CUSTOMER REPORT

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Microbiological efficacy testing of Aavi Leaf air purification device

Author: Satu Salo

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Report's title

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Customer, contact person, address	**Order reference**
Aavi Technologies Oy Pekka Rantanen Tulppatie 1 FI-00880 Helsinki	
Project name	**Project number/Short name**
AirCleaningTre	VTT-V-114712-17

Summary

The efficacy of Aavi Leaf ® Pro air purification device in removing microbes from the air was tested using a study design where strong microbial aerosol was released into a closed space. Microbial aerosol contained bacterial spores (*Bacillus atrophaeus*), fungal spores (*Aspergillus niger*), vegetative bacterial cells (*Staphylococcus simulans*) and viruses (phage MS2). When the device was switched off bacterial spores survived well in the air of the experimental room during the trial. During the first hour when the device was on bacterial spore levels in the air dropped over three Log units while the levels of mould spores and viruses dropped below the detection level (10 microbes/m^3).

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Written by

Satu Salo,
Senior Scientist

Accepted by

Maria Saarela
Research Team Leader

VTT's contact address

VTT, Satu Salo, PO Box 1000, 02044 VTT, Finland

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1. Description and objectives

Since microbes can spread via air contamination risks in critical targets can be reduced by lowering the levels of microbes in the air. In this study air decontamination was studied using Aavi Leaf ® Pro air purification device provided by the customer (Figure 1). The device has been designed to be used in spaces were people are present while the device is on.
In this study the air in a closed room was contaminated with microbial aerosol and the microbial load in the air was monitored by taking air samples at different time points.
The efficacy of the device in removing microbes from the air was assessed by comparing two set ups - one where the device was on and another one where the device was switched off.

