Changes in the Upper Hunter since 2012 and predicted impact on sources of particulate matter

Feedback from the 2024 Community Forum raised questions about the relevance of the Upper Hunter Fine Particle Characterisation Study which was completed by the NSW EPA in 2012. The study identified and quantified the major components of PM2.5 particles in the Muswellbrook and Singleton air regions, as well as provided data on seasonal changes of PM2.5 particles in the Upper Hunter. The study focused on the PM2.5 size particles only, as particles of this size have greater health risks than coarser particle pollution. The complete study can be accessed here: https://www.environment.nsw.gov.au/topics/air/research/previous-research/upper-hunter-fine-particle-characterisation-study

The Dialogue Secretariat met with NSW DCCEEW to discuss the validity of the study in February 2025. It was acknowledged that while there had been some changes in the region since the study was conducted, the significance and impact of these changes on the concentrations of PM2.5 in the area was likely not to be significant.

The Joint Environment Working Group discussed the matter at the March meeting and agreed for the Dialogue Secretariat to undertake a desktop review to consider the potential impacts to PM2.5 concentrations of known changes in the region. A summary of the changes are outlined in the table below followed by more detailed analysis.

Impact/change	**Data or supporting information**	**Likely impact**
Liddell power station closure in 2023	EPA has completed modelling on the impact of the Liddell closure on air quality.	Small reduction in NO, NO_2, O_3 and PM2.5 across the greater metropolitan region and small changes concentrated in the Hunter region. The likely impact of Liddell Power Station closure has resulted in a slight, mainly localised improvement in air quality.
Historical monitoring of PM2.5 in the Muswellbrook region	Monthly monitoring of PM2.5 species between 2001 and 2021 by ANSTO	Annual monitoring of PM2.5 speciation has shown that there has been very little changes in the absolute values and relative percentages of PM2.5 species since the initial speciation study was completed.
Wood smoke and use of wood fired heating	Information provided by Muswellbrook and Singleton Council	Woodsmoke was the largest contributor to PM2.5 in the region. Local councils have undertaken initiatives since 2013 to reduce and manage woodsmoke use. The impact of these initiatives has not been quantified, and both Councils have advocated for the 2013 characterisation study to be updated.
Raw coal production	Dialogue Annual Air Quality Update	Raw coal production is not a major contributor to PM2.5. The Annual Air Quality Report has shown consistently that there is not a strong correlation between raw coal production and PM2.5.
Population changes	Census - Australian Bureau of Statistics	Both the population and number of dwellings in the Upper Hunter have moderately grown in the previous decade (7.9% increase in private dwellings and 6.8% population growth). It is unlikely this moderate increase would significantly impact the air quality or concentrations of particulate matter in the region.
Rehabilitation and disturbance in the region	UHMD Annual Rehabilitation Reporting, based on data from the Resources Regulator	Comparing the annual average PM2.5 concentration with total hectares of disturbed land from mining shows that there is no strong trend over time.

Ongoing monitoring information from the NSW Government

The NSW Department of Climate Change, Energy, the Environment and Water (DCCEEW) publishes seasonal updates on the air quality in the Upper Hunter region. The latest report, published in April 2025 for the Summer 2023-2024 update showed that at both Muswellbrook and Singleton population centres, daily particle levels were below national benchmarks 99% of the time, while hourly particle levels were in the good to fair air quality categories 99.8% of the time.

The update reports on rolling annual air quality trends for both PM2.5 and PM10 from summer 2012-13 onwards. The graph for PM2.5 below shows that between 2012-13 and 2023-24 there has been minimal changes in the total PM2.5 averages (when 2019-2020 is excluded due to the significant bushfire season). These results indicate that there has not been substantial changes to the total PM2.5 concentrations in the region, and generally show an overall decrease in average concentrations of PM2.5. Although not of direct relevance to this review, it should be noted that similar trends are observed for PM10.

