Hypothesis

Higher temperatures and CO_2 levels will be observed, indicating increased bacterial activity

pH levels and humic acid levels will increase with biochar additions

Biochar amendments will ultimately lead to a drop in phytotoxicity

Materials & Methods

Experimental Set-up

- **Four groups created** with cow manure and wheat straw as feedstock
  - mixed to C:N of 25:1 and moisture content of ~65%

CK
Control with no treatment

PC
0.5% plastic (dry weight)

BC10
10% biochar & 0.5% plastic (dry weight)

BC20
20% biochar & 0.5% plastic (dry weight)

Pyrolysis at 950 °F

pH of 9

304 m^2/g

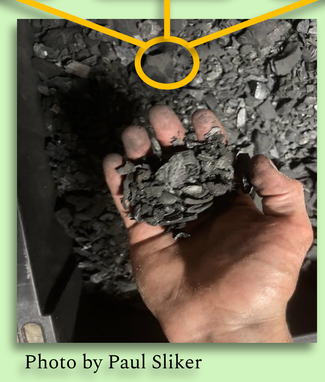


Photo by Paul Sliker

26.1% Macro-plastics

19.9% > 1mm

56.1% < 1mm

HDPE particles

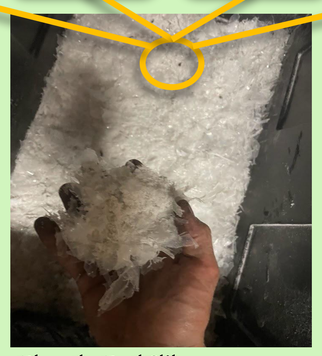


Photo by Paul Sliker

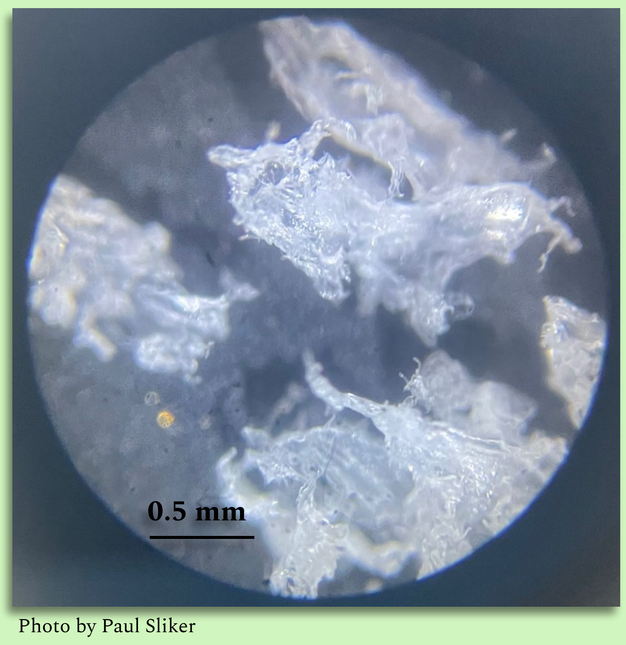


Photo by Paul Sliker

Mid-sized microplastic particle used in the experiment

Testing & Analysis

- **NH_3 and CO_2** levels measured by placing gel probes in jars with fresh compost samples for 4 hours

Photo by Paul Sliker

- **pH levels** measured by mixing dried compost samples with DI water. Resulting mixture was read with a calibrated pH meter

Photo by Paul Sliker

- Phytotoxicity was determined by germinating 10 *Brassica Oleracea* seeds in a mixture of 10 parts DI water to 1 part fresh compost.

Germination index was calculated using the formula below

Photo by Paul Sliker

$$GI(\%) = \frac{seed germination(\%) \times root length of treatment}{seed germination(\%) \times root length of control} \times 100$$

- **Temperature** was measured with a digital thermometer, temperature data representing the average of two spots in each treatment
- **Humic acid** levels were determined by sending fresh compost samples to an agricultural laboratory
- After data collection, a one-way ANOVA was performed to test for significance ($p < 0.05$)

