Indoor air quality in professional maintenance and cleaning service rooms

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SUMMARY

Professional cleaners maintain their cleaning equipment's in specific cleaning service rooms. Indoor air quality of the rooms is important not just for the occupational hygiene issues but also because the rooms are used in many cases as break rooms and recreation rooms by the cleaning workers. In the rooms, there are also cleaning agents and machines (e.g. laundry and mop cleaner machines). The use of the machines increases the thermal load, and the use of cleaning agents may increase concentrations of volatile organic compounds in the rooms. The aim of this study was to determine the indoor air quality of the cleaning service rooms. Temperature, relative humidity, ventilation rates, fine particles, and volatile organic compounds (VOCs) were measured in 14 rooms. The mean temperature of the rooms was 24 °C (max 27 °C). Air change rates varied from 0.4 to 11.7 l/h. The highest particle concentrations were measured during the cleaning of mops. The concentration of TVOC in the rooms varied from 20 to 6000 µg/m^3.

PRACTICAL IMPLICATIONS

Ventilation rates need to be high in the cleaning service rooms because of the high thermal load of the laundry machines. This is especially important in those rooms which are used also as break rooms by the cleaning workers.

KEYWORDS

Cleaning, indoor air quality, volatile organic compounds, ventilation

1 INTRODUCTION

Cleaning workers expose to a wide range of chemicals and impurities released into the air during their work (Wolkoff et al. 1998, Nazaroff and Weschler 2004, Bello et al. 2009, Hyttinen et al. 2015). Some of the impurities are hazardous and they may have acute and chronic health effects (e.g. some biocides, disinfectants and solvents). Cleaning workers keep and maintain their cleaning equipment's in specific rooms, which contains e.g. floor scrubbers, laundry/mop cleaner machines, vacuum cleaner washer extractors, clean and dirty mops and the variety of cleaning products which some of them are inhalant irritants. At the same time cleaning workers may use those same rooms for a break and recreation (e.g. lunch times and coffee breaks).

The aim of this study was to investigate indoor air quality of cleaning service rooms. Temperature, relative humidity, ventilation rates, particles and volatile organic compounds were measured in 14 cleaning service rooms.

2 MATERIALS/METHODS

The measurements were conducted in 14 cleaning service rooms in Finland. Cleaning service rooms were located in six university buildings, three schools, three kindergartens, theatre and retirement home in central Finland. Approximately half of the rooms were also used for a break and recreation by the cleaning workers.

Temperature and relative humidity were measured by Vaisala HMI41/ HMP42 device (Vaisala, Finland). Ventilation rates were measured by Swema 3000 instrument with SwemaFlow 125D hood (Swema, Farta, Sweden). Volatile organic compounds (VOCs) were collected by Tenax (Markes International Ltd., United Kingdom) adsorbent by active sampling in cleaning service rooms. The sampling times were 30-60 min and the sampling flow varied from 0.141 to 0.172 ml/min. Battery-operated sampler pumps (SKC 222 and AirChek 3000, SKC Inc., PA, USA) were used. VOC-samples were analysed by a gas chromatograph (Agilent 7890) equipped with a mass selective detector (Agilent 5975C) after thermal desorption (TD) (Markes TD-100). Particles were measured as on-line by Dust Trak DRX (TSI Inc., USA) aerosol monitor and mass of the particles was based only on photometric measurement. Zero calibration was done before all the measurements. The logging interval was 10 seconds and measurements lasted for several hours.

3 RESULTS

Cleaning service room volumes, temperatures, relative humidity, air flows and maximum particle concentrations are presented in table 1. Mean temperatures of cleaning service rooms were 23.6 ± 1.6 °C (minimum 21.6 °C and maximum 27.2 °C) and relative humidity 24.7±9.1 %. Air exchange rates of cleaning service rooms varied from 0.4 to 11.7 h^{-1} (mean 4.3±2.9 1/h).

Maximum PM_{10} particle concentrations were 1.24 and 1.88 mg/m^3 when cleaning of mops was done (Table 1). However, high peak concentrations lasted only a short-term (less than a few minutes). Basically, particle concentrations were most of the measurements low and only a peak emissions occurred. Particle concentrations varied typically in between from 0.02 to 0.3 mg/m^3. In figures 1 and 2 are presented PM_{10} particle concentrations in two cleaning service room.