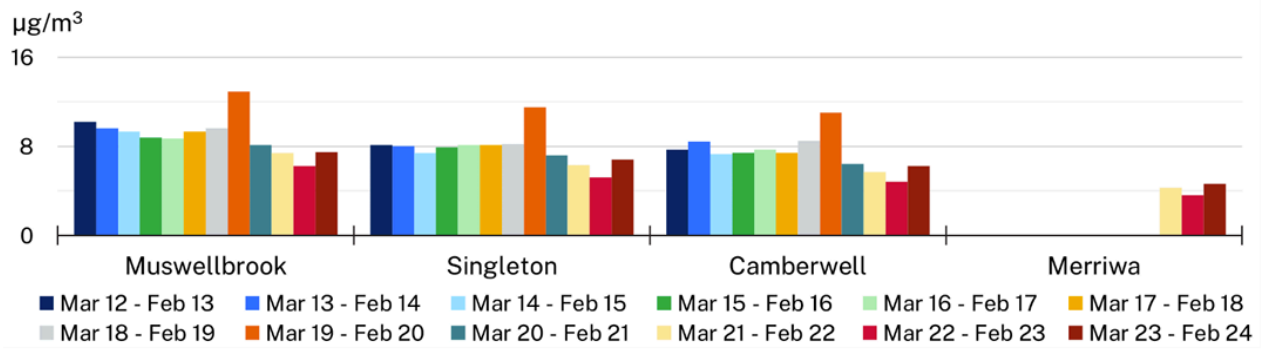

Figure 1: PM2.5 rolling annual averages from summer 2012-13 to 2023-24

The update also reports on the number of days above the PM2.5 daily benchmark set at 25 µg/m^3. Figure 2 below, shows the exceedances of the daily PM2.5 benchmark over the same period from 2012-13 to 2023-24. In 2023-24 there was one day where the PM2.5 concentration was above the benchmark at Muswellbrook and Merriwa (19 December 2023). This exceedance was closely linked to the bushfire at the Pilliga Nature Reserve near Narrabri. Excluding the bushfire season in summer 2019-20 there has been no exceedances of PM2.5 in the region.

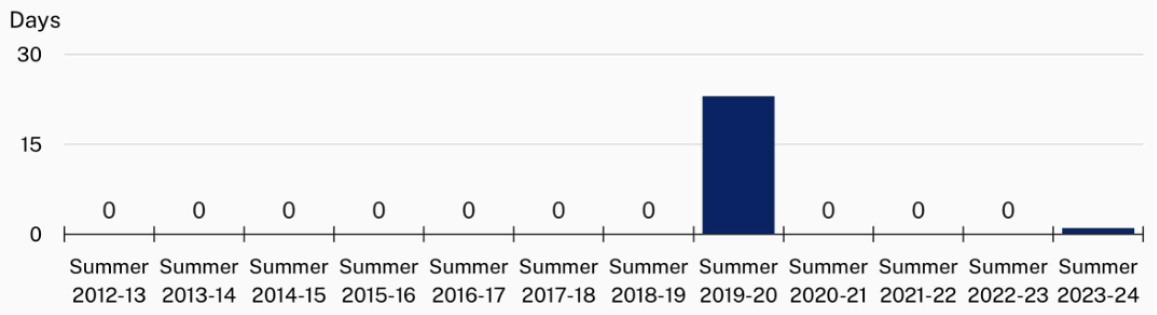

Figure 2: Number of days above the PM2.5 daily benchmark in the Upper Hunter

The complete data set and associated report can be accessed here: https://www.environment.nsw.gov.au/publications/air-quality-monitoring-network-upper-hunter-spring-2023-seasonal-newsletter

ANSTO's monthly monitoring of PM2.5 in the Muswellbrook region

As part of the Aerosol Sampling Program, ANSTO collected monthly data relating to fine PM (PM2.5) concentrations across nine key regions of Australia. Fine particle samples are collected on stretched Teflon filters and analyzed using x-ray emission spectrometry to determine the individual pollutants. Muswellbrook is one of the locations studied by ANSTO, and monthly data on the concentration of PM2.5 species has been reported monthly from between 2001 and 2024. The project has ceased in other areas, however with support from Muswellbrook Council remains ongoing in the area. Muswellbrook Council has provided monthly data from between 2022 and 2024, and ANSTO has published the data sets from between 2001 and 2021, which can be accessed here:
https://www.ansto.gov.au/science/environment/impact-of-contaminants/air-quality/asp-databases

The monthly reporting includes data for the absolute values and relative percentages of nine of the contributing sources of PM2.5. The absolute values are graphed in Figure 3, and the relative percentages are graphed in Figure 4.

