Diurnal Variation in Greenhouse Gas Fluxes from a Feedyard Pen Surface

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INTRODUCTION

The US beef industry produces nearly 11.3 billion kg of beef per year, contributing $35 billion to the economy. At the same time, the livestock industry is responsible for 198 Tg of carbon dioxide equivalents (CO_2-eq) annually which is 3.4% of the total national greenhouse gas (GHG) emissions (Stackhouse *et al*., 2011). The Texas Panhandle is the largest cattle feeding area within the US contributing 42% of the national beef production.

Little information exists on the GHG emissions from feedyards and accurate methods are required to estimate GHG emissions from feedyards under High Plains' conditions. The overall goal of this project is to develop a mechanistic understanding of factors influencing the emissions of GHG gases from pen surfaces under the region's typical seasonal conditions.

METHODOLOGY

Three studies providing insight into the emission response to diurnal temperature variation are reported in this paper.

Study 1:

- Ten NFT-NSS chambers were deployed in a feedyard pen (fig 1 & 2).
- Flux was measured four times per day (08:00, 10:00, 12:00 and 14:00 CST) on five consecutive days.
- Gas samples were collected into evacuated vials and analyzed on a Varian 450 gas chromatograph.
- A 37 mm rainfall event occurred on the evening of day 1.

Figure 1. Chamber base layout view at start of study.

Figure 2. Pen view on day 5 of study.

Study 2:

- An automated flux chamber (Model 8100-104, Li-Cor Inc., Lincoln, Neb.) was placed over a pan of beef cattle manure
- Fluxes of N_2O-N were monitored before and after the application of a single simulated rainfall event of 25.4 mm.
- The automated chamber and LGR real-time N_2O analyzer (fig 3) were used to measure flux every 30 min. The automated chamber system (fig 4) was programmed to place the lid on the chamber base for 5 min at 30 min intervals (5 min on, 25 min off).
- Diurnal flux variation was studied for 6 d before and 5 d after the simulated rainfall application.
- Ambient air temperature was monitored in the laboratory 2 m above the flux chamber for the duration of the experiment.

Figure 3. Real-time LGR N_2O analyzer, multiport inlet unit, vacuum pumps, and standard gases used to quantify N_2O flux from manure-filled chamber pans.

Figure 4. Schematic of the five flux chambers, real-time N_2O analyzer, multiport inlet unit, vacuum pumps, and standard gases used to quantify N_2O flux from manure-filled chamber pans.

METHODOLOGY (cont.)

Study 3:

- N_2O-N flux was measured using five square 1 m^2 chambers. Each steel chamber pan was 203 mm deep, with a movable aluminum lid of dimensions 1022 mm x 1022 mm x 122 mm height (fig 5).
- The pans were filled with 89 mm of caliche (a native regional soil) with a wet basis water content 41.5 g kg^{-1}. The soil was manually compacted to a dry bulk density of 1.55 Mg m^{-3}. Air-dried beef cattle manure was compacted to 109 mm depth on top of the caliche at a dry bulk density 0.61 Mg m^{-3}.
- To simulate a one-time rainfall event, either 0, 6.3, 12.7, 25.4, or 50.8 mm water was applied to each pan.
- N_2O-N Emissions were monitored for 45 d following simulated rainfall application (fig 6).
- Diurnal flux was studied in detail on days 3 and 16 following simulated rainfall by measuring N_2O-N flux every 1 to 2 h over the 24 h period.

