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Efficiency of OXYTEC compact indoor air purifier (Freshair) on reducing and inactivating airborne viruses

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The report consists of:
9 pages of text
3 figures
2 tables

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1 Subject of the study

The aim of the investigation was to test the reduction and inactivation of airborne surrogate viruses (enveloped Phi6 bacteriophage with comparable structure, particle size and environmental stability to SARS-CoV-2 [1], [2], [3], [4], [5]) by the air purifier (device specifications see Table 1).

Table 1: Device specifications

Device name	Freshair
Manufacturer	OXYTEC air & water purification system
Device installation	6.10.20
Operation principle	UV-C/Ozone circulating air technology (1 x 8 Watt)
Device dimensions	L 380 cm x Ø 130 cm
Room size	up to 50 m³
IBP internal check number	E3413
Measurement period	Week 45

According to literature [2], the natural half-life of airborne viruses is approx. 2 hours. Therefore, the tests were exclusively related to aerosols in the air. The natural half-life must be taken into account when calculating the efficiency of the device

The setup of the test was based on DIN ISO 16000-36 [6] to test airborne bacteria, realistically adapted to the specific requirements of viruses. The viruses were collected from indoor air in accordance with DIN ISO 16000-16 [7], the filters were constructed in compliance with DIN ISO 16000-17 [8]. The number of active viruses ("virulence") was determined in the laboratory using the plaque-based assays method ([9], [10]).

Note: Viral activity testing on surfaces require a different method, as the stability of viruses in liquids ("smear infection") must be considered.

2 Method

The experiments took place in a temperature and humidity controlled room used for testing (room size: 45 m³) without additional air exchange.

The air purifier was positioned in the centre of the room at a height of two metres (see Figure 1). The viruses were introduced into the room at a distance of 45 centimetres facing the unit. The dosing was initially carried out without turning on the device in order to achieve a high virus load in the room. Then the dosing was stopped and the air purifier was operated for a total running time of 24 hours. During the entire running time, the particle distribution in the room, the temperature and humidity as well as the ozone content were measured.)

Figure 1: The (test) setup consisting of the air purifier (Freshair), a dosing unit and an air sampler in the testing room.

At certain times, the viruses were drawn to an air sampler (MBASS30 version 3 adapted for filter operation by the company Umweltanalytik Holbach GmbH, Wadern, Germany) and subjected to a plaque assay test for microbial analysis in the laboratory (see Figure 2).

Figure 2: Microbial analysis.

3 Results

The contaminated air was pulled in by the air purifier and passed through the filter. Inside the device, viruses were inactivated when exposed to UV radiation and the ozone that was formed. The maximum concentration of ozone in the room itself remained low (max. 6 ppb). Figure 3 shows the distribution of viruses in the room over the measurement period and the dates of sampling:

- **P1**: 1 – 2 h, blank value before starting the dosing of the viruses

- **P2**: 2,33 – 3,33 h, dosing of viruses

- **P3**: 4 – 5 h, corresponds to 15 min to 75 min when the dosing of the viruses has been completed and the device is switched on.

- **P4**: 5 – 6 h, corresponds to 75 min to 135 min when the dosing of the viruses has been completed and the device is switched on.

- **P5**: 6 – 7 h, corresponds to 135 min to 195 min when the dosing of the viruses has been completed and the device is switched on.

The two curves reflect the ranges of the particle measured by the measuring instruments (p-Trak/TSI and Fidas Frog/Pallas). The p-Trak covers the nanoscale range from 20 to 1000 nm, therefore mainly covers the range of individual viruses (virus size (approx. 100 nm) in the air. The Fidas Frog covers a larger scale range from 0.2 to 20 µm and thus detects aerosol-bound viruses (approx. 1 to 3 µm).

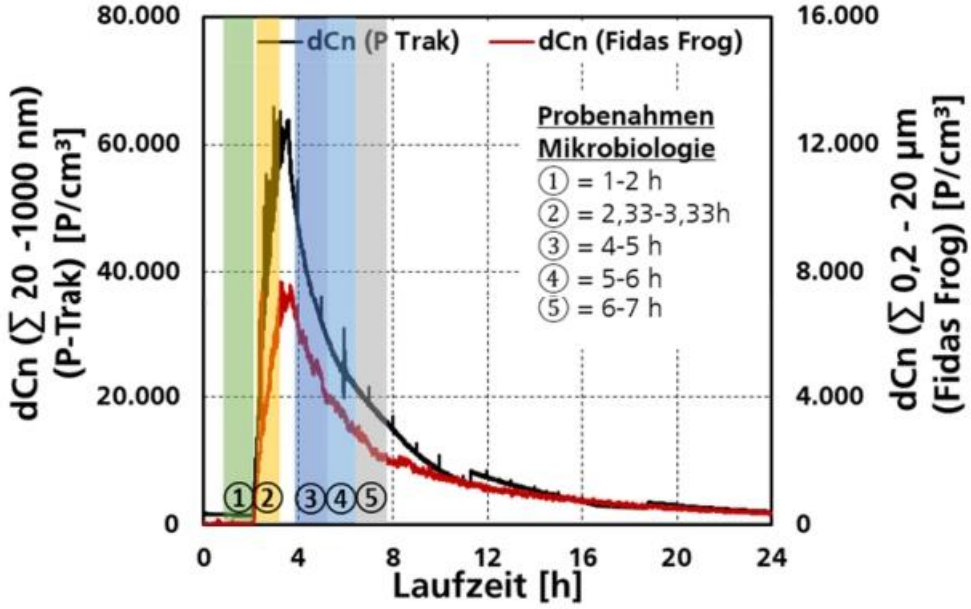

Figure 3: Distribution of viruses in the room and the dates of sampling.

