Field Testing of an Air Filtration System for a Pig Transport Trailer

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SUMMARY

The spread of airborne transmissible disease such as PRRS continues to be a serious threat to the Canadian swine industry as this disease causes significant economic losses to infected herds. This project aimed to develop an additional line of defense against infection of airborne diseases by designing an air filtration system for a swine transport trailer to maintain a pathogen-free environment inside the trailer during transport. Testing and evaluation of the prototype air filtration system showed that the use of antimicrobial filters (i.e., MERV 16 and fabric bag filters) can effectively capture bioaerosols in the air and prevent their entry into the animal compartment of the trailer.

INTRODUCTION

The growth and success of the Canadian pork industry over the past decades depended significantly on access to highly improved genetics. High-value breeding stock produced from nucleus and multiplier farms inevitably would need to be transported to the commercial producers, thus putting these valuable genetic stock at risk of exposure to pathogens circulating in the transit areas. While individual farms have biosecurity procedures to ensure that the delivered animals are not introduced to the herd if infection was detected, the risk of infection of the breeding stock during transport can be significant, particularly during passage through pig dense areas of Quebec, Ontario and Manitoba, where disease outbreaks can still happen despite current biosecurity protocols in place. Thus, it is imperative that measures be developed to protect breeding stock during transport, thereby avoiding infection of these high-value animals and the consequent significant economic loss.

"Air filtration system showed that the use of antimicrobial filters can effectively capture bioaerosols in the air preventing entry into the trailer"

This project's overall goal was to design, develop, and evaluate an air filtration system that can be fitted to a transport vehicle to prevent infection of the high-value breeding stock during transport. The specific objectives were to fabricate and install a prototype system in an actual transport trailer, and evaluate the performance of the filtered trailer system.

EXPERIMENTAL PROCEDURE

An initial design which included an axial fan, air filtration system (pre-filter combined with high-efficiency filter), air inlets, and air exhaust vents with shutter was formulated based on literature review and information gathered from previous and existing filtered trailers. The components were installed on a commercial swine transport trailer (goose-neck trailer with 16' body length, 6'6" width and 6'height). The air filtration components were fitted in the goose-neck area and was operated using a forced-ventilation system (Figures 1 and 2).

The retrofitted trailer was tested for effectiveness in maintaining a pathogen-free environment inside the trailer during operation of the filtration system. A bacteriophage φX174 (ATCC 13706-B1) which is a benign model used as surrogate for pathogenic microorganisms in filtration studies, was used in this test.

During the actual testing and evaluation, the bacteriophage solution was aerosolized in the goose-neck area of the trailer using a fogging equipment. Air samples were collected upstream (inlet side) and downstream the filtration system (inside the trailer) using a 3-piece sampling cassette with mixed cellulose filter (MF-Millipore), and a vacuum pump operated at 2.5 Lpm flow rate. Bacteriophage concentrations collected on the sample filters were determined based on amplification of a specific deoxyribonucleic acid (DNA) sequence in the target organism using quantitative polymerase chain reaction (qPCR).

Two types of air treatment filters were tested: MERV 16 with a pre-filter and antimicrobial fabric bag-type filters. Both types of filters are used in air filtered commercial barn installations.

The concentration of bacteriophage φX174 at the inlet area (upstream side) was reduced significantly ($p=0.002$, $n=9$) after passing through the MERV 16 filter. The average reduction relative to the upstream concentration was about 89.3%; during the tests, a few instances showed that the MERV 16 achieved a 100% reduction in bacteriophage concentration.

The effectiveness of the fabric bag filter in removing bacteriophage in the air is shown in Figure 3. Similar to MERV 16 filter, the fabric bag filters achieved significant reduction ($p=0.02$, $n=3$) in bacteriophage φX174 concentration. Relative to the upstream concentration, the fabric bag filters had an average reduction of about 99.8%.

Figure 1. Commercial swine transport trailer with installed air inlets (inset) for the air filtration system.

Figure 2. Ventilation fan and air filter holder were installed in gooseneck area which was partitioned from the animal compartment of the trailer. Exhaust vents (inset) were installed on both sides of the trailer.

Comparing the percent reduction achieved by the two filter types, MERV 16 filters were not significantly different (p=0.695) from the fabric bag filters.

Based on the information gathered from conducting the tests, a number of recommendations were identified to improve the operation and effectiveness of the system. These included creating more openings in the inlet as well as in the exhaust area to reduce the fan static pressure, installation of an environmental controller for better regulation of the temperature inside the trailer, and installation of a temperature monitoring system and carbon dioxide detection system with alarm function that can be detected in the truck driver cab.

CONCLUSION

Based on the work completed for this project, the following conclusions can be made:

1. Using information available from literature and other resources, various design components can be identified and assembled to develop an air filtration system for an existing commercial swine transport trailer to maintain a pathogen-free environment inside the trailer during transport of animals.
2. Testing and evaluation of the prototype air filtration system showed that the use of antimicrobial filters (i.e., MERV 16 and fabric bag filters) can effectively capture bioaerosols in the air and prevent entry into the animal compartment of the trailer, thereby protecting the animals from potential infection by airborne transmissible diseases during transport.

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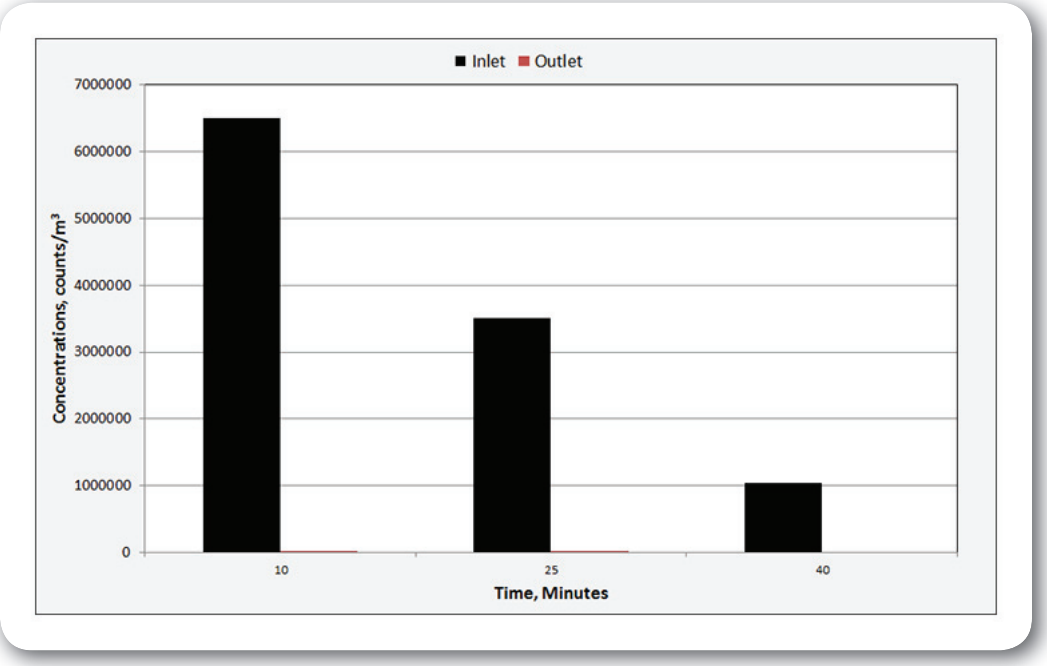

Figure 3. Concentrations of bacteriophage at the upstream and downstream side of the fabric bag filter.