Poultry Emissions
Studies Update

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Presentation Outline

• Recently published studies
• Southeastern Broiler Air Emissions Study
• Layer NH$_3$ Mitigation Studies
Layer NH$_3$ Emissions

Belt Battery House
Manure Storage

High-Rise House
(manure under birds)
### Comparison of Ammonia Emission Factors for Layer Houses (g NH₃ AU⁻¹ d⁻¹)

<table>
<thead>
<tr>
<th>Country</th>
<th>House Type (season)</th>
<th>Manure Removal</th>
<th>NH₃ ER</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>England</td>
<td>Deep pit (winter)</td>
<td>NA</td>
<td>192</td>
<td>Wathes et al. (1997)</td>
</tr>
<tr>
<td>England</td>
<td>Deep pit (summer)</td>
<td>NA</td>
<td>290</td>
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<tr>
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<td>239</td>
<td>Nicholsen et al. (2004)</td>
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<tr>
<td>USA (OH)</td>
<td>High-rise (March)</td>
<td>Annual</td>
<td>523</td>
<td>Keener et al. (2002)</td>
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<td>417</td>
<td>Keener et al. (2002)</td>
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<td>USA (IA)</td>
<td>High-rise (all year)</td>
<td>Annual</td>
<td>299</td>
<td>Yang et al. (2002)</td>
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<tr>
<td>USA (IA&amp;PA)</td>
<td>High-rise (all year)</td>
<td>Standard diet</td>
<td>298</td>
<td>Liang et al. (2005)</td>
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<tr>
<td>USA (IA)</td>
<td>High-rise (all year)</td>
<td>1% lower CP diet</td>
<td>268</td>
<td>Liang et al. (2005)</td>
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<tr>
<td>Netherlands</td>
<td>Belt (N/A)</td>
<td>Twice/wk w/o drying</td>
<td>31</td>
<td>Kroodsma et al. (1988)</td>
</tr>
<tr>
<td>Netherlands</td>
<td>Belt (N/A)</td>
<td>Weekly w/ drying</td>
<td>28</td>
<td>Kroodsma et al. (1988)</td>
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<td>Denmark</td>
<td>Belt (all year)</td>
<td>NA</td>
<td>52</td>
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<td>Germany</td>
<td>Belt (all year)</td>
<td>NA</td>
<td>14</td>
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<tr>
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<td>Belt (all year)</td>
<td>NA</td>
<td>39</td>
<td>Koerkamp et al. (1998)</td>
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<tr>
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<td>Belt (all year)</td>
<td>Weekly</td>
<td>96</td>
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<tr>
<td>England</td>
<td>Belt (all year)</td>
<td>Daily</td>
<td>38</td>
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<td>USA (IA&amp;PA)</td>
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<td>Daily w/o drying</td>
<td>17.5</td>
<td>Liang et al. (2005)</td>
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<td>USA (IA&amp;PA)</td>
<td>Belt (all year)</td>
<td>Twice/wk w/ drying</td>
<td>30.8</td>
<td>Liang et al. (2005)</td>
</tr>
</tbody>
</table>

1 AU (animal unit) = 500 kg body weight

*Table adapted from* - Liang et al. (2005)
Broiler NH$_3$ Emissions

### Comparison of Ammonia Emission Factors for Broilers (g NH3 b-1d-1)

<table>
<thead>
<tr>
<th>Reference (Year)</th>
<th>Flock Characteristics</th>
<th>Litter*</th>
<th>Emission Rate</th>
<th>Monitoring</th>
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<tbody>
<tr>
<td>Study Location*</td>
<td>Market Age (Age during Measurement)</td>
<td>Final Wt.</td>
<td>Stocking Density</td>
<td>Emission Rate</td>
</tr>
<tr>
<td></td>
<td>(day)</td>
<td>(kg)</td>
<td>(b m⁻²)</td>
<td>g b⁻¹ d⁻¹</td>
</tr>
<tr>
<td>Wheeler (this study) USA, PA, KY</td>
<td>42 (1-45)</td>
<td>2.2</td>
<td>14.7</td>
<td>N</td>
</tr>
<tr>
<td></td>
<td>42 (2-42)</td>
<td>2.2</td>
<td>14.7</td>
<td>B, T</td>
</tr>
<tr>
<td></td>
<td>49 (1-53)</td>
<td>2.5</td>
<td>13.4</td>
<td>B, T</td>
</tr>
<tr>
<td></td>
<td>63 (1-55)</td>
<td>3.3</td>
<td>10.8</td>
<td>B, T</td>
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<tr>
<td>Seifert (2004) USA, DE</td>
<td>42 (29-37)</td>
<td>n/a</td>
<td>20.0</td>
<td>B?</td>
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<tr>
<td>Müller (2003) German/ Czec h</td>
<td>32 (13-30)</td>
<td>1.6</td>
<td>n/a</td>
<td>N?</td>
</tr>
<tr>
<td>Lacey (2003) USA, TX</td>
<td>49</td>
<td>2.4</td>
<td>13.5</td>
<td>B</td>
</tr>
<tr>
<td>Burns (2003) USA, TN</td>
<td>42 (1-42)</td>
<td>2.3</td>
<td>16.1</td>
<td>B</td>
</tr>
<tr>
<td>Demmers (1999) UK</td>
<td>32 (1-32)</td>
<td>1.9</td>
<td>25</td>
<td>N</td>
</tr>
<tr>
<td>Wathes (1997) United Kingdom</td>
<td>32 (24-35)</td>
<td>1.1W 1.4 Su</td>
<td>9.3 W 9.4 Su</td>
<td>N?</td>
</tr>
<tr>
<td>Groot Koercamp (1998)² UK</td>
<td>N?</td>
<td>0.48</td>
<td>N?</td>
<td>0.27</td>
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<tr>
<td>Netherlands</td>
<td>N?</td>
<td>0.21</td>
<td>N?</td>
<td>0.44</td>
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<tr>
<td>Denmark</td>
<td>N?</td>
<td>0.21</td>
<td>N?</td>
<td>0.44</td>
</tr>
<tr>
<td>Germany</td>
<td>N?</td>
<td>0.21</td>
<td>N?</td>
<td>0.44</td>
</tr>
</tbody>
</table>

