Quantifying greenhouse gas emissions during thermophilic composting to evaluate the climate mitigation potential of ecological sanitation (EcoSan) systems

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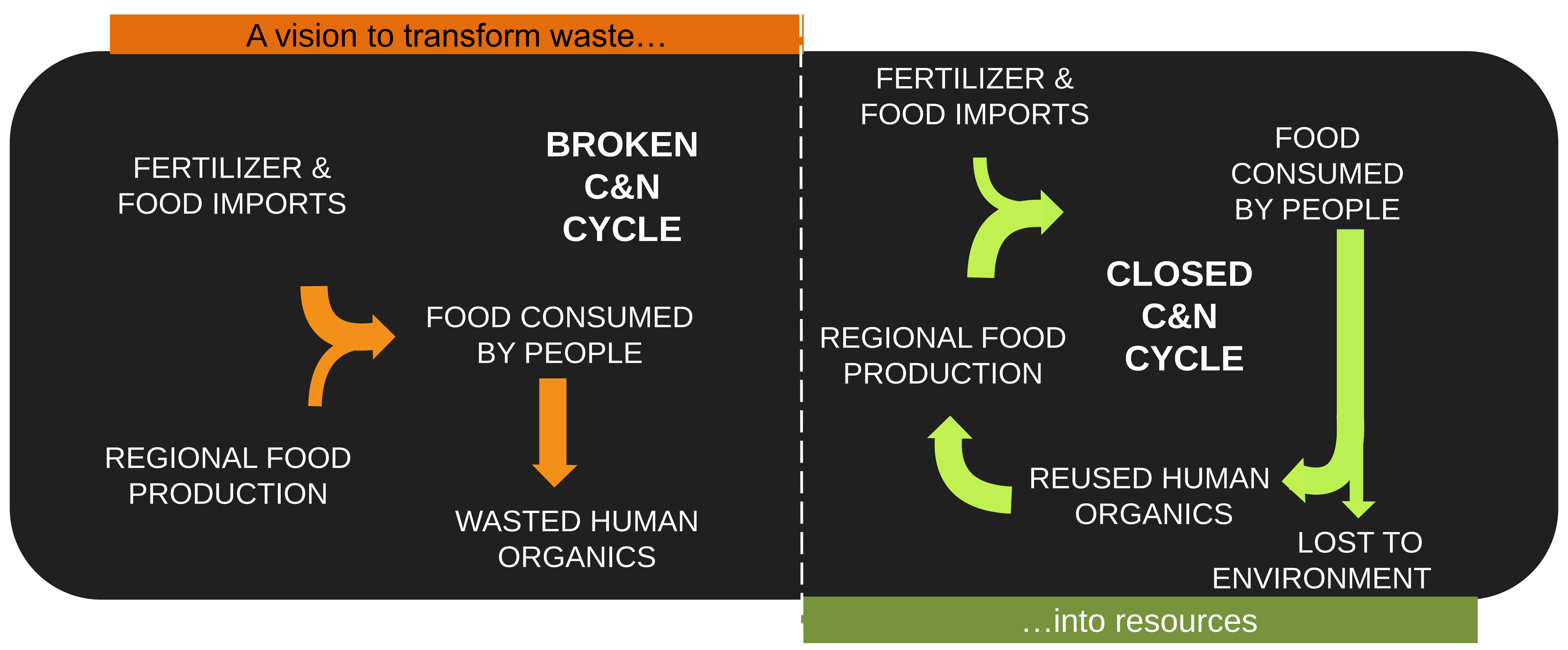
1. The Global Sanitation Crisis

- 4.1 billion people lack sanitation or improved wastewater treatment globally [World Heath Organization, 2015]. One-billion of these people live in growing, informal urban communities at a high risk of preventable infectious disease.

2. Closing the "Poop-Loop" with EcoSan



3. Collaboration with SOIL Haiti

Sanitation in Haiti

- 10.6 million people; 55% in urban areas
- Access to sanitation dropped 1990-2010
  - From 26%, to 17% [WHO, 2013]
  - Preventable disease contributes to high infant mortality
  - Currently experiencing the largest cholera epidemic in recent history

Founded in 2006, **SOIL Haiti** provides an EcoSan implementation in Port au Prince and Cap-Haïtien which covers the key components of the sanitation cycle.

