SIZE SEGREGATED CHARACTERIZATION OF PM_{10}, $PM_{2.5}$ AND PM_1 DOWNWIND OF THE LEIPZIG CONURBATION IN GERMANY – AN EIGHT YEAR STUDY

G. SPINDLER, E. BRÜGGEMANN, TH. GNAUK, K. MÜLLER and H. HERRMANN

Institut für Troposphärenforschung, Permoserstraße 15, 04318 Leipzig,

Keywords: PARTICLE MASS, FILTER SAMPLING, LONG TIME MEASUREMENT, CARBON

INTRODUCTION

Up to the end of the 80-ies the region around Leipzig was one of the most polluted areas in Central Europe (Spindler at al., 1999). The collection and characterization of environmental particulate matter has been in the interest of atmospheric sciences, human health and environmental policy for several years (Pope and Dochery, 1999; Grassian, 2002). A size segregated long term characterization is necessary because particles with different aerodynamic diameters show different residence times in the troposphere, are differently composed and have different human health effects e.g., Particles smaller than 10 µm (PM_{10}) are able to pass the larynx whereas particles smaller than 2.5 µm ($PM_{2.5}$) reach the pulmonary aveoli. For a period of eight years (1995 to 2002) weekly filter pack samples PM_{10} and $PM_{2.5}$ have been collected using a low flow air sampler (LF) at the IfT research station in Melpitz. From 1999 PM_1 has been collected additionaly. The particle size fractions were weighted and analyzed for the content of water soluble ions. In the PM_1 fraction the content of organic carbon (OC) and elemental carbon (EC) was quantified, additionally.

EXPERIMENTAL

The sampling was performed at the research station Melpitz, situated in Germany (12°56'E, 51°32'N, 86 m above sea level) in the vicinity of the city of Torgau on a flat old meadow surrounded by agricultural land. The nearest road is a national road (B 87) passing by about 1.5 km to the north. Edges of forests are 2.5 km to the north (Dübener Heide) and 1 km to the south (Dahlener Heide). Under the dominating wind direction (SW-WSW), the station is influenced by the downstream plume of a large conurbation (cities of Halle and Leipzig) of about one million inhabitants, 40 to 50 km away. The LF sampler is the Partisol 2000 Air Sampler (Rupprecht and Patashnik Co. Inc., USA). For the weekly filter samples PM_{10}, $PM_{2.5}$ and PM_1 Teflon filters with 47 mm diameter (Millipore, Eschborn, Germany, Type 4700, 3 µm pore size) were used. The weekly sampling volume was 84 m^3. The cut-offs are realized with virtual impactors. After a conditioning time at least 24 hours (50 % relative humidity, 20 °C) the particle mass was determined gravimetrically (Mettler AT 261 Delta Range balance, Mettler Toledo GmbH, Germany). Water soluble ions were determined from each filter. Standard ion chromatography with columns from Dionex, USA and Metrohm, Switzerland was used for that purpose. An additional impactor for PM_1 contains a quartz filter for the determination of OC and EC with a thermographic method. OC was detected at 650 °C in N_2 and EC after them during a new heating step at 650 °C in O_2 using a Ströhlein C-mat 5500 carbon analyser.

RESULTS

The mass distribution in the particle fractions is shown for 1999 to 2002 together with the EC and OC content in PM_1 particles in Figure 1. The yearly course of the mass concentration distribution between the size fractions in Figure 1 and the relative part of $PM_{2.5}$ mass on the fraction of PM_{10} for 1995 to 2002 in Table 1 demonstrates the maximum for the largest particles (PM_{10}-$PM_{2.5}$) during summer time only. In summers more coarse mode particles exist, because surfaces, especially those covered with short vegetation, dry faster (Klemm et al., 2002), the absolute precipitation time is lower and the precipitation events are more intensive than in other seasons. Coarse particles caused from re-emission by turbulences and agricultural activities in the surroundings, are transported only over short distances in a local area, because they have a higher deposition velocity than smaller particles. The size fraction ($PM_{2.5}$-PM_1) shows the smallest particle mass concentration over the whole year.

