Urban and Suburban Intermodal Fraction of Atmospheric Aerosol in Winter 2014

Kozáková, Jana
2015

URBAN AND SUBURBAN INTERMODAL FRACTION OF ATMOSPHERIC AEROSOL IN WINTER 2014

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Keywords: Intermodal fraction, $PM_{2.5-1}$, Sioutas impactor

INTRODUCTION

Fine (PM_1) and coarse ($PM_{10-2.5}$) aerosols differ not only in size, but also in their chemical composition, health effects, sources, and others. A dividing line between fine and coarse aerosol has not been clearly defined. The fractions overlap in the aerodynamic particle size range 1-2.5 μm, also called the intermodal fraction. Sources of both coarse and fine aerosols contribute to the intermodal fraction to different extents depending on meteorological conditions and location. According to several studies, the intermodal fraction was highly correlated with coarse aerosol in dry areas during high wind speed episodes (Kegler et al., 2001, Claiborn et al., 2011). In contrast, other studies have shown higher or comparable correlation between the intermodal and fine aerosol (Geller et al., 2012, Jalava et al., 2006).

The aim of this study is to characterize the intermodal fraction in urban and suburban localities and estimate to what extent fine/coarse aerosol sources contribute to this fraction.

EXPERIMENTAL SETUP

24 h samples of size resolved aerosol particles were sampled by a Personal Cascade Impactor Sampler (PCIS) at four sites in the Czech Republic during summer and winter measuring campaigns (see the Table 1 and Figure 1). At all sites we also measured a 5 min resolution of particle number concentrations using a Scanning Mobility Particle Sizer-SMPS and Aerodynamic particle sizer-APS. These two spectrometers (TSI Inc.) covered the aerosol diameter size range from 14 nm to 10 μm (using a PM_{10} sampling cyclone). Only results from the PCIS are presented in this abstract. Meteorological conditions (Temperature-T, Relative Humidity-RH, Wind Speed-WS, and Wind Direction-WD) were recorded at all measuring sites. Ion composition of aerosol samples was analysed using ion chromatography. Images and individual particle analyses were recorded by scanning electron microscope with an energy dispersive X-ray analyser (SEM + EDX).

Figure 1. Positions of measuring sites in Prague and Ostrava.

Table 1. Description of measuring sites.

Urban site	Ostrava Radvanice	residential area near a large industrial zone and traffic roads, domestic heating	winter (6.2. – 5.3.2014)
	Prague Benátská street	city center with traffic and roads	summer (21.8. – 4.9.2014)
			winter (17.2. – 3.3.2015)
Suburban site	Ostrava Plesná	residential area, domestic heating	winter (6.2. – 5.3.2014)
	Prague Suchdol	residential area, domestic heating, and traffic road	summer (21.8. – 4.9.2014)
			winter (5.2. – 19.2.2015)

RESULTS AND CONCLUSIONS

The highest average concentrations of all three fractions were observed in Ostrava Radvanice, which we expected because of the nearby industrial source. In Prague, the lowest concentrations of PM_1 and $PM_{2.5-1}$ were recorded in summer, while the lowest concentrations of $PM_{10-2.5}$ were recorded during winter campaign.

PM_1 represented the highest portion (average 83%) of the total PM_{10}, while the intermodal and the coarse fraction constituted the minor part (Fig. 2).

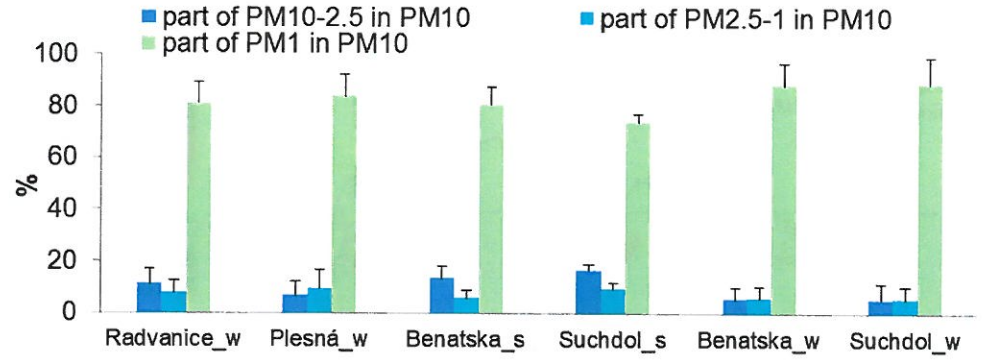

Figure 2. Portions of PM fractions in the total PM_{10} (columns with standard deviation bars).

