Size distributed metallic elements in submicron and ultrafine atmospheric particles from urban and industrial areas: a source assessment

S. Mbengue [1,2], L. Alleman [1,2] and P. Flament [1,3]

[1] Univ Lille Nord de France, F-59000 Lille, France
[2] Mines Douai, CE, F-59508 Douai, France
[3] ULCO, LPCA, F-59240 Dunkerque, France
Keywords : particles, size distribution, metallic elements, enrichment factor
saliou.mbengue@mines-douai.fr

In recent decades, studies have evidenced the relationship between high concentrations of airborne particles (PM) and increased mortality and morbidity related to respiratory and cardiovascular diseases (Künzli *et al.*, 2000; Pope et Dockey, 2006). PM_{10} and $PM_{2,5}$ are usually selected as the monitoring parameters for air quality evaluations. However metallic elements associated with inhalable particles, particularly in the finest fraction, have been shown to increase human lung and cardiopulmonary injuries (Schaumann *et al.,* 2004; Osornio-Vargaset *et al.*, 2003). In toxicology and source assessment, particle size is a key parameter. The objective of the present study is to give new insights about the size distribution and source emissions of potentially toxic heavy metals in an urbano-industrial area representative of other major industrial regions in Europe.

The $PM_{10,}$ PM_1 and $PM_{ultrafine}$ fractions were collected under "industrial" and "urban-traffic" wind sectors, in one of the largest industrial cities of France (Dunkirk) during winter 2012. The PM were sampled using low pressure cascade impactors and elemental analyses were performed by ICP-AES (Al, Ca, Fe K, Mg and Na) and ICP-MS (As, Ba, Cd, Co, Cr, Cu, La, Mn, Mo, Ni, Pb, Rb, Sb, Sr, Ti, V and Zn).

Both, meteorological conditions and emission sources variability were found to be important parameters that control the size distribution and the chemical composition of particles. The PM_{10}, PM_1 and $PM_{0.29}$ mass concentrations were respectively 23.6 ± 6.0, 10.1 ± 4.1 and 2.4 ± 1.1 µg/m^3, under industrial influence and 29.8 ± 4.1, 16.6 ± 3.9 and 5.8 ± 2.1 µg/m^3 under urban-traffic influence. Regarding the relative concentration of the twenty three elements investigated, the submicron fractions (PM_1 and $PM_{0.29}$) accounted respectively for about 41.8 ± 10.8% and 9.8 ± 2.4% of the PM_{10} mass for the industrial sector and 56.8 ± 16.2% and 20.2 ± 9.3% for the urban-traffic one. This comparison suggests that urban sources produce, in average, finer particles and in a larger amount than industrial sources. Regarding the relative concentration of metallic elements, the submicron fractions (PM_1) represented 46 ± 24 % for industrial and 52 ± 23 % for urban-traffic sectors, with generally higher proportions for the ultrafine fraction ($PM_{0.29}$) under an urban-traffic sector influence (14 ± 8% and 24 ± 9%, respectively), associated to sources located within the city and suburban traffic.

This result imply that, even for an urban environment potentially influenced by the proximity of metallurgical activities, traffic within the urban district and nearby house heating may overwhelmingly influence the metallic content of atmospheric nanoparticles. However, industrial processes may significantly affect the neighboring urban atmosphere with metal-rich particles, especially in the accumulation mode ($PM_{0.29-1}$). They have been attributed, in this size range, to primary particles emitted by steelworks and metal refinery processes. These aerosols can easily reach our sampling site located in the nearby urban area (2000 m). We also evidenced that vehicular emissions remain the main sources of Cu and Sb in the submicron fraction.

This work was part of a program from the "Institut de Recherche en ENvironnement Industriel" (IRENI) and was financially supported by the Nord-Pas-de-Calais Regional Council, the French Ministry of Higher Education and Research, the European Regional Development Fund (ERDF) and Ecole des Mines de Douai.

Künzli, N., Kaiser, R., Medina, S., Studnicka, M., Chanel, O., Filliger, P., Herry, M., Horak Jr, F., Puybonnieux-Texier, V., Quénel, P., Schneider, J., Seethaler, R., Vergnaud, J-C. Sommer, H. (2000) *The Lancet* **356**, 795-801.

Osornio-Vargas, A., Bonner, J. C., Alfaro-Moreno, E., Martinez, L., Garcia-Cuellar, C., Poncede-Leon Rosales, S., et al., (2003) *Environ. Health Perspect.* 111, 1289–1293.

Pope, A.C., Dockery, D.W., (2006) *Air & Waste Manage. Assoc.* **56**,709–742.

Schaumann, F., Borm, P.J.A., Herbrich, A., Knoch, J., Pitz, M., Schins, R.P.F., Luettig, B., Hohlfeld, J.M., Heinrich, J., Krug, N. (2004) *Am. J. Respir. Crit. Care Med.* **170**, 898–903.