Figure 5. FT-NSS Flux Chambers

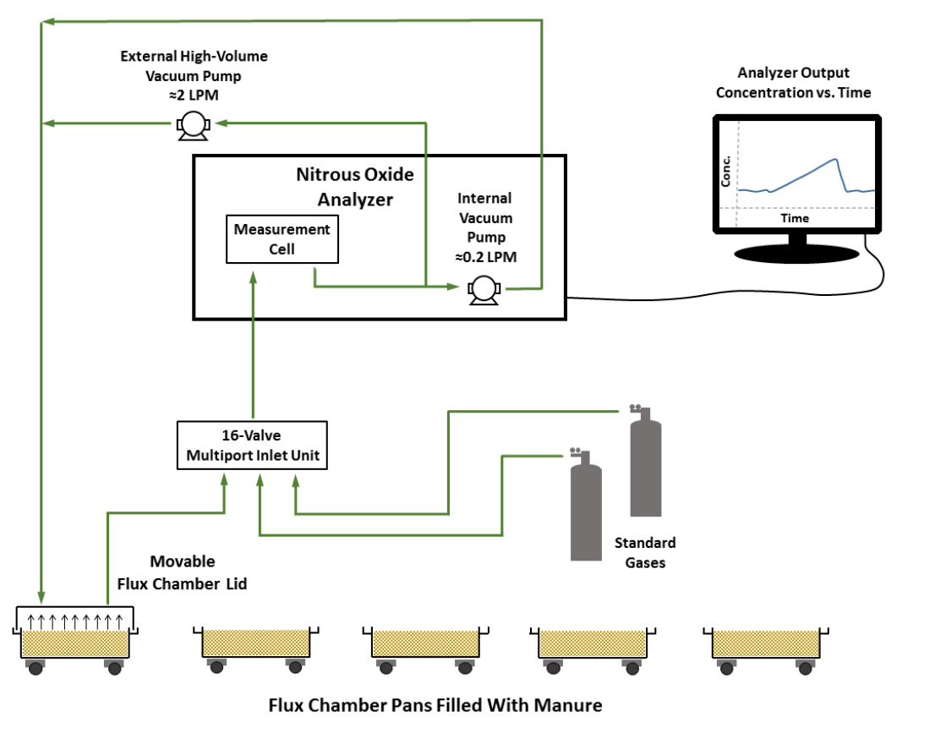


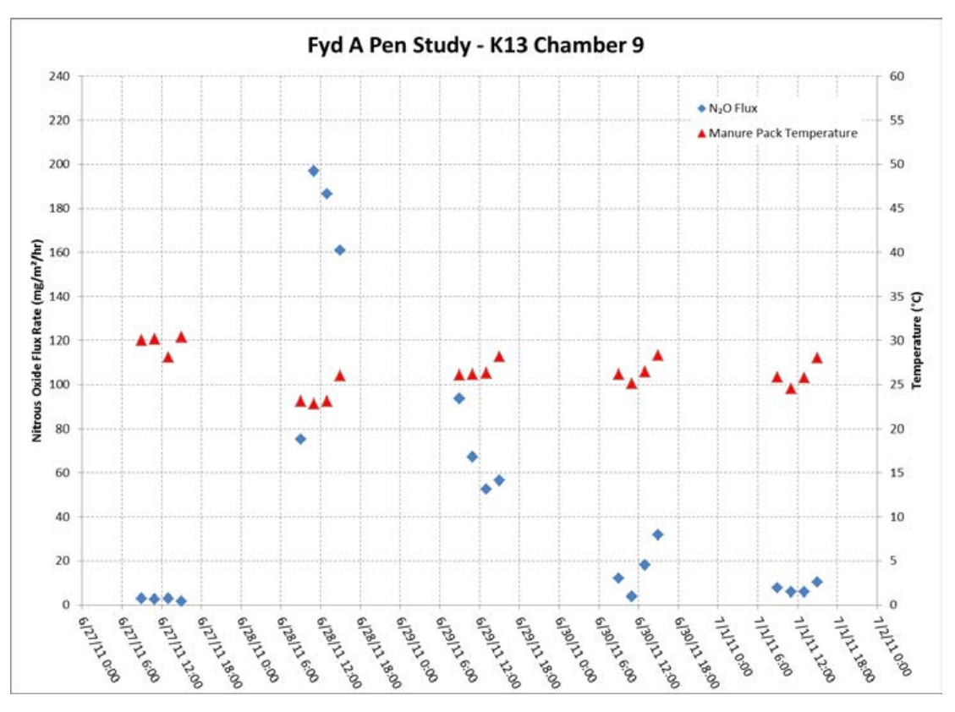
Figure 6. Schematic of the five flux chambers, real-time N_2O analyzer, multiport inlet unit, vacuum pumps, and standard gases used to quantify N_2O flux from manure-filled chamber pans.