Statistical dependence between the intermodal fraction and other monitored variables can be determined with Spearman correlation coefficients (Fig. 3). $PM_{2.5-1}$ was strongly correlated with $PM_{10-2.5}$ during all the campaigns (R=0.4-0.8), but an association with PM_1 was less frequent (R=0-0.8). During the Suchdol winter campaign $PM_{2.5-1}$ was negatively correlated with WS, which was probably due to higher relation with PM_1. Oppositely, WS correlation was found for the Suchdol summer campaign (higher relation to $PM_{10-2.5}$).

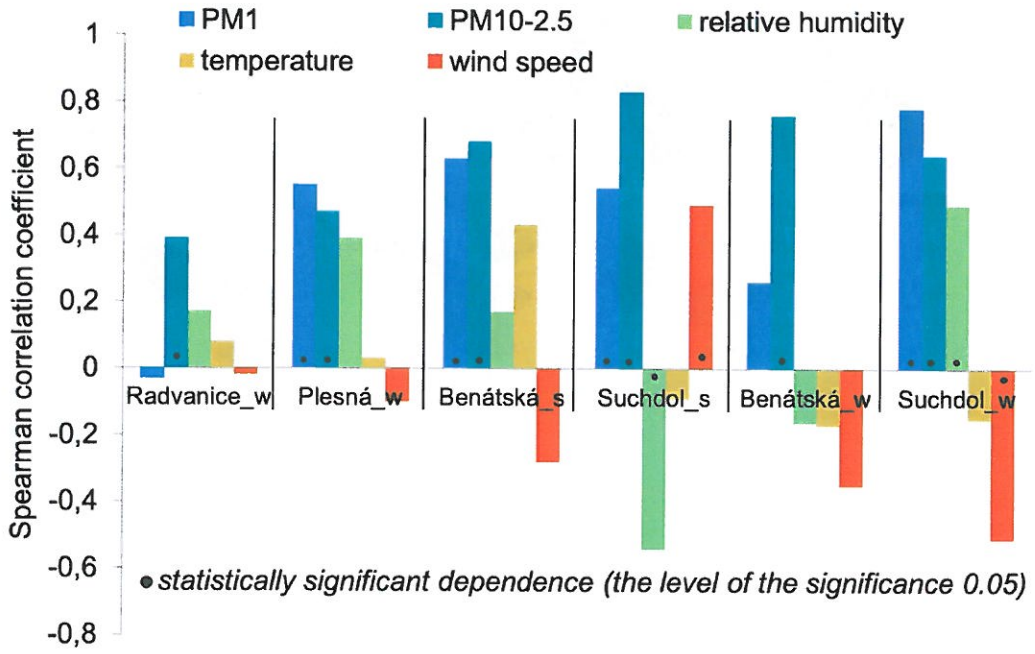

Figure 3. Spearman correlation coefficients between $PM_{2.5-1}$ and other variables.

