CHARACTERISING THE FINE PARTICLE POLLUTION WITHIN THE AIRSHED SURROUNDING A MINE IN AUSTRALIA

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1. Introduction

It is well known that the resource and energy sectors underpin the Australian economy, however, mining activities specifically can have a notable impact on the environment. As such, rigorous assessments are often made prior to approval of any mining activities. The activities themselves can extend for years or even decades, during which the environmental impacts on air, water quality and many more can shift. Government regulatory bodies play a vital role in ensuring the continued protection of the natural habitats and surrounding residential areas.

ANSTO's Aerosol Sampling Program (ASP) has been routinely sampling and characterising fine PM2.5 pollution at numerous sampling sites since 1991. This study explores the impact of mining activities on ambient fine particle pollution over a 12-month period around a mine situated in rural NSW but adjacent to residential towns and suburbs. Four receptor sites were chosen, generally representing the north, east, south, and west directions around the mine. PM2.5 particles were collected on filters over for a 24-hour period twice a week at each of the four sites. These filters were measured for mass and black carbon, then non-destructively characterised using accelerator-based ion beam analysis (IBA) techniques. These IBA techniques provided daily concentrations on over 20 different elements from hydrogen to lead, including black carbon. These data were then used in positive matrix factorisation (PMF) source apportionment techniques to generate source fingerprints and their contributions to the total daily PM2.5 mass. Point source intersection analysis using wind back trajectories was then used to further clarify the possible sources for these fingerprints.

2. Results

Table 1 summarises the mean, median and maximum of the PM2.5 mass measured at four sampling sites during the 12-month period. The sites labelled ASP67, 68, 69 which were closest to the mine, had a similar PM2.5 mean mass over the 12-month period. ASP70 had a slightly higher PM2.5 mean mass, which was expected as this site was an urban site situated close to the most populous region in the study compared with the other three sites. The PM2.5 mass measurement from an independent EPA PM2.5 sampler co-located with ASP70 gave greater confidence in the measurements made during this study, this data has also been provided in Table 1 for comparison.

Table 1: Mean, Median and maximum PM2.5 masses at the four sampling sites.

Site (24-hr PM2.5 mass)	ASP67 (μg/m^3)	ASP68 (μg/m^3)	ASP69 (μg/m^3)	ASP70 (μg/m^3)	EPA (μg/m^3)
Mean	2.7 ± 0.8	2.7 ± 0.9	2.7 ± 0.9	5.3 ± 2.8	5.3 ± 4.9
Median	2.3	2.1	2.4	4.02	4.5
Max	6.8	8.0	6.9	35.1	38.9
Date of Max	8th-Feb-23	23rd-Mar-22	8th-Feb-23	15th-Jun-22	15th-Jun-22

Accelerator-based IBA was used to identify elemental concentrations of the following species: *H, N, Na, Al, SI, P, S, Cl, K, Ca, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Se, Br, Sr, Pb and BC*. These concentrations were then statistically analysed to determine the relationship between elements to identify fingerprints. six fingerprints were identified at the ASP67 site (Figure 1). The highest contributor to the total mass was secondary sulfates.

The percentage of the soil contribution to the total mass was one of the lowest contributors (5.3% - Figure 1). However, as soil was presumed the most likely source of any fugitive emissions, further modelling was carried out with wind data.

The polar plots showed that the PMF soil fingerprint was generally emanating from the mine during elevated days where the soil concentration was two and a half times the mean (black region – Figure 2).

