

# Emission factors for Vietnamese beef cattle manure sun-drying and the effects of drying on manure microbial community

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## Background and the objectives

- Vietnam had 5.8 million head of cattle in 2018, >90% of which were beef cattle, and its livestock production contributed approx. 32% of the national agriculture sector's gross domestic product (GDP). GHG (CH<sub>4</sub> and N<sub>2</sub>O) emission from cattle production occurs in enteric fermentation and manure management. Both CH<sub>4</sub> and N<sub>2</sub>O can be produced by the activity of microbes in manure. In Vietnam, most beef cattle manure is collected and spread on land for sun-drying. Currently, the GHG emissions from Vietnamese livestock manure are estimated by IPCC Tier 1 approach. Therefore, there is a need for a country-specific national emission factor to estimate nationwide GHG emissions from manure.
- Here, we conducted the present study to:
  - identify the major manure management method by a farm survey (20 farms in Ben tre province),
  - measure the GHG emission by a chamber-based method, to provide the country-specific data for this category as required for a Tier 2 approach,
  - monitored the changes in the microbial community and the abundance of functional genes that are required for microbial GHG production over time to understand the pattern of GHG emission.

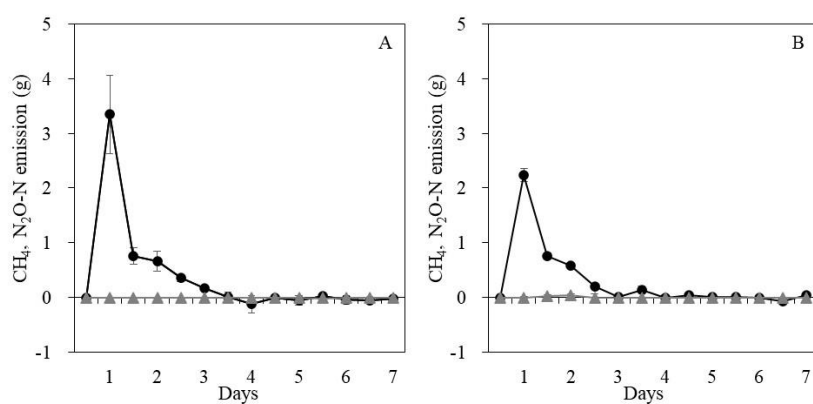
## Results: 1. Farm survey

- All were family farms with 5.0 ± 1.5 people/farm, with an average working time of 5.8 ± 1.1 h/day. The total cattle per farm was 9.3 ± 4.4 head, with an average body weight of 400 ± 57 kg. The cattle were fed elephant grass, Para grass, rice straw, and some others, with a dry matter intake (DMI) of 10.6 kg head<sup>-1</sup> day<sup>-1</sup>. All 20 farmers treated the manure from their cattle with a sun-drying method.



## Results: 2. GHG emission measurement

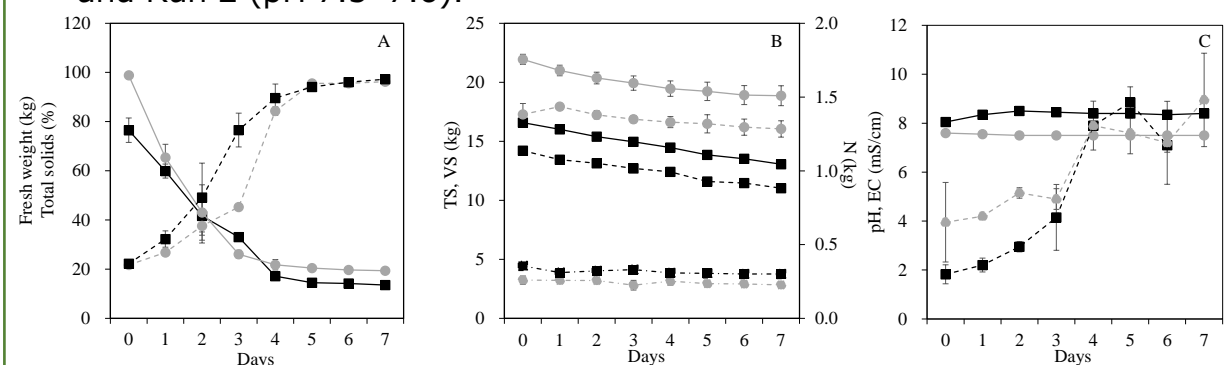
- For both runs, methane emissions were detected at the beginning of the drying period, from day 1 to day 3. The N<sub>2</sub>O emission was always at a background level during the 7-day drying period.
- The total CH<sub>4</sub> emission was 4.55 ± 0.72 g, which accounted for only 0.03% of the initial VS. The calculated CH<sub>4</sub> emission factor was 0.295 ± 0.078 g kg<sup>-1</sup> VS. Most of the VS contained in the initial manure (86.5%) remained in the final product. Most of the remaining VS could be explained by the sampling for the chemical analysis (12%).



Methane (circles) and N2O (triangles) emission during the beef cattle manure sun-drying experiments in Runs 1 (A) and 2 (B). Error bars: SD (n = 2).

