UNIVERSITY OF SASKATCHEWAN

Cultivating Knowledge Agriculture Across the Disciplines

Agriculture and Human Health

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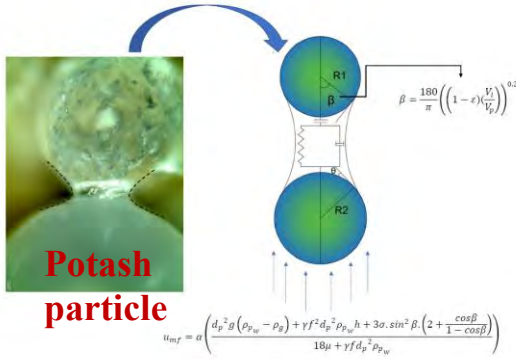
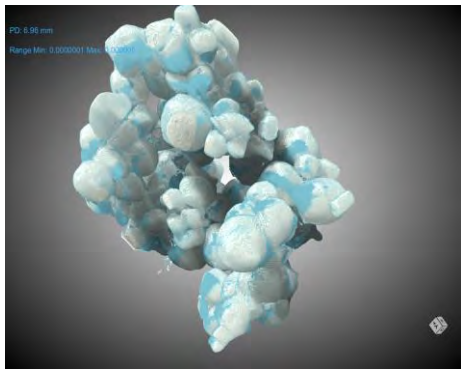
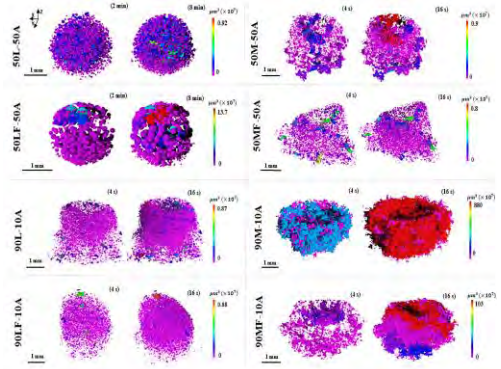
About me----Lifeng.zhang@usask.ca

- Professor in the Chemical & Biological Engineering Department.
- Research areas encompass:
  - Fluidization and multiphase flow systems
  - Clean energy and sustainability
  - Biomass and bioenergy
  - Electrostatics and electrosprays
- Current research projects include:
  - Application of electrostatic and electrospray systems in agriculture
  - Fluidization and fluidized bed drying
  - Synchrotron X-ray imaging of transport phenomena in porous media

Oat Hull Pellets

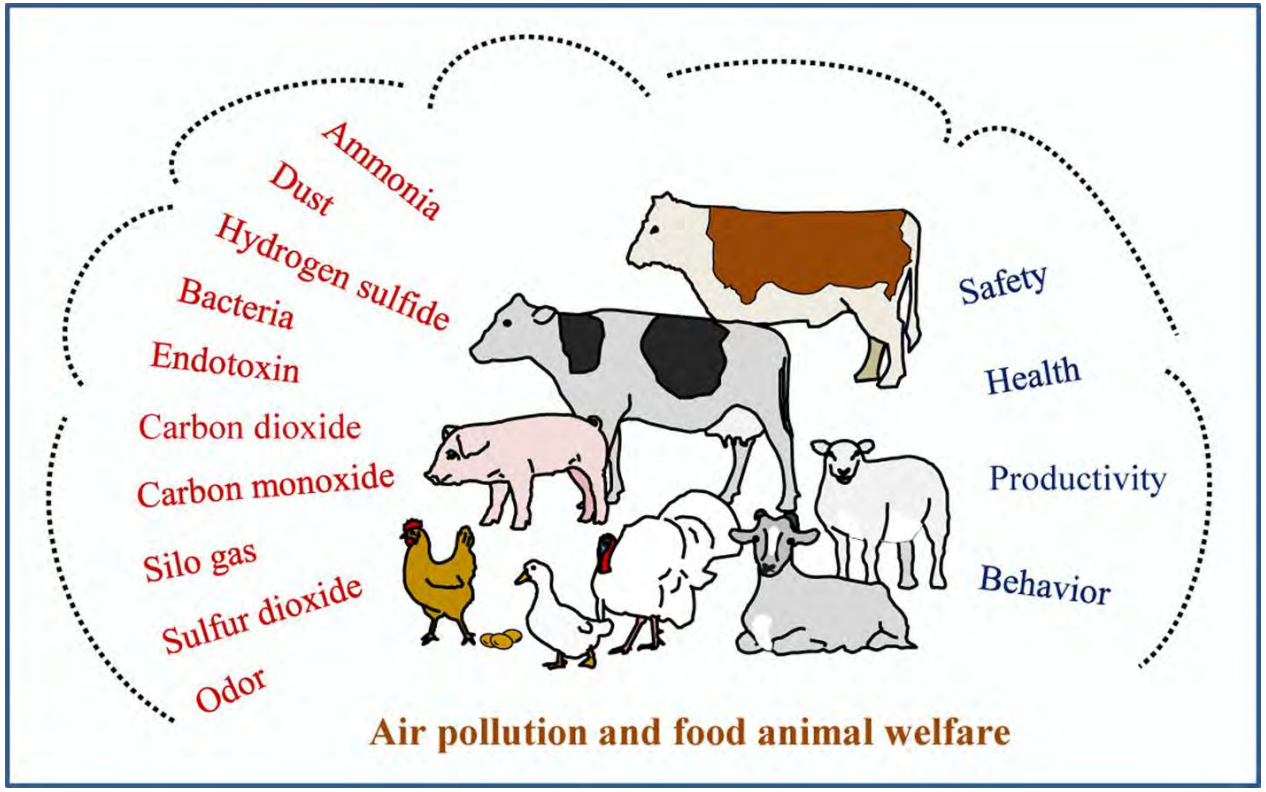






Development and assessment of emerging green technologies for reduction of aerosol risks and hazards in animal farms

Introduction- Air Pollution in Animal Farms



Solutions

- Manure handling and management strategies have been implemented.
- Air treatment techniques and technology have been developed and investigated.

