VALIDATION OF VEHICLE ROAD PM10 EMISSION MODELS BY THE KARLSRUHE PM VALIDATION DATA SET AND THE RESULTS OF THE REGULAR GERMAN STATE MONITORING STATIONS

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INTRODUCTION

The first daughter directive of the EU air quality guideline (1999/30/EU) introduced an upper limit for the concentration of PM10 in the ambient air. Field measurements show an exceedance of these values in the vicinity of vehicle roads. However, PM10 emission modelling of paved roads, especially the contribution of the road abrasion, being in the same order of magnitude as the exhaust pipe contribution, is not satisfactorily solved. This is a major drawback when looking for measures against the exceedance of the limit value.

The paper deals with the description of 2 data sets, being presently evaluated and compared to the results of the paved road PM10 emission model of the US-EPA (1997) and to an adaptation of this model for conditions in Germany (Lohmeyer et al., 2001 and Düring et al., 2002). The methodologies for acquisition and use of the 2 data sets are completely different, they are described below. The first data set results from specially designed continuous high frequency simultaneous lee- and windward roadside PM10 and NO_x concentration measurements at a highly trafficked and truck loaded open country perimeter road. These data are aiming to provide information for example about the influence of rain, differences in emissions of trucks and passenger cars etc.. The second data set results from the continuously operated regular roadside stations of the German States Air Quality Monitoring System. The evaluation of these data is aiming to get information for example about the influence of the material of the road surface, the state of the roads (new, old, cracked etc.), i.e. information which can only be obtained by examining a high number of roads.

KARLSRUHE PM VALIDATION DATA SET

Description of the monitoring site

For the Karlsruhe PM validation data set the data acquisition is done at a site in the open country where the road is perpendicular to the prevailing wind directions. With a traffic volume of 60 000 vehicles/day and a truck content of 14 % the road was expected to have enough emissions to monitor them in a good range for the instruments. The monitoring equipment was set up in July/August 2002 at both sides of the road (except for wind) in a distance of 6 m and 7 m off the road, thus lee- and windward measurements can be done simultaneously to detect the influence of the road.

The following parameters are monitored:

a) Concentrations: See Table 1. PM10, PM2.5, NO_x and CO at both sides of the road. PM is measured as well by gravimetry (24 h mean values) as well as by ß-meters as 3 h running mean to get an indication for the variation over the day. SO_2 is included as there is a major emission in the vicinity. Except for SO_2, the data are taken at heights of 3.2 m and 6 m in order to see whether the PM emissions, calculated from the measurements (see chapter 4), yield the same result for the 2 heights.

b) Traffic: number of vehicles per class (passenger cars, light and heavy-duty vehicles) and speed by induction loops in the road. Hourly mean values.
c) Meteorological parameters: wind speed (cup anemometer), wind direction (vane), humidity, temperature, atmospheric pressure, global radiation, and precipitation. Hourly mean values.

The gravimetric PM measurements are done using both fibreglass (for the gravimetry) and quartz filters for the analysis of the composition of the dust. The analysis of the dust on the filters presently covers the contents of OC (organic carbon) and EC (elementary carbon to determine the soot content coming from the exhaust pipes and from the tire abrasion), nitrate, sulphate and ammonium (mainly for secondary aerosols), iron and calcium (for road abrasion and material from the crust of the earth) as well as arsenic, lead and cadmium as heavy metals.

Table 1. The concentration measurements at the B10 in Karlsruhe

	south of road		north of road	
	height 3.2 m	height 6m	height 3.2 m	height 6 m
PM2.5 daily mean (gravimetric)	x	x	x	x
PM10 daily mean (gravimetric)	x	x	x	x
PM2.5 3 h running mean (ß-meter)	x	x	x	x
PM10 3 h running mean (ß-meter)	x	x	x	x
NO_x hourly mean	x	x	x	x
CO hourly mean	x	x	x	x
SO_2 hourly mean	x	x	-	-
benzene hourly mean	is under consideration			

Further information
The State of Baden-Württemberg Ministry of Environment and Traffic, financing this monitoring site and the evaluation of the results of the presently installed instruments, would like to see this side as a nucleus of research concerning PM aspects in the vicinity of roads. Therefore it invites other research groups (from abroad and from Germany) to make use of the results coming from that site or to set up their own instruments, complementing the site and making use of the basic information, already being there.

