Using Computational Fluid Dynamics to Investigate Movement of Antibiotic Resistant Bacteria Within a Dairy Facility

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Abstract

Antibiotic resistant bacteria can survive for a long time and travel long distances if they become aerosolized. Computational fluid dynamics (CFD) is a powerful tool that can help understand how the movement of air affects the transport of bioaerosols and the spread of bacteria. In this research, air flow within a dairy facility was modeled using ANSYS to investigate the transport of antibiotic resistant bacteria. Both simulation and experimental results closely matched and illustrated how bioaerosols can travel via wind throughout the dairy facility.

Antibiotic Resistance

- Kirby-Bauer (KB) test using eight antibiotic disks was performed on bacteria isolated from aerosol and manure samples.
- Antibiotic resistance in aerosol samples were diagonally spread out (Figure 4).
- Bacteria from all manure samples were highly resistant to antibiotics (Figure 5).

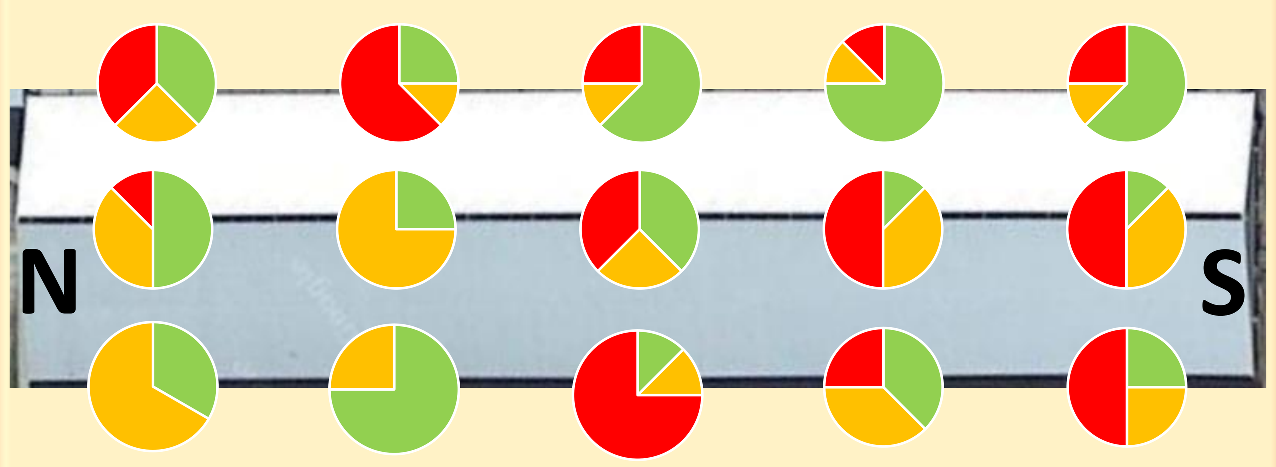

Figure 4. Antibiotic resistance in 15 aerosol samples

Resistant Intermediate resistance Susceptible

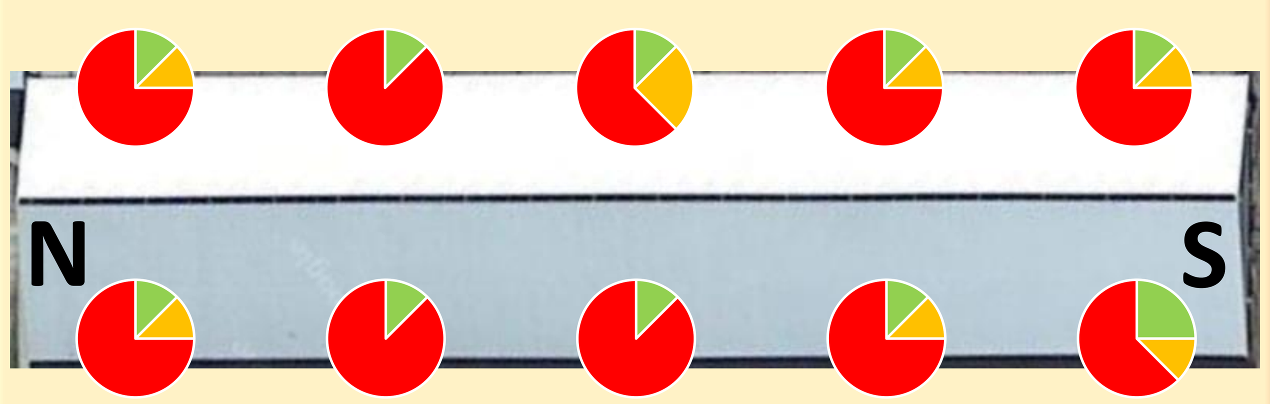

Figure 5. Antibiotic resistance in 10 manure samples

Methodology

Figure 1. Dairy facility in Stephenville. "N" and "S" indicate northern and southern sides.

