Fact sheet:

Upper Hunter Valley Particle Characterisation Study Final Report

The fine particle characterisation study in the Upper Hunter was developed and funded jointly by NSW Health and the Office of Environment and Heritage (OEH), and undertaken by CSIRO (Commonwealth Scientific and Industrial Research Organisation) and ANSTO (Australian National Nuclear Research and Development Organisation). It has been completed and the final report released. An overview of the study objective, method and key findings are summarised in this fact sheet.

Background

The Upper Hunter Air Quality Monitoring Network (UHAQMN) has measured elevated particulate matter ($PM_{2.5}$) concentrations in Muswellbrook and Singleton during winter ($PM_{2.5}$ is particulate matter with a diameter of less than 2.5 micrometres). As there are multiple sources of $PM_{2.5}$, including mining, coal-fired power generation, diesel vehicles, road and rail transport, solid fuel heaters and prescribed burning, NSW Health and OEH commissioned a research study to better understand the composition and sources of fine particles in the Upper Hunter. This information is needed to better target NSW Government programs aimed at reducing fine-particle pollution; the finer $PM_{2.5}$ particles are of the greatest concern owing to their impact on health.

Study details

Study objective

The objective of the Upper Hunter Valley Particle Characterisation Study was to determine the major components and sources of $PM_{2.5}$ in the two main population centres in the Upper Hunter Valley, namely Singleton and Muswellbrook.

Methodology overview

Sampling was undertaken at the UHAQMN sites in Singleton and Muswellbrook for the whole of calendar year 2012, with samples collected over 24 hours every third day. The sampling equipment comprised a CSIRO high volume sampler (with $PM_{2.5}$ particles collected on quartz filters), and ANSTO's low volume aerosol sampling program (ASP) $PM_{2.5}$ cyclone samplers (with samples collected on Teflon filters). The types of filter material were dictated by requirements of the analysis techniques.

ANSTO used ion beam analysis to determine the concentrations of twenty elements in the samples, and also measured the black carbon concentrations. CSIRO used ion chromatography to measure concentrations of soluble ions (including chloride, nitrate, sulfate, ammonium, sodium and potassium) and anhydrous sugars (levoglucosan and mannosan) that are found in wood smoke, as well as organic carbon.

The chemical composition of all the samples was analysed using a mathematical technique called positive matrix factorisation (PMF) to identify factors contributing to the total $PM_{2.5}$ concentration. The key source of emissions in each factor was identified using a range of information, including source characteristics, wind data and the pattern of seasonal variation in the factor.

Results

Table 1 lists the PMF factors that were identified based on the dominant sources identified in their fingerprints. The contribution of each factor to total annual $PM_{2.5}$ concentrations measured at Singleton and Muswellbrook is provided in the table. The CSIRO and ANSTO analyses used slightly different PMF techniques but produced very similar factors, which added confidence to the study findings. Differences in results were indicative of the uncertainties in apportioning source contributions.

Table 1 Summary of the PMF factors, main species, contributions of these factors at each site and potential sources

Factor number and assigned name	Main species in factor	Contribution of the factor to total annual $PM_{2.5}$ mass at:		Potential sources
		Singleton	Muswellbrook	
Factor 1: wood smoke	levoglucosan, mannosan , OC1	14 ± 2%	30 ± 3%	Domestic wood heaters
Factor 2: vehicle/industry	BC, OC1, OC2, SO_4^{2-} Fe, Zn, Mn, Cu	17 ± 2%	8 ± 1%	Vehicles, industry
Factor 3: secondary sulfate	NH_4^+, SO_4^{2-}	20 ± 2%	17 ± 2%	Local and regional sources of SO_2, such as power stations
Factor 4: biomass smoke	OC2, OC3, OC4, K^+, SO_4^{2-}, Al, Si, Ti, BC	8 ± 2%	12 ± 2%	Wildfires, hazard reduction burns
Factor 5: industry aged sea salt	Na^+, Mg^{2+}, SO_4^{2-} and with almost no Cl^-	18 ± 3%	13 ± 2%	Sea salt, local and regional sources of SO_2, such as power stations
Factor 6: soil	Al, Si, Ca, Ti and Fe	12 ± 2%	11 ± 1%	Soil dust, fugitive coal dust
Factor 7: sea salt	Na^+, Cl^-, and Mg^{2+}	8 ± 1%	3 ± 1%	Sea salt
Factor 8: secondary nitrate	NO_3^- and includes some NH_4^+, Cl^-, Na^+, OC	3 ± 2%	6 ± 1%	Motor vehicle NO_2, power station NO_2

Notes:

OC1 to OC4 – fractions of organic carbon, distinguished by how volatile the organic compounds are. OC1 is the most volatile fraction. As organic aerosol ages the organic compounds present become less volatile.