RESULTS

Study 1:

- A significant peak in N_2O emission flux occurred following a rainfall event between day 1 and day 2 sampling (fig 7).
- The flux decreased over the next 3 days as did the diurnal temperature response (fig 8).

Figure 7. Flux variation over 5 day study period



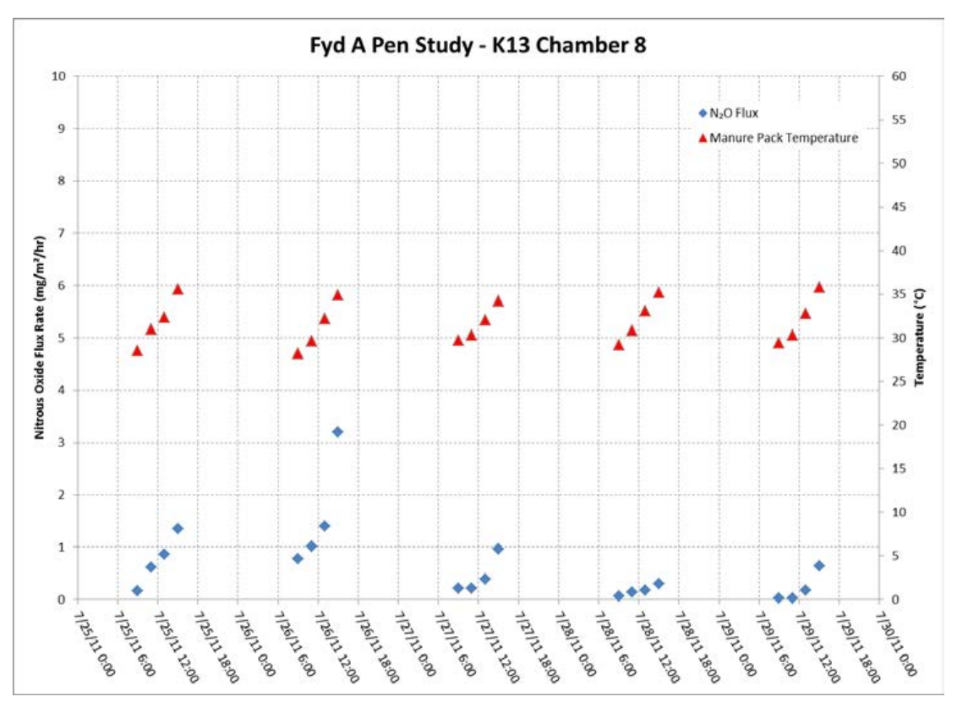


Figure 8. Daily response to temperature of emission flux

Study 2:

- Diurnal pattern was evident for 6 days before and 5 days after simulated rainfall event (fig 10 & 11).
- The flux increase resulting from rainfall event significantly exceeded temperature response (fig 9)

