Measuring ammonia emission from livestock on grassland

Sven G. Sommer
University of Southern Denmark
## Ammonia emission from sows and piglets

(Eriksen et al. 2002)

<table>
<thead>
<tr>
<th></th>
<th>Kg N ha⁻¹</th>
<th>% of N in feed</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Input: Feed</strong></td>
<td>880</td>
<td></td>
</tr>
<tr>
<td><strong>Output: Piglets</strong></td>
<td></td>
<td>44</td>
</tr>
<tr>
<td><strong>Nitrate leaching</strong></td>
<td>141-308</td>
<td>16-35</td>
</tr>
<tr>
<td><strong>Ammonia volatilization</strong></td>
<td>114</td>
<td>13</td>
</tr>
<tr>
<td><strong>Denitrification</strong></td>
<td>69</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>81-100</td>
</tr>
</tbody>
</table>
Ammonia emission was measured using a micrometeorological mass balance method (Integrated Horizontal Flux method – IHF)
Micrometeorological mass balance technique

\[
netF_x = \bar{u} \bar{C}_{dw} - \bar{u} \bar{C}_{uw}
\]

\[
Q = \frac{1}{X} \int_{z_0}^{z_p} F_x \, dz
\]

Tom Misselbrook
IGER
Passive ammonia horizontal flux samplers

Space shuttle – Leuning sampler

Passive denuder
Ferm sampler
Passive denuders, on a wind vane with bearings
Mount these on a mast
Mast where placed upwind the field with grazing sows

Dimensions of field was known
Wind direction was measured
Micrometeorological mass balance method

<table>
<thead>
<tr>
<th>% of measurements Rejected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind did not pass over the pasture before reaching passive denuder</td>
</tr>
<tr>
<td>Background NH$_3$ conc. high – no enrichment measured</td>
</tr>
</tbody>
</table>
Ammonia emission
3 years of study presented

![Graph showing ammonia emission over the year](image)
Emission related to sows per ha

NH₃ emission, kg NH₃-N ha⁻¹ d⁻¹

Sows per ha⁻¹

0.0 | 0.2 | 0.4 | 0.6 | 0.8 | 1.0 | 1.2 | 1.4 | 1.6 | 1.8 | 2.0 | 2.2 | 2.4 | 2.6 | 2.8 | 3.0 | 3.2 | 3.4 | 3.6 | 3.8 | 4.0 | 4.2 | 4.4 | 4.6 | 4.8 | 5.0 | 5.2 | 5.4 | 5.6 | 5.8 | 6.0 | 6.2 | 6.4 | 6.6 | 6.8 | 7.0 | 7.2 | 7.4 | 7.6 | 7.8 | 8.0 | 8.2 | 8.4 | 8.6 | 8.8 | 9.0 | 9.2 | 9.4 | 9.6 | 9.8 | 10.0

0 | 10 | 20 | 30 | 40 | 50

0 | 10 | 20 | 30 | 40 | 50
Emission related to nitrogen in feed per ha

NH₃ emission, g NH₃-N m⁻² d⁻¹

FU m⁻² d⁻¹

Wind-tunnel designed to measure spatial variation in emission
Emissions measured with wind tunnel

NH$_3$ emission, g NH$_3$-N m$^{-2}$ day$^{-1}$

Distance from feeder, m

Month

Micrometeorological mass balance technique

<table>
<thead>
<tr>
<th>Month</th>
<th>g NH₃ m⁻² d⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sept. 97</td>
<td>0.00</td>
</tr>
<tr>
<td>June 98</td>
<td>0.00</td>
</tr>
<tr>
<td>Aug. 98</td>
<td>0.02</td>
</tr>
<tr>
<td>Oct. 98</td>
<td>0.04</td>
</tr>
<tr>
<td>Nov. 98</td>
<td>0.06</td>
</tr>
<tr>
<td>Dec. 98</td>
<td>0.08</td>
</tr>
<tr>
<td>Jan. 99</td>
<td>0.10</td>
</tr>
<tr>
<td>Feb. 99</td>
<td>0.12</td>
</tr>
<tr>
<td>Mar. 99</td>
<td>0.14</td>
</tr>
<tr>
<td>Apr. 99</td>
<td>0.16</td>
</tr>
</tbody>
</table>

Wind tunnel

<table>
<thead>
<tr>
<th></th>
<th>g NH₃ m⁻² d⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min</td>
<td>0.01</td>
</tr>
<tr>
<td>Max</td>
<td>2.5</td>
</tr>
</tbody>
</table>
The ‘measuring mast’ in the centre of a circular field with grassing livestock

Open path measurements combined with backward Lagrangian Stochastic (bLS) dispersion technique.

**Source of gas**
- Grazed field
- Beef field lot
- Field plot
- Manure store

**Light source**
- DOAS: Xenon lamp
- FTIR: Infrared
- Laser: Gas related

**Wind**
- Wind speed

**Receiver**
The mast is downwind a source of ammonia bLS technique

Compost heap

Slurry applied to field

Ammonia emission IHF method, kg N ha\(^{-1}\) period\(^{-1}\)

Ammonia emission BLS method, kg N ha\(^{-1}\) period\(^{-1}\)

Sanz et al. 2010
Sommer et al. 2005
Quantitative measurements of ammonia and methane loss from animals. Chapter for CABI (McQuinn S. 2012).

<table>
<thead>
<tr>
<th>Category</th>
<th>bLS vs. other techniques</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle grassing</td>
<td>Under estimated CH$_4$ emissions 7% relative to the SF$_6$ tracer technique</td>
<td>McGinn et al. (2009)</td>
</tr>
<tr>
<td>Cattle grassing</td>
<td>Good fit of CH$_4$ emissions from confined cattle to the IHF technique</td>
<td>Laubach and Kelliher (2008)</td>
</tr>
<tr>
<td>Stockpile of manure</td>
<td>Good fit to the IHF techniques for NH$_3$ emissions from stocked beef cattle manure</td>
<td>Sommer et al., (2004)</td>
</tr>
</tbody>
</table>
Conclusion

• Gas emission from grassing livestock can be measured with IHF and bLS techniques
• The techniques have been tested under a variety of conditions and proven reliable
• Measurements may be rejected due to weather conditions
Gas measuring technique

Air from source

Air flow control
Particle filter and critical orifice,

Tube coated inside with oxalic acid

Air flow control
Particle filter and critical orifice,
We used bLS to measure CO2 and CH4 emission from a composting deep litter heap