The number of airborne viruses decreased along the curve (temporal progression) due to sedimentation ("deposition"). Since the room air purifier is based on the principle of inactivation of viruses, the level of inactivation or the duration of inactivation was measured.

The sampling periods for airborne viruses are highlighted in the diagram. Their activity measured in the laboratory, i.e. the extent to which the viruses are potentially capable of multiplying, is calculated in Table 1. Included in the calculation are the sedimentation and the natural half-life of the airborne viruses which was determined during the tests [1-3]. The reference value for calculating the reduction was based on the loss of activity of viruses in suspension in relation to time (known from our own measurements) and the decay curve of the particle measuring device (P-Trak). Concerning microbiological samplings, each of which lasted one hour, all data of the particle measurement were averaged over this period.

Table 2: Measurement of viral activity

Date of sampling	Measured reduction of viral activity (measurement data) [%]	Calculated reduction rate R without sedimentation */**	Calculated reduction rate R with sedimentation */**
P1	- ***	-	-
P2	0	-	-
P3	57,94	0,5387	0,3535
P4	99,91 ****	0,9962 ****	0,9925 ****
P5	99,91 ****	0,9958 ****	0,9891 ****

* Reduction rate R = 1-Ct/Ci (Ci for the air purifier not in operation and Ct with the air purifier in operation).

** Taking into account the natural half-life of viruses in indoor air (according to literature [2]), sedimentation coefficient was calculated using the decay curve in Fig. 3.

*** P1 Blank value before the virus dosing, no evidence in the room.

**** below statistical detection limit of 12%. Reduction rate R greater than 0.88 or reduction rate greater than 88%.

4 Study summary on the efficiency of the OXYTEC compact indoor air purifier (Freshair) on reducing and inactivating airborne viruses

An office with a size of 45 m³ was used for testing and was exposed to surrogate viruses (enveloped Phi6 bacteriophage with comparable structure, particle size and environmental stability to SARS-CoV-2) for 1 hour. Afterwards the air purifier Freshair (from OXYTEC air & water purification system) was switched on. **After less than 2 hours of operation, the concentration of viruses in the room was reduced by over 99 %.**

A maximum ozone concentration in the air of 12 µg/m³ is measured in this study. This represents only one tenth of the legal limit.The Federal Immission Control Act sets up the ozone concentration to 120 µg/m³ as a safe limit (maximum target value). [11].

5 Literature

[1] Carvallo, N.A. de, Stachler, E.N., Cimabue, N., Bibby, K. (2017): Evaluation of Phi6 Persistence and Suitability as an Enveloped Virus Surrogate. Environmental Science & Technology 51: 8692-8700.

[2] Prussin, A.J., Schwake, D.O., Lin, K., Gallagher, D.L., Buttling, L., Marr, L.C. (2018): Survival of the Enveloped Virus Phi6 in Droplets as a Function of Relative Humidity, Absolute Humidity, and Temperature. Applied and Environmental Microbiology 84(12).

[3] Whitworth, C., Mu, Y., Houston, H., Martinez-Smith, M., Noble-Wang, J., Coulliette-Salmond, A., Rose, L. (2020): Persistence of bacteriophage Phi 6 on Porous and Nonporous Surfaces and the Potential for Ist Use as an Ebola Virus or Coronavirus Surrogate. Applied and Environmewntal Microbiology 86(17): 1-11.

[4] Casanova, L.M. & Waka, B. (2013): Survival of a Surrogate Virus on N95 Respirator Material. Infection Control and Hospital Epidemiology 34(12): 1334-1335.

[5] Turgeon, N., Toulouse, M.-J., Martel, B., Molneau, S., Duchaine, C. (2014): Comparison of Five Bacteriophages as Models for Viral Aerosol Studies. Applied and Environmental Microbiology 80(14): 4242-4250.

[6] DIN ISO 16000-36:2019-07, Indoor air pollution - Part 36: Standard method for assessing the reduction rate of culturable airborne bacteria by air purifiers using a test chamber (ISO 16000-36:2018, Corrected version 2019-03-01).

[7] DIN ISO 16000-16:2009-12, Indoor air pollution – Part 16: Detection and enumeration of moulds - Sampling by filtration (ISO 16000-16:2008).

[8] DIN ISO 16000-17:2010-16 Indoor air pollution - Part 17: Detection and enumeration of moulds - Culture-based method (ISO 16000-17:2008).

[9] Baer, A. & Kehn-Hall, K. (2014): Viral Concentration Determination Through Plaque Assaya: Using Traditional and Novel Overlay Systems. Journal of Visualized Experiments 93: 1-10.

[10] Dulbecco, R. 1952. Production of plaques in monolayer tissue cultures by single particles of an animal virus. Proc. Natl. Acad. Sci. USA 38:747–752.

[11] 39th Ordinance (*39. BImSchV*) implementing the Federal Emmission Act on air quality standards and emission ceilings. Annex 7 (to Article 9) Target values and long-term objectives for ozone,