Table 1. Characteristics and conditions of the cleaning service rooms

Number	Location	Volume m^3	Temperature, °C	RH %	Exhaust (l/s)	Air exchange rate (1/h)	Maximum PM_{10} (mg/m^3)
1	University, Kuo1	30	21.7	29.5	33.3	4.0	0.27
2	University, Kuo2	53	23.2	37.6	32.3	2.2	1.88
3	Kindergarten 1 Jyväskylä	25	22.9	32.9	81	11.7	0.17
4	Retirement home Jkl	30	24.0	21.4	40	4.8	0.12
5	Kindergarten 2 Jyväskylä	15	23.0	26.0	27.9	6.7	-
6	University 1 Jyväskylä	44	23.7	17.0	37.5	3.0	1.24
7	University 2, Jyväskylä	40	23.0	17.0	28.6	2.6	-
8	University 3, Jyväskylä	37	22.5	12.0	69	6.7	0.33
9	University 4, Jyväskylä	34	23.6	15.7	45.4	4.8	-
10	Kindergarten, Äänekoski	21	24.0	-	23.5	4.0	-
11	School Jyväskylä,	44	26.5	39	-	-	-
12	School Jyväskylä	50	27.2	-	5.0	0.4	-
13	Theatre, Kuopio	166	21.6	23.7	100.9	2.2	-
14	School Kuopio	95	-	-	86.3	3.3	-

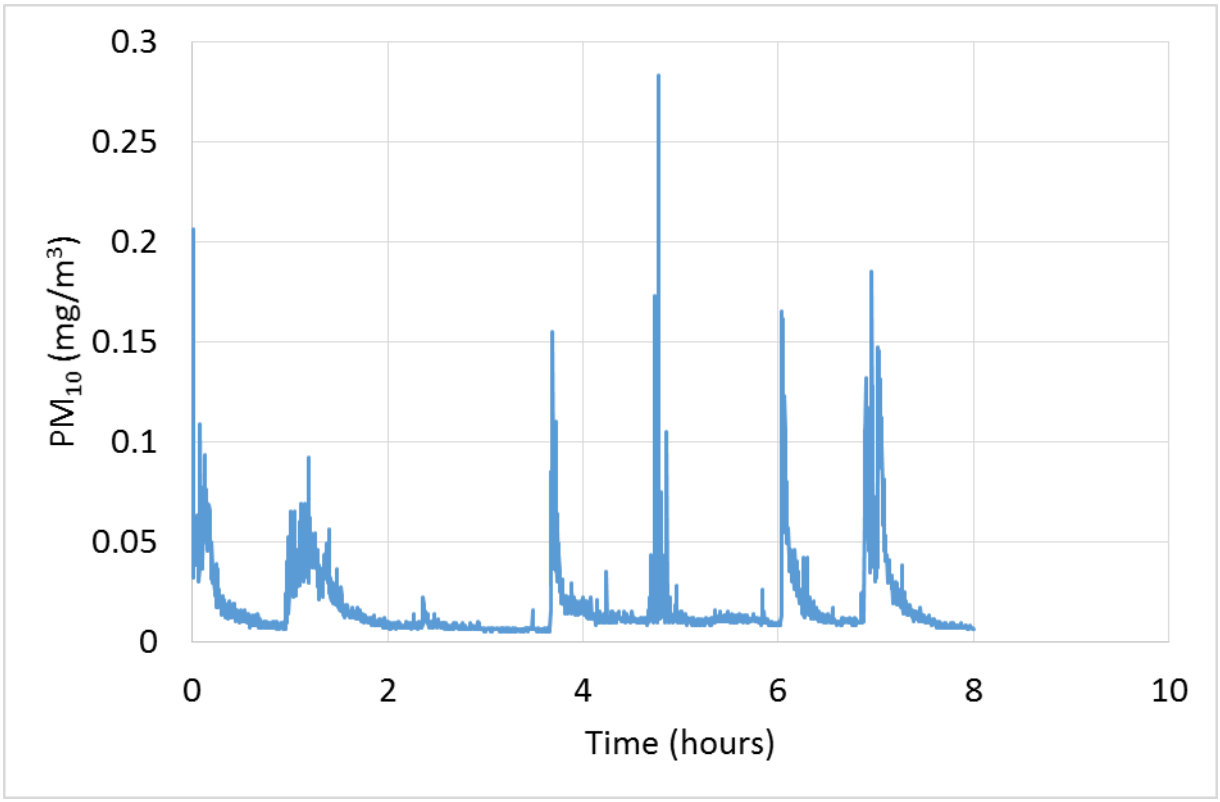

Figure 1. PM_{10} particle concentrations in the cleaning service room one.

