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UVc-disinfection of air borne microorganisms by BÄRO disinfection r.

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Introduction

Airborne pathogens are known to be one reason for nosocomial infections in hospitals. The number of *Aspergillus* infections, for example is rising, especially on hematological wards *(Brandis et al., 1994)*. Leukemia and bone marrow transplant patients are particularly susceptible to *Aspergillus* infections (*Riede U. N.,1995)* even under normal air concentrations of this pathogen. There is evidence to suggest that a critical infection dose is necessary to cause aspergillosis in immunocompromised patients. In the Netherlands the installation of room mounted HEPA-filter systems in patient rooms has reduced the incidence of *Aspergillus* infection (*Dr. Voss Mycology / Netherlands Hospital Nijmegen,* personal communications). Unfortunately, due to the fact that HEPA filters have a high resistance to airflow (e.g. 250 Pa to 350 Pa when clean), relatively powerful fans are required. Consequently, the HEPA-filter units have been found to be loud and are therefore often not accepted in patient rooms. The use of UVc lamps overcomes many of the problems associated with HEPA filters, insomuch that air resistance is much less and thus smaller, quieter fans can be used.

UVc irradiation has been used for decades to reduce microorganisms on surfaces, in water and in the air. In former times open and indirect UVc lamps were used to kill airborne microorganisms *(Philips Lighting, 1993)*. Unfortunately, with many of these older technologies, poor results were achieved because of the distance to the target "microorganism" was too great and thus the dose received was too low. Another disadvantage was the production of ozone by lamps which emitted UV light at wavelengths shorter than 200 nanometers and problems associated with reflected radiation which caused conjunctivitis and erythems. To solve these problems BÄRO -Technology developed a number of UVc disinfection units which use fans to draw the air from outside into a closed radiation chamber. Air is passing through the UVc unit is always only a small distance from the lamps (maximum distance being 20 mm) so that a large dose is received by any microorganisms which enter the unit. The UVc lamps have a strong emission band at 254 nm but do not produce light with a wavelength shorter than 200 nm. Therefore no ozone is produced by the system. Figures 1 and 2 show two air disinfection units manufactured by BÄRO –Technology.

Figure 1 BÄRO 'Damp Room' UV air disinfection unit

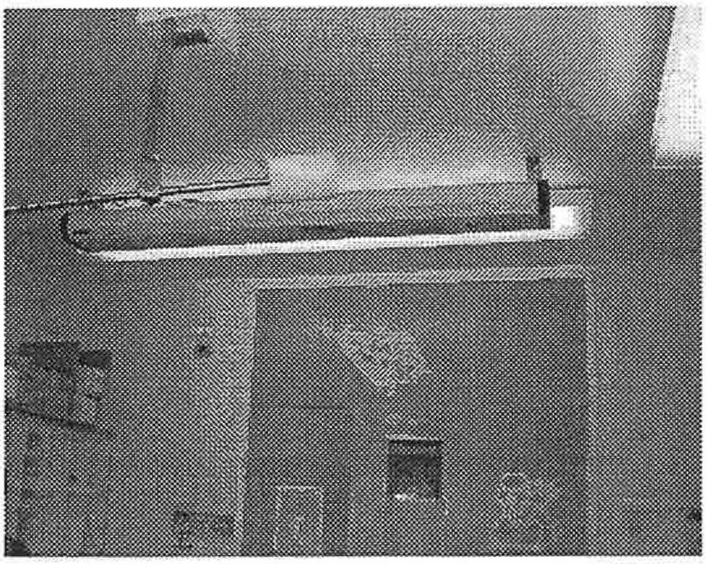

Figure 2 BÄRO Model No. 8904 UV air disinfection unit

Testing of the UVc Disinfection Unit

In order to determine the 'single-pass' disinfection efficiency of the BÄRO units, a unit containing four 55w (electrical power) UVc lamps was tested. Air was drawn into the radiation chamber by a fan at a flow rate of 160 m^3/h. The efficiency of disinfection process was tested by sampling airborne microorganisms in the discharge air stream after disinfection.