Results

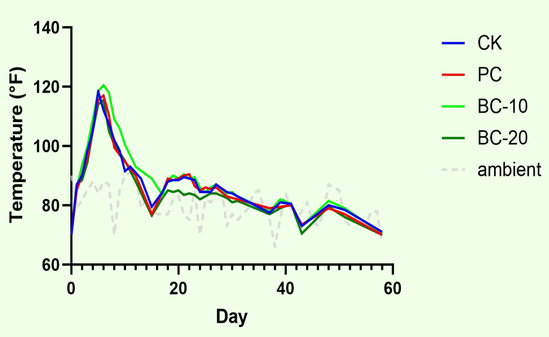


Figure 1. Averaged temperature of each group over the composting period

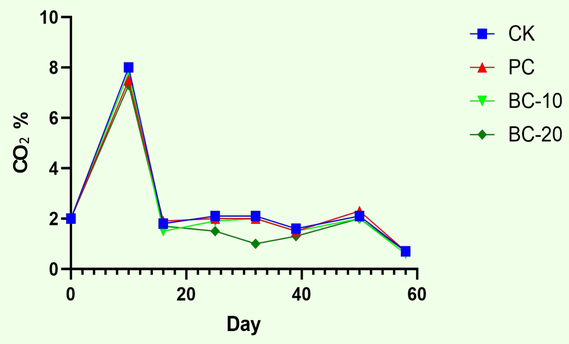


Figure 2. CO_2 levels of each group over the composting period

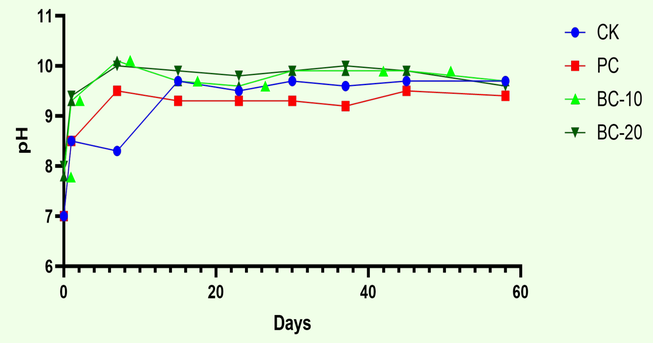


Figure 3. pH levels across the composting period. Significant ($p < 0.05$) differences were observed between groups

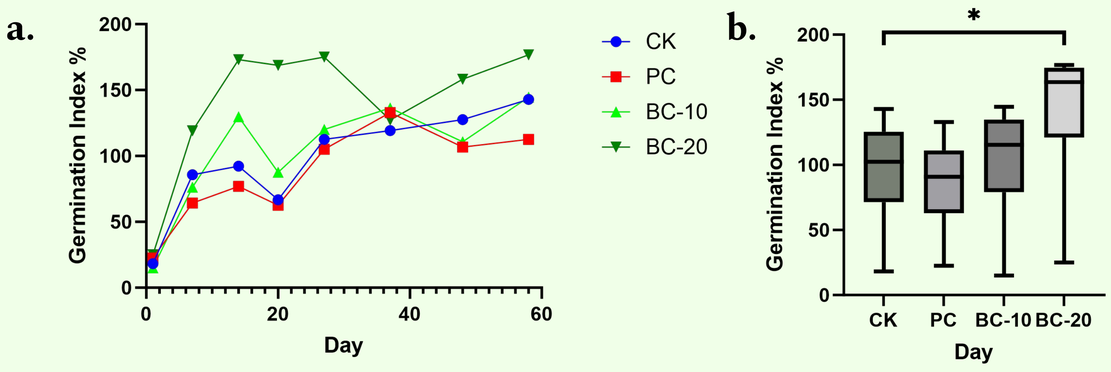


Figure 4. Germination index levels across the composting period. Significant ($p < 0.05$) differences were observed between groups

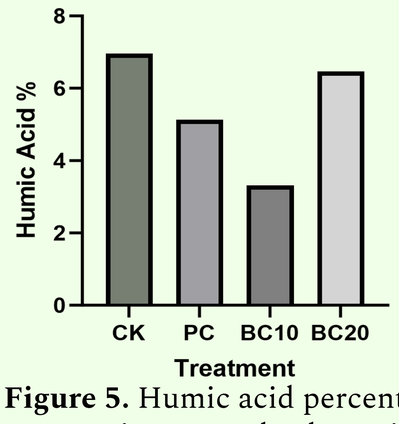
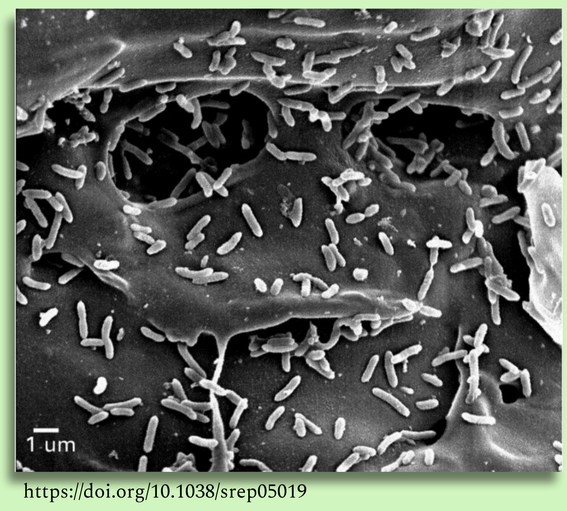


Figure 5. Humic acid percent in each composting group by dry weight at the end of composting period

NH_3 levels dropped to undetectable levels after one week and were not measured for the rest of the experiment

Introduction

- **Plastics and microplastics** (**MPs**) have become prolific in recent years, present in nearly all environmental and biological systems
- **Composting** is the aerobic decomposition of biomatter
  - sensitive system which relies of the proliferation of bacteria and fungi
- **Biochar** is a stable form of carbon made from heating organic materials in the absence of oxygen (pyrolysis) to prevent release of CO_2 into the atmosphere
  - applications for carbon sequestration
  - applications for agriculture and composting as well



https://doi.org/10.1038/srep05019

Micrograph of bacterial inoculum on biochar

Review of Literature

Compost has a plastic problem

- Large amounts of microplastics end up in compost and consequently farms as a result of transportation, collection, and homogenization (Bläsing et al., 2018)
- Polyethylene and polypropylene MPs had significant negative effects on compost quality and bacterial diversity, reducing its value as a soil amendment (Song et al., 2022)

