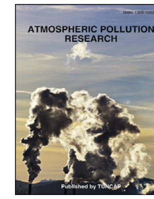
Atmospheric Pollution Research xxx (2016) 1–9

HOSTED BY

Contents lists available at ScienceDirect

Atmospheric Pollution Research

journal homepage: http://www.journals.elsevier.com/locate/apr



Original article

Elemental composition and source identification of very fine aerosol particles in a European air pollution hot-spot

Petra Pokorná [a, b, *], Jan Hovorka [a], Philip K. Hopke [b]

[a] Institute for Environmental Studies, Charles University in Prague, Benátská 2, 128 01 Prague 2, Czech Republic
[b] Center for Air Resources Engineering and Science, Clarkson University, Box 5708, Potsdam, NY 13699-5708, USA

ARTICLE INFO

Article history:
Received 22 December 2015
Received in revised form
4 March 2016
Accepted 6 March 2016
Available online xxx

Keywords:
Positive matrix factorization
Highly time resolved elemental composition
Rotating-drum impactor
Synchrotron X-ray fluorescence

ABSTRACT

Positive Matrix Factorization (PMF) was used to identify sources of $PM_{0.09-0.26}$, very fine aerosol particles, in a residential district of Ostrava Radvanice and Bartovice, a European air pollution hot-spot. Two-hours resolved elemental composition of very fine particulate matter samples were collected by the eighth stage of Davis Rotating-drum Universal-size-cut Monitoring (DRUM) impactor for the campaign period of the 26th January to the 21st February 2012. The campaign consists of smog (26.1–14.2) and post-smog (15–21.2) periods defined by their PM_1 concentrations. Three factors were resolved by PMF: coal combustion, raw iron production and steel production. Coal combustion, associated with high concentrations of Se, Br, Pb, K, and As, dominated during the whole period. The contribution of raw iron production, a factor with high concentration of Mn, Fe, Co and Cr, increased significantly when ambient air temperature and the wind direction changed from NE to SW. Alternatively, the contributions of steel production, associated with Cl, K and Zn, were high under NE winds and decreased during the post-smog period. The mass of very fine particles correlated well with CO concentrations (smog $r^2 = 0.86$, post-smog $r^2 = 0.43$), which may indicate an industrial plume. The low value of S/Se (1448) suggests the impact of local/city-wide stationary coal combustion sources located to the N–NE of the monitoring site.

1. Introduction

Urban-air quality continues to be an important regulatory issue because air pollution in general, and airborne particles in particular, constitute human health risks (Wehner et al., 2002). Fine and ultrafine particles are of particular interest because the apparent toxicity of PM_{10} can be most easily explained in terms of the increased thoracic penetration and alveolar deposition of the finer fraction (Donaldson et al., 2001). The high surface area of the very fine particles with particle sizes $\leq$ 200 nm (Heal et al., 2012), increases their role as adsorption substrates and their potential surface chemical reactivity (Braniš et al., 2010). The studies from the southern Central Valley of California identify some potential causal agents for the ischemic heart disease (IHD) mortality, such as very fine (90–260 nm) and ultrafine (<90 nm) metals. The strongest correlation was found in very fine to ultrafine metals, with most related to vehicular sources (Cahill et al., 2011).

The Moravian-Silesian Region with the regional city Ostrava is one of the most air-polluted regions not only in the Czech Republic but in Europe according to long-term observations (Houthuijs et al., 2001; CENIA, 2012). The combination of a steel industry with coking plants causes some of the worst air quality in the EU with an health impact to human population, particularly to children (Dostal et al., 2013; Sram et al., 2013). Topinka et al. (2015) determined carcinogenic polycyclic aromatic hydrocarbons (c-PAHS) together with other toxicity markers (genotoxic potential, oxidative DNA damage and dioxin activity) in size fractionated PM sampled on daily basis in winter 2012 (in parallel to the presented study) to asses size and time variability of all toxicity parameters. The results suggest that genotoxicity and dioxin-like activity are the major toxic effects of organic compounds bound to size segregated aerosol, while oxidative DNA damage is not induced by extractable organic matter of aerosol particles.

* Corresponding author. Institute for Environmental Studies, Charles University in Prague, Benátská 2, 128 01 Prague 2, Czech Republic.
E-mail address: pokorna@natur.cuni.cz (P. Pokorná).

Peer review under responsibility of Turkish National Committee for Air Pollution Research and Control.

http://dx.doi.org/10.1016/j.apr.2016.03.001

The source identification of fine and coarse aerosol particles has already been conducted in Ostrava in winter 2012 (Pokorná et al., 2015). However, the apportioned aerosol particle sizes were limited to aerodynamic diameter > 150 nm. Due to the aerosol particle size limitation and indication of the distinct toxicity of the very fine particles (Topinka et al., 2015), the objective of the presented study is to apportion sources of $PM_{0.09-0.26}$ in the residential district Ostrava – Radvanice and Bartovice, Czech Republic in the winter of 2012.

2. Material and methods

2.1. Measurements

Aerosol sampling was conducted using a mobile monitoring station, placed in residential district of Ostrava – Radvanice and Bartovice, Czech Republic (Fig. 1) from 26th January to the 21st February 2012. Details of the sampling site are described elsewhere (Pokorná et al., 2015). A Davis Rotating-drum Uniform-size-cut Monitor (8 DRUM, Delta Group UC Davis) was used to collect particles in eight size modes; 90–260 nm, 260–340 nm, 340–560 nm, 0.56–0.75 μm, 0.78–1.15 μm, 1.12–2.5 μm, 2.5–5 μm, 5–10 μm on lightly greased (Apiezon-L^{TM}) Mylar substrates at a flow rate of 8.9l min^{-1}. Particles impacted on the eighth stage of the 8 DRUM, 90 < D_p < 260 nm, were evaluated as the very fine aerosol fraction ($PM_{0.09-0.26}$) (Cahill et al., 2011).

The sample strip of very fine aerosol fraction were analyzed in 2 h increments. Two-hours mass concentrations of very fine particles were calculated from appropriate size ranges of 5 min integrates of particle size distribution of the size range 14.6–736.5 nm, determined by a Scanning Mobility Particle Sizer (SMPS 3936L-25, TSI). Five minutes average values of NO, NO_2, NO_x,

Fig. 1. Outline map of Czech Republic, borders of the city of Ostrava and detailed map of the district Ostrava – Radvanice and Bartovice with location of the monitoring station and highlighting the metallurgy complex.