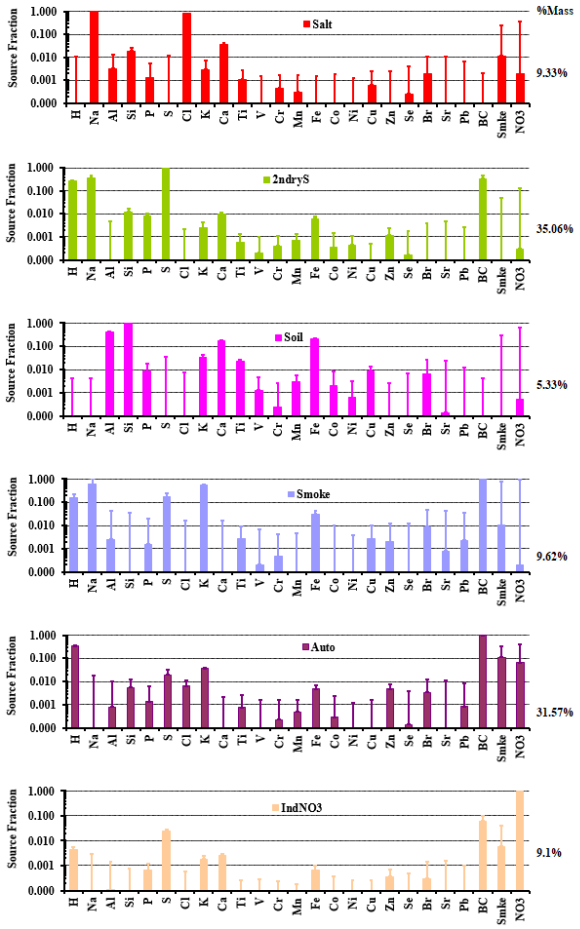

Figure 1. PMF fingerprints for the eastern site (ASP67) within the airshed of the mine.

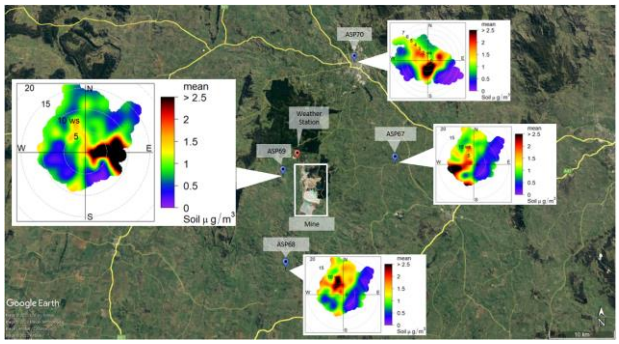

Figure 2. Polar plots at the four sampling sites around the mine (white box). The black denotes 2.5 times the mean concentration, the site to the west of the mine has been enlarged.

The wind trajectory intersection modelling revealed hourly trajectories over 24 hours for every day in the study. It showed that there were only a few days from the 104 available sampling days when the soil fingerprint was two and a half times the mean concentration, above 0.5 µg/m^3 and all 24 trajectories went through the mine (Table 2 – ASP69). There was also only a single day for ASP69 when the soil concentration was two and a half times the mean and four or less wind trajectories went through the mine.

Table 2. wind trajectory intersections with the mine on days where Soil greater than two and a half times the mean concentration at ASP69 as an example, where either all 24 trajectory intersections or four or less trajectory intersections (<17%) are shown.

ASP69				
10m	# Traj	Mass	Soil	%Soil
Date	in 24 hrs	(µg/m^3)	(µg/m^3)	
02-Mar-22	24.0	1.7	0.9	53
22-May-22	24.0	2.9	1.8	61
06-Jul-22	24.0	2.3	1.5	63
10-Jul-22	24.0	2.0	0.7	37
21-Aug-22	3.0	2.3	1.1	49

3. Summary

The study was able to identify at least six source fingerprints for each of the four sampling sites. The study also examined the contribution of the different source fingerprints to the total daily PM2.5 mass. A specific focus on the PMF soil fingerprint was made during the study as the major industrial activity in the area was a mine. However, it is worth noting that the overall PM2.5 mean mass measured was low compared with urban locations. The contribution of the soil to the total mass measured was also low. The soil fingerprint was modelled with wind back-trajectory data providing details on the path of air parcels before reaching the sampling sites. This identified the likely contribution from the mine to the soil source fingerprint. This was particularly valuable for evaluating the link between emission sources and receptor site fingerprints, the later which represents the fine particle pollutants in the air, inhaled by residents near the sampling sites.

References

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