Umwelt Bundesamt

For People and the Environment

As of November 16, 2020

# Use of mobile air purifiers as a supportive ventilation measure in schools during the COVID-19 pandemic

**Opinion of the Indoor Air Hygiene Commission (IRK), German Federal Environment Agency**

## Preliminary remarks

Following the publication of the Indoor Air Hygiene Commission (IRK)'s recommendation on proper ventilation and the use of ventilation technology in schools during the Covid-19 pandemic on August 12, 2020 (IRK 2020-1), there has been much discussion as to whether mobile air purifiers should be used in the cold season to supplement or even substitute active ventilation by windows in the classrooms. The German Federal Environment Agency (UBA) recommends in its handout of October 15, 2020, which was drawn up following a resolution of the Standing Conference of the Ministers of Education and Cultural Affairs (KMK) on September 23, 2020, that mobile air purifiers should only be used in exceptional cases and as an additional measure (UBA 2020-1). This stance is reiterated in the UBA's supplementary opinion of October 22, 2020, specifically on the use of mobile air purifiers (UBA 2020-2).

The IRK at the German Federal Environment Agency addressed the issue of the use of air purifiers in detail at its meeting on October 27, 2020, and now supplements the UBA opinion of October 22, 2020, with further detailed information.

Accordingly, mobile air purifiers can be useful as a supplementary measure, but only where sufficient ventilation is not possible. In addition, certain prerequisites must be observed when selecting the unit and setting it up.

German Federal Environment Agency
Management of the Indoor Air Hygiene Commission
Director and Professor Dr.-Ing. H.-J. Moriske
heinz-joern.moriske@uba.de
030/8903 5496
Wörlitzer Platz 1
06844 Dessau-Roßlau
www.umweltbundesamt.de

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# Types of mobile air purifiers

For the purposes of this recommendation, mobile air purifiers include all devices which are mobile (i.e., movable) purifying devices that allow indoor air to pass through.

These chiefly operate through the following procedures:

A) Air purification via high-performance particulate filters (see note below for filter efficiency)

B) Purification via other filter techniques (e.g. activated carbon filters, electrostatic filters)

C) Air treatment using UV-C technology

D) Air treatment by means of ozone, plasma or ionisation

E) Combination of several methods.

**High-performance HEPA filters** are able to effectively trap extremely small particles, such as those to which SARS- CoV-2 viruses (approx. 0.1 µm in size) can adhere. Most filters of classes H 13 and H 14 are typical fibrous filters that work by mechanical particle retention. In addition, the filtering effect of fibrous filters can be further exploited by adsorbent materials or via electrostatic properties. Air purifiers with such filters can be assumed to be generally effective. Small aerosol particles can adhere to each other more strongly under certain ambient conditions, e.g., an environment with high relative humidity. In such cases, fine filters of filter classes ISO ePM1 70% or ISO ePM1 80% are also capable of trapping virus-laden particles. Nevertheless, this is by no means the norm. It should also be noted that the relative humidity in a room sometimes mentioned in public discourse as an additional measure cannot be increased arbitrarily, as this would increase the risk of mould growth.

Some manufacturers recommend combining filtering with UV-C radiation (see paragraph below) in order to kill or inactivate viruses and other pathogens retained on the high-performance HEPA filters by UV radiation so that the filters can later be safely changed and disposed of. Alternatively, contaminated filters can be heat-treated to kill the pathogens. However, the filters treated via these methods remain contaminated with retained particles, and regularly replacing the filters is still unavoidable because air cannot sufficiently pass through the filters if they become clogged.

**UV-C radiation** can inactivate SARS-CoV-2 viruses; nevertheless, the radiation dose needed when using UV-C in mobile air purifiers still requires further investigation. Before purchasing and using mobile air purifiers with UV-C, the IRK recommends asking the manufacturers for verifiable proof of their effectiveness, also when used under real-room conditions, such as in classrooms, as this is particularly important for the necessary irradiation intensity and the residence time of the virus-laden particles within the irradiated zone. UV-C radiation can have negative health impacts. For this reason, the German Federal Office for Radiation Protection (BfS) urgently recommends ensuring that mobile devices with UV-C technology do not emit any UV-C radiation – directly or diffusely – into the room (BfS 2020). If this does nevertheless occur, such devices may only be operated if no people are present in the room or if it is impossible for them to be irradiated. Irradiation of eyes and the skin must be avoided under any circumstances. The IRK and the BfS also recommend asking the manufacturers for information on safe operation (avoiding direct contact with UV-C radiation).

For mobile devices that utilise **ionisation or plasma**, the IRK does not consider their effectiveness against viruses and bacteria to have been sufficiently tested in typical room conditions and room sizes such as typical classrooms. Furthermore, if ozone is formed as part of the operation, there is a risk that reaction products harmful to health may be released into the indoor air during actual operation due to chemical reaction with other substances (Gunschera et al. 2016, Siegel 2016). Before purchasing and using devices with ionisation and plasma processes, the IRK recommends asking the manufacturers for proof that in addition to the effectiveness test under real-room conditions, no harmful emissions are produced.

