THE STUDY OF HARD FLOOR SURFACE CLEANING PRACTICES AND THE EFFECTS ON DUST PARTICULATE LEVELS IN EIGHT PERTH HOMES.

J Nastov*, R Tan and P Dingle.

School of Environmental Science, Murdoch University, South Street Murdoch 6150, Western Australia, Australia.

ABSTRACT

Dust particulates were studied in eight Perth homes before, during and after cleaning with different hard floor cleaning methods to determine if there was a difference in the levels generated. The respirable and thoracic particulate concentrations significantly increased after cleaning with the broom and dustpan (method D) when used in house 6. Inhalable particulates increased from 33.5μg/m^3 to 64.5μg/m^3 and thoracic particulates increased from 21.0μg/m^3 to 37.0μg/m^3. In house 4 there was a significant difference in the PM_{10} concentrations generated during cleaning between the allpurpose fibre floor cleaner (method C) and method D. Method D generated PM_{10} concentrations of 105.25μg/m^3 in the kitchen compared to method C (6.33μg/m^3). In the living room method D generated PM_{10} concentrations of 83.75μg/m^3 compared to method C (10.16μg/m^3). When using the dust fibre floor cleaner the airborne particulate concentrations were similar to the wet cleaning methods tested (<20.00μg/m^3).

INDEX TERMS

Dust particulates, Cleaning, Hard floor surfaces, Perth.

INTRODUCTION

The indoor environment can be considered as the most important environment in relation to our health, as we spend up to 90% of our life indoors (Dingle and Franklin, 2002). In addition, the airtight constructions of modern buildings often concentrates pollutants so that their levels may be higher inside than they are outside. With growing incidences of asthma, allergies, common airway infections and other hypersensitivity reactions, cleaning for health becomes imperative and greater research is needed in this area (Sundell, 2000). Cleaning is the activity of removing contaminants, pollutants and undesired substances from an environment or surface to reduce damage or harm to human health or valuable material (Cole, Dulaney and Leese, 2000). The risk of airway infections, e.g. colds, sinusitis, ear and throat infections and influenza, which are spread by direct contact and airborne contamination is increased with decreasing hygiene levels and standards of cleaning (Sundell, 2000).

Particles are considered a major indoor air pollutant (Leese *et al.*, 1997). Strong links between floor dust and health symptoms have been found in studies and the fractions most implicated in causing health effects are those of the respirable or thoracic particles (aerodynamic diameter <10 μm, PM_{10}) and fine particles (aerodynamic diameter <2.5 μm, $PM_{2.5}$) (Colome *et al.*, 1992).

* Contact author email: jnastov@central.murdoch.edu.au

Particles found indoors may be polluted by chemical substances, physical and biological with toxic and allergenic properties. Physical contaminants in dust include heavy metals, mineral particulates, synthetic and natural fibres. Biological contaminants in dust include pollen, spores, moulds, bacteria, viruses, animal dander and skin cells (Etkin, 1994).

Cleaning studies and concerns over hygiene have largely focused on surface concentrations with little or no focus on airborne levels. While surface contamination is important in areas where food preparation occurs due to links to food poisoning, airborne concentrations generated during cleaning are probably even more important as we can inhale these airborne contaminants every time cleaning occurs. Over 99% of dust particulates are small enough to enter the lower regions of our lungs which can cause health problems (Jenkins, Guerin and Tomkins, 2000), as well as contaminate other surfaces. Certain cleaning activities have been found to exacerbate particulate problems in indoor air as dust is often re-suspended. Some recent focus has been on airborne levels generated from vacuum cleaning of carpets (Na, Dingle and Tan, 2000, White and Dingle, 2002) but none on hard floor surfaces, even though due to the visual contaminates of hard floor surfaces, they are cleaned more often than carpets. In many countries there is a move towards hard floor surfaces to replace carpets.

A previous study has shown a link between improved cleaning and the quality of indoor air by reducing dust, fungi and bacterial concentrations (Franke *et al.*, 1997) and dry methods have been found to resuspend more dust than wet methods (Leese *et al.*, 1997). The purpose of this study was to ascertain the impact of dry and wet cleaning with different cleaning products including generic brands and fibre technology on hard floor surfaces on $PM_{2.5}$, PM_{10} and PM_{100}.

METHODS

Eight homes from the Perth metropolitan area were involved in this study. All of the homes used in this study contained hard floor surfaces, including wood, tiles, slate or vinyl throughout the kitchen, living room and hallways. Floor cleaning was conducted twice a week, with a minimum of three days between samples for the duration of eight weeks in the kitchen and living rooms of each home. The study was conducted over summer, December, January and February, to ensure similar climatic conditions. Perth experiences a dry hot Mediterranean climate with temperatures in the 30's with an afternoon sea breeze during the summer months.

Three fibre floor cleaners and four generic brands of floor cleaning products were tested and are presented in Table 1. In addition, the sponge mop was also tested with an added antibacterial detergent containing benzalkonium chloride 2%w/w as the active ingredient and was used according to the manufactures instructions.

