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Study to Investigate the Existence of Secondary Contamination on AHU HEPA Filters at a School of Public Health

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Abstract

A study to determine the effectiveness of HEPA filtration against bacteria in a public health institutional building ventilation system is presented. HEPA Filters in air handlers at the School of Public Health of a top Ivy League school were analyzed to determine if bacteria was propagating from the upstream side, through the filter to the downstream side, known as “secondary contamination.” Existing traditional HEPA filters, which had been in continuous operation for six years, were analyzed and “secondary contamination” was found. These filters were replaced with a mix of traditional HEPA filters and anti-microbial Enzymic HEPA filters and were analyzed after seven months of continuous operation. Scanning Electron Microscope (SEM) pictures of the filter media upstream, interior and downstream are presented. Sample analysis has determined that secondary contamination occurred in the replacement traditional HEPA filter in as little as seven months, while no such secondary contamination occurred through the Enzymic HEPA filter.

Introduction

Concerns over indoor air quality (IAQ) in public buildings continue to evolve in parallel with the geo-political, biotechnological and social landscape. Whether attention stems from fear of a bio-terrorism attack in a city, increased visibility of drug-resistant bacteria and TB, or the co-mingling of citizens who have recently traveled from abroad, public concern will continue to rise.

HEPA air filters in building Air Handling Units (AHUs) have long been assumed to provide ample protection against airborne contaminants, including bacteria. Recent finding indicate that bacteria is able to migrate through traditional HEPA filters in as little as 3-4 months. This migration is called “secondary contamination” and not only renders HEPA filters ineffective against bacteria, but worse, these HEPA filters become *contamination sources*.

Antimicrobial air filtration solutions do exist, however, they are seldom employed and are generally treated with antimicrobial surface coatings, which can become coated with debris and rendered ineffective.

A study is necessary to prove the existence of “secondary contamination” in AHU HEPA filters and validate an acceptable solution. If “secondary contamination” exists, institutions may opt to improve their air filtration strategies.

Schools of Public Health are an excellent test bed for verifying the existence of secondary contamination. These buildings make ample use of HEPA filtration, conduct biological experiments, house laboratory animals and unite diverse peoples who may have recently traveled from around the world.

Objectives

- (1) prove the existence of microbial secondary contamination in AHU HEPA filters used continuously for more than six years
- (2) prove the existence of microbial secondary contamination in AHU HEPA filters used continuously for as few as seven months
- (3) confirm the efficacy of Enzymic HEPA filters at eliminating secondary contamination in AHU HEPA filters

Methodology

The initial round of analysis involved the existing HEPA filters, which had been in continuous use for approximately 6 years, in two 5x5 AHU filter banks. Media samples were aseptically cut in a square (5cm x 5cm or greater) from the center of the filters located in the middle of the 5x5 filter bank. Samples were packaged in a sterile bag that was sealed inside a plastic zip-lock freezer bag and sent to Nikki-Universal Co. Ltd. (NU). NU took Scanning Electron Microscope (SEM) photographs of the media at the upstream, interior and downstream locations. SEM Model: JSM-5300, Jeol Ltd.

All fifty HEPA filters were replaced with twenty-five traditional HEPA filters commingled with twenty-five Enzymic HEPA filters. After seven months of continuous use, one of each filter type was removed and samples were again taken and sent to NU for SEM analysis.

Results

Phase 1 – Analysis of Existing HEPA Filtration (in use for six years)

Figure (1) contains all photographs of the samples taken from the original HEPA filter, which had been in operation for approximately six years.

