

Design of a Passive Bacteria Filter for HVAC Ducts

Bart Zvitcovich

Freeport High School, Freeport NY USA

Abstract. A current concern within the ventilation systems of skyscrapers and large buildings is the growth of the *Legionella pneumophila* bacteria in air ducts and cooling towers. This aerobic strain of bacteria causes Legionellosis, a respiratory infection leading to Legionnaires Disease and Pontiac Fever. In order to combat this problem, filters alone are insufficient. The apparatus developed in this project sprays a mist of an antibacterial solution which comes in contact with bacteria in the air flow, and is carried with the bacteria through the vent, eliminating the bacteria. In order to test this, a dye-based solution was used on Glo-Germ fluorescent microparticles. Quenching of the small particles by the dye represents a bacteria cell or colony being drenched by an antibacterial solution. Quenching was measured by a change in optical fluorescence intensity. This system was used successfully and quenched about a quarter of the Glo-Germ particles with a single pass.

Keywords: Legionnaires Disease, Bacteriology, Filter, Air Ducts

INTRODUCTION

A current problem plaguing the industrialized world is the flow bacteria through the air ducts within buildings and confined areas. With large buildings, such as skyscrapers, hotels, museums, and factories, an effective filtration system is needed throughout the HVAC (heating, ventilation, and air-conditioning) system. The cooling towers, humidifiers, whirlpools, and other climate control systems within buildings are a common breeding place for the *Legionella pneumophila* bacteria, the cause of Legionellosis [1]. Legionellosis is an illness caused by this bacterium and either resulting in Legionnaires' disease, a severe infection leading to pneumonia, or Pontiac fever, a respiratory illness. First discovered in 1976 at an American Legion gathering in Philadelphia, Pennsylvania, where 221 were affected and 34 died. Since then, the disease has broken out many times in North America, Europe, and Australia; the starting point has frequently been identified as cooling towers and air ducts [2]. Legionellosis is a particular problem as urban governments demand energy-efficient buildings, which rely on recycled air supplies. This experiment tested the concept of using an antibacterial mist to eliminate harmful bacterial from the air supplies in buildings. An antibacterial mist is envisioned as part of a larger system which includes UV lights and filters treated with metallic oxides [3] and antibiotics to attract and kill bacteria.

METHODS

A table-top wind tunnel (model ScanTEK2000 ST180 Aerodynamics Module, LJ Technical Systems, Norwich UK) was used to represent an air duct. An airbrush (model VL Double Action, Paasche Airbrush Corp., Chicago IL USA) was placed near the focal point within the wind tunnel. It sprayed an ethanol based dye into the air flow, which came into contact with Glo-Germ™ powder (Glo-Germ Corp., Moab UT USA). Glo-Germ is a micron-size polymer powder which fluoresces under UV light stimulus. The Glo-Germ powder was used to represent small aerobic bacteria or small colonies flowing through the duct. The dye was used to mask, and therefore effectively quench, the fluorescence of the powder. The Glo-Germ, in some trials along with the dye, was carried to a circular paper filter (Ahlstrom Corp., Helsinki Finland) that was placed on a grid in the wind tunnel. The filter was removed and digitally photographed before and after quenching. Photoshop (version CS3, Adobe Corp., San Jose CA USA) was used to quantify the fluorescence levels. Approximately 90% of each filter image was selected with an ellipsoidal region of interest, averaged, and converted to grayscale. The grayscale values were recorded as percentages.

RESULTS

Figure 1 shows clusters of Glo-Germ particles collected on filter papers. The picture prior to quenching shows high concentrations of small glowing particles. After quenching, fewer Glo-Germ particles are glowing. Grayscale values were found to be 59% for unquenched trial, and 73% for the quenched trial, a 24% decrease in fluorescence.