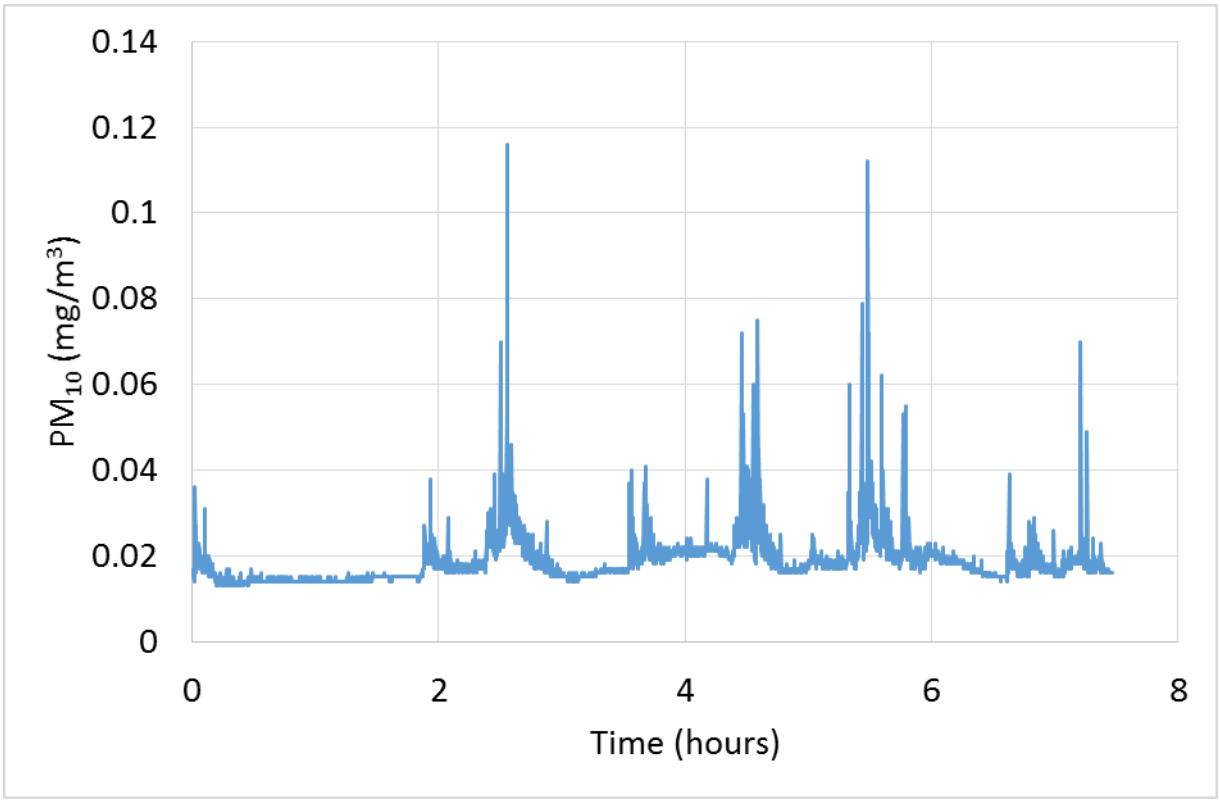

Figure 2. PM_{10} particle concentrations in the cleaning service room two.

In table 2 is presented most commonly found VOCs in the cleaning service rooms. TVOC-concentrations varied in service rooms from 20 to 6000 µg/m^3. High levels of aromatic hydrocarbons and 2-butoxyethanol were measured in two cleaning service rooms. The reason for the unexpectedly high concentration of 2-butoxyethanol might be related to a spill of cleaning agent. Therefore, measurements were repeated and the second time VOC concentrations were notably lower than the first time: The second time TVOC in room one was 201 µg/m^3 and in room two 141 µg/m^3.

Table 2. VOC concentration in cleaning service rooms (µg/m^3)

Compound	1	1	2	2	3	4	5	6	7	8	9	10	11	12	13	14
TVOC (C_6-C_{16})	6031	201	4172	141	50	50	70	35	18	127	88	74	50	104	196	176
Acetic acid	-	68	4	2	-	-	-	< 1	-	1	< 1	-	-	10	18	11
2-ethyl-1-hexanol	5	-	7	8	-	-	-	-	-	-	1	-	19	-	-	2
2-butoxy-ethanol	5842	2	29	8	-	-	-	-	-	-	-	-	-	2	-	-
Dipropylene glycol methyl ether	22	76	71	25	-	-	-	-	-	-	-	-	-	-	-	-
Limonene	1	-	16	6	-	8	9	1	< 1	4	1	1	-	-	1	-
Alpha-pinene	5	1	1	< 1	4	2	6	1	-	4	1	1	4	2	4	6
Nonanal	3	12	12	12	3	< 1	3	6	2	7	12	7	3	6	5	14
Decanal	-	14	8	12	2	< 1	2	6	4	7	7	7	2	-	5	26
Xylenes	4	1	2686	19	-	2	18	-	-	8	-	-	-	1	33	-
Toluene	5	1	10	1	-	1	8	< 1	1	2	< 1	-	-	2	1	2
Benzene	3	1	3	4	9	-	6	< 1	< 1	2	1	1	9	2	2	2
Ethyl benzene	2	-	1241	3	-	< 1	-	-	-	3	-	-	-	3	8	-
TXIB	-	-	27	-	-	-	1	-	-	72	2	-	-	-	4	1
D5 (decamethyl syclopentasiloxane)	2	2	37	15	-	18	< 1	4	1	15	25	49	-	3	2	8

