Field Evaluation of DDGS Diet, Alum Manure Additives, and BMPs to Reduce Ammonia Emissions

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Overview

• Test barns
• Effects of “Alum” and “Aluminum Chloride” applications.
• Effects of DDGS in the diet, combined with several best management practices.
• Effects of only BMPs.
Field Test Site

Instrument shelter

201 m x 21 m
169K hens

48-in dia

Conventional high-rise houses (completed 1994)
High-Rise Layer Barns

- 169K hens, 8-rows, 4-tier crates.
- Sidewall fans spaced 7.3 m apart.
- 10 fan stages.
- "Turbo" ventilation system
- Manure scraped daily.
- Manure drying enhanced with 18, 918-mm dia. pit circulation fans.
Alum and Aluminum Chloride Applications

• Nitrogen is released as ammonium (NH$_4^+$) under acidic or neutral conditions, or as NH$_3$ at higher pH. Acidifying agents reduce manure pH and decrease NH$_3$ volatilization.

• The addition of alum to poultry litter:
  – reduces NH$_3$ volatilization.
  – increases total and soluble N and N/P ratios.
  – lowers in-house NH$_3$ concentrations.
Alum Application System

• A 3000-gal holding tank stored the chemical.
• 1500 gal alum + 1500 gal water.
• Spray tubes and sprinkling nozzles were installed along the barn length.
• An air pump provided pressure for spraying, and the water pump filled the spray pipe with the solution.
• Solutions were sprayed for 4 s per hr.
Monitoring Plan

- Thermocouple
- Air sampling (1-13)
- Anemometer (SVA)
- RH/Temp probe
- Static pressure port
- TEOM PM monitor
- Vibration sensor on each fan
- Fan number

Floor plan (201 m x 21 m)
Measurement Plan

- Ammonia was measured with a chemiluminescence analyzer (Model 17C, Thermo Scientific), after conversion to nitric oxide.
- A photo-acoustic infrared monitor (Mine Safety Appliances) was collocated with the 17C.
- Fan operation & static pressure were monitored for barn ventilation rate.
- Temperature, humidity, wind speed, and direction.
Table 1. Tests conducted during study.

<table>
<thead>
<tr>
<th>Test</th>
<th>Date</th>
<th>Description</th>
<th>Emission difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9/1-9/10</td>
<td>ESCS</td>
<td>11%</td>
</tr>
<tr>
<td>2</td>
<td>9/11-9/20</td>
<td>Alum</td>
<td>29%</td>
</tr>
<tr>
<td>3</td>
<td>9/21-9/29</td>
<td>ESCS</td>
<td>12%</td>
</tr>
<tr>
<td>4a</td>
<td>9/30-11/4</td>
<td>ESCS + alum, some nozzles were clogged</td>
<td>16%</td>
</tr>
<tr>
<td>4b</td>
<td>11/5-12/12</td>
<td>ESCS + alum, nozzles were cleaned on 11/4</td>
<td>16%</td>
</tr>
<tr>
<td>4c</td>
<td>12/22-1/20</td>
<td>ESCS + alum, new hens in B2, nozzles cleaned (1/12)</td>
<td>17%</td>
</tr>
<tr>
<td>5</td>
<td>1/21-2/9</td>
<td>ESCS + alum (A7, single dose)</td>
<td>33%</td>
</tr>
<tr>
<td>6</td>
<td>2/10-2/15</td>
<td>ESCS + alum (A7, 1.5 dose)</td>
<td>23%</td>
</tr>
<tr>
<td>7</td>
<td>2/16-3/7</td>
<td>Alum (A7, 1.5 dose) + evening manure scraping*</td>
<td>40%</td>
</tr>
<tr>
<td>8</td>
<td>3/8-3/31</td>
<td>Aluminum chloride + evening manure scraping</td>
<td>27%</td>
</tr>
</tbody>
</table>

* ESCS operation was discontinued on March 4, 2006.
The mean untreated NH$_3$ emission rate was 480 g/d-AU (1.35 g/d-hen).
The alum and AlCl$_3$ applications reduced NH$_3$ emission by 23%. 

