COMPARISONS OF MICRO-ORGANISM LOADING FROM TWO AIR FILTER MATERIALS DURING THE FIRST EIGHT WEEKS OF SERVICE LIFE

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ABSTRACT

As part of an ongoing investigation on service life of air filtration material, a new type of air filtration material (multi-layered polymer) was compared with a widely used material to determine growth or survival of micro-organisms after normal dust loading. Blinding was performed by the manufacturer supplying the materials as anonymous "A" and "B". Micro-organisms were extracted after 2, 4, 6, and 8 weeks by washing (shake out) and plating the solution onto agar media, incubated and differentiated. Vital fluorescence microscopy was also performed. The results showed a significant difference ($P \leq 0.000$) between filter materials with a higher amount of total micro-organisms extracted from Material A than B after two weeks. The highest total Fu count was extracted from Material A after two weeks. The difference between the two materials was still significant ($P \leq 0.04$) after 4 weeks. After this period, the difference becomes smaller with time and appears to be heading towards an equilibrium point at around 8 weeks service. After mycological differentiation, the range in fungi was also greatest on Material A with 13 genera identified while only 9 genera were identified on Material B. Fluorescence microscopy of the shake out solution revealed more living and growing fungi on Material A than on B. The experiment showed that the type filter material had the greatest influence on survival of micro-organisms during the first 4 weeks. Increased service time appears to equalise the difference between materials.

INTRODUCTION

The heating ventilation and air conditioning (HVAC) systems supplying indoor spaces are often proposed as both a potential distributor of pollutants and as a source of pollutants from components such as cooling towers, air filters, cooling coils and duct work[1].

Regarding all the various components of HVAC systems, the air filters are becoming an increasing singular concern to indoor air quality research which is due to their main function which is to accumulate both animate (micro-organisms) and inanimate (dust) airborne particles[2]. The potential problem is that normal outdoor dust contains particles that could act as nutrients for the high numbers of micro-organisms also normal in the outdoor air. The question facing researchers now is service life, that is: "how long can filter material be allowed to accumulate material before the filters begin to contribute to poor air quality or cause health effects"[3].

The question of how long a filter material should be allowed to accumulate dust (service life) is not well defined as it is difficult to test in situ. Current methods of determining service life

by measuring air pressure drop over the filters do not take into account possible contamination from micro-organisms and their potential adverse health effects[4].

The most commonly found micro-organism on air filters are fungi and Bacteria followed to a much lesser degree by algae and protozoa. Of these, fungi and bacteria seem able to survive and can even grow given the right conditions and produce spores and other contaminants. While fungi and bacteria appear in similar quantities, fungi are a much greater concern as they produce a significantly greater accumulation of biomass on air filters because they are much larger in size than bacteria[5].

The experiments concerned in this investigation were designed to provide an answer to the question of which of two air filtration materials will reduce the growth or survival of micro-organisms after normal dust loading conditions.

METHODS

The experiment measured the amount of micro-organism extracted from two different unused air filter materials after 2, 4, 6, and 8 weeks periods of exposure (service life). The two filter types were chosen by the manufacturer and were delivered as anonymous materials "A" and "B" to ensure "blinding" of the experiment to our laboratory.

