Atmospheric Pollution Research xxx (2017) 1–13

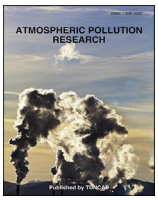
HOSTED BY

ELSEVIER

Contents lists available at ScienceDirect

Atmospheric Pollution Research

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



Evaluation of indoor/outdoor urban air pollution by magnetic, chemical and microscopic studies

M. Jeleńska [a], B. Górka-Kostrubiec [a, *], T. Werner [a], M. Kądziałko-Hofmokl [a], I. Szczepaniak-Wnuk [a], T. Gonet [b], P. Szwarczewski [c]

[a] Institute of Geophysics, Polish Academy of Sciences, Ks. Janusza 64, 01-452 Warsaw, Poland
[b] Faculty of Geology, University of Warsaw, Żwirki i Wigury 93, 02-089 Warsaw, Poland
[c] Faculty of Geography and Regional Studies, University of Warsaw, Krakowskie Przedmieście 30, 00-927 Warsaw, Poland

ARTICLE INFO

Article history:
Received 12 September 2016
Received in revised form
12 January 2017
Accepted 13 January 2017
Available online xxx

Keywords:
Outdoor pollution
Indoor pollution
Magnetic method
SEM
Heavy metals

ABSTRACT

The paper presents comparison of outdoor and indoor air pollution by means of magnetic characteristics of dust settled on the floor indoors (ID) and particulate matter (PM) gathered outdoor on air filters. Samples were collected for one year period in three different locations in Warsaw, Poland. PM was collected in samplers placed at the yard of buildings and ID was collected inside these buildings using a vacuum cleaner. The magnetic methods supplemented by chemical elements analysis and microscope observations were applied to identification of magnetic mineralogy, concentration and grain-size of magnetic fraction and morphology and shape of particles.

The results demonstrated differences in magnetic mineralogy and in grain-size distribution between PM and ID. The magnetite was the main magnetic phase in PM and magnetite with metallic iron in ID. The ratios of hysteresis parameters for PM and ID were located in different areas on Day-Dunlop diagram; PM data in the area for PSD magnetite and fine SP grains and ID data around SD + MD mixing curves for magnetite.

The difference in magnetic mineralogy, especially the lack of metallic iron in PM, can be explained by the limitation of dust samplers that cannot collect grains larger than roughly 50 μm due to our microscopic observations. PM samplers collect population of dust with smaller grain size than vacuum cleaner or simple sweeping of a floor. The difference in granulometry and outdoor/indoor sources could be one of the reasons for which we did not observed the simple relation between magnetic susceptibility of ID and PM.

1. Introduction

Since many years, magnetometry has been used for studying soil and air pollution. Magnetometry is a method which uses magnetic parameters for evaluation the content of iron-rich magnetic compounds (ferro-magnetic *sensu lato* oxides and/or sulphides) occurring in pollution (Maher and Thompson, 1999; Evans and Heller, 2003). It is well established that heavy metal (HM) and other trace toxic elements (TE) are accompanied and originally joint to iron compounds. Additionally, magnetometry is an inexpensive, quick and sensitive method. Because of that magnetic methods are successfully applied to evaluation of the pollution level of air and soil in cities and industrial regions.

Airborne particulate matter (PM) suspended in air consists of a mixture of natural and anthropogenic particles. Natural sources are mostly long-way atmospheric transport of PM, and soil as well as re-deposition of crushed material. Anthropogenic PM is emitted into atmosphere as the result of vehicle traffic and as products of industrial activity and domestic heating systems. After entering indoors, the outdoor pollution (e.g. organic matter, mineral dust, inorganic aerosols, among them HM and TE particles and others) are included in the total reservoir of indoor dust.

Indoor dust (ID) is an important source of air pollution we breathe in homes, offices, schools etc. According to many studies

* Corresponding author.
E-mail address: kostrub@igf.edu.pl (B. Górka-Kostrubiec).
Peer review under responsibility of Turkish National Committee for Air Pollution Research and Control.

http://dx.doi.org/10.1016/j.apr.2017.01.006

indoor air pollution is very dangerous for health of habitants, working staff, school children etc., having impact on asthma, cardiovascular and cancer diseases and others diseases (Donaldson and Stone, 2003; MacNee and Donaldson, 2003). Among various pollutants HM and TE are especially important due to the serious long-term effects on human health. Because of that, it is important to know what is the impact of outdoor pollution on the pollution level of indoor air. Several studies of indoor sub-micrometres airborne PM examined mass concentrations of PM10, PM2.5 and PM1 inside offices (Horeman and Van Grieken, 2010) or in the university rooms (Gemenetzis et al., 2006; Kagi et al., 2007). It was found that the mass concentration of PM1 was elevated by use of office printers or computers. Particles in the range of 1 μm - 10 μm were mainly associated with outdoor sources such as soil powder setting and resuspension (Horeman and Van Grieken, 2010).

Up to now, magnetometry has been used mainly for study of outdoor pollution. In particular, magnetic properties of PM deposited on filters were examined to identify industrial and traffic pollution (Muxworthy et al., 2002, 2003; Shu et al., 2001; Sagnotti et al., 2006; Petrovsky et al., 2013; Castaneda-Miranda et al., 2014). Except of our works (Jeleńska et al., 2011; Król et al., 2013; Górka-Kostrubiec et al., 2014; Górka-Kostrubiec, 2015; Szczepaniak-Wnuk and Górka-Kostrubiec, 2016; Górka-Kostrubiec and Szczepaniak-Wnuk, 2016) only Halsall et al. (2008) and Jordanova et al. (2012) investigated an indoor air pollution in urban environments by using the magnetic method. Halsall et al. (2008) examined the relation between outdoor and indoor air pollution around the city of Lancaster, UK by measuring PM concentrations, properties of magnetic particles and polyromantic hydrocarbons (PAH) concentrations. The high vapour levels of 2−3 ring PAHs and generally low isothermal remanence magnetization (IRM) in indoor environments indicated limited ingress of outdoor air pollution to indoors. However, the data pointed out traffic as the major source of particles −bound PAHs, PM as well as magnetic particles.

