OGOS 2008

ATMOSPHERE AIR PURIFIER

HEALTH TECHNOLOGY ASSESSMENT UNIT
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MINISTRY OF HEALTH MALAYSIA
011/08

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February 2008

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EXECUTIVE SUMMARY

The indoor air purification technique is widely used to reduce air pollutants. The use of portable air cleaning devices, are suitable for offices and residential settings. This has been steadily growing over the last 10 years. The indoor air purifier is believed to be able to remove main irritants that affect poor indoor air quality such as microrganisms, viruses, molds, dust, pollen, dangerous airborne chemicals, gases, fumes and persistent odours like cigarette smoke.

The ATMOSPHERE Air Purifier features the CLASUSTM filtration system consisting of 3 stages of filtration. The contaminated air enters through and around the front shield where it encounters the pre-filter, the first stage filtration. The second stage consists of a HEPA filter for removing contaminants. The last stage is the carbon filter where objectionable smells are removed.

There were sufficient retrievable scientific evidences to support that High Efficiency Particulate Arrestor (HEPA)-Filter have a minimum efficiency of more than 90% for particles of 0.3 microns in diameter. Evidences showed that the Air purifier or air cleaner with the HEPA filter could remove air pollutant and particulate matter such as molds, bacteria, smoke contaminant as well as allergens caused by cat and dogs. Insufficient scientific evidences were obtained with regards to the efficacy of HEPA filter in capturing viruses, gaseous pollutants or radon and its progeny. The stand alone air purifier with HEPA filters are not designed to remove gaseous chemicals or odors from the air, they are often combined with other technologies which remove smoke and odors, such as carbon filter. Similarly, the HEPA filter does not actually kill disease-causing agents like bacteria and viruses. A HEPA filter may trap most bacteria and prevent them from re-entering the air. However, some bacteria and almost all viruses are too small to be filtered by HEPA filter.

Based on the review, the portable air purifier may be considered to be used in a recommended room size taking into account the capacity of the equipment with certain provisos:-

i) Quality of installation of this device is of critical importance, to maintain the quality of the portable air purifier.
ii) The filters need to be changed according to the manual of the device and must not be exposed to humidity.
iii) The filters must not be leaking and should fit the frames of the device correctly.
iv) Handling of the contaminated filters is important if there are any suspected pathogens in the fibers of the filters.

In order to evaluate the efficacy of the ATMOSPHERE air purifier, studies should be carried out at our various local indoor settings and validate the equipment performance especially on the viruses, gaseous pollutants or radon and its progeny.

ATMOSPHERE AIR PURIFIER

1. INTRODUCTION

There are many types of air purifier available in the market. The indoor air purification technique is widely used to reduce air pollutants. The use of portable air cleaning devices, are suitable for offices and residential settings and has been steadily growing over the last 10 years. However, there is a wide variation in the performance of air cleaners that is dependent on the specific air cleaner design and various indoor factors. The indoor air purifier is believed be able to remove main irritants that affect poor indoor air quality such as, microrganisms, viruses , moulds dust, pollen, dangerous airborne chemicals , gases , fumes and persistent odours like cigarette smoke.

This technology review was done following a request from Director General, Ministry of Health Malaysia.

2. OBJECTIVE

This technology review is to determine the safety and effectiveness of a portable device that utilizes HEPA filter as an air purifier

3. TECHNICAL FEATURES

Air circulation process work

The ATMOSPHERE Air Purifier features the CLARUSTM filtration system consisting of 3 stages of filtration. Contaminated air is drawn at low velocity toward the front of the unit to minimize noise and drafts. The contaminated air enters through and around the front shield where it encounters the pre-filter, the first stage of filtration. The pre-filter removes large, lint-like particles. The second stage consists of HEPA filter that was

claimed able to remove contaminants such as smoke, bacteria and virus or particles as small as 0.009 microns in size. The last and final stage is the carbon filter where objectionable smells, such as tobacco, pet, cooking odors, formaldehyde, dioxin and ozone are removed. The purified air is driven out to the back and upward through the grill of the rear housing of the device at a high velocity to maintain good room mixing of the air. While often over looked in air treatment performance, is the room air mixing which is a very important aspect of room cleaning. Air treatment systems, work by "dilution" in that they are constantly diluting the contaminated air of the room with the cleaned or purified air that is discharged from the unit.