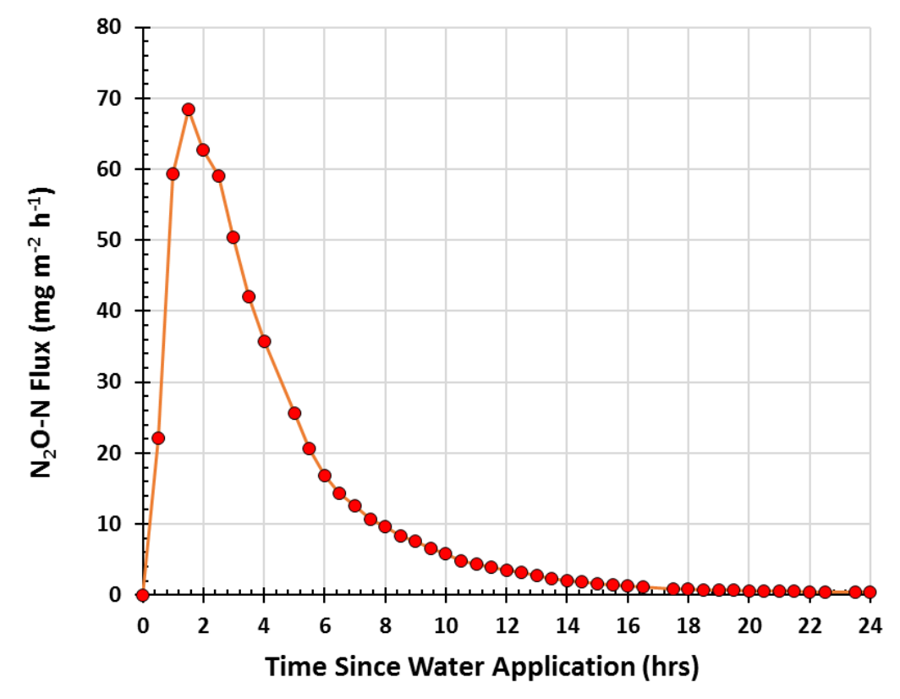


Figure 9. Flux variation over 24 hours following a 25 mm simulated rainfall event

