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Research—Water and Air Quality around CAFOs

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Background

- Swine CAFOs can pose threats to public health as sources of chemical and biological agents
- Ambient air can be contaminated by the release of odor, gas, and dust plumes
- Surface waters and ground waters can be contaminated by manure wastes
- Respiratory, gastrointestinal, and mental health problems have been documented among workers and neighbors
Swine Odor, Gas, and Dust Plumes

- More than 160 chemical compounds
- Gases: hydrogen sulfide, ammonia, carbon dioxide
- Volatile organic compounds
- Particulate matter (PM10, PM2.5)*
- Bacteria and fungi

*PM10—particulate matter 10 microns and less in size
PM2.5—particulate matter 2.5 microns and less in size
Water Contaminants Associated with Swine Manure

- High levels of nitrates and phosphates
- Heavy metals, including arsenic and copper
- Bacterial and viral pathogens
- Antibiotic residues
- Antibiotic-resistant bacteria?
Transfer of Antibiotic-Resistant Bacteria

Swine CAFO Exposure Assessment Study
Study Objectives

1. To test air samples collected within a swine CAFO for the presence of antibiotic-resistant bacteria

2. To test surface water and ground water samples upstream and downstream of a swine CAFO for the presence of antibiotic-resistant bacteria
Methods: Air Sampling

1. Obtained access to a swine CAFO

2. Developed an air sampling strategy and sampled in 12/03 and 1/04 using an all-glass impinger

3. Isolated bacteria from air samples
   - Standard methods used for the isolation of *Enterococcus* spp. (EPA, 2000)

4. Conducted antimicrobial susceptibility testing using standard methods (NCCLS, 2002)
   - Susceptibility to erythromycin, clindamycin, virginiamycin, tetracycline, and vancomycin was tested

Methods: Water Sampling

1. Developed water sampling strategy and sampled from 9/02 to 1/04
   - Upstream and downstream surface and ground water samples (1L) were collected

2. Isolated bacteria from water samples
   - Standard membrane filtration methods used for the isolation of Enterococcus spp. (EPA, 2000)

3. Conducted antimicrobial susceptibility testing using standard methods (NCCLS, 2002)
   - Susceptibility to erythromycin, clindamycin, virginiamycin, tetracycline and vancomycin was tested

Mean concentration of airborne bacteria was $10^4$ colony-forming units (CFUs)/m$^3$.

- 137 presumptive Enterococcus spp.

- Other bacterial species also were identified.
Airborne bacteria isolated from a swine CAFO using methods for the isolation of *Enterococcus* species

<table>
<thead>
<tr>
<th>Bacteria</th>
<th>No. of isolates (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Enterococcus</em></td>
<td>47 (34)</td>
</tr>
<tr>
<td><em>E. avium</em></td>
<td>5 (4)</td>
</tr>
<tr>
<td><em>E. dispar</em></td>
<td>4 (3)</td>
</tr>
<tr>
<td><em>E. durans</em></td>
<td>2 (1)</td>
</tr>
<tr>
<td><em>E. faecalis</em></td>
<td>6 (4)</td>
</tr>
<tr>
<td><em>E. faecium</em></td>
<td>1 (&lt;1)</td>
</tr>
<tr>
<td><em>E. hirae</em></td>
<td>14 (10)</td>
</tr>
<tr>
<td><em>E. mundtii</em></td>
<td>1 (&lt;1)</td>
</tr>
<tr>
<td><em>E. pseudoavium</em></td>
<td>2 (1)</td>
</tr>
<tr>
<td><em>E. raffinosus</em></td>
<td>1 (&lt;1)</td>
</tr>
<tr>
<td>Other</td>
<td>11 (8)</td>
</tr>
<tr>
<td><em>Staphylococcus</em></td>
<td>44 (32)</td>
</tr>
<tr>
<td><em>S. aureus</em></td>
<td>1 (&lt;1)</td>
</tr>
<tr>
<td>Coagulase-negative staphylococci</td>
<td>43 (31)</td>
</tr>
<tr>
<td><em>Streptococcus</em></td>
<td></td>
</tr>
<tr>
<td><em>Viridans group streptococci</em></td>
<td></td>
</tr>
<tr>
<td><em>Micrococcus luteus</em></td>
<td>1 (&lt;1)</td>
</tr>
<tr>
<td>Total</td>
<td>137 (100)</td>
</tr>
</tbody>
</table>

Adapted by CTLT from: Chapin et al. (2005). *Environmental Health Perspectives*, 113, 2, 137-142.
Results: Air Sampling

- Regardless of bacterial species, 98% of all isolates were multi-drug resistant, expressing high-level resistance to at least two antibiotics.