The ATMOSPHERE Air Purifier has three pre-installed filters:-

i) Cleanable pre-filter
The pre-filter is made from a nano composite technology material and removes larger airborne lint and dust particles from the air before they enter the particulate filter.

ii) A replaceable carbon (odor) filter*

The ATMOSPHERE Air Purifier also features an carbon filter that utilizes 1,900 grams of a chemically engineered activated carbon that has a surface area approximately equal to 366 US football fields (226 soccer fields) or over 17 million square feet (1.6 million square meters).

iii) A replaceable HEPA (particulate) filter

HEPA stands for High Efficiency Particulate Arrestor and is a performance standard for particulate filters. In order to achieve a true 'HEPA' rating, a particulate filter needs to capture 99.97% of 0.3 micron sized particles that are drawn into it at rated airflow.

The ATMOSPHERE Air Purifier is claimed to be able to reduce particulate concentration by 80% in about 30 minutes – in the recommended room size of 390 square feet (36 square meters)

Through independent laboratory testing, the Association of Home Appliance Manufacturers (AHAM) has verified that the ATMOSPHERE air purifier's clean air delivery rate (CADR) can remove airborne smoke, dust and pollen. CADR is widely accepted as a valid measure for comparing the performance of portable air cleaners. It has been reviewed and referenced by the U.S. Federal Trade Commission and the U.S. Environmental Protection Agency.

The best location for the system

The ATMOSPHERE Air Purifier can be placed in any room of a home. The housing design ensures proper clearance between the Air Purifier and the wall to allow full circulation of purified air. According to the manufacturer the air purifier can also be placed in the center of a room, or in a corner, with no change in effectiveness.

Ability of the ATMOSPHERE™ Air Purifier

According to AHAM – Atmosphere Air Purifier claimed to be able to clean air with a room size up to 390 square feet. (Approximately 20 x 19.5 foot room) or 36 square meters (approximately 6 by 6 meter room). This conforms to the AHAM CADR Certification Program criteria of about 80% reduction of airborne particulate contaminants in a room of up to 390 square feet.

4. METHODOLOGY

4.1. Searching

Electronic databases were searched, which included Pubmed, Ovid, full text journal which covers the Medline, CINAHL, HTA Databases, FDA website and Google for published reports. Additional articles were identified from reviewing the bibliographies of retrieved articles. There was no limitation in the search. The search strategy used the terms, which are either used singly or in various combinations: HEPA filter, high efficiency particulate air filter, portable air filter, Air cleaner, effectiveness, safety, smoke, dust, mites, virus, microrganisms, fungus, bacteria, micropartiles and particulates.

4.2. Selection

All articles published and unpublished related to safety, effectiveness and cost effectiveness of ATMOSPHERE Air Purifier were appraised and evidence graded according to US/Canadian Preventive Services Task Force (Appendix 1)

5. RESULTS AND DISCUSSION

This technology review is based on one full text literature of systematic review that included 10 randomised controlled trials, 1 full text paper on the experimental study design, 12 abstracts of experimental study design,1 narrative review and a report. All the studies indicated the relevant evidences with regards to the efficacy of High Efficiency Particulate Arrestor (HEPA) as a filtering agent alone and as a potable air filtering system.

