The Assessment of Particulate Matter (PM2.5) Removal Efficiency on Air Cleaner Products through Full Scale Test in Korea

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ABSTRACT

This study is designed to investigate the particulate matter removal efficiency of domestic air cleaner products and seeks to compare the particulate matter removal efficiency in a laboratory with that in real life.
To this end, a test was conducted in a full-scale testing laboratory at the Korea Institute of Civil Engineering and Building Technology (KICT), and the actual particulate matter removal efficiency of air cleaners was estimated by measuring changes in indoor concentrations of particulate matter (PM2.5) before and after the operation of air cleaners. For the test, CA certified air cleaners, which are most widely used in Korea, were used, and Dust Track II Aerosol Monitor 8532 that provides real-time mass concentration readings was used for measurement.
In the test, the same influencing factors as those of the actual house were set in the full-scale testing laboratory, and changes in concentrations of indoor-generated particulate matter were measured consecutively. Three company products were used as test specimens. The methods of removing particulate matter for each product are divided into electrostatic precipitation technique, HEPA filter and others (360-degree HEPA air filtration system). Through this study, changes in particulate matter concentrations by removal method, application area, installation location and number of units installed were measured, and the efficiency of particulate matter removal using air cleaners was examined based on the results.

KEYWORDS

Air Cleaner, Particulate Matter, Filter

1 INTRODUCTION

Modern people spend more than 90% of their time indoors in a 24 hour period due to changes in lifestyles and working patterns. According to the World Health Organization (WHO), the number of deaths from air pollution is estimated at up to 6 million a year, and the number of deaths caused by indoor air pollution is estimated at 2.8 million worldwide.
With the recent rise in particulate matter air pollution in Korea, there has been an urgent need for appropriate measures, and this social climate has resulted in the expansion of market size for air cleaners.
Methods that are currently being applied to domestic air cleaners on the market in Korea include the method to remove particulate matter using a filter, the electrostatic precipitation, which is a method of dust collection that applies high voltage to electrodes and attaches dust particles to the electrode plates, and the method of using activated carbon to absorb and remove gaseous substances.
The related companies have developed air cleaners to reduce the concentrations of various pollutants, including particulate matter, but the focus is mainly on the performance evaluation of a laboratory-scale air filtration system.

Therefore, this study aims to investigate the particulate matter (PM2.5) removal efficiency of air cleaners on the market in real life, and it seeks to measure changes in particulate matter concentrations depending on removal method and application area before and after the operation of air cleaners, and thus to estimate the particulate matter removal efficiency of air cleaners based on the results.

2 RESEARCH METHODS

In this study, a commercial product with CA mark[1] was installed and tested within one hour after removing the package immediately before the test. The removal methods of air cleaners used were electrostatic precipitation technique, HEPA filter and others (360-degree HEPA air filtration system). For airflow rate, automatic airflow control, which is the most frequently used at homes in general, was adopted in the test. The air cleaners used in this study are shown in Table 1 below.

The air cleaner was located in the center of the living room, and the changes of particulate matter concentrations in the kitchen and the living room were consecutively measured using the TSI DustTrack II Aerosol Monitor 8532 that provides real-time mass concentration readings.

Particulate matter was generated randomly for 10 minutes using cigarette smoke with particle less than 1.0 microns in diameter (PM1.0), and the removal efficiency was estimated using the difference in concentrations before and after the operation of air cleaners for 60 minutes.

The test was conducted on the 7th floor of the Zero Carbon Green Home in the Korea Institute of Civil Engineering and Building Technology (KICT). Figure 2 shows the test location and equipment.

Table 1: Air cleaners used for research

Number	Removal Method	Application Area (㎡)
1	Electrostatic precipitation technique	40
2	Others(360-degree HEPA air filtration system)	40
3		60
4		80
5	HEPA filter	40

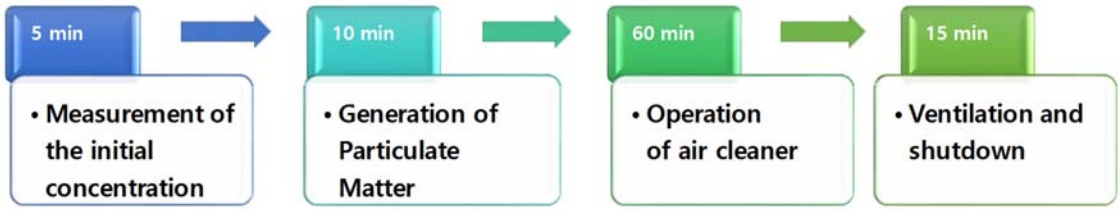

Figure 1: Research process

[1]**CA mark is granted to the products which pass strict tests by certified test agencies in accordance with collective standards for testing indoor air cleaner (SPS-KACA002-132) established by Korea Air Cleaning Association in order to provide consumers with reliable indoor air cleaners**