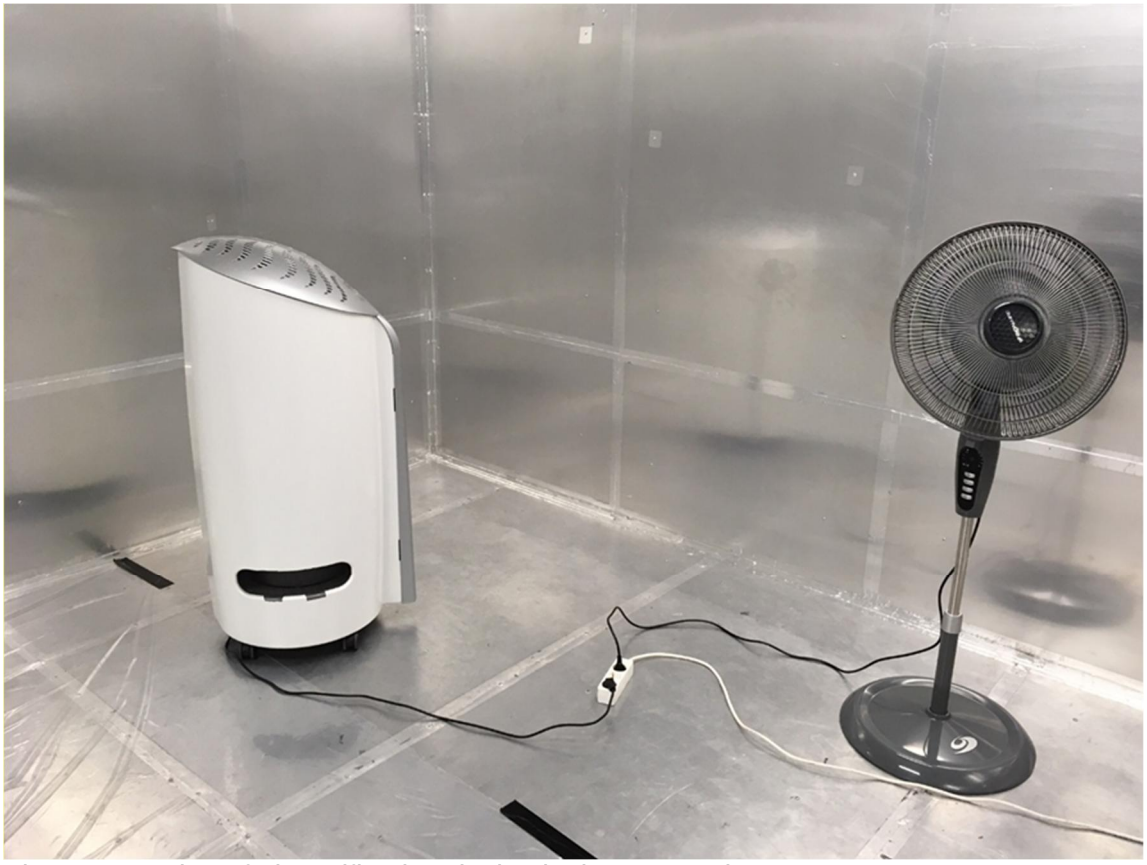

Figure 1. Aavi Leaf air purification device in the test environment.

2. Methods

The air in the closed test room (33.4 m^3) was sprayed with aerosol that contained bacterial spores (*Bacillus atrophaeus*, VTT E-052737), fungal spores (*Aspergillus niger*, VTT D-081297), vegetative bacterial cells (*Staphylococcus simulans*, VTT E-97784^T) and viruses (bacterial phage MS2, a commonly used surrogate for norovirus). *B. atrohpaeus* spore suspension was performed by culturing strain VTT E-052737 from VTT Culture Collection for 7 d at 30°C in Nutrient Broth including $MnSO_4$ x H_2O 10 mg/l. Suspension was centrifuged and heated for 15 min in a water bath at 80°C. After heating suspension was washed twice using Ringer solution and centrifuge. Microbial inoculum used for contamination of air contained microbes in Ringer solution at the following levels: *A. niger* 5 x 10^6 CFU (colony forming units)/ml, MS2 7 x 10^7 phages/ml, *B. atrophaeus* 2 x 10^8 CFU/ml and *S. simulans* 3 x 10^7 CFU/ml. Aerosol was formed by spraying strong microbial inoculum into the air by using hand-operated pressure sprayer (Figure 2). Four desilitres of the inoculum was placed into

the syringe and sprayed for 1 min into the air. Aavi Leaf ® Pro air purification device was on during the procedure at its most efficient setting. There was also a powerful fan present in the room to efficiently mix the air. The room was kept closed expect for the sampling occasions (once every hour). Air samples (one cubic metre) were collected on a filter (Sartorius, Gelatine Disposables) using Klotz HF8 impactor every hour, including time point zero, immediately after spraying (sampling time was 2000 sec/sample). Samples were taken at the time points 0, 1, 2 and 3 h. Microbial levels on filters were determined with culture based techniques. Following growth media and conditions were used: moulds - Potato Dextrose Agar (PDA; incubation 25°C, 5 d), bacteria - Plate Count Agar (PCA; incubation 30°C, 3 d) and viruses - *Escherichia coli* containing Nutrient Agar (NA; incubation 37°C, 1 d). Similar samples were collected also in a situation when the device was switched off. The efficacy of the device was estimated by comparing the results when the device was on or off. Trials were performed in triplicate during 28.2-2.3.2017 at Tampere VTT test facility.

Figure 2. The hand-operated pressure sprayer used to spray the microbial inoculum.

3. Results

The mean values (either colony forming units of phages per cubic metre) of the triplicate measurements are shown in Table 1. *S. simulans* did not grow in any of the samples (air sampling on filter took more than 30 min, which can dry bacteria). The limit of detection in this study design was 10 CFU/m^3.

Table 1. Mean values of the culture based results performed in triplicate.

