Human Health: Pathogens and Contaminants in Livestock Systems
Building Air Quality and Exposures

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GREAT PLAINS Center for Agricultural Health www.GPCAH.org

Air Quality in Swine Buildings

R. Anthony 2011-16

M. Nonnenmann, 2016-21

Examining engineering controls to reduce contaminant concentrations in swine production buildings

- Many have tried to get workers to use respirators ("dust masks"), but low adoption continues
- Can we engineer the system to remove the hazards to workers and animals?

https://gpcah.public-health.uiowa.edu/center-projects/intervention-to-reduce-exposures-in-cafos/

https://gpcah.public-health.uiowa.edu/indoor-air-quality/

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Outline

- What is in the air?
- Health effects review
- Contaminants – dust and others
- Safe exposures (OELs)
- Study data
- Source reduction

What is in the Air?

- **Dust: Organic compounds including:**
  - fecal materials
  - feed particles
  - animal dander
  - molds
  - pollen
  - insect parts
  - virus/bacteria
- **Historical measures of endotoxin**
  - Lipopolysaccharides that are contained in the cell wall of gram-negative bacteria
  - Might play a major part in the etiology of pulmonary inflammation and lung disease (grains)

Gases

Ammonia: irritant (urine)

CO_2: not at regulated levels, but concerns of high levels reducing cognition and increasing response to swine worker dust (respiration, heaters)

Other gases: H_2S, Methane (manure digestion, bacterial contamination)

Health Effects Review

- Increased **bronchial inflammation** (Pedersen *et al.*, 1996; Larsson *et al.*, 1994)
- Cross-shift **decreases in lung function** correlated to exposures (Reynolds *et al.*, 1995)
- **Accelerated lung function** decline (Iversen and Dahl, 2000)
- **Bronchial hyperresponsiveness** (Vogelzang *et al.*, 2000)
- **Higher prevalence of chronic bronchitis and airflow obstruction** for Canadian swine workers spending 3 hours/day or more in swine confinement buildings Corimer *et al.* (1991)
- Dose-response relationship **between respiratory symptoms** and **number of hours per day** inside swine confinement buildings in Europe. Radon *et al.* (2002)

Recommended exposure limits are recommended to account for the **MIXTURE** of contaminants in livestock buildings →

Health Effects Review

- Because of these health effects, should consider the Risk of **MIXTURES**
  - Combine factors causing same health outcomes

- Over 8-hour work-shift:
  - 2.5 mg/m^3 of 'total' dust

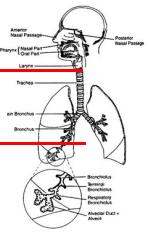
Dust Fractions and Regions of the Respiratory Tract

Region

Nasopharyngeal (NP) ("head airways")

Tracheobronchial (TB)

Pulmonary (P) ("gas exchange")

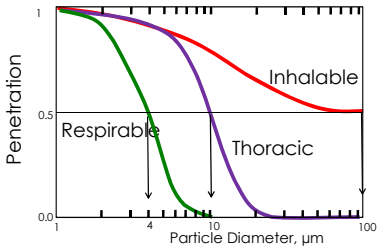


Occupational Sampling Conventions


Button


IOM


SKC AI Cyclone



Health Effects Review

- Because of these health effects, should consider the Risk of **MIXTURES**
  - Combine factors causing same health outcomes
- Over 8-hour work-shift:
  - 2.5 mg/m^3 of 'total' dust
  - 7 ppm ammonia
- These industry-specific recommended exposure limits are:
  - ***lower than OSHA's particulates not otherwise regulated (dust) and ammonia PELs*** and
  - lower than the recommended ACGIH TLVs for particulates not otherwise specified and ammonia
  - But widely recommended in the agricultural literature to prevent illness

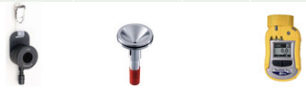
The archived presentation is available at:
https://lpelc.org/archived-webinars/

Swine Production

- Exposure limits (from ACGIH, updated annually)
- Industry Recommendations
  (Donham et al., 1989, *British Journal of Industrial Medicine)*

Threshold	Inhalable Dust, mg/m³	Respirable Dust, mg/m³	NH_3*, ppm	CO, ppm	CO_2, ppm
100% Limit	10	3	25	25	5000
Industry Recommendations	**2.8**	**0.23**	**7.5**	**-**	**1540**

*Short-term NH_3 exposures are also important, STEL = 35 ppm

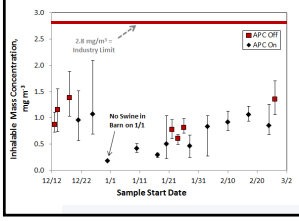


Concentration Measures – Midwest, Swine

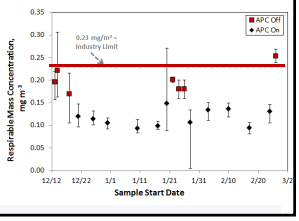
Study goal to improve air quality by installing ventilation system: Pull air out of room → Filter in → Return to room

Field Deployment 1 Results: Dust

Inhalable dust:

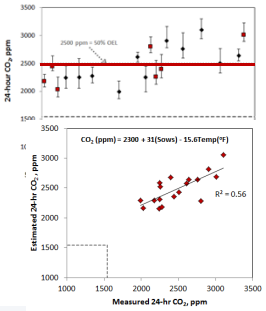


Respirable dust



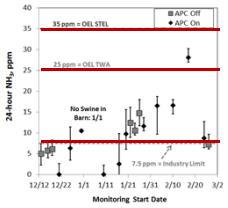
Field Deployment 1 Results: Gases

- H_2S, CO: no problems with this barn
- CO_2: *All days* exceeded 1540 ppm
  - 44% exceeded 50%OEL
  - CO_2 unaffected by APC status *(p=0.27)*
  - Sow and outdoor temperature useful to estimate room CO_2