Containment | Transport | Treatment | Recovery | End-use

Working with SOIL, we aim to build a biogeochemical understanding of EcoSan's ability to tackle multiple sustainability challenges:

1. Sanitize waste
2. Increase local yields
3. **Mitigate greenhouse gases (GHG)**
4. Improve soil health

Study questions: How much GHG emissions are produced during EcoSan composting, and how might management mitigate them further?

4. Experimental Design

Highly replicated (*n* = 12), weekly gas sampling (static chambers) over compost:

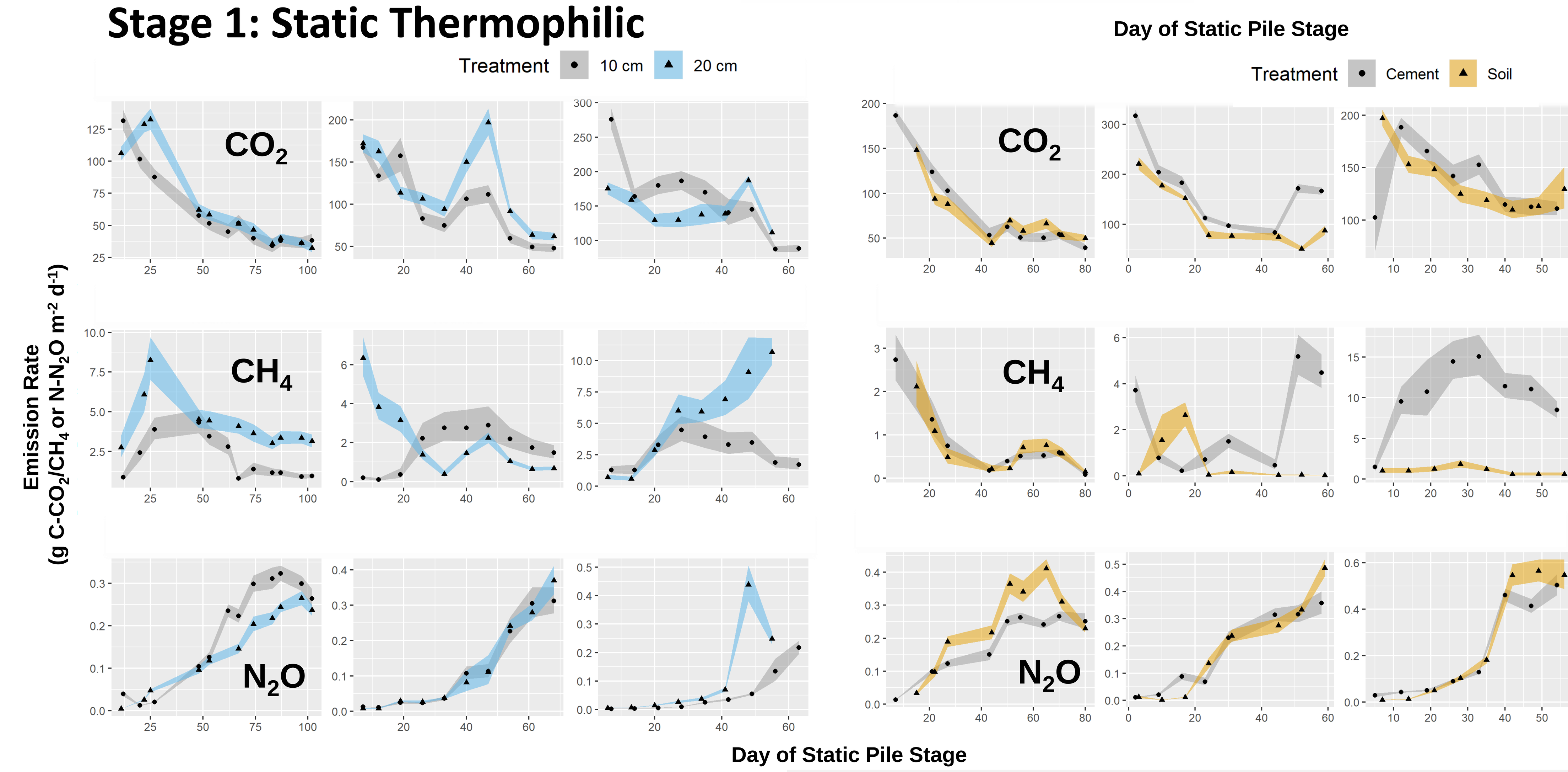
3 Composting Stages
1. Static thermophilic (10 wks)
2. Turned thermophilic (8 wks
3. Curing windrow (12 wks)

