Managing emissions and nutrient losses from cattle manure through cascades with carbonized materials in Kenya.

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Problem statement

- Manure is a very important source of plant nutrients and helps to improve soil organic matter and fertility.
- Nutrient losses during manure storage reduce its fertilizer quality (low nitrogen content) and lead to environmental pollution (nitrate leaching), bad odor (ammonia emissions), and climate change (methane and nitrous oxide emissions).
- Climate-smart manure management practices are urgently needed for better nutrient circularity and crop-livestock integration.

Research questions

- Can charcoal and biochar reduce nutrient losses through ammonia (NH_3) volatilization and methane (CH_4) and nitrous oxide (N_2O) emissions from cattle manure?
- Given that biochar is produced at higher temperatures and has greater porosity and surface area than charcoal, is it more effective in reducing losses than regular charcoal?
- Are higher levels (30%) versus lower levels (10%) of biochar/charcoal addition more effective in reducing nutrient losses from manure?

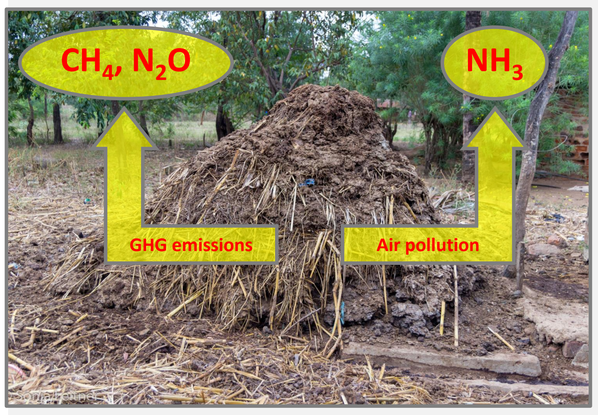

Figure 1: On smallholder farms, manure is often stored in unprotected heaps, which leads to high nutrient losses, environmental pollution, and poor fertilizer quality. (Photo: ILRI/Sonja Leitner)

Benefits of biochar and charcoal

- Both hold nutrients on their surface area, preventing losses. Biochar has a higher surface area and thus a higher nutrient-holding potential.
- They improve manure aeration, which reduces methane emissions.
- They improve microbial activity and manure decomposition, resulting in better fertilizer quality.
- They reduce ammonia volatilization and mitigate air pollution and nitrogen loss.

Experimental setup

Figure 2: Fresh cattle manure was collected from the ILRI farm. (Photo: ILRI/Ludy Keino)

Figure 3: Cattle manure was mixed with either biochar or charcoal at 10% or 30% weight. Biochar was either activated with steam, or non activated. (Photo: ILRI/Ludy Keino)

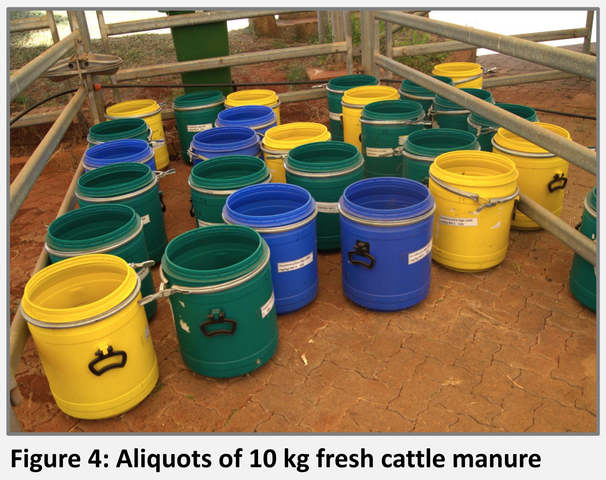

Figure 4: Aliquots of 10 kg fresh cattle manure were incubated in 40 L buckets under a roof outside Mazingira for 105 days. Lids were kept open to allow for ventilation. (Photo: ILRI/Chebet Arusey)

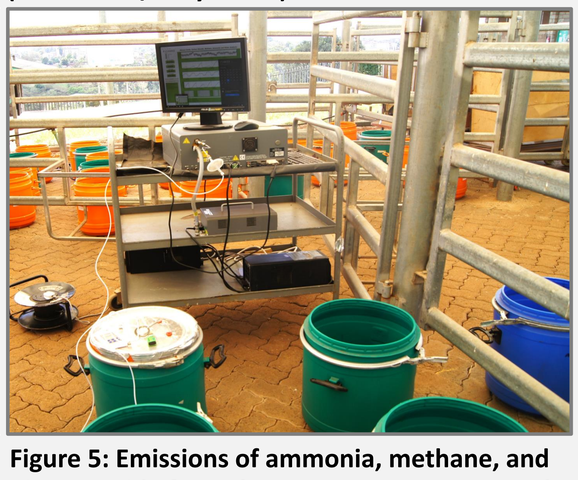

Figure 5: Emissions of ammonia, methane, and nitrous oxide from the manure were measured with a Picarro laser spectrometer. (Photo: ILRI/Chebet Arusey)