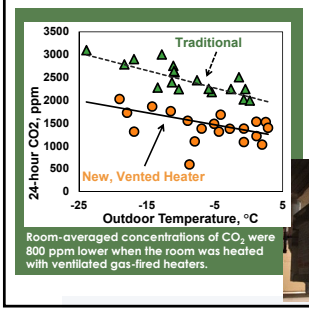


Field Deployment 1 Results: Gases

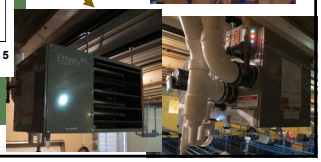
- NH_3: One OEL exceeded
  - 3 "off" days and 8 "on" days > 7 ppm
  - 1.6 ppm mean increase with APC on *(p > 0.31: Wilcoxon; Non-parametric)*
- *Increasing ventilation in the room was not associated with NH3 increases… Concentration does build over winter*



Field Testing: Heaters CO



Room-averaged concentrations of CO_2 were 800 ppm lower when the room was heated with ventilated gas-fired heaters.



Midwest Heater Recommendations

- Commonly used models may be contribution substantially to indoor CO_2 concentrations
- Replacement is cost-effective ($1500 per new vs $1000 per old)
- Additional reductions could have been achieved by replacing hallway heaters as well

Poultry Data

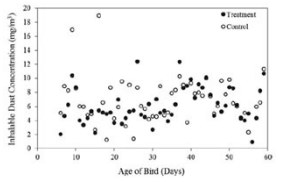


Figure 3. Inhalable dust concentrations in each broiler chicken house throughout the growth period.

Threshold	Inhalable Dust, mg/m³	NH_3^*, ppm
100% Limit	10	25
*Mixture	2.8	7.5

Inhalable **dust**: 5.5-6.0 mg/m³ (GM)
Ammonia: 9.5-10.6 ppm (GM), (GSD ~1.8 SD)

https://doi.org/10.1080/15459624.2016.1211285

Cattle/ Dairy

Table 3. Basic measurement attributes and concentrations of inhalable dust (mg m⁻³) and endotoxin (EU m⁻³) exposure measured through personal sampling in Danish cattle farmers

Period	n	f	k	Dust AM	Dust GM (GSD)	Dust Range	Endotoxin AM	Endotoxin GM (GSD)	Endotoxin Range	r
All measurements										
Overall	124	26	77	1.6	1.0 (2.7)	<LOD–9.8	760	360 (3.8)		
Summer	62	26	62	1.5	0.9 (2.5)	0.2–9.8	510	290 (3.2)		
Winter	62	26	62	1.8	1.1 (2.9)	<LOD–9.4	1010	450 (4.0)		
Only main stable measurements										
Overall	101	26	65	1.5	1.0 (2.7)	<LOD–9.8	750	350 (3.6)		
Summer	50	26	50	1.4	0.9 (2.4)	0.2–9.8	480	290 (3.0)		
Winter	51	26	51	1.6	1.0 (3.0)	<LOD–9.4	1020	430 (4.2)		

124 samples:
Mean inhalable dust 1 mg/m³

For dust, exposure was higher when fully automatic (robotic) milking was used **and during**
- re-penning of animals
- handling of silos
- ***handling of feed and seeds***
- ***distributing bedding.***

Dust exposure increased also as a result of use of rail feed dispensers in a model ***without fully automatic milking***.

https://academic.oup.com/annweh/article/58/6/707/137368

Wrap up:

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For more, visit this for a quick but recent summary of the literature: http://www.omafra.gov.on.ca/english/livestock/swine/facts/93-001.htm

Next up:
Michael Pate, Respiratory Protection

Publications: Swine Barn Air Quality

1. Peters TM, Anthony TR, Taylor C, Altmaier R, Anderson KR, O'Shaughnessy PT (2012). Distribution of particle and gas concentrations in a swine gestation confinement animal feeding operations. *Annals of Occupational Hygiene*, 56(9):1080-1090. PMC4777339
2. Park JH, Peters TM, Altmaier R, Sawvel RA, Anthony TR (2013). Simulation of air quality and cost to ventilate swine farrowing facilities in winter. *Journal of Computers and Electronics in Agriculture*, 98:136-145. PMC4770838
3. Reeve KA, Peters TM, Anthony TR (2013). Wintertime factors affecting contaminant distribution in a swine farrowing room. *Journal of Occupational and Environmental Hygiene*, 10(6):287-296. PMC4753562
4. Anthony TR, Park JH, Altmaier R, Peters TM (2014). Modeled effectiveness of ventilation with contaminant control devices on indoor air quality in swine farrowing facility. *Journal of Occupational and Environmental Hygiene*, 11(7):434-449. PMC4753560
5. Peters TM, Sawvel RA, Park JH, Anthony TR (2015). Evaluation of a Shaker Dust Collector for Use in a Recirculating Ventilation System. *Journal of Occupational and Environmental Hygiene*, 12(9):D201-D210. PMC4753559
6. Anthony TR, Cai C, Mehaffy J, Sleeth DK, Volckens J. (2017) Performance of a prototype high-flow inhalable dust sampler in a livestock production facility. *Journal of Occupational and Environmental Hygiene,* 14(5): 313-322. PMC5503137