Can commonly-used active air cleaning technologies improve indoor air quality? A literature review

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1 Introduction

Numerous air cleaning technologies have been developed and used to improve indoor air quality, but there have been no systematic assessments of these technologies. This is particularly true with regard to (1) application at realistic indoor conditions, (2) long term performance, and (3) production of unwanted by-products during operation. Consequently, a literature review was undertaken to collect state-of-the-art information on air cleaning technologies focusing on both their effect to remove indoor air pollutants and the problems that may occur during their application.

2 Methods

The scientific peer-reviewed literature on the effects of commonly used active gas-phase and particle phase air cleaners on indoor air pollutants in nonindustrial indoor environments was reviewed by a multidisciplinary group of scientists with expertise in medicine, epidemiology, toxicology and engineering. The focus was only on air cleaning techniques for which indoor air flows through a device and returns to the indoor air (active air cleaners). The selected air cleaning technologies were reviewed regarding their efficiency to reduce/remove indoor air pollutants including particles, microorganisms, inorganic and organic gases; radon was not included. The effects on health and/or occupant performance were not considered in this review.

The scientific literature was gathered by searching through the following databases: ISI Web of Science (1910-June 2009), ScienceDirect (1823-June 2009), MEDLINE (1965-June 2009) and Engineering village 2 (1884-June 2009). Google Scholar was used as a supplementary search. Three kinds of keywords were used, including various air pollutants, air cleaning technologies and different indoor environments. The bibliography of retrieved articles was also reviewed to identify references that were otherwise missed.

During the literature search, over 26,000 articles were identified. 400 articles were selected as relevant based on their titles and abstracts by two authors, who also further reduced the number of articles to 160 based on the full texts. These articles were reviewed by the panel using predefined inclusion criteria during their first meeting. Additions were also made by the panel. In this process 133 articles were selected for thorough review. Each article was reviewed by

two scientists, one assigned to be a prime reviewer and the other one assigned to be secondary reviewer. Each reviewer reviewed 17 to 18 articles. The articles were assigned to the reviewers for review completely at random and not depending purely on their expertise; no article was assigned to a scientist if he was one of the authors.

3 Results

Of the 133 articles thoroughly reviewed and discussed by the panel, 59 articles were judged relevant and conclusive. The performance of air cleaners is best measured and compared (between cleaning devices) by a Clean Air Delivery Rate (CADR). However, many of the articles reviewed in this study did not include an explicit determination of CADR, or single-pass removal efficiency or volumetric flow rates to allow for an implicit calculation of CADR. Fig. 1 summarizes the reported CADR and single-pass removal efficiency values in the reviewed 59 articles.

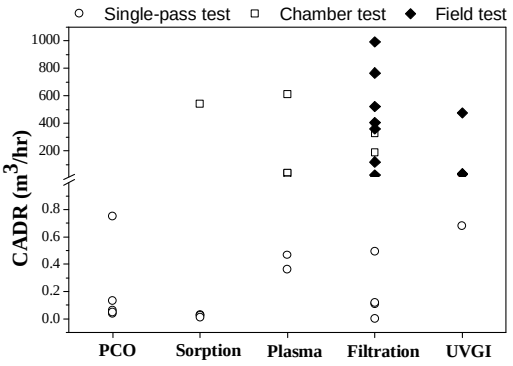

Fig. 1 Summary of reported CADR values in the reviewed articles.

Some "new" air cleaning technologies, such as PCO and plasma etc., can handle with more than one type of indoor air pollutants. For example, PCO can decompose almost all indoor organic compounds, and also can sterilize indoor microbes. This potential makes them become hot research topic in the past decade. However, they all have a serious problem: producing harmful by-products. Fig. 1 shows PCO and plasma have very low CADR values because most of them were performed in laboratory studies. Even if they got high single-pass efficiencies, the current data indicated that they are lack of data in practical applications.

For the "typical" air cleaning technologies, such as sorption, filtration and UVGI, they generally can remove one type of indoor air pollutants. Many studies show that filtration and UVGI have been well performed in real environment applications.

4 Conclusions

The following consensus statements were made based on the 59 articles: (1) Filtration is an efficient technology for removing particles, although used particle filters can be a source of sensory pollution. (2) Sorption is an efficient technology for removing some gaseous pollutants, including VOCs, formaldehyde, O_3, provided that the adsorption system is properly designed and operated. More information is needed on the long term performance of air cleaners using sorption principles. (3) UVGI is a proven technology for inactivation of some airborne microorganisms, but ozone may be produced during operation. (4) PCOs can reduce concentrations of some gaseous pollutants (e.g., BTEX, formaldehyde), but may generate harmful by-products. To identify and to control by-products and catalyst poisoning is necessary when this technique is applied for prolonged periods. (5) Plasma air cleaning can reduce concentrations of some gaseous pollutants. It can also produce harmful by-products such as ozone, and its energy consumption tends to be high. (6) Ozone is not recommended for indoor air cleaning, because of producing harmful by-products. (7) Benchmarks and standard condition and procedures for evaluating air cleaner performance are necessary. Labeling of air cleaners will be valuable in the future.

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6 References

There are 59 articles used in this review.