

Spatial and temporal variation of PM₁₀ concentrations at the street level: a case study for the city of Münster

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INTRODUCTION

Although traffic-induced particulate matter is known to affect health risks of people living close to major roads, small-scale variability and dispersion of PM₁₀ (particles with diameters below 10 µm) are still not well investigated by measurements. Depending on the traffic intensity, wind direction and speed and building topography, PM₁₀ concentration can vary considerably within a city. How does PM₁₀ concentration change with increasing distance from a busy street? What can we call a safe distance? These questions have become more important since the European commission released the directive 1999/30/EC (EC 1999) that defines thresholds for PM₁₀ in order to protect human health.

The main goal of this project is to investigate and model the concentration field of PM₁₀ at major roads in the urban area of Münster and to compare its small-scale spatial distribution in different traffic situations. We present an explorative study to assess the dispersion of traffic-caused PM₁₀ emissions by taking measurements with a mobile handheld device. Simultaneous traffic intensity counts by a web cam allow the exploration of the relations between traffic sources and concentration distribution.

STUDY AREA & METHODOLOGY

The ongoing study takes place in the urban area of Münster. We sample PM₁₀ concentration fields at a major road by using the TSI DustTrak DRX Handheld, a new photometric measurement device able to measure five different size fractions of particles (PM₁₅, PM₁₀, PM₄, PM_{2.5}, and PM₁) simultaneously. Additionally, the fixed monitor measurements of the Landesamt für Natur Umwelt und Verbraucherschutz (LANUV) NRW network are used for stationary reference measurements and estimation of the background concentration levels. The two stations in Münster measure PM₁₀ in 30 min intervals using a tapered element oscillating microbalance (TEOM) measurement device. Our first investigation was an explorative comparison of the mobile photometer measurements and the stationary gravimetric measurements at the same sample point to ensure the comparability of the different measurement techniques.

As an additional step we include parallel traffic measurements. A web cam installed on a high position over the sampled street site can count the number of vehicles passing by. This is done by an application subtracting each frame from the previous one on the fly to detect changes caused by moving objects. This technique does not provide a classification by vehicle type but an automated quantification of vehicles independently from traffic intensity.

To associate the traffic volume with the mobile PM₁₀ measurements at different distances to the street, two different approaches are chosen. The first one is a statistical approach based on a randomized sampling strategy whereas the second one follows an analytical paradigm. We adjust a simplified transport model to estimate the distribution of particles through wind and test its output with our own measurements.

Randomized sampling

Taking samples of PM₁₀ concentration with a mobile handheld device implies to move through space and time while measuring. As we are interested in comparing spatial distributions, it is necessary to consider the expected temporal variability. Therefore, our sampling locations are not ordered by increasing distance from the street (e.g., 10m, 20m, 30m, 40m ...) but selected randomly (e.g., 90m, 20m, 70m, 60m ...) as shown in fig. 1. On average, this approach will cancel out the time component of the measured PM₁₀ concentration leaving only the spatial distribution. We will use this technique in different traffic situations but under stable meteorological conditions.

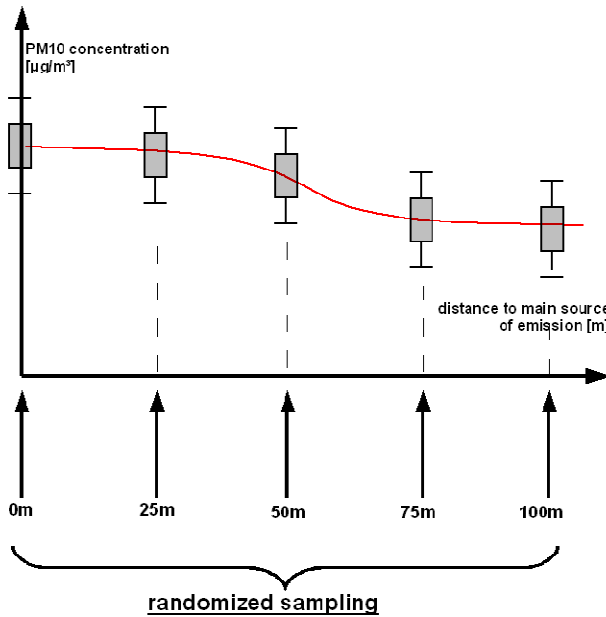


Fig. 1. Randomized sampling strategy.

Simplified transport model

To model the dispersion of PM10 resulting from different traffic situations, we implement and apply a simplified advection-dispersion-model. We assume no chemical transformations and no loss of particles (which is reasonable for short time periods). The concentration variance in time and space is then modelled as three partial differential coefficients. Thus, the dispersion of PM10 only depends on the two wind horizontal vector components. For this purpose, wind direction and speed is measured additionally to PM10 concentration. The estimated concentration dispersion can be compared to the measured concentrations. Using the model for back calculation of the measured concentration to the time of origin at the street allows a direct link to the traffic intensity at this time. This may help to explain variations in the spatio-temporal concentration field with the traffic sources.

CONCLUSION AND OUTLOOK

The approach taken could be useful to better understand small scale variations in urban PM10 concentration fields. Understanding these patterns helps assessing health risks of humans living, working and commuting in highly trafficked street environments.

BIBLIOGRAPHY

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