Figure 2: Equipment and location

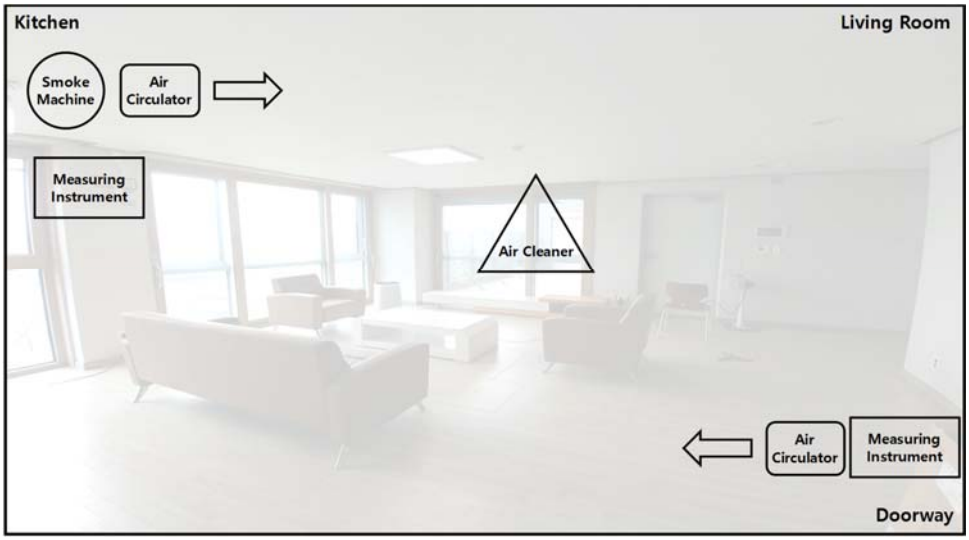

Figure 3: Configuration of test equipment

3 RESEARCH RESULTS

3.1 Measurement of particulate matter removal efficiency by removal method

This test was carried out using air cleaners with the same application area (40 ㎡) among the products with CA marks, which adopt different particulate matter removal methods, after the articulate matter was randomly generated for 10 minutes with the use of 10 cigarettes. It was

found that the particulate matter (PM2.5) concentrations ranged from 1,600 to 2,000 μg/㎥ depending on the variation in particulate matter levels in ambient air.

Test results confirmed that the particulate matter (PM2.5) removal efficiency of an air cleaner using the electrostatic precipitation technique was 95%, showing that the final concentration was close to the initial concentration after the operation of the air cleaner for one hour, and that of the HEPA filter was 91%, and that of others 78%, respectively.

Reproducibility testing was conducted two to three times to determine the validity of the test, and the reproducibility testing results also showed the same removal efficiency.

Table 2: Particulate matter removal efficiency by removal method

Removal Method	Application Area (㎡)	Airflow Rate	Particulate Matter (μg/㎥)			Removal Efficiency (%)
			Initial concentration	Maximum concentration	Concentration after operation	
Electrostatic precipitation technique	40	Automatic control	112	2625	138	94.76
Others	40	Automatic control	54	2550	550	78.45
HEPA filter	40	Automatic control	54	2405	206	91.43

