Modelling PM_{10} dust emission potential on a road surface

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Introduction

Emissions of road dust particles are influenced by both direct generation in the tyre/road interface and by suspension of particles deposited on the road surface. Suspension will be a result both from the action of the tires on the road surface and the turbulence occurring under passing vehicles. The suspension is depending on the total dust load of a certain road surface, but also the availability of the dust itself, which to a large extent is negatively related to the road surface wetness, as a moist road surface will allow a lower degree of suspension than a dry road surface (Amato et al., 2012). A strong linear relationship between the road surface texture and the emission potential of five pavement surfaces with different surface characteristics was found by Blomqvist *et al* (2011) under controlled conditions in a laboratory experiment. This implied that road surface texture is an important property for road dust emission through suspension and thus should be a parameter in emission modelling. This paper is aiming to find a method to model the dust emission potential on road surfaces with varied characteristics, and how the model parameters depend on the road surface texture as the most important characteristic.

Methods

The PM_{10} concentration was measured (TSI, DustTrak) in a confined chamber placed on different asphalt surfaces where a known amount of artificial road dust (filler material made of crushed stone <200 µm, with 20% PM_{10}) was manually distributed using a brush. The asphalt surfaces (Figure 1) had all been worn by studded tyres in a road simulator (Gustafsson *et al* 2009). Road surface macro texture was measured on the surfaces by the sand patch method (EN 13036-1).

Suspension of the particulate material on the road surfaces was achieved by the method presented by Etyemezian *et al* (2007) at 1000 rpm (See the instrumental set-up in Figure 2). Each measurement was replicated five times (Blomqvist, et al. 2011).

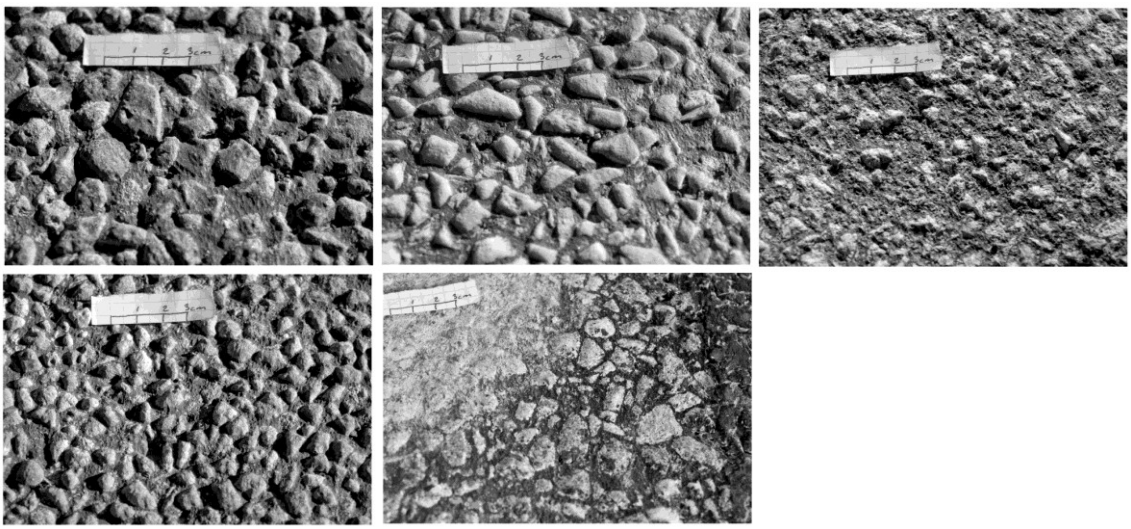

Figure 1: The pavements slabs tested

Figure 2: The instrumental set-up for dust emission potential measurements

The five tested pavement slabs were of different pavement types, had different stone minerals and, most important, had road surface texture values (mean texture depth) varying between 1.3 and 2.1 mm (Table 1).

Table 1: Pavement type, stone mineral and road surface macro texture (mean texture depth, MTD) on the tested pavement surfaces (Blomqvist et al., 2011).

No	Pavement type	Stone mineral	Road Surface Texture (mm)
1	SMA 16	Porphyry	2.1
2	SMA 11	Quartzite	1.6
3	AC 11	Limestone	1.4
4	SMA 8	Porphyry	2.1
5	SMA16	Quartzite	1.3

SMA = Stone Mastic Asphalt, AC = Asphalt Concrete, 8, 11, 16 = Maximum stone size (mm) in pavement

Results

In order to understand how the processes behind suspension of road dust on the road surface are influenced by the road surface characteristics, a model (eq. 1) was fitted to the data described above and presented in Blomqvist et al. (2011).

$$C\ t\ = \frac{S}{D}\ 1 - e^{-D \cdot t}\ + C0 \cdot e^{-Dt} \text{ (equation 1)}$$

In the model C0 is the initial value of the PM_{10}-concentration C, S is the source strength and D is the deposition velocity within the measuring chamber.