UMEG, having set up and managing the site, will additionally use it for example as test site for new instruments. In that frame UMEG is presently planning to test a high frequency particle counter.

DATA SET FROM REGULAR GERMAN STATE MONITORING STATIONS
All over Germany approximately 25 state monitoring stations are situated near vehicle roads. All available data at these stations for the year 2000 (or 2001) were collected as annual mean of PM10 and NO_x concentrations, background concentrations, wind, rain, traffic volume, speed, slope of the road etc.). From these data the PM10 emissions will be determined for the road near each station as described in the following chapter. These results will be compared to the PM10 emission model described in Düring et al. (2002). In contrast to the Karlsruhe PM validation data set, this data set contains detailed information on the influence of the material of the road surface and its quality etc. at least as far as these parameters vary for the data available.

DETERMINATION OF THE PM10 EMISSIONS FROM THE CONCENTRATION MEASUREMENTS

There are at least 3 methods to determine the PM10 emissions from the roadside concentrations away from intersections. Their applicability depends on the available information and the local conditions.

a) Mass balance

Knowing the windward and the leeward vertical wind speed and PM10 profile, one can determine the incoming and outgoing PM10 mass flows, their difference being the PM10 emission of the road. That was done for example by Imhof et al. (2002); it cannot be done for the measurements reported here, as no complete vertical profiles are available.

b) NO_x as a tracer

Knowing the additional road concentration Δ_c (= total concentration near the road as monitored minus background concentration known by background monitoring stations) for PM10 and NO_x and knowing the NOx-emission E of the road (by knowledge of the traffic volume, vehicle speed etc.) on can use NO_x as a tracer. The NO_x data give the relationship between the vehicle-induced emission of the street and the concentration at the monitoring site. So the PM10 emission of the street can simply be calculated by the statement

$$E_{PM10} / E_{NOx} = \Delta_{c\,PM10} / \Delta_{c\,NOx}$$

with E_{PM10} being the only unknown parameter.

That statement contains the assumption, that the release to the atmosphere and the dispersion is the same for NOx and PM10. Even if that is doubtable, one might consider, that this difference is balanced out, if for practical traffic air pollution dispersion modelling the same procedure is used for PM10 and NO_x (as it is usually done). For that case it is even necessary to handle release and dispersion of PM10 and NO_x as if they would be the same.

Of course, for using NO_x as a tracer, it is necessary, that the NO_x emissions of the road are determined correctly. That sounds like an easy problem, but it probably is not, as presently the German Handbook of NO_x Emission Factors (INFRAS, 1999) seems to get a major update with significantly increased emission factors for trucks.

In a first step, the measurements reported here will be handled as described above to determine the PM10 emission. TREMOD (2000) will be used for the determination of the NO_x emissions, as it already contains the latest data sets.

c) Inverse dispersion modelling

Knowing the meteorological conditions at the site and the additional road concentration of PM10, one might use a dispersion model to calculate the PM10 emission, necessary to produce the observed PM10 additional road concentrations. That procedure has the disadvantage to require detailed information about the surrounding buildings configuration and the meteorology which might not be available, it contains the uncertainties of a dispersion model and it needs more manpower than using NO_x as a tracer.

At intersections, methods a) and b) do not work, and inverse dispersion modelling would work only if the relationship between the PM10 emissions of the 2 roads would be known, which usually is not the case.

CONCLUSIONS

There is a lot of work going on, aiming to improve the knowledge about PM emissions in Germany. The first results will be available within the coming 6 months; hints about the availability will be given in www.Lohmeyer.de/aktuelles.htm.

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