However…

- Existing technologies have limitations in responding to the challenges in livestock barns.

Problems

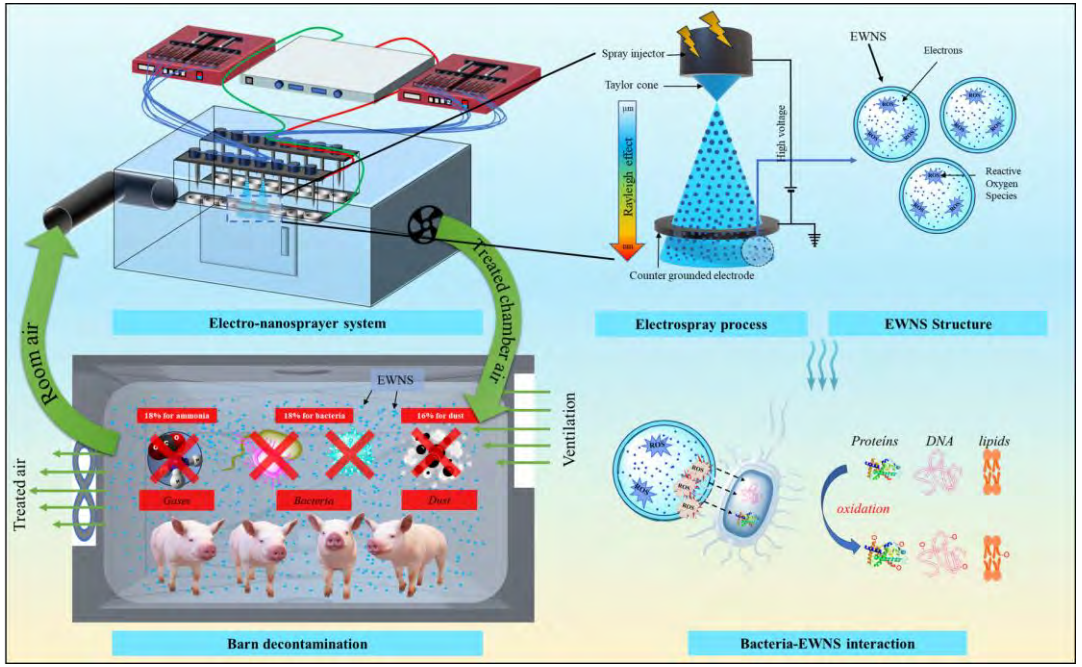
- Exposure to bioaerosols, noxious gases, and concentrated dust in animal buildings has been associated to respiratory symptoms of animals and exposed workers.

Zhao et al., (2014). Airborne Microorganisms From Livestock Production Systems and Their Relation to Dust. Critical Reviews, Environmental Science and Technology, 44(10), 1071–1128. https://doi.org/10.1080/10643389.2012.746064; Ni et al., 2021, A critical review of advancement in scientific research on food animal welfare-related air pollution, Journal of Hazardous Materials, 408, 124468.

Introduction

Our research team developed and tested two technologies for the reduction of particulate matter (bioaerosol and dust), microbes on surfaces, and gases in livestock facilities.

- **Electro-nanospray**
  - Small-scale pig room in PSCI
  - Swine transport trailer
- **Electrostatic particle ionization (EPI)**
  - Small-scale broiler rooms in IRDA (Quebec)
  - Large-scale broiler rooms in the Poultry Centre (UofS)

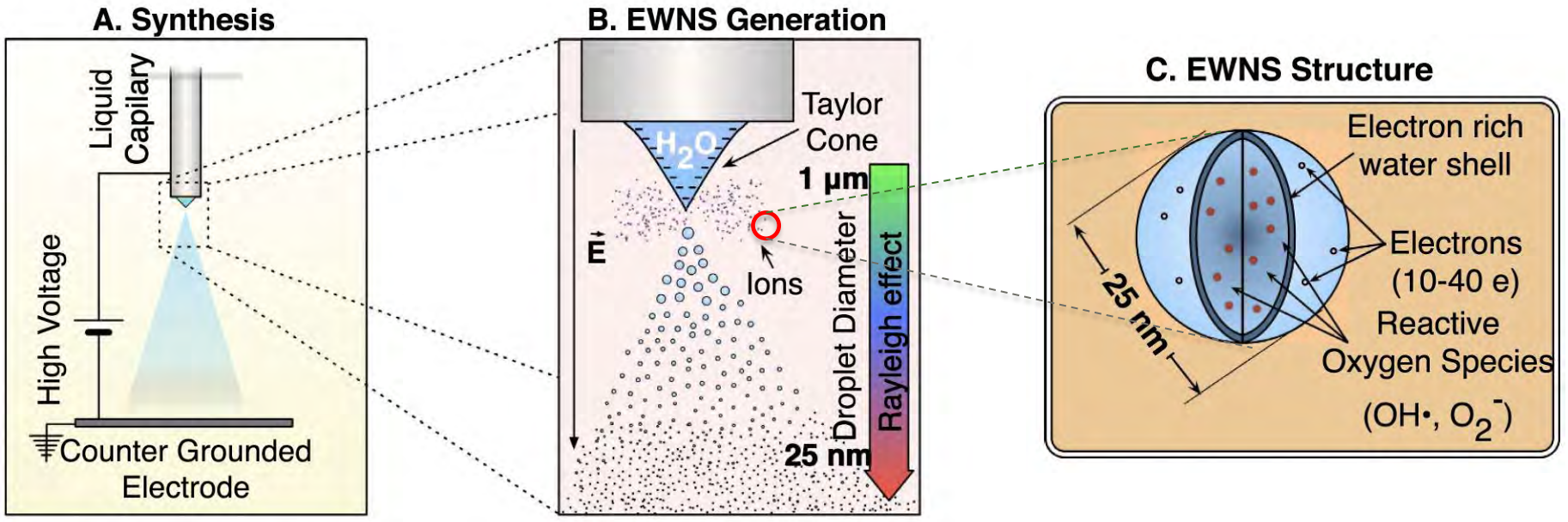


Introduction- Engineered Water Nano-Structures (EWNS)

Electro-nanosprays generate engineered water nano-structures (EWNS) by applying high-voltage, low-amperage current to a metal capillary containing water.

