Public Health Impacts of Industrial Farm Animal Production

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# Agricultural Dusts

<table>
<thead>
<tr>
<th>Animal Products</th>
<th>Plants &amp; Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>- feces</td>
<td>- feed (Grain &amp; Additives)</td>
</tr>
<tr>
<td>- hair</td>
<td>- pollen</td>
</tr>
<tr>
<td>- feathers</td>
<td>- insects/parts</td>
</tr>
<tr>
<td>- urine</td>
<td></td>
</tr>
<tr>
<td>- dander</td>
<td></td>
</tr>
</tbody>
</table>
What is in Agricultural Organic Dusts?

High levels of microbes and their byproducts (bacteria, molds)

- Inflammatory substances
  1. Endotoxin
  2. Glucans
  3. Proteinases

Other toxins/irritants/allergens

1. Mycotoxins
2. Allergens (mites, roaches, their feces)
3. Tannins
4. Plicatic acid
Hazards increase with:

1. Degree of confinement
2. Degree of microbial contamination
3. Length and concentration of exposure
4. Concurrent exposures
   - Ammonia
   - Smoking
5. Genetics
Gases Associated with Manure

1. Ammonia
2. Liquid systems
   - Ammonia
   - Anaerobic degradation
     - Hydrogen Sulfide (H₂S)
     - Methane (CH₄)
     - Carbon Dioxide (CO₂)
     - Some 160 other gases
Hydrogen Sulfide Exposure

- Liquid manure
- Anaerobic (> 3 feet down)
- Agitation
- Confined space
- Cellular toxin
- Extreme irritant
- Predilection for CNS
- Paralyze sense of smell
- Sudden unconsciousness
- Respiratory cessation
- Pulmonary edema
The circles indicate overlapping symptoms and conditions. The percentages indicate approximate rates of swine workers who experience these conditions.
Components of an Agricultural Occupational Health and Safety Program

- **Worker Identification and Documentation for State, National Surveillance, Reporting**
- **Employment Medical Examinations**
  - When first hired
  - Annually
    - Physical examinations
    - Spirometry, pre-and post-shift
    - Influenza vaccination
  - Referral for further examination treatment with asthma, significant impairment, zoonotic infectious disease, trauma, other medical conditions
Components of an Agricultural Occupational Health and Safety Program

• Industrial Hygiene
  Hazard identification and signage (language appropriate)
  Employee education
  Wellness and prevention
  Respirator program with face fit and maintenance
  Periodic environmental sampling
  Exhaust ventilation sampling dust control
Environmental Health

• Aerial spraying of manure slurry produces further transport and higher airborne exposures

Duplin Co. NC. Air spraying of swine waste to lower lagoon level.
Source: Statement of Richard J. Dove before the Senate Cmte on Env & Public Works, Sept. 6, 2007

“Center pivot irrigation is a widely used method of (manure) application at many of our farms.”
Source: www.psfarms.com
Industrialized Operations Dominate

110 operations nationwide with >50,000 hogs produce over half the nation’s pork

Now 71.5% of hog inventory at >5,000 head

Regulatory framework is still that of small family farms

Right-to-farm laws not consistent with industrial livestock production

Decisions on siting made at state level
Scope of the livestock industry: an example

• Premium Standard Farms is permitted to confine >900,000 hogs at its CAFOs in Mercer, Putnam and Sullivan Co, MO
• PSF produces two million hogs annually in Missouri.
• PSF stores and applies more than 750 million gallons of animal waste annually on more than 83,000 acres in northern Missouri.
• PSF’s CAFOs, slaughterhouses and retailing pork operations are fully integrated.

CAFO Toxicants

Confinement Barn

Bioaerosols
Disinfectants
Feed Additives

Odoriferous vapors
Urine, feces, bacteria

Gases & Vapors
Odors, Bioaerosols

Manure Application

Manure Pit

Lagoon

Urine, feces, bacteria
Industrial Livestock Facility – NW Iowa

Prevailing winds are from the NNW and SE
H$_2$S and NH$_3$

1,290 ft from a CAFO

10 months monitoring data

Health Guidelines:
- 30 ppb H$_2$S
- 150 ppb NH$_3$
**Air Emissions – Particulate Matter**