Device off/on	Time (h)	*A.niger* (CFU/m^3)	*B.atrophaeus* (CFU/m^3)	MS2 (phages/m^3)
off	0	31 000	1 378 788	13 000
off	1	2 316	318 182	90
off	2	299	126 970	45
off	3	97	81 606	25
on	0	30 152	866 667	63
on	1	<10	156	<10
on	2	<10	87	<10
on	3	<10	<10	<10

Figure 3 shows the levels of moulds in the samples at different time points when Aavi Leaf ® Pro air purification device was on or off. Figures 4 and 5 show the corresponding levels for bacterial spores and viruses, respectively.

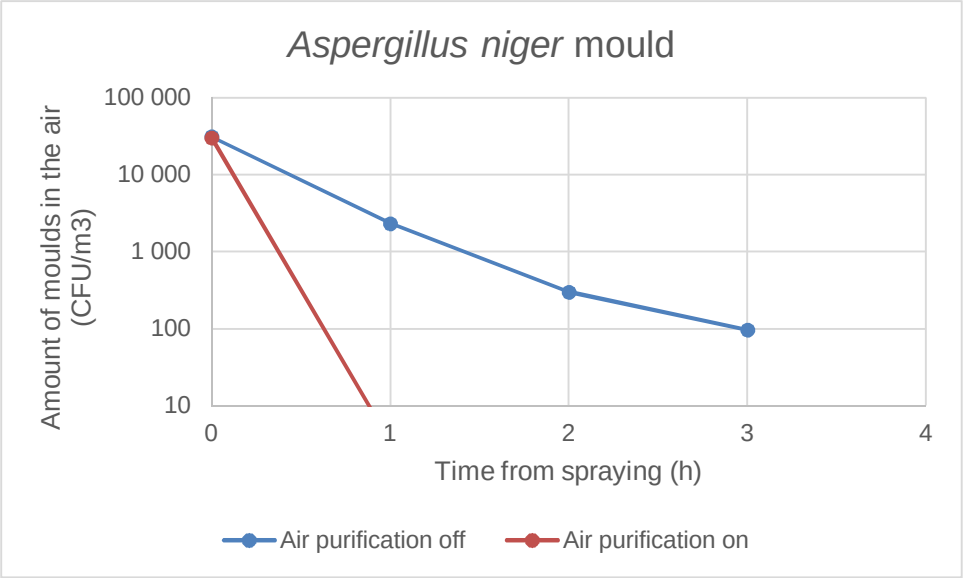

Figure 3. The levels of *Aspergillus niger* in the air samples when the device was on or off.

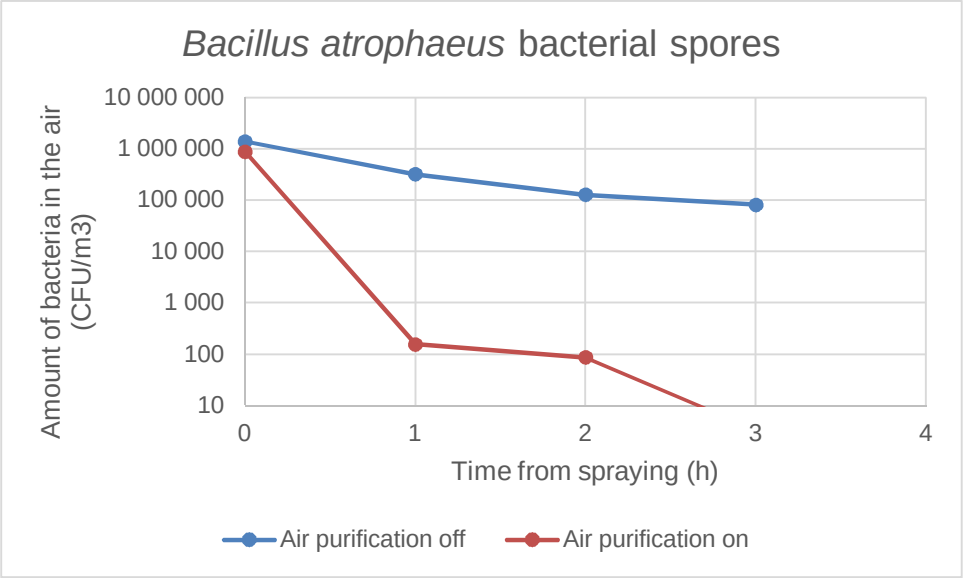

Figure 4. The levels of *Bacillus atrophaeus* in the air samples when the device was on or off.