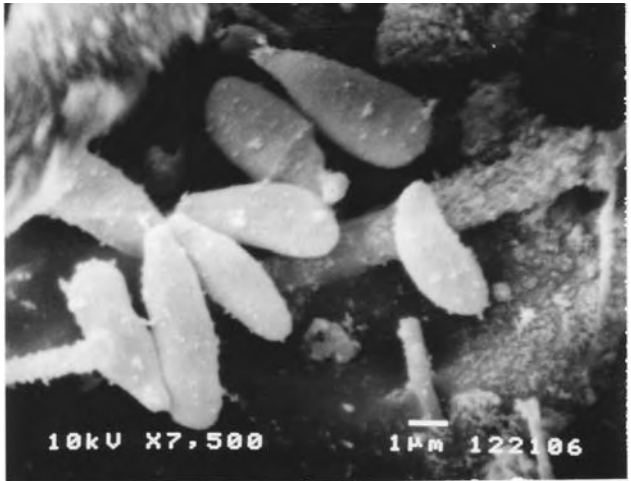
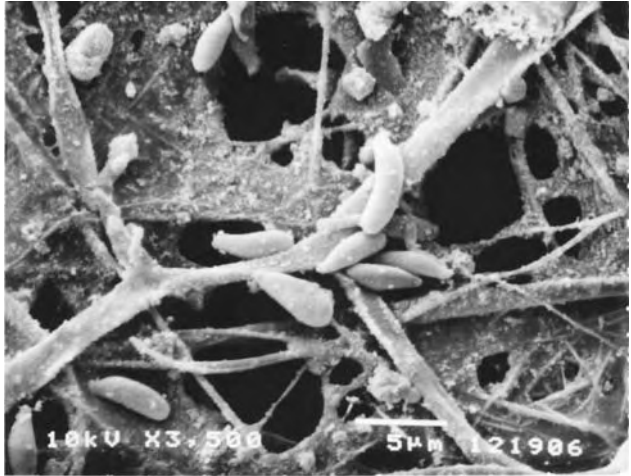
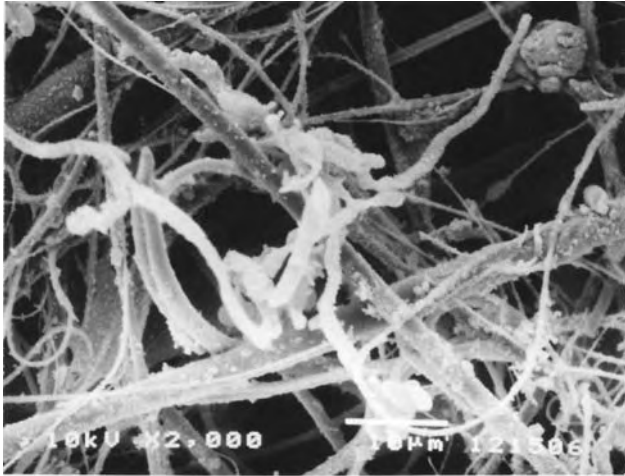
The upstream face of the filter is contaminated with various amorphous debris and distinct micro-organisms.

The interior of the filter exhibits a reduced amount of particulate debris, however, microorganisms are present, which have grown from the upstream face of the filter.

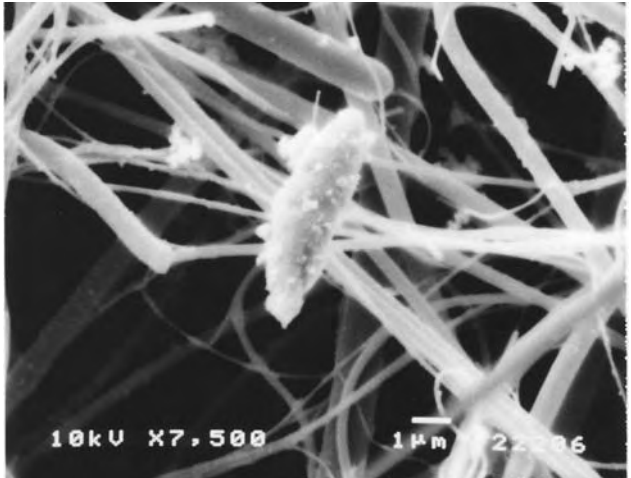
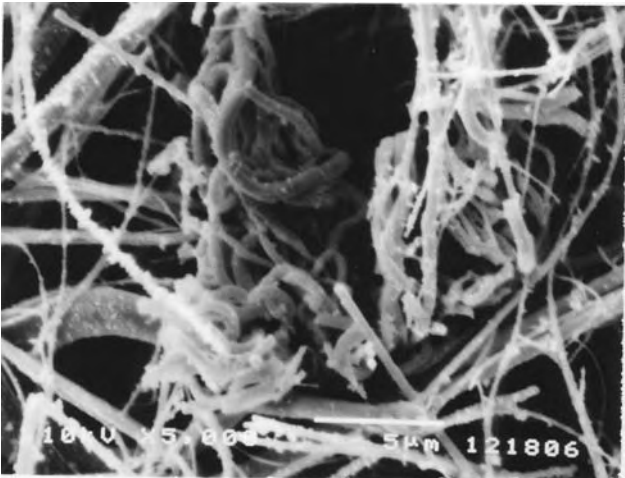
The downstream filter face shows a miniscule amount of particulates. Microorganisms are present and have grown through the filter from the upstream face. These microorganisms now have access to the clean side of the filter; Secondary Contamination has occurred.