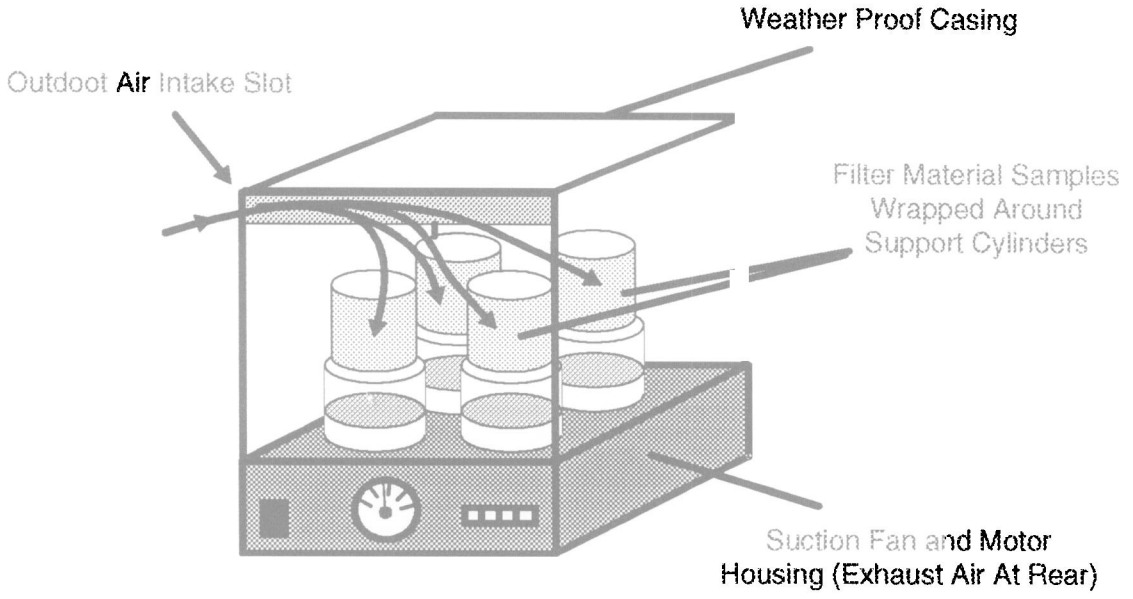

Figure 1 Schematic Diagram of Airotester (After Müller 1998 [5])

Materials A and B were exposed simultaneously in a simulated filtering device known as an Airotester (see Fig.1). Both materials received the same conditions which allowed a direct comparison to determine which has a greater influence on growth and survival of micro-organisms. The Airotester units were positioned on the roof of the Institute for Hygiene, adjacent to the permanent meteorological and pollen counting station. The start date of the experiments was in the second week of March 1998 and continued for 10 weeks until June 1998.

Samples from the filter material were washed out and the solution plated onto agar media (Shake Out Method). Fungal and bacteria colonies were counted and reported as the number of colony forming units per square metre of filter material (cfu/m^2) and differentiated as bacteria, moulds, and yeasts. Moulds were also differentiated to genera level. Duplicate and parallel samples were also checked for repeatability of the results and no significant differences were found. Fluorescence microscopy was performed directly on the filter materials and on the wash solution from the above mentioned samples.

RESULTS AND DISCUSSION

Table 1 Colony Forming Units of Yeasts, Moulds, Bacteria and Total Micro-organisms extracted from Both Filter Types (cfu/m^2)

	Filter type	Week 2	Week 4	Week 6	Week 8
Yeasts	A	48 000	32 000	48 000	32 000
	B	225 000	112 000	209 000	0
Moulds	A	4 879 000	2 263 000	2 552 000	2 921 000
	B	2 247 000	1 653 000	2 744 000	2 760 000
Bacteria	A	2 905 000	1 509 000	2 456 000	2 600 000
	B	2 022 000	1 140 000	2 616 000	2 407 000
Total Micro-organisms (yeasts + moulds + bacteria)	A	7 832 000	3 804 000	5 056 000	5 553 000
	B	4 494 000	2 905 000	5 569 000	5 168 000

Shake Out Results: The results showed a significant difference ($P \leq 0.000$) between filter materials with a higher amount of total micro-organisms extracted from Material A than B after two weeks (see Table 1.). The highest total cfu count of 7.8 million cfu/m^2 extracted from Material A after two weeks. The difference between the two materials was still significant ($P \leq 0.04$) after 4 weeks. After this period, the difference becomes smaller with time and appears to be heading towards an equilibrium point which appears to have more to do with the dirt loading than the filter materials themselves.