5.1 SAFETY

A study by *Price DL et al 2003* an experiment, revealed that HEPA filters treated with antimicrobial preservative able to reduce or decay colonisation of microrganisms. The colonisation of microrganisms were observed at the load surfaces of HEPA filters about 90-95% of the filters. This study also indicated that the HEPA filters that were not treated has permeated the growth of fungi such as *Aspergillus flavus and Cladosporium sepsis*. Beside that the environmental factors such as air filters in heating situations, ventilation, and air conditioning environment especially those exposed to moisture may serve as point sources for indoor molds.[1]

5.2. *Efficacy of HEPA filter*

A systematic review (*Ellem et al 2002*) , which included ten randomised controlled trials examined the influence of a residential air filtration system on patients with asthma. This study indicated that the indoor filter appears to be effective in reducing some of the airborne irritants. The study found that the high efficiency particulate air (HEPA) filter has efficiencies to filter small particles than other filters. The minimal particle removal efficiency of a HEPA filter was identified about 99.97% for particles >0.3 µm in diameter. The study also indicated that HEPA filters were able to reduce contaminant caused by cats at homes, dust particles, molds spores and cigarette smokes. In another narrative review done in 1992 which was indicated in the systematic review has given recommendations for patients with severe allergies or asthma to use vacuum and air cleaners with HEPA filter.[2, Level 1]

In an investigation done by the Green R et al 1999 found that the HEPA filter was able to reduce the contamination caused by dogs. The baseline airborne in the a room with dogs was estimated about GM 27.1 ng Can f1/m ^{3} range 2.63-3.29 that is about 3.8 fold greater when the dogs were not in the room ($p<0.05$). The study concluded that HEPA air cleaners could reduce (Can f 1) the airborne contamination caused by dogs about 90% from the baseline in the rooms with dogs.[3]

In a pilot study conducted by Olmted RN, which compared the impact of freestanding HEPA Filter units with a novel portable anteroom system (PAS)-HEPA combination unit (PAS-HEPA) placed outside a operating room. This study indicated that the free standing PAS- HEPA filter unit, confirmed to have removed over 94% of an initial release of at least 500,000 submicron particles/ft within 20 minutes. Therefore this may be considered to enhance the safety of a patient who were exposed to airborne infections.[5]

In a most recent report by *Kogan et al 2008* which conducted experiments and modeling to determine the effectiveness of commercially available in-room air cleaners (i.e. particulate matter filtration devices) .Two air cleaners were evaluated for their single pass filtration efficiency as a function of air flow rate, particulate diameter (ranging from 0.03 µm to 10 µm) and the device tested utilized HEPA filter and electrostatic precipitation technology.

The report indicated that the HEPA air cleaner provided reasonable particulate matter filtrations in the test room, when compared to the case when the air cleaner was not operating.[6]

Bacteria and virus

There were two experimental studies that had evaluated the efficacy of HEPA filter in capturing airborne particles in the size of virus particles. The Experimental study performed by *Tian F, et al 2006,* indicated that The HEPA filter could filtrate 99.99% stimulating viruses (*Escherichia coli* bacteriophage f [2]) in the air.[7]

The other experimental study that was done in 1995 by Rutala WA et al, evaluated the engineering control measures to prevent nosocomial transmission of disease such as tuberculosis. Four portable high –efficiency air (HEPA) filtration units were evaluated, for their ability to remove aerosolized particles. Following to that, the rooms were challenged with aerosolized mineral oil in the range of 0.3 to 5.0 microns at levels 10-20 times the normal airborne particle load in the rooms at baseline. The evaluation found that the portable filtration units were effective in accelerating the removal of aerosolized submicron particles. In non ventilated room, time required by the various portable filtration units for removal of 90% of aerosolized particles (> or =0.3 microns) was ranged from a low of 5 to 6 minutes to a high range of 18 to 31 minutes, compared to the control (no filtration unit), >171 minutes. In the hospital rooms , individual filtration units has removed 90% of aerosolized particles (> or =0.3 microns) in times ranging from 5 to 8 minutes to 9 to 12 minutes, compared to the control (no filtration unit), 12 to 16 minutes. The location of the portable filtration unit (center versus corner) did not affect the clearance rate of airborne particles. Therefore the study indicated that portable filtrations units can rapidly reduce levels of airborne particles similar in size of infectious droplet nuclei. Therefore the portable high –efficiency air (HEPA) filtration units may be useful in reducing the risk of viral particles in the similar size of aerosolised particles such as tuberculosis.[8]

