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Summery
The result of the investigation gives a review about the determination of traffic-related pm10 sources.
On a high traffic site and a urban background site in Stuttgart pm10 samples were collected, segregated by their size fraction.
The morphology and particle sizes of the PM were investigated by high resolution SEM. For the determination of the samples elemental composition, energy dispersive x-ray analysis (EDX) was used.

As a result of the microanalysis investigations the different PM fractions were assigned to 3 different classes. The first fraction with coarse particles was identified as road dust with mainly mineral particles. In the fraction with the smallest particles, pure diesel soot particles were identified. The fraction between those was dominated by droplet-deposition of ammonia salts. Those “particles” must have arrived as droplets on the sample surface. These so called “secondary aerosols” were probably generated by gas to particle conversion process.

Identification of Traffic-Related PM10 Sources at a High Traffic Site in Stuttgart, Germany

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Abstract

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Goals of the Investigation

The main source of the anthropogenic particulate matter exposure is probably given by road traffic.
The aim of the investigation was to collect pm10 samples, segregated by size fractions, on a high-traffic site and on a urban background site in Stuttgart.
Beside means of the morphology, particle sizes of single particles and agglomerates including the elemental composition of the samples, potential sources of the exposure should be identified.

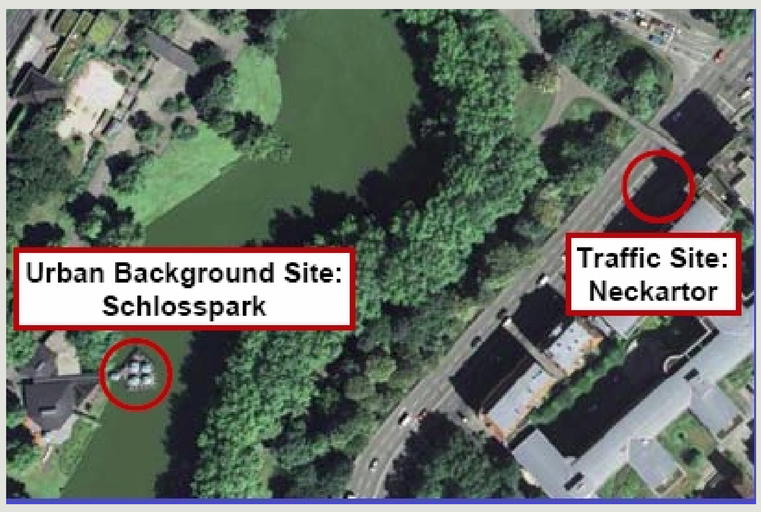

Image 1. Aerial view of points of measurements

Methods

Sampling

The samples were collected segregated by size fractions in a 8 stage Anderson Cascade Impactor on Al-filters. Only the Backupfilter consisted of nitrocellulose.
The amount of particulate matter on each stage of the impactor was evaluated by gravimetric methods.

Identification

To show the morphology of the pm10 and to measure single microstructures, a high resolution SEM (ZEISS Crossbeam 1540 XB) was used. Images of nanostructures with magnifications up to 200 kx were taken. Nano particles were additionally imaged by transmission electron microscopy (TEM Jeol, JEM 2000 FX II).
The elemental composition of the particulate matter accumulations and single microstructures were determined by energy-dispersive X-ray microanalysis (Bruker AXS XFlash Detector 4010).
Area analyses including hypermappings as well as point analyses of microstructures were made.

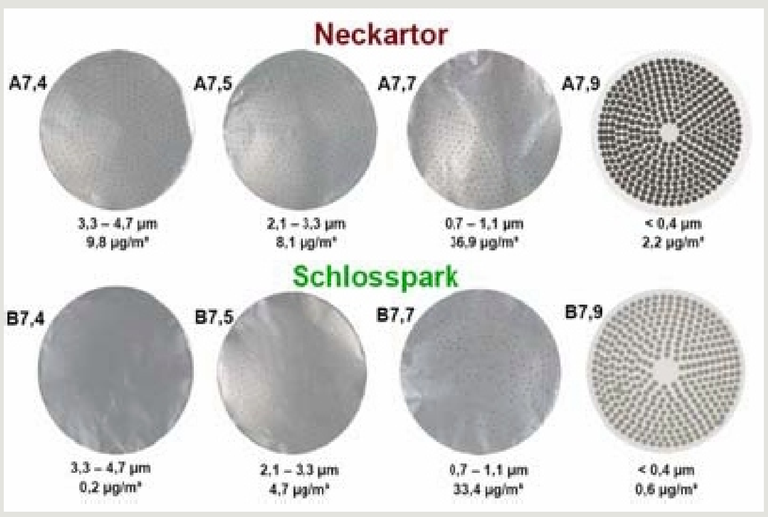

Image 2. Al-filters and backup-filter (right position) with different PM10 size stages

Results

As a result of the microanalysis investigations the different pm fractions were assigned to 3 different classes.
The first fraction with a particle size distribution of 2,1-10 µm is assigned to road dust with mainly mineral particles (image3 / right side).
In the fraction with the smallest particles <0,4 µm pure diesel soot particles were definitely identified (image 3 / left side).

On the fraction between those, with the size distribution 0,4-1,1 µm, secondary aerosols like ammonia salts and agglomerated particles are observable. The deposition of droplets with dissolved SOx, NOx and ammonium are probably the source of the salts that were found in this size distribution. This thesis is supported by the huge size of the salt crystals and the tidemark around the particle accumulation on the sampling filter of the impactor (see image 3 in the middle and image 5).

