Emissions of CO_2, CH_4, and NH_3 from Dairy Cow Feces and Manure

Enzhu Hu[1,2], Pakorn Sutitarnnontr[2], Markus Tuller[3], and Scott B. Jones

1. Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing, China

2. Dept. Plants, Soils and Climate, Utah State University, Logan, Utah

3. Dept. of Soil, Water, and Environmental Science, The University of Arizona, Tucson, Arizona

Introduction

Animal manure and its common use as a fertilizer contribute to gaseous emissions, including CO_2, CH_4, and NH_3, which have significant potential to increase air pollution and adversely affect human and animal health (Leytem et al., 2011). Segregating urine from feces to reduce or eliminate contact between urease in the feces and urea in urine is a promising concept that can significantly reduce volatile N (Ndegwa et al., 2008).

The objectives of this study were to:

- Compare differences in CO_2, CH_4, and NH_3 emissions from dairy feces and dairy manure (i.e., mixture of feces and urine);
- Track and compare the chemical change in dairy feces and manure during the ambient drying process.

Experimental Setup

The fresh dairy feces and manure were obtained from the Caine Dairy Teaching and Research Center feedlot (Wellsville, UT) on Jan. 4 and Mar. 31, 2013, respectively. Both trials were conducted over 12 days in a research greenhouse at Utah State University.

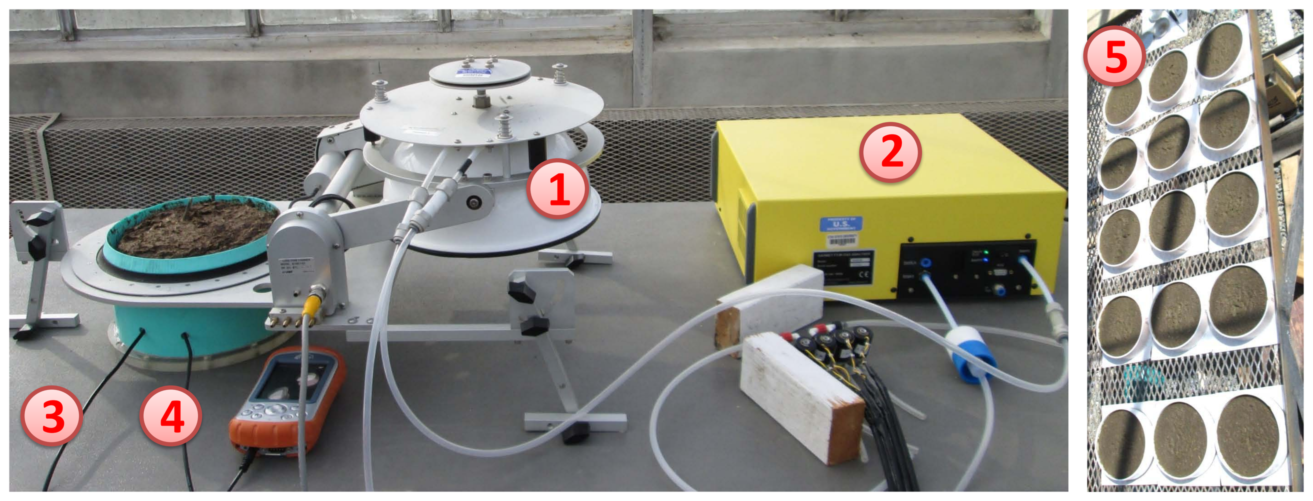

Fig. 1. Experimental Facility. 1 – Dynamic closed Chamber, 2 – FTIR, 3 – moisture sensor wire, 4 – thermistor wire and 5 – samples for chemical analysis.

A closed-dynamic chamber (LI-8100-101, LI-COR, USA) equipped with a soil moisture sensor (GS3, Decagon, USA) and a portable FTIR spectroscope (Gasmet DX-4030, Finland) were employed to measure gas concentrations in 10 minute cycles, air temperature, as well as feces/manure temperature and moisture content.

Gas fluxes ($\mu mol \cdot m^{-2} \cdot s^{-1}$) were estimated from chamber concentration buildup using a linear regression method.

On Days 0, 3, 6, 9, and 12, pH, moisture content (M_C, the mass of water relative to the total wet mass, g/g), dissolved organic carbon (DOC), total carbon (TC), total ammoniacal nitrogen (TAN), and total nitrogen (TN) were measured (Peters et al., 2003).