- *None of the isolates were resistant to vancomycin, an antibiotic that has never been approved for use in the U.S.*
Results: Air Sampling

Phenotypes of antibiotic resistance among airborne bacteria collected from a swine CAFO

<table>
<thead>
<tr>
<th>Bacteria</th>
<th>Antibiotic resistance pattern</th>
<th>No. of isolates (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Enterococcus</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>E. dispar</em> (n = 4)</td>
<td>Ery, Clin, Tet</td>
<td>4 (100)</td>
</tr>
<tr>
<td><em>E. durans</em> (n = 2)</td>
<td>Ery, Clin</td>
<td>1 (50)</td>
</tr>
<tr>
<td><em>E. faecalis</em> (n = 6)</td>
<td>Ery, Clin, Tet, Virg, Tet</td>
<td>1 (17)</td>
</tr>
<tr>
<td><em>E. faecium</em> (n = 1)</td>
<td>Ery, Clin, Tet, Virg</td>
<td>4 (66)</td>
</tr>
<tr>
<td><em>E. hirae</em> (n = 14)</td>
<td>Ery, Clin</td>
<td>1 (17)</td>
</tr>
<tr>
<td><em>Staphylococcus aureus</em></td>
<td>Ery, Clin, Tet, Virg</td>
<td>1 (100)</td>
</tr>
<tr>
<td><em>Coagulase-negative staphylococci</em> (n = 42)</td>
<td>Ery, Clin, Tet, Virg, Tet</td>
<td>1 (7)</td>
</tr>
<tr>
<td>Other <em>Enterococcus</em> (n = 11)</td>
<td>Ery, Clin, Tet, Virg</td>
<td>9 (64)</td>
</tr>
<tr>
<td><em>Viridans group streptococci</em> (n = 43)</td>
<td>Ery, Clin, Tet, Virg</td>
<td>4 (29)</td>
</tr>
</tbody>
</table>

Abbreviations: Clin, clindamycin; Ery, erythromycin; Tet, tetracycline; Virg, virginiamycin.

Chapin et al. (2005). *Environmental Health Perspectives*, 113, 2, 137-142.
Results: Water Sampling

- 200 presumptive *Enterococcus* spp.

- Mean concentrations of drug-resistant *Enterococcus* spp. were
  - $10^2$ CFUs/100mL in surface water
  - 10 CFUs/100mL in ground water

- Ground and surface water isolates downstream of the CAFO displayed patterns of antibiotic resistance similar to those observed in the airborne isolates
Preliminary antibiotic resistance results: water sampling

- Antibiotic-resistant non-\emph{E. faecalis Enterococcus} spp. in ground and surface water downstream and upstream of a swine CAFO

Source: Chapin et al.
Conclusions

- High levels of multi-drug-resistant bacteria are present in CAFO air and in surface and ground waters downstream

- CAFO workers and growers are at high risk of exposure to airborne isolates

- Neighbors could be exposed to both airborne and waterborne resistant bacteria through inhalation or ingestion

- Air and water contaminated by swine CAFOs may serve as exposure pathways for the transfer of resistant bacteria from swine to humans
Currently, the issue of antibiotic-resistant bacteria in air or water associated with CAFOs is not on the radar screen of the U.S. government.

- Environmental Protection Agency
  - Gases, particulate matter, volatile organic compounds in air
  - Levels of bacterial indicators and nutrients in water

- Food and Drug Administration
  - Levels of antibiotic-resistant bacteria in food

This research suggests that the issue of resistant bacteria in the environment surrounding CAFOs needs regulatory attention.