NH₃ and N₂O emissions from three bedded pack barns in The Netherlands

EAAP Warsaw

2-9-2015, Hendrik Jan van Dooren
J.M.G. Hol, K. Blanken, P.J. Galama
Introduction

- Bedded pack barns as alternative for loose housing
- Inspired by examples in USA (Minnesota) and Israel
- Change in dairy housing has different effects
  - Welfare and animal health
  - Management (of bedding)
  - Cost price of milk
  - Use of compost as fertilizer
- First few farmers around 2007
- 2015: around 50 farmers
- Research on welfare, health, milk quality, costs and environment
Why emission measurements?

- Environmental impact of ammonia and nitrous oxide
  - Acidification/Eutrophication
  - Global warming
- Nitrogen losses from housing represents economic value
- Establishing an ammonia emission factor for this housing system
  - Dutch system of ammonia emission factors of housing systems (in kg NH$_3$ per cow per year)
    - 4 farms, 6 times over 1 year.
- References system: Loose housing slurry system (11 kg NH$_3$ per cow per year, zero grazing)
- Emissions before and after housing
Objective

- To measure ammonia and nitrous oxide emissions from compost and composting (wood chips) bedded pack barn(s).

- Expectations:
  - Higher NH$_3$ emissions due to larger area per cow
  - Risk of N$_2$O emissions due to composting processes

- Flux chamber measurements
### Overview of bedded pack dairy barns

<table>
<thead>
<tr>
<th>Farm number</th>
<th>Material</th>
<th>Lying area (m²/cow)</th>
<th>Walking area Material</th>
<th>Walking area (m²/cow)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wood chips (WC)</td>
<td>12,5</td>
<td>Concrete slats</td>
<td>5,0</td>
</tr>
<tr>
<td>2</td>
<td>Wood chips (WC)</td>
<td>15,0</td>
<td>Concrete slats</td>
<td>4,0</td>
</tr>
<tr>
<td>3</td>
<td>Wood chips (WC)</td>
<td>15,0</td>
<td>Concrete slats</td>
<td>4,0</td>
</tr>
<tr>
<td>4</td>
<td>Wood chips (WC)</td>
<td>16,0</td>
<td>Solid asphalt</td>
<td>3,0</td>
</tr>
<tr>
<td>5</td>
<td>Wood chips (WC)</td>
<td>8,5</td>
<td>Concrete slats</td>
<td>1,5</td>
</tr>
<tr>
<td>6</td>
<td>Compost (C)</td>
<td>18,0</td>
<td>Concrete slats</td>
<td>4,0</td>
</tr>
<tr>
<td>7</td>
<td>Compost (C)</td>
<td>22,0</td>
<td>None</td>
<td>0,0</td>
</tr>
<tr>
<td>8</td>
<td>Compost (C)</td>
<td>9,5</td>
<td>Concrete slats</td>
<td>7,0</td>
</tr>
<tr>
<td>9</td>
<td>Compost (C)</td>
<td>22,0</td>
<td>Concrete slats</td>
<td>4,0</td>
</tr>
<tr>
<td>10</td>
<td>Straw (S)</td>
<td>10,0</td>
<td>Concrete slats</td>
<td>3,0</td>
</tr>
</tbody>
</table>

- Each selected barn had two 24 hour measurements
- Farm 9 only NH₃. - Low input level.
Measurements methods

- $E = V \ (NH_3,_{out} - NH_3,_{in})$ (similar for $N_2O$)

- Ventilation ($V$ in $m^3/h$) - two tracer gas methods
  - $V = \frac{CO_2$-prod}{(CO_2,_{out} - CO_2,_{in})}$
  - CO$_2$ balance method (CIGR CO$_2$ production equations)
  - Estimation of CO$_2$ production of bedding.
  - SF$_6$ tracer gas method (constant injection rate)

- Concentration measurements ($mg/m^3$)
  - NH$_3$/CO$_2$: Outlet Open path laser (GasFinder, Boreal)
  - N$_2$O: Lung method and GC in lab
  - SF$_6$: CompactGC (Interscience)
  - CO$_2$: Innova 1312 photo acoustic gas monitor
Schematic setup of measurements (1 and 8)
Measurement of CO$_2$ production from the bedding of farm 9

- Flux chamber (closed) on 20 spots per day
- Around 20 spots each day
- Result: 30-40% of cow production
- Conclusion: CO$_2$ release from bedding can’t be ignored!!
Results: ammonia emission

- Red line is reference level: 11 kg NH$_3$/animal/year
Results: nitrous oxide emission

- Red line is reference level: 0.23 kg N$_2$O/animal/year
Results: nitrogen losses through NH$_3$/N$_2$O

- N-loss (reference = 100%)
  - Wood chips: 166%
  - Compost: 397%

- N$_2$O share
  - Wood chips: 11%
  - Compost: 5%
  - Reference: 2%
First attempt to explain differences

- Clear temperature differences between compost and composting of wood chips
- Difference in microbial activity (composting)
- Effect of available area
Conclusions

- Ammonia emissions compost 2.5 times higher than composting wood chips
- Compost and wood chips both higher than reference system
- Considerably higher $\text{N}_2\text{O}$ emissions:
  - Wood chips > Compost
- Further development of composting of wood chips
  - Optimization of composting process
  - Reduction of emission from feed alley
- No further development of compost barn
- Comparison of systems should include losses before and after housing.
Thank you

Report: Sustainability aspects of ten bedded pack dairy barns in The Netherlands

http://edepot.wur.nl/350932