2 Paired Pile Treatments
1. 10 or 20 cm Cover
2. Cement or Soil Lining

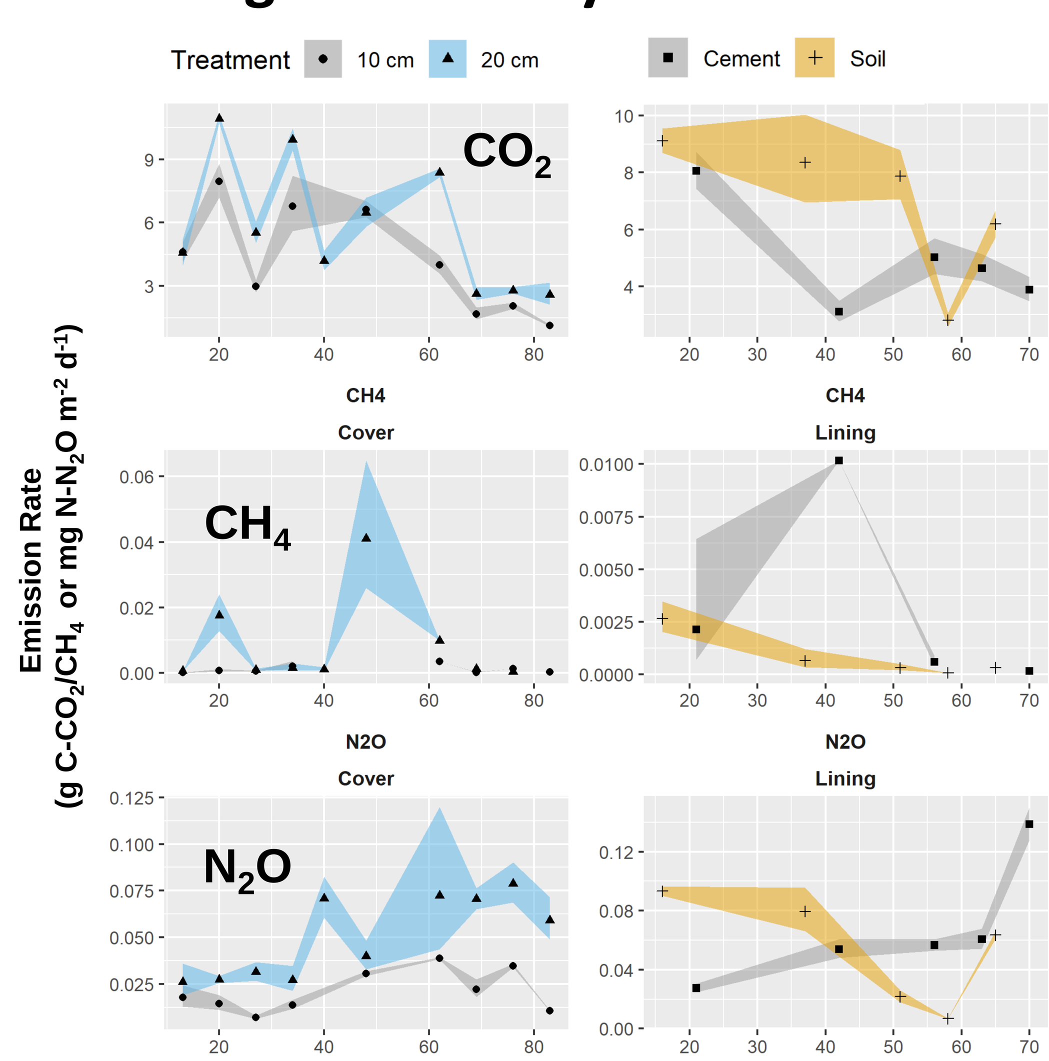
Composting Operational Stages

5. RESULTS

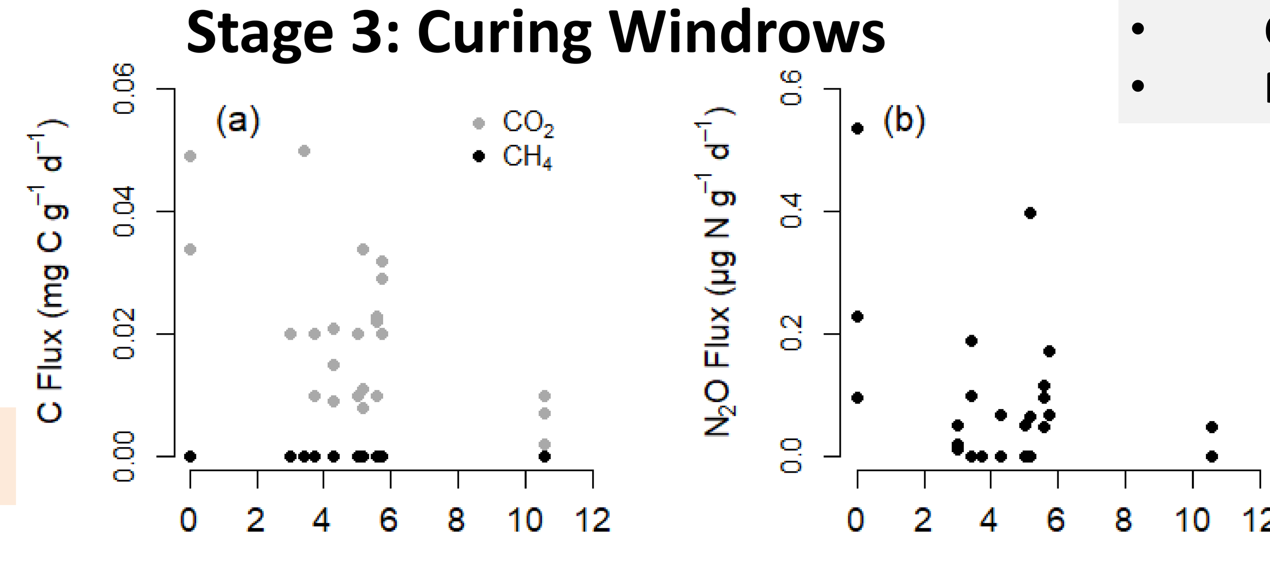
Stage 1: Static Thermophilic



Stage 2: Actively Turned Piles



Stage 3: Curing Windrows



Stage 1 Results

Dynamics varied over repeated (3) sampling rounds

- CO_2 peaked then declined, reflecting thermophilic dynamics
- CH_4 emissions were more variable, with stronger treatment effects
- N_2O emissions gradually increased over time

Stage 2 Results

Gas emissions were much more dynamic than stage 1, due to regular aeration and mixing during turning

- CO_2 showed pulses associated with turning events and gradually declined
- CH_4 dropped dramatically with some minor emission events
- N_2O was continuously emitted, showing some dynamics and a slight increase over time

