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Composition of airborne particulate matter in the industrial area versus mountain area[☆]



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Summary The paper deals with research of air pollution in two different locations on the Moravian-Silesian Region, Czech Republic. These are the sites Ostrava-Radvanice, which is located in the area affected by the industry and Ostravice in the mountains (without significant effect of the industry). The dust particles collected at these locations were subjected to a wide range of analyses. The mass concentration, the mass-size distribution, mineralogical composition, the concentration of PAHs (polycyclic aromatic hydrocarbons), and the concentrations of selected metals (Cd, Pb, Zn, Fe, Mn, As, Ni, Co, and Cr) were observed at the particulate matter.

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Introduction

Dust particles in the atmosphere can have an important influence on human health. The extent of their influence is connected not only with particle size distribution of PM (particulate matter) but also with the ability to absorb toxic and carcinogenic compounds (Chung et al., 2008). PM can be divided according to the size into super coarse ($>10\ \mu\text{m}$), coarse ($2.5\text{--}10\ \mu\text{m}$), belonging to the accumulation mode ($0.1\text{--}2.5\ \mu\text{m}$), Aitken mode – ultrafine ($10\text{--}100\ \text{nm}$) and nucleation mode ($15\text{--}40\ \text{nm}$) (Hsieh et al., 2009). The

coarse particles are produced mainly by resuspension of dust, demolition and construction works, combustion in local heaters and biogenic sources. Ultrafine particles originate mostly in combustion, high-temperature processes and atmospheric reactions (Amann et al., 2006).

PM is partly formed by minerals with different origin. Quartz, albite, orthoclase, microcline, muscovite and chlorite belong among common resuspended minerals (Amato et al., 2011). Secondary minerals form particles originated in the atmosphere by physical and chemical reactions (gypsum, boussingaultite, sal ammoniac, halite, and lecontite) (Song et al., 2014). Particles from metallurgy contain minerals formed during metallurgical processes and minerals used as input raw materials for metallurgical processes (hematite, magnetite, or maghemite), and components from metallurgical production (graphite, akermanite, mayenite, spinel) (Journet et al., 2014). Carbonates (calcite and magnesite)

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can be components of construction materials or can be released during dosing of limestone into blast furnaces, or can be part of resuspension.

PM can also contain considerable amounts of PAHs (polycyclic aromatic hydrocarbons) – organic compound formed by two or more aromatic rings (Lee and Van Tuan, 2010). PAHs originate mostly during carbonization and incomplete combustion of organic materials (Masih et al., 2012). Combustion of coal represents a source of anthracene, fluoranthene, pyrene, benzo[a]anthracene, chrysene and benzo[k]fluoranthene. Coke ovens produce anthracene, phenanthrene, benzo[a]pyrene and benzo[g,h,i]perylene. Waste incinerators produce pyrene, in lesser quantities also phenanthrene and fluoranthene. Industrial incinerators produce indeno[1,2,3-cd]pyrene and chrysene. Wood combustion is a source of PAHs – anthracene, phenanthrene, fluoranthene and pyrene. Petrol engines release above all benzo[g,h,i]perylene, benzo[a]pyrene and benzo[a,h]anthracene. Diesel engines produce benzo[b]fluoranthene and benzo[k]fluoranthene (Ravindra et al., 2008).

Metals are present in trace concentrations in fossil fuels and biomass and they also can be present in PM. Combustion and industrial processes can be therefore source of these metals in the atmosphere (Smeets et al., 2010). Metals V, Pb, Fe, Cr, Co, Mo, Ni, Cd, As, Sb, and Zn are produced mostly by industry. On the other hand, vehicle traffic produces mostly V, Fe, Pb, Zn, Cd, Mn, Ba, Sr, Al, U, Th, Zr, Cs, Rb, Sb, Sn, and Cu. Combustion of fossil fuels produces mostly V, As, Cu, Co, Mo, Ni, Sb, Cr, Fe, Mn, and Sn (Moreno et al., 2006).

This article is focused on evaluation of dust particles at the two different localities situated in the industrial and mountain parts of the Moravian-Silesian Region during various seasons of the year. Its aim is to find and discuss the possible differences in concentration and particle size distribution of PM or chemical and mineralogical composition of particles.