- Fifteen aerosol samples and ten manure samples were collected (Figure 2).
- ANSYS was used to design a 3D model of the dairy facility.
- Wind was generated from 36 axial fans (9 rows of 4 fans). The fans are tilted downwards at a 15 degree angle.
- Air velocities were measured at the locations of sample collection.

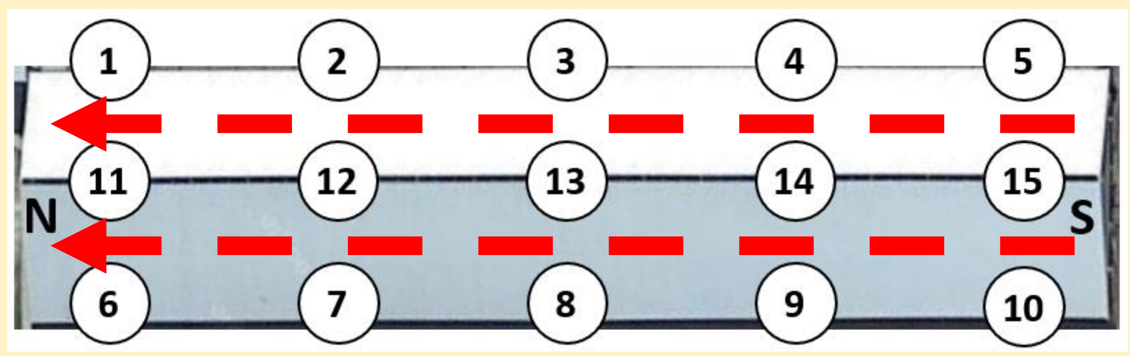

Figure 2. Locations of aerosol and manure collection. Red dashed arrows indicate wind from axial fans.

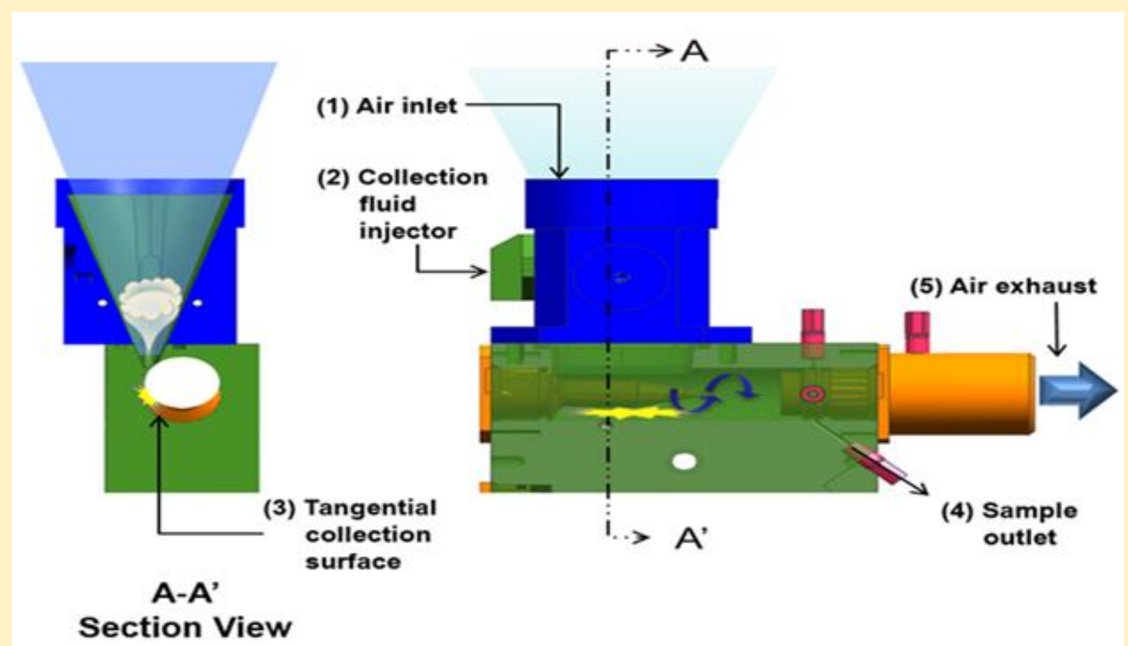

Figure 3. Wetted Wall Cyclone used for aerosol collection

Air Flow Model Using CFD

- Natural ventilation from the environment and wind from axial fans affected the air flow.
- Air velocity data from the CFD simulation closely matched experimental air velocity measurements.