The IRK advises against the use of devices that directly treat the air inside the device with ozone in order to achieve virus inactivation as the ozone can be released into the indoor air. Ozone is a strong irritant for the respiratory tract. Ozone has been shown to react with other substances in indoor air, which may form new pollutants such as formaldehyde (Moriske et al. 1998). In addition, ozone reacts with many materials, often leading to the formation of undesirable secondary products (Poppendieck et al. 2007).

Besides utilising mobile air purifiers, disinfectant fogging directly into the indoor air to inactivate the viruses is also increasingly being discussed.

The IRK advises against fogging **hydrogen peroxide solution ($H_2O_2$)** or **sodium hypochlorite solution (NaOCl)** into the indoor air. Both are potent oxidising agents and – depending on the concentration – have an acute irritating effect on skin and mucous membranes. Fogging of other disinfectants without taking special protective measures and carrying out exposure analyses is also not recommended.

Under no circumstances may the user be in the room during the disinfection process, and adequate ventilation must be provided after use to avoid exposure to the active ingredients. In the event that an officially mandated measure requires room disinfection to be carried out in the absence of individuals, the information on how to do so can be found in section 3.3 of the list of disinfectants and disinfection methods tested and approved by the Robert Koch Institute (Robert Koch Institute 2017).

## Effectiveness of indoor air purifiers

The performance of an air purifier under practical conditions is key to ensuring the effective prevention of infections. Yet, test certificates are often only based on standardised laboratory conditions. These alone are not sufficient to guarantee the effectiveness of the devices under practical conditions according to the IRK. Presently, there is insufficient reliable data that are collected under practical conditions for many models and device types. The advertisements often only indicate the filter efficiency of the fibrous filter itself, e.g., 99.95% regarding the total particle count for filter class H 13. Since an air filter device circulates only part of the indoor air, this reduction at the filter is not equivalent to the actual reduction of the particle load a) in the mobile unit and b) in an actual room.

As mentioned, any statements on the efficiency of mobile air purifiers in classrooms usually come from tests under laboratory conditions. In the meantime, initial experimental results from different approaches for model rooms (Kähler et al. 2020, Exner et al. 2020), as well as initial investigations in real classrooms (Curtius et al. 2020), are now available, but the results are somewhat mixed. Some reported effective particle reductions (Kähler et al. 2020, Curtius et al. 2020), while others, depending on the set-up and the measurement points in the room, only achieved effective reductions (tested with bacteriophages) in the device's vicinity but hardly any effect at other measurement points further away (Exner et al. 2020).

Given the limited data available, the IRK maintains that the effectiveness of the devices should be properly evaluated under the respective practical conditions before they are used. Accordingly, the actual operating conditions (e.g. room conditions, occupancy density, set-up of the air purifier in the room, any airflow obstacles) must be taken into account and not just the performance data (especially the airflow rate – see note below; the degree of separation in the case of filters).

*Note: Technical data for volume flow rates must be provided in a transparent manner. As part of this, sound power values and electrical power consumption must be indicated for specific volume flow rates. The sound power should be determined according to a normative method of Accuracy Class 1 (e.g., DIN EN ISO 3741). The design of the devices with regard to the sound parameters should be carried out according to the recommended values for different rooms according to VDI 2081. The devices should always be compliant with VDI 6022. The particle filter classes are defined in EN ISO 16890. There should be complete airflow through the room, and "dead zones" should be avoided.*

In order to sufficiently remove aerosol particles from the air of entire classrooms, the devices must be designed accordingly. A criterion frequently used in this context is the so-called "Clean Air Delivery Rate (CADR)", i.e., the rate that purified air can be delivered. The CADR value indicates the volume of air that is purified of aerosols in the size range 0.09 µm to 11 µm within a specified time. In Germany, the volume flow rate is often given in cubic metres per hour ($m^3/h$). The performance of the device is characterised by the reduction efficiency of the relevant particle size classes and the volume flow rate required for the application (see note above). It should be noted that the CADR value is determined under standardised laboratory conditions with defined particles (smoke, dust, pollen) at the highest performance level (AHAM AC-1 2019) and does not allow any specific conclusions to be drawn regarding effectiveness against bio aerosols.

