Mass distribution of elements among four fractions of suspended dust in Zabrze, Poland.

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Keywords: PM1, EDXRF, size-resolved elemental composition, Silesia.

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Despite the increasing number of studies concerning determination of concentrations and elemental composition of, especially the fine dust, the existing amount of relevant information and data on these subjects is noticeably insufficient, i.a. in the Eastern Europe area. Knowledge about the chemical composition, including the elemental composition of, particularly the submicron dust in Poland, is very limited. The aim of this study was to determine and compare the elemental composition of four fractions of suspended dust in an urban area, characteristic for the Upper-Silesian Agglomeration in terms of the exposure of its population.

Diurnal samples of the four dust fractions (PM_1, $PM_{1\text{-}2.5}$, $PM_{2.5\text{-}10}$ and $PM_{10\text{-}40}$) were collected for eight months (January-August) in Zabrze with the use of a DEKATI-PM10 cascade impactor. The elemental composition of PM samples was determined by means of energy dispersive X-ray fluorescence (Epsilon 5, PANalytical Inc., Rogula-Kozłowska et al. 2013).

Average concentrations in the winter – heating season (January-April) and average concentrations in the summer – non-heating season (May-August) of 35 elements bound to each of the four examined fractions of dust were calculated. Additionally the influence of anthropogenic sources on the concentrations of elements bound to each PM fraction was estimated based on the analysis of so called enrichment factors (EF, Fig. 1), and the strength of linear relationships (Pearson's linear correlation coefficients) between each pair of elements were investigated – separately for fine and coarse dust.

The highest concentrations in Zabrze were observed for nonmetals – sulfur and chlorine, and their concentrations were significantly lower in the summer than in the winter–heating, season. Both elements – S and Cl – were concentrated mainly in the finest particles. Their share in the coarse dust, even in the summer season, was small. The concentrations of both sulfur and chlorine in the air of Zabrze are determined by anthropogenic sources.

Si, Al and Fe, Mg, K, Ca and Ti, Sr, Rb in the air of Zabrze consist a group of elements of a typically crustal origin. In Zabrze concentrations of these elements, regardless of the fraction of dust to which they are bound, are determined by natural sources. This conclusion is confirmed by small seasonal variations in concentrations of these elements or cases, in which concentrations of the elements are higher in the summer than in the winter season.

A significant portion of mass of crustal elements, particularly Al, Si and Fe, was concentrated in the coarse dust fractions. However, thorough analysis of mass distribution of these components among the dust fractions indicates that some of them – K, Ca, Mg, Rb, Sr, can be additionally emitted from anthropogenic sources. It particularly concerns the fraction bound to fine dust and the winter-heating season. The estimated contribution of soil matter to the mass of TSP is about 6.8 and 9.7 % in the winter and summer season, respectively. The share of soil matter in PM_1 is one half smaller.

Concentrations of the remaining metals in most cases did not exceed 100 $ng \cdot m^{-3}$ (except for Mn, Zn, Ge, Sb, La) and usually varied seasonally – were higher in the winter season. Co, Cu, Zn, Pb and As were concentrated mainly in fine dust, while V, Mn, Co, Cr, Ni, Ag, Cd and Ba were mostly bound to coarse dust. It was assumed that the first group, present in higher concentrations as components bound to fine dust, are mainly of anthropogenic origin and are closely associated with combustion processes. The remaining elements, especially in the winter, originate partly from combustion processes, but resuspension of road dust is the source of the majority of their mass.

The largest contributors to the levels of elements bound to fine dust in Zabrze are the sources of emission including burning of fossil fuels, biomass, waste and liquid fuels in domestic furnaces and car engines. Also the possible influence of industrial sources was identified. Concentrations of elements in coarse dust are determined by resuspension of soil and road dust, and to a lesser extent, by municipal emission.

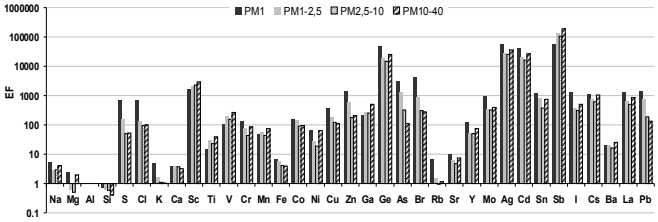

Figure 1. Average values of *EF* for PM_1-, $PM_{1\text{-}2.5}$-, $PM_{2.5\text{-}10}$- and $PM_{10\text{-}40}$-related elements in Zabrze in the period: January-August

This work was partially supported by the grant No. N N523 564038 from the Polish Ministry of Science and Higher Education.

Rogula-Kozłowska, W., Błaszczak, B., Szopa, S., Klejnowski, K., Sówka, I., Zwoździak, A., Jabłońska, M., Mathews, B. (2013) Environ. Monit. Assess., 185, 581-601.