Emissions of Ammonia, Methane, and Nitrous Oxide from Dairy Production Systems in a Semi-Arid Climate

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The Cost of Doing Emissions Work

- Equipment: $536,000
- Salaries & Supplies: $1,800,000
- IDEAL Funding: $427,959
Farm 1. 700 Milking Cow Production Facility (780 total cows with ~60 m² cow⁻¹)

Farm 2. 10,000 Milking Cow Production Facility (10,800 total cows with ~55 m² cow⁻¹)

Farm 3. 10,000 Milking Cow Production Facility (10,000 total cows with ~27 m² cow⁻¹)
Emissions from Housing
Ammonia Emissions from Open Lot Dairy Housing

Difference in Methods?
- ID1, ID2, TX-N, CA used a non-interference method (inverse dispersion modeling)
- TX used a chamber method

Changes in Feeding and Influence of Lot Management?
- Manure samples were taken from the TX-N site during each sampling month. Manure ammonia increased from 0.02% during three of the seasons to 0.04% during the summer sampling event
- Also during this time they were harrowing the lots and hauling out manure
Climate Variability

Need to look at temperature AND precipitation patterns
Ammonia Emissions from Open-Freestall Dairy Housing

**NH₃ Emissions (g Head⁻¹ d⁻¹)**

<table>
<thead>
<tr>
<th>ID</th>
<th>CA-N</th>
<th>WA-N</th>
<th>CA-1</th>
<th>CA-2</th>
<th>WA</th>
</tr>
</thead>
<tbody>
<tr>
<td>80</td>
<td>0</td>
<td>60</td>
<td>140</td>
<td>100</td>
<td>120</td>
</tr>
</tbody>
</table>

**Difference in Methods?**

- ID, CA, WA used non-interference methods (inverse dispersion modeling, micromet). CA-2 measurements were during low emissions time periods and in Feb.

- CA-N and WA-N estimated emissions from wind velocities in barn and concentration measurements.

**Biologically Reasonable?**

- With non-interference methods NH₃ losses range from 15 to 17% of N intake or 21 to 24% of excreted N. *(does not account for losses in manure storage)*

- NH₃ losses from CA-N dairy would be 0.7% of N intake or 1% of N excreted
Comparison of Average Ammonia Emissions From Housing with NAEMS Data

Variations in climate, feed and housing type
Ammonia not lost in housing is likely lost somewhere else
Differences in Animal Populations and Feed Efficiencies
- E. Canada site had dry cows and heifers on open-lot
- China-3 had heifers
Nitrous Oxide Emissions from Open Lot & Open-Freestall Dairy Housing

Differences in Animal Populations and feed efficiencies

- China-3 had heifers
Comparison of Annual Measured and Simulated (IFSM) Ammonia Emissions from Dairy Housing

If we have a model that is easy to use, then we can generate emission factors that could be used for:

- Air Quality Management Plans
- Assess changes in management practices
- EPA/NRCS/State Agencies
Contribution of Different Production Sectors on Emissions at Open Lot Dairy Lots

**Ammonia**
- Lots: 78%
- WW Pond: 7%
- Compost: 15%

**Methane Spring**
- Lots: 74%
- WW Pond: 6%
- Compost: 20%

**Methane Summer**
- Lots: 55%
- WW Pond: 13%
- Compost: 32%

**Nitrous Oxide**
- Lots: 57%
- WW Pond: 10%
- Compost: 33%
Contribution of Different Production Sectors on Emissions at OFS Dairy

**Ammonia**

- Spring: 25%
- Summer: 25%
- Fall: 25%
- Winter: 25%

**Methane**

- Spring: 25%
- Summer: 25%
- Fall: 25%
- Winter: 25%

- Orange: Open-Freestall
- Yellow: Wastewater Ponds
Based on a calculated N balance:
22-30% of total N ingested was lost as NH$_3$
32-42% of total N excreted was lost as NH$_3$
54-72% of urinary N excreted was lost as NH$_3$
Measuring Ammonia and Greenhouse Gas Emissions from Dairy Wastewater Ponds
Ammonia Emissions from Wastewater Ponds

NH_3 (kg/d)

NH_3 (kg/ha/d)
Relationship Between Wastewater Emissions, Climate and Chemical Characteristics

- Emissions are related to temperature only within a given dairy.
- Total N and TAN have a large influence over emissions.
• Emissions are related to temperature only within a given dairy
• Total Solids, Volatile Solids and Chemical Oxygen Demand have a large influence over emissions
Nitrous Oxide Emissions from Wastewater Ponds

No clear trends in lagoon physical and chemical properties and N$_2$O emissions
Projects in Progress

• Finishing up study looking at emissions from manure storage (lagoons and composting) and developing models to better predict lagoon emissions

• Improving process based models for estimating emissions from dairy production systems in western U.S.

• Looking at whole farm nitrogen balances and cycling

• Investigating the impacts of dietary alterations on nutrient/pathogen excretion, nutrient losses and pathogen survivability in storage and nutrient use/losses and pathogen survivability in land application of manures

• GHG emissions from land application of manure under irrigated cropping systems
Questions?