Table adapted from - Wheeler et al. (2006)
Southeastern Broiler Air Emissions Study  
(Burns, Xin, Gates & Hoff)

• Air emissions from two Tyson Foods broiler houses in Western Kentucky are being monitored

• Both broiler houses monitored continuously for a one year period

• Monitoring for all emissions began in January 2006, emissions calculation period 2/20/06 – 3/1/07
Study Purpose

Data from this project are proposed as representative air emissions from southeastern U.S. broiler houses for use in the Air Compliance Agreement (ACA)
Pollutants Measured

- Ammonia
- Carbon Dioxide
- Hydrogen Sulfide
- Non-Methane Hydrocarbons
- Methane
- Particulate Matter
  - Total Suspended Particulate
  - PM$_{10}$
  - PM$_{2.5}$
## Monitoring Equipment Selection

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Monitoring Instrument</th>
</tr>
</thead>
<tbody>
<tr>
<td>NH₃</td>
<td>Innova 1412, Innova AirTech Instruments A/S, Denmark</td>
</tr>
<tr>
<td>CO₂</td>
<td>Innova 1412, Innova AirTech Instruments A/S, Denmark</td>
</tr>
<tr>
<td>H₂S</td>
<td>UV Fluorescence Hydrogen Sulfide Analyzer Model 101E, Advance Pollution Instrumentation, San Diego, California</td>
</tr>
<tr>
<td>NMHC</td>
<td>Model 200 Heated Methane/Non-Methane/Total Hydrocarbon Analyzer, VIG Industries, Anaheim, California</td>
</tr>
<tr>
<td>THC</td>
<td>Model 200 Heated Methane/Non-Methane/Total Hydrocarbon Analyzer, VIG Industries, Anaheim, California &amp; Innova 1412, Innova AirTech Instruments A/S, Denmark</td>
</tr>
<tr>
<td>CH₄</td>
<td>Model 200 Heated Methane/Non-Methane/Total Hydrocarbon Analyzer, VIG Industries, Anaheim, California &amp; Innova 1412, Innova AirTech Instruments A/S, Denmark</td>
</tr>
<tr>
<td>TSP</td>
<td>Tapered Element Oscillating Microbalance (TEOM) Series 1400a with TSP inlet head, Thermo Electron Corporation, East Greenbush, New York</td>
</tr>
<tr>
<td>PM₁₀</td>
<td>PM₁₀ - Tapered Element Oscillating Microbalance (TEOM) Series 1400a with PM₁₀ inlet head, Thermo Electron Corporation, East Greenbush, New York</td>
</tr>
<tr>
<td>PM₂₅</td>
<td>PM₂₅ - Tapered Element Oscillating Microbalance (TEOM) Series 1400a with PM₁₀ head and a 2.5 micron cut cyclone, Thermo Electron Corporation, East Greenbush, New York</td>
</tr>
</tbody>
</table>
Broiler Houses Monitored

- Two sites about 30 miles apart
- Mechanically ventilated houses—four 36” sidewall fans and ten 48” tunnel fans
- 43 x 510 ft, each housing 25,800 birds in winter & 24,400 birds in summer
- 50-53 d growth period (~6 lb. market wt)

Monitoring for NH₃ emissions began in Oct. 2005
Schematic Layout of Broiler House & Monitoring Locations

- = 36” sidewall fan
- = 48” fan
= Ambient air sampling point
= Pressure Differential Sampling Point
= Air sampling point
T = Temperature sample point
RH = Relative Humidity sample point
B = Barometric pressure sample point

Dimensions:
- 98’
- 105’
- 120’
- 135’
- 510’ (outside)
- 52’
- 22’ 9”
- 24’ 2”
- 5’

Key Points:
- Evaporative Coolers
- Brood Curtain
- Control Room
- Feed Bin
- Trailer
- Gravel Pad

