Methods to measure ammonia emissions from animal houses: the case of the Netherlands

J. Mosquera\textsuperscript{1}, G.-J Monteny\textsuperscript{1} and J.W. Erisman\textsuperscript{2}

\textsuperscript{1} Wageningen University & Research Centrum
\textsuperscript{2} Energy Research Centre of the Netherlands
Ammonia cycle

Transport and reaction

\[ \begin{align*}
\text{NH}_4\text{HSO}_4 & \quad \text{NH}_4\text{NO}_3 \\
(\text{NH}_4)_2\text{SO}_4 & \\
\text{NH}_4\text{NO}_3 & 
\end{align*} \]

Deposition

Effects

- Acidification
- Eutrophication
- Loss of biodiversity
Ammonia emissions

NH\textsubscript{3} emissions (kton per year)


128 kton

100 kton
Ammonia reduction

- Regulations
  - Covering of outside slurry storage
  - No broadcast application of manure
  - Green Label award for low emitting houses
  - Transition towards low emitting pig and poultry houses
  - Regional differentiation (sensitive regions)
  - MINAS
## Agricultural sources

<table>
<thead>
<tr>
<th>Sources</th>
<th>Houses+ Storage</th>
<th>Land application</th>
<th>Grazing</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pigs</td>
<td>35</td>
<td>7</td>
<td>---</td>
<td>42</td>
</tr>
<tr>
<td>Cattle</td>
<td>91</td>
<td>25</td>
<td>14</td>
<td>130</td>
</tr>
<tr>
<td>Poultry</td>
<td>13</td>
<td>3</td>
<td>---</td>
<td>16</td>
</tr>
<tr>
<td>TOTAL</td>
<td>139</td>
<td>35</td>
<td>14</td>
<td>188</td>
</tr>
</tbody>
</table>
Measurement protocols

- Housing systems categorized by species and types
- Measurement technique
- Duration of the measurements
- Period of the year
- Management
Animal houses

Emission = Ventilation * Concentration in exhaust
Mechanically ventilated animal houses

- Ventilator
- Sample line
- \(\text{NO}_x\) monitor
- Fan wheel
- Anemometer
- Sample line to \(\text{NO}_x\)
- Fan wheel anemometer
Naturally ventilated animal houses

\[ Q_{\text{NH3}} = \frac{Q_{\text{tracer}}}{C_{\text{tracer}}} C_{\text{NH3}} \]
Current protocols: benefits and drawbacks

➢ Benefits
  - Process-level information
    • Management
    • Daily/ Seasonal patterns

➢ Drawbacks
  - Labor intensive
  - High costs (equipment, maintenance, personal)
  - Small number of animal houses measured
Options for improvement

- **New sampling strategies**
  - Based on data series and statistics
  - Sources of variance
  - Autocorrelation

- **New measurement techniques**
  - Accuracy/ Precision
  - Representativity
  - Costs
New strategies

- **Sources of variance**

\[
\sigma^2_{\text{system}} = \frac{\sigma^2_{\text{between_farms}}}{\#\text{farms}} + \frac{\sigma^2_{\text{within_farms}}}{(\#\text{farms} \times \#\text{days})} + \frac{\sigma^2_{\text{equipment}}}{(\#\text{farms} \times \#\text{days} \times \#\text{replicates})}
\]

- More locations to be measured

- **Autocorrelation**

- Shorter measurement periods
- Year round measurements
Passive flux samplers under ventilation shafts

Control tube
Pressure taps
Connecting piece
Measurement tube
Source

D₀

Ventilator
Passive flux samplers
Protocols and methods: costs
Flux frame method
Plume measurements (ECN)
Quick box method

Tracer gas, \( \text{NH}_3 \)

Tracer gas
Further research

- **Low cost sensors for ammonia**
  - Management → emissions
  - Ventilation rate
  - Detection limit

- **Open path Tunable Diode Laser**
  - Interference with other gases
  - Laser stability
  - Ventilation rate
Conclusions (I)

- **New strategies**
  - More animal houses to be measured
  - Shorter measurement periods
  - Year round measurements

- **Mechanically ventilated animal houses**
  - Passive flux samplers under the ventilation shafts

- **Naturally ventilated animal houses**
  - Intern tracer gas ratio method with canister+denuder
  - Flux frame method
  - Plume measurements
Conclusions (II)

- Animal houses with outdoor yards
  - Integrate system: Flux frame method, plume measurements
  - House and outdoor yards (quick box) apart

- Further research
  - Low cost sensors for ammonia
  - Open path Tunable Diode Laser