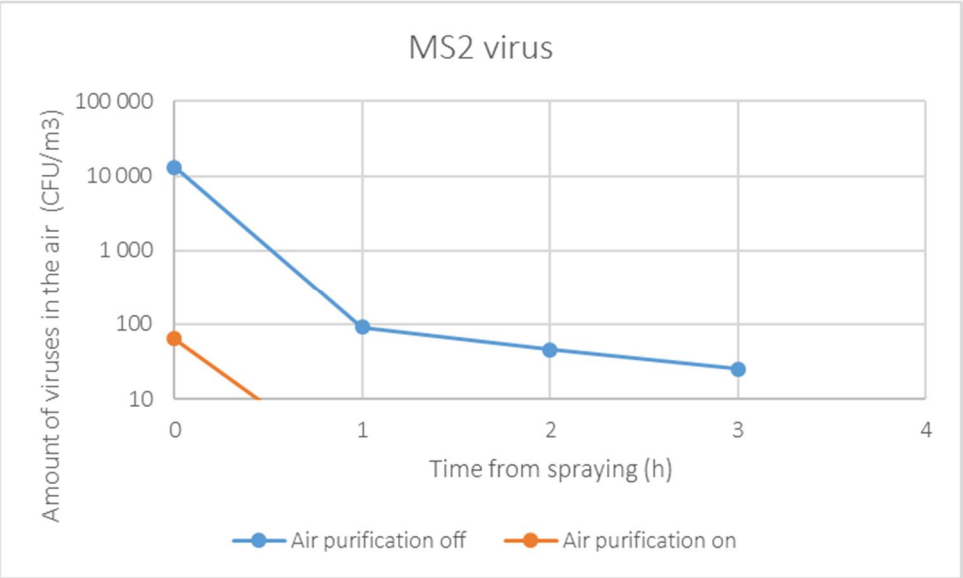

Figure 5. The levels of the phage MS2 in the air samples when the device was on or off.

4. Summary

The efficacy of Aavi Leaf ® Pro air purification device in removing microbes from the air was investigated using a study design where the air in a closed space was artificially contaminated with microbial aerosol containing bacteria (both vegetative cells and spores), fungi and viruses. Microbes were not added during the trial and thus also the natural inactivation of microbes in the air was occuring during the trial. Vegetative cells of *Staphylococcus simulans* could not be detected at all in the air during the trial. Bacterial spores on the other hand retained their viability in the air when the device was switched off. During the first hour the device lowered the bacterial spore levels over three Log-units and during the same time fungal spore and phage levels dropped under the limit of detection (10 microbes/m^3).

In this study design strong microbial suspension was sparyed for one minute into the air to ensure a high level of microbes in the air. In normal circumstances these high levels of microbes are not encountered in the air. Microbial vegetative cells - unlike spores - usually survive poorly in the air. Also in this study some lowering of microbial levels was seen in the samples taken when the device was switched off. In this study set up no new microbes were introduced into the room. In real life both humans and airflow move microbes around and have an effect on how long the microbes stay in the air.

Aavi Leaf ® Pro air purification device clearly lowered the microbial levels in the air already after one hour in the study desing applied.

References

This is an English version of cusromer report VTT-CR-02641-17 “Aavi Leaf ilmanpuhdistuslaitteen tehon testaus mikrobeilla” originally written in Finnish.