Figure (1) Traditional HEPA Filter After Six Years of Continuous Use

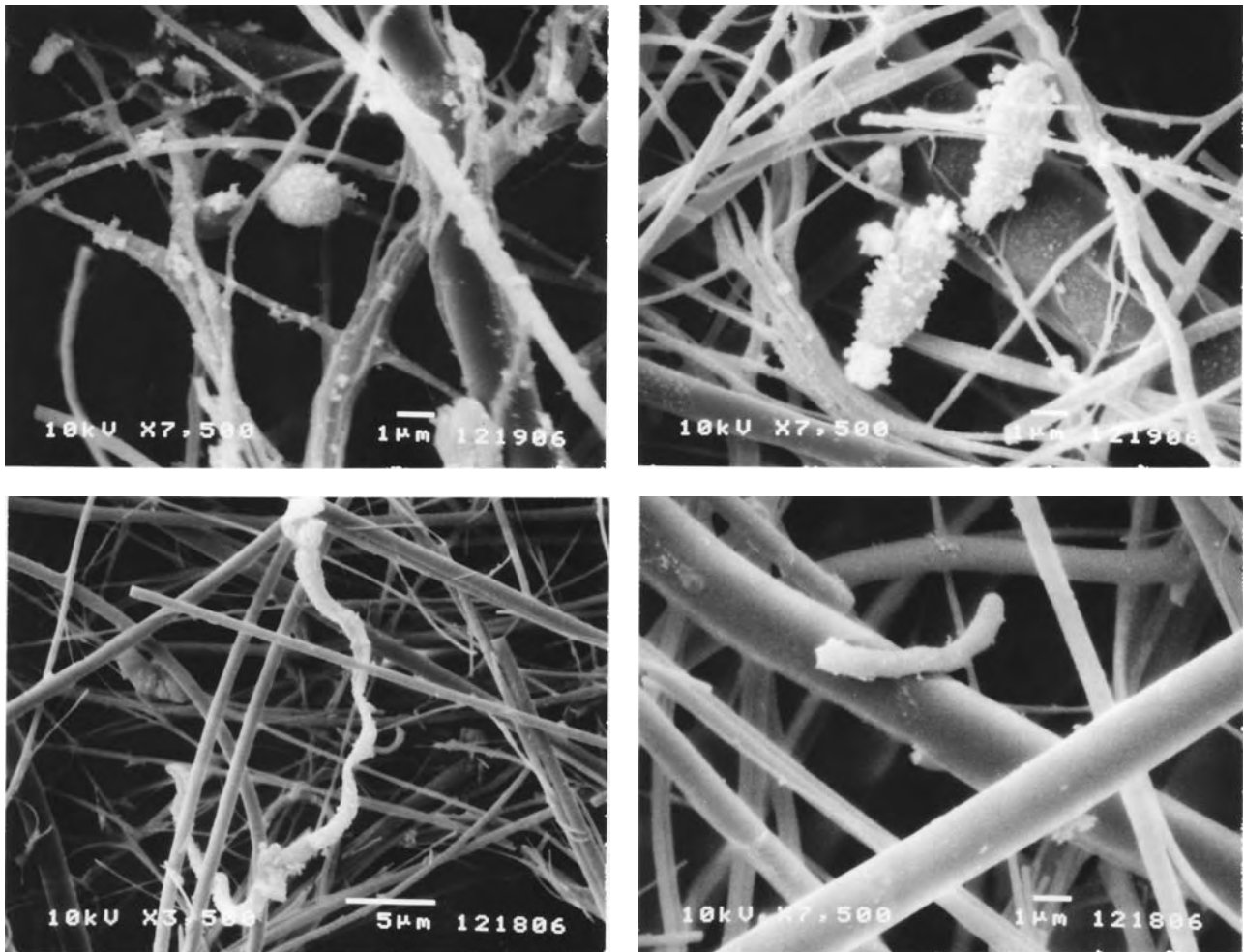
Upstream



Interior



Downstream



Phase 2 – Analysis of Replacement Traditional HEPA & Enzymic HEPA Filtration (in use for 7 months)

Figure (2) shows all SEM photographs of the upstream face of the replacement traditional HEPA filter. There are very fine particulates, less than 1 micron, found on the upstream face of the conventional HEPA filter.