<table>
<thead>
<tr>
<th>Microorganisms</th>
<th>Plant Materials in Feed Dust</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bacteria, fungi, viruses, Amoebae</td>
<td>Proteins, starches, carbohydrates</td>
</tr>
<tr>
<td><strong>Products of Bacteria</strong></td>
<td><strong>Feed Additives</strong></td>
</tr>
<tr>
<td>Endotoxin, peptidoglycans, CpG DNA, spores</td>
<td>Antibiotics, Vitamins, minerals, amino acids</td>
</tr>
<tr>
<td><strong>Products of Fungi</strong></td>
<td><strong>Aeroallergens</strong></td>
</tr>
<tr>
<td>Spores, β(1-3)-glucans, mycotoxins</td>
<td>Animal dander, plant pollens, mite feces, arthropod allergens</td>
</tr>
</tbody>
</table>

Exposure to bioaerosols is a risk factor for serious respiratory diseases: - asthma, chronic rhinitis, organic dust toxic syndromes, multi-drug resistant *Staphylococcus aureus* (MRSA), allergy
Air Emissions – Gases & Vapors

• VOCs
  • sensory and pulmonary irritants

• Vapors
  • ammonia, hydrogen sulfide, hydrazine

• Odoriferous volatile fatty acids
  • butyric, valeric, caproic acids

• Odoriferous nitrogen-containing compounds
  • amines, indoles, skatoles, pyridines, methyl pyrazines

• Phenolic compounds
  • phenols, cresols

• Greenhouse gases
  • carbon dioxide, methane, nitrous oxide
<table>
<thead>
<tr>
<th>Volatile Organic Compounds</th>
<th>Vapors and gases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetaldehyde</td>
<td>Ammonia</td>
</tr>
<tr>
<td>Acetone</td>
<td>Hydrogen sulfide</td>
</tr>
<tr>
<td>Acetophenone</td>
<td>Dimethyl sulfide</td>
</tr>
<tr>
<td>Acrolein</td>
<td>Hydrazine</td>
</tr>
<tr>
<td>Benzaldehyde</td>
<td>Sulfur dioxide</td>
</tr>
<tr>
<td>Benzene</td>
<td>Carbon dioxide</td>
</tr>
<tr>
<td>bis (2-ethylhexyl) phthalate</td>
<td>Carbon monoxide</td>
</tr>
<tr>
<td>2-butanone</td>
<td>Odoriferous volatile fatty acids</td>
</tr>
<tr>
<td>Carbon disulfide</td>
<td>Butyric and isobutyric acid</td>
</tr>
<tr>
<td>Carbonyl sulfide</td>
<td>Caproic and isocaproic acid</td>
</tr>
<tr>
<td>Chloroform</td>
<td>Valeric and isovaleric acid</td>
</tr>
<tr>
<td>Crotonaldehyde</td>
<td>Propionic acid</td>
</tr>
<tr>
<td>Ethyl acetate</td>
<td>Phenylpropionic acid</td>
</tr>
<tr>
<td>Formaldehyde</td>
<td>Lauric acid</td>
</tr>
<tr>
<td>Formic acid</td>
<td>Acetic and phenylacetic acid</td>
</tr>
<tr>
<td>Hexane</td>
<td>Phenol</td>
</tr>
<tr>
<td>Isobutyl alcohol</td>
<td>Ethyl phenol</td>
</tr>
<tr>
<td>Methanol</td>
<td>Cresols</td>
</tr>
<tr>
<td>2-methoxyethanol</td>
<td>Nitrogen-containing compounds</td>
</tr>
<tr>
<td>Naphthalene</td>
<td>Ammonia</td>
</tr>
<tr>
<td>Pyridine</td>
<td>Amines</td>
</tr>
<tr>
<td>Tetrachloroethylene</td>
<td>Pyridines</td>
</tr>
<tr>
<td>Toluene</td>
<td>Indole</td>
</tr>
<tr>
<td>Triethylamine</td>
<td>Skatole</td>
</tr>
<tr>
<td>Xylene</td>
<td>Trimethylamine</td>
</tr>
<tr>
<td></td>
<td>Tri- and tetra-methyl pyrazines</td>
</tr>
</tbody>
</table>
### Odorous Compounds Measured by GC-MS

