

High-resolution sampling, analysis and source apportionment of particulate matter at Woolston, Christchurch, New Zealand

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In 2004, the New Zealand government introduced a National Environmental Standard (NES) of 50 $\mu\text{g m}^{-3}$ (24-hour average) for particles less than 10 μm in aerodynamic diameter (PM_{10}). The NES places an onus on regional councils to monitor PM_{10} and publicly report if the air quality in their region exceeds the standard. In airsheds where the PM_{10} standard is exceeded such as Christchurch, information on the sources contributing to those air pollution episodes is required to effectively manage air quality and formulate appropriate mitigation strategies.

This paper presents the results of an analysis of particulate matter (PM_{10} , $\text{PM}_{2.5}$ and $\text{PM}_{10-2.5}$) concentrations (two-hourly averages) and chemical composition measured at the Woolston monitoring site in the Christchurch airshed. The data have been used in a receptor modelling study using positive matrix factorisation (PMF) to determine the emission sources contributing to particulate matter concentrations and estimate their contribution.

The novel aspect of the current study is the use of two-hourly samples which enables a high resolution analysis of temporal variations of the sources contributing to particulate matter concentrations for both the coarse and fine fractions. Of high interest in Christchurch are the particulate matter load generated by biomass burning (domestic heating), motor vehicles and demolition/construction activities following the 2011 earthquakes.

Elemental concentrations in the samples were determined using ion beam analysis (IBA) techniques at the New Zealand IBA facility operated by GNS Science in Lower Hutt (Trompetter *et al.*, 2005; Barry *et al.*, 2012).

The key results from the study are:

Biomass combustion (31%) was the most dominant contributor to PM_{10} concentrations, with soil (23%), marine aerosol (19%), motor vehicles - diesel (15%), motor vehicles - petrol (9%) and sulphate (3%), the other emission sources contributing to the PM_{10} mass during the monitoring period.

When considering the 26 days recorded during the monitoring period when the PM_{10} standard was exceeded at the site (exceedance days), biomass burning was the most significant contributor to PM_{10} mass (49%), with soil the second contributor (29%) and lesser contributions from motor vehicles - petrol (9%), motor vehicles - diesel (8%), marine aerosol (3%) and sulphate (2%).

Diurnal and daily patterns in source contributions derived from high resolution (two-hourly) sampling were used to validate each source profile and showed that each source was unique.

The two-hourly data enabled the presentation of source contributions as a function of both wind speed and direction using polar plots, providing valuable information about potential source locations for each source identified.

The receptor modeling results have shown that arsenic and lead concentrations measured in Woolston were strongly associated with the biomass burning source. This finding would suggest that timber treated with copper chrome arsenate (CCA) and recycled painted timber are potentially used as part of the fuel stream in domestic wood burners, as shown in recent studies undertaken in two other towns in New Zealand, Nelson (Ancelet *et al.*, 2015) and Wainuiomata (Davy *et al.*, 2012).

Anthropogenic activities, both from domestic source emissions (biomass burning for home heating) and industrial activities (generation of dust) in the Woolston area were likely to be the main contributors to exceedances of the standard for PM_{10} .

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