

Particulate Matter Concentrations in Multi-Unit Social Housing

Alireza Mahdavi^a, Daniel Haaland^a,
Jeffrey A. Siegel^{a,b}

a. Department of Civil Engineering, University of
Toronto, Toronto, Ontario, Canada

b. Dalla Lana School of Public Health, University
of Toronto, Toronto, Ontario, Canada

Paper I.D.: 1011

Session ID: 50



Civil Engineering

UNIVERSITY OF TORONTO

Highlights

- Indoor air quality (IAQ) in multi-unit social housing can be poor, where the population may be more vulnerable to the poor housing conditions.
- Particulate matter (PM) number concentration has a substantial variation among social housing units.
- Smoking significantly elevates PM number concentration.
- Even non-smoking units may have high PM number concentration, due to the connection with smoking units.
- None of the other parameters, such as unit type or building location, are consistently influential on PM number concentration.
- Total suspended particle (TSP) concentration measured by gravimetric analysis is not necessarily a good indicator of PM number concentration.

Introduction

- Indoor air quality (IAQ) in multi-unit social housing can be poor due to the high concentration of particulate matter (PM), which is one of the greatest health concerns (Logue et al., 2012).
- The objective of this study is to investigate PM concentrations in social housing apartments that will go through an energy retrofit. These apartments are located in Toronto, Canada.

Methods

- We measured PM number and total suspended particle (TSP) concentrations in 75 units in 7 multi-unit social housing apartments (Table 1).

Table 1: Apartment characteristics for PM sampling

Building	Stories	# of Tested Units	Unit Type
A	4	11	Senior
B	4	9	Senior
C	7	14	Bachelor
D	7	3	Senior
E	11	13	Bachelor
F	19	11	Family
G	18	13	Family

- The buildings were located 1.3 – 2.1 km from major highways.
- Smoking was detected through an occupant survey or by a visual evidence.
- The units were sampled twice (spring and fall) and will be sampled during the same period after retrofits have occurred.
- PM number concentration was measured using DC1700 Dylos counters (Figure 1a) at one-minute intervals for a test period of one week, for two size channels of >0.5 (small) and >2.5 μm (large).
- TSP mass was measured by gravimetric analysis of 12 cm filters used in portable air cleaners (Figure 1b) and deployed for the test period (one week). TSP mass was then converted to TSP concentration using flow rate, runtime and filter efficiency.