Leytem, A.B., Dungan, R.S., Bjorneberg, D.L., et al., 2011. Emissions of ammonia, methane, carbon dioxide, and nitrous oxide from dairy cattle housing and manure management systems. Journal of Environmental Quality 40, 1383–1394.

Ndegwa, P.M., Hristov, A.N., Arogo, J., et al., 2008. A review of ammonia emission mitigation techniques for concentrated animal feeding operations. Biosystems Engineering 100, 453–469.

Peters, J., Combs, S.M., Hoskins, B., et al., 2003. Recommended methods of manure analysis. Cooperative Extension Publishing Operations, University of Wisconsin-Extension, Madison, WI, USA.

Temperature- and Water-dependent Fluxes

- Temperature and water content significantly impact gas production and gas diffusion processes driving emissions from dairy cow feces and farmyard manure (Fig. 2);
- Feces exhibits significant CH_4 emissions but undetectable NH_3, while emissions from manure are opposite (Fig. 2d and e);
- There are significantly higher cumulative emissions of CO_2 and CH_4 from feces than that from manure, while the cumulative NH_3 emission from manure is higher than that from feces (Fig. 3).
- Differences in cumulative gas emissions appear to be caused by combined effects of chemical constituency and initial moisture content (Fig. 3).

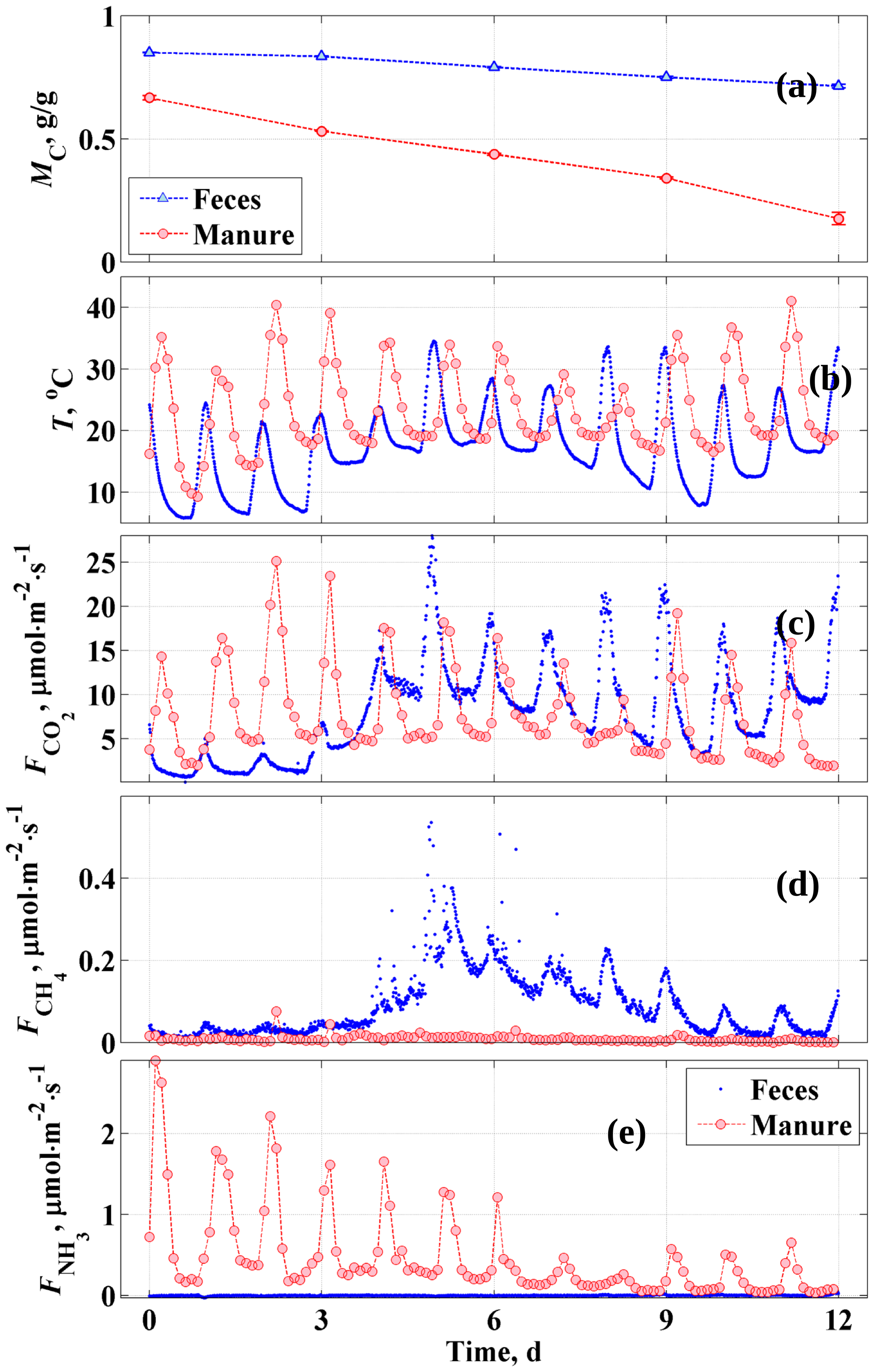

Fig. 2. Changes in moisture content (M_C), temperature (T), as well as gas fluxes of CO_2, CH_4, and NH_3 during the 12-day ambient drying process of feces and manure.

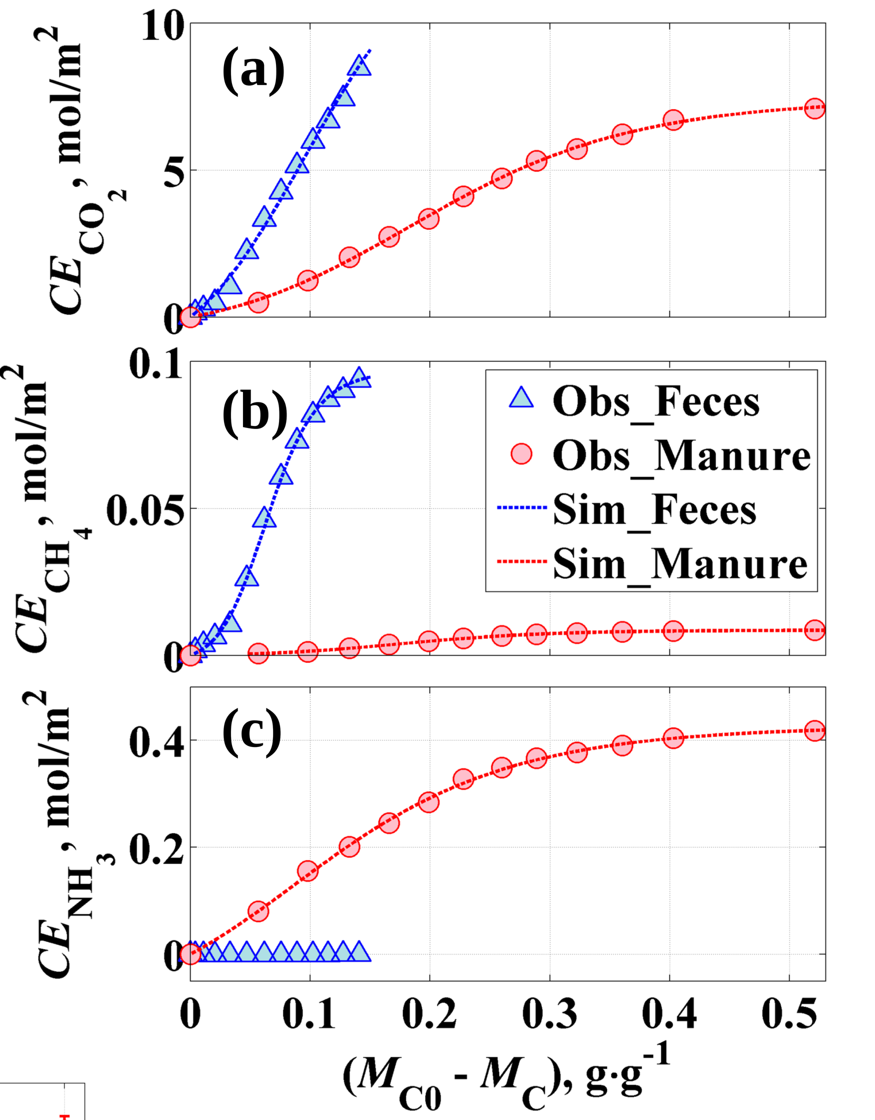

Fig. 3. Cumulative gas emissions as a function of moisture.

