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Section K

New Methods of Determination of Average Particle Emission Factors for two Groups of Vehicles on a Busy Road

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New Method Of Determination Of Emission Factors For Different Types Of Vehicles On A Busy Road

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INTRODUCTION

Aerosols of fine and ultra fine particles have become of increased concern in relation to human health in urban areas. Therefore, busy roads that are the main source of fine particles in the urban environment are of a particular interest for researchers in the aerosol science. This paper presents an approximate model that allows simple and reliable predictions of fine particle concentrations near a busy road, and a simple method for the determination of the average emission factor for different types of vehicles on the road.

METHODS AND RESULTS

Recently, the CALINE4 model, designed for calculation of concentrations of carbon monoxide near a busy road (Benson, 1992), has been adapted for the analysis of aerosols of fine and ultra-fine particles coming from a busy road (Gramotnev *et al*, 2003). A scaling procedure for the CALINE4 model has been developed and justified. A new method for the determination of average emission factors for fine particle emission from an average fleet (one average vehicle) on a road has been developed. This method is based on measurements of particle concentration only at one point near the road (Gramotnev *et al*, 2003). The examples of the calculated and experimental dependencies of concentration of fine particles on distance from the road clearly demonstrate the applicability of the method (see the figure).

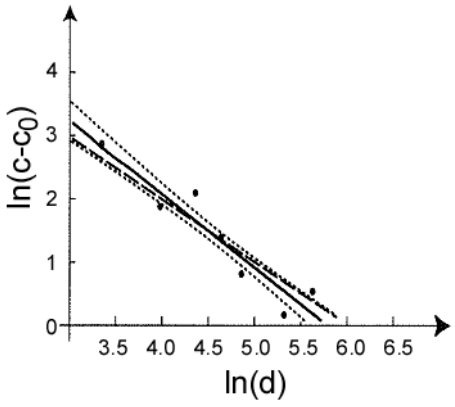

Figure. The experimental (solid line) and theoretical (dashed line) dependencies of the average total number concentration (in cm^{-3}) without the background, $c - c_0$, on distance from the middle of the road (in meters). The dotted curves give the standard errors for the experimental (solid) line. Measurements were taken on 30 July 2002 - see the Table.

At the same time, use of the CALINE4 model for prediction of concentrations of fine particles from a proposed road requires knowledge of the average emission factors for different types of vehicles and the anticipated number of such vehicles on the road. However, estimate of these emission factors from the literature is difficult, due to the substantial spread (2 to 3 orders of magnitude) of their values, depending on make and age of the vehicles, measurement techniques, etc. Therefore, there is a strong need to reliably determine average emission factors for different types of vehicles on existing roads. These factors could then be used in the CALINE4 model for the prediction of aerosol

pollution from a proposed road. In this paper, a new simple method is developed for the determination of the average emission factors for different types of vehicles on a road. As an example, the calculation of the emission factors for heavy-duty diesels and cars is presented.

Using the method developed in (Gramotnev *et al*, 2003), the emission factor was determined for the average fleet on the Gateway Motorway (Brisbane, Australia) at different traffic conditions: 18.1% of heavy trucks on the weekday, 30 July 2002, and 2.7% on the weekend, 24 November 2002. The total number concentration of fine and ultra fine particles in the range from 14 nm to 710 nm was measured at 15 m from the kerb of the road by a scanning mobility particle sizer (SMPS-3071) and a condensation particle counter (CPC-3010). The meteorological parameters (temperature, wind speed, wind direction) were measured every 20 seconds. One hour average of wind speed and direction that are inputs in the CALINE4 model are presented in the table together with their standard deviations. The calculated values of the emission factors for the average fleet on the road are given in the last row of the table.

Table 1

Parameters	**30 July 2002**	**24 Nov. 2002**
concentration at 15 m, [particle/cm^3]	$20.3 \cdot 10^3$ (±16%)	$2.2 \cdot 10^3$ (±13%)
background concentration, [particle/cm^3]	$2.3 \cdot 10^3$ (±4%)	$0.74 \cdot 10^3$ (+9%)
traffic flow, [vehicle/hour]	4295 (±2%)	3694 (±2.2%)
heavy duty diesels, [vehicle/hr]	776 (±2.3%)	100 (±15%)
cars and light trucks, [vehicle/hr]	3694 (±2.3%)	3594 (±2.3%)
Wind direction, [°] degrees to the North	142° (SD = 48°)	28.54° (SD = 39.43°)
Wind speed, [m/s]	2.3 m/s (SD. = 0.8)	2.2 m/s (SD. = 0.7)
temperature, [°C]	22	27
emission factor, [particle/vehicle/mile]	$4.5 \cdot l0^{14}$ (±23%)	$0.37 \cdot l0^{14}$ (±24%)

In the case of the line source approximation, the calculated emission factor for the average fleet

$$E_f = n_t \cdot e_t + (l\text{-}n_t) \cdot e_c \qquad (1)$$

where e_c and e_t, are the emission factors for cars and heavy duty trucks, respectively, and n_t is the fraction of heavy-duty trucks in the traffic flow. Therefore, using the emission factors calculated for the average vehicle on the road (see the last row in the table) and the fractions of heavy-duty vehicles n_t =0.181 and 0.027 for the experiments on 30 July and 24 November, respectively, we can write a set of two approximate linear equations similar to equation (1). Application of the methods of linear modeling (Kreyszig,1999) to this set gives the value of the emission factor for heavy-duty trucks: $17.2 < e_t < 29.6$ (x $l0^{14}$ particle/vehicle/mile), and the value of the emission factor for cars $0.26 < e_c < 0.45$ (x $l0^{14}$ particle/vehicle/mile).

CONCLUSIONS

If we have a proposed road with an expected traffic flow and expected fractions of cars and heavy-duty vehicles, then the determined values of the average emission factors e_c and e_t, together with the use of the CALINE4 model, allows the prediction of the fine particle pollution in the vicinity of the road. Similar calculations can also be carried out for existing roads without measuring particle concentrations, but rather counting the traffic flow on the road.

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