The deposition velocity, D, is ideally found by measuring on a surface with unlimited amount of artificial road dust material which gives a constant source, S. In the real world situation, however, the amount of road dust is not unlimited, why the source strength was substituted with a source strength exponentially decreasing by time (eq. 2, Figure 3, left).

$$S = S1 \cdot e^{-kt} \qquad \text{(equation 2)}$$

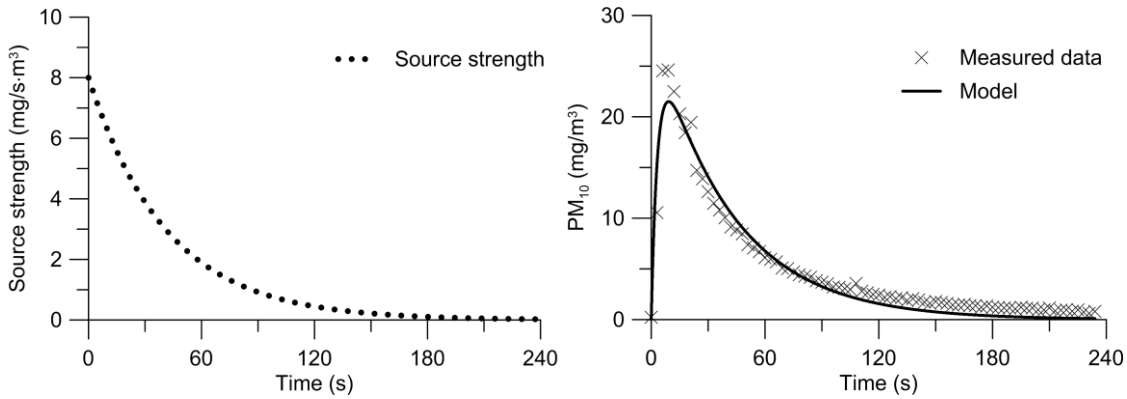

Figure 3: To the left: Exponential decreasing source strength. To the right: Fitting the model to measured data

The model output fitted the measured data fairly well (see example in Figure 3, right). The fitted model parameters S1 (in eq. 2), k (in eq. 2) and D (in eq. 1) are plotted in Figure 4 against the mean profile depth in each tested pavement slab. This shows that S1 is strongly negative related to the road surface texture (Figure 4, left), k may have a negative relation to the road surface texture and, finally, D is positively related to the road surface texture.

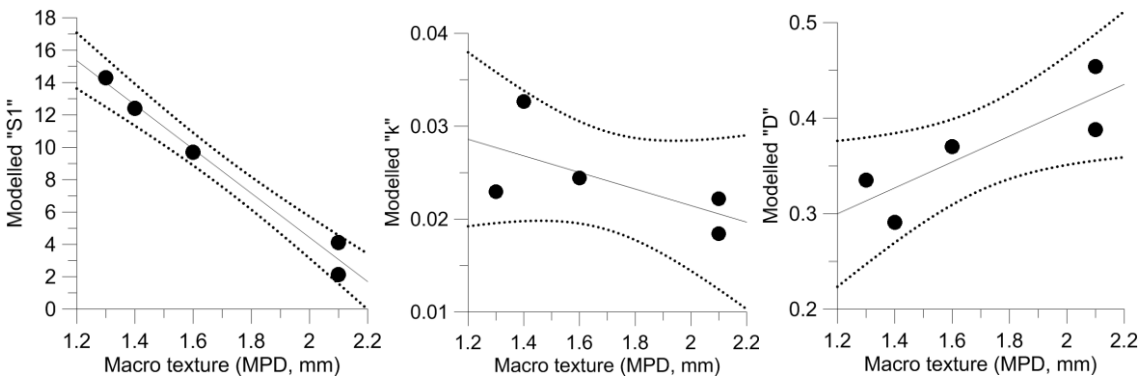

Figure 4: The modelled parameters as influenced by the road surface texture. From left: S1 (see equation 2), k (see equation 2), and D (see equation 1). The solid line is a linear regression line fitted to the data, and the dotted lines are the 95%-confidence interval of the fitted line.

Discussion

The model described here will facilitate the understanding on how the source strength of suspended road dust will behave on different road surfaces with varied road surface textures. Initial tests of the measuring set-up in the field (urban streets) have however revealed that instrument settings need to be further adjusted for use in the field.

References

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EN 13036-1, Sand patch, macro texture CEN-standard, (equivalent to ASTM E965)