Optimizing NFT-NSS Chamber Techniques for Greenhouse Gas Emissions Measurements from Feedyard Pen Surfaces

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INTRODUCTION

The US beef 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. Approximately, 5 million tonnes of manure is produced each year in beef cattle feedyards in the region leading to environmental pollution including GHGs (Sweeten *et al.*, 2012). Little information exists on the GHG emissions from feedyards and accurate methods are required to estimate GHG emissions from feedyards under High Plains' conditions.

- GHG emissions inventory is dominated by Enteric emissions.
- GHG emissions inventory for the feedlot manure management system is dominated by methane in mass terms but by nitrous oxide in CO_2-eq terms.
- Little research has been undertaken on CH_4 and N_2O emissions from feedlot manure management systems and particularly under climatic conditions and management strategies representative of this major US cattle feeding region.
- IPCC Workbook (& EPA Reporting Rule) N_2O Emission Factor = 0.02 N_2O-N/kg Kjdl N excreted

GHG EMISSION MEASUREMENT

Non-Flow Through – Non-Steady State Chambers

- Widely used in soil and environmental science
  - Gracenet & other protocols
- Measure relatively small area
  - Influence of spatial and temporal variability
- Potential to influence emission rate if poorly conducted
  - Chamber environment (T & BP)
  - Chamber base installation
  - Chamber base effect
- Non-real time measurements
  - Gas Chromatograph

Figure 1. View of NFT-NSS chamber and base with temperature sensors installed adjacent to the base.

Figure 2. View of NFT-NSS chamber under moist condition compared with dry conditions in Figure 1.

Figure 3. NFT-NSS chamber with top installed and sealing skirt rolled up.

Figure 4. Two rows of five NFT-NSS chambers installed in a pen.

Adopted NFT-NSS Chamber Measurement Protocol

- NFT-NSS chambers are used to sample emissions from pen surfaces.
- All study measurements for are performed starting at 12:00 h US Central Standard Time (CST).
- Ten chamber bases are installed in a recently emptied pen in two rows on a Friday afternoon
- Measurements are conducted from the following Monday to Friday for each study
- Four samples collected over 30 min (0, 10, 20, 30)
- Quadratic flux calculation procedure

Adopted Protocol Rationale and Issues

Ten chamber bases are installed on a Friday in a recently emptied pen.

- Emission rate varies spatially
- Greater chamber numbers yield a better average and allows exploration of different areas within pen
- Compromise with labor and resource availability
  - One operator can manage 10 chambers

Recently Emptied Pen

- Animals would disturb bases & chamber caps and/or potentially be injured
- Cannot practically 'guard' bases for any length of time while animals are present

Chamber Details

- 8 in. dia PVC Pipe Cap.
  - Septa equipped sampling port
  - 1/8 in. dia balance tube.
- 8 in dia steel pipe Base
  - Lower edge sharpened to aid installation
  - Installed 3 in. into manure pack
  - Rubber skirt rolled up to seal Cap to Base
- Measurements conducted from the following Monday to Friday for each study.

Installation Option Issues

- Testing evaluated installation of chamber bases in feedlot pens
  a) Steel pipe Base driven 3 in. into manure pack
  b) Manure and/or sand piled around chamber
  c) Plastic skirt w/wo weights attached to chamber
- Measured fluxes were higher and more consistent with driven bases -> leakage was occurring with other base systems

Installation of bases can fracture soil, resulting in temporarily enhanced emissions

