AIRUSE-LIFE+: Synergistic daily and hourly PM source apportionment in urban environments of Southern Europe

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The AIRUSE-LIFE+ project aims at testing mitigation measures and developing new strategies for the improvement of air quality in Southern European countries. In order to characterise similarities and heterogeneities in PM sources in urban areas from Southern EU, an extensive source apportionment study was carried out at 3 urban background sites (Barcelona, Florence and Milano, BCN-UB, FI-UB, MLN-UB), a sub-urban background site (Athens, ATH-SUB) and a traffic site (Porto, POR-TR).

This source apportionment study takes advantage of the combination of long-term daily data-sets, characterized by an extended chemical speciation, with short-term high time resolution (1-hour) data-sets, obtained by PIXE analysis of streaker samples. While time-extensive daily data give an overall representative picture of the PM composition, hourly data help in disentangling the contributions from different aerosol sources due to the capability of tracking rapid changes as the ones occurring in many particulate emissions as well as in atmospheric transport and dilution processes.

PM10 and PM2.5 daily samples were collected for one year (from January 2013), every third day from midnight to midnight, on quartz microfiber and Teflon filters, obtaining at least 122 samples per PM fraction and site. A full chemical characterization, including anions, cations, major and trace elements (by PIXE and ICP-MS or ICP-AES), Elemental Carbon (EC), Organic Carbon (OC), Carbonatic Carbon (CC, only in PM10) and levoglucosan (only in PM2.5) was performed for each sample.

Hourly samples were collected for shorter periods (~ 3 weeks in winter and 3 weeks in summer) by means of low volume two stages Streaker samplers. In these devices, the coarse and fine aerosol fractions (i.e. PM2.5-10 and PM2.5, respectively) are simultaneously collected on two rotating substrates, thus producing two continuous PM streaks. PIXE analysis of these samples by a properly collimated proton beam provided the elemental concentrations ($Z > 10$) with hourly time resolution.

Positive Matrix Factorization (US-EPA PMF5 version) was applied in a harmonized way to the data of the 5 cities (separately for daily and hourly samples). Input data were prepared using the Polissar procedure and PMF results for different number of factors were systematically explored to find out the most reasonable solution. Some constraints were added to the base run solution aimed at reducing the rotational ambiguity, driving the solution towards a priori information based on partial knowledge of emission sources. For daily samples, source profiles and contributions were normalized by setting the PM mass as "total variable". For hourly data, no information about the PM mass concentration is available: in this case, only relative source profiles was obtained and source time series are in arbitrary units (an example is shown in Figure 1).
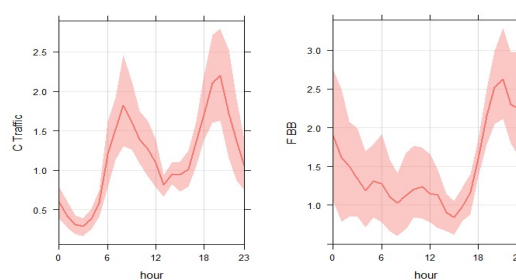

Fig 1. Daily patterns, obtained by PMF analysis of hourly data, of the Traffic (coarse fraction) and Biomass burning (fine fraction) sources (a.u.) at Porto.

For daily data, in order to increase the statistic, the PM2.5 and PM10 data sets were merged in a single input matrix for PMF. This approach helped in disentangling different traffic contributions, like the exhaust one, which is characterized by EC in the fine fraction, and the non-exhaust, mainly traced by Fe, Cu and Ba in the coarse fraction.