N₂O and CH₄ emissions from cattle manure heaps in Kenya

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EGU online, BG3.3 Gas exchange between soil, plants and atmosphere, 08 May 2020
Background – Agricultural GHG emissions & productivity in the global context

- **Africa** - 15% of agricultural GHG emissions come from Africa
- **Americas** - 25% of emissions related to manure

**AFOLU GHG-emissions by sector**

- Enteric fermentation
- Manure left on pasture
- Manure management
- Manure applied to soils
- Burning - savanna
- Synthetic fertilizer
- Rice cultivation
- Crop residues
- Cultivation org. soils
- Burning – crop res.

FAO, Tubiello et al. 2014
Low productivity, high GHG emissions of livestock in sub-Saharan Africa (SSA) → high yield-scaled GHG emissions

Productivity increase urgently needed to ensure food security & meet demand of growing population

Sustainable intensification, climate change adaptation & mitigation (co-benefit)

Herrero et al., PNAS, 2013 (Numbers are from 2010)
Smallholder mixed crop-livestock farms:

- 50% of agricultural workforce employed in livestock production
- Average farm size 0.5-2 ha
- Crops (e.g. maize, wheat, barley, tomatoes, onions, sunflower, ...)
- Few animals per farm (e.g. 2-5 cattle, some goats, sheep, chicken, pigs, ...)
- Cattle: Local and “improved” breeds (e.g. Boran x Friesian)
- Manure management common, manure as fertilizer

*FAOSTAT, World Bank, ILRI*
Research questions & hypotheses

What is the magnitude of \( \text{CH}_4 \) and \( \text{N}_2\text{O} \) emissions from manure heaps in Kenyan smallholder farming systems?

1. Due to feed scarcity (e.g. dry season) and poor quality of feeds, manure-borne \( \text{CH}_4 \) and \( \text{N}_2\text{O} \) emissions are lower in Kenya than in developed countries.

2. Manure from hungry cows emits less \( \text{N}_2\text{O} \) compared to well-fed cows because of higher N retention under sub-maintenance energy feeding.

3. Manure from cattle fed with tropical forage grasses has low N concentration and lower \( \text{N}_2\text{O} \) emission factors (% manure-N emitted as \( \text{N}_2\text{O}-\text{N} \)) compared to IPCC Tier 1 default \( EF_{\text{N}_2\text{O}} \) for solid manure storage.
1. Experiment: Sub-maintenance energy feeding trial

Setup:

- Location: Mazingira Centre, Nairobi, Kenya
- Animal feeding trial with Boran steers
- Diet at 3 levels of metabolic energy requirement (MER):
  - 120% MER (yummy)
  - 100% MER (ok)
  - 60% MER (hangry!)
- Manure incubation in uncovered heaps (n = 3 á 100 kg FM) for 5 months
- Daily to 3x/week gas sampling
1. Experiment: Sub-maintenance energy feeding trial

CH₄ flux highest in first 15 days

CH₄ emissions lower than IPCC Tier 1 default value

No difference in CH₄ emissions between MER treatments
1. Experiment: Sub-maintenance energy feeding trial

- **N₂O peak from day 5-40**
- **Manure from hungry cows emits less N₂O**
- **Manure N lower & C/N higher in hungry cows**
- **Emission factor 50% lower than IPCC Tier 1 default value**
2. Experiment:
Tropical forage grass feeding trial

Setup:
• Location: Mazingira Centre, Nairobi, Kenya
• Animal feeding trial with Boran steers
• Three tropical forage grasses (fed *ad libitum*)
  – Napier grass
  – Rhodes grass
  – Brachiaria grass
• Manure incubation in uncovered heaps (n = 3 × 100 kg FM) for 5 months
• Daily to 3x/week gas sampling
2. Experiment: Tropical forage grass feeding trial

- CH$_4$ flux highest in first 3 weeks
- No difference in manure moisture content
- Manure from Rhodes grass diet has lowest CH$_4$ emissions
- Again, CH$_4$ emissions lower than IPCC default values
- Carbon in Rhodes manure is less readily converted to CH$_4$
2. Experiment: Tropical forage grass feeding trial

- **N\textsubscript{2}O peak from day 5-40**

- **Manure C/N of forage grass diet 2x higher than “European-style” diet**

- **Cumulative N\textsubscript{2}O similar for all grasses**

- **Again, N\textsubscript{2}O emission factor below IPCC default value**
Conclusions

• Manure N concentration from African smallholder farms lower than in developed countries
• Current IPCC default factors for manure $N_2O$ and $CH_4$ are too high compared to *in situ* measurements.
• This potentially invalidates current mitigation practices in SSA because baselines are incorrect, also reporting under UNFCCC is biased.

*What needs to be kept in mind:*

• Spatial variability (characteristics & intensity of farming systems varies across Africa)
• With agricultural intensification total $N_2O$ and $CH_4$ emissions in SSA likely to go up
• However, with improved management (closed nutrient cycles) productivity can go up faster than emissions $\Rightarrow$ GHG emissions intensities could go down
• Also, more productive and diverse systems are often more resilient to stresses.
Thank you for tuning in!

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