In order for the different cleaning products to be compared, each house was treated with one type of cleaning product in the first four weeks and then a different product was substituted for the second four weeks of the study (Table 1.) Two cleaning products were used in each home to determine if the data recorded was a result of the product, or related to the home. All cleaning products were used as intended by the manufacturer.

Table 1. The different types of cleaning products tested and the cleaning interventions tested at the eight homes during the study.

Cleaning Method	Product	House number cleaning method used in (weeks 1-4)	House number cleaning method used in (weeks 5-8)	Material of head	Type of treatment
A	Dust fibre floor cleaner, 21304	3	7	ENJO fibre	Dry
B	Mixed fibre floor cleaner, 21302	2	5	ENJO fibre	Wet
C	Allpurpose fibre floor cleaner, 21303	1	4	ENJO fibre	Wet
D	Broom and dustpan	4	6	Synthetic nylon	Dry
E	Dry dust mop	8	3	Modacrylic	Dry
F	Standard mop	5	1	Cotton	Wet
G	Sponge mop	6	2	Synthetic sponge	Wet
H	Sponge mop + detergent	7	8	Synthetic sponge	Wet

The levels of respirable, thoracic and inhalable dust particles were measured before and after the cleaning procedure using a Respicon personal particle sampler with an Airchek PCXR8 vacuum pump, flow rate at 3.11 l/min. Pallflex membrane filters were used in the sampler which were weighed pre and post sampling with a Sartorius 4503 micro balance. Monitoring equipment was located in the center of the living room. Stands were erected for the placement of Respicons which were placed 1-2m away from all walls, doors and windows. The monitoring of airborne dust was conducted at the beginning of each week, prior to cleaning and repeated directly after each cleaning session. The sampling time was 8 hours for all homes.

The levels of aerosol dust being emitted into the air during the cleaning procedures was monitored using the DustTrak™ aerosol monitor model 8520 with a PM_{10} nozzle attached. The DustTrak™ was placed 1-1.2m from the ground and positioned in the center of the room. Each monitoring session lasted as long as the respective cleaning activity.

The data was analyzed using SPSS, Paired-Samples T Test at 95% C.I. to determine if there was any significant difference between the different cleaning methods tested.

RESULTS

Table 2 displays the concentration of inhalable, thoracic and respirable airborne particulates 8 hours pre and post cleaning. Cleaning method D in house 6 significantly increased the inhalable particulate concentration after cleaning from 33.5-64.5μg/m^3 ($p=0.029$). When cleaning method H was used in house 7 there was also a significant increase from 25.7-40.8μg/m^3 ($p=0.022$).

Cleaning method D in house 6 significantly increased the thoracic particulate concentration after cleaning from 21.0μg/m^3 to 37.0μg/m^3 ($p=0.042$). There was no significant difference in the respirable particulate concentration pre and post cleaning for each method.

Table 2. The dust particulate concentration 8 hours pre and post cleaning in eight Perth homes using different cleaning methods.

House number	Cleaning method	Inhalable Pre - Post ($\mu g/m^3$)	Thoracic Pre - Post ($\mu g/m^3$)	Respirable Pre - Post ($\mu g/m^3$)
1	C	33.0 – 37.6	25.3 – 31.0	16.7 – 16.8
1	F	37.0 – 28.6	24.2 – 18.7	16.7 – 12.0
2	B	38.7 – 45.5	30.3 – 32.0	16.0 – 20.5
2	G	42.0 – 30.7	25.7 – 19.4	17.0 – 9.9
3	A	46.3 – 36.0	32.0 – 24.2	19.0 – 15.7
3	E	39.7 – 39.7	28.2 – 22.4	23.0 – 12.1
4	D	45.3 – 57.5	34.3 – 40.3	23.7 – 24.7
4	C	33.5 – 35.1	22.7 – 22.5	16.0 – 14.2
5	F	42.3 – 40.5	31.3 – 28.0	21.0 – 16.8
5	B	49.7 – 43.6	30.5 – 22.4	18.0 – 13.4
6	G	36.5 – 30.6	23.7 – 14.7	18.5 – 8.1
6	D	33.5 – 64.5	21.0 – 37.0	14.5 – 22.7
7	H	25.7 – 40.8	21.3 – 24.5	16.0 – 14.2
7	A	46.2 – 37.4	30.7 – 22.7	20.2 – 13.0
8	E	72.7 – 47.3	38.0 – 37.8	24.3 – 22.2
8	H	53.2 – 44.0	29.0 – 23.3	13.7 – 18.9

