Sources of the PM10 aerosol in Flanders, Belgium, and re-evaluation of the contribution from wood burning

W. Maenhaut[1,2], R. Vermeylen[2], M. Claeys[2], J. Vercauteren[3] and E. Roekens[3]

[1]Department of Analytical Chemistry, Ghent University, Gent, BE-9000, Belgium
[2]Department of Pharmaceutical Sciences, University of Antwerp, Antwerpen, BE-2610, Belgium
[3]Flemish Environment Agency (VMM), Antwerpen, BE-2000, Belgium
Keywords: PM10, PMF, levoglucosan, wood burning.
Presenting author email: willy.maenhaut@ugent.be

From 30 June 2011 to 2 July 2012 PM10 aerosol samples were simultaneously taken every 4th day at four urban background sites in Flanders, Belgium. The sites were in Antwerpen, Gent, Brugge, and Oostende. Sampling was done for 24 h and 47-mm diameter Pallflex® Tissuquartz™ 2500 QAT-UP filters were used.

After sampling the PM10 mass concentration was determined by weighing; organic and elemental carbon (OC and EC) were measured by thermal-optical transmission analysis (Birch and Cary, 1996), the wood burning tracers levoglucosan, mannosan and galactosan were determined by gas chromatography/mass spectrometry (Maenhaut et al., 2012), 8 water-soluble ions were measured by ion chromatography, and 15 elements were determined by a combination of inductively coupled plasma atomic emission spectrometry and mass spectrometry.

The multi-species dataset was subjected to receptor modeling by positive matrix factorization (PMF). Use was made of EPA PMF 5 (Norris et al., 2014) and of its capability of handling multiple site data. A 10-factor solution was retained as final solution. The 10 factors (with their overall average percentage contributions to the experimentally measured PM10 mass) were wood burning (9.5%), secondary nitrate (24%), secondary sulfate (12.6%), sea salt (10.0%), aged sea salt (19.2%), crustal matter (9.7%), non-ferrous metals (1.81%), traffic (10.3%), non-exhaust traffic (0.52%), and heavy oil burning (3.0%). The wood burning factor explained, on average, 29% of the PM10 OC and its contributions to both the PM10 mass and OC showed for each of the four sites a clear seasonal variation, with highest levels in winter, followed by fall, spring, and summer. The average percentage contributions of wood smoke for the four sites were quite substantial in winter and ranged from 12.5 to 20% for the PM10 mass (from 3.5 to 6.1 µg/m^3) and from 47 to 64% for PM10 OC. Wood burning appeared to be also a notable source of As, Cd, and Pb.

The contribution from wood burning to the PM10 mass and OC was also assessed by making use of levoglucosan as single marker compound and the levoglucosan to wood smoke PM10 mass and wood smoke OC conversion factors of Schmidl et al. (2008). Using this approach, very similar apportionments were found as in our 2010-2011 one-year study on the impact of wood burning in Flanders (Maenhaut et al., 2012) where we used the same approach. However, the apportionments were much lower than those deduced from PMF. It seems that the conversion factors of Schmidl et al. (2008), which are derived from burning hard and soft woods in Austrian wood stoves, may not be applicable to wood burning in Flanders. From scatter plots of the PMF-derived wood smoke OC and PM versus levoglucosan, we arrive at conversion factors of 9.7 and 22.6, respectively (see Figure 1). We therefore suggest these new conversion factors for deriving the contribution from wood smoke when using levoglucosan as single marker in future studies in Flanders. It is estimated that the percentage uncertainty, which is associated with these conversion factors is smaller than 20%.

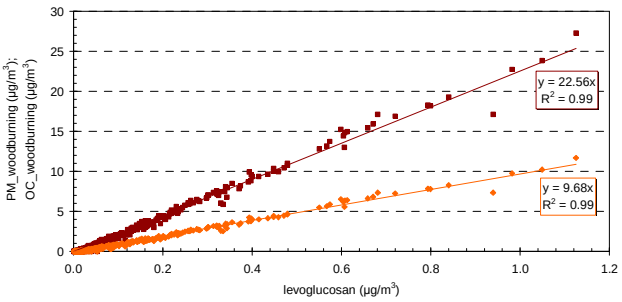

Figure 1. Scatter plots of PMF-derived wood smoke PM (brown squares) and OC (red diamonds) versus levoglucosan and regression lines, forced through the origin.

It is concluded that the impact from wood burning on the PM10 mass and OC levels in Flanders is substantially larger than previously thought, and that the potential for PM10 reductions by targeting wood burning has been underestimated.

This study received financial support from the Life+ Project ATMOSYS of the European Commission. The authors thank Franco Lucarelli and Silvia Nava from the I.N.F.N.-Florence for advice on the use of EPA PMF 5.

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