A NEW KIND OF PORTABLE ENVIRONMENTAL MONITORING METHOD

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ABSTRACT

A new monitoring method for particulate matter will be presented. To evaluate the possible impact of the particulate matter in the ambient air on human health, it is necessary to get more information aside from the PMx values. This new method not only gives simultaneously the values for PM_{10}, $PM_{2.5}$ and PM_1, but at same time the size distribution of the sampled particles. Further the amount of the semi-volatile fraction on the particulate matter and with additional sensors it is also possible to look for specific components like particle bound PAH and the amount of soot in the ambient air.

INTRODUCTION

The values for Particulate Matter (PM) only give a limited amount of information about particles in ambient air. In most cases there is only a mean mass value, which gives no information about the composition of the dust or temporal changes. A high mass value could come from a few coarse particles or from a huge amount of small particles. For a better assessment of the possible impact on human health, there is a need for more information. It is desirable to measure the concentration and composition of fine particulate matter in the atmosphere on a real-time basis. Such data collection is cost effective, provides details on processes occurring in the atmosphere and allows for better prediction of episodes which are important with respect to human health. Fine particulate mass in the atmosphere includes non-volatile components such as sulfate, crustal material and elemental carbon which are easily measured by a variety of techniques. However, also included in the fine particulate material is semi-volatile material, i.e. ammonium nitrate, some organic material and water, which is much more demanding to monitor (Eatough et al., 2003). It is necessary to determine the aerosol size distribution in combination/addition with different speciation technologies to get also an insight on the composition of the particulate matter.

METHOD

Optical particle counter (particle counting with the method of orthogonal light scattering) are widely used to measure particle counts and mass of ambient aerosols. For this new approach a OPC (optical particle counter), a Grimm dust monitor ENVIRONcheck 107, has been used to determinate the particle mass distribution and the different PMx values. This monitors use light-scattering technology for single particle counts in which a semiconductor laser serves as the light source. The ambient air to be analyzed is drawn into the unit via an internal volume controlled pump at a rate of 1.2 liters/minute. The pump also generates the necessary clean sheath air which is filtered and passes through the sheath air regulator back to the optical chamber. This is to ensure that no dust contamination comes in contact with the laser-optic assembly. This particle free airflow is also used for the reference zero test during the auto-calibration. The inlet air is usually unaltered prior to introduction to the light-scattering chamber. However, the inlet air can be heated if desired. The scattered signal from each particle passing through the laser beam is collected at approximately 90° by a mirror and transferred to a recipient diode. After a corresponding reinforcement, the signal of the diode is recorded with a multi-channel size classifier. A pulse height analyzer then classifies the signal transmitted in each channel. These counts are stored in the data storage card for future analysis. To prevent condensation, the monitor incorporates a special sample probe drying system and does not alter the probe.

Different studies have shown that the semi-volatile fraction of $PM_{2.5}$ accounts for 20%…50% of the total $PM_{2.5}$ mass. To determine the appropriate PM value, it is important to measure not only the non-volatile fraction but also the semi-volatile content. With filter sampler the semi-volatile components may be lost due to the on-going sampling, to gas-solid or even fluid-solid reactions. Other common dust monitors are heating the sample probe to prevent condensation. But doing so, they loose the semi-volatile fraction by heating up the sample. As a result, most measurements are underestimated.

With this newly developed instrument it is now possible to get a realistic value of $PM_{2.5}$ and to calculate a correction (location) factor for existing measurements. The instrument is measuring first the total amount of particles (volatiles and non-volatiles) in the ambient air with the standard non-heated sample inlet and the according PM_{10} and $PM_{2.5}$ values are obtained. The sample inlet will then be heated up to 100°C and in a second measurement the non volatile fraction of the sample air is measured (semi-volatiles are stripped out by heating up the sample probe to 100°C). The difference between the two results is the semi-volatile fraction of the ambient air. By processing both measurement cycles, it is possible to get the mass value of the semi-volatile fraction.

To obtain additional information about the composition of the particulate matter, it is possible to attach different sensors to the dust monitor. In the sample air stream outlet of the OPC, behind the measuring chamber, a new kind of PAH (polycyclic aromatic hydrocarbon) sensor and a soot sensor for continuous monitoring could be incorporated. The results are the amount of particle bound PAH and soot in the same sample air, which previously has been monitored for the particle mass distribution.