<table>
<thead>
<tr>
<th>Compound</th>
<th>CAS #</th>
<th>Odor Threshold, ug/m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indole</td>
<td>120-72-9</td>
<td>0.2</td>
</tr>
<tr>
<td>Methyl mercaptane</td>
<td>74-93-1</td>
<td>2.1</td>
</tr>
<tr>
<td>Skatole</td>
<td>83-34-1</td>
<td>3.1</td>
</tr>
<tr>
<td>Dimethyl sulfide</td>
<td>75-18-3</td>
<td>5.9</td>
</tr>
<tr>
<td>Trimethyl amine</td>
<td>75-50-3</td>
<td>5.9</td>
</tr>
<tr>
<td>p-Cresol</td>
<td>106-44-5</td>
<td>8.3</td>
</tr>
<tr>
<td>iso-Valeric acid</td>
<td>503-74-2</td>
<td>10.5</td>
</tr>
<tr>
<td>n-Butyric acid</td>
<td>107-92-6</td>
<td>14.5</td>
</tr>
<tr>
<td>n-Valeric acid</td>
<td>109-52-4</td>
<td>20.4</td>
</tr>
<tr>
<td>Dimethyl disulfide</td>
<td>624-92-0</td>
<td>47.9</td>
</tr>
<tr>
<td>Propionic acid</td>
<td>79-09-4</td>
<td>110</td>
</tr>
<tr>
<td>Benzaldehyde</td>
<td>100-52-7</td>
<td>186</td>
</tr>
<tr>
<td>Carbon disulfide</td>
<td>75-15-0</td>
<td>302</td>
</tr>
<tr>
<td>Acetic acid</td>
<td>64-19-7</td>
<td>363</td>
</tr>
<tr>
<td>Phenol</td>
<td>108-95-2</td>
<td>427</td>
</tr>
</tbody>
</table>
## Descriptors of Odor Quality

<table>
<thead>
<tr>
<th>Chemical Name</th>
<th>Smell</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen sulfide</td>
<td>Rotten eggs</td>
</tr>
<tr>
<td>Dimethyl sulfide</td>
<td>Rotting vegetables</td>
</tr>
<tr>
<td>Butyric, isobutyric acid</td>
<td>Rancid butter</td>
</tr>
<tr>
<td>Valeric acid</td>
<td>Putrid, fecal smell</td>
</tr>
<tr>
<td>Isovaleric acid</td>
<td>Stinky feet</td>
</tr>
<tr>
<td>Skatole</td>
<td>Nauseating, fecal</td>
</tr>
<tr>
<td>Indole</td>
<td>Intense fecal</td>
</tr>
</tbody>
</table>
U.S. Greenhouse Gas Inventory for Agricultural Emissions

- Agriculture accounts for 7.4% of the total U.S. release of greenhouse gases

<table>
<thead>
<tr>
<th>Source</th>
<th>Gigagrams</th>
<th>Teragrams CO₂ Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methane, CH₄</td>
<td>Total</td>
<td>7674</td>
</tr>
<tr>
<td></td>
<td>Enteric fermentation</td>
<td>5340</td>
</tr>
<tr>
<td></td>
<td>Manure management</td>
<td>1966</td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>369</td>
</tr>
<tr>
<td>Nitrous Oxide, N₂O</td>
<td>Total</td>
<td>1210</td>
</tr>
<tr>
<td></td>
<td>Agric. Soil management</td>
<td>1178</td>
</tr>
<tr>
<td></td>
<td>Manure management</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>2</td>
</tr>
</tbody>
</table>

Health Effects of Low-Level Exposures

• Ammonia, NH₃
  Sensory irritation, cough, excessive airway mucus production, epithelial damage in upper airways, inflammation

  Irritation of eyes, nose, sinuses, skin

  At higher levels: pulmonary edema, lung scarring, ocular damage, reactive airways dysfunction syndrome

  ATSDR chronic minimal risk level = 300 ppb

  UI-ISU AQS: 150 ppb at residence; 500 ppb at CAFO property line (1 hr average) and no more than 7 exceedances per calendar year (with 48 hr notice)
Health Effects of Low-Level Exposures

- Hydrogen sulfide, $\text{H}_2\text{S}$
  - Eye & throat irritation, headache, nausea, lung irritation, cough, sleeplessness
  - Elevated rates of respiratory infection, asthma, chronic bronchitis
  - Neuropsychologic disturbances, mood disorders, visual impairment
  - Lethal at higher concentrations

ATSDR intermediate minimal risk level = 30 ppb

UI-ISU AQS: 15 ppb at residence; 70 ppb at CAFO property line (1 hr average) and no more than 7 exceedances per calendar year with 48 hr notice
Health Effects of Noxious Odors

- Diminished quality of life, loss of use of property, emotional stress
- Neuropsychiatric abnormalities, mood disorders, sleep disturbances
- Measured by olfactometry in dilution factor for non-detection
- UI-ISU AQS- opinion 1: Limited to 7:1 dilution at the residence, 15:1 at the property line, up to 7 residence and 14 property line exceedances/yr (with 48 hr notice)
## Epidemiological Studies