Bacteria, fungal spores and yeasts are observed on the upstream face of the conventional HEPA.

Figure (2) Replacement Traditional HEPA Filter After Six Months of Continuous Use

Upstream

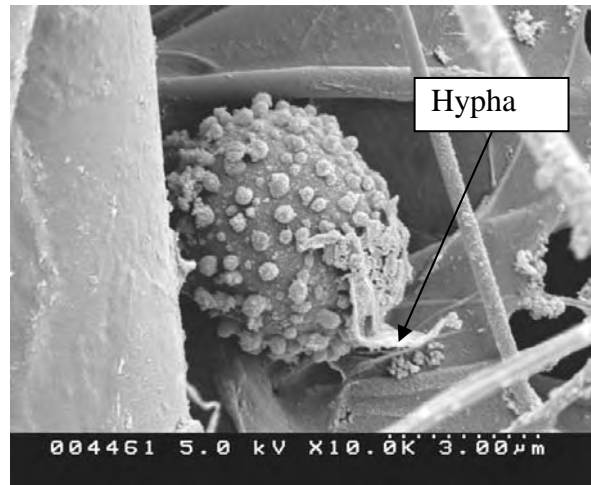
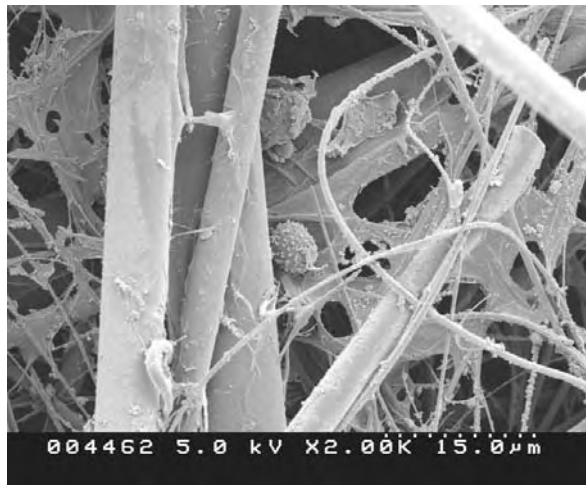
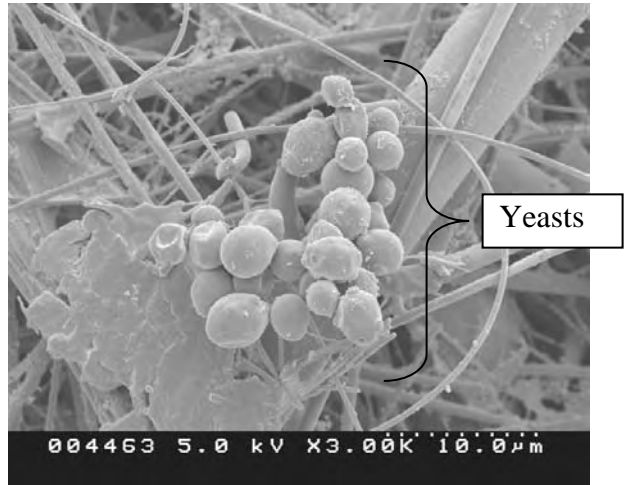
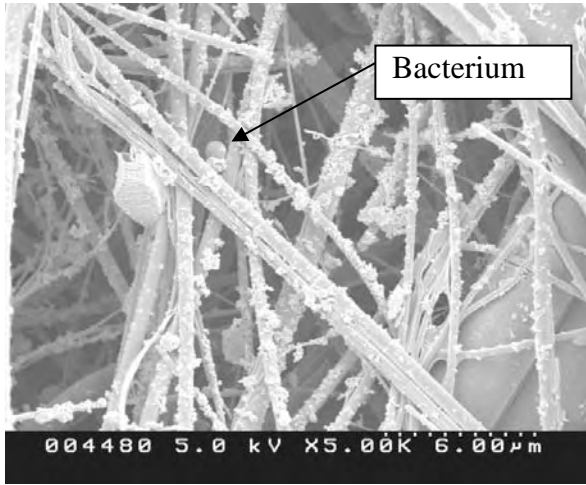
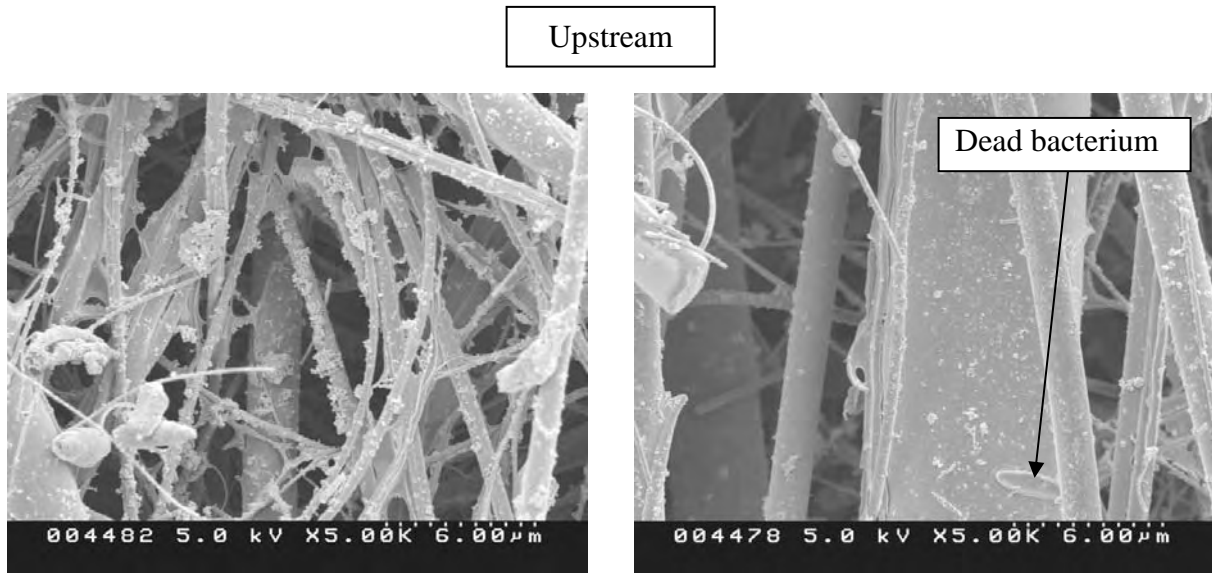
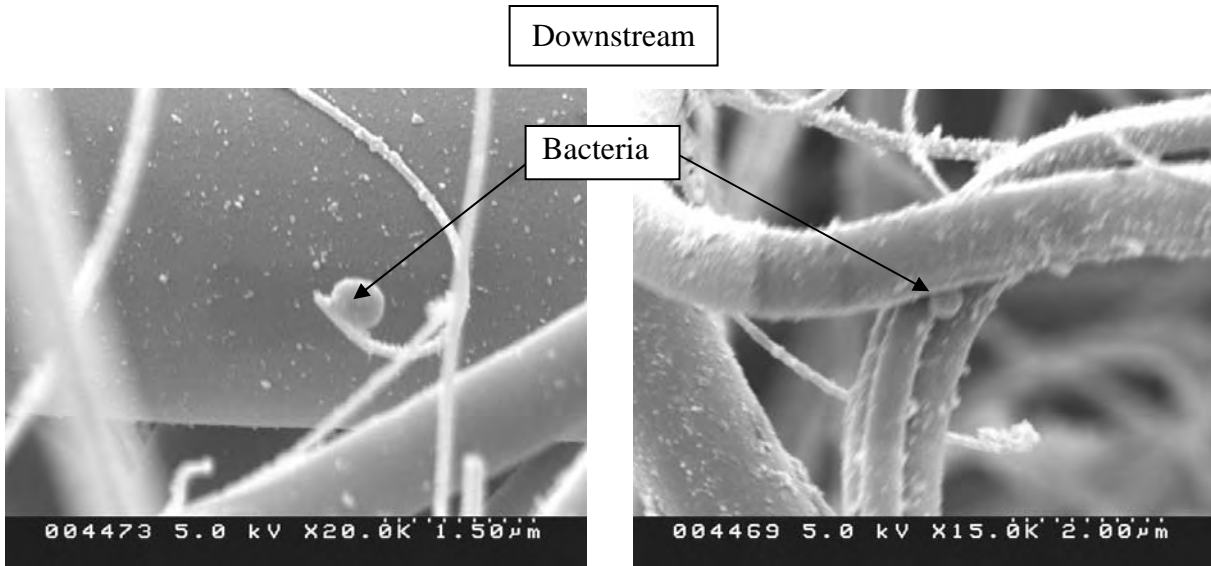