Figure 3 shows a relatively stable trend for most PM2.5 species across the years with minimal variation. Ammonium sulfate ($(NH_4)_2SO_4$) which is attributed to coal and fossil fuel burning, agriculture and vehicles, has been relatively stable during the time period. Organic Matter containing Hydrogen (OMH) is a measure of any organic compound containing hydrogen, oxygen or carbon in the air. OMH is influenced by natural events such as organic burning (e.g. wood fire burning, and bushfires) as well as emissions from power generation. Figure 3 shows a relatively stable OMH level with the exception of 2019-2020 which is likely attributed to the bushfires in the region. The absolute values of the soil component of PM2.5 has slightly varied over the period. The measurement of soil represents the different oxides found in soil which occur from both natural sources such as wind and dry conditions, as well as agriculture, earth moving industries and mining. While this may be linked to changes in coal mining behavior, it is also influenced by the significant drought the region experienced between 2017 and 2019. Black Carbon (BC) which impacts the visual appearance in the region and is attributed to burning, motor vehicles and the mining industry, remained relatively stable during the time period. Potassium (K), Iron (Fe), Zinc (Zn) and Lead (Pb) are all trace elements present in the atmosphere which are released with biomass or wood burning, incineration and motor vehicles. These trace elements have remained relatively stable throughout the period.

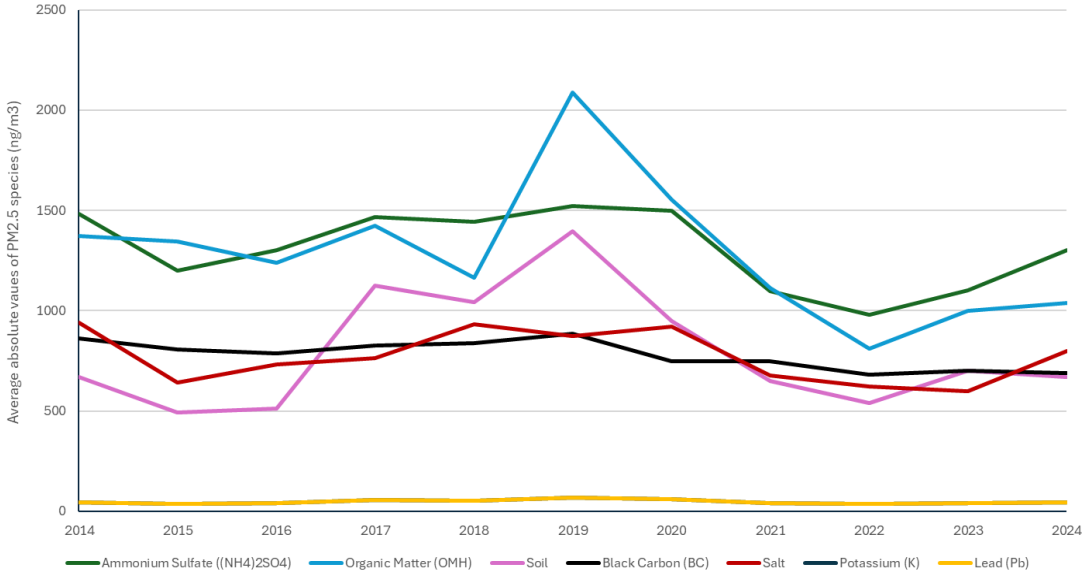

Figure 3: Annual average absolute values of PM2.5 species recorded in Muswellbrook, data sourced from ANSTO Aerosol Sampling Program

Similarly, the relative percentages of yearly average of PM2.5 species between 2014 and 2024 is graphed in Figure 4 below. Overall, the relative percentages of PM2.5 have remained relatively stable over the 10 year period monitored, noting some of the variations are due to weather events such as the 2019 bushfires.

The results presented in Figure 3 and Figure 4 indicate that there has not been major changes in the amount or concentration of PM2.5 species since 2014 shortly after the initial speciation study was undertaken.