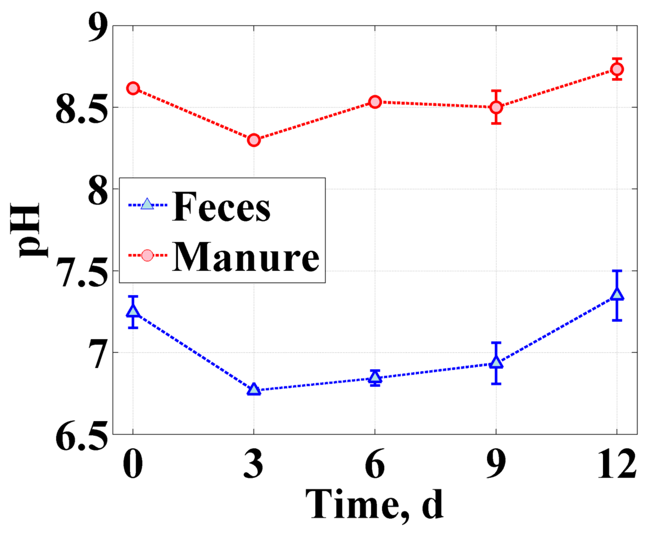

Fig. 4. Temporal changes in pH

Table 1. Maximum loss of CO_2, CH_4, and NH_3

Max Loss	Dung	Manure
CO_2, %TC	9.36	4.30
CH_4, %TC	0.064	0.005
NH_3, %TN	NA	7.97

Chemical Changes

- The pH of manure was about 1.5 times higher than feces while both exhibited similar pH adjustments over time.
- Feces DOC content increased during the first week due to reactions under anaerobic conditions; after 6 days DOC decreased along with the emission of CH_4. The DOC/TC ratio of manure declined continuously from 12.6 to 4.4%.
- Without urine, TAN only accounted for 7.6% of TN in feces; the urea-TAN/TN in the manure went from over 50% to feces levels by the end of the 12 day experiment.

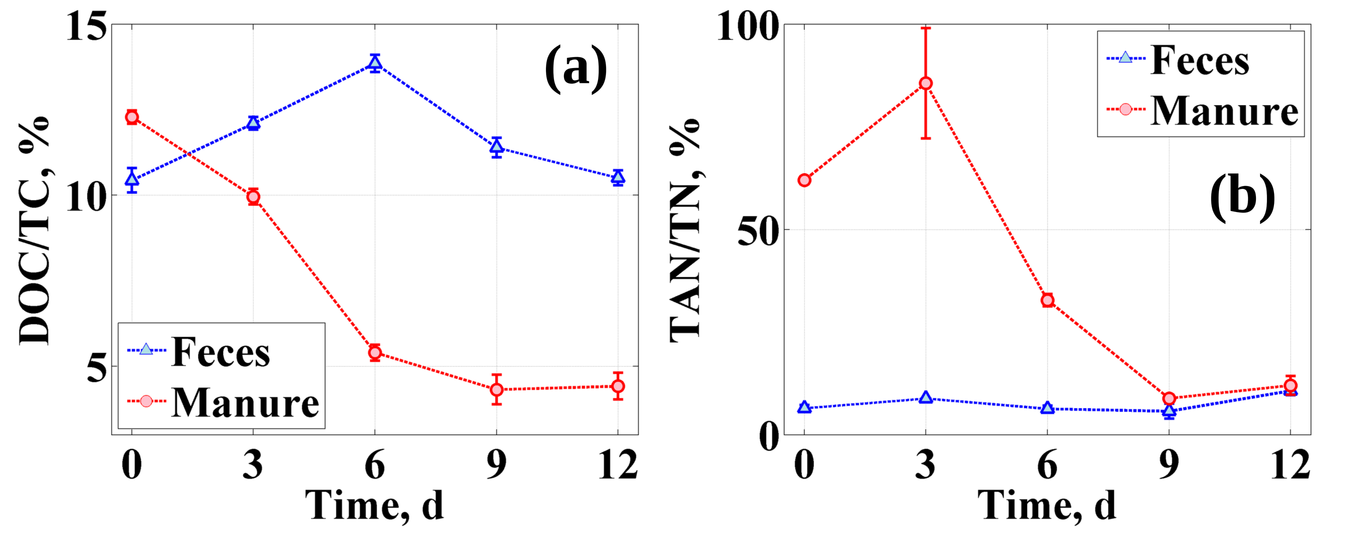

Fig. 5. Changes in DOC/TC and TAN/TN during the 12-day ambient drying process of feces and manure

Acknowledgments

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