Fungal contamination

A study conducted by *Eren A et al 2008,* has investigated the effect of constructions in hospital environment on crucial units for immunocompromised patients. The developments of opportunistic infections were investigated in 43 patient's room. Those rooms were identified to have molds growth. The molds that were identified was such as *Penicillium chrysogenum* (sputum isolates) and Aspergillus fumigatus. An evaluation was performed to compare the indoor air samples before and after changing the HEPA filter. Therefore the study evaluated the indoor air quality of the rooms after the change of HEPA filters. The study found, statistically significant decrease in the total colony and spore numbers between the samples taken before and after the filter had been changed ($P<0.005$).[9]

A pilot study conducted by Berstein et al, which investigated whether dehumidification in combination with high-efficiency particulate arrestance (HEPA) filtration is effective at reducing airborne mold spore levels in day care centers.

This study indicated that reducing indoor relative humidity and airborne mold spore levels using high-efficiency dehumidification units equipped with HEPA filtration was effective at controlling indoor dew point in day care centres.[10]

Another laboratory study on fungal investigation were evaluated on the children aged 6 and 11 at the residential environments in Perth, Australia. The study was conducted at the bedrooms of their homes. The study indicated that the concentrations and composition of airborne fungal spores in homes fitted with portable HEPA filtration units were reduced. There were reductions in fungal contamination about 35% and particulate contamination levels about 38% in the homes that used HEPA filter.[11, Level II-3]

In door Aerosol

There was an evaluation study on HEPA filter system that was commonly used in residences to alleviate airborne dust concentrations. Scanning using electron microscopy was used to quantify and characterise the ambient aerosols collected from filtered and non- filtered rooms. The evaluation indicated that, the particle concentrates were significantly lower in samples collected in the presence of the filter system (mean 23-28 coarse particle per liter, about 63% reduction; 13 to 3 inorganic submicron particles cm-[3;] 85 to 33 total submicron particle cm^3, 62% reduction with $P<0.05$.) [12]

Another experimental study on standalone air cleaners for shelter place had studied the efficacy of the HEPA filter in the removal of particles size 0.1-2 micron. The result of the screening analysis suggested that stand alone (potable) air cleaners that contain high efficiency particle filters can be effective for reducing indoor fine particles concentrations. However the relative effectiveness of stand-alone air cleaners for reducing occupants exposure to particles of outdoor origin depends on several factors, including the type of heating, ventilating and air- conditioning (HVAC) filter, HVAC operation, building air exchange rate , particle size, and duration of elevated outdoor particles concentration. The study predicted a maximum of 90% particle reduction with three stand alone air cleaners.[13]

Smoke pollution

There was an evaluation study done by Barn P, et al, which studied the effectiveness of portable HEPA filter air cleaner in reducing indoor pollutants. Samples were collected from indoor and outdoor of 21 winter and 71 summer homes impacted by wood burning during 2004-2005 and compared the indoor and outdoor Particulate Matter (PM). The particulate F (inf) and air cleaner effectiveness (ACE) were calculated for each house. The findings showed that the remaining indoor and with the use of air cleaner can effectively reduce PM (2.5) exposure during residential wood burning.[14]

House dust mite

In an evaluation study conducted by Antonicelli L, the efficacy of an air cleaning device equipped with HEPA filter was studied in patients who were allergic to house dust mite (Dermatophagoides sp). There was a reduction in the Dermatophagoides sp. allergen in the houses with the use of HEPA filter.