Results

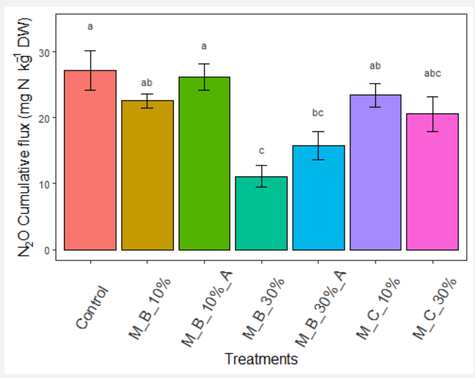

Figure 6: Nitrous oxide (N_2O) emissions from cattle manure containing different levels (10% and 30%) of biochar (B) that was either non-activated or steam activated (A) and regular charcoal (C) compared to controls without amendment.

- Addition of 30% biochar significantly reduced cumulative N_2O emissions compared to the control without addition.
- There was no effect of biochar activation on N_2O emissions.

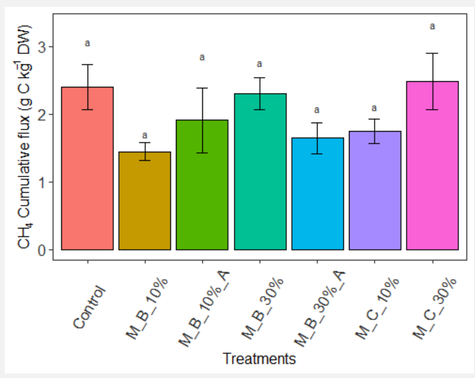

Figure 7: Methane (CH_4) emissions from cattle manure containing different levels (10% and 30%) of biochar (B) that was either non-activated or steam activated (A) and regular charcoal (C).

- Even though there was a slight trend of reduced CH_4 emissions in manure amended with low levels of non-activated biochar and charcoal or high levels of activated biochar, this effect was not significant.

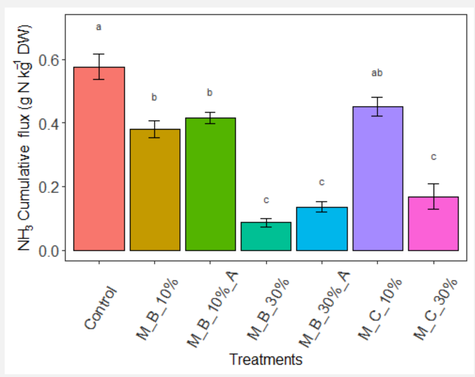

Figure 8: Ammonia (NH_3) emissions from cattle manure containing different levels (10% and 30%) of biochar (B) that was either non-activated or steam activated (A) and regular charcoal (C).

- Biochar and charcoal addition strongly reduced manure NH_3 emissions.
- Higher rates of biochar and charcoal addition (30%) were more effective in reducing NH_3 than lower (10%) rates.
- There was no effect of biochar activation on NH_3 emissions.

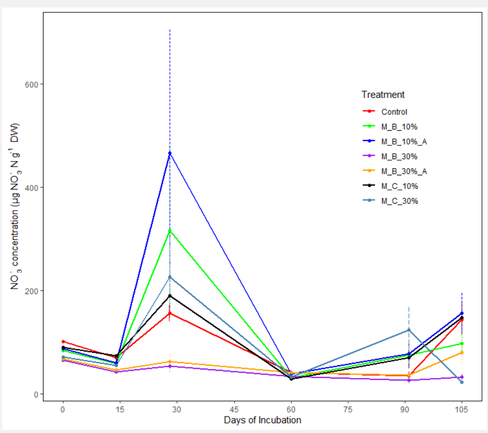

Figure 9: Effects of different levels of biochar and charcoal on nitrate (NO_3^-) concentrations of cattle manure.

- Nitrate concentration increased after 28 days due to manure decomposition and nitrification. Nitrate was lower in manure with 30% biochar, indicating that biochar can reduce nitrate leaching from manure storage.
- In contrast, regular charcoal and low levels of biochar did not reduce nitrate leaching risks.

Conclusions

- Both biochar and charcoal are promising manure amendments to reduce greenhouse gas emissions and air pollution from cattle manure.
- Biochar can potentially help to decrease nitrate leaching risks from cattle manure storage.

Additional note

For biochar and/or charcoal production, waste materials such as rice husks, maize shanks, coconut shells, or biomass from invasive plants (such as Prosopis) should be used to ensure sustainability.

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