When suitable mobile air purifiers are used in a complementary manner, the following must be observed:

- The airflow rate (or CADR) must be appropriate for the size of the classroom and the natural air exchange in the room (usually five to six times the room volume per hour; not comparable with air exchange via windows) and must not produce any draughts. In order to achieve effective purification, the airflow rate must generally be set higher than the air exchange requirement for window ventilation – see note under "Ventilation systems and ventilation in schools".
- It must be ensured to the greatest extent possible that the entire indoor air is covered by the devices throughout the operation.
- The noise emission of the respective device must not cause disturbance either in general or to particular pupils or teachers. The acoustic data of the devices for nominal operation must be specified by the manufacturer.
  The IRK considers noise levels (continuous sound level) exceeding 40 dB(A) to be disruptive to classroom activities.
- Any undesirable secondary products (pollutants) must not be released. The devices must be maintained regularly by professionals.

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# Contributors

Dr. rer. nat. Cornelia Baldermann
Bundesamt für Strahlenschutz (BfS), Neuherberg

Dr. rer. nat. Wolfram Birmili
Umweltbundesamt, Dessau-Roßlau
Innenraumhygiene

Prof. Dr. rer. nat. Melanie M. Brinkmann
Technische Universität Braunschweig
Institute of Genetics – Biozentrum, Braunschweig

Dr. Rolf Buschmann
Bund für Umwelt und Naturschutz Deutschland (BUND), Berlin

Dipl. Chem. Reto Coutalides Coutalides Consulting, Schaffhausen (Schweiz)

Dipl. Biomath. Anja Daniels
Umweltbundesamt, Dessau-Roßlau
Innenraumhygiene

Madlen David
Umweltbundesamt, Dessau-Roßlau
Toxikologie, gesundheitsbezogene Umweltbeobachtung

Dr. rer. nat. Kerstin Etzenbach-Effers
Verbraucherzentrale NRW, Düsseldorf

Prof. emeritus Dr. med. Dr. h.c. Martin Exner Universitätsklinikum Bonn
Institut für Hygiene und Öffentliche Gesundheit

Dr. Astrid Gräff
Deutsches Institut für Bautechnik (DIBt), Berlin

Dr. rer. biol. hum. Ina Gümperlein
Institut für Arbeits-, Sozial- und Umweltmedizin
Klinikum der Universität München

Prof. Dr. med. Caroline Herr Bayerisches Landesamt für Gesundheit und Lebensmittelsicherheit, München

Dr. rer. nat. Charlotte Herrnstadt Umwelt- und Innenraumanalytik, Kassel

Dr. Oliver Jann, DirProf.
Bundesanstalt für Materialforschung und - prüfung (BAM), Berlin

Dr. rer. nat. Frank Kuebart
Eco-INSTITUT Germany GmbH, Köln

Dipl. Chem. Wolfgang Misch, Berlin

Prof. Dr.-Ing. habil. Birgit Müller
Hochschule für Technik und Wirtschaft, Berlin

Prof. Dr.-Ing. Dirk Müller RWTH Aachen University E.ON Energy Research Center
Institute for Energy, Efficient Buildings and Indoor Climate, Aachen

Dr.-Ing. Heinz-Jörn Moriske, DirProf.
Umweltbundesamt, Dessau-Roßlau
Beratung Umwelthygiene

Dr. Wolfgang Plehn, DirProf.
Umweltbundesamt, Dessau-Roßlau
Stoffbezogene Produktfragen

Dipl. Biol. Nicole Richardson
Sachverständigenbüro Richardson, Witten

Prof. Dr. rer. nat. Tunga Salthammer
Fraunhofer Wilhelm-Klauditz-Institut (WKI), Braunschweig

Dr.-Ing. Christian Scherer
Fraunhofer-Institut für Bauphysik, Valley
Dipl.-Ing. Heidemarie Schütz
Bundesinstitut für Bau-, Stadt- und Raumforschung (BBSR), Berlin

Dr. rer. nat. Regine Szewzyk
Umweltbundesamt, Dessau-Roßlau
Mikrobiologische Risiken

PD Dr. rer. nat. Hans-Christoph Selinka
Umweltbundesamt, Dessau-Roßlau
Mikrobiologische Risiken

Dr. med. Wolfgang Straff
Umweltbundesamt, Dessau-Roßlau
Umweltmedizin und gesundheitliche
Bewertung

Dipl.-Ing. Peter Tappler
Bundesministerium für Nachhaltigkeit
und Tourismus, Wien, Österreich

Dipl.-Ing. Marc Thanheiser Robert Koch-
Institut, Berlin Angewandte Infektions-
und Krankenhaushygiene

Dipl. Chem. Jörg Thumulla Anbus
analytik GmbH, Fürth

Myriam  Tobollik Umweltbundesamt,
Dessau-Roßlau Umweltmedizin und
gesundheitliche Bewertung

Dipl.-Phys. Alfred Trukenmüller
Umweltbundesamt, Dessau-Roßlau
Grundsatzfragen der Luftreinhaltung

Dr. rer. nat. Norbert Weis Bremer
Umweltinstitut GmbH

Dipl. Chem. Martin Wesselmann
Gebäudediagnostik Wesselmann,
Hamburg