Biochar holds promise as a solution

- Biochar additions to compost shown to significantly increase degradation of organic pollutants in compost while raising enzyme and bacterial activity (Lv et al., 2022)
- Biochar amendments overall have been shown to accelerate degradation of organic matter, increase compost maturity, and lower phytotoxicity (Xiao et al., 2017)

https://doi.org/10.1021/acs.est.8b02212

Microplastic contamination in agricultural soils

Problem

- Plastic pollution threatens the viability of composting operations
- Little to no previous research on biochar and plastic co-composting
- Previous research on biochar amendments to compost has given inconsistent results

Goal

Investigate the effects of biochar on plastic and MP contaminated compost

- Examine physicochemical characteristics
- Determine phytotoxicity and humic substance concentrations

Utilization of Biochar to Accelerate Aerobic Decomposition and Increase Compost Quality in the Presence of Plastic and Microplastic Pollutants

Discussion

- No significant differences in temperature observed, similar to findings by Xiao et al., in 2017
  - Consistently lower temperatures in BC20
- CO_2 levels followed a similar trend to temperature
  - similar decrease in BC20, indicating a decrease in microbial density caused by biochar dilution

- Increased aeration and decreased density of nutrients and bacteria as a result of biochar dilution

- Sharp initial rise in the germination index of BC20
  - decreased density of phytotoxic compounds and increased volatilization of ammonia
- Biochar amendments of 10% DW were successfully able to match ending GI of CK, even in contaminated compost

- Significant increases in pH caused by inherent alkalinity of biochar
  - drop in pH with plastic contamination, similar to findings by Song et al.
  - biochar amendments effectively mitigated the pH drop caused by plastics

- Unexpected humic acid levels in BC10
  - poor sample collection or problems during transportation

Conclusions

Hypothesis Generally Supported

- Overall, biochar amendments successfully mitigated pH and GI drops caused by plastics
- Biochar applications of 20% or more by dry weight possibly harmful, however
  - difficult to tell the cause of increased GI
  - similar to findings by Xiao et al., in 2017

Limitations

- Small bin size
  - not representative of large scale composting operations
  - facilitated heat loss which prevented compost from reaching optimal temperatures
- No enzymatic analysis
  - would give a better representation of organic matter degradation and ability to degrade pollutants in compost

Future Research

- Investigating main pollutants released by plastics and the main cause of phytotoxicity drops
  - Chemical or structural?
- Understanding interactions between plastic particles and pH
- Methods for the removal of plastic contaminants
  - Investment into improved composting infrastructure and transportation
- Investigations into biopolymer synthesis

References

Bläsing, M & Amelung, W. (2018). Plastics in soil: Analytical methods and possible sources. *Science of the Total Environment, 612*, 422-435. https://doi.org/10.1016/j.scitotenv.2017.08.086

Chen, S., Rotaru, A.-E., Shrestha, P. M., Malvankar, N. S., Liu, F., Fan, W., Nevin, K. P., & Lovley, D. R. (2014). Promoting interspecies electron transfer with biochar. *Scientific Reports*, *4*(1). https://doi.org/10.1038/srep05019

De Souza Machado, A. A., Lau, C. W., Till, J., Kloas, W., Lehmann, A., Becker, R., & Rillig, M. C. (2018). Impacts of microplastics on the soil biophysical environment. *Environmental Science & Technology*, *52*(17), 9656-9665. https://doi.org/10.1021/acs.est.8b02212

Huerta, E. R., & Pliatsika, K. (2022, January 3). Analysis of Surface Area and Pore Size Distribution in Biochar. In *Surface area and porosity analysis in biochar at celignis biomass lab*. Celignis Analytical. Retrieved October 10, 2023, from https://www.celignis.com/biochar-surface-area.php

Lv, Y., Bao, J., Li, S., Liu, D., Dai, D., Qv, M., & Zhu, L. (2022). Biochar amendment of aerobic composting for the effective biodegradation of heavy oil and succession of bacterial community. *Bioresource Technology*, *362*, 127820. https://doi.org/10.1016/j.biortech.2022.127820

Song, Y., Wang, Y., Li, R., Hou, Y., Chen, G., Yan, B., & Mu, L. (2022). Effects of common microplastics on aerobic composting of cow manure: Physiochemical characteristics, humification and microbial community. *Journal of Environmental Chemical Engineering*, *10*(6), 108681. https://doi.org/10.1016/j.jece.2022.108681

Xiao, R., Awasthi, M. K., Li, R., Park, J., Pensky, S. M., Wang, Q., Wang, J. J., & Zhang, Z. (2017). Recent developments in biochar utilization as an additive in organic solid waste composting: A review. *Bioresource Technology*, *246*, 203-213. https://doi.org/10.1016/j.biortech.2017.07.090