EWNS:

- nanosize
- highly mobile
- highly charged
- non-toxic
- long life span
- Biocidal effects
- No chemical residues



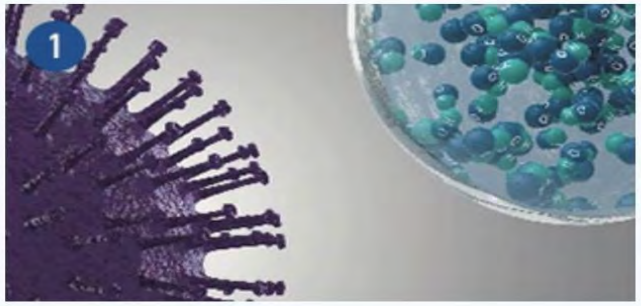
Generate ROS

Pyrgiotakis, G., Vedantam, P., Cirenza, C., McDevitt, J., Eleftheriadou, M., Leonard, S. S., & Demokritou, P. (2016). Scientific Reports. 6, 1–12. https://doi.org/10.1038/srep21073

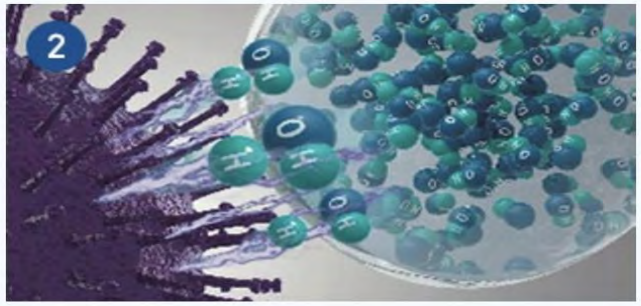
Introduction

EWNS treatment mechanisms

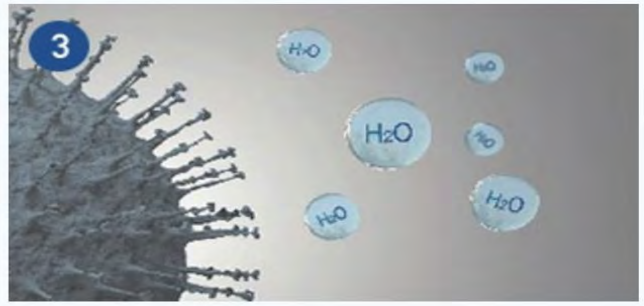
➢ Bacteria inactivation



1. EWNS reaches pollutant

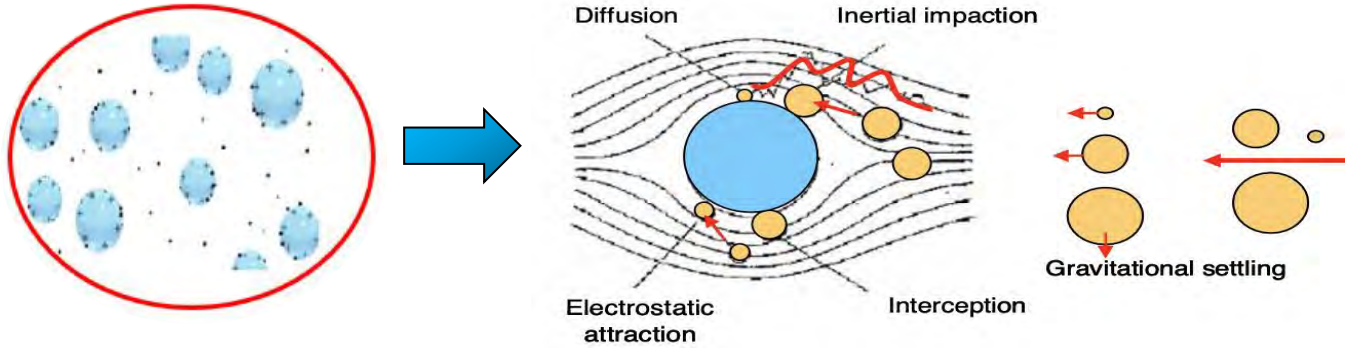


2. Hydroxyl radicals denature pollutant proteins



3. Bacteria is inhibited

➢ Dust removal

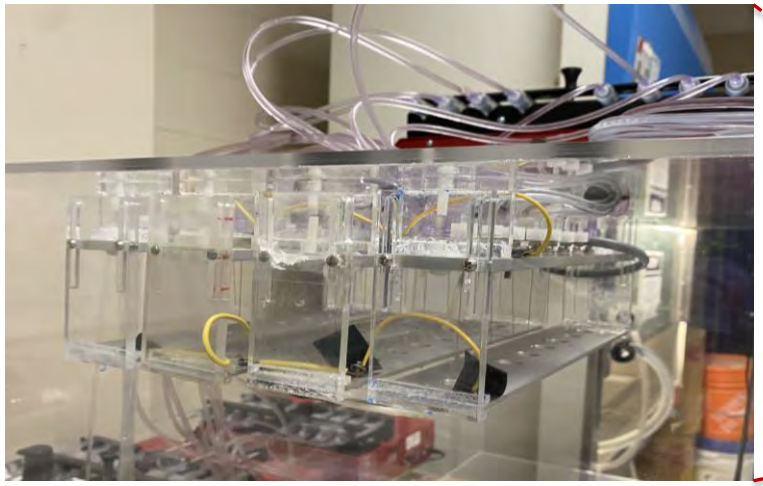


Pyrgiotakis, G., McDevitt, J., Yamauchi, T., & Demokritou, P. (2012). Journal of Nanoparticle Research, 14(8), 1–11. Unger, L., Ehouarn, P., & Borra, J. (2003). Journal of Aerosol Science.