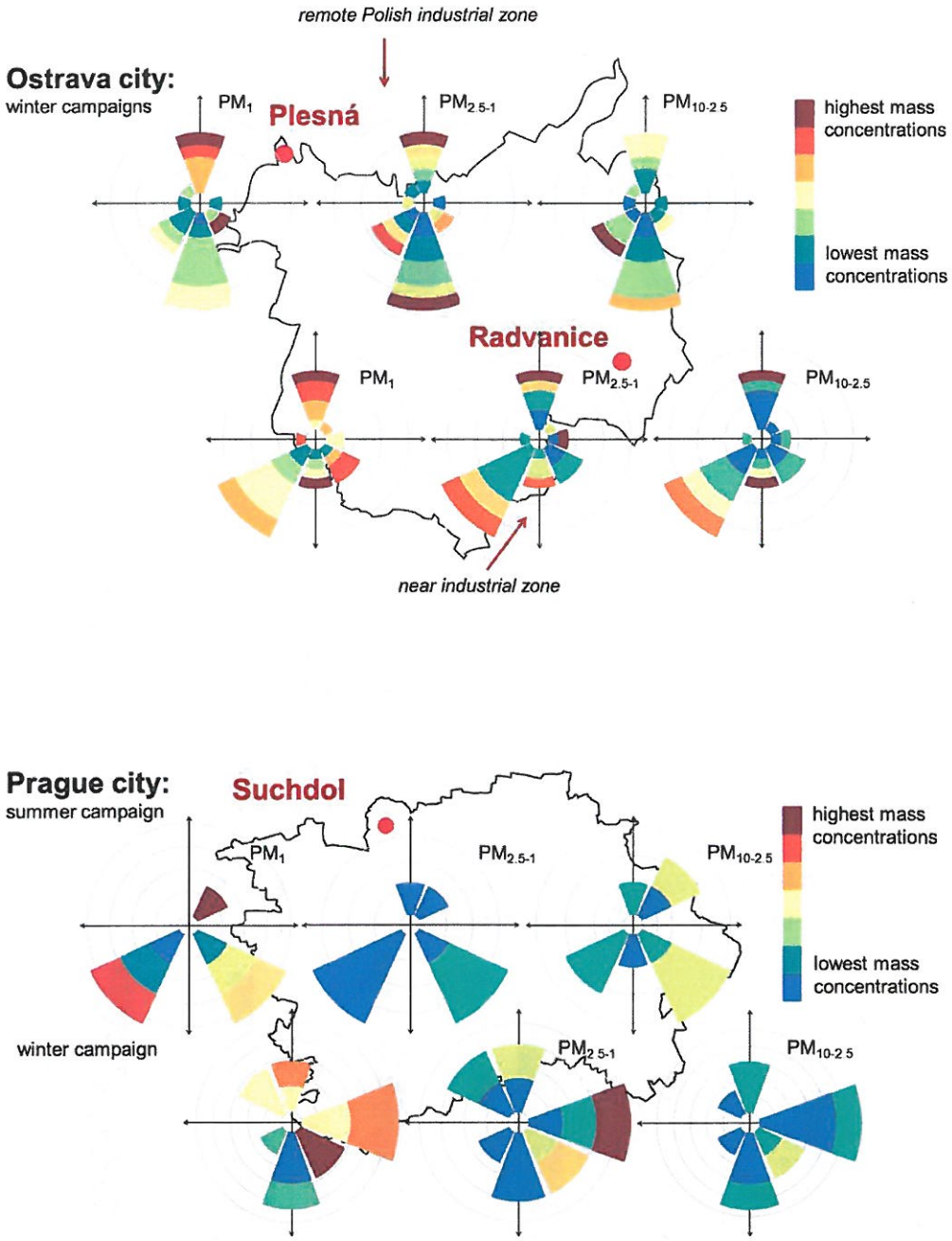

Figure 4 and 5. Frequency of observations by wind direction for each PM fraction and selected campaigns.

In Plesná the highest concentrations of PM_1 and $PM_{10-2.5}$ occurred during different prevailing WDs, but $PM_{2.5-1}$ was independent in this case. During the Suchdol summer campaign the highest concentrations of PM_1 occurred during different prevailing WDs than those for $PM_{2.5-1}$ and $PM_{10-2.5}$ (Fig. 4 and 5).

