

A simple photometry based measuring system (APM-2) for automatic time resolved monitoring of PM10 and PM2.5

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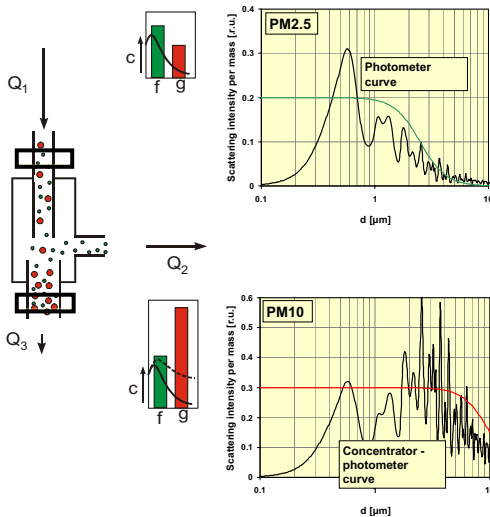
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MOTIVATION

Current and future EU-standards on PM10 and PM2.5 require the measurement of these aerosol fractions in the outside air. In view of identifying relevant emission sources, checking the effects of abatement actions such as traffic control, street cleaning in cities etc., determination of aerosol fluxes by comparison of indoor and outdoor concentration, on-line dust detection systems are highly demanded. Simple and reasonably priced instruments are still missing on the market. In this paper we present data obtained with a novel instrument, APM-2, for time-resolved concentration monitoring of the PM10 and the PM2.5 sub-fraction of the environmental aerosol.

THE MEASURING PRINCIPLE

The instrument combines inertial classification and photometric aerosol detection. It consists of a PM10 inlet head followed by a virtual impactor with a cut-off diameter of 2.5 µm and a constant angle light scattering photometer. The virtual impactor serves as a particle size classifier, separating PM2.5 from PM2.5-10 and a concentrator for the size fraction PM2.5-10. The concentration enrichment stage is achieved by splitting up the main flow, Q₁, of 3.3 l/min entering the stage into a minor flow, Q₃, of 0.2 l/min and a major flow, Q₂, of 3.1 l/min. This is done in a set-up of two opposing nozzles separated by a gap: a sending nozzle and a receiving nozzle. The minor flow proceeds straight through the receiving nozzle opposing the inlet nozzle, whereas the major flow is sucked off perpendicularly. All aerosol particles with a diameter larger than 2.5 µm suspended in the main flow will pass straight through the gap between the nozzles and will enter the receiving nozzle. Thus, all large particles will be incorporated in the minor flow. This enrichment compensates for the decreasing particle mass-based photometric sensitivity with increasing particle diameter. The combination of the enrichment characteristic and the detection characteristic of the photometer approximates the PM10 definition curve. Thus both the PM2.5 concentration in the main flow and the PM10 concentration in the minor flow channel can be detected photometrically (see figures below).

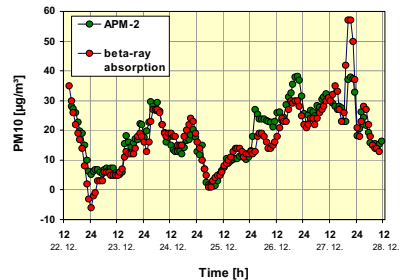


Only one photometer is used in the device. Using a computer controlled valve system the instrument detects the aerosol alternatively in the main flow channel or the minor flow channel. Filtered air is passed periodically through the optical cell to compensate for long term drifts of the photometer off-set.

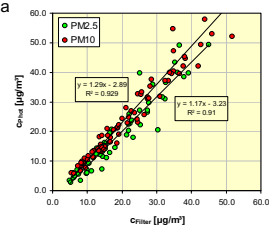
RESULTS

The optical sensor is calibrated via the mass concentrations obtained gravimetrically from filter samples. Measurements for the urban aerosol in Hannover show good long term stability of the instrument.

In view of the temporal concentration pattern the APM-2 data compare well with data obtained with the beta-ray absorption technique. The figure shows PM10 data of the urban background in Hannover taken at two different sites 5 km apart.



The results of a first intercomparison study carried out at the Institute of Metrology, Prague are shown in the next figures. The data plotted are 24-h average values of PM2.5 and PM10 concentrations as measured by the APM-2 and as determined from filter samples analyzed gravimetrically. The upper plot shows the raw data obtained when using the original calibration of the photometric sensor as carried out in Hannover. Although the sample flow passed through the APM-2 is slightly heated an overestimation of the photometrically measured concentration at high outside humidity due to water uptake of the aerosol particles cannot be ruled out. A humidity correction was applied to the data, improving the correlation between the corrected photometric and the gravimetric PMx concentration data.



$$c_{Phot,corr} = c_{Phot} \cdot 1.05 \text{ (r.h./\% 40)}$$

