Non-volatile sub-23 nm particle concentrations in a busy street canyon

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Introduction

The European Union legislation limiting the number of solid particles emitted by vehicles follows Particle Measurement Program (PMP) protocol that takes into account only particles above 23 nm in size [1]. Even though sub-23 nm emission particles are in many cases known to be volatile, also non-volatile particles have been observed in this size range [e.g. 2, 3]. In addition, it has been found that the size range of traffic emitted particles extends even down to 1-3 nm [4]. In this study, we measured the number concentration of non-volatile sub-23 nm particles in a busy street canyon and compared the results to the size range of > 23 nm.

Methods

Measurements were carried out at an urban supersite measurement station operated by Helsinki Region Environmental Services (HSY) in May 2018.

Particle number measurement

Condensation Particle Counter Battery (CPC Battery) provided by Airmodus

Thermal treatment

Hot + cold ejector diluter, 300 °C => non-volatile

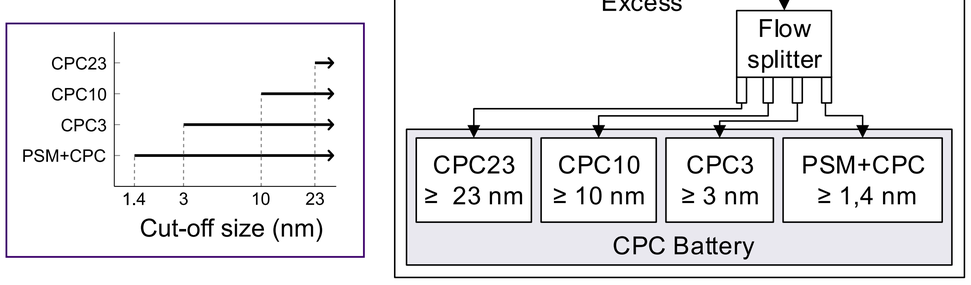


Figure 1. *Measurement setup and illustration of particle sizes measured by CPC Battery.*

- Simultaneous CO_2 measurement data was used in the evaluation of the emission factors.
- Passing vehicles were counted from videos recorded on 9.-10.5.2017.

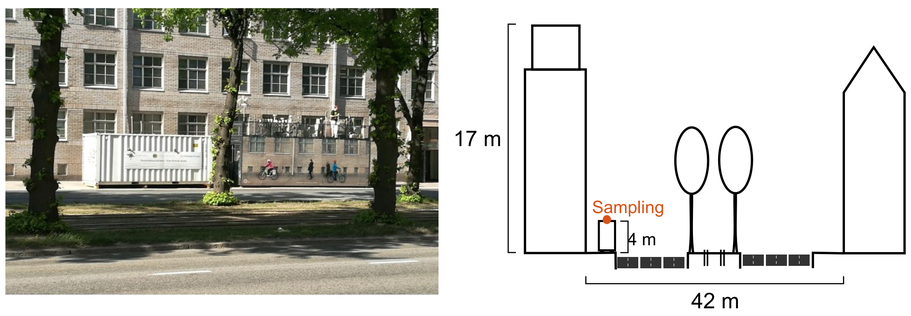
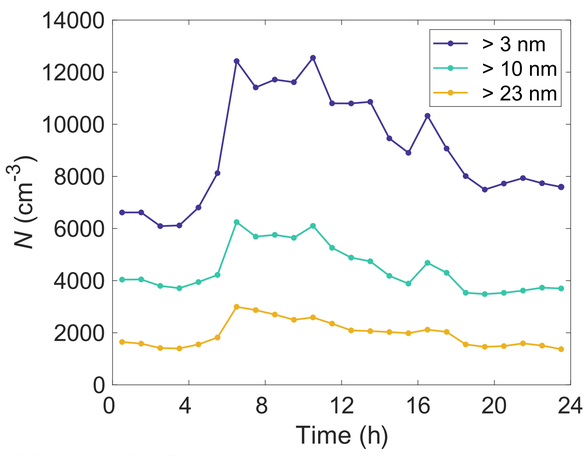


Figure 2. *Measurement environment. The traffic rate of the street is ~28,100 vehicles/day. Photo by Kimmo Teinilä.*

Results



The highest concentrations of non-volatile particles were measured between 6-11 a.m. on workdays (Fig. 3).

This time frame corresponds to morning rush hour and typical driving hours for heavy-duty vehicles (Fig. 4).

