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Source Apportionment by PMF of Wide Range Particle Size Spectra

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Source apportionment of airborne particulate matter has generally used either chemical mass balance, which requires a detailed knowledge of source composition, or techniques based upon factor analysis such as PMF which have typically been applied to large multi-element datasets. Neither method has proved very effective at discriminating particles from non-exhaust traffic sources and it is only with the recent application of the ME2 programme that progress has been made in quantifying resuspended particles. In this paper we describe a different approach in which wide range particle size distributions are measured and PMF2 used to identify the main factors contributing to the measured distributions. Airborne particulate matter has been sampled continuously at a roadside site in London and particle size spectra measured using a Scanning Mobility Particle Sizer and Aerodynamic Particle Sizer. The sampling site is located within a street canyon on a major highway (Marylebone Road) in central London. The aerosol size spectra have been reduced to hourly averages and the average SMPS and APS spectra for each hour merged using an enhanced algorithm recently developed for this purpose (Beddows et al., 2010). The algorithm operates by adjusting the effective density so as to obtain the optimal fit for number, surface area and volume distributions. The ultimate size spectra cover the range from 15 nm to 10 μm diameter. The hourly data have been subject to analysis by PMF2 which revealed 10 factors. For each factor, a number and volume size distribution, together with the wind directional dependence, diurnal pattern and association with gas phase pollutants, meteorological factors and traffic volumes is created. From these, the source of each factor has been inferred. Four of the factors, accounting in all for 40.5% of particle volume and 71.9% of particle number, are associated with emissions on the adjacent road. These factors comprise solid mode exhaust particles, nucleation mode exhaust particles, brake wear and resuspended particles. The solid mode exhaust particles are the biggest contributor to both particle volume (amongst the emissions from the adjacent road) and particle number (all emissions). A further six factors were associated with the urban background. A regional factor accounted for 26.8% of the total volume of particles but only 3% of the total number while other factors were associated with accumulation mode particles, suburban traffic, nitrates, a second regional factor and a cooking aerosol factor. The quantitative attribution compares closely with published data derived with other methods although the contribution of resuspended particles is somewhat less than in two published studies from other cities. Differences in local conditions including climate may well contribute to this difference. The contribution of brake dust was rather larger than that estimated directly from the barium concentration but sufficiently close to be considered broadly consistent. PMF analysis over the wide size range of particles has proved to be an extremely effective way of source apportionment of particles of different origins.

Reference

Beddows, D.C., Dall'Osto, M. and Harrison R.M., 2010. An enhanced procedure for the merging of atmospheric particle size distribution data measured using electrical mobility and time-of-flight analysers, Aerosol Sci. Technol. 44, 930-938.