Compositional data analysis of element concentrations of simultaneous size-segregated PM measurements

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Abstract

There is a growing interest in particulate matter (PM) due to its impact on human health, air quality and global climate change (WHO, 2006; Prospero, 2007; IPCC, 2013). PM is a mixture of particles suspended in the air and they differ in size, chemical composition and emission sources. The assessment of the chemical composition of PM and of its size distribution in relation to its possible emission sources is a starting point in order to plan actions aimed at mitigating the levels of PM to protect the environment and public health (Putaud and others, 2010). Selected sets of chemical elements have been linked to specific sources of PM such as mineral matter, sea spray, fuel-oil combustion and secondary aerosols. However, the identification of a set of elements useful in the discrimination of specific natural sources (e.g. fugitive and desert dusts events) and anthropogenic sources of mineral matter (e.g. road dust and construction/demolition activities) has proven to be problematic, since these sources can have the same range of chemical elements in common (Thorpe and Harrison, 2008).
This preliminary study presents the application of compositional data analysis (Pawlowsky-Glahn and Buccianti, 2011) to element concentrations of size-segregated PM simultaneous measurements (i.e. PM_{10}, $PM_{2.5}$ and PM_1 aerosol particles with aerodynamic diameters smaller than 10, 2.5 and 1 μm, respectively) as reported in the literature by Matassoni and others (2011). These measurements refer to a typical suburban background site with (in-dust days) and without (non-dust days) the contribution from a Saharan dust event. The selected elements were Al, Si, Ca, Fe, Ti, Mg, Sr, commonly interpreted as related to mineral matter (Viana and others, 2008). The element concentrations of size-segregated PM simultaneous measurements related to in-dust and non-dust days have been converted into two compositional data sets based on weight percent (Pawlowsky-Glahn and Egozcue, 2006). The compositional data analysis provides evidence that the two compositional data sets are statistically distinct. This outcome shows that the Saharan dust even (in-dust days) can concur with local anthropogenic sources of mineral matter (non-dust days) to determine the chemical composition of PM of the suburban background site. Therefore, the compositional data analysis applied to element concentrations of size-segregated PM simultaneous measurements can be an effective technique useful in the study of environmental sites polluted by specific natural sources of mineral matter (e.g. Saharan dust events) and related sources.

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