EPMAN
Expert Panel on Mitigation of Agriculture Nitrogen

Laura Valli
Building air wash methods
Emerging technologies
Bounds for abatement plants in livestock houses

- Natural ventilation
- High variability in air flow rate during the year (more than 10 times)
- Particulate matter in the air flow
- Fairly complex plants, not familiar for farmers
- High costs for channelling and fans
- Overdimensioning, energy consumption for ventilation
- PM abatement before treatment plant (increase costs and energy request)
- Risk that they are switched-off
When and where are they easier applicable?

- In very critical situation as a further reduction measure
- In country with strict air quality regulations (Germany, NL, …)
- In tunnel ventilation houses (poultry farms)
- In treatment plants (composting, drying, NH$_3$ stripping, ….)
What techniques are available?

- Biofilters
- Trickle bed reactors (bioscrubbers)
- Chemical scrubber
- Muti-stage plants

The requirements in animal houses are:
- Simple and modular
- Low pressure drop
Modular chemical scrubber

Regenerative scrubber

NH3 abatement efficiency = 58%
Low pressure drop < 100 Pa
Modular water air scrubber

- Air flow rate reduction < 10%
- PM abatement 40-60%
- NH$_3$ removal = unsatisfactory
- Costs = 0.5 € per pig produced
Single-stage techniques

Nozzle groups spray water on the front of the filter bank

PM abatement 45%
NH₃ removal = 78%
Multiple-stage techniques

source: KTBL publication 464

Figure 2.9: Design of a three-stage installation and its main functional elements
Multiple-stage techniques

Nozzle groups spray water on the front of the filter bank so that the dust cannot cling to the filter bank.

A filter inspection isle lies between filter bank 1 and 2.

The third element is a root timber and is used for the microbial transformation of odour-carrying agents.
## Removal efficiency
(from KTBL)

<table>
<thead>
<tr>
<th>Technique</th>
<th>NH$_3$</th>
<th>Odour</th>
<th>PM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biofilter</td>
<td>Not suitable</td>
<td>80-95%</td>
<td>&gt; 70%</td>
</tr>
<tr>
<td>Bioscrubber</td>
<td>&gt; 70%</td>
<td>&gt; 70%</td>
<td>&gt; 70%</td>
</tr>
<tr>
<td>Chemical scrubber</td>
<td>70-95%</td>
<td>30-50%</td>
<td>&gt; 70%</td>
</tr>
<tr>
<td>Multi-stage</td>
<td>70-95%</td>
<td>70-90%</td>
<td>&gt; 70%</td>
</tr>
</tbody>
</table>
Costs (KTBL analysis)

- Operational costs = 60% of total costs
- Of which:
  - Electricity = 45-50% (of which 50-70% for ventilation),
  - Acid, water and wastewater = 28-34%,
  - Labour (70-80 h/y) and repairs = 21-22%
## Costs (Ogink & Bosma, NL)

<table>
<thead>
<tr>
<th></th>
<th>Construction</th>
<th>Low NH$_3$ pen</th>
<th>Chem. scrubber</th>
<th>Multi-phase scrubber</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Investment</strong></td>
<td>New</td>
<td>38</td>
<td>35</td>
<td>47</td>
</tr>
<tr>
<td><strong>Modification</strong></td>
<td>30</td>
<td>47</td>
<td>59</td>
<td></td>
</tr>
<tr>
<td><strong>Operational</strong></td>
<td>New</td>
<td>4.0</td>
<td>11.0</td>
<td>12.7</td>
</tr>
<tr>
<td><strong>Modification</strong></td>
<td>6.3</td>
<td>15.0</td>
<td>16.2</td>
<td></td>
</tr>
</tbody>
</table>
Aspects to be considered

- Disposal of discharge solutions
- Pollution swapping (NH$_3$ converted in N$_2$O in biofilter,…) 
- Increase in energy consumption
- Seasonal changes in ventilation rate (bypass, cooling)
- End-of-pipe techniques don’t improve climate conditions of the housing (differently from BATs) and don’t contribute to animal performance
- Risk that the farmer minimize ventilation rate
- Monitoring and recording by Local Authorities
Emerging techniques
Solid-liquid separation

Slurry or digestate from anaerobic digestion

**Solid fraction:**
- organic matter, organically bound nitrogen and phosphate
- soil improvement product providing organic matter and phosphate, with low leaching potentials to surface and groundwater and with a low nitrogen-working coefficient

**Liquid fraction:**
- high amounts of mineral nitrogen
- applied in agriculture used as a replacement of chemical nitrogen fertilizer, with a high nitrogen-working coefficient
Distribution by irrigators of clarified slurry mixed to irrigation water