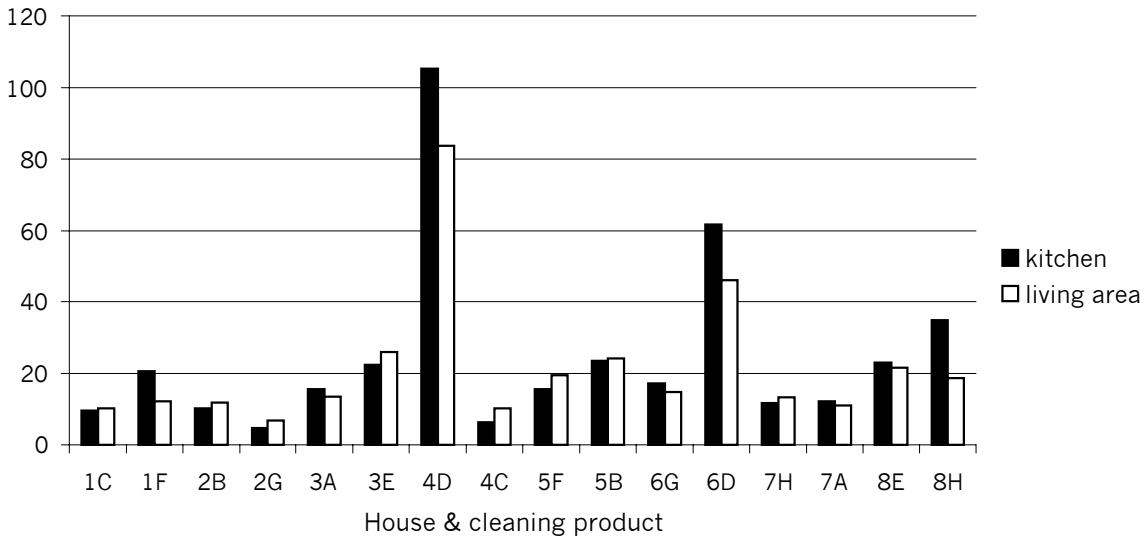

Figure 1. The mean airborne particulate concentrations generated during cleaning in eight Perth homes using different cleaning products.

The mean PM_{10} concentrations generated by the process of cleaning hard floor surfaces is displayed in figure 1. When cleaning the kitchen the concentration of PM_{10} was significantly different in house 4 with cleaning method C and D ($p=0.044$). Cleaning method C was significantly lower ($6.33\mu g/m^3$) compared to cleaning method D ($105.25\mu g/m^3$). When cleaning

the living room there was also a significant difference with cleaning methods D and C in house 4 ($p=0.001$). Cleaning method D was significantly higher (83.75μg/m^3) than cleaning method C (10.16μg/m^3).

DISCUSSION

Airborne particulate concentrations pre and post cleaning

Previous studies have found that very thorough cleaning will reduce the airborne dust concentrations (Kildeso *et* al., 1998). Cleaning method D (broom and dustpan) when used in house 6 resulted in a significant increase in inhalable and thoracic particulate concentrations over the 8 hour duration after cleaning in house 6. Previous studies have similarly shown that dry cleaning methods increase airborne particulate concentrations (Leese *et al.*, 1997). By contrast, in this study the other dry cleaning methods (dust fibre floor cleaner and dry dust mop) did not increase levels of PM_{10}.

This study also found that cleaning with method H (sponge mop + detergent) in house 7 significantly increased the inhalable particulate concentration. When used in house 8, method H did not increase the inhalable dust particulate concentration. Although cleaning method H is a wet cleaning method and is therefore less likely to increase the airborne particulate matter, the cleaning chemical added to the water may effect the way the cleaning method traps and holds the dust collected. Further research into the effects added chemicals have on airborne particulate concentrations is required.

None of the cleaning methods tested resulted in a significant difference in the 8 hour averaged respirable particulate concentrations before and after cleaning. Cleaning is known to cause large particulates to be resuspended (Lee, Li and Ao, 2002), which settle out quickly. By comparison, the smaller particles, while large in number may not have enough mass to become apparent using the gravimetric methods used in this study.

Airborne PM_{10} concentrations generated during cleaning

Cleaning with methods C and D in house 4 generated a significantly different concentration of airborne PM_{10} in the kitchen and living room. Cleaning method D (broom and dustpan) generated significantly higher concentrations of PM_{10} in both the kitchen and living room in house 2 compared to cleaning method C (allpurpose fibre floor cleaner). The higher levels of PM_{10} generated while cleaning with method D displays the amount of airborne particulates which users of the cleaning method are exposed to while attempting to improve the levels of dirt and dust in the area.

CONCLUSION

Previous studies have noted that dry cleaning methods generate higher levels of airborne dust particulates compared to wet cleaning methods (Schneider, Nilsen and Dalh, 1993). Not all dry cleaning methods tested significantly increased the airborne particulates during and after cleaning. The dry dust mop and dust fibre floor cleaner did not significantly increase the airborne particulates as a result of cleaning. By using a suitable method it is possible to clean hard floor surfaces without increasing the airborne particulate concentrations. When using the dust fibre floor cleaner the airborne particulate concentrations were similar to the wet cleaning methods tested (<20.00μg/m^3). Further research is recommended to determine airborne fungi and bacteria

concentrations and surface bacteria concentrations after cleaning with the cleaning methods used in this study.

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