Biochar and covering as optimization strategies for cattle manure composting: Trade-offs in gaseous emissions and safety

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Introduction

- Recycling livestock manure through composting improves nutrient cycling and reduces health risks in sub-Saharan Africa's smallholder farms.
- Composting practices like turning and mixing can increase nutrient losses via greenhouse gas (GHG) and ammonia (NH_3) emissions.
- Optimizing composting to reduce gaseous nutrient losses while maintaining quality and safety is key for better manure management.
- We evaluated optimized cattle manure composting practices and their effects on emissions, nutrient changes, and compost safety under controlled conditions.

Guiding research questions

- Does biochar addition and covering during composting increase the thermophilic period to reduce pathogens and enhance compost safety?
- Does biochar addition, covering and turning affect greenhouse gas and ammonia emissions during composting?
- How does biochar addition and covering affect the final nutrient composition of the compost?

Materials and Methods

Compost treatments

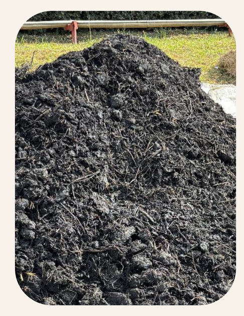
1. **UC=** Untурned control
2. **CoV=** Turned cover
3. **Nocov=** Turned + nocover
4. **BC=** Turned + 10% biochar
5. **BC+Cov=** Turned + 10% biochar + cover

All treatments replicated three times
200 kg cattle manure-straw mixture (4:1,w/w) in 600- L plastic containers

* For turned treatments –
Three times during the hot phase.

steps and measurements

Composted for 3 months



Final compost **with biochar**

Final compost **without biochar**

Results

Composting process

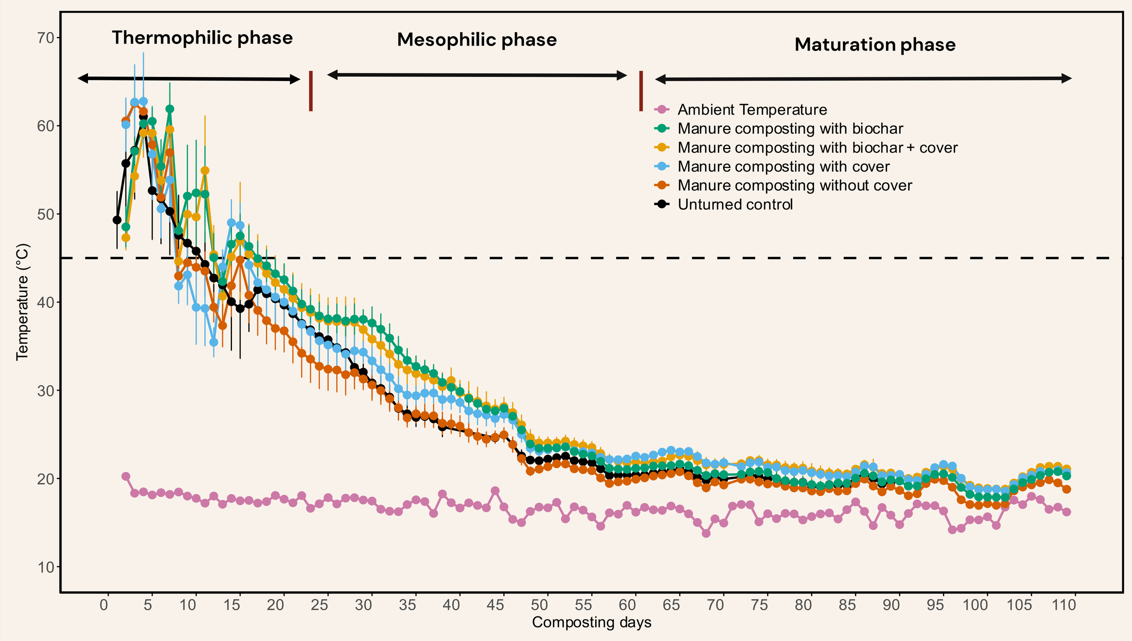


Figure 1. Changes in temperature profiles across different composting phases and treatments.