Microorganisms were sampled under isocinetic conditions by the use of a Sartorius MD 8 air sampler (membrane filtration). Air was filtrated through gelatine filters with a pore diameter of 3 micrometers. Flow rate was 4 m^3/h with a sampling time of 15 minutes, so that in total 1 m^3 of air was analyzed.

Gelatine filters were placed directly on Plate-Count Agar Medium (Merck) or were dissolved in phosphate buffered saline, pH 7.20. Aliquots of the dilutions were plated on PC-agar or for the detection of moulds on Sabouraud-agar medium (Merck) supplemented with 20mg/l chloramphenicol. The plates were placed in an incubator at 37°C for determination of total microorganisms and at 28°C for the detection of moulds. Agar plates were daily controlled and the colonies were counted. The inactivation rate was calculated by comparing the microbiological data collected with the UVc lamps switched off with that collected with the UVc lamps switched on.

Results

The results of the inactivation experiments for airborne microorganisms are shown in Figure 3.

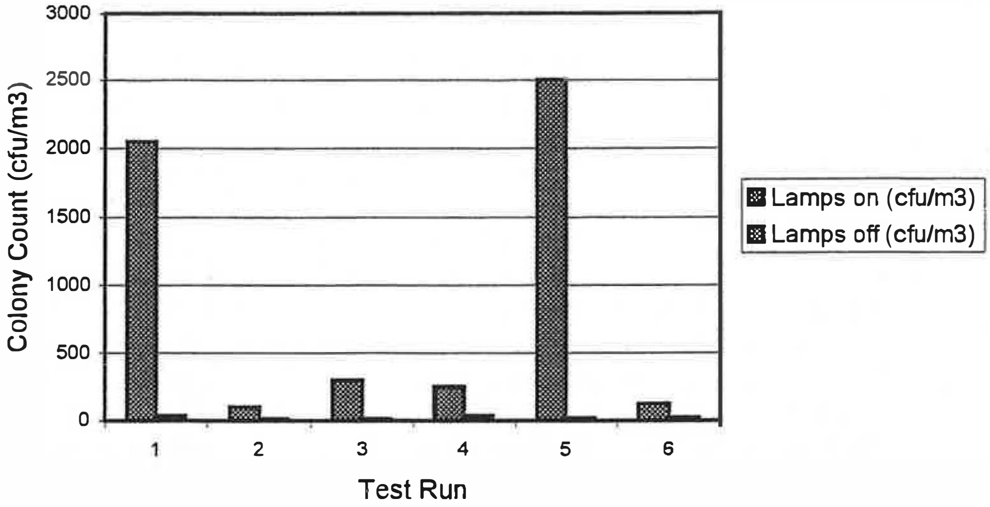

Figure 3 Test results for 6 experimental runs

The data shows six approaches with differing concentrations of total microorganisms. The average reduction in the microorganism count, after passing through the BÄRO unit was 91.4 %. During the tests the main species on the PC-Agar plates were identified as *Micrococcus, Bacillus* and *Aspergillus* spp.. Regarding the chloramphenicol supplemented Sabouraud agar medium the inactivation rate for moulds was calculated to be 77.1% (*data not shown*). The data was calculated from six independent experiments.

Field Trial

A field trial of a BÄRO UV unit (Model No. 8904) with a UV power of 44 W, was undertaken in a doctors surgery. Trial results for a sample days are presented in Figure 4. The results show that UV unit substantially reduced the bioburden in the surgery and in particular capped the peak that would otherwise occur during the daytime.

