Bioaerosols in Agriculture: Quantifying Total Airborne Bacteria Concentrations Using Molecular Biology Tools

Kelci R. Knight[1], MW Nonnenmann[1], CL Boles[1], K O'Brien[1], M Farnell[2], T Tabler[2], TR Anthony[1], S Ischer[1], R Altmaier[1]

[1]Department of Occupational and Environmental Health, The College of Public Health, The University of Iowa

[2]Department of Poultry Science, Mississippi State University

Background

Bioaerosols are present in agricultural settings and are known to cause infectious and respiratory diseases among workers.

Poultry and swine workers are at increased risk because of an enclosed work environment with minimal ventilation especially in winter months. Agricultural dust is like composed of animal feed and dander, urine, feces, and microbes that have been identified as being composed of primarily Bacteria DNA.

Methodology using a combination of inhalation exposure sampling and molecular biology tools is needed to assess and quantify the bioaerosol exposure. Our results will help determine the optimal sampling strategies and the impact of new technologies on bioaerosol generation used in an agricultural.

Objectives

1. Quantify and compare airborne bacteria concentrations (i.e. DNA copies per m3 of air) among two animal production industries (i.e., poultry and swine) using qPCR.

2. Compare bacteria concentrations in a broiler poultry production building with and without using water-sprinkling technology.

3. Compare bacteria concentrations among aerosol samples collected during mobile sampling and stationary sampling in a swine production.

Methods

Area Sampling:

Broiler Poultry Sampling in MS (Jan. 2015-March 2015):

- 2 building; 1 building equipped with a water sprinkler cooling system and 1 building without the sprinkler system
- Centrally located mannequin with an inhalable button sampler, 4.0 LPM, collected on PVC filter for 30 minutes

Swine Farrowing Sampling in IA (Dec. 2016- Feb. 2017):

- Randomly chosen room that contained ~420 pigs
- Deployed centrally located stationary basket (Figure 3) and a mobile sampling cart moved to 22 positions for 5 min. each (Figure 3)
- Cart and basket collected swine dust with an IOM sampler, 2.0 LPM, collected on PVC filter for 2.5 hours

DNA Extraction and Bacteria Detection:

- Extracted using lab optimized protocol Sucrose-Tris-EDTA (STE)
- 16S rRNA gene was targeted and quantified with qPCR as DNA copies, referred to in this poster as bacteria units (BU)
- Bacteria units were adjusted for sampler flow rate and reported as BU/m^3

Data analyzation:

- Anderson- Darling Normality Test
- Mann-Whitney Non-Parametric Test with a p-value criterion of <0.05
- Paired t-test with a p-value criterion of <0.05

Experimental Setup

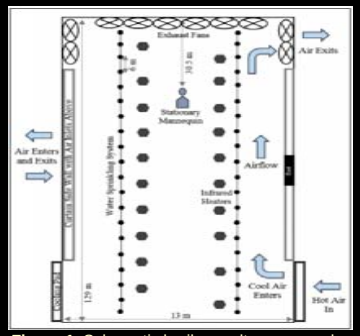

Figure 1. Schematic broiler poultry room and sampling locations.

Figure 2. Poultry sampling mannequin.

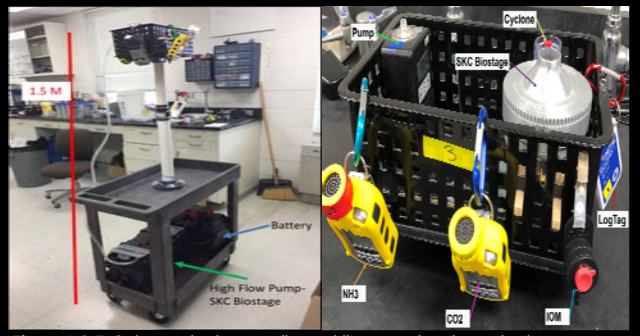

Figure 4 & 5. Swine production sampling mobile cart and stationary basket.

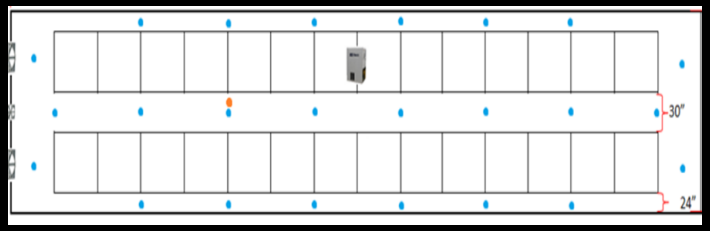

Figure 3. Schematic diagram of a swine farrowing room and sampling locations. Orange dot denotes stationary basket, Blue dots denote mobile sampling cart.

Results

Table 1. Arithmetic mean (SD) concentrations for bacteria units, flowrate adjusted bacteria units, and dust from all sampling conditions across swine and poultry locations.

Location	Condition	n	Bacteria Units	Bacteria Units/m^3	Dust Conc. (mg/m^3)
Swine	All Samples	28	5.17E+08 (7.57E+08)	2.00E+09 (2.96E+09)	3.74 (1.53)
	Cart	22	6.23E+08 (7.85E+08)	2.46E+09 (3.08E+08)	3.63 (1.33)
	Basket		3.53E+08 (7.16E+08)	1.28E+09 (2.74E+09)	3.91 (1.59)
Poultry	All Samples	87	5.01E+09 (1.90E+10)	4.18E+10 (1.59E+11)	7.28 (2.65)
	Control	46	8.40E+09 (2.58E+10)	7.01E+10 (2.15E+11)	7.58 (2.94)
	Sprinkler	41	1.20E+09 (8.59E+08)	1.00E+10 (7.16E+09)	6.94 (2.27)

Table 2. P-values of statistical tests performed for each objective comparison.

Objective	P-value	Confidence Interval (%)
Poultry vs. Swine	0.0001*	95.1
Sprinkler vs. Control	0.6249	95.0
Cart vs. Basket	0.056	95.0

Conclusions

Analysis suggest that the poultry industry has higher bacteria concentrations then the swine industry (Objective 1).

The use of water sprinkler treatment does not significantly increase or decrease bacteria concentration therefore, these systems are not increasing the bacterial hazards for workers or animals when used in broiler production (Objective 2).

Analysis in swine production suggests that airborne bacteria concentration is similar whether a worker is primarily in one location or if they are moving through the room (Objective 3).

Future Research

Our findings will aid in the accumulation of basic information about sampling, extracting and quantifying bioaerosols in agriculture.

Our findings will inform future sampling strategies for measuring contaminant concentrations of bioaerosols in broiler poultry productions and swine farrowing rooms.

These data are important for helping understand the impact of building/encompassing production practice changes on the work environment. Also, we can assess the impact of potential interventions to reduced worker and animal bioaerosol exposures in the agricultural environment.

Acknowledgements

This research was funded by Great Plains Center for Agricultural Health (CDC/NIOSH – U54OH007548), Southwest Center for Agricultural Health, Injury Prevention and Education (CDC/NIOSH - 5 U54 OH07541-15), Heartland Center for Occupational Health and Safety a NIOSH/CDC Education and Research Center (T42OH008491)