Three-way Positive Matrix Factorization analysis of PM_{10} in Brisbane, Australia

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Particle mass and number concentrations measured at a receptor site reflect emissions from a range of sources. To resolve the dominant factors from the empirical measurements that are associated with the characteristics and identities of the sources, different types of receptor models, particularly the 2-way Positive Matrix Factorization (PMF) have been used in recent years.

For example, PMF has been used extensively for the source apportionment of chemical composition data (Reff et al. (2007)); particle size distribution data (Zhou et al (2004), Friend et al (2012)), aerosol mass spectrometric data (Crilley et al, (2013)), and gaseous, chemical, and particle size data (Kasumba et al (2009). Various particle sources including: different types of combustion, marine emissions, industrial emissions, nucleation and secondary particles have been identified in such studies.

While literature is replete with the use of 2-way PMF receptor methods, the 3-way PMF which also has non-negativity constraints and is freer from rotational ambiguity has received relatively less patronage from researchers.

Paatero and Juntto applied the 3-way PMF to the hourly concentrations of a single pollutant such as carbon monoxide (Paatero and Juntto, (2000)) and obtained instructive diurnal concentration variations that could be linked to the sources of this pollutant.

The objective of the current study was to replicate this type of analysis on PM_{10} data collected at a government air quality monitoring site in Brisbane, Australia, and correlate the results with the corresponding gas-phase pollutants data collected at the same site. Because the current data can be examined in terms of pollutant concentrations, days of the week and hours of the day, we reasoned that analysis of the data by the 3-way PMF method could give insights into the possible sources of the PM_{10} at this receptor site.

The site is located at latitude -27.4205 and longitude 153.1208 and the data used for the study consisted of the 24-hourly meteorological measurements and the concentrations of PM_{10}, CO, NO, NO_2, NOx, and SO_2 collected throughout 2014. Preliminary examination of the data revealed that the concentrations of PM_{10} as well as those of the gaseous species were generally below the National Air Quality Standards (2005) for each pollutant.

Following the exclusion of whole missing days from the data matrix, 4152 PM_{10} data points were subjected to 3-way PMF analysis. Five factors were resolved from the analysis and diurnal variation plots, such as that shown in Figure 1, were constructed for the factors.

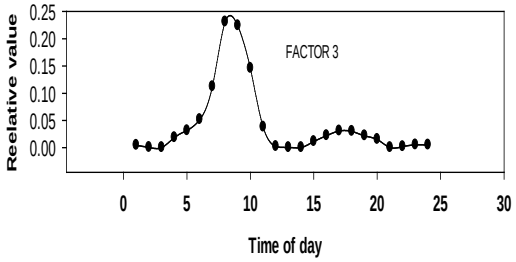

Figure 1: An example plot of the resolved diurnal variation plot.

Patterns in the hourly, daily and monthly time series plots of the resolved factors and Pearson correlation with the gaseous species and wind speed data suggest that the sources of PM_{10} at the site possibly include aircraft emissions, vehicle emissions, cooking, wind-blown dust or sparse nucleation (cf Zhou et al (2004)) and photochemical reactions.

These results demonstrate that the PM_{10} data are stable enough for factor analysis. However, further studies are warranted to develop and explore the applicability of this procedure to a wider range of pollutants. Such studies are currently in progress in our laboratory

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