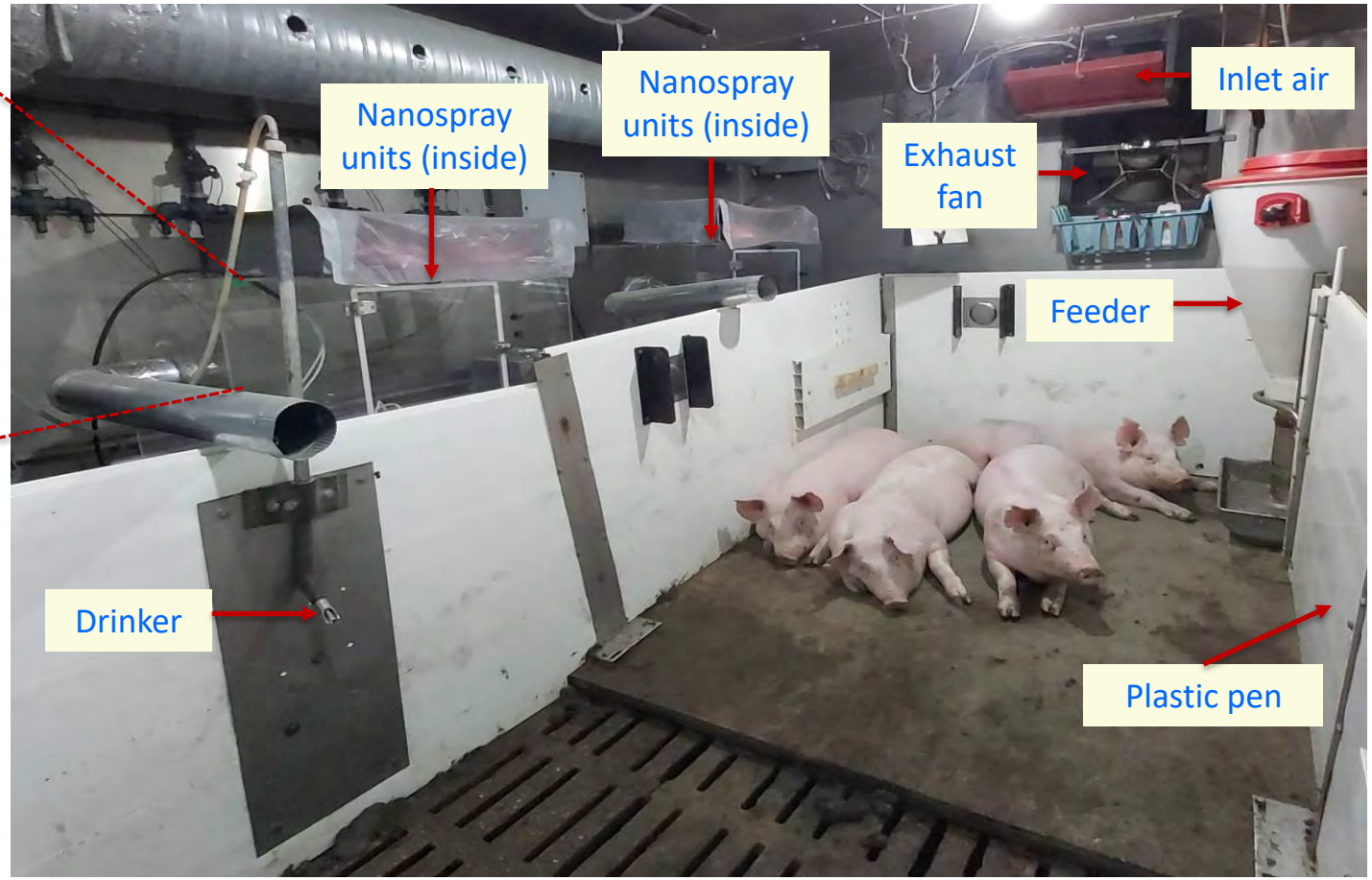
Introduction – Microbial Deactivation of EWNS

Sources: Vaze et al. (2018), *Food Control*, Huang et al., 2021. *Environmental Science: Nano,* Vaze et al., 2019. *Food Control,* Aminian et al., 2024. *LWT Food Science and Technology*, Huang et al., 2019. *ACS Sustainable Chemistry and Engineering*, Barraza-Garcia et al., 2024. *MRS Advances,* [19]Vaze et al., 2019. *Nanomedicine: Nanotechnology, Biology, and Medicine,*

Electro-nanospray: Pilot-scale study (PSCI)



