Greenhouse Gas Emissions and Feedlot Manure Composting

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Greater concentrations of livestock in CFOs

Manure management a major environmental issue

- Alberta has 6.6 m cattle or 43% of the national herd (2001 Census)
- Co. of Lethbridge has a licenced capacity of ~668,000 head in feedlots (2000)
- Produce ~1.3 m tonnes manure annually
- Several feedlots are >25,000 head
Traditional manure handling

- Bull’s-eye effect:
- Fresh manure hauled short distances
- Land close to feedlot:
  - may receive too much manure → soil, water and air quality issues
- Land distant from feedlot:
  - nutrient deficient
Feedlot manure handling

- Pen cleaning
- Raw manure land application
- Stockpiling
- Composting
Feedlot manure composting:

• Some individual operations compost with their own equipment
• Others contract out their manure composting
• Either way:
  • Manure is formed into long narrow windrows
  • Involves incorporation of air into manure by regular turning
  • Takes 3 months active (turning) and 3 months curing
• Percent of manure composted is still low: <10%
What is composting?

C loss

CH₄

CO₂

N loss

NH₃

N₂O

Heat

H₂O

Organic Matter (C, N)
Minerals, Water, Microbes

Compost Windrow

Raw Manure

Compost

O₂
# Feedlot manure composting/GHG trials at Lethbridge Research Centre

<table>
<thead>
<tr>
<th>Year</th>
<th>Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>Passive vs. Active Aeration</td>
</tr>
<tr>
<td>1999</td>
<td>Straw vs. Wood Bedding</td>
</tr>
<tr>
<td>2002</td>
<td>Check vs. Phosphogypsum Addition</td>
</tr>
</tbody>
</table>

Emissions measured by modified vented chamber method

Summer composting

Active – turned 7 times over 100 d period

Not measured during curing
### Effect of aeration method on cumulative GHG emissions

<table>
<thead>
<tr>
<th></th>
<th>CO₂-C</th>
<th>CH₄-C</th>
<th>N₂O-N</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂-C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Passive</td>
<td>74b</td>
<td>132a</td>
<td>34b</td>
<td>240b</td>
</tr>
<tr>
<td>Active</td>
<td>168a</td>
<td>170a</td>
<td>59a</td>
<td>397a</td>
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</tbody>
</table>

Hao et al., 2001
Effect of bedding material on cumulative GHG emissions

<table>
<thead>
<tr>
<th>Bedding</th>
<th>CO₂-C</th>
<th>CH₄-C</th>
<th>N₂O-N</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Straw</td>
<td>165a</td>
<td>187a</td>
<td>10a</td>
<td>362a</td>
</tr>
<tr>
<td>Wood</td>
<td>146a</td>
<td>189a</td>
<td>11a</td>
<td>346a</td>
</tr>
</tbody>
</table>

Hao et al., 2004
Effect of phosphogypsum (PG) addition on cumulative GHG emissions

<table>
<thead>
<tr>
<th></th>
<th>CO$_2$-C</th>
<th>CH$_4$-C</th>
<th>N$_2$O-N</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check</td>
<td>94a</td>
<td>323a</td>
<td>2a</td>
<td>419a</td>
</tr>
<tr>
<td>PG-10%</td>
<td>109a</td>
<td>60ab</td>
<td>4a</td>
<td>173a</td>
</tr>
<tr>
<td>PG-20%</td>
<td>110a</td>
<td>11b</td>
<td>3a</td>
<td>124a</td>
</tr>
<tr>
<td>PG-30%</td>
<td>132a</td>
<td>9b</td>
<td>4a</td>
<td>145a</td>
</tr>
</tbody>
</table>

Hao et al., 2005
GHG emissions during open windrow feedlot manure composting

- C loss = 40-50% of initial C mass
  - 95% as CO$_2$ and 5% as CH$_4$
- N loss = 20-30% of initial N mass
  - 95% as NH$_3$ and 5% as N$_2$O

High GHG concs. in internal pore space of compost windrows ≠ High surface emission rates
Compost & greenhouse gas emissions

- Measured from compost windrows: a small part of the picture
- Need to measure every step of the way!

Compost & greenhouse gas emissions over time (≈ 10 yr)

Fresh Compost

Compost site

Field
# Whole feedlot approach to GHG emissions

<table>
<thead>
<tr>
<th>Manure location</th>
<th>Traditional</th>
<th>Composting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feedlot pens</td>
<td>Cleaned once or twice per yr.</td>
<td>Manure piled up and partially composted. Pens cleaned more often</td>
</tr>
<tr>
<td>Haulage (1)</td>
<td>From feedlot to field 1-15 km → lots of water!</td>
<td>From feedlot to compost site &lt;1 km</td>
</tr>
<tr>
<td>Compost site</td>
<td>n/a</td>
<td>Volume reduced to 70% of initial. Water mass loss = 80%</td>
</tr>
<tr>
<td>Haulage (2)</td>
<td>n/a</td>
<td>Further than raw manure: up to 100 km</td>
</tr>
<tr>
<td>Land spreading</td>
<td>Less uniform, high rates</td>
<td>More uniform, low rates</td>
</tr>
<tr>
<td>Soil incorporation</td>
<td>Mandatory within 24 hr</td>
<td>Not mandatory, e.g. pasture, no-till</td>
</tr>
<tr>
<td>In soil</td>
<td>High N and C mineralization</td>
<td>Low N and C mineralization</td>
</tr>
</tbody>
</table>

**Need Data**

**GHG Data**

**GHG Data**
Feedlot manure compost for wellsite reclamation

• Pre-1983 wellsites
  • No requirement to save topsoil
• When drilling finished
  • Need to reclaim to equivalent land capability
• Compost increased yields
  • captured more atmospheric CO$_2$
  • Increased soil C storage
Knowledge gaps: manure composting

- Greenhouse gas emissions
  - Seasonal effect?
- Reducing C and N losses
  - Why is composting ‘good’ if we’re losing so much C and N?
- What is compost?
  - Quality assurance
- Nutrient release characteristics
- Mortality composting
- Plant disease suppression
- Soil reclamation
  - Imported vs. indigenous organic matter
- Economics