Field Comparison of Four Aerosol Sampling Devices in Four Agricultural Environments

P.S. Thorne, K.J. Donham, P.T. O’Shaughnessy, University of Iowa, GPCA
M. Nonnenman, SE Oklahoma State University
Scope of Problem

- 1,000,000 workers at risk for occupational lung disease from organic dust exposure in the U.S.

- Suggested OELs based on 37 mm cassette, cyclone

- New Inhalable Aerosol Samplers offer significant improvement for studies to reduce respiratory disease, but were not designed for organic dusts.
Previous Studies

- Deviation from theory demonstrated for wood dust, paper, textile, cereal, flour, food.
- Mahar, Reynolds, Thorne *AIHAJ* 1999
Goals of this Field Study

Evaluate performance of two Inhalable samplers (IOM and Button) in comparison to two traditional samplers (37 mm Cassette and Cyclone) in four agricultural environments (Swine, Chicken, Turkey, Dairy) and to determine relationships between these devices.
# Building Characteristics

<table>
<thead>
<tr>
<th>Building</th>
<th>Type</th>
<th># Animals</th>
<th>Ventilation</th>
<th>Feed</th>
<th>Manure</th>
<th>Sampler Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swine - CO</td>
<td>Finishing</td>
<td>1,000</td>
<td>Natural</td>
<td>Mechanical</td>
<td>Shallow pit</td>
<td>2 m from feeder</td>
</tr>
<tr>
<td>Swine – IA</td>
<td>Finishing</td>
<td>1,100</td>
<td>Mechanical</td>
<td>Mechanical</td>
<td>Deep pit</td>
<td>Center</td>
</tr>
<tr>
<td>Chicken – CO</td>
<td>Egg</td>
<td>375,000</td>
<td>Mechanical</td>
<td>Mechanical</td>
<td>Rotating belt</td>
<td>2 m from pens</td>
</tr>
<tr>
<td>Chicken – IA</td>
<td>Egg</td>
<td>100,000</td>
<td>Natural</td>
<td>Mechanical</td>
<td>Slurry pit</td>
<td>Center</td>
</tr>
<tr>
<td>Turkey – CO</td>
<td>Finishing</td>
<td>7,500</td>
<td>Natural/mech</td>
<td>Mechanical</td>
<td>Scrape</td>
<td>Center</td>
</tr>
<tr>
<td>Turkey – IA</td>
<td>Finishing</td>
<td>6,500</td>
<td>Natural/mech</td>
<td>Mechanical</td>
<td>Scrape</td>
<td>Center</td>
</tr>
<tr>
<td>Dairy – CO</td>
<td>Milk/heifers</td>
<td>1,500</td>
<td>Natural/mech</td>
<td>Via tractor</td>
<td>Flush</td>
<td>2 m from stall</td>
</tr>
<tr>
<td>Dairy - IA</td>
<td>Milk</td>
<td>50</td>
<td>Natural</td>
<td>Manual</td>
<td>Scrape</td>
<td>Center</td>
</tr>
</tbody>
</table>
Samplers

- IOM (2 L/mn)
- Button sampler (2 L/mn)
- Cyclone (2.5 L/mn)
- Closed-face cassette (2 L/mn)
- 5 um PVC filters for all
Sampling Configuration

- Sampling times ranged
- 8 to 12 hours
- Ten sampling sessions in each environment in both Iowa and Colorado
- Pairs of samplers
Statistical Analysis

- SAS v. 9.1
- Distributions
- Log transformation of sampler ratios
- CVs, GLM, T-tests, Correlations, Step-wise Linear Regression
Coefficients of Variation (%) for Dust Concentrations – Field Studies (N = 40)

<table>
<thead>
<tr>
<th>Sampler</th>
<th>Swine</th>
<th>Chicken</th>
<th>Turkey</th>
<th>Dairy</th>
</tr>
</thead>
<tbody>
<tr>
<td>IOM</td>
<td>4.2</td>
<td>4.8</td>
<td>8.6</td>
<td>7.0</td>
</tr>
<tr>
<td>Cassette</td>
<td>7.1</td>
<td>7.2</td>
<td>10.8</td>
<td>29.4</td>
</tr>
<tr>
<td>Button</td>
<td>9.2</td>
<td>4.8</td>
<td>8.9</td>
<td>7.0</td>
</tr>
<tr>
<td>Cyclone</td>
<td>17.8</td>
<td>15.2</td>
<td>13.8</td>
<td>31.4</td>
</tr>
</tbody>
</table>
Mean Dust Concentrations – mg/m³

Dust Concentration - mg/m³

IOM
Cassette
Button
Cyclone

Swine  Chicken  Turkey  Dairy
Regression (through 0) of Samplers Relative to IOM for Swine Field Studies (N = 20)

\[
y = 0.6468x
\]

\[
y = 0.5154x
\]

\[
y = 0.062x
\]
Regression (through 0) of Samplers Relative to IOM for Chicken Field Studies (N = 20)

- IOM vs Button: $y = 0.7168x$
- IOM vs Cassette: $y = 0.56x$
- IOM vs Cyclone: $y = 0.1671x$
Regression (through 0) of Samplers Relative to IOM for Turkey Field Studies (N = 20)