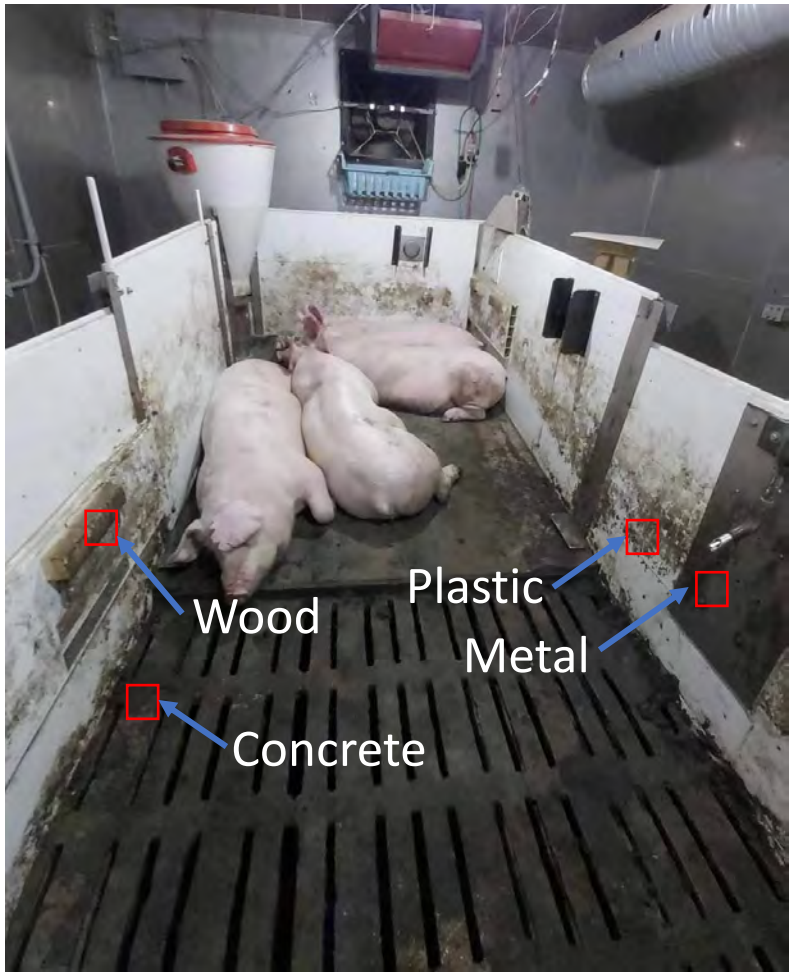
- 1 control, 1 treatment room
- Room size: 4.2 m × 3.6 m × 2.7 m
- 4 grower pigs per room
- 2 trials
- Microorganisms (air and surfaces), dust, gases



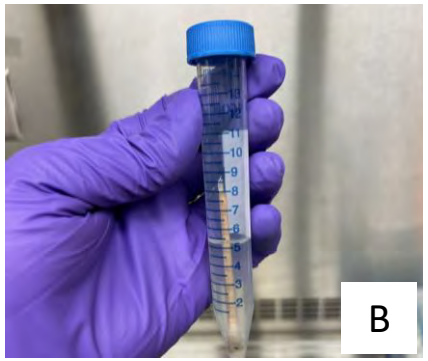
Experimental setup in the treatment room

Electro-nanospray: Pilot-scale study (PSCI)

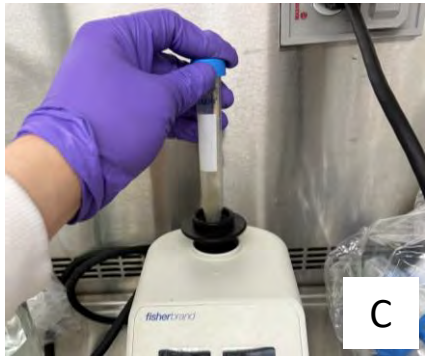
Collection of samples from barn surfaces



