SIZE SEGREGATED CHARACTERIZATION OF FINE PARTICULATE MATTER IN LEIPZIG AND MELPITZ AEROSOL

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INTRODUCTION

The European standard for suspended particulate matter in air (PM_{10}) will lead to strict regulations with regards to the mass concentration of PM_{10} particulate matter. For Saxonian cities the observance of these new regulations will be problematically. So the Sächsisches Landesamt für Umwelt und Geologie (SLUG) directed the IfT to characterize the size segregated particulate matter at three sites in NW Saxony to identify sources of the small particles during two measurement campaigns in winter 1999/2000 and in summer 2000.

METHODS

The three sites selected for particle collection were a central cross road near the main railway station, the measuring platform of the IfT building in Leipzig and the IfT research station in Melpitz.
Nine typical dry winter days and eight typical dry summer days have been selected for the 24 hour collection of particles by five-stage BERNER impactors (only four stages have been investigated: 0.05 – 0.14 µm, 0.14 – 0.42 µm, 0.42 µm – 1.2 µm and 1.2 – 3.5 µm) as well as $PM_{2.5}$ high volume filter samplers (DIGITEL).
The chemical characterization of the impactor and filter samples was performed with regards to their ionic content (ammonium, sodium, potassium, magnesium, calcium, sulfate, nitrate, chloride and oxalate), OC-EC (Organic Carbon – Elemental Carbon).

RESULTS

Between the two measurement campaigns not only important differences but also mutualities have been identified. The traffic emissions were stable at both campaigns. During the winter campaign the particulate matter composition was heavily influenced by individual household heating with brown coal briquettes, output from electrical power plants and heating power plants and by the lower mixing height. During the summer campaign the influence of biogenic emissions must be taken into account.
In Table 1 a summary of all collected samples give the mass distribution between the size fractions.

Stage	Mass proportion [%]	Minimum [%]	Maximum [%]	Absolute Standard Deviation [%]	Variation Coefficient [%]
Stage 1	**6**	3	15	4.6	77
Stage 2	**21**	16	24	3.3	16
Stage 3	**51**	43	57	5.1	10
Stage 4	**22**	17	27	4.1	19

Table 1. Mean values of the particle mass distribution between the four stages of the investigation

The main amount of particulate matter, nearly 80 %, is found in small particles below 1.2 µm, which are most important because of their atmospheric stability, lung penetrating and toxic effects.

Stage 1 particles (50 – 140 nm)
The smallest particles mainly consist of elemental and organic carbon directly from traffic emissions or from gas to particle conversion or condensation of organics on particle surfaces at the sampling site

in the city of Leipzig, which is dominated by traffic emissions. The mean winter concentration for Total Carbon (TC = OC+EC) is 77% of mass. From Leipzig city to the IfT and, furtheron to Melpitz a strong decrease in mass is observed for summer and winter. During winter measurements nitrate was observed at all sites as the most important ionic component (13-17% of stage mass) whereas in the summer campaign sulfate was dominating (5-20% of stage mass).

Stage 2 particles (140 – 420 nm)

These particles are older than the smaller ones and therefore contribution from the transport from outside the direct measurement region begins to play a role. During the winter at the IfT and in Melpitz the emissions from individual heating systems and from power plants are responsible for the main part of the EC/OC content, not the traffic emissions. In summer at all sites submicron crustal material and oxidized organic carbon represent 7 to 23 % of mass. The nitrate concentration during the winter was between 18 and 21 % of the stage mass whereas for sulfate only 8 to 10 % have been measured. In the summer campaign for nitrate 5-6 % and for sulfate 16 to 25 % were observed. The water content was estimated to 10 % by the method of McInnes et al. (1996).

Stage 3 particles (0.42 – 1.2 µm)

About 51 % of the mass have been found at this stage, at which the ionic components dominate (33 – 55 %). The winter carbon fraction was found to be between 31 and 14 % dominated by the traffic only at the city measuring point. The total carbon amount measured at these particles decreased to 31 – 14 %. At the other sites the household emissions and the long range transport from power plants dominate. During the summer 5 to 6 % of the mass have their origin in biogenic sources. Following the approach of McInnes et al. the water content was estimated to be 20 %. Crustal materials reach 22 – 25 % during the summer.

Stage 4 particles (1.2 – 3.5 µm)

Aged particles and larger primary particles (sea salt, crustal material) dominate here. About 22 % of the total mass have been found in this mode. The mass concentration decreases in winter and summer from the city to the institute and furtheron to Melpitz but the differences are small. The carbon fraction decreased to a minimum (23 – 13 %). The summer content reaches 29 – 35 %. The ionic component concentration was found to be 26 – 35 % in summer and during the winter campaign to 40 – 51 %. According to the content of ionic and crustal material the water content was estimated to 20 % (McInnes et al.). In the summer the content of biogenic material was found to be between 6 and 8 %.

Summary

Reflecting the specific regional source structure the most important sources of particulate matter have been identified for four impactor stages in a winter and a summer period. The meteorological situation during both periods was not typically for the region with very mild winter with good exchange conditions. The summer measurement period in July was untypically cold. During both periods days with continental air masses from the East could not be observed, which generally showed higher particle loads in the past (K. Müller, 1999).

An extrapolation of the data to the PM_{10} standard of the European Union have shown that compliance will be problematically in the Saxonian cities. The most important anthropogenical sources of small particles have their origin in traffic and household emissions.

The contributions to OC and EC for traffic (segregated in diesel and gasoline part), domestic heating and biogenic emissions were identified for each stage.

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References

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