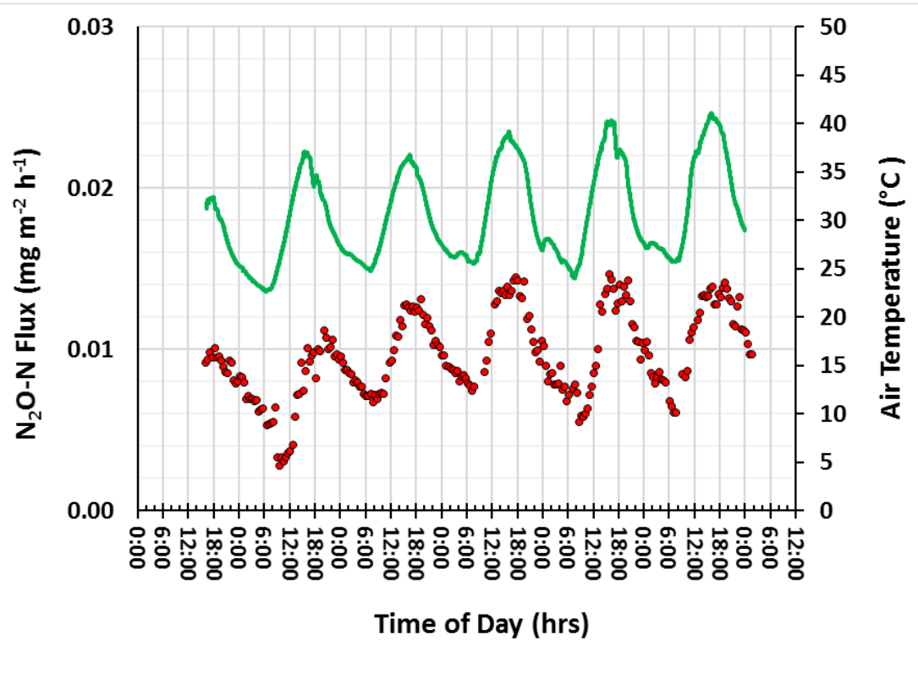


Figure 10. Flux variation over 6 days before water addition

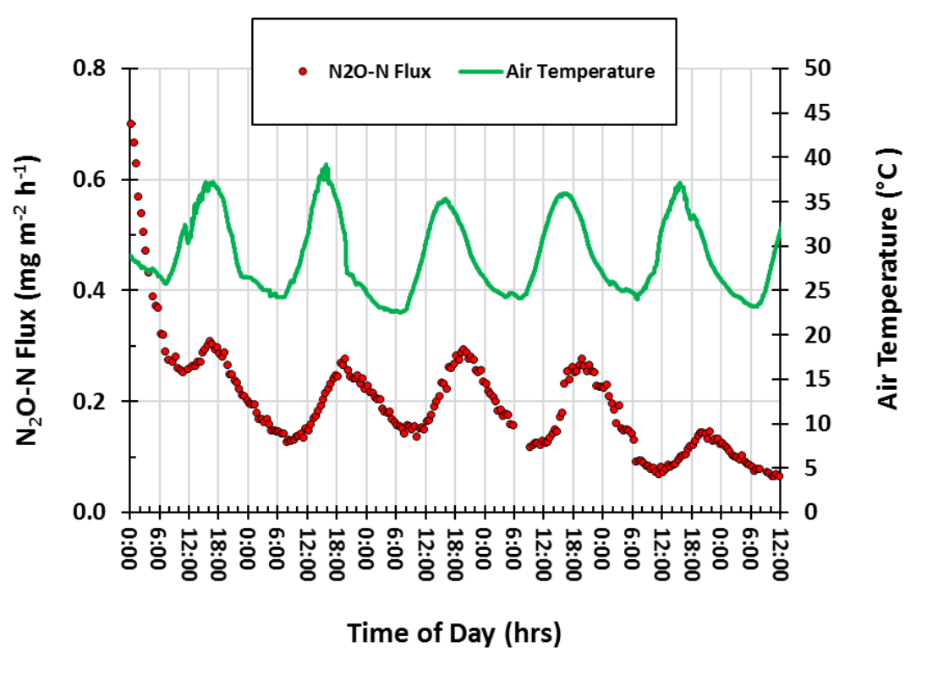


Figure 11. Flux variation over 5 days following water addition

RESULTS (cont.)

Study 3:

- Two N_2O-N emission episodes were observed following the simulated rainfall events (fig 12)
- The magnitude of the diurnal variation in emission flux increased with greater water addition and decreased with time after addition (fig 13-16).

