Developing methodology for testing of gas-phase air cleaners based on perceived air quality.

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ABSTRACT

The existing standards for testing gas-phase air cleaners are based on challenging them with gaseous substances. They do not describe air quality measurement using perception, and human emissions (bioeffluents) are not used as challenge pollutants. The present work examines the method that can be used as an alternative or together with other methods used for testing gas-phase air cleaners. The work is a part of the IEA's Annex 78. Three gas-phase air cleaners were tested in the Technical University of Denmark labs. Testing was conducted in rooms adapted for laboratory experiments ventilated with different outdoor air supply rates; emissions from typical building materials and people were used as challenge pollutants. The effects of using air cleaners were examined by rating the air quality's acceptability and odor intensity. For this purpose, participants (subjects) were recruited. The rating was made by entering the rooms or on the air extracted from the rooms; in both cases, the subjects were blind to exposure conditions. The air was sampled at the lowest ventilation rate for the subsequent GC/MS analysis. The results showed that air cleaners using activated carbon performed better than the ones using ion generators. The former improved perceived air quality when challenged with emissions from building materials but not when human emissions were present. The experience gained will allow for developing the standard for gas-phase air cleaners that can be compatible with the requirements for ventilation in the current standards based on sensory ratings and considering emissions from building materials and people.

KEYWORDS

Gas-phase air cleaners, Perceived air quality, Volatile organic compounds, Activated carbon, Human bio-effluents.

1 INTRODUCTION

The existing standards for testing gas-phase air cleaners use a single or mixture of selected volatile organic compounds or other pollutants to test the efficiency of air cleaners. None of them includes how air quality is tested using sensory perception. Consequently, there is an incompatibility between standards for ventilation, where requirements are mainly based on sensory perception and the performance of gas-phase air cleaners. Besides, the methods proposed in the standards do not account for the potential by-products generated in the air cleaning process that may cause air quality to be poorer than without air cleaners. This work aimed to examine the performance of various air cleaners using sensory perception of air quality and use the experience for developing the method that can be implemented in future standards for air cleaners.

2 METHODS

The experiment was conducted in March 2022 at the Technical University of Denmark. A two-stage test was carried out. In Stage 1, we examined whether the air cleaners negatively affect indoor air quality. Those who passed this stage were examined in Stage 2, comparing their performance against improved ventilation with outdoor air. We examined four portable air cleaners (PACs): PAC1a used an ion generator, PAC2p, PAC4p used activated carbon, and PAC3a used a UV/ozone reaction. They were operated at average speed (neither turbo nor

sleep). Emissions from building materials and humans (human bio-effluents) were used as a challenge pollution. We recruited eight people to source as a source of human bio-effluents. Thirty subjects were recruited during Stage 1, and thirty-one during Stage 2. They performed sensory evaluations of air quality using the scale of acceptability and odor intensity. Different experimental conditions were created in rooms adapted for experimental purposes. The volume of the experimental room was 55.7 m^3: the air temperature was 23°C, and the relative humidity was 30%. The conditions were created by changing ventilation rates, setting different sources of pollution, and running or idling air cleaners. Ventilation rates (outdoor air supply rates) were set at 7.5, 12, 21 and 30 L/s. The sensory assessments were made by entering the room and on air extracted from the rooms into diffusers. The first assessment was used to rate air quality. The subjects were blind to exposure conditions. Results were analyzed using the Wilcoxon Signed Rank Test. At the lowest ventilation rates, the air was sampled on Tenax and DNPH for the subsequent chemical analyses performed by the commercial laboratory.

3 RESULTS

Figure 1 shows the selected results of the experiment from Stage 2. The sum of VOC concentrations with the PAC1a was almost the same as those without air cleaner when the pollution source was building materials or human bio-effluents. The sum of VOC concentrations with PAC2p was lower than those without air cleaners when the pollution source was building materials, human bio-effluents, and a mixture of both. Acceptability of air quality rated by the subjects with PAC1a was not significantly different when the pollution source was building materials or human bio-effluents compared with no air cleaner. It was significantly improved with PAC2p when the pollution source was building materials compared with no air cleaner; no change was seen when sources were human bio-effluents or a mixture of building materials and human bio-effluents. Similar results were seen for PAC4a. These results suggested activated carbon type air cleaners effectively reduced the VOCs regardless of pollution source and improved perceived air quality when the pollution source was building materials. However, when the pollution source included human bio-effluent, perceived air quality was not improved.

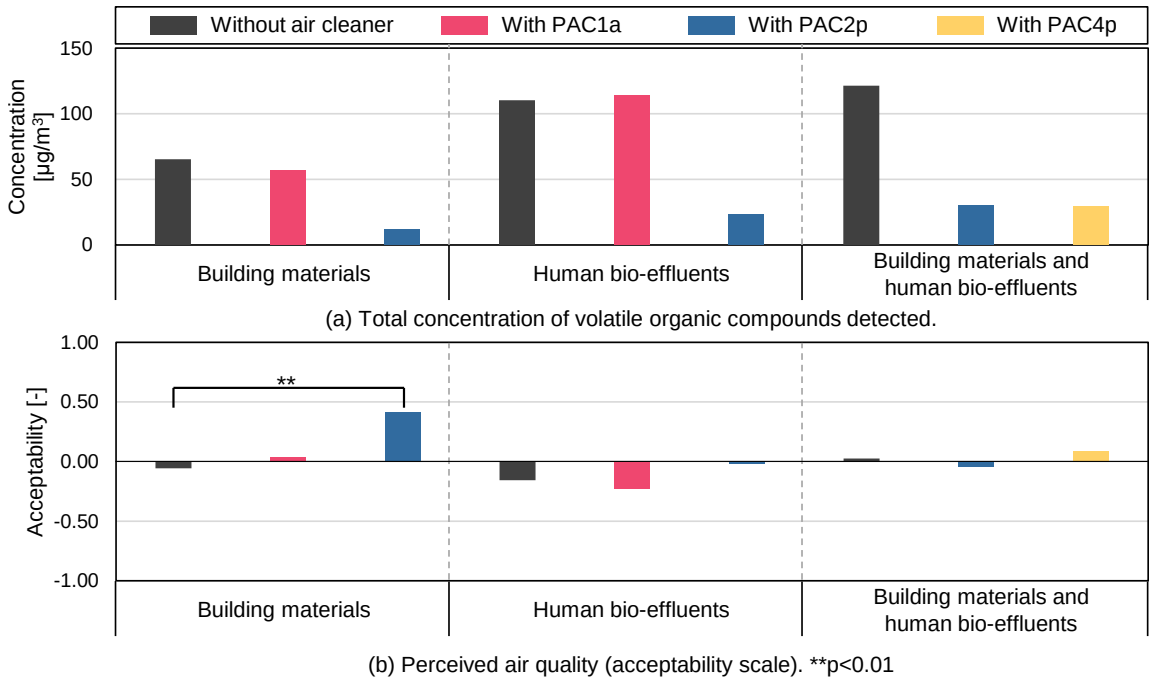

Figure 1: Results of chemical measurements (summed concentrations of VOCs) and perceived air quality (acceptability).

4 CONCLUSIONS

Present results suggest better performance of air cleaners using activated carbon but not for all pollutants. Using two two-stage assessment procedures and sensory ratings of air quality allowed for identifying air cleaners that performed poorly and even aggravated air quality. Present results require confirmation by other groups, but the experience gained can be used to develop the methodology that can be implemented in future revisions of standards that examine the performance of gas-phase air cleaners.

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