BC – black carbon	Mn – manganese	Mg^{2+} – magnesium	Si – silicon
SO_4^{2-} – sulfate	Cu – copper	NO_3^- – nitrate	Ti – titanium
Fe – iron	NH_4^+ – ammonium	Na^+ - sodium	K^+ – potassium
Zn – zinc	Cl^- – chloride	Al – aluminium	

The factors which have been determined through the analysis conducted are not based on specific emission source profiles but on known ratios of specific element concentrations and other information. The identification of most of the factors is reasonably clear cut because of the use of either unique tracer species (e.g. levoglucosan for Factor 1 (wood smoke), or two or more species whose ratios are defined by a particular source (e.g. Si and Al in Factor 6 (soil), Na^+ and Mg^{2+} in Factor 7 (sea salt), and NH_4^+ and SO_4^{2-} in Factor 3 (secondary sulfate). However, in the case of Factor 2 (vehicle/industry) and Factor 4 (biomass smoke), the identification of the contributing sources is less definitive.

Seasonal variations in the contributions from each Factor to $PM_{2.5}$ concentrations measured at Singleton and Muswellbrook are shown in Figure 1 and 2, respectively. Factor 1 (wood smoke) dominates at both sites during the winter, while Factor 3 (secondary sulfate) and Factor 5 (industry aged sea salt) makes higher contributions during summer months.

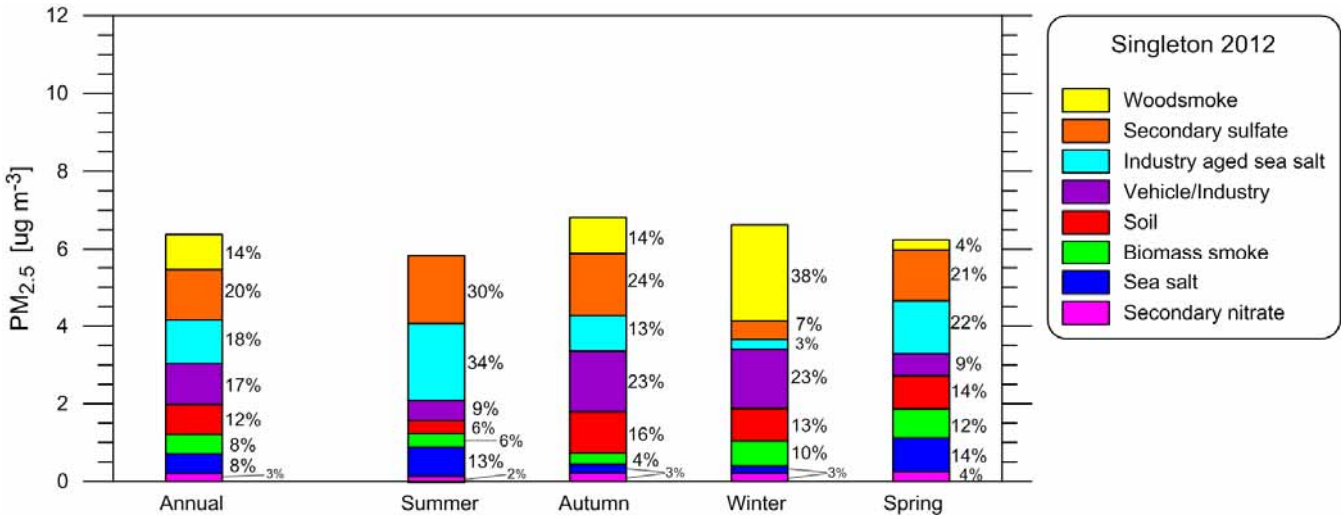

Figure 1 Annual and seasonal contributions of the PMF factors to $PM_{2.5}$ in Singleton