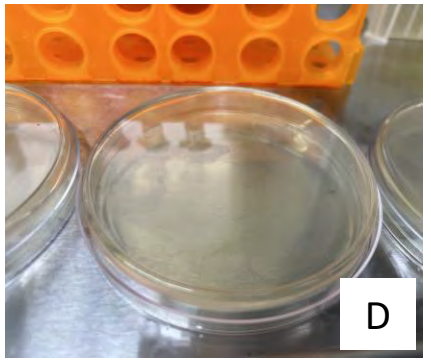
Swabbing on barn surfaces



Contaminated cotton swab in PBS solution



Vortexing of swab samples in PBS solution



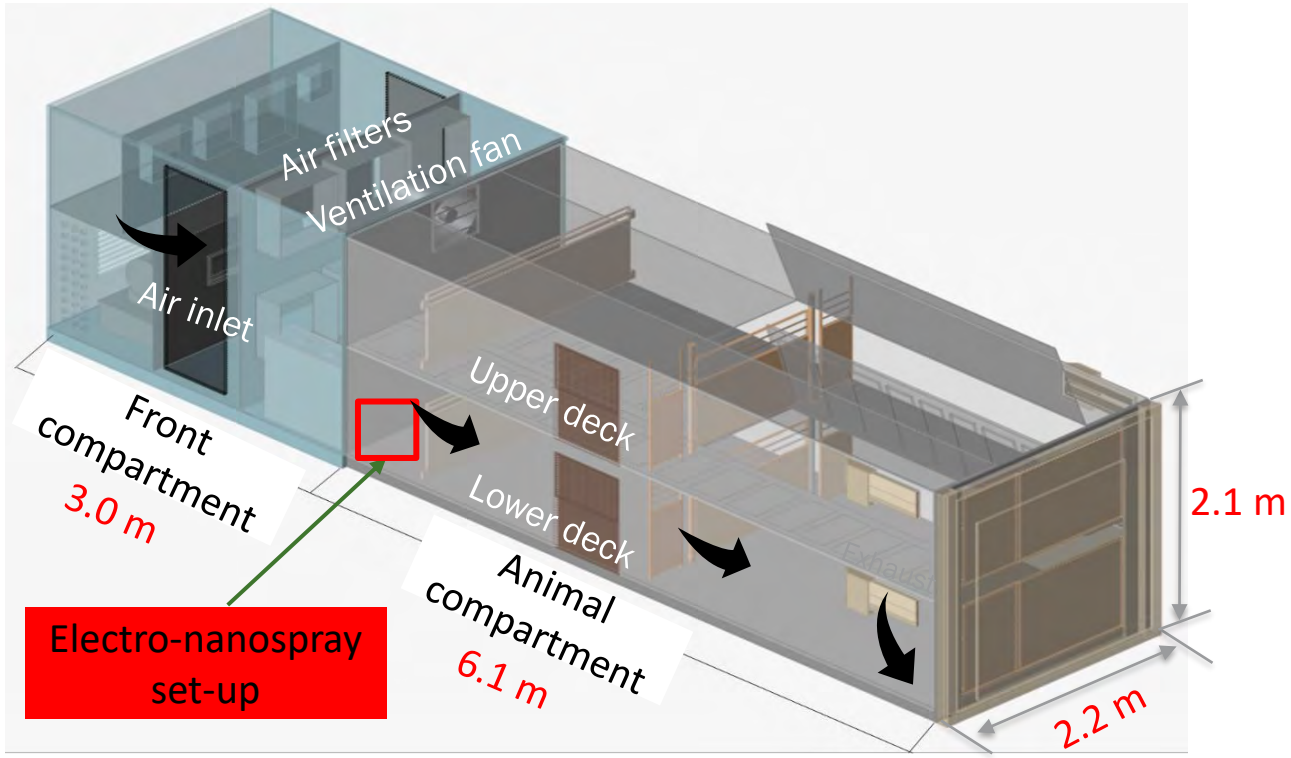
Plating of solution on agar plates

Electro-nanospray: Pilot-scale study (PSCI)

Results	
Parameters	**Reduction (%)**
Airborne microorganisms	18
Airborne dust	16
Ammonia	18
Microorganisms on surfaces: concrete, metal, wood, and plastic	55, 50, 52, and 59, respectively
Pig performance	No negative impact

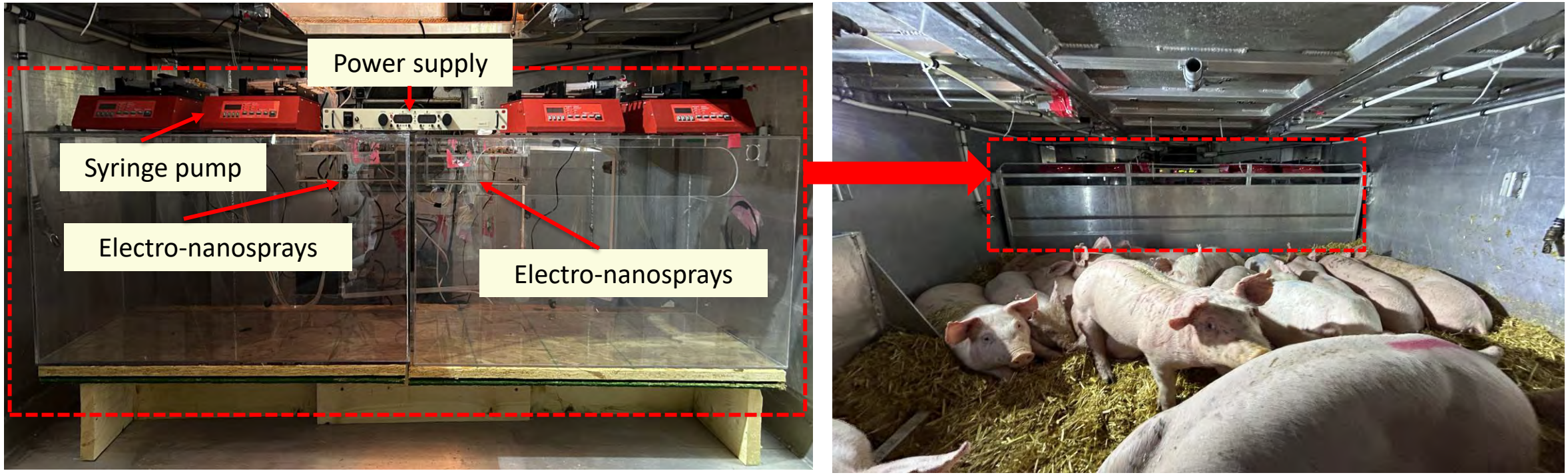
Electro-nanospray: Swine transport trailer

Photo and schematic of the swine transport trailer



Electro-nanospray: Swine transport trailer

Electro-nanospray setup inside the trailer



- 1 control trip and 3 treatment trips to towns around saskatoon
- 40 pigs per trip
- Average duration per trip = 8 h