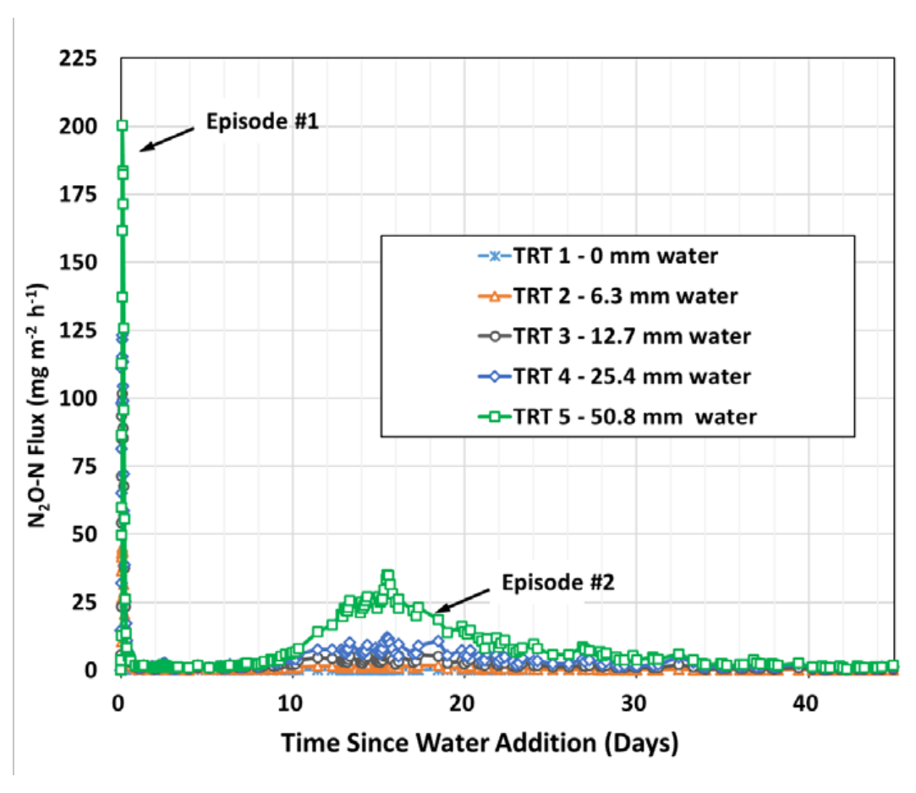


Figure 12. N_2O-N emission pattern over the 42 days following simulated rainfall event