### Association between CAFOs and Asthma

<table>
<thead>
<tr>
<th>Study</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Merchant et al 2005</td>
<td>Keokuk County Rural Health Study (Iowa), 1000 rural households with high rates of childhood asthma, 44.1% among children living and often working on farms raising swine</td>
</tr>
<tr>
<td>Sigurdarson &amp; Klein 2006</td>
<td>Iowa children in school proximate to CAFO, OR of 5.71 for doctor diagnosed asthma</td>
</tr>
<tr>
<td>Mirabelli et al 2006 a, b</td>
<td>NC children living within 3 miles of CAFO had significantly more doctor-diagnosed asthma, used more asthma meds and had more asthma-related ER visits and/or hospitalizations than children &gt; 3 miles</td>
</tr>
<tr>
<td>Radon et al 2007</td>
<td>Adults in 4 rural German towns in proximity to CAFOs reported asthma with increasing odor annoyance; the concentration of CAFOs within 500 meters was found to be a predictor of wheeze and decreased FEV1</td>
</tr>
</tbody>
</table>
Keokuk County Rural Health Study – Round 1
Childhood Asthma Outcomes

♦ Doctor diagnosed asthma = 72/610 = 12%
♦ Asthma/medication for wheeze in last 12 months = 101/610 = 17%
♦ Current wheeze = 120/490 = 24%
♦ Cough with exercise = 117/493 = 24%

Source: Environmental Health Perspectives, 2005;113(3)
Keokuk County Rural Health Study – Round 1
Asthma Outcome Prevalence and Swine Exposure

Source: *Environmental Health Perspectives*, 2005; 113(3)
Control Approaches to Limit Exposures to Air Emissions

- Local control of zoning decisions (overturned in Iowa)
- County health department rulings (overturned by Iowa Supreme Court)
- Master Matrix to guide evaluation for permitting (Iowa)
- Set backs - typically 500 to 3000 ft
- Biofilters
- Enclosed manure storage
- Subsurface soil injection of manure slurry
- Industrial or municipal waste treatment systems
- Law suits, civil judgments, consent agreements
CAFO Emission Controls

Urine, feces, bacteria
Exhaust fan
Biofilter
Flushed shallow pit
Closed Manure Storage Tank
Knifing manure or municipal waste system
Control of Airborne Exposures

Emission control by active biofiltration
Features of Emission Controls

• Biofiltration
  - Highly effective in Denmark and The Netherlands
  - Low capital investment
  - ~$3.00 per 1000 cfm per year to power fans
  - Power with wind turbines
• Municipal wastewater treatment systems
• Innovative waste treatment models (e.g., Aitken, GIL)
• Knifing manure into the soil
  - Reduces nutrient loss and surface water pollution.
  - Works with conservation tillage systems - less disruption of crop residues.
Environmental Health Impacts of Concentrated Animal Feeding Operations: Anticipating Hazards - Searching for Solutions

- International Conference and Workshop
- Six workgroup consensus papers published in *Environmental Health Perspectives*, 2007
  - Overview of the issues and recommendations
  - Respiratory health effects
  - Modeling and monitoring of air toxics
  - Water quality issues
  - Influenza pandemics and antibiotic resistance
  - Community health and socioeconomic issues

Environmental Health Impacts of Concentrated Animal Feeding Operations: Anticipating Hazards – Searching for Solutions

- The 31 scientists identified 26 priority research needs and 16 recommendations for translating science to policy.

- “There was general agreement among all workgroups that the industrialization of livestock production over the past three decades has not been accompanied by commensurate modernization of regulations to protect the health of the public, or natural, public-trust resources.”

Putting Meat on the Table:
Industrial Farm Animal Production in America

A Report of the Pew Commission on Industrial Farm Animal Production

www.pcifap.org

Recommendations
National Commission on Industrial Farm Animal Production 2006-2008

• Funded by the Pew Charitable Trust through a grant to the Johns Hopkins Bloomberg School of Public Health

• Chaired by former Governor of Kansas John Carlin and included 14 other commissioners from the private and public sectors—all with substantial knowledge and experience in animal agriculture, public health, animal health, medicine, ethics, public policy and rural sociology

• Included 11 meetings and thousands of pages of peer-reviewed and technical reports and testimony

• Included commissioned reports on Antibiotic Resistance and Human Health, Occupational and Community Public Health Impacts, Environmental Impacts, Economics of Farm Animal Production, and Impact on Rural Communities

• Final report issued in April, 2008, targeting policy makers nationally and a continuing effort to disseminate and recommend policy options. See www.pcifap.org for technical reports and final report.
Report Contents

• How the Current System Developed

• Public Health

• Environmental Risks

• Animal Welfare

• Rural America

• Conclusions: Toward Sustainable Animal Agriculture

• Recommendations of the Commission
Public Health Recommendations

1. Restrict the use of antimicrobials in food animal production to reduce the risk of antimicrobial resistance to medically important antibiotics.

