SOURCES CONTRIBUTION TO METAL CONCENTRATIONS IN PM2.5 IN A COASTAL INDUSTRIALIZED AREA

Pascal Flament [(1)], S. Mbengue [(2, 3)], L.Y. Alleman [(2)] and K. Deboudt [(1)]

[(1)]: Université du Littoral - Côte d'Opale, LPCA, Dunkerque, France
[(2)]: Mines Douai, SAGE, Douai, France
[(3)]: Czech Academy of Sciences, Global Change Research Institute, Brno, Czech Republic
pascal.flament@univ-littoral.fr

Keywords: $PM_{2.5}$, Trace elements, Industrial emissions, Sources apportionment

Introduction

Industrial activities have a significant contribution to the global load of atmospheric particulate matter in Europe (1.3×10^6 $t.yr^{-1}$ of $PM_{2.5}$, accounting for 40% of the total PM_{10} emissions: Pulles et al., 2007). Exposure to $PM_{2.5}$ has progressively been recognized to have a strong impact on human health. Atmospheric particles measured in industrial areas are generally enriched in potentially toxic trace metals, which are considered to play a role in oxidative stress leading to chronic pulmonary disease and asthma. In this study, we apportion the main industrial sources contributing to the concentrations of metal-bearing fine particles in one of the most important coastal industrial area in Europe.

Methods

The sampling site taken place in the south border of the industrial area of Dunkirk, a French harbor along the southern bight of the North Sea. Atmospheric particulate matter was collected for three weeks by cascade impaction (particle size-classes ranging from 30 nm to 2.5 µm). Concentrations of 6 major and 17 trace elements were analyzed by ICP-AES and ICP-MS, following the procedure detailed in Mbengue et al. (2014). To identify the different metal-bearing particle sources in $PM_{2.5}$, Principal Component Analysis (PCA) and Multiple Linear Regression Analysis (MLRA) were performed.

Results

During the campaign, the mean $PM_{2.5}$ mass concentration exceeded the European Union (EU) 1-year average limit value (25 $\mu g.m^{-3}$) in northeasterly (32.5 ± 11.9 $\mu g.m^{-3}$) and northwesterly (28.2 ± 7.9 $\mu g.m^{-3}$) meteorological situations, i.e. when local winds blew predominantly from the metallurgy and oil refining sectors of the industrial area, respectively. Conversely, the concentrations were lower under urban influence (southwesterly winds). Except for Fe and Mn, mainly associated with supermicronic particles, elements with a main anthropogenic origin, i.e. industry or traffic (As, Cd, Co, Cr, Cu, K, Ni, Pb, Sb, V, and Zn) display more than 60% (and up to 85%) of their mass in the submicron and ultrafine (< 100 nm) fractions.

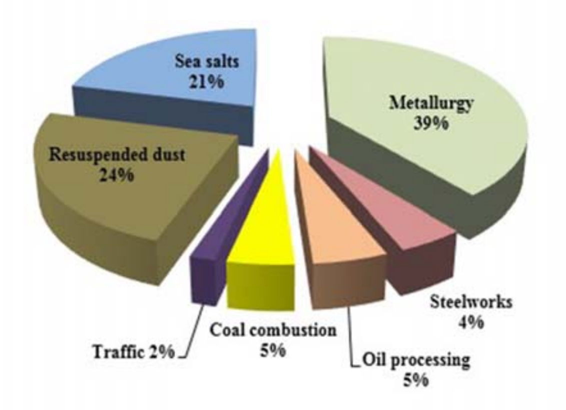

Figure 1: Metal-sources apportionment using the mean concentrations of the selected tracers in $PM_{2.5}$

Seven representative tracers for the source-types identified in the studied area have been proposed after a comparative analysis of the source profiles extracted by PCA: Mn for metallurgy, Ni for oil processing (refining, fuel-oil combustion), Pb for steelworks, As for coal combustion, Cu for road traffic, Al for resuspended dust and Na for sea sprays and aged sea salts. Based on the mean concentrations measured in $PM_{2.5}$, a metal-sources apportionment was performed using the MRLA results. The obtained results (Figure 1) showed, without surprise, that metal working (Fe-Mn alloy refining, iron- and steel-making) is the main source (> 40%) controlling metal concentrations in fine particles, followed by resuspended dust (24%). More surprisingly, the source called "sea salts" is also an important contributor (21%) to metal concentrations. This could be due to coalescence between hygroscopic fresh sea salts and local emissions, at the particle scale (Choël et al., 2006).

Conclusion

More than 50 000 inhabitants living in the Dunkirk southwest suburbs are exposed to industrial plumes, bearing fine and ultrafine metal-rich particles. It is therefore suggested that local air quality management plans address these observations, for example by mean of a special monitoring, dedicated to a specific survey of fine and ultrafine particulate matter in this multi-influenced urban zone.

References

Choël, M.; Deboudt, K.; Flament, P.; Lecornet, G.; Perdrix, E.; Sobanska, S. (2006). Fast evolution of tropospheric Pb- and Zn-rich particles in the vicinity of a lead smelter, *Atmos. Environ. 40,* 4439-4449.

Mbengue, S.; Alleman, L.Y.; Flament, P. (2014). Size-distributed metallic elements in submicronic and ultrafine atmospheric particles from urban and industrial areas in northern France, *Atmos. Res. 135*, 35-47.

Pulles, T.; Kuenen, J.; Van der Gon, H.D.; Woodfield, M.; Kindbom, K. (2007). Estimation of emissions of fine particulate matter ($PM_{2.5}$) in Europe. *Netherlands Organisation for Applies Scientific Research (TNO);* Apeldoorn, The Netherlands.