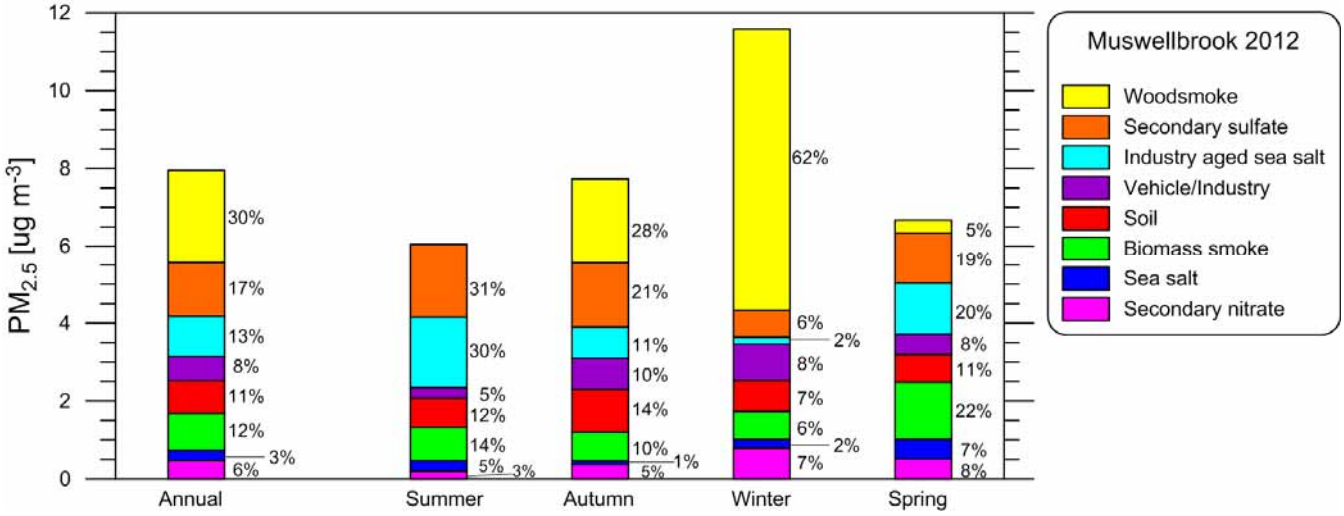

Figure 2 Annual and seasonal contributions of the PMF factors to $PM_{2.5}$ in Muswellbrook

Discussion

The Upper Hunter Valley Particle Characterisation Study focused on determining components and sources of ambient (airborne) $PM_{2.5}$ at the Singleton and Muswellbrook UHAQMN sites. The factors contributing to annual $PM_{2.5}$ concentrations were ranked as follows for the Singleton site:

- Factor 3 (secondary sulfate), 20 ± 2%
- Factor 5 (industry aged sea salt), 18 ± 3%
- Factor 2 (vehicle/industry), 17 ± 2%
- Factor 1 (wood smoke), 14 ± 2%
- Factor 6 (soil), 12 ± 2%
- Factor 4 (biomass smoke), 8 ± 2%
- Factor 7 (sea salt), 8 ± 1%
- Factor 8 (secondary nitrate), 3 ± 2%.

At Muswellbrook the factors were ranked as:

- Factor 1 (wood smoke), 30 ± 3%
- Factor 3 (secondary sulfate), 17 ± 2%
- Factor 5 (industry aged sea salt), 13 ± 2%
- Factor 4 (biomass smoke), 12 ± 2%
- Factor 6 (soil), 11 ± 1%
- Factor 2 (vehicle/industry), 8 ± 1%
- Factor 8 (secondary nitrate), 6 ± 1%
- Factor 7 (sea salt), 3 ± 1%

The NSW Environment Protection Authority's (EPA) 2008 Air Emissions Inventory (www.epa.nsw.gov.au/air/airinventory2008.htm) lists sources of $PM_{2.5}$ emissions for the Upper Hunter region as follows:

- coal mining (66% of emissions)
- industrial vehicles and equipment (13.5%)
- coal-fired power stations (13%)
- with other sources contributing less than 5%, including woodheating at 0.6%.

The Air Emissions Inventory provides important information on regional emissions, with the study findings presenting additional information about source contributions to airborne $PM_{2.5}$ in the major population centres.

The Air Emissions Inventory comprises estimates of total emissions for the whole Upper Hunter, whereas this study is based on the airborne $PM_{2.5}$ concentrations observed at the Singleton and Muswellbrook monitoring sites. For emissions from a source to be detected at a measurement site (receptor), they must be transported (blown by the wind) from the source to the receptor. As the distance from the source to the receptor increases, so the concentration decreases due to mixing and dilution, and an increasing amount of $PM_{2.5}$ is removed by deposition to the ground, vegetation, etc.

For example, the emissions inventory calculates $PM_{2.5}$ emitted from a range of dust generating sources, such as unsealed roads. As these $PM_{2.5}$ emissions are transported from the source, they mix in the atmosphere and become more dilute. They can also mix with other sources of $PM_{2.5}$. Measurements of $PM_{2.5}$ at Singleton and Muswellbrook contain both the dilute emissions transported from distant sources, as well as more concentrated emissions from sources closer to the monitoring.

Additionally, the Air Emissions Inventory only includes primary particles whereas the $PM_{2.5}$ measured in this study includes both primary and secondary particles.

Further information

For further information on the study method, analysis and results, reference should be made to the Upper Hunter Valley Particle Characterisation Study Final Report, available at www.environment.nsw.gov.au/aqms/uhaqmnfpcs.htm.

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