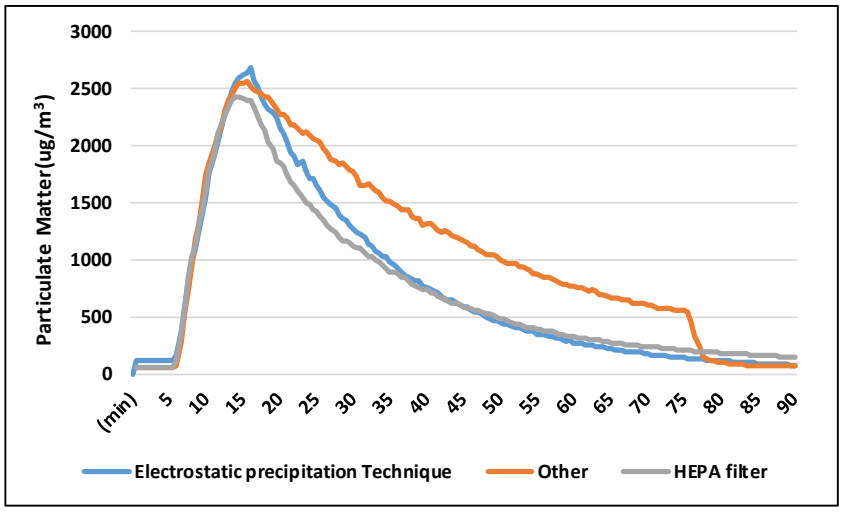

Figure 4: Particulate matter removal efficiency by removal method

3.2 Measurement of Particulate matter removal efficiency by application area

The measurement of particulate matter removal efficiency was made on air cleaners with different application areas among the products with CA marks, which adopt the same particulate matter removal method. The particulate matter removal efficiency by application area was measured with respect to other method (360-degree HEPA air infiltration system), which showed the lowest removal efficiency in the particulate matter removal performance test by removal method.

The air cleaners whose application areas are 40 ㎡, 60 ㎡ and 80 ㎡ were used in the test, and it was confirmed that the particulate matter removal efficiency increased to 82%, 89% and 94% as the application areas became larger.

Table 3: Particulate matter removal efficiency by application area

Removal Method	Application Area (㎡)	Airflow Rate	Particulate Matter (㎍/㎥)			Removal Efficiency (%)
			Initial concentration	Maximum concentration	Concentration after operation	
Others (360-degree HEPA air filtration system)	40	Automatic control	92	1685	307	81.78
	60	Automatic control	123	1970	219	88.91
	80	Automatic control	102	1850	105	94.32

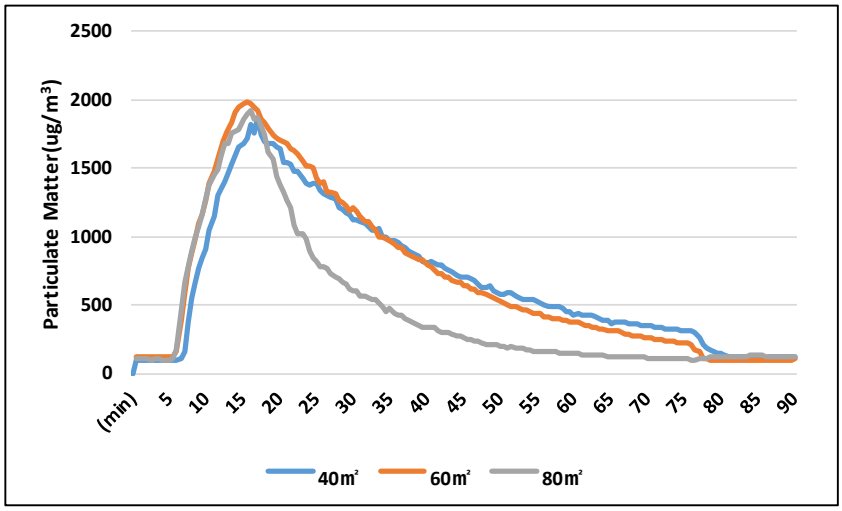

Figure 5: Particulate matter removal efficiency by application area

3.3 Measurement of particulate matter removal efficiency by installation location

As additional research, the particulate matter removal efficiency of air cleaners by installation location was measured in the actual home. The air cleaners were located at the center, interior wall and edge of the living room as shown in Figure 5 below. The test was conducted using the air cleaner of the other method (360-degree HEPA air filtration system) as in Section 3.2.

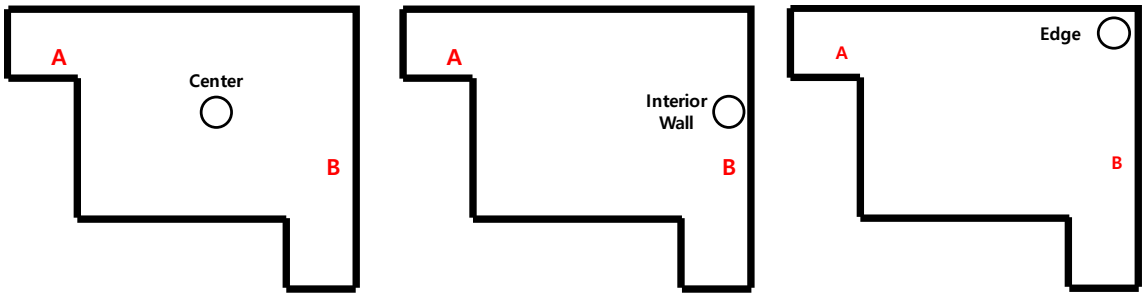

Figure 6: Locations of air cleaners

Test results revealed that when the air cleaner was located at the center, it showed the best particulate matter removal efficiency of 68.51%, followed by 66.54% on the wall and 63.35% on the edge of the living room, exhibiting a slight difference.