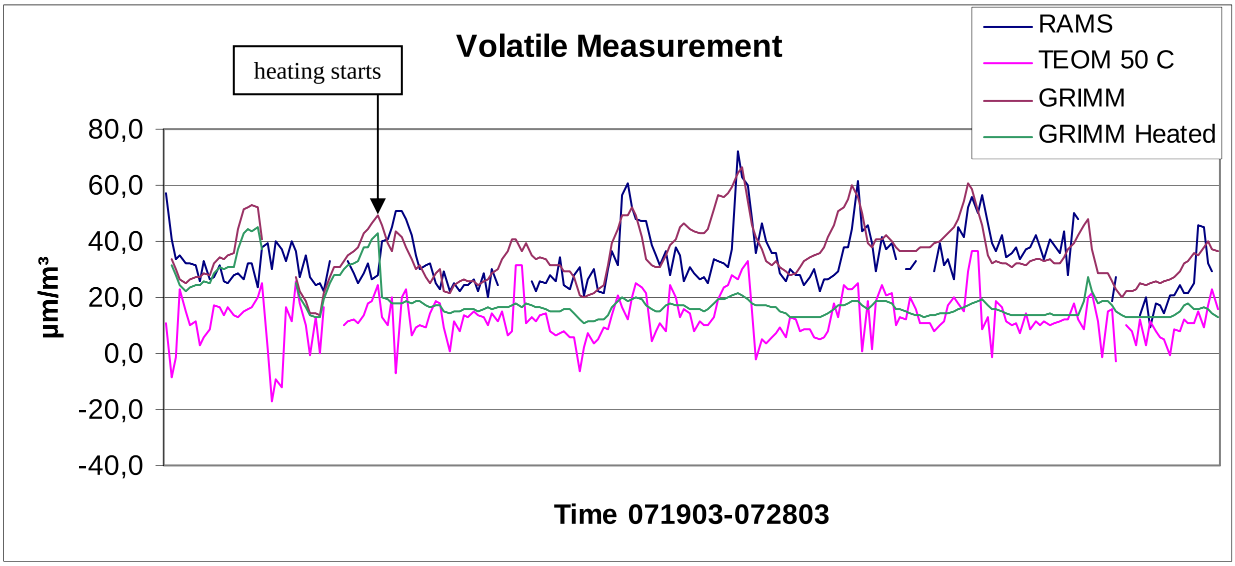
PAH are a product of incomplete combustion processes, known to be carcinogenic. Particle bound PAH could be inhaled and deposited in human respiratory system. Coming from the outlet of the OPC, the particles are drawn in the PAH sensor where they are ionized by a eximer lamp. Through the design of the sensor only particle bound PAH are ionized. This is done by a photoionizing process. The charged particles are then collected on a filter inside of an electrometer. The resulting current is proportional to the amount of particle bound PAH.

The soot sensor is attached in the same way as the PAH sensor. The particles are collected on a filter. The collected soot particles are blackening the filter surface. By measuring the change in reflection of the surface, it is possible to get a value for the amount of soot particle collected.

The whole system configuration is made for the mobile use and is installed in a robust weather proof housing.. This allows for mobile measuring campaigns, hotspot measuring or source apportionment.

RESULTS AND DISCUSSION

In a field test the instrument was compared with a RAMS (Delbert J. Eatough, 2003) and a TEOM with a heated sample system at 50°C. At the start of the field test, both OPC were not heated and were following the RAMS with their measured values. The TEOM with the heated sample inlet was measuring lower values. As can be seen in the diagram, after the start of the heating of the second OPC, the values observed are following the values of the TEOM, whereas the unheated OPC is still following the RAMS. The obtained values of the heated OPC are more smooth than the values of the TEOM. Through the higher temperature of the sample inlet of the heated OPC (100°C) than of the TEOM (only 50°C) more volatiles has been stripped out.



The obtained PM_{10} values corresponded to the mean values of high volume samplers. However, when the sample pipe was heated, the mass values dropped in some cases down to 2/3 of the previous values. This phenomena is related to the amount of VOC fraction the ambient air. The effect was even more obvious for PM2.5, where the volatile fraction accounts for 30…50% of the total mass value. This effects were not seen with the HC concentration. Variations however occurred due to different air temperatures.
In order to quantitatively evaluate the correlation, other methods were used, results will be reported.

In another field test (conducted by the Tropospheren Institut in Leipzig, Germany) this new instrument was compared against three High-Volume sampler Digitel DAH80 equipped with a PM_{10}, a $PM_{2.5}$ and a PM_1 sample head. Comparison not only was made for the PM values, but an analysis of the collected particles was made. The work is still going on. But the evaluation of the semi-volatile content obtained from the analysis with the measuring results from the new Grimm dust monitor shows a high correlation between the two measurements. The final results will be presented in future paper.

SUMMARY

The combination of different continuous monitoring methods into one portable Environmental system will not only permit access to particle size distribution and particle adsorption values, it may also be a very useful tool for atmospheric airborne particle studies. Especially for field campaigns, hotspot measurements or source apportionment will this be a preferred technology.

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