Electro-nanospray: Swine transport trailer

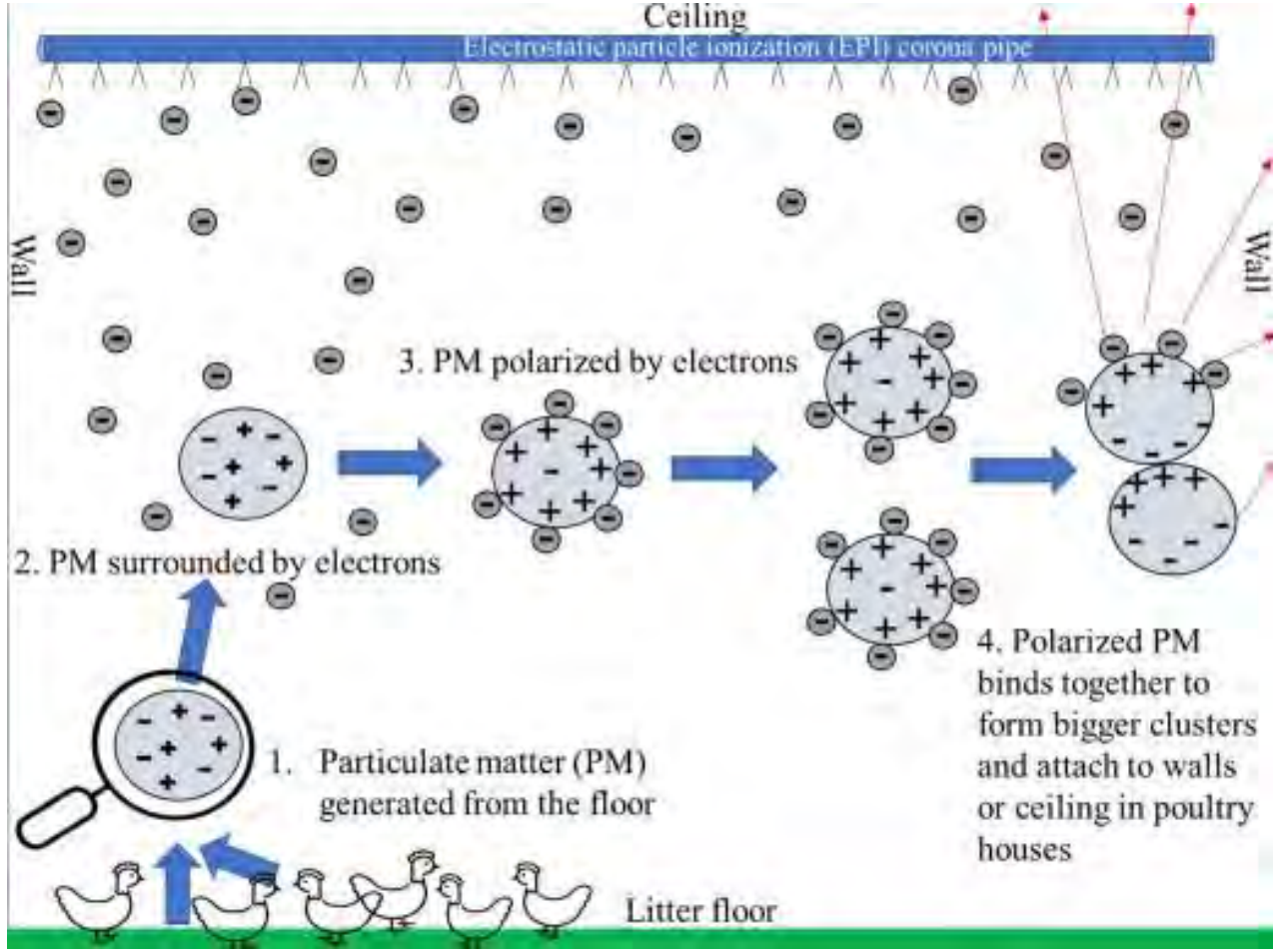
Collection of air and microbial samples inside the trailer

Electro-nanospray: Swine transport trailer

Results	
Parameters	**Reduction (%)**
Airborne microorganisms	30
Airborne dust	24
Surfaces (metal)	82

Introduction- Electrostatic Particle Ionization (EPI)

Mechanism for dust removal by EPI

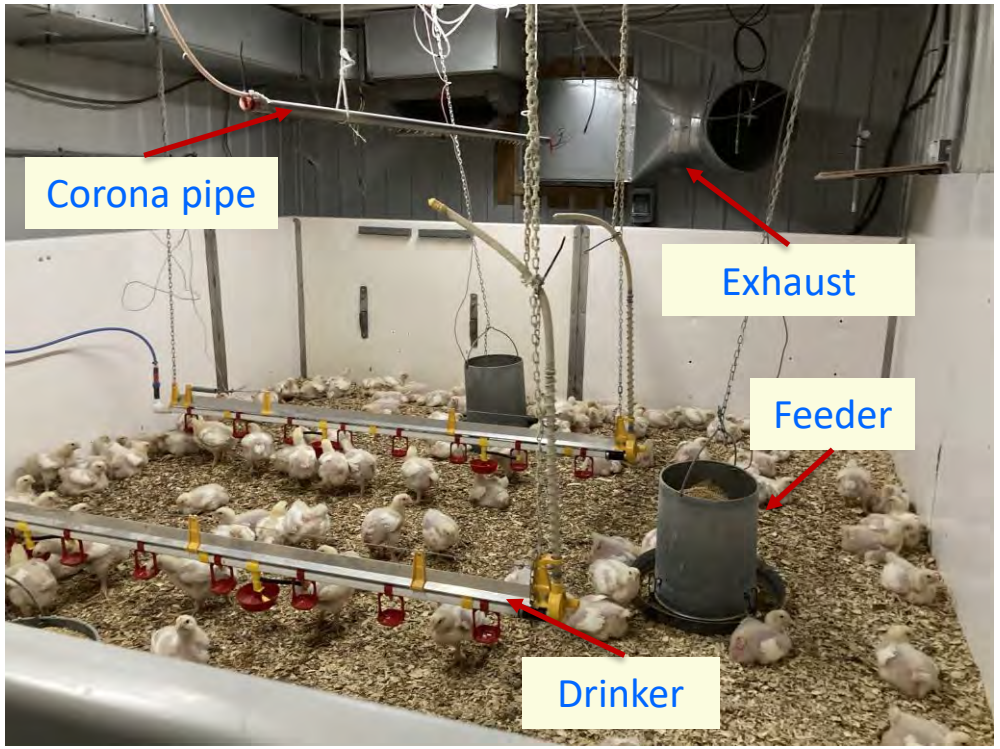


Electrostatic particle ionization (EPI)

- creates a static charge to particles in the air by application of a high-voltage, low-amperage current to a corona pipe
- charged particles are collected on surfaces with opposite charge

Institute for Integrative precision agriculture (IPA), University of Georgia. https://iipa.uga.edu/electrostatic-particle-ionization-technology-for-air-quality-management-in-poultry-houses/

EPI system: Small-scale study (IRDA)



