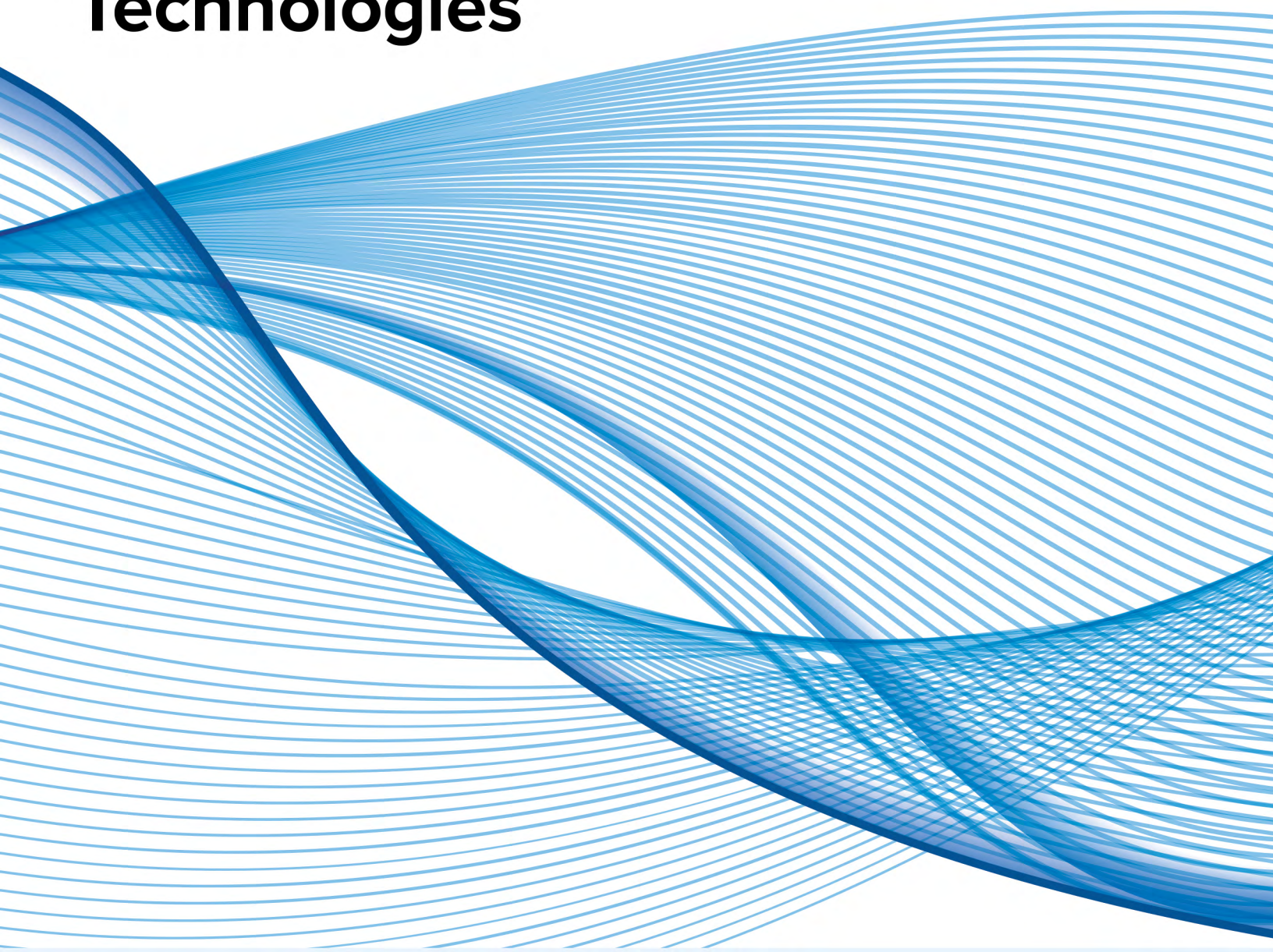
Alternative Air Cleaning Technologies



Special Topics in Indoor Air Quality: Alternative Air Cleaning Technologies

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Background

There are various alternative air cleaning technologies in addition to ventilation, filtration, and germicidal ultraviolet light. In general, these are methods in which chemically reactive species are pumped into a room. The intent is for these reactive species to either inactivate viruses, increase the deposition rate onto surfaces, or allow fine particulate matter to be removed through a lower-quality filter in the HVAC system. These methods include ionization, bi-polar ionization, gaseous hydrogen peroxide, UV photocatalytic oxidation (UV with a catalyst like titanium dioxide), nano-confined catalytic oxidation, ozone emitters, hydroxyl emitters, plasma, and other active technologies. Some of these technologies have been shown to have low effectiveness in reducing pollutant concentrations. Changing the chemical composition of a space can also possibly create harmful by-products.[1,2,3] Based on current evidence, additive air cleaning technologies should be avoided.

Alternative Air Cleaning Methods

Ionizers

Ion generators act by charging airborne particulate matter in a room so that they are attracted to various surfaces in the space. They can also enhance the ability of airborne particles to form agglomerates (also known as coagulation). By sticking together many smaller particles to form larger ones, the traditional HVAC system can remove fine particulate matter more efficiently. Other common names for ionizers that create negative ions are ion generators, ionic air purifiers, electrostatic air purifiers, and plasma-based air purifiers. Some ionizers can create both negative and positive ions known as bi-polar ionizers or plasma waves. Manufacturers claim effective removal of aerosolized particles from the indoor environment. However, some researchers found little to no effective removal of fine particulate matter during operation. Some of the concerns related to this technology include the negative impact of elevated negative ions in the air[4] as well as the negative effects of exposure to large, concentrated ions.