Figure (3) Replacement Enzymic HEPA Filter After Six Months of Continuous Use



Dust distribution on the Enzymic HEPA filter is the same as on the conventional HEPA, but the remains of dead bacterium are present. The cell wall of the bacteria has collapsed due to the lytic enzyme action. No living bacteria is observed.

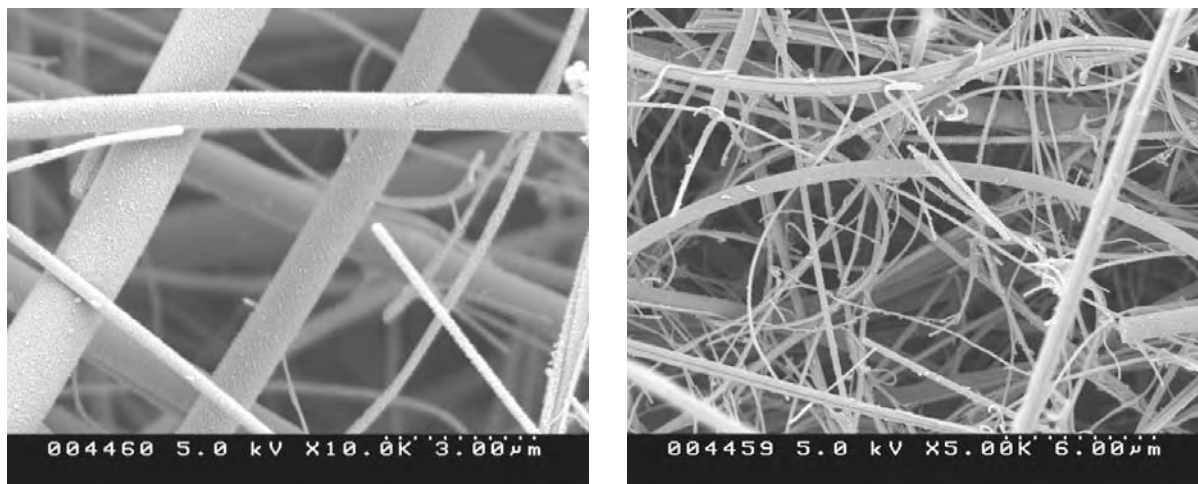
Figure (4) Replacement Traditional HEPA Filter After Six Months of Continuous Use



Bacteria are observed on the downstream face of the conventional HEPA indicating that secondary contamination has already started.

Figure (5) Replacement Enzymic HEPA Filter After Six Months of Continuous Use

Downstream



The downstream face of the Enzymic HEPA filter does not contain any bacteria or noticeable particulate presence.

Conclusion

Traditional HEPA filters under continuous operation for six years in the air handling units of a School of Public Health at a major university were found to be a contamination source of bacteria, fungal spores and yeasts. Living bacterium were discovered on the upstream face and migrated through to the downstream face of these six year-old HEPA filters resulting in secondary contamination.

New replacement HEPA filters also demonstrated secondary contamination after just seven months.

There was no such secondary contamination on the Enzymic HEPA filter after seven months. No living organisms were found on the Enzymic HEPA filter at all. Dissolved bacteria was found only on the upstream filter face media.

In summary, institutions and facilities managers need to re-analyze their air filtration strategy to determine if bacteria mitigation is important. If it is, then standard HEPA filtration is insufficient for periods greater than seven months, and an antimicrobial HEPA filtration solution such as the Enzymic HEPA filter should be employed.