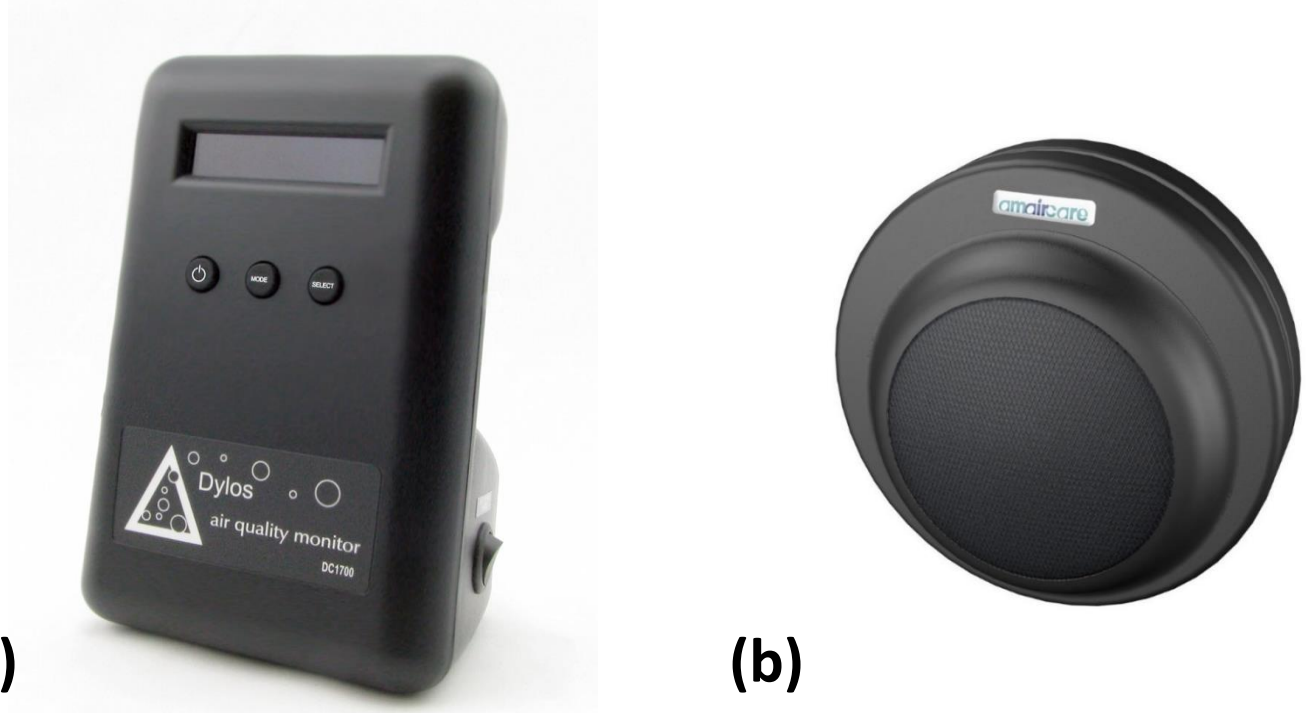


Figure 1: a) DC1700 Dylos counter; b) portable air cleaner with 12 cm filter

Discussion

- Smoking is the only major parameter that elevates PM number concentration in social housing apartments, and none of the other parameters such as building type or location are as pronounced as smoking.
- Even with the lack of smoking in some social housing units, there is still a chance of high PM number concentration due to the connection between smoking and non-smoking units.
- The planned energy retrofits might not reduce PM concentration because of the dominance of smoking as a source. Furthermore, retrofits could make the apartment enclosures more airtight and therefore trap more PM indoors.

Conclusions

- There is a substantial variation of PM number concentration among social housing units.
- Improving IAQ in social housing is important to protect the vulnerable populations that live there.
- Smoking significantly elevates PM number concentration.
- Gravimetric TSP is not always a good indicator of PM number concentration.

Results

- Figure 2a illustrates the PM number concentration in different units. Smoking resulted in a significant elevation of number concentration for both small and large channels (Wilcoxon signed rank test, $p < 0.05$). Some non-smoking units also had high concentrations, due to other PM sources indoors, transfer of particles from other units or infiltration from outdoors.

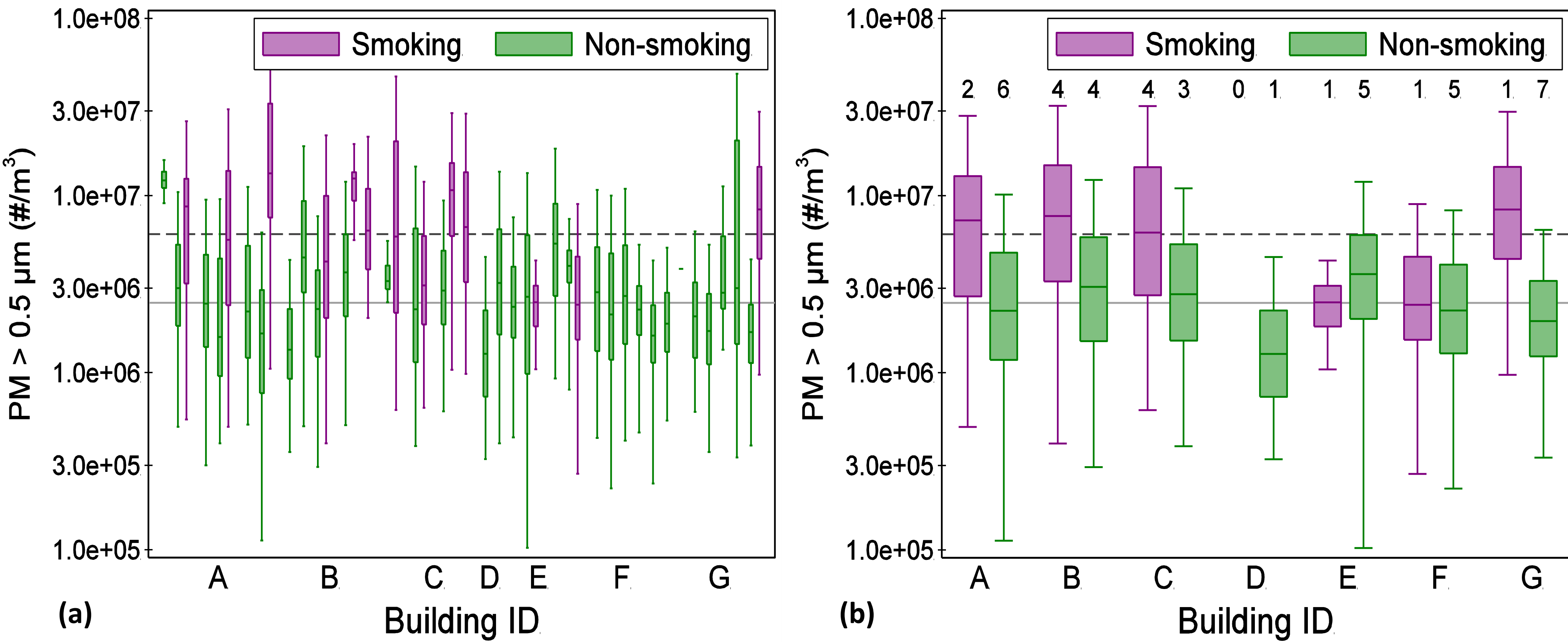


Figure 2: Impact of smoking on the number concentration of PM > 0.5 μm for a) units and b) buildings. The dashed and solid lines in each figure represent medians of smoking and non-smoking units, respectively.