Gaseous emissions

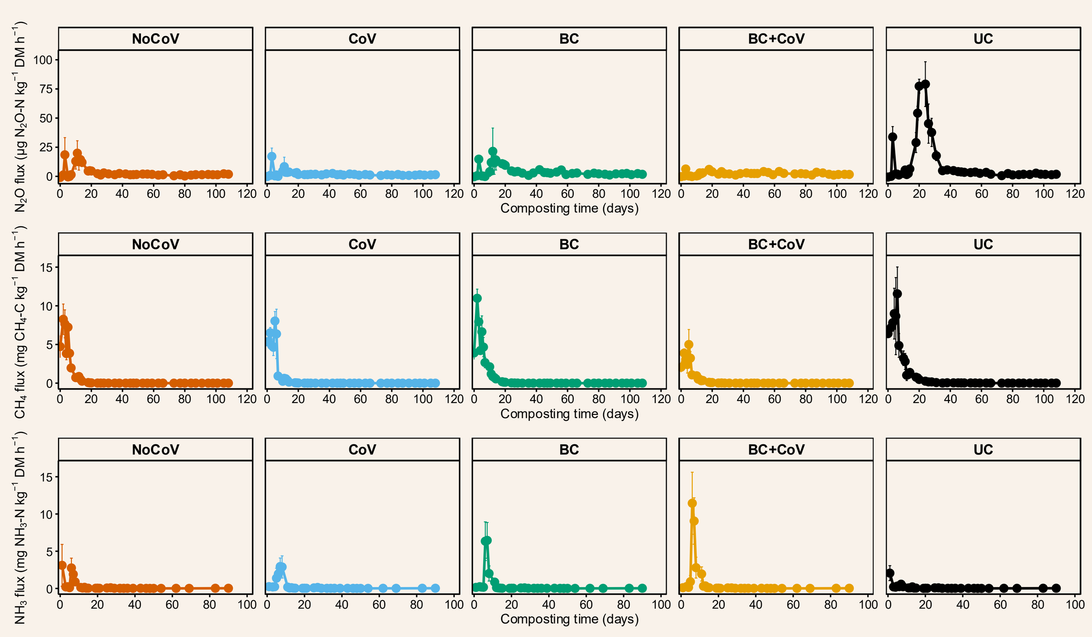


Figure 2. Dynamics of N_2O, CH_4, NH_3 fluxes during the composting experiment. UC (Untурned control), BC (Manure composting with 10% biochar), BC+CoV (Manure composting with 10% biochar + straw cover), CoV (Manure composting with straw cover), and NoCoV (Manure composting without cover or biochar).

Nutrients

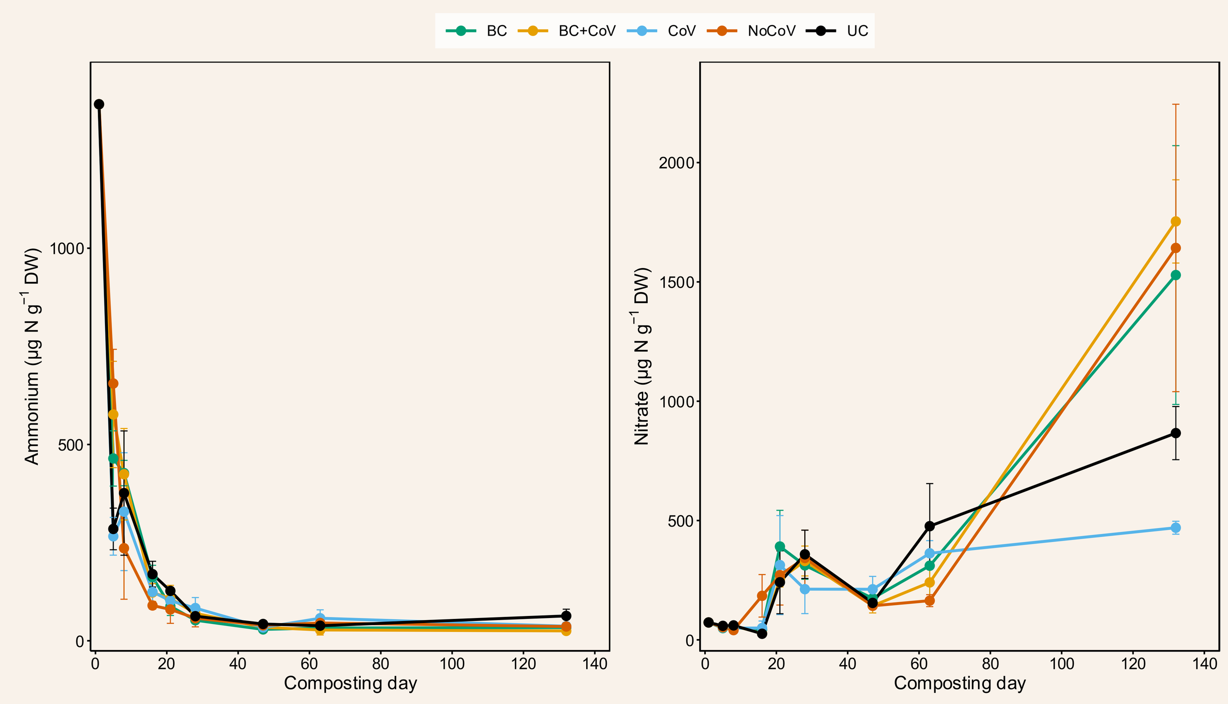


Figure 3. Nutrient dynamics NH_4^+–N, NO_3–N during the composting process for the different treatments.
UC (Untурned control), BC (Manure composting with 10% biochar), BC+CoV (Manure composting with 10% biochar + straw cover), CoV (Manure composting with straw cover), and NoCoV (Manure composting without cover or biochar).

Conclusions

All composting strategies achieved sanitizing temperatures (>50 °C), while biochar prolonged (16 days) the thermophilic phase, supporting effective compost sanitization.

Biochar, combined with covering, effectively mitigated GHG emissions, reducing cumulative N_2O by 61–77% and CH_4 by 51–77% relative to the control.

NH_3

Adding biochar and covering increased NH_3 emissions, highlighting a trade-off between GHG mitigation and N conservation and the need to better control NH_3 losses during composting.

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