In the breakdown into micro-organism groups, higher levels of moulds and bacteria were extracted from Material A. Figure 2 shows the differences between the types of micro-organisms on filter material B. Higher amounts of yeasts were extracted from material B, however the amount of yeasts extracted at all were significantly lower than the other two groups of organisms by 1 or 2 orders of magnitude. Yeasts were also not present on Material B after 8 weeks. Bacteria numbers peaked at week 2 on both filter types. Mould numbers peaked on Material A after 2 weeks but peaked after 6 weeks on Material B. The moulds also showed highest number of organisms for the whole experiment with 4 800 000 cfu/m^2 extracted from Material A after 2 weeks.

Mycological Differentiation: After mycological differentiation, the range in fungi was also greatest on Material A with 13 genera identified while only 9 genera were identified on Material B (see Table 2). Material A allowed more environmentally sensitive fungi to grow or survive while Material B allowed only those species commonly found to grow or survive. The Material B also supported ruderal fungi but only at 4 weeks.

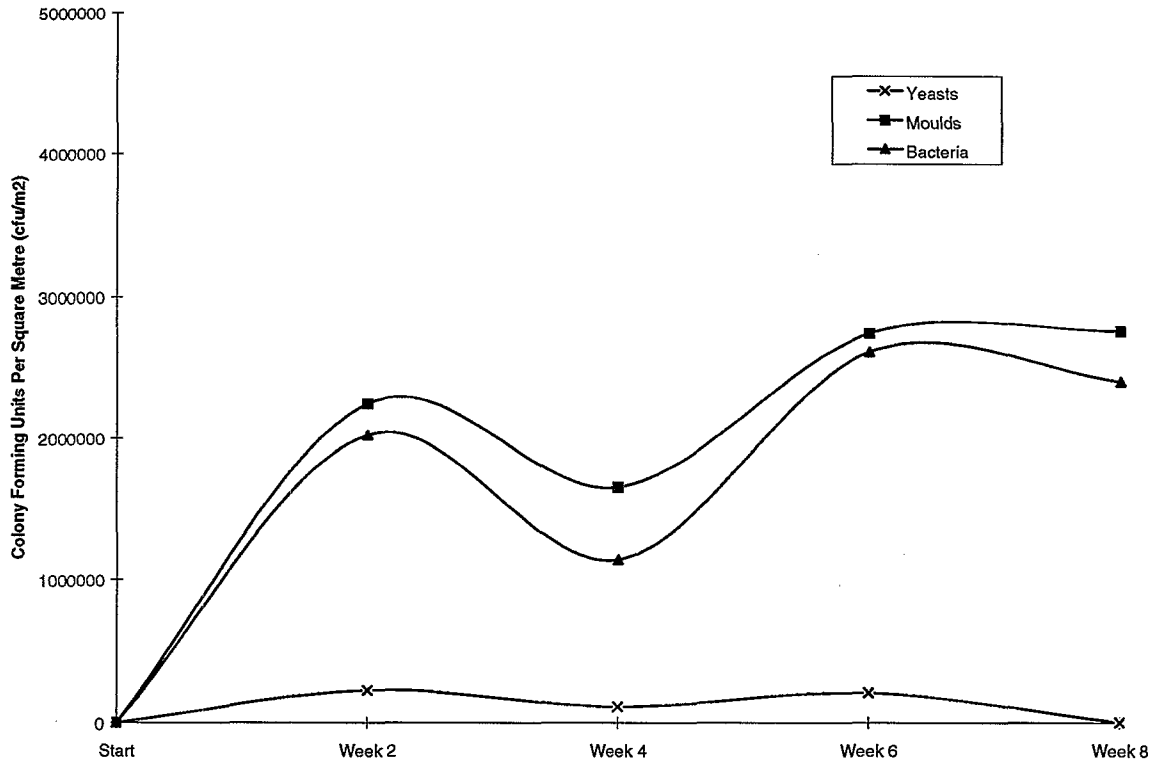

Figure 2 Filter Material B: Average Yeasts, Moulds and Bacteria Over 8 Weeks

Fluorescence Microscopy: Microscopy of the shake out fluid revealed more living fungi were identified on Material A than on B. Material B only yielded lower numbers of observations of viable spores or conidia and several viable yeast cells. However, the observations on Material A allows the following commentary on the state of health of the micro-organisms on that material:

- After week 2 on Material A: living hyphae were observed at a stage of advanced growth after germination from a spore or conidia and were fully vital and showed this fungus was taking nutrients from its environment.