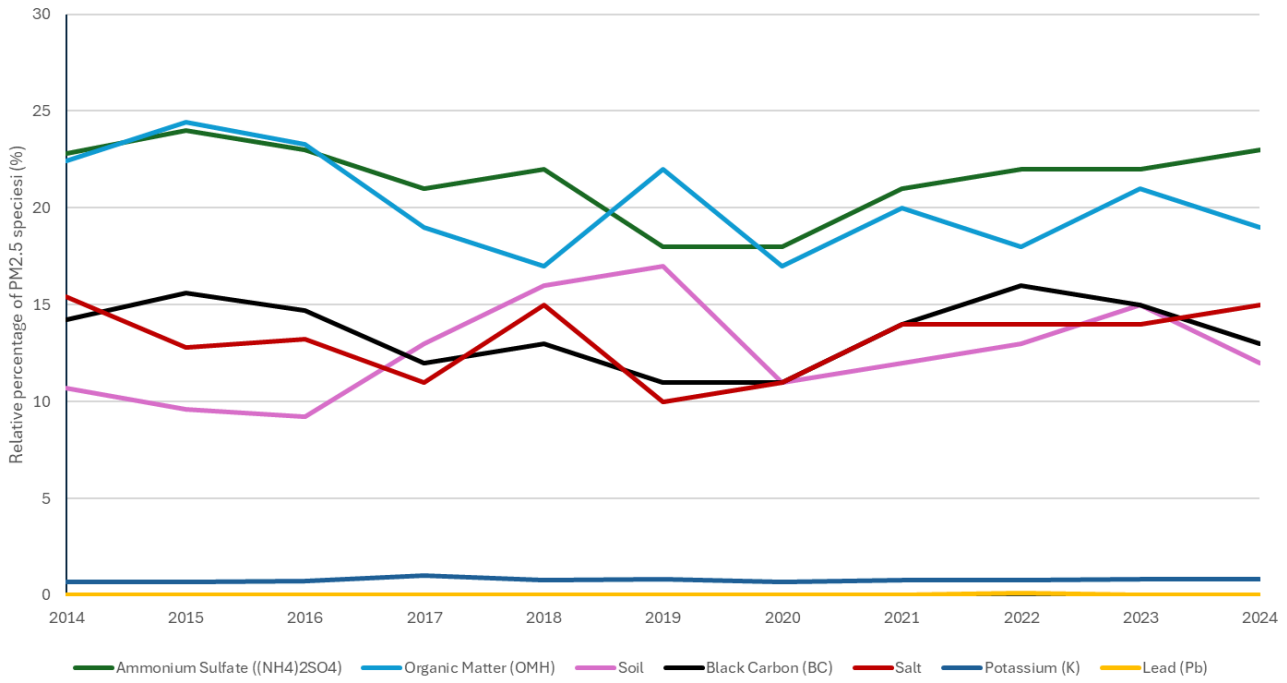

Figure 4: Annual average relative percentage of PM2.5 species recorded in Muswellbrook, data sourced from ANSTO Aerosol Sampling Program

Closure of the Liddell Power Station

A significant change in the region is the closure of the Liddell Power Station which was fully decommissioned on 28 April 2023. The EPA prepared a report on the impact of the closure on local and regional air quality which can be found here:
https://www.epa.nsw.gov.au/sites/default/files/23p0374-impact-liddell-regional-air-quality.pdf

The report modelled two scenarios, one with the power station operational and then one which excluded the emissions from the power station. The results indicated that the closure of the station would lead to a slight decrease in average nitrogen oxides (NO, NO_2) and ozone (O_3) levels in the region. The annual average PM2.5 concentration was modelled to decrease by about 0.18 µg/m^3 (from 23 µg/m^3 when the power station was operational), with the maximum reduction experienced geographically near the power station, and only very minor changes were modelled more broadly across the Upper Hunter.

The report concluded that the closure of the power station has potential for slightly improved air quality at the local scale, but the changes more regionally are minimal.

Changes in usage of wood fired heating and wood smoke

The Upper Hunter Fine Particle Characterisation Study showed that wood smoke was the largest PM2.5 contributor responsible for about 30% in Muswellbrook and 14% in Singleton of the total concentrations.