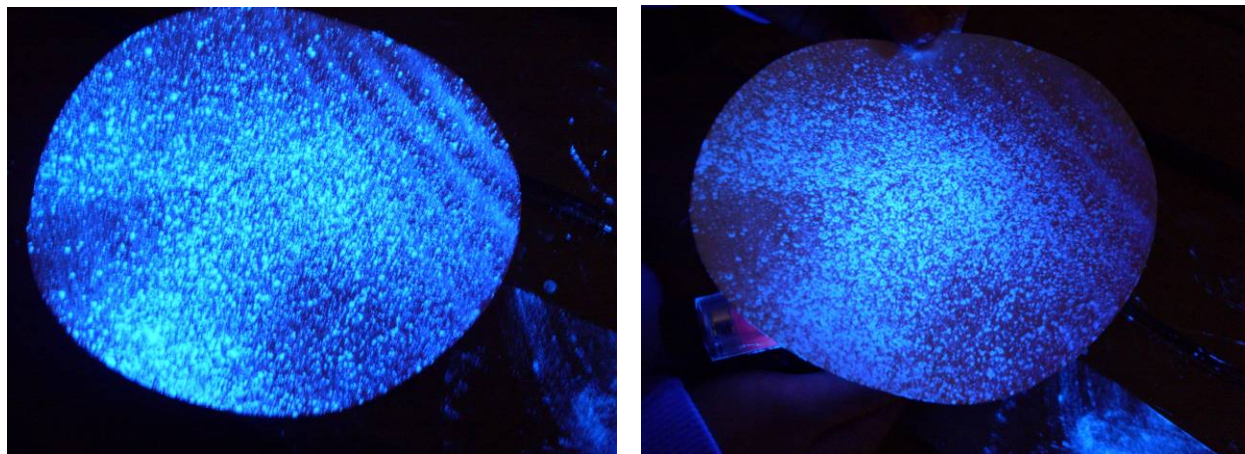


Figure 1. Photo on the left is an unquenched filter paper and the photo on the right is a quenched paper exposed to the dye solution. The differences in the concentrations of unquenched Glo-Germ on the outer part of the grouping exhibit the possible effectiveness of this system.

DISCUSSION

If this pilot project were to be scaled to an apparatus which sprays an almost continuous mist of antibacterial solution, eventually a puddle of the liquid would form after being carried through the vent. In order to stop the movement of liquid, a sharp turn to the left, right, or upwards in the vent will allow air to move but the liquid will fall into a pan at the designated turning point. From here the liquid could be captured and either recycled or discarded. This precaution prevents the liquid from traveling out the vent and onto the floor of the building, but allows for sufficient exposure to the possible contaminated air. This filtration system can also utilize metallic oxides, such as aluminum, zinc, or iron oxides, on the filter. There has been proved bacterial adhesion to such surfaces, making the effective filtration level higher without decreasing the airflow further [3]. To test an entire bacterial filtration system, a benign phosphorescent bacterial strain could be used. The effectiveness of the system could be monitored by the brightness of cultures of filtered bacteria.

CONCLUSIONS

In a model system of bacteria flowing through an airduct, a sprayed liquid antibacterial agent was found to be effective at eliminating a quarter of the bacteria. Antibacterial sprays in HVAC systems might be used effectively to prevent the spread of *Legionella pneumophila*.

ACKNOWLEDGMENTS

The author acknowledges the advice and assistance of Dr. R. Muratore of Freeport High School.

REFERENCES

1. Mayo Clinic Staff. Legionnaires disease. Mayo.clinic.com. Pub: Dec 10, 2008. Visited: 10/15/10. <http://www.mayo.clinic.com/health/legionnaires-disease/DS00853>.
2. Wikipedia, The Free Encyclopedia. Legionellosis. Visited 10/7/09. <http://en.wikipedia.org/wiki/legionellosis>.

3. Bacterial adhesion to glass and metal-oxide surfaces. Baikun Li and Bruce E. Loganb. Colloids and Surfaces B: Biointerfaces 36 (2004) 81–90.