Stage 3 Results

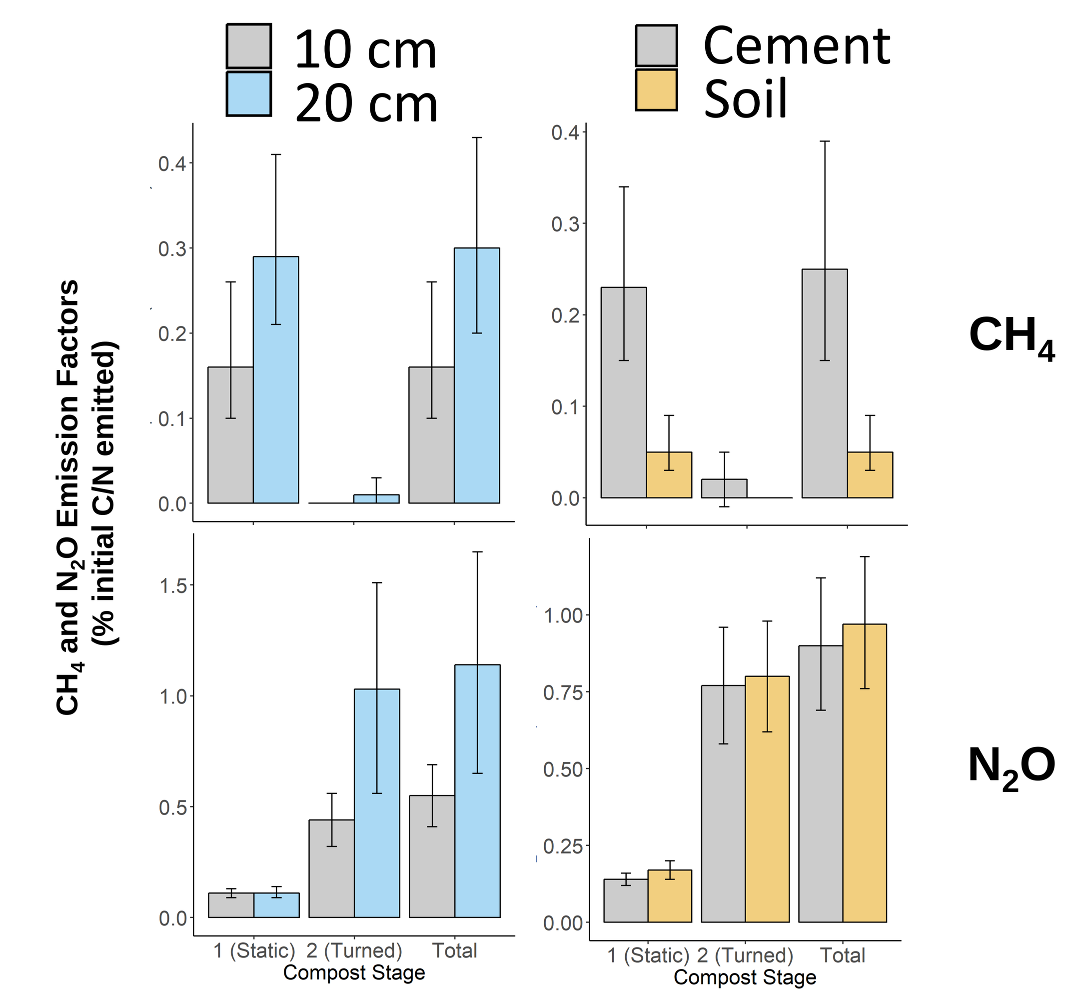
Methane emissions declined first, then other GHGs

- CO_2 emissions declined steadily during curing
- CH_4 emissions were zero throughout curing
- N_2O emissions declined steadily during curing

Paired Pile Treatments

Emissions Factors (EF)

Fluxes are normalized by unit mass of initial material C/N. This allows for upscaling and comparison of fluxes across mgmt. approaches.



The cover experiment showed that deeper cover layers do not mitigate methane emissions, and may increase them. **The lining experiment** showed that high CH_4 emissions can be reduced with a permeable soil lining, with no effect on N_2O.

Conclusions

CH_4 EF of 0.1-0.3% initial C were up to 10x lower than IPCC EF *for manure mgmt. composting,* comparable to empirical data on forced aeration, and lower than solid storage across all solid waste types (Pardo et al. 2015).

N_2O EF of 0.5-1.5% initial N were in the same range as IPCC EF for *manure mgmt. composting*, comparable to empirical data on compacted material, and much lower than aerated piles across all waste types.

Pardo G, Moral R, Aguilera E and del Prado A 2015 Gaseous emissions from management of solid waste: A systematic review *Glob. Chang. Biol.* **21** 1313–27

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