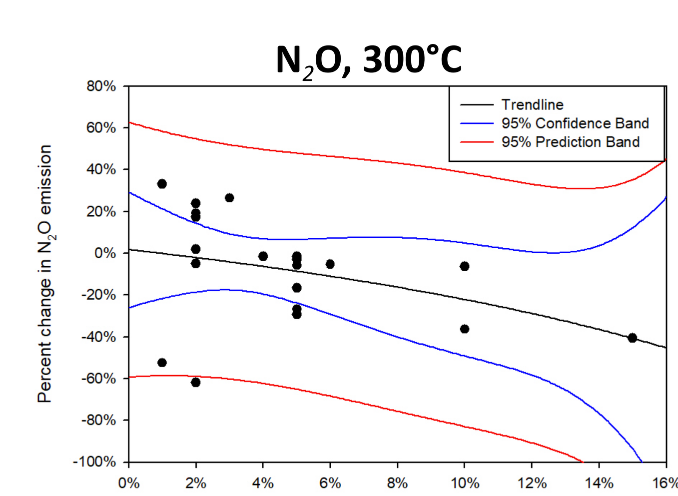

Figure 7. Change in N_2O emission vs. Rate of Biochar Application, Pyrolysis Temp of 300°C

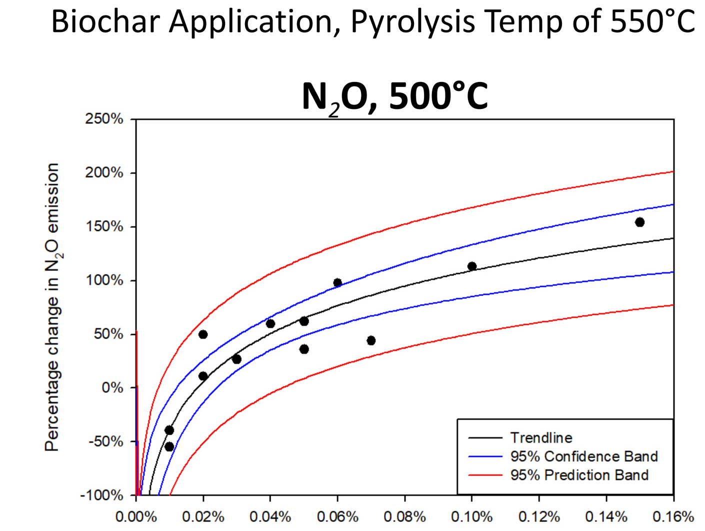

Figure 8. Change in N_2O emission vs. Rate of Biochar Application, Pyrolysis Temp of 500°C

Discussion

The data collected on woody biochar point to some interesting results:

Methane:

300°C: Application Rate ↑, CH_4 emissions ↑

550°C: Application Rate ↑, CH_4 emissions ↓

Carbon Dioxide:

300°C: Application Rate ↑, CO_2 emissions ↑

500°C: Application Rate ↑, CO_2 emissions ↑

550°C: Application Rate ↑, CO_2 emissions ↓

When produced under lower temperatures, biochar remains **a large portion of biodegradable carbon** and possesses **mesopores that may provide microhabitats** for microbial growth and their metabolic activities.

When produced under higher temperatures, biochar contains mostly **recalcitrant carbon**, which is resistant to degradation. The predominant **micropores cannot provide microhabitats**; instead, their **strong adsorption** of dissolved nutrients and carbon from surrounding soils **reduces the amounts available for soil microorganisms**.

Nitrous Oxide:

300°C: Application Rate ↑, N_2O emissions ↓

550°C: Application Rate ↑, N_2O emissions ↑

Carbon content of biochar increases with pyrolysis temperature (Zhou *et al*. 2016). Research shows a **strong correlation between nitrate adsorption and the carbon content of biochar** (Kameyama *et al*., 2015). This may provide **more nitrate for bacteria to convert to nitrous oxide**, thus stimulating nitrous oxide emissions when high-temperature biochar is applied.

Next Steps

- Applications of biochar derived from **other types of feedstocks** (e.g., herbaceous feedstock):
  - ✓ How will GHG emissions be affected?
  - ✓ What are the influences of pyrolysis temperature and soil properties?
- Comparisons of the **short-term effects** and **Long-term effects** of biochar applications on GHG emissions

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References

References shall be provided upon request.