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Atmospheric Environment

# Characterization of organic compounds in the PM2.5 aerosols in winter in an industrial urban area

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HIGHLIGHTS

- Analysis of selected organic compounds in PM2.5 aerosols in Ostrava in winter 2012.
- Very high concentration of PM2.5 and organic compounds during period of smog episode.
- Molecular markers and diagnostic ratios for identification of emission sources.
- Combustion of coal and wood and traffic identified as main emission sources of PM2.5.

GRAPHICAL ABSTRACT
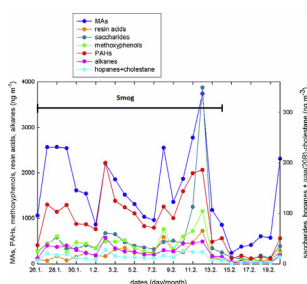
ARTICLE INFO

ABSTRACT

Urban aerosol particles in the fine fraction (PM2.5) were collected over the sampling interval of 24-hrs on quartz filters in Ostrava (Czech Republic) in winter 2012. The collected aerosols were analysed for selected organic compounds that serve as tracers of the main emission sources. The campaign was carried out under two different meteorological scenarios. During a smog episode due to high concentration of aerosols in the first part of the campaign, high concentrations of PM2.5 aerosols (mean concentration of 159 $\mu g\ m^{-3}$) and PAHs bound to particles were found, while in the second part of the campaign, after the smog episode, much lower concentrations of aerosols (mean concentration of 49.3 $\mu g\ m^{-3}$) were observed.

Analysis of the source specific molecular markers and diagnostic ratios of PAHs, hopanes and alkanes imply that combustion of coniferous wood and coal in residential heating and traffic belong to the biggest emission sources of organic compounds associated with the PM2.5 aerosols collected during the winter campaign in Ostrava-Radvanice. The industrial production of coke and iron is another important contributor to the concentrations of B*a*P and other carcinogenic PAHs.

The level of air pollution in Ostrava-Radvanice was considerably determined by the overall meteorological situation during the campaign. The highest concentrations of PM2.5 and bound organic compounds were found during a smog episode characterized by poor dispersion conditions due to temperature inversion and weak north-eastern wind, while during the subsequent period characterized by north-west or west wind, the concentrations of aerosols and bound organic compounds were much lower. Transboundary transport of polluted air from the Silesian Voivodeship could have contributed to the pollution in the Moravian-Silesian region during the smog episode.

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1. Introduction

Atmospheric particulate matter (PM) has been shown to play an important role in many environmental problems (Seinfeld and Pandis, 1998) and to cause adverse health effects (Dockery et al., 1993; Brunekreef and Holgate, 2002).

A lot of large cities in Europe suffer from deteriorated air quality and smog formation resulting from high concentrations of atmospheric aerosols (Sluyter, 1995; de Leeuw et al., 2001). Problems with poor air quality also occur frequently in Ostrava, especially in winter due to temperature inversion episodes and smog formation characterized by increased PM concentrations. Ostrava is the largest city of the Moravian-Silesian Region (Czech Republic) that, together with the adjacent Silesian Voivodeship in Poland, Po Valley in Northern Italy and some Bulgarian or Romanian cities, is counted among the worst air quality regions in the EU (Houthuijs et al., 2001; Horálek et al., 2006; EEA, 2012; EEA, 2013; Sram et al., 2013). High concentration of industry and concentrated transport infrastructure in the whole area cause long-lasting problems of high levels of air pollution by aerosol particles of anthropogenic origin, which are among the highest in Europe (EEA, 2012, 2013).

Organic compounds constitute a major fraction of particulate matter in the atmosphere in urban areas, often over 30% of the fine particulate mass (Jacobson et al., 2000). Although an increasing attention has recently been paid to a study of the chemical composition of PM, studies on the detailed organic composition of urban atmospheric aerosols are still relatively scarce. This is mainly due to the wide variety of organic compounds present. However, knowledge of the organic composition of atmospheric aerosols is required to judge the possible implications for human health, environmental problems or emission sources identification.

Over the past years, much attention has been paid to the identification of emission sources of PM in various urban areas. In the Czech Republic, a few selected organic components in the aerosols have recently been analysed (Leníček et al., 2000; Křůmal et al., 2010; Dvorská et al., 2012; Křůmal et al., 2013). However, in Ostrava only limited information is available on the organic components of PM (CHMI, 2011).

The objective of the presented paper is to study organic compounds, including monosaccharide anhydrides (MAs), polycyclic aromatic hydrocarbons (PAHs), resin acids, methoxyphenols, hopanes and $\alpha\alpha\alpha(20R)$-cholestane, aliphatic hydrocarbons, acyclic isoprenoids and saccharides in PM2.5 aerosols (PM with aerodynamic diameter < 2.5 μm) collected at residential district of Ostrava-Radvanice in the Czech Republic during the winter campaign 2012. Analyses of organic molecular markers and diagnostic ratios of selected PAHs, MAs, hopanes and alkanes were used to identify the possible emission sources of PM2.5 aerosols.

2. Experimental

2.1. Aerosol collection and sampling site

Atmospheric aerosols in the size fraction PM2.5 were sampled on a daily basis over 24-hr periods with nominal start time at 9 am (local time) in winter 2012 (26 January–21 February) in the garden of a family house in Ostrava-Radvanice (a total number of 26 samples). Radvanice, located near the industrial part of Ostrava, is regarded as one of the most heavily polluted district of Ostrava. Detailed localization of the sampling site is shown in Fig. 1.

The PM2.5 aerosols were collected on quartz fibre filters (150 mm diameter, Whatman QM-A) using a high-volume sampler (DHA-80, Digitel, 30 m^3 h^{-1}) equipped with a PM2.5 size selective inlet. To remove organic contaminants, the quartz filters were burned at 500 °C for 24 h before sampling. Collected aerosols were analysed on the contents of selected organic compounds.

The sampling campaign was performed under two different atmospheric conditions: a period of smog episode (26 January–14 February, 20 samples) and a period after the smog episode (15–21 February, 6 samples). The period of smog episode is characterized by a low temperature with the mean value of −10.1 °C and light wind (<1.5 m s^{-1}). North-eastern wind prevailed during the whole period. The period after the smog episode is characterized by a

Fig. 1. Map of the Czech Republic showing the sampling site in Ostrava and its surroundings.