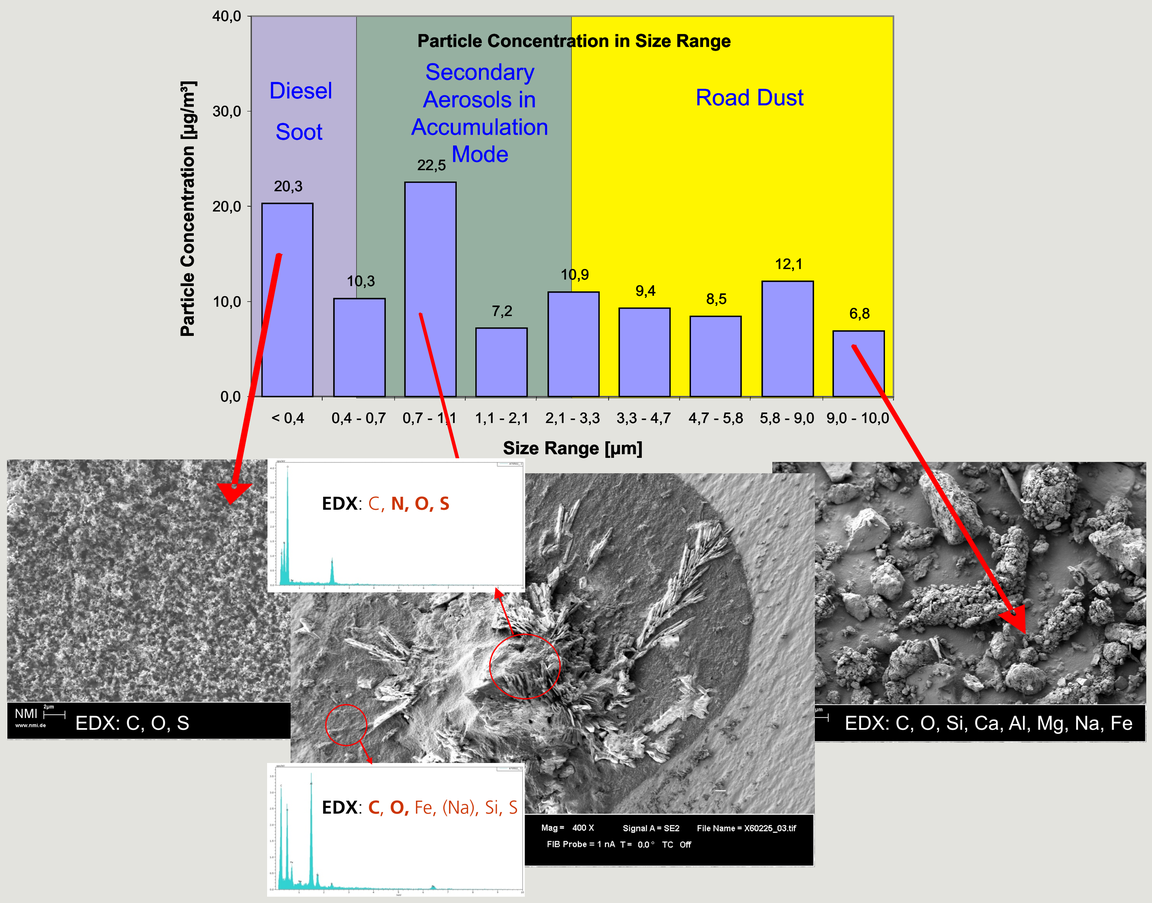

Image 3. Classification of the pm10 fractions in 3 different classes (SEM-Images and EDX-Analyses)

The equations 1 and 2 show two possibilities for the formation of ammonium-salts ,that were found on the investigation of pm with the size distribution 0,4-1,1 µm.

1. By the neutralisation of liquid H2SO4 with NH3(gas):

2 NH3 (gas) + H2SO4 (liquid) □(NH4)2SO4 (solid) (Equation 1)

2. By the oxidation of nitrogen oxides (from traffic e.g.) with OH to nitric acid. The nitric acid reacts with NH3 (liquid) to ammonium nitrate (salt):

HNO3 (gas) + NH3 (liquid) □ NH4NO3 (solid) (Equation 2)

Image 4 shows schematically the formation of secondary aerosols. Aerosoles in the superfine mode grow fast by coagulation and condensation from the gas phase. Thereby they form aerosols in the accumulation mode that will be washed out of the atmosphere by rain (wet deposition). With the increasing diameter of the aerosol, the influence of sedimentaion is dominating.

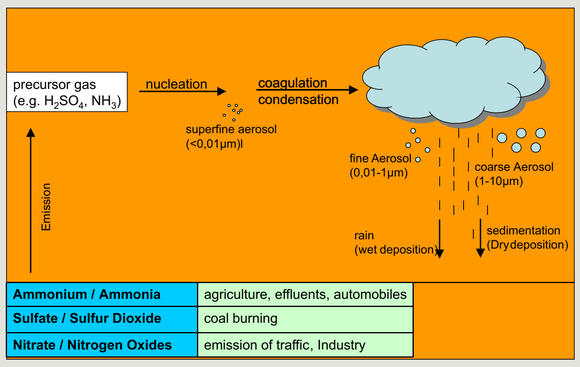

Image 4. Formation of secondary aerosols

Image 5. Huge ammonium-crystal on impactor-filter with size distribution 0,7-1,1 µm