Alum Application NH$_3$ Emissions
Alum Test Results

• The highest paired NH₃ emission reductions were observed in Tests 5 (33%) and 7 (40%), which were probably due to the combined effects of well-functioning nozzles, evening manure scraping, and application of the A7 alum.

• Due to the lack of test replication and only one treated barn and one control barn, it is not known which factor contributed the most.

• The emission rate differences between the two barns averaged 32%, and ranged from -10% to 52% between January 21 and March 31.
A newly installed nozzle and lateral tube next to the ESCS system (left, picture was taken on September 8), and a clogged nozzle (right, picture was taken on November 1)
Limitations

- Application of dry alum was not economically feasible.
- Manure moisture content (%) ranged from the upper 20s (warm months) to the upper 30s (cold months), thus limiting the amount of liquid alum that could be applied.
- The nozzles were easily clogged by salt accumulation.
- The chemicals were acidic and corrosive.
- The major limitation is related to the fact that manure on 2nd floor is untreated.
Costs and Limitations

- Alum = $0.13/L, AlCl₃ = $0.14/L, without delivery charges.
- $44 per barn per day.
- The automatic spray controller cost about $3000, and the doubled-wall holding tank was $6500.
- The labor to maintain the controller, air and water pumps is about 3 hours per week per barn.
DDGS and BMPs Tests

- To determine effectiveness and potential of DDGS and best management practices (BMPs) in mitigating NH₃ emissions from commercial high-rise layer houses.
- DDGS = fiber-enhanced diet.
- The BMPs included the operation of 36 manure drying fans in the manure pit, reduced crude protein in the feed, improved waterline leak management practices, and lower bird density.
# DDGS+BMPs Measurement Plan

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<th>Test</th>
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</tr>
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<tbody>
<tr>
<td>1</td>
<td>8/1-8/6</td>
<td>Reduced bird density¹</td>
</tr>
<tr>
<td>2</td>
<td>8/7-8/27</td>
<td>Stabilizing period¹</td>
</tr>
<tr>
<td>3</td>
<td>8/28-12/10</td>
<td>DDGS + BMPs</td>
</tr>
<tr>
<td>4</td>
<td>12/11-1/14</td>
<td>BMPs only, old manure</td>
</tr>
<tr>
<td>5</td>
<td>1/15-2/18</td>
<td>Manure removal period¹</td>
</tr>
<tr>
<td>6</td>
<td>2/19-3/17</td>
<td>BMPs only, new manure</td>
</tr>
</tbody>
</table>

¹ Emission rate was not used to calculate effectiveness of tests
DDGS and BMPs Tests
Mean Manure MC and pH

Day in 2007 and 2008

MC, %

pH

H1 MC
H2 MC
H1 pH
H2 pH
DDGS and BMPs Tests
Feed Fiber Contents

Crude fiber, %

Day in 2007 and 2008

H1 Crude Fiber
H2 Crude Fiber
DDGS and BMPs: Emissions of H1 (untreated) and H2 (treated)
DDGS and BMPs Tests

• In test 1, reduction = 37%, caused by Lower bird density.
• For BMPs + DDGS, reduction = 72% (n=90 days).
• For BMPs only, reduction = 64%, but had residual manure from previous tests.
• After re-bedding, for BMPs only, reduction = 55%.
• Pit fans + leakage management successfully lowered the manure MC.
That’s all. Thanks!
DDGS and BMPs: Bird Population and Live Mass

Day in 2007 and 2008

Bird Number

Live Mass, AU

B1 Bird Number
B2 Bird Number
B1 Live Mass
B2 Live Mass
DDGS and BMPs: Emission per Live Mass Values

Emission, g/d-AU

Day in 2007 and 2008

B1
B2
DDGS and BMPs: Emissions of H1 (untreated) and H2 (treated)