[5] In addition, ionizing devices can emit by-products such as ozone (O3), **Volatile Organic Compounds (VOCs)**, as well as ultrafine aerosols. **The United States Environmental Protection Agency** cautions that using ionizers can increase the rate of particle deposition in the respiratory tract, which may not reduce the dose of particles to the lungs.[6]

Photocatalytic Oxidation

Photocatalytic oxidation is a technique that employs light and a catalyst to break down and transform pollutants through chemical reactions. The catalyst, typically made of titanium dioxide, is activated by ultraviolet light to generate oxidants that then react with VOCs. The composition of air flowing through the device and its design can result in the production of unintended by-products such as aldehydes,

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[1] A. L. Holder, H. S. Halliday, and L. Virtaranta, "Impact of do-it-yourself air cleaner design on the reduction of simulated wild-fire smoke in a controlled chamber environment," *Indoor Air*, vol. 32, no. 11, p. e13163, Nov. 2022, doi: 10.1111/INA.13163.

[2] US EPA, "Guide to Air Cleaners in the Home," 2008.

[3] P. K. Barn, C. T. Elliott, R. W. Allen, T. Kosatsky, K. Rideout, and S. B. Henderson, "Portable air cleaners should be at the forefront of the public health response to landscape fire smoke," *Environ Health*, vol. 15, no. 1, pp. 1–8, Nov. 2016, doi: 10.1186/S12940-016-0198-9/TABLES/2.

[4] Z. Liu et al., "Near-real-time monitoring of global CO_2 emissions reveals the effects of the COVID-19 pandemic," *Nature Communications 2020* 11:1, vol. 11, no. 1, pp. 1–12, Oct. 2020, doi: 10.1038/s41467-020-18922-7.

[5] L. Dong, W. Yang, W. Yang, Y. Li, W. Wu, and G. Wang, "Multivalent metal ion hybrid capacitors: a review with a focus on zinc-ion hybrid capacitors," *J Mater Chem A Mater*, vol. 7, no. 23, pp. 13810–13832, Jun. 2019, doi: 10.1039/C9TA02678A.