Singleton and Muswellbrook Councils have undertaken multiple initiatives since 2013 to reduce and manage wood smoke pollution in the region.

Between 2015 and 2017, the EPA ran the NSW Wood Smoke Reduction Program. Both Singleton and Muswellbrook Councils participated in the program which provided funding to support community education programs, smokey chimney surveys and enforcement actions as well as financial incentives (initially $500 then extended to $1,500) to replace old polluting wood heaters with cleaner alternatives.

Muswellbrook Council reported that in both 2013 and 2014 only one wood heater was replaced each year. However in 2016, when the rebate was increased to $1,500, 10 wood heaters were replaced and in 2017, 17 households applied for the rebate.

Muswellbrook Council continues to offer rebates for residents to engage a chimney sweep professional, as well as continued education and media engagement regarding burning wood at high temperatures to reduce smoke and the importance of a clean flue. Muswellbrook Council also runs a smokey chimney check program where educational brochures and tip cards are left at premises which show evidence of a smokey chimney. In 2015, 94 residents were issued the educational brochure and tip card for one time, 14 premises were issued a second tip warning card, and 3 premises were issued a third tip warning card. Following 2015, Council amended the approach and following the first brochure and warning, a letter was sent from the Council Environmental Health Officer explaining that fines could be issued under the *Protection of the Environment Operations Act 1997* if the smokey chimney was not addressed. Following this, no more than two warnings have been issued to a household.

Muswellbrook Council has also provided information regarding the number of complaints received regarding chimney smoke. Overall complaints have remained relatively stable since 2013, with increased complaints during 2020/21 which is most likely linked to Covid and an increase in people being home.

Year	Number of complaints about chimney smoke received by Muswellbrook Council
2012/13	1
2013/14	5
2014/15	4
2015/16	4
2016/17	7
2017/18	5
2018/19	3
2019/20	4
2020/21	11
2021/22	4
2022/23	7
2023/24	5

Overall, the impact of the initiatives from Council have not been directly measured in terms of reduction in PM2.5.

Raw Coal Production

Particulate matter generated from coal production is related to PM10 species rather than finer particles of PM2.5. It is not expected that changes to raw coal production would have any impact on the PM2.5 concentrations or speciation.

For completeness, the Dialogue annually undertakes the Air Quality Monitoring project which investigates the relationship between raw coal production and PM10 concentration. In 2024, and similar to previous years, no correlation or a very weak correlation between raw coal production and annual average PM10 concentrations (R^2 between 0.33 and 0.64) was seen. For more information see: https://miningdialogue.com.au/project/air

Population changes

In the 2021 Census, 28,066 private dwellings were recorded in the Upper Hunter, which was a 7.9% increase in dwellings from 2011 where 26,017 private dwellings were recorded in the Census.

The population in the Upper Hunter has also been relatively stable since 2013 when the Study was completed. In the 2021 Census 64,704 people lived in the Upper Hunter, compared to 60,557 people in 2011 (6.8% increase).

It is unlikely that such a moderate increase in dwellings and population would have a significant impact on the air quality or particulate matter concentrations in the region, in particular individual based contributors such as wood smoke and vehicle particulate emissions which were previously identified as large contributors to PM2.5 concentrations.

Rehabilitation and disturbances at mine sites

The Dialogue has been reporting on the annual rehabilitation and disturbance at mine sites from across the Upper Hunter since 2012. For detailed reporting see: https://miningdialogue.com.au/project/rehabilitation

Since 2013, there has been an increase of 7,784 hectares of disturbed land, and 5,222 hectares of land rehabilitated during the same period. Since 2013, the overall proportion of disturbed land that has been rehabilitated has remained relatively stable, from 33% in 2013 to 35% in 2023.

Figure 5 below has been prepared to consider if there is a correlation between average PM2.5 concentrations across the period with the total area of disturbed land from mining. The results indicate that there is not a strong correlation, if any, between the PM2.5 concentrations at the population centers for Singleton and Muswellbrook. This is highlighted when considering the increase in total disturbed land in 2015, with the reduced annual average concentration of PM2.5 in both Muswellbrook and Singleton. Similarly in 2022 where relatively low PM2.5 concentrations were observed with an increased amount of disturbance.

