

Indoor vacuum cleaner emissions: particle size distributions and health impact

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1 Introduction

Vacuuming can be considered as an essential cleaning activity in households. However, during this domestic work, resuspension of particles may occur (Vicente et al., 2019). Household dust may come from indoor and/or outdoor sources. Dust is a complex mixture of particles that may contain toxic, carcinogenic or allergic components. Several studies have shown that dust particles can penetrate the respiratory tract and adversely affect the health of those present. The objective of this study is to determine the size distribution of resuspended particles during vacuum cleaning in a living room of a house, located in a suburban area of León (Spain).

2 Materials/Methods

The measurements were made in a living room of a house, with closed door-window conditions, using four vacuum cleaners: washable filter bag less vacuum (V_1), wet vacuum (V_2), bag vacuum (V_3) and HEPA filter equipped robot (V_4), for about 45 min each. Particle size distributions were measured using both: i) a PCASP-X (PMS, Inc.) in a range between 0.1 and 10 μm ; ii) a SMPS (TSI) for the submicrometer particles ranging from 8 to 310 nm. Following the standard ISO, 1995, the aerosol size fractions deposited in respiratory tract regions (inhalable,

thoracic, tracheobronchial and respirable) were also estimated. Further, the aerosol light-attenuation at seven wavelengths was continuously measured with an Aethalometer model AE31 (Magee Scientific, USA).

3 Results and Discussion

Table 1 shows that there is an increase in the particle number concentration during cleaning with the four vacuum cleaners, compared to the value obtained before cleaning. This increase was between 100 and 7753 % for particles in the nucleation mode ($N_{<30\text{nm}}$). In general, the concentration of particles in the accumulation mode ($N_{>100\text{nm}}$) decreased between 17 and 40%, except for washable filter bag less vacuum. The maximum particle concentrations were recorded for $N_{<30\text{nm}}$ particles during vacuum cleaning, except for the HEPA filter equipped robot, for which the peak was registered after cessation of activity. (Fig. 1b). An increase of about 50 % was observed for coarse particles (between 0.1 and 2 μm), reaching values above 40,000 particles cm^{-3} . The results indicate that, in general, vacuum cleaners produce fine particles depending on the type of motors used for their operation.

Table 1. Maximum particle concentration registered for the total distribution (N_t) and for

each of the three modes: nucleation ($N_{<30\text{nm}}$), Aitken ($N_{30-100\text{nm}}$) and accumulation ($N_{>100\text{nm}}$) (in particles cm^{-3}) and variation of the particle number concentration before and during vacuuming (Δ_N) in %.

		V ₁	V ₂	V ₃	V ₄
N _t	Max	45,774	65,789	106,576	7,349*
	Δ_N	274	1647	163	-21
$N_{<30\text{nm}}$	Max	27,838	54,253	74,922	1,676**
	Δ_N	4,148	7,753	384	116
$N_{30-100\text{nm}}$	Max	11,091	11,057	37,045*	3,107*
	Δ_N	93	347	44	-37
$N_{>100\text{nm}}$	Max	8,998	554	3,263*	2,778*
	Δ_N	28	-17	-19	-40

*Value obtained before vacuuming (considered between 10 min and 1 hour before vacuuming).

**Value obtained after vacuuming (considered between 30 min and 1 hour after vacuuming).

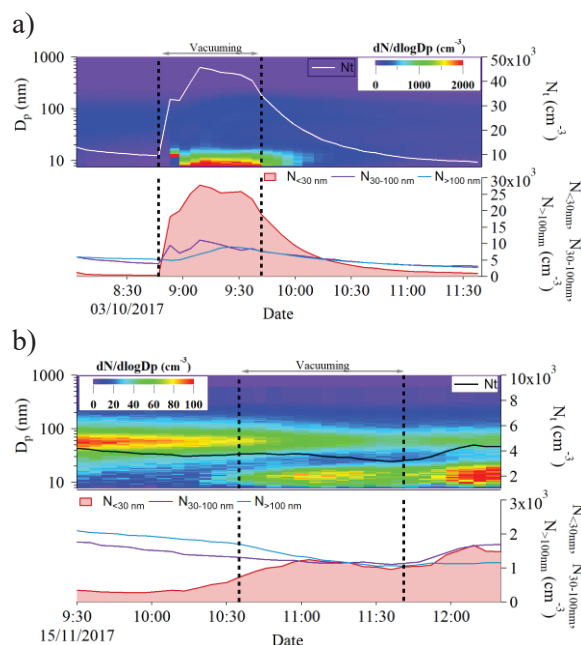


Figure 1: Evolution of the aerosol size distributions and particles concentration for each of the three modes: nucleation, Aitken and accumulation using: a) V₁ and b) V₄.

Concentration of black carbon (BC) increased during vacuum cleaning activity between 80 and 200 %, except for the HEPA filter equipped robot, for which BC decreased by 17 %.

The results showed that for the inhalable fraction, the percentage of the particles inhaled through the nose and mouth was about 99 %. For the tracheobronchial fraction in healthy adults, the percentage of particles that could be deposited in the trachea and bronchi varied

between 1 and 4 %. For the respirable fraction, it has been estimated that the percentage of particles that could pass through the non-ciliated airway and reach the alveolar zone ranged between 90 and 95 %.

4 Conclusions

The results show that the concentration of particles emitted from vacuuming equipment can be high during the vacuuming process, affecting the mass fraction of the particles deposited in the respiratory regions. However, the levels of particles emitted during the process can be reduced by using vacuum cleaners equipped with HEPA filters. The emission of particles, mainly fine particles, from vacuum cleaner motor, as well as from the resuspension of household dust, must be further evaluated using a wider range of vacuum cleaners and operating conditions.

5 Acknowledgement

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6 References

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