2. Clarify antimicrobial definitions to provide clear estimates of use and facilitate clear policies on antimicrobial use.

3. Require pharmaceutical companies to provide a calendar-year report of the quantities sold for use in farm animals.

4. Improve monitoring and surveillance of antimicrobial resistance in the food supply, the environment, and animal and human populations in order to refine knowledge of antimicrobial resistance and its impacts on human health.
Public Health Recommendations (continued)

5. Increase veterinary oversight of all antimicrobial use in food animal production to prevent overuse and misuse of antimicrobials.

6. Implement a disease-monitoring program and a fully integrated and robust national database for food animals to allow 48-hour trace-back through phases of their production.

7. Fully enforce current federal and state environmental exposure regulations and legislation, and increase monitoring of the possible public health effects of IFAP on people who live and work in or near these operations.

8. Increase research on the public health effects of IFAP on people living and working on or near these operations, and incorporate the findings into a new system for siting and regulating IFAP.
Public Health Recommendations (continued)

9. Strengthen the relationships between physicians, veterinarians, and public health professionals to deal with possible IFAP risks to public health.

10. Create a Food Safety Administration that combines the food inspection and safety responsibilities of the federal government, including the USDA, FDA, EPA and other federal agencies into one agency to improve the safety of the US food supply.

11. Develop a flexible risk-based system for food safety from farm to fork to improve the safety of animal protein produced by IFAP facilities.

12. Improve the safety of our food supply and reduce use of antimicrobials by more aggressively mitigating production diseases (disorders associated with IFAP management and breeding)
Environmental Impact Recommendations

1. Improve enforcement of existing federal, state, and local IFAP facility regulations to improve the siting of IFAP facilities and protect the health of those who live near and downstream from them.

2. Develop and implement a new system to deal with farm waste (that will replace the inflexible and broken system that exists today) to protect Americans from the adverse environmental and human health hazards of improperly handled IFAP waste.

3. Increase and improve monitoring and research of farm waste to hasten the development of new and innovative systems to deal with IFAP waste and to better our understanding of what is happening with IFAP today.

4. Increase funding for research into improving waste handling systems and standardize measurements to allow better comparisons between systems.
Animal Welfare Recommendations

1. The animal agriculture industry should implement federal performance-based standards to improve animal health and well-being.

2. Implement better animal husbandry practices to improve public health and animal well-being.

3. Phase out the most intensive and inhumane production practices within a decade to reduce IFAP risks to public health and improve animal well-being.

4. Improve animal welfare practices and conditions that pose a threat to public health and animal well-being.

5. Improve animal welfare research in support of cost-effective and reliable ways to raise food animals while providing humane animal care.
Community Impact Recommendations

1. States, counties and local governments should implement zoning and siting guidance governing new IFAP operations that fairly and effectively evaluate the suitability of a site for these types of facilities.

2. Implement policies to allow for a competitive marketplace in animal agriculture to reduce the environment and public health impacts of IFAP.
Conclusions

• The highly integrated industrial farm animal production system in the US has resulted in adverse public health, environmental, animal welfare and community impacts—effectively transferring these human, environmental, animal and community impact costs to the affected rural communities.

• The Pew Commission on Industrial Farm Animal Production has thoroughly examined these several issues and has made a series of recommendations designed to mitigate these adverse impacts and to encourage transition of this industry to a more sustainable future.

• Major forces including energy costs, limited water resources, and climate change dictate that this industry must adopt a more ecological approach to sustain its viability in the decades ahead.
ACKNOWLEDGMENTS

Many faculty members at the University of Iowa and College of Public Health made significant contributions to the Occupational and Community Public Health Impacts technical report and participated in a seminar that contributed to the development of the Community Impact technical report, including Kelly Donham, Greg Gray, Keri Hornbuckle, Patrick O’Shaughnessy, David Osterberg and Peter Thorne. I thank them for their expertise and generous contribution to this Pew Commission report and this presentation.

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