[6] US EPA, "Indoor Air Quality (IAQ)." Accessed: Mar. 15, 2024. [Online]. Available: https://www.epa.gov/indoor-air-quality-iaq

phosgene, and chlorinated VOCs. Therefore, caution should be exercised when using photocatalytic oxidation as a means of air purification.[7]

Gaseous Hydrogen Peroxide

Gaseous hydrogen peroxide is a potent oxidizing agent that has been used as a method for cleaning the air of certain pollutants. Hydrogen peroxide can be toxic if ingested, inhaled, or by contact with the skin or eyes. Inhalation of household-strength hydrogen peroxide (3%) can cause respiratory irritation and inhalation of vapours from concentrated solutions (higher than 10%) may result in severe pulmonary irritation. While some methods generate hydrogen peroxide at lower concentrations, the use of gaseous hydrogen peroxide can result in the formation of by-products including gaseous contaminants. Therefore, caution should be exercised when using gaseous hydrogen peroxide in any occupied space.

Ozone Generation

Ozone generators are devices that generate ozone, a highly reactive molecule that can break down certain pollutants, like airborne pathogens. While ozone generators have been marketed as a solution for improving air quality, they should not be used due to safety and health concerns. Ozone can be harmful to human health, potentially causing respiratory irritation and other health problems when exposed to high concentrations. Additionally, ozone can react with other chemicals in the air to form harmful by-products that can contribute to air pollution. **Health Canada** recommends against the use of ozone generators.

Hydroxyl Generation

Hydroxyl generators are devices that generate hydroxyl radicals, which are highly reactive species that can break down pollutants in the air. The use of hydroxyl generators can result in the production of harmful by-products, such as ozone and particulate matter.[8]

Safety & Effectiveness

ASHRAE 241-2023 Normative Appendix A provides a standard for safety and effectiveness for all air cleaners.[9] To measure effectiveness, the equivalent clean air delivery rate can be determined using a decay test following Stephens et al, (ASHRAE Journal, April 2022).[10] Claims about the percentage of reduced pathogens do not necessarily translate to effective use in real-world environments. ASHRAE 241 also provides a safety standard to ensure ozone, particulate matter and formaldehyde are generated at safe levels. For alternative air cleaners to be used, they should be regulated and required to comply with ASHRAE 241-2023 Normative Appendix A.[11] There is not sufficient evidence

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[7] D. B. Collins and D. K. Farmer, "Unintended Consequences of Air Cleaning Chemistry," *Environ Sci Technol*, vol. 55, no. 18, pp. 12172–12179, Sep. 2021, doi: 10.1021/ACS.EST.1C02582/ASSET/IMAGES/LARGE/ES1C02582_0007.JPEG.
[8] D. B. Collins and D. K. Farmer, "Unintended Consequences of Air Cleaning Chemistry," *Environ Sci Technol*, vol. 55, no. 18, pp. 12172–12179, Sep. 2021, doi: 10.1021/ACS.EST.1C02582/ASSET/IMAGES/LARGE/ES1C02582_0007.JPEG.
[9] ASHRAE, "ASHRAE Standard 241, Control of Infectious Aerosols." Accessed: Aug. 20, 2024. [Online]. Available: https://www.ashrae.org/technical-resources/bookstore/ashrae-standard-241-control-of-infectious-aerosols
[10] B. Stephens, E. Gall, M. Heidarinejad, and D. Farmer, "Interpreting Air Cleaner Performance Data," *ASHRAE J*, Apr. 2022.
[138] Government of Ontario, "Guide to the Occupational Health and Safety Act." Accessed: May 29, 2024. [Online]. Available: https://www.ontario.ca/document/guide-occupational-health-and-safety-act
[11] ASHRAE, "ASHRAE Standard 241, Control of Infectious Aerosols." Accessed: Aug. 20, 2024. [Online]. Available: https://www.ashrae.org/technical-resources/bookstore/ashrae-standard-241-control-of-infectious-aerosols

that alternative air cleaners are more effective than traditional air cleaning technologies, i.e., outdoor ventilation, filtration, and germicidal ultraviolet light. We currently recommend against their use.

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