Figure 3. *Diurnal variation of non-volatile PN concentrations during workdays.*

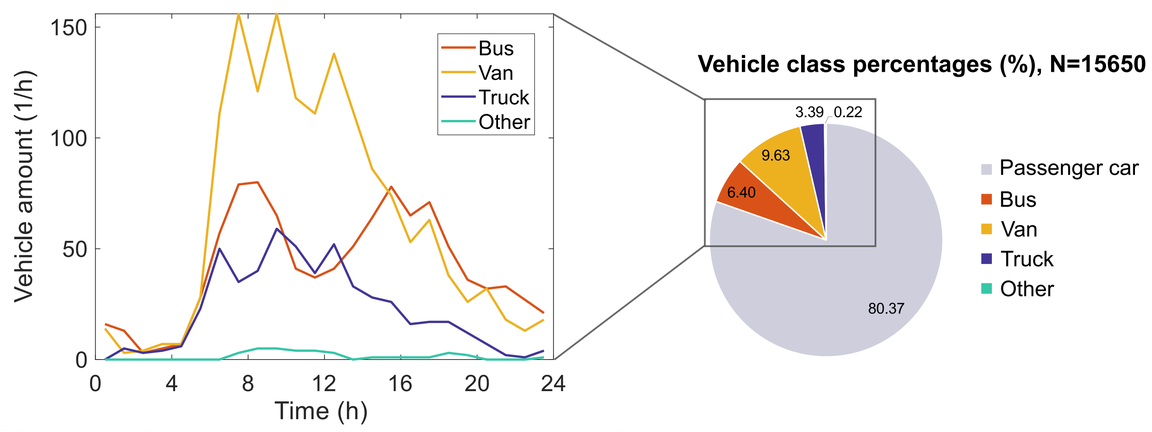


Figure 4. *Diurnal variation and amount of vehicles passing the station on the same side of the street.*

The non-volatile > 23 nm particles accounted for ~20 % of the total non-volatile PN (d_p > 3 nm) (Fig. 5).

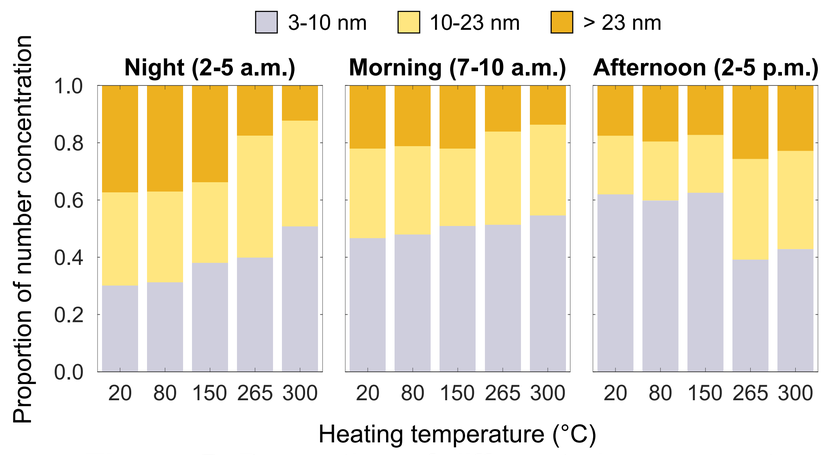


Figure 5. *Proportion of different size ranges to total particle number (d_p> 3 nm).*

Table 1. *Emission factors (EF).*

	$EF_{non\text{-}volatile}$ (kg_{fuel}^{-1})	EF_{all} (kg_{fuel}^{-1})
3-23 nm	$4.5 \cdot 10^{14}$	$2.8 \cdot 10^{15}$
> 23 nm	$1.4 \cdot 10^{14}$	$2.3 \cdot 10^{14}$

Emission factor (EF) for number of non-volatile 3-23 nm particles was ~3 times larger than the EF for non-volatile > 23 nm particles (Table 1).

Conclusions

- The Condensation Particle Counter Battery is an advantageous tool for counting small particles at the roadside.
- A considerable amount of non-volatile sub-23 nm particles exist in a street canyon environment.
- The traffic may be a major source of non-volatile sub-23 nm particles in urban areas.

References

[1] Giechaskiel, B., Manfredi, U., & Martini, G. (2014) SAE Int. J. Fuels Lubr. 7(3):2014.
[2] Kittelson, D., Watts, W. & Johnson, J. (2006). Journal of Aerosol Science, 37(8), 913 – 930.
[3] Mayer, A. C. et al. (2010). SAE Technical Paper 2010-01-0792.
[4] Rönkkö, T. et al. (2017). PNAS, 114(29), 7549-7554.

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