Experimental setup in the treatment room

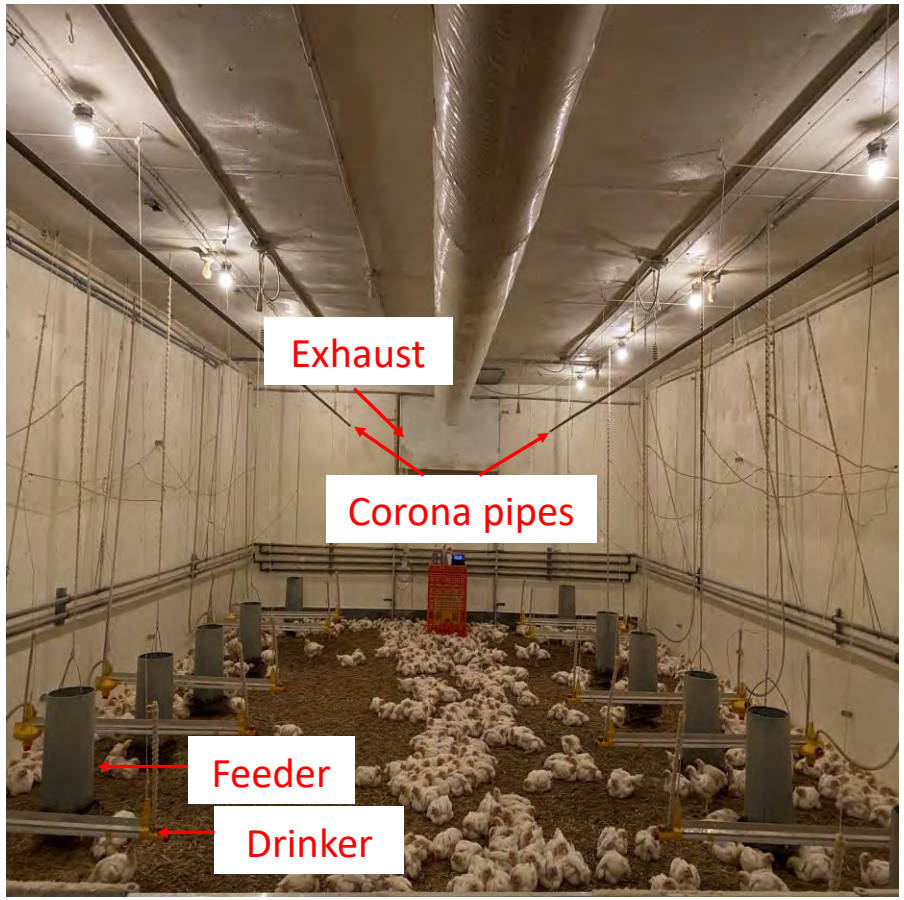
- 1 control room, 1 treatment room
- Room size: 5.2 m × 3.7 m × 2.0 m
- 150 broiler chickens per room
- 2 trials
- Airborne microorganisms, dust, gases, odour

Corona pipe: 1.8 m long and 25 mm OD with 25-mm long stainless-steel corona points

EPI system: Small-scale study (IRDA)

Results	
Parameters	**Reduction (%)**
Airborne microorganisms	57
Airborne dust (PM_1, $PM_{2.5}$, PM_4, PM_{10}, total dust)	39-45
Ammonia	No significant reduction
Odour	50

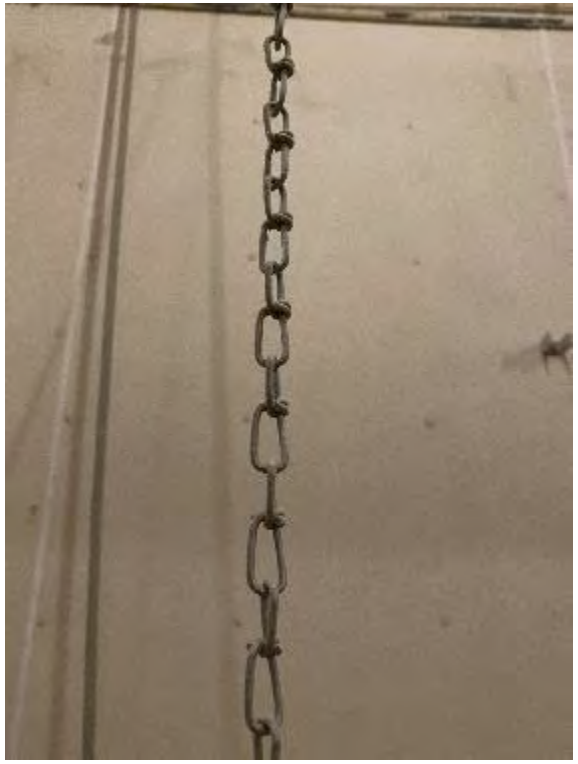
EPI system: Large-scale study (Poultry Centre)



Experimental setup in the treatment room

- 3 control rooms, 3 treatment rooms
- Room size: 11.7 m × 6.4 m × 2.9 m
- 800 broiler chickens per room
- Airborne microorganisms, dust, gases,

Photos – Dust layers



Control room

Treatment room

EPI system: Large-scale study (Poultry Centre)

Results	
Parameters	**Reduction (%)**
Airborne microorganisms	48
Airborne dust (PM_1, $PM_{2.5}$, PM_4, PM_{10}, total dust)	40-50
Ammonia	No significant reduction
Mortality rate	No significant impact
Feed conversion ratio	No significant impact

Conclusions and Outlook

- The electro-nanospray technology can potentially decontaminate pig facilities and other animal barns.
- The EPI system has potential to improve the air quality in broiler houses.
- Further tests are required to optimize both technologies for larger scale productions and to validate their effectiveness, feasibility, and impacts on animal productivity and health of exposed workers prior to their full commercial application.

Acknowledgments - Project Team

- UofS: Lifeng Zhang; Shelley Kirychuk; Huiqing Guo; Karen Schwean-Lardner; Myra Martel; Brooke Thompson; Roger Bolo; Angelo Alluag; Mehdi Foroushani; Felipe Garcia; Jordan Si; Yingjie Yang
- PSCI: Bernardo Predicala; Alvin Alvarado; Marjorette Baguindoc; Sam Gelowitz; Karu Bandaralage
- IRDA: Stephane Godbout; Dalila Larios
- Laval University: Caroline Duchaine; Valerie Letourneau

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- Canadian Centre for Rural and Agricultural Health
- Poultry Research and Teaching Unit- UofS
- University of Saskatchewan
- Chicken Farmers of Saskatchewan (CFS)

Thank you!