Material and methods

The monitored sites are located in the Moravian-Silesian Region in the northeast part of the Czech Republic. Neighbours are Slovakia to the southeast and Poland to the north and east. The dominant sectors of industrial activity are metallurgy, hard coal exploitation, energy industry, and chemical industry. Dust particles in the atmosphere were sampled at the selected localities during 2013–2014. Following determinations were performed: mass concentration, particle size distribution of PM (ELPI* electric low-pressure cascade impactor), mineralogical composition of the total dust deposition (X-ray diffraction), concentrations of PAHs (high-volume sampler, analysis by HPLC-PDA according to ISO 11338-2), and heavy metals (high-volume sampler, decomposition in a mixture of acids in microwave oven, analysis by ICP emission spectroscopy). The locality Ostrava-Radvanice represents a typical area influenced by industrial activity, while the locality Ostravice represents a background, mountain region without direct influence of industrial activity (Fig. 1).

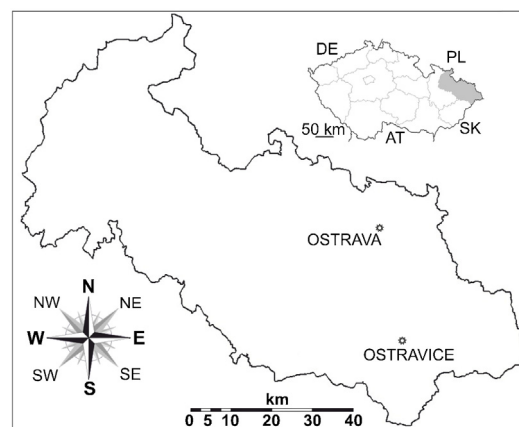


Figure 1 Location of sampling sites in the Moravian-Silesian Region.

Results and discussion

The total concentration of dust particles (PM_{10}) during summer at the locality Ostravice was $15.2 \mu\text{g}/\text{m}^3$, at Ostrava-Radvanice was $11.5 \mu\text{g}/\text{m}^3$, during transitional period at Ostravice was $17.7 \mu\text{g}/\text{m}^3$, at Ostrava-Radvanice was $15.5 \mu\text{g}/\text{m}^3$, during winter at Ostravice was $24.4 \mu\text{g}/\text{m}^3$, and at Ostrava-Radvanice was $30.2 \mu\text{g}/\text{m}^3$.

Fig. 2 and Fig. 3 illustrate particle size distribution of PM. Both localities have multimodal distribution of weight concentrations of PM (without conspicuous peak) during summer. During transitional period, both localities can be observed with bimodal distribution of weight concentrations of PM with main peak in the range from $0.156 \mu\text{m}$ to $0.614 \mu\text{m}$ (54% for Ostravice and 50% for Ostrava-Radvanice) and the second less important peak which is represented by coarse particles (11% for Ostravice and 14% for Ostrava-Radvanice). Both localities have identical

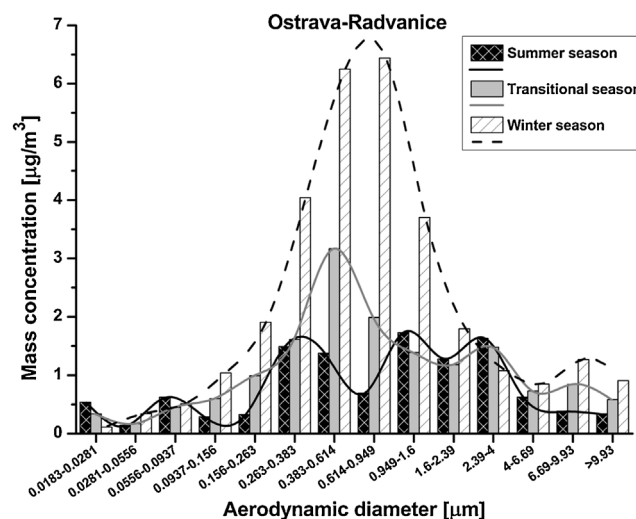


Figure 2 Concentration of particles in particle size classes, Ostrava-Radvanice.

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