Determination of particle emission factors of individual vehicles under real-life conditions

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Introduction

Particle number emissions by road traffic are mostly in the ultrafine size range (< 100 nm) and pose a risk to public health, especially in urban regions. For future legislation and the development of new techniques reducing the particle burden, more knowledge about the variation range between individual vehicles is needed.

A new experimental setup for the measurement of particle number emission factors (EF) from individual vehicles is presented here, which was designed for continuous on-road sampling.

Setup

The air is continuously sampled in the street. After the passage of a vehicle, the sample taken directly from the emission plume is diluted with particle- and CO_2-free background air (cf. Fig. 1 and Fig. 2) and distributed to the measurement instrumentation, consisting of a condensation particle counter (CPC, TSI-3010) and a CO_2-analyser (PP Systems WMA-4).

On the basis of the CO_2 and particle excess number concentrations within the plumes from simultaneous measurements, the particle EF is derived, assuming an EF_{CO2} of 164 g km^{-1} veh^{-1}, which is the average CO_2 emission of the on-road vehicle fleet.

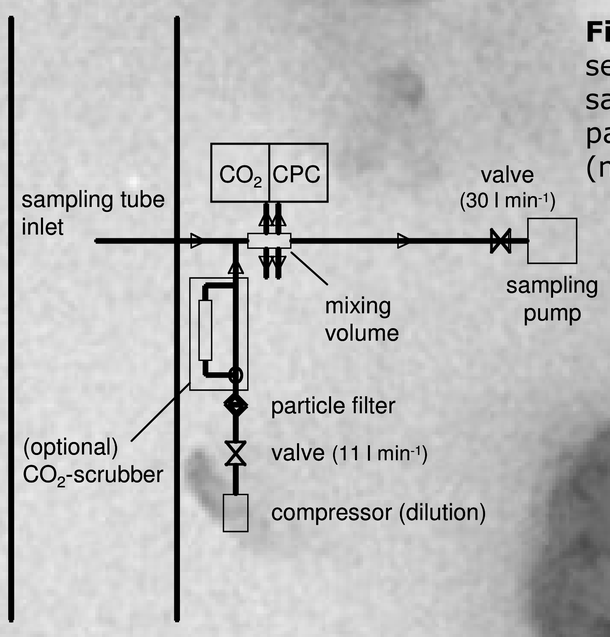

Figure 1 Measurement setup for simultaneous sampling of CO_2 and particle concentration (not to scale).

Determination of emission factors

Emission factors, i.e. the amount of a specific pollutant produced per unit distance, have previously been derived from different types of measurements like

- Roadside measurements of the average fleet
- Tunnel measurements of the average fleet
- On-road chasing measurements of a limited number of individual vehicles

The method presented here allows the on-road sampling of a large number of individual vehicles.

Experiments

Two experiments were performed in the Göteborg area using the described setup (cf. Fig. 1). The objectives were in the first instance to test the method and further to (1) derive particle EFs from individual cars in an everyday vehicle fleet and (2) study the intra-vehicle variation of the particle EF under specified driving conditions, respectively. The experiments covered 2-4 hours each.

The dilution of the sample is necessary due to the large variation range of particle emissions, exceeding the measurement range of the used CPC.

Licence plate number:

⇨ type of vehicle
⇨ age of vehicle
⇨ engine type
⇨ piston displacement
⇨ weight of vehicle
⇨ etc.

for the passing fleet

Figure 2 Car approaching the measurement site. Note the inlet tube in the centre of the near side lane.

Results I

From measurements in everyday city traffic, i.e. with driving speeds between 30 and 50 km h^{-1}, particle EFs of the order of 2.1 x 10^{13} part km^{-1} veh^{-1} (cp. Fig. 3a) were obtained. The values are predominantly within the range stated in the literature for petrol-fuelled vehicles (cp. *Jones & Harrison*, 2006), except for one which is considerably higher, indicating the passage of a diesel car. The experiment proved the applicability of the method to distinguish individual vehicles' emissions.

Results II

The second experiment involved the variability of particle emissions from four vehicles driving with a known speed and gear (Fig. 3b). Car I, a diesel vehicle, showed the lowest variability (1.10 ± 0.21 x 10^{14} part km^{-1} veh^{-1}) for passages with 50 km h^{-1} (4th gear). A higher variability for the same car was observed when driving with higher engine rpm, i.e. 3rd gear. For the measurement sensitivity used in this experiment the petrol car emissions were only apparent for higher driving speeds (70 km h^{-1}).

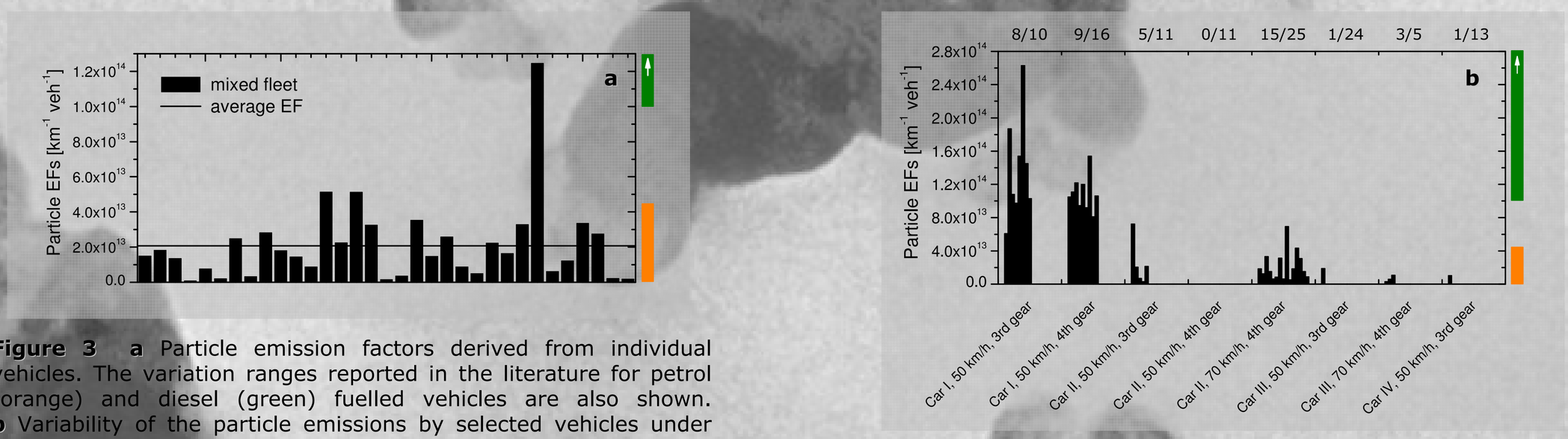

Figure 3 **a** Particle emission factors derived from individual vehicles. The variation ranges reported in the literature for petrol (orange) and diesel (green) fuelled vehicles are also shown. **b** Variability of the particle emissions by selected vehicles under predetermined conditions. Car I is diesel-powered.

References

Jones, A.M. and R.M. Harrison (2006), Estimation of the emission factors of particle numbers and mass fractions from traffic at a site where mean vehicle speeds vary over short distances, *Atmos. Environ.*, 40, 7125-7137.

Acknowledgements

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