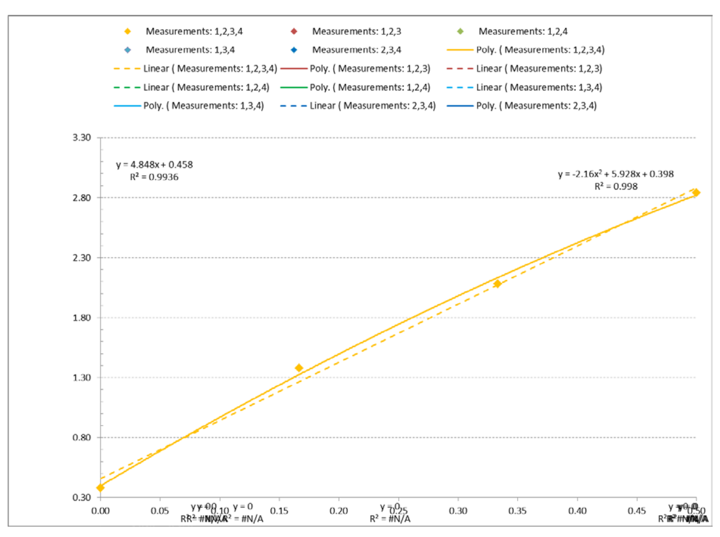
- Gracenet Protocol
  - Wait at least 24 hours before taking measurements
- Testing confirmed an enhanced flux following installation of chamber bases in feedlot pens
  - Wait at least 48 hours before taking measurements
    - Bases are installed on a Friday afternoon
    - Measurements from the following Monday to Friday for each study

Figure 5. Installing bases under dry conditions in feedyard pen.

Flux Calculation Procedure Options

- Linear Regression (LR)
- Quadratic Method (Quad)
- Hutchinson and Mosier (H/M)
- Pedersen HMR (HMR)

Adopted Quadratic Method as response can be non-linear.



Analytical Protocol and Issues

Very wide concentration ranges

- Much greater than that experienced in cropping or pasture system measurements

Rajan GHG Stats for Calibration Standard Determination

FREQUENCY TABLES

CO2 Bin	CO2 Frequency	CH4 Bin	CH4 Frequency	N2O Bin	N2O Frequency
300	0	1.5	0	0.25	0
400	6	1.75	2	0.5	1898
500	1053	2	859	0.75	43
600	475	2.25	991	1	4
700	216	2.5	83	1.25	1
800	103	3	10	More	0
900	52	3.5	1		
1000	18	More	0		
1100	12				
1200	5				
1300	2				

Casey GHG Stats for Calibration Standard Determination

FREQUENCY TABLES

CO2 Bin	CO2 Frequency	CH4 Bin	CH4 Frequency	N2O Bin	N2O Frequency
300	0	1.5	0	0.2	0
400	24	2	383	0.3	40
500	938	2.5	1183	0.4	2017
600	154	3	779	0.5	435
700	108	4	538	0.6	258
800	120	4.5	138	0.7	225
900	112	5	84	0.8	145
1000	131	10	436	0.9	114
1500	471	15	250	1	84
2000	332	20	127	1.25	174
2500	293	25	81	1.5	119
3000	183	50	216	1.75	78
3500	168	75	51	2	63
4000	150	100	32	2.25	44
5000	270	200	56	2.5	40
6000	171	300	27	2.75	29
7000	140	400	12	3	29
8000	108	500	5	4	68
9000	81	600	1	5	34
10000	75	700	1	6	28
11000	51	More	0	7	28
12000	39			8	13
13000	39			9	13
14000	30			10	12
15000	29			25	80
16000	20			50	64
17000	14			75	42
18000	18			100	25
19000	10			200	58
20000	11			300	30
21000	11			400	10
22000	12			500	1
23000	6			More	0
24000	7				4400
25000	10				

We currently run 7 level calibration standards

CO_2: 301, 501, 998, 5000, 10000, 20000, 50000 ppm
CH_4: 1.5, 5.01, 10, 100, 499, 2000, 10000 ppm
N_2O: 0.26, 1.01, 5.1, 25, 75.1, 150, 300 ppm

GHG Calibration Issues

- Electron Capture Detectors (N_2O) are not linear
  - May be treated as linear by some analysts over a limited range.
  - A lab running cropping samples may not know their linear range!
- Our system is linear up to about 10 ppm
  - Analyze using low range calibration curve
  - Any chromatograms with indicated concentration > 10 ppm are reprocess using high range calibration.

SUMMARY OUTCOMES

- Unique Issues in measuring GHG emissions from pen surfaces
- Small 'insignificant' variations from protocol turn your results to 'manure'!
  - Good measurement strategy and equipment
  - Sample collection and storage
  - Sample analysis
    - Know your system MDL
    - Know your concentration range
- Flux calculation
- Temporally Variable Results
  - Large influence of rainfall events
  - Fast response to changing microclimate
- Challenges in data analysis study

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