The indoor air quality changed spontaneously from 4.4µg to 1.75 µg of dust in between 1 to 2 months with the use of HEPA filter air cleaner.[15]

In another experimental study done by Reisman et al 1990 , evaluated thirty -two patients who had symptomatic perennial rhinitis and /or asthma during the fall and winter months and had a positive skin test with house dust mite (mite- extract). A room air cleaner installed with HEPA filter was placed in the bedroom for eight weeks. This study showed an average 70% reduction in the particulate matter greater than or equal to 0.3 micron with the HEPA filter. Patient's subjective responses also suggested benefit from the filter.[4]

Effectiveness of Air purifier with an activated carbon and HEPA filter

In a narrative review done by Roehlich F et al, found that the air purifier developed for tunnel , toll and garage booths or cubicles was found to be effective in removing CO, hydrocarbons, NO2 and other particulates. This air purifier consist of Catalytic oxidation, activated carbon and a HEPA filter and tunnel tests showed the air impurities were adequately removed.[16]

In a mathematical modeling done by LI H, Chen Y, it was performed to evaluate the performance of the HEPA- carbon filtration system for polychlorinated dibenzodioxins and dibenzofurans (PCDD/Fs) removal and to optimize its design and operation. The evaluation found that the overall removal efficiency is 78.7% for 2, 3, 7, 8-tetrachloro dibenzop-dioxins, 89.8% for octa-chlorodibenzodioxin, 78% for tetra-chlorodibenzofuran, and 89.8% for octa-chlorodibenzofuran. The larger the mass emission from the HEPA filter, the lower the overall removal efficiency and the larger the ratio of the filter rate flow, the higher the overall removal efficiency (90%). The removal of the four selected compounds does not change as the relative humidity increases less or equals to 90%.[17]

5.3 COST EFFECTIVENESS

There was no published scientific evidence on cost effectiveness of the ATMOSPHERE air purifier as a portable air cleaner that utilises the HEPA filter as the main component.

6. CONCLUSION

There were sufficient retrievable scientific evidences to support that High Efficiency Particulate Arrestor (HEPA)-Filter having a minimum efficiency of more than 90% for the particles of 0.3 microns in diameter. Evidences showed that the Air purifier or air cleaner with the HEPA filter could remove air pollutant and particulate matter such as molds, bacteria, smoke contaminant, allergens caused by cat and dogs. Insufficient scientific evidences were obtained with regards to the efficacy of HEPA filter in capturing viruses, gaseous pollutants or radon and its progeny.

The stand alone air purifier with HEPA filters are not designed to remove gaseous chemicals or odors from the air, they are often combined with other technologies which remove smoke and odors, such as carbon filter. Similarly, the HEPA filter does not actually kill disease-causing agents like bacteria and viruses. A HEPA filter may trap most bacteria and prevent them from re-entering the air. However, some bacteria and almost all viruses are too small to be filtered.

7. RECOMMENDATION

Based on the review, the portable air purifier may be considered to be used in a recommended room size for residential areas, taking into account the capacity of the equipment with certain provisos :-

i) Quality of installation of this device is of critical importance, to maintain the quality of the portable air purifier.
ii) The filters need to be changed according to the manual of the device and must not be exposed to humidity.
iii) The filters must not be leaking and should fit the frames of the device correctly.
iv) Handling of the contaminated filters is important if there are any suspected pathogens in the fibers of the filters.

ATMOSPHERE air purifier is not recommended for Ministry of Health facilities.

8. REFERENCES

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9. APPENDIX

9.1 Appendix 1

DESIGNATION OF LEVELS OF EVIDENCE

I Evidence obtained from at least one properly designed randomized controlled trial.

II-I Evidence obtained from well-designed controlled trials without randomization.

II-2 Evidence obtained from well-designed cohort or case-control analytic studies, preferably from more than one center or research group.

II-3 Evidence obtained from multiple time series with or without the intervention. Dramatic results in uncontrolled experiments (such as the results of the introduction of penicillin treatment in the 1940s) could also be regarded as this type of evidence.

III Opinions or respected authorities, based on clinical experience; descriptive studies and case reports; or reports of expert committees.

SOURCE: US/CANADIAN PREVENTIVE SERVICES TASK FORCE (Harris 2001)