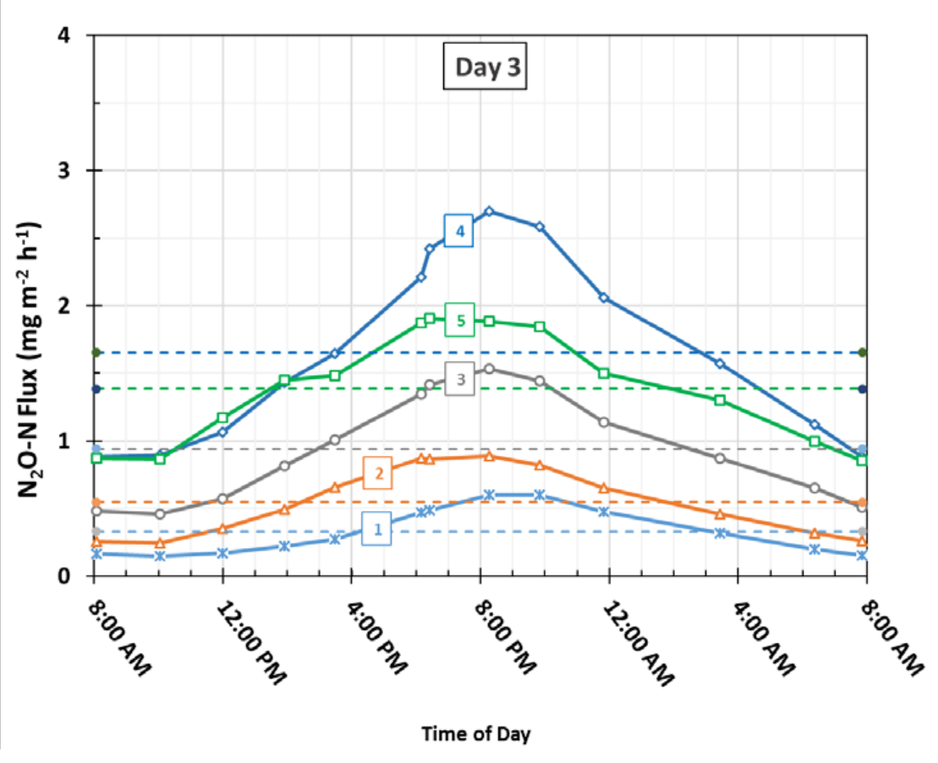


Figure 13. Diurnal pattern in N_2O-N Flux - Day 3

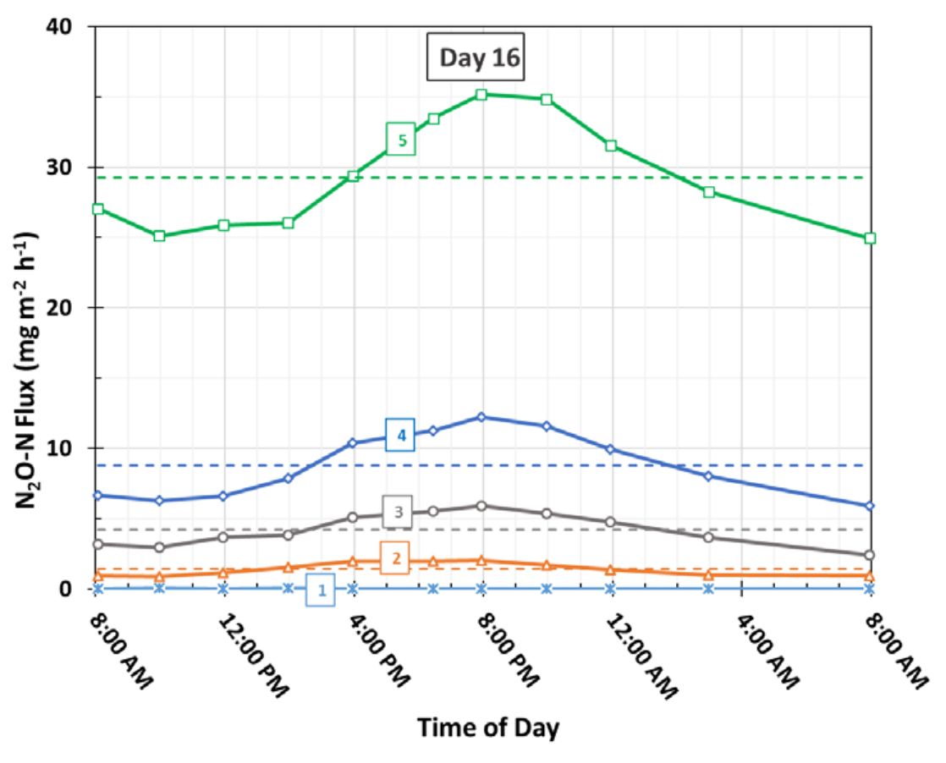


Figure 14. Diurnal pattern in N_2O-N Flux - Day 16

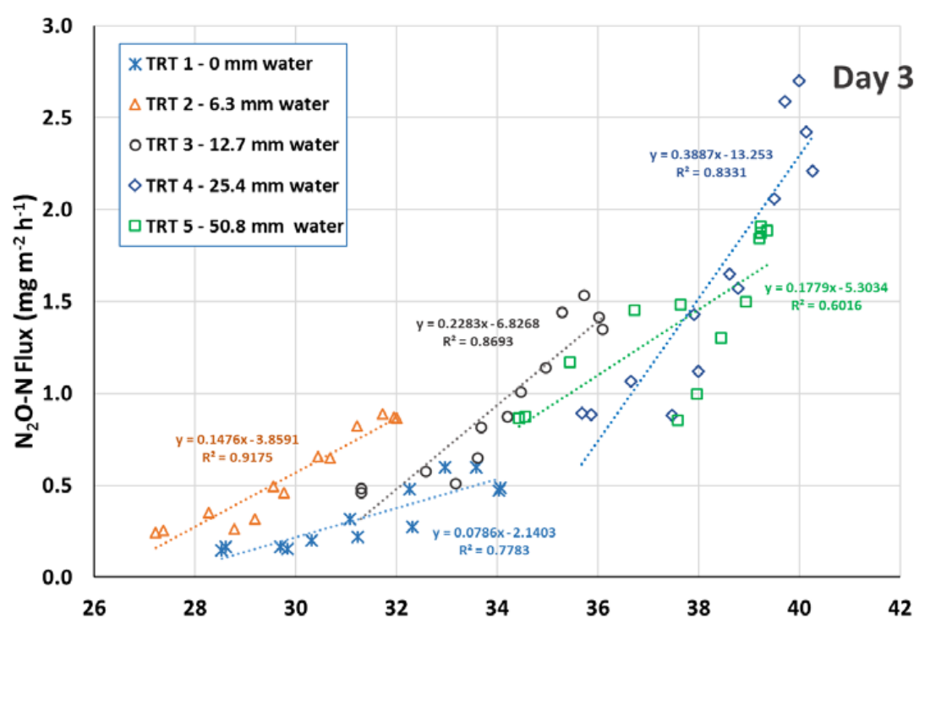


Figure 15. Temperature Influence on N_2O-N Flux - Day 3

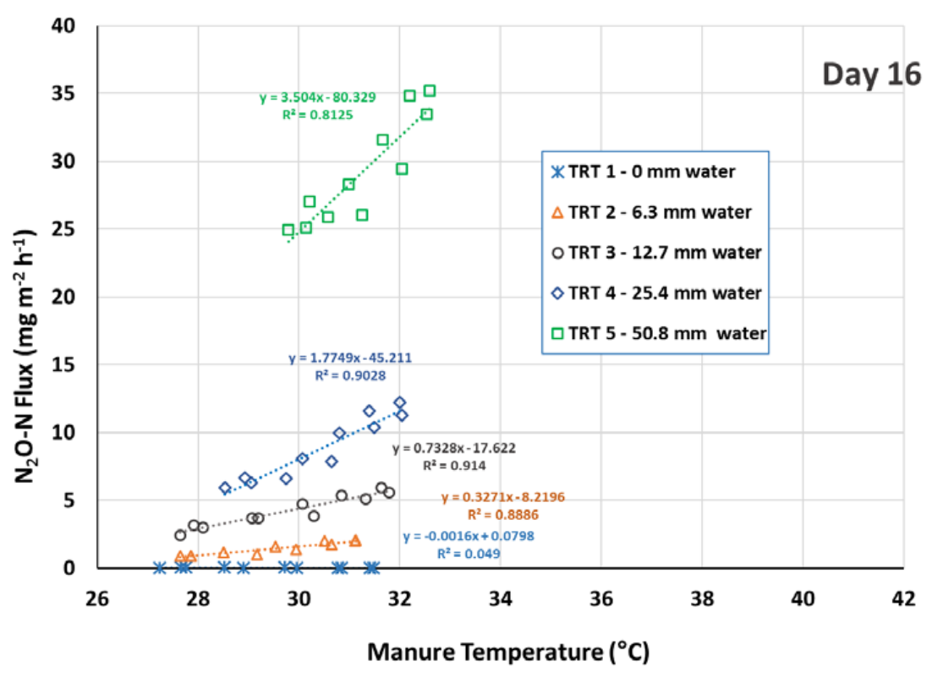


Figure 16. Temperature Influence on N_2O-N Flux - Day 16

Table 1. Time of day for sampling which best represents the mean daily flux based on manure temperature at 55 mm depth.

		---------------- Day 3 ----------------			---------------- Day 16 ----------------		
TRT	Water applied (mm)	Mean N_2O Flux (mg m^{-2} h^{-1})	Day	Night	Mean N_2O Flux (mg m^{-2} h^{-1})	Day	Night
1	0	0.33	16:30	03:00	0.031	*	*
2	6.3	0.55	14:30	01:30	1.41	13:00	00:00
3	12.7	0.94	15:00	02:30	4.22	15:00	01:30
4	25.4	1.65	15:30	03:00	8.80	15:00	01:30
5	50.8	1.39	13:30	02:00	29.2	16:00	02:00

* No definitive diurnal pattern was observed

RESULTS SUMMARY

- Diurnal patterns in N_2O-N flux were observed both in air-dried manure, and in manure that had received simulated rainfall. The amplitude (A) of the diurnal variation (calculated as (Max-Min)/2) ranged from 0.23 to 5.1, and varied depending on amount of water applied and time after water application. Max/Min values ranged from 1.4 to 4.1, and decreased with increasing water added.
- The sampling time in the day which best represented the mean daily flux varied between 13:00 and 16:30, and between 00:00 and 03:00.
- The N_2O-N flux was positively correlated with manure temperature. However, the slopes varied greatly depending on the amount of water applied, and the time since water application. These results are similar to those observed in Study 1 in a commercial feedyard pen following a rainfall event.

FUTURE WORK

- An instrument trailer containing the real-time LGR N_2O and CH_4 analyzers and control system monitoring six, Li-Cor 8100-104 automated chambers will be seasonally deployed to a pen at a commercial feedyard.