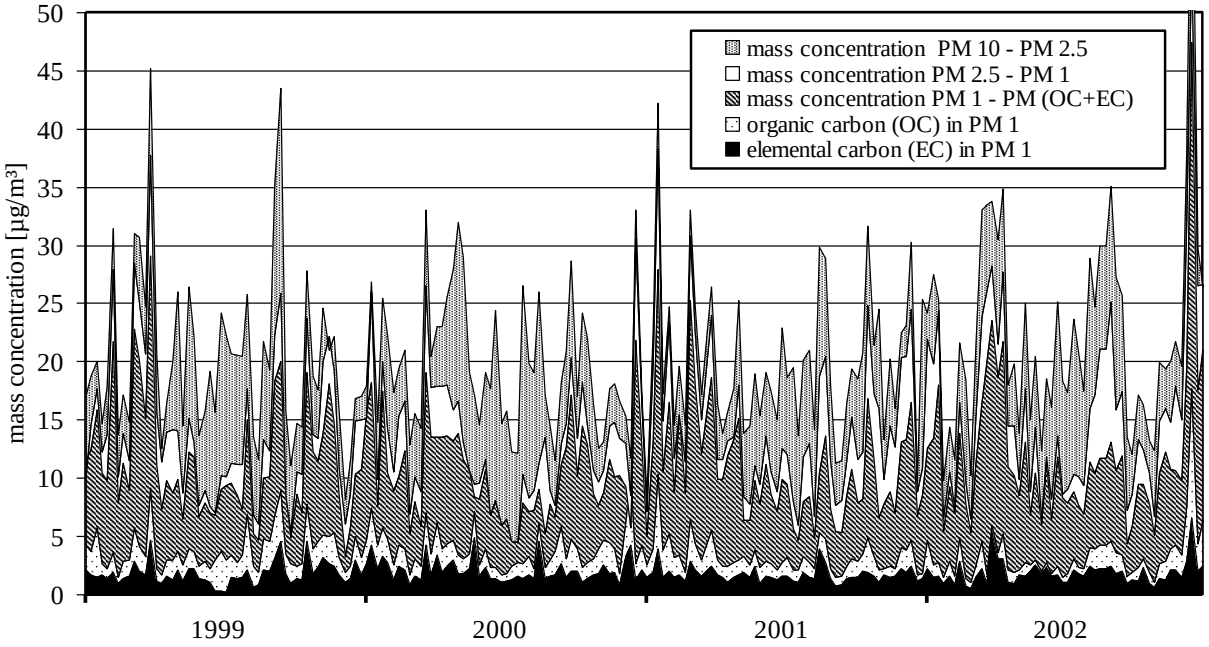

Figure 1. Mass distribution in the particle fraction and part of OC and EC in the PM1 particle fraction.

The mean content of total carbon (TC=OC+EC) in the winter time for 1999 to 2002 shows a somewhat higher value (3.8 µg/m³) as in summer time (3.2 µg/m³) and decreases especially in summer time from 3.8 µg/m³ (1999) to 2.9 µg/m³ (2002). The relative part of EC from TC increased in summer time over the four years from 43.5 % (1999) to 65.3 % (2002) (57.6. % in 2000 and 56.6 % in 2001).

year	$PM_{2.5}$ [%] summer	$PM_{2.5}$ [%][a)] winter	year	$PM_{2.5}$ [%] summer	$PM_{2.5}$ [%][a)] winter
1995	66.1	83.5	**1999**	58.5	76.0
1996	67.9	81.5	**2000**	55.3	82.6
1997	55.4	73.5	**2001**	64.8	74.0
1998	63.5	79.6	**2002**	64.0	79.4[b)]

a) month January to March from the following year b) mean for October to December

Table 1. Mass contribution of $PM_{2.5}$ to PM_{10} (100%) distinguished between winter (October to March) and summer (April to September)

ACKNOWLEDGEMENTS

The measurements are part of the framework of the national research program AFO2000 (project VERTIKO, 07ATF37) founded from the German Federal Ministry of Education and Research. For the measurements and numerous analyses we thank A. Grüner, A. Thomas and H. Bachmann.

REFERENCES

Grassian, V.H. (2002). Chemical Reactions of Nitrogen Oxides on the Surfaces of Oxides, Carbonate, Soot, and Mineral Dust Particles: Implication for the Chemical Balance of the Troposphere. *J. Phys. Chem. A*, 106, 860-877.

Klemm, O., Milford, C., Sutton, M. A., Spindler G. & van Putten, E. (2002). A climatology of leaf surface wetness. *Theor. Appl. Climatol*., 71, 107-117.

Pope, C.A. & Dockery, D.W. (1999). Epidemiology of particle effects, *Air Pollution and Health*., 31, 673-705.

Spindler, G., Müller, K. & Herrmann, H. (1999). Main particulate matter components in Saxony (Germany) – trends and sampling aspects. *ESPR – Environ. Sci. & Pollut. Res*., 6, 89-94.