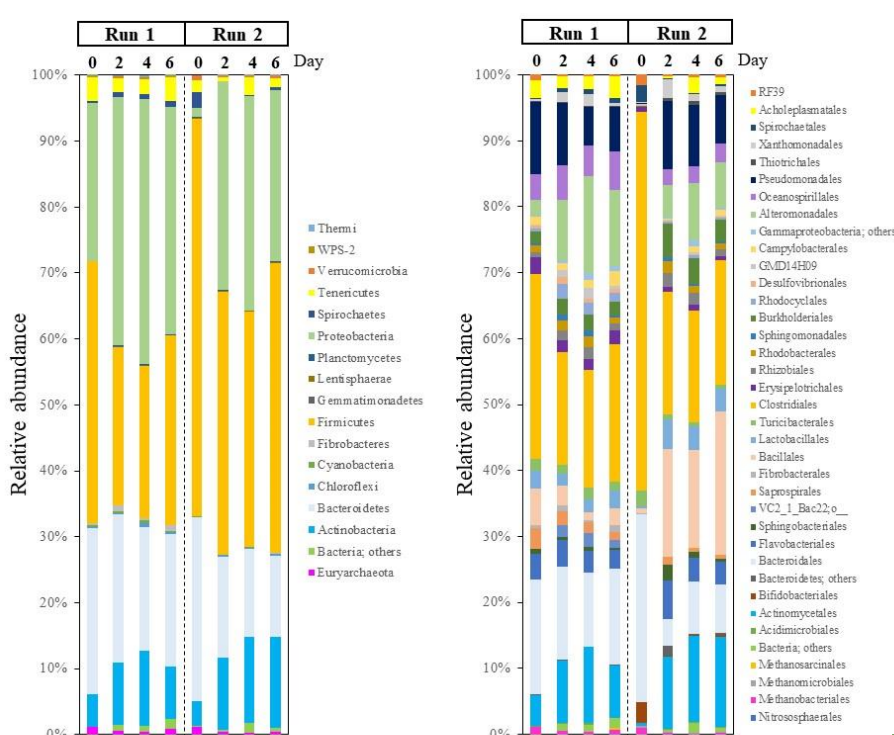
## Results: 3. Physical properties of manure

- The weight of the manure dropped significantly from 87.7 ± 13.2 kg to 16.6 ± 3.5 kg during the drying process. Moisture loss occurred mainly from day 1 to day 4 by evaporation, and the weight was stable from day 5 to day 7 in both runs.
- In contrast, the TS (%) increased significantly from 22.0 ± 0.8% to 96.7 ± 0.6%. During this drying process, the losses of TS, VS, and N were very limited. The manure pH was also stable during the drying process, but there was a small difference between Run 1 (pH 8.0–8.5) and Run 2 (pH 7.5–7.6).



Changes in the physicochemical parameters during the Vietnamese beef cattle manure sun-drying experiment. A: Weight, solid lines; total solids (TS), dashed lines. B: Total solids (TS), solid lines; volatile solids (VS), dashed lines; total nitrogen (N), dotted lines. C: pH, solid lines; electrical conductivity (EC), dashed lines. Black squares: Run 1. Gray circles: Run 2. Error bars: standard deviation (SD) (n=2).

## Results: 4. Manure microbiome



Changes in the bacterial/archaeal community at the phylum level (A) and order level (B) during the sun-drying experiments.

- We observed that a significant shift in manure microbiome occurred in the initial period (days 0–2). It seems likely that this change is attributable to the significant loss of moisture. The effect of the changes in pH or EC seems likely limited since no significant changes in these parameters were observed in this initial period. It can be said that severe drying stress by sun-drying reshaped the cattle manure microbial community in the present experiment.
- The estimated function of the microbial community also suggests that the methane metabolism decreased significantly between days 0 and 2. Although the methanogen could still be detected after the 7 days of drying, all data indicate that CH<sub>4</sub> emission occurred only at the beginning of the drying period, and methanogens were completely inactivated in the latter half of the process due to the loss of moisture and the higher oxygen concentration in the manure.
- Regarding the emission of N<sub>2</sub>O, the abundance of nitrifiers for both AOB and AOA was low throughout the drying process. The results also show that no AOB was detected throughout both experiments, and only 2 of a total 1.46 million sequences were detected as AOA (*Nitrososphaera*).
- The N metabolism tended to be increased between days 0 and 2, but the increase was not significant. These results may explain why (1) we did not detect any significant N<sub>2</sub>O emission throughout the measurement period, and (2) only some nitrification occurred under the oxic conditions, especially in the latter half of the process.

## Conclusion

- Our farm survey demonstrated that sun-drying is the dominant beef cattle manure management system in Vietnam. In this process, the estimated emission factors for CH<sub>4</sub> and N<sub>2</sub>O were 0.295 ± 0.078 g kg<sup>-1</sup> VS and 0.132 ± 0.136 g N<sub>2</sub>O -N kg<sup>-1</sup> N<sub>initial</sub>, respectively, which are lower than the current default values provided by the IPCC for a Tier 1 approach. The sun-drying process induced a significant shift of the total microbial community, which may be attributed to a lower moisture content with significant drying stress.
- The relative abundance of the hydrogenotrophic methanogen *Methanobrevibacter* also fell significantly at the initial stage of the drying process, supporting that the emission of CH<sub>4</sub> occurred only at the beginning.

## Acknowledgement

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