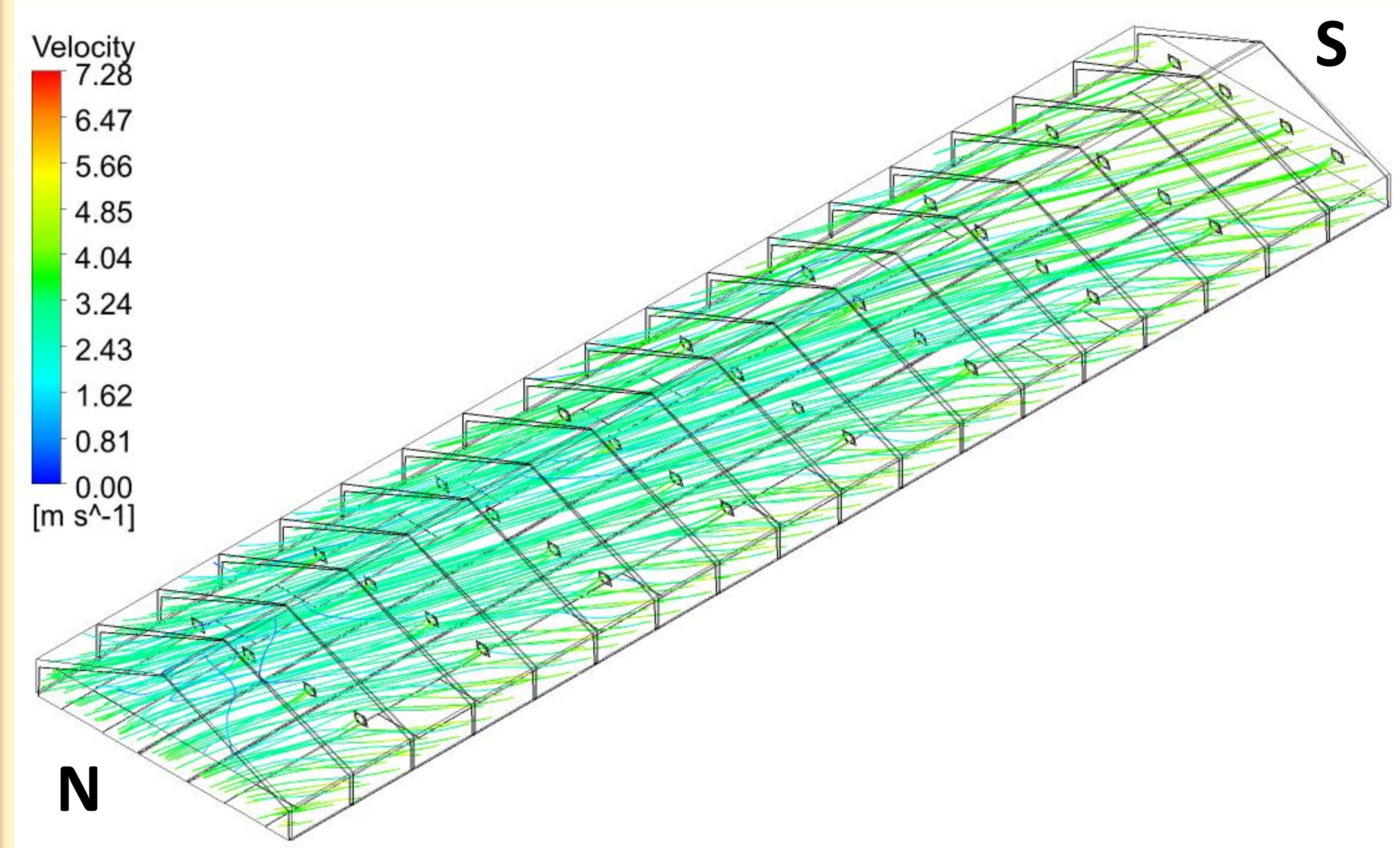

Figure 6. Isometric view of the CFD simulation

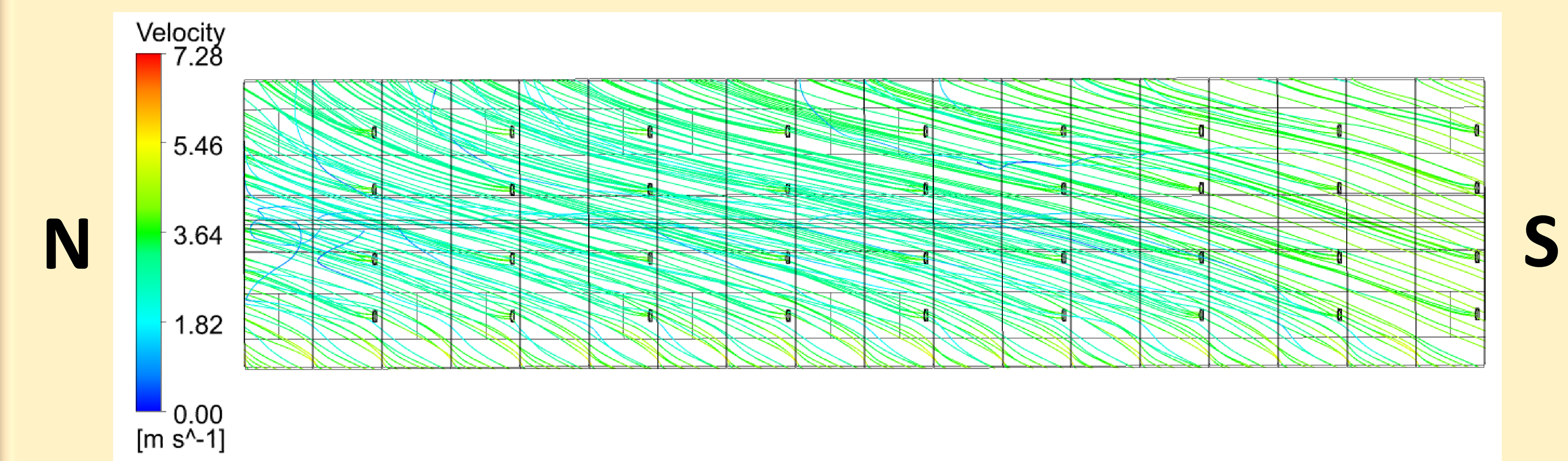

Figure 7. Top view of the CFD simulation

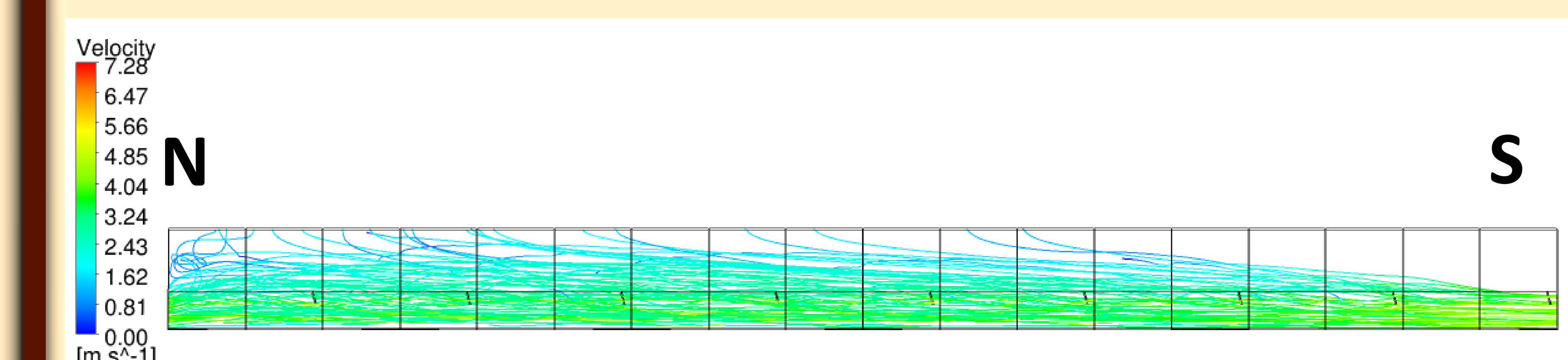

Figure 8. Side view of the CFD simulation

Discussion

- Results from the simulation closely matched the antibiotic resistance map and experimental air velocity measurements.
- The CFD model revealed that air flow had a significant influence on the dissemination of antibiotic resistant bacteria in the dairy facility.

Future Directions

- Different fluid equations and models will be used to improve the accuracy of the CFD model.
- A larger domain will be set up to consider the effects of cows and natural ventilation on the spread of antibiotic resistant bacteria.

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