- After week 4 on Material A: clumps of material captured by the filter materials had a number of living spores attached and shows the potential for other particles to act as nutrient or moisture sources to aid in the survival of fungal spores and conidia.

- After week 6 on Material A: a branching separated hyphae showed a fungi at an advanced stage of development and growth. Vital staining confirmed the hyphae were living and healthy but were searching or starvation hyphae elongating (after exhaustion of a nutrient source) in order to secure new nutrients at some distance from the original source.

Results from the fluorescent microscopy show that more living fungi were identified on Material A than on B which supports the previous conclusions from the shake out and fungi differentiation results.

Table 2 Fungal Genera found on both filter materials

	Filter Material	A				B			
	Week	2	4	6	8	2	4	6	8
Fungal Type	**Genus**								
Non Sporulating	Sterile Mycelia	✓	✓	✓	✓	✓	✓	✓	✓
Common Fungi	*Aspergillus spp.*	✓	✓	✓	✓	✓	✓	✓	✓
Can grow in a wide range of conditions	*Botrytis spec.*	✓	✓	✓	✓	✓	✓	✓	✓
	Cladosporium spp.	✓	✓	✓	✓	✓	✓	✓	✓
	Penicillium spp.	✓	✓	✓	✓	✓	✓	✓	✓
	Alternaria spp.	✓	✓	✓		✓	✓	✓	✓
Uncommon Fungi	*Epicoccum spp.*		✓	✓			✓	✓	
Require special conditions	*Chaetomium spec.*			✓					
	Neurospora spp.	✓	✓						
	Paecilomyces spp.			✓					
	Trichoderma spp.			✓					
	Trichothecium spec.		✓						
	Ulocladium spec.			✓					
Ruderal Fungi	*Rhizopus spp.*						✓		
Require simple structured nutrients	*Mucor spec.*						✓		

CONCLUSIONS

The experiment was successful in showing that the type filter material had the greatest influence on survival of micro-organisms during the first 4 weeks, but that increased time equalises the difference between the materials.

The apparent equilibrium in cfu numbers after four weeks service life is more likely due to the dust loading on the filters rather than the filter material itself. That is, a point is reached where the amount of micro-organisms entering the filter more or less equals the sum of micro-organisms dying on the filter plus the micro-organisms reproducing on the filter.

The fungal differentiation and fluorescent microscopy showed that Material A may provide a better micro-environment for the survival of fungi. This is illustrated by the much larger range of fungal genera that were identified from Material A; by several sensitive genera which require special conditions for survival or growth on material A; and by vital fluorescent staining showing fungi living and surviving in healthy condition. Material B on the other hand only allowed those species commonly found on filters to survive or grow, and only spores or conidia were observed surviving on the material.

Compared to Material A, the new type of air filtration material (multi-layered polymer) that was Material B appears more suitable for use in HVAC systems as the material itself appears able to reduce the growth or survival micro-organism and reduces the range of fungal genera.

AKNOWLEDGEMENTS:

Funding for this project was provided by Scandfilter AB, S-51285 Svenljunga, Sweden. Extra help in fungi differentiation and interpretation of results was also performed by Prof. Gernot Lysek, Michael Hesse, Ulrike Kircheis and Berit Müller of the Institut fur Hygiene, Umweltmedizin und Arbeitsmedizin, Freie Universität Berlin, Hindenburgdamm 27, D-12203 Berlin, Germany.

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