4 DISCUSSION

Despite the high ventilation rates, temperatures of the cleaning service rooms were relatively high indicating high thermal load by the machines. The highest temperature was measured in the room where the ventilation rate was the lowest.

Peak emissions of the particles were measured during the cleaning of mops. Although the exposure to particles was only a short-term, source control or, at least, face masks for the respiratory protections should be considered when handling the dirty mops.

Aldehydes, aromatic hydrocarbons, glycol ethers, siloxanes and terpenes were commonly found in the cleaning service rooms and their concentrations with two exceptions were mainly low. Limonene was commonly found in most of the rooms. It has been used widely as a fragrance in personal care products and cleaning products. However, in professional cleaning products terpenes are not commonly used. Therefore, terpenes might have emitted from building materials (wood), textiles or occupants rather than cleaning agents. Siloxanes (especially decamethyl cyclopentasiloxane, D5) was commonly found from all the samples. D5 is a common compound in personal care products such as antiperspirants, household cleaning products, electronics, and textiles (Tang et al. 2015).

VOC measurements were relatively short-term (30-60 minutes per cleaning service room). Therefore, their concentrations may vary in cleaning service rooms during the day and week. Variations in concentrations might occur when cleaning workers are mixing their cleaning products. On the other hand, high ventilation rates of the rooms dilute VOC concentrations effectively. High concentration of 2-butoxy ethanol was probably caused by a spill of the cleaning product. Alkoxyalcohols (e.g. 2-butoxy ethanol) have been used for waxes/wax removing agents and as solvents for removing fatty substances (Wolkoff et al. 1998). In one case, concentrations of aromatic hydrocarbons (mainly xylenes) were high in room two and reason for that was not revealed. Measurements were repeated and the second time VOC concentrations were in both rooms low.

5 CONCLUSIONS

Indoor air quality of the rooms is important not just for the occupational hygiene issues but also because the rooms are used in many cases as break rooms and recreation rooms by the cleaning workers. The temperature inside the cleaning service rooms was relatively high because of thermal load of the cleaning machines. However, the high ventilation rates kept indoor air quality in most of the rooms at a reasonable level. Some peak emissions of particles were measured and they were related to the cleaning of mops. Therefore, personal protection and/or source control (e.g. local exhaust ventilation) should be considered to limit the emissions and spreading of the particles released from the dirty mops. VOC concentrations were mainly low in the rooms although all the cleaning agents were stored and mixed there. However, at least one spill accident of the cleaning products occurred during the study, indicating a moderate risk when handling such products.

ACKNOWLEDGEMENT

The authors acknowledge The Finnish Work Environment Fund and the city of Jyväskylä for financing this research.

6 REFERENCES

Bello A., Quinn, M., M. Perry, Milton D., 2009, Characterization of occupational exposure to cleaning products used for common cleaning tasks - a pilot study of hospital cleaners, Environmental health, 8, 11.

ISO. 2004. *ISO 16000-6:2004*, Indoor air – Part 6: Determination of volatile organic compounds in indoor and test chamber air by active sampling on Tenax TA sorbent, thermal desorption and gas chromatography using MS/FID.

Nazaroff W. and Weschler C., 2004 Cleaning products and air fresheners: exposure to primary and secondary air pollutants, Atmospheric Environment 38, 2841-2865.

OECD SIDS, Screening Information Data Sets (SIDS), Concise International Chemical Assessment Documents (CICADs), Dipropylene Glycol Methyl Ether http://www.inchem.org/pages/cicads.html, 2001

Tang X., Misztal P.K., Nazaroff W.W. and Goldstein A.H. 2015. Siloxanes are the most abundant volatile organic compound emitted from engineering students in a classroom. *Environ Sci Technol Lett* 2: 303-307.

Wolkoff P., Schneider, T., J. Kildesø, Degerth R., Jaroszewski M. & Schunk H. 1998. Risk in cleaning: chemical and physical exposure. The Science of the Total Environment 215: 1-2: 135-156.