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Atmospheric deposition of trace elements at urban and forest sites in central Poland – insight into seasonal variability and sources

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Abstract

This paper includes the results of chemical composition of bulk deposition samples collected simultaneously at urban (Poznań city) and forest (Jeziory) sites in central Poland, between April 2013 and October 2014. Rainwater samples were analyzed for trace elements (As, Zn, Ni, Pb, Cu, Cr, Cd) and physicochemical parameters. Overall, three metals, i.e. Zn, Pb and Cu were the most abundant anthropogenic constituents of rainwater samples from both locations. In Poznań city, the rainwater concentrations of trace elements did not differ significantly between spring and summer. However, they were elevated and more variable during the cold season (fall and winter), suggesting strong contribution from local high-temperature processes related to coal combustion (commercial and residential sector). In contrast to the urban site, relatively low variability in concentrations was found for Cu, Ni, Zn at the forest site, where direct impact of emission from vehicle traffic and coal-fired combustion (power plants) was much lower. The bulk deposition fluxes of Ni, As, Pb and Zn at this site exhibited a clear trend, with higher values during the cold season (fall and winter) than in spring and summer. At the urban site, the sums of total bulk deposition fluxes of Zn, Cu, Pb, Ni, As, Cr, Cd were as follows: 8460.4, 4209.2, 2247.4, 1882.1, 606.6, 281.6 and 31.4 μg m^{-2} . In addition, during the winter season, a significantly higher deposition fluxes of Cu and Zn were observed for rain (on average 103.8 and 129.4 μg m^{-2}, respectively) as compared to snow (19.7 μg Cu m^{-2} and 54.1 μg Zn m^{-2}). This suggests that different deposition pattern of trace elements for rain, mixed and snow was probably the effect of several factors: precipitation type, changes in emission and favorable meteorological situation during rain events.

keywords: trace elements, bulk deposition, emission sources, rainwater, seasonal variation

Introduction

The input of trace elements (TEs) via dry and wet deposition is a large source of contamination for plants, soil and water systems. Therefore, the understanding of its seasonal variation is fundamental for the further development of local and regional policies related to urban air quality and ecosystem protection. Trace elements are emitted to the atmosphere mainly from different anthropogenic sources and they often exhibit toxic properties. Several recent measurement campaigns have provided evidence that urban areas play a key role in determining the impact of PM2.5-containing inorganic and organic compounds on the air quality, climate system and human health (Khan et al., 2016). The major hotspots of metallic compounds are linked to various industrial activities (i.e. fossil fuel and oil combustion, nonferrous metal smelting, iron/steel manufacturing, waste incineration, cement production), residential wood combustion and traffic (tire/brake wear).

The series of short- and long-term observations of trace elements has been performed at different sites across the globe (Connan et al., 2013, Gunawardena et al., 2012, 2013, Guo et al., 2015). These studies provided empirical evidence that changes in emission and meteorological conditions (i.e. mixing layer height, ambient temperature, precipitation amount, atmospheric circulation) can have a significant impact on the transport, transformation and deposition of trace elements. As a result, atmospheric deposition of trace elements is an important issue involved in the