- IOM vs Button: $y = 0.4903x$
- IOM vs Cassette: $y = 0.5472x$
- IOM vs Cyclone: $y = 0.1117x$
Regression (through 0) of Samplers Relative to IOM for Dairy Field Studies (N = 20)

- IOM vs Button: $y = 0.3383x$
- IOM vs Cassette: $y = 0.1983x$
- IOM vs Cyclone: $y = 0.15x$
Geometric Mean (Geometric Standard Deviation) of Ratios of Sampler Concentrations

<table>
<thead>
<tr>
<th>Sampler</th>
<th>Swine (N = 20)</th>
<th>Chicken (N = 21)</th>
<th>Turkey (N = 20)</th>
<th>Dairy (N = 21)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyclone/ IOM</td>
<td>0.053 (2.0)</td>
<td>0.082 (2.3)</td>
<td>0.119 (1.7)</td>
<td>0.218 (3.8)</td>
</tr>
<tr>
<td>Button/ IOM</td>
<td>0.565 (1.6)</td>
<td>0.801 (1.4)</td>
<td>0.534 (1.3)</td>
<td>0.687 (2.1)</td>
</tr>
<tr>
<td>Cassette/ IOM</td>
<td>0.503 (1.2)</td>
<td>0.673 (1.5)</td>
<td>0.597 (1.3)</td>
<td>0.487 (2.7)</td>
</tr>
</tbody>
</table>
# Mean MMAD and $(\sigma g)$

$(N = 10)$

<table>
<thead>
<tr>
<th></th>
<th>Swine</th>
<th>Chicken</th>
<th>Turkey</th>
<th>Dairy</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO</td>
<td>8.4 (2.4)*</td>
<td>29.5 (4.5)</td>
<td>12.2 (2.9)</td>
<td>7.7 (7.6)</td>
</tr>
<tr>
<td></td>
<td>[Grimm]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IA</td>
<td>10.7 (3.5)</td>
<td>13.4 (2.3)</td>
<td>12.5 (7.5)</td>
<td>ND*</td>
</tr>
</tbody>
</table>
Coarse Dust Distribution

- Total
- Inhalable
- Closed-Face
- Respirable

- MMAD = 5.93
- GSD = 3.29
- Inhal/Tot = 81.75%
- Resp/Tot = 37.16%
- Resp/Inhal = 45.46%
- CF/Inhal = 90.29%
Fine Dust Distribution

- MMAD = 2.95
- GSD = 3.09
- Inhal/Tot = 88.53%
- Resp/Tot = 58.51%
- Resp/Inhal = 66.09%
- CF/Inhal = 95.02%
The CFC collected about 80% of expected in both CAFOs.
The Cyclone undercollected from expected in Swine CAFO.
## Mean (SD) Temperature °C and % RH (N = 10)

<table>
<thead>
<tr>
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<th>Chicken</th>
<th>Turkey</th>
<th>Dairy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CO – Temperature</strong></td>
<td>5.0 (4.7)</td>
<td>ND</td>
<td>18.9 (5.4)</td>
<td>9.8 (4.7)</td>
</tr>
<tr>
<td><strong>IA – Temperature</strong></td>
<td>19.9 (0.9)</td>
<td>19.0 (1.9)</td>
<td>13.1 (3.1)</td>
<td>6.4 (3.3)</td>
</tr>
<tr>
<td><strong>CO – RH</strong></td>
<td>32 (10.3)</td>
<td>ND</td>
<td>20.3 (7.7)</td>
<td>29.1 (16.2)</td>
</tr>
<tr>
<td><strong>IA – RH</strong></td>
<td>56.1 (5.4)</td>
<td>62.3 (2.2)</td>
<td>80.4 (7.5)</td>
<td>81.0 (5.8)</td>
</tr>
</tbody>
</table>
Analysis of Variance – GLM Models

- Log Ratios
- $R^2 = 0.80$
- Dust type, State, Sampler type (remain in model)
  - With MMAD, TEMP, RH
- $R^2 = 0.88$
- Temperature, Sampler Type (remain in model)
Stepwise Linear Regression

• IOM = 0.55 +1.57 Cassette – 0.15 Dust type
  – (R^2 = 0.85)

• IOM = 1.56 +1.36 Button + 0.0096 Dust Type – 0.073 TEMP
  – (R^2 = 0.78)

• IOM = 2.61 +3.36 Cyclone – 0.505 Dust Type
  – (R^2 = 0.44)
Conclusions

IOM has best precision between paired sampling devices, cyclone worst.

Dust concentrations –

IOM > Button ~ Cassette > Cyclone
Conclusions

Relationship between samplers relative to IOM depends on dust type (environment, MMAD) and sampler type. ANOVA GLM indicates temperature (season?) important factor.

Dairy environment with lowest MMAD shifts Cyclone/IOM ratio higher than other environments with higher MMAD (as anticipated)

Other factors (particle shape, density, charge?) may be important in addition to aerosol size distribution.

Practical problems with Button (feathers) and IOM (milking parlors)
Conclusions

• Conversion factors to adjust concentrations measured with different devices must be determined for different environments. Will be useful for comparison of older vs. newer studies and ultimately development of Occupational Exposure Limits based on Inhalable fraction.

• Future - this work will be combined with controlled laboratory studies to suggest conversation factors.
Acknowledgements

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