Jordanova et al. (2012) sampled pairs of indoor-outdoor urban dust collected for one month period in 6 cities in Bulgaria. Magnetite was identified as a main mineral of magnetic fraction which consisted of spherical and irregular particles of pseudo-single-domains. The lower values of remanence coercivity of outdoor dust compared with corresponding indoor dust were interpreted as the penetration of smaller fraction of outdoor PM to indoor environments. Moreover, the authors stated that the absence of seasonal variations of magnetic susceptibility of outdoor and indoor samples was most probably due to the dominant role of traffic-related emission.

Previous magnetic studies (Jeleńska et al., 2011; Król et al., 2013; Górka-Kostrubiec et al., 2014; Górka-Kostrubiec, 2015; Szczepaniak-Wnuk and Górka-Kostrubiec, 2016; Górka-Kostrubiec and Szczepaniak-Wnuk, 2016) of indoor air pollution showed that level of household dust contamination by heavy metals can be evaluated by magnetic susceptibility and other magnetic parameters. Correlations of magnetic susceptibility with concentration of heavy metals indicated that this magnetic parameter is a good proxy of heavy metals content in household dust.

The key aims of this study is to evaluate the urban outdoor and indoor pollution in the same place, for the same time period. For this purpose we applied magnetic methods supplemented by chemical elements analysis and microscope observations to evaluate the pollution in dust settled on the floor indoors and in atmospheric PM deposited on filters. The collection of ID and PM samples was gathered in three localities in Warsaw characterized by different surroundings: in the outer city centre, out of the centre and in the very centre of the city.

We looked for the possible influence of local environment on the magnetic properties such as magnetic mineralogy and domain structure, and chemical composition of outdoor and indoor dust. Moreover, we were interested in contribution of outdoor pollution to indoor one and supposed influence of indoor activity on pollution level.

2. Methods

2.1. Sampling sites

The PM and ID samples were collected in three places in Warsaw (Fig. 1) chosen carefully according to the pollution map of Warsaw (Górka-Kostrubiec et al., 2014). Site A is located at the Institute of Geophysics, Polish Academy of Sciences (PAS), in the outer city centre in the busy street with tramways and buses not far from highway but close to the large park. Site B is located at the Space Research Centre, PAS, out of the centre in small street with cars and buses, in the green area, but in the vicinity of heat and power station. Site C is located at the Institute of Geological Sciences, PAS, in the very centre of the city, in narrow but busy street without tramways and buses. All the buildings have only natural ventilation system without air condition. The buildings are very similar in terms of the number of floors, the activity of office workers and materials covering rooms and corridors. Only in building C more office floors are carpeted. The PM and ID samples were collected in all the sites in the same period from November 1st, 2014 to October 31st, 2015.

2.2. PM collecting and preparation

The PM was collected on the filters using the low-volume air samplers PNS-15 (Atmoservice, Poland) which were situated on the courtyards of studied buildings. In order to collect a wide range of particle size, the so-called “total PM head” was used in the

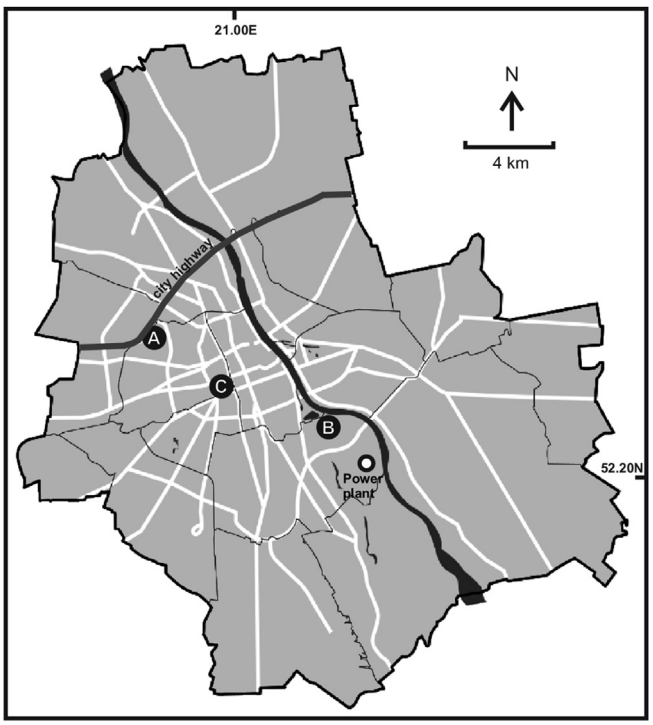


Fig. 1. The location of the sampling sites in Warsaw. A - Institute of Geophysics, PAS, B - Space Research Centre, PAS, C - Institute of Geological Sciences, PAS. The location of the city highway close to site A and the heat and power plant in the close distance to B site are also indicated.

Please cite this article in press as: Jeleńska, M., et al., Evaluation of indoor/outdoor urban air pollution by magnetic, chemical and microscopic studies, Atmospheric Pollution Research (2017), http://dx.doi.org/10.1016/j.apr.2017.01.006