Table 4: Particulate matter removal efficiency by installation location

Removal Efficiency	Application Area (㎡)	Airflow Rate	Installation Location	Particulate Matter (㎍/㎥)			Removal Efficiency (%)
				Initial concentration	Maximum concentration	Concentration after operation	
Others (360-degree HEPA air filtration system)	40	Automatic control	Center	35	2825	890	68.51
		Automatic control	Interior wall	39	2575	862	66.54
		Automatic control	Edge	37	2670	979	63.35

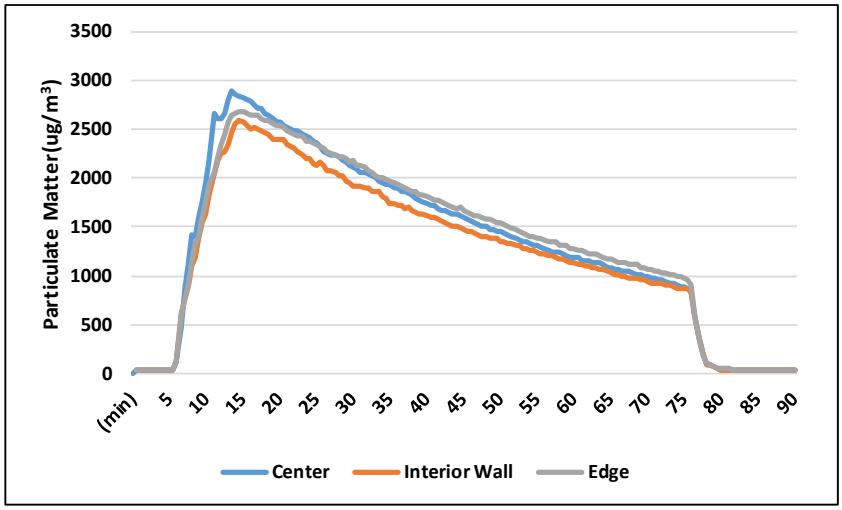

Figure 7: Particulate matter removal efficiency by installation location

4 CONCLUSIONS

In this study, air cleaner products sold in Korea were tested to investigate the particulate matter removal efficiency at the actual home. The different particulate matter removal methods of the air cleaners were compared and examined, and a comparative review on the particulate matter removal efficiency by application area was also performed on the same removal method. Additionally, the particulate matter removal efficiency by installation location at the actual home was identified to determine the location at which the air cleaner shows the best efficiency.

For the test by particulate matter removal method, a comparative review on the electrostatic precipitation techniques, HEPA filter and others (360-degree HEPA air filtration system) was performed, and it was found that the electrostatic precipitation technique showed much better particulate matter removal efficiency than other methods. In the case of the electrostatic precipitation technique, about 95% of the particulate matter was removed after one hour of operation from the maximum particulate matter concentration. This result suggests that not only the removal method but also the design, and air supply/exhaust system should be taken into consideration. In this regard, it is planned that an additional test considering the design, air supply/exhaust system and the number of units installed will be carried out in the future.

In the test of the particulate matter removal efficiency by application area on air cleaners with CA marks, the air cleaners whose application areas are 40 ㎡, 60 ㎡ and 80 ㎡ were tested, and it was confirmed that as the application area of the air cleaner becomes larger, the particulate matter removal efficiency increases. The air cleaner that has the largest application area showed the particulate matter removal efficiency of about 94%. In addition, the particulate matter removal efficiency by installation location was measured by an additional test. The results confirmed that although there was no significant difference depending on each location, the air cleaner was placed at the center of the living room, it showed the best particulate matter removal efficiency.
This study sought to investigate the particulate matter removal efficiency in real life rather than to evaluate the particulate matter removal performance in a laboratory, and thus the particulate matter removal efficiency perceived in real life was estimated through a review on the real-life efficiency by each type of air cleaners.

5 ACKNOWLEDGEMENTS

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