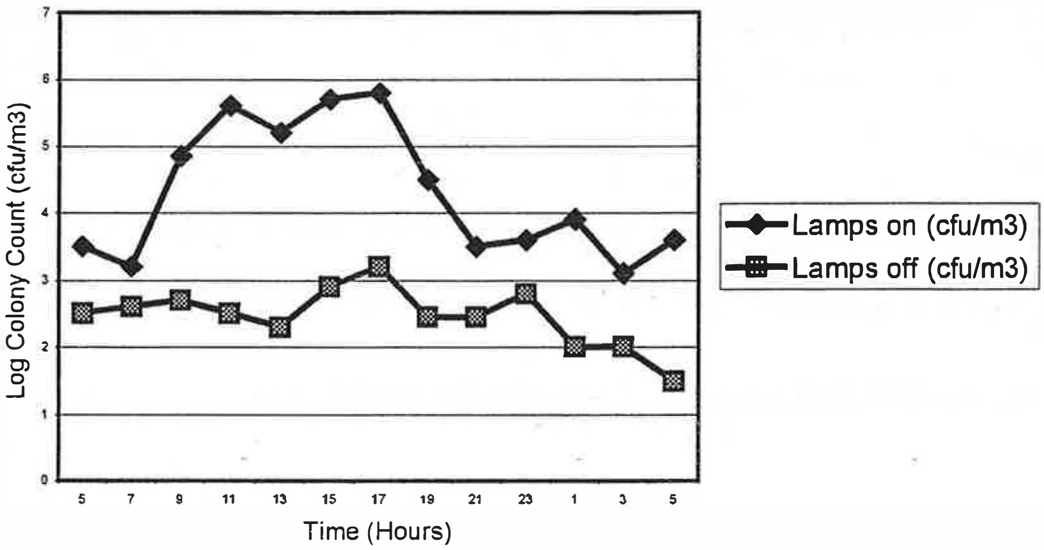

Figure 4 Results of trial in a doctor's surgery

Discussion

The data presented in Figure 3 shows the single-pass efficiency of the BÄRO UVc disinfection units. As can be seen, the number of microorganisms present in the air is drastically reduced by just a single-pass through the UVc radiation chamber. However, the killing rate with regard to moulds is lower especially in the case of *Aspergillus niger* which is particularly resistant to UV light.

The single-pass killing rate of the UVc disinfection module is only one parameter responsible for germ reduction in a defined room volume. Another, important parameter is air volume flow rate passing through the unit. Both parameters are important and should be optimized in order to achieve the best results. In cleaning the air, UVc disinfection units behave in a similar way to a mechanical ventilation system and their effect on room air is to dilute the pathogen concentration in the room space. Consequently, the higher the air flow rate through the UVc unit, the greater will be its room effectiveness. In closed rooms the level of airborne microorganisms in the air is reduced, the longer the system remains in operation (BÄRO Technology unpublished results). It seems that the effect of UVc light is additive on microorganisms, although a lower constant level is eventually reached at which the bacterial level is stabilized. This view is supported by the data presented in Figure 4, which shows the bioburden in the doctor's surgery stabilizing at a lower level, through the operation of the UV lamps.

Although, airborne microorganisms are continuously reduced by UVc modules, in hospital environment, microorganisms are always being introduced into the room space either through open doors, or from the skin/hair of patients, or from visitors etc. Therefore the disinfection and contamination rates will eventually reach a balanced state and the bioburden level will stabilize. In a recent clinical trial, the BÄRO units placed in the most enclosed rooms appear to have achieved the greatest reduction in the level of airborne microorganisms (*Dr. C. Beggs, University of Leeds,* personal communication).

It is the intention of BÄRO Technology to develop their UVc disinfection units, in order to optimize the single-pass killing rate and the disinfected air volume flow rate, so that microorganisms are reduced below a critical infection level. It is hoped that similar results will be achieved through the use of UV units to those achieved by HEPA-filter systems in hospitals, but with much reduced noise levels. The results obtained from trials of HEPA-filter units in patient rooms at the hospital in Nijmegen, Netherlands, vindicate further research into UVc air disinfection techniques.

References

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