- Digestate from anaerobic digestion mixed with irrigation water applied on maize with drip pipelines

Filtering group

Pipelines setting
Distribution by drip pipelines of digested slurry mixed to irrigation water

- High N uptake (20% higher than in the case of raw slurry applied at one time)

<table>
<thead>
<tr>
<th>N input-output</th>
<th>Drip pipelines with slurry</th>
<th>Drip pipelines with water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical fertilizer</td>
<td>78</td>
<td>78</td>
</tr>
<tr>
<td>Slurry</td>
<td>194</td>
<td>245</td>
</tr>
<tr>
<td>Total N input</td>
<td>272</td>
<td>323</td>
</tr>
<tr>
<td>N uptake</td>
<td>290</td>
<td>247</td>
</tr>
</tbody>
</table>
Distribution of digested slurry mixed to irrigation water

Very low NH$_3$ emissions (< 5% N$_{tot}$)

Ammonia emissions are strongly reduced (up to 80%) with reference to an application of raw slurry by the same system.
Emerging techniques: PM abatement

Big Dutchman system
Emerging techniques: anaerobic digestion

Emissions from anaerobic digested cattle slurry
Poultry manure drying tunnel

<table>
<thead>
<tr>
<th></th>
<th>NH₃ [kg head⁻¹ y⁻¹]</th>
<th>N₂O [kg head⁻¹ y⁻¹]</th>
<th>CH₄ [kg head⁻¹ y⁻¹]</th>
<th>CO₂ [kg head⁻¹ y⁻¹]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Layer House Mean (year)</td>
<td>0.152</td>
<td>0.002</td>
<td>0.094</td>
<td>65.3</td>
</tr>
<tr>
<td></td>
<td>St. Dev.</td>
<td>0.035</td>
<td>0.004</td>
<td>0.056</td>
</tr>
<tr>
<td></td>
<td>Min-Max</td>
<td>0.044-0.290</td>
<td>0.000-0.017</td>
<td>0.000-0.354</td>
</tr>
<tr>
<td>Drying tunnel Mean (year)</td>
<td>0.167</td>
<td>0.001</td>
<td>0.010</td>
<td>3.39</td>
</tr>
<tr>
<td></td>
<td>St. Dev.</td>
<td>0.026</td>
<td>0.001</td>
<td>0.005</td>
</tr>
<tr>
<td></td>
<td>Min-Max</td>
<td>0.126-0.210</td>
<td>0.000-0.003</td>
<td>0.003-0.028</td>
</tr>
</tbody>
</table>
Low protein diet in fattening pigs

Finishing pigs from 100 to 160 kg (6 pen with 12 pig per pen, 2 fattening cyles)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Standard diet</th>
<th>Low protein diet</th>
<th>Standard diet</th>
<th>Low protein diet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein in diet</td>
<td>[% wb]</td>
<td>14</td>
<td>12</td>
<td>13</td>
<td>9</td>
</tr>
<tr>
<td>ICA</td>
<td>[kgfeed/kgmeat]</td>
<td>3.9</td>
<td>4.0</td>
<td>3.9</td>
<td>4.0</td>
</tr>
<tr>
<td>N excreted</td>
<td>[kg/pig place/y]</td>
<td>17.8</td>
<td>14.1</td>
<td>17.1</td>
<td>10.8</td>
</tr>
<tr>
<td>N emitted from pig house</td>
<td>[kg/pig place/y]</td>
<td>3.2</td>
<td>2.3</td>
<td>3.1</td>
<td>1.4</td>
</tr>
</tbody>
</table>

Graph showing reduction of protein in diet, N excreted, and N emitted from the pig house vs standard diet.
Animal welfare (broiler and turkey)

- Higher bird density cause wetter litter and crust formation, worsening animal health (foot dermatitis) and welfare, but lower density..
Animal welfare (broiler and turkey)

• …. may have negative effects on NH3 emissions, especially in winter, when the air flow rate is reduced and the litter crust make a cap for the emissions
Animal welfare (pigs)

Directive 2001/88/EC on pig welfare establishes a maximum width of 18 mm for openings in slatted flooring used for groups of rearing pigs. In the case of finishing pigs over 110 kg, a maximum opening width of 20-22 mm is usually adopted to speed up manure discharge and reduce fouling of both the floor and the animal skin.
Additives (poultry litter)

Ammonia emissions [mg/m2.h]

**Results:**

in the BDL portions the emissions from the treated litter were 27-30% lower than the control, while in the UDL portions the additive efficiency is not evident. With a weighted average the additive efficiency was circa 25%
Materials and methods

two strips of litter were identified in a house for broilers close to the end of their fattening cycle
Device used for ammonia emission measurements

The measurement technique is based on the “static air chamber method” for flux measurements.