- Figure 2b illustrates the PM number concentration in different buildings. Smoking was the only important influential parameter on number concentration and building or unit type did not consistently influence concentration.
- Figure 3 indicates the median PM number concentration in terms of TSP concentration, for both channels for the units that passed gravimetric analysis quality control. No strong correlation was observed between the two parameters. This was not consistent with Dacunto et al. (2015) who found strong correlations between the number and PM_{2.5} mass concentrations. The inconsistency could be due to the different particle densities at different sizes, measurement uncertainties, and the difference between TSP and PM_{2.5}.

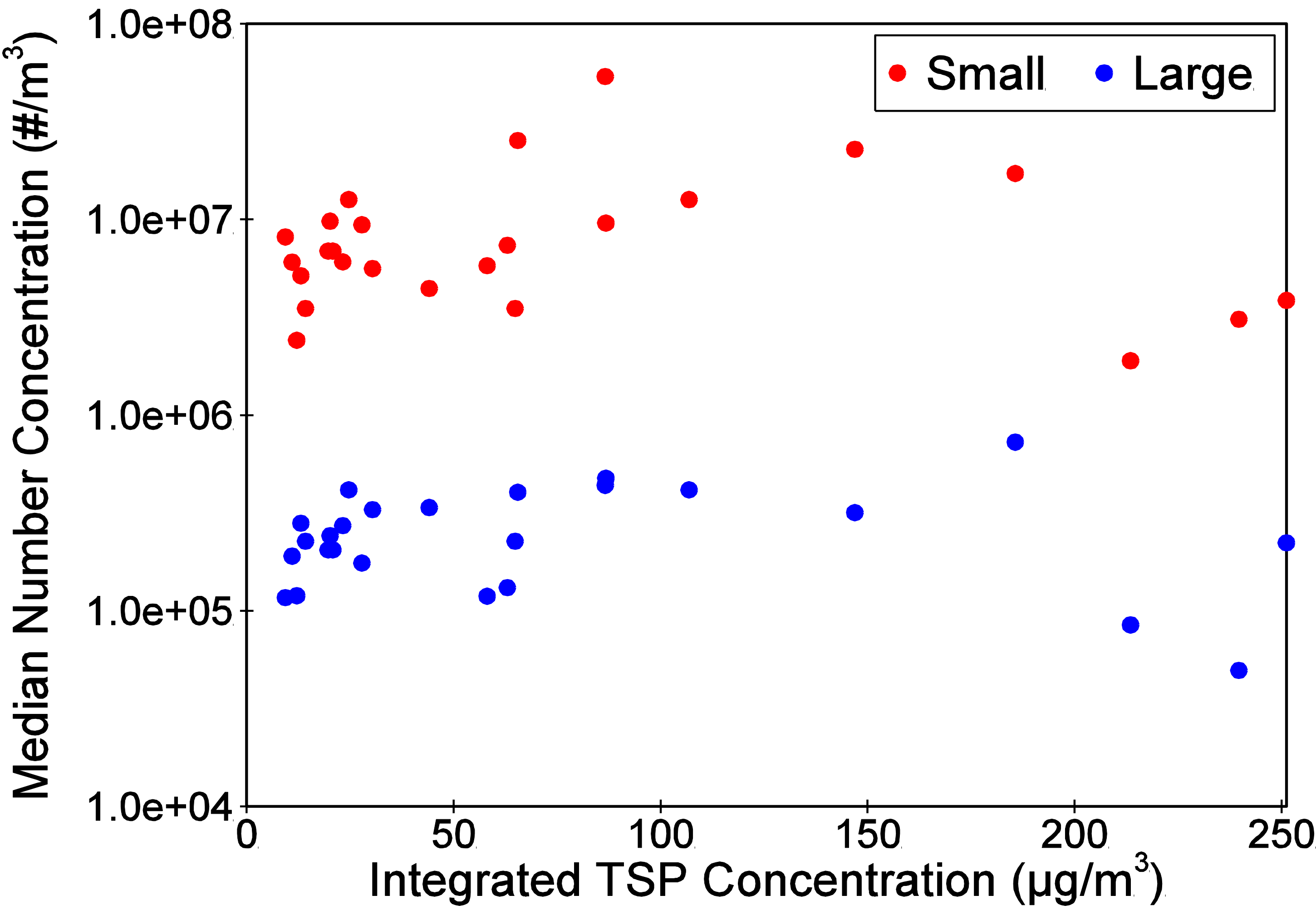


Figure 3: Small and large size median concentrations vs. integrated TSP concentration

References

- Dacunto, P.J. et al. (2015) Determining PM 2.5 calibration curves for a low-cost particle monitor common indoor residential aerosols, *Environ. Sci. Process. Impacts, Royal Society of Chemistry*, 17, 1959–1966.
- Logue, J.M. et al. (2012) A method to estimate the chronic health impact of air pollutants in U.S. residences, *Environ. Health Perspect.*, 120, 216–222.

Acknowledgements

- Funding was provided by the Natural Science and Engineering Research Council of Canada (NSERC) Grant RGPIN-2014-06698.
- Authors would also express their gratitude to Mr. Brett Lessard, the Toronto Atmospheric Fund (TAF), the social housing agency and residents of participating apartments.