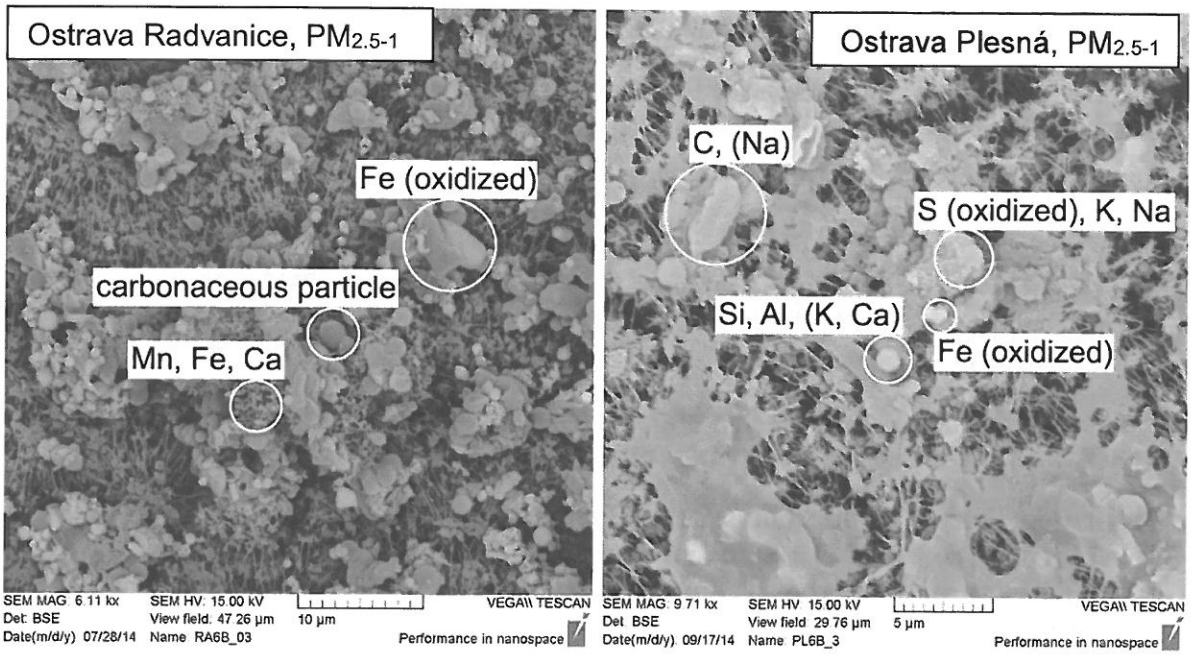

Figure 6 and 7. Images and individual particle analyses recorded by scanning electron microscope with energy dispersive X-ray analyser (SEM + EDX).

According to ion chromatography, the average highest amount of SO_4^{2-} (sulphate) was detected in the fine fraction, followed by the intermodal and coarse fraction. As is also known, concentrations of crustal elements (Ca^{2+}, Mg^{2+}) were highest in the coarse and intermodal fractions and lowest in the fine fraction. The highest concentrations of K^+ ions were measured in the fine fraction during winter and summer campaigns. The highest concentrations of Na^+ and Cl^- were observed in all three fractions. We did not determine NO_3^- and NH_4^+ due to the high background of the teflon filters we used.

The shapes of aerosol particles varied (Fig. 6, 7). We observed regular spherical iron particles (Fe, Fe oxidized or Si+Al+Fe) in all three fractions and carbonaceous particles mainly in the fine fraction. Other particles usually appeared in irregular shapes, and were, for example, composed of salt (NaCl), sulphate (potassium/sodium/ calcium sulphate), aluminosilicates, sodium nitrate, and clay minerals. "Spongy" structures were also common, and were composed of iron with other elements (Ca, Na, Cl), carbonaceous particles, or a mix of salt (NaCl) with oxidized iron.

In our measurements, the behavior of the intermodal fraction depended on season, wind speed, relative humidity, and type of the locality. In all cases the intermodal fraction was strongly associated with the coarse fraction, and the correlation with the fine fraction was also high, except for two sites (Radvanice and Benátská) in winter.

We will try to determine detailed behaviour of the intermodal fraction using 5 min resolution data set from SMPS and APS. Complete aerosol source identification of the intermodal fraction will be obtained with the help of SEM + EDX (samples from the Prague campaigns) and back trajectories modeling.

ACKNOWLEDGEMENT

The project is supported by the Czech Grant Agency (P503/12/G147) and the Charles University Grant Agency (274213).

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