Legend:
- = 36” sidewall fan
- = 48” fan
= Ambient air sampling point
= Pressure Differential Sampling Point
= Air sampling point
T = Temperature sample point
RH = Relative Humidity sample point
B = Barometric pressure sample point
Mobile Air Emissions Monitoring Unit (MAEMU)
In-house Air Sample Intake with In-line Filters
Schematic of Gas Sampling System

Ambient air

Location 1

Location 2

Location 3

Filter

Exhaust

Red lines are heated

INNOVA 1412

API 101E

VIG 200

Compact Fieldpoint DAQ

Flow meter

P: Pump, M: Manifold, S: Solenoid; S1-4: Normal Closed; S5-8: Normally Open

Broiler House MAEMU
Positive Pressure Gas Sampling System (GSS)
Gas Analyzers inside MAEMU
Particulate Matter measured using TEOMs

TSP
PM$_{10}$
PM$_{2.5}$
Determination of Building Ventilation Rate (Q_e)

• 14 ventilation fans per house
  – Four 36 inch sidewall fans
  – Ten 48 inch tunnel fans

• Operational curve for each exhaust fan developed in-situ using FANS system
FANS Testing
Variation in airflow rates among 0.9-m (36 inch) and 1.2-m (48 inch) fans, as measured with the FANS.

1 cfm = 1.7 m$^3$/hr

1 inch WC = 248.9 pa
DAQ and Control System

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
<th>Output Signal</th>
</tr>
</thead>
<tbody>
<tr>
<td>INNOVA</td>
<td>1412</td>
<td>ASCII</td>
</tr>
<tr>
<td>SP</td>
<td>Static Pressure Transmitter</td>
<td>4-20 mA</td>
</tr>
<tr>
<td>RH</td>
<td>Relative Humidity</td>
<td>4-20 mA</td>
</tr>
<tr>
<td>FL</td>
<td>Flow meter</td>
<td>0-5V</td>
</tr>
<tr>
<td>B</td>
<td>Barometer</td>
<td>4-20 mA</td>
</tr>
<tr>
<td>TC</td>
<td>Thermocouple</td>
<td>mV</td>
</tr>
<tr>
<td>F</td>
<td>Fan induction sensor</td>
<td>V</td>
</tr>
<tr>
<td>S</td>
<td>Solenoid Valve</td>
<td></td>
</tr>
</tbody>
</table>

Device Connections:
- INNOVA 1412 to cFP-AI-110(1), cFP-AI-110(2), cFP-AI-110(3)
- cFP-AI-110(1) to RH1, RH2, RH3, FL, B
- cFP-AI-110(2) to SP1, SP2
- cFP-AI-110(3) to F1, F2, F3
- cFP-TC-120 to TC1, TC2, TC3, TC O
- cFP-DO-400 to ch1, ch2, ch3, ch4, ch5, ch6, ch7, ch8

Satellite Dish connected to PC.
Screen Display of Real-Time Air Emissions Monitoring
Ammonia Emission Rate
Ammonia Emission (Flock Emission)

Bird age, day

NH$_3$ emission
<table>
<thead>
<tr>
<th>Project Activity</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
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<tbody>
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<td>4th Qtr.</td>
<td>1st Qtr.</td>
<td>2nd Qtr.</td>
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<td>Purchase Monitoring Equipment</td>
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<td>Prepare QAPP</td>
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<td>EPA Review of QAPP</td>
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<td>QAPP Revisions</td>
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<tr>
<td>Prepare Monitoring Trailers</td>
<td>X</td>
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<td>On-site Equipment Installation</td>
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<td>Monitoring System Testing</td>
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<td>Collect Data</td>
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<td>Analyze Data</td>
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<td>Progress Reports</td>
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<td>Final Emissions Report</td>
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</tbody>
</table>
ISU Layer NH$_3$ Mitigation Study (Xin & Burns)

- NH$_3$ emissions from two Rose Acre Farms High-Rise Layer houses in central Iowa are being monitored
• Both High-rise units house ~ 286,000 layers. Layers in the control house are fed a standard diet while layers in the treatment house are fed a diet designed to reduce ammonia emissions.
MAEMU placement so that two barns (control & treatment) can be measured using one unit
Layer NH₃ Mitigation Study

- NH₃ emissions monitoring system installation was recently completed

- NH₃ emissions as well as bird performance will be monitored for one year from the control and treatment high-rise houses
Layer NH$_3$ Emissions Study
(Xin, Burns & Arthur)

• NH$_3$ emissions are being calculated using a Nitrogen mass-balance approach for eight varieties of layers in conjunction with Hy-Line

• Project data collection is 2/3 complete
Recently Completed ISU Layer NH$_3$ Mitigation Studies


Questions ?
Ammonia Emission Rate

Time, hr:min

NH₃ ER
Positive Pressure Gas Sampling System

Initial “shake-down” data collection has begun
Cross-section View of Air Sampling Point Location

- 3 ft fan at 4.3 ft
- 4 ft fan at 3.8 ft
- 4.0 ft ceiling height
- 3.0 ft floor height
- 7.5 ft air sampling point location
- 4.0 ft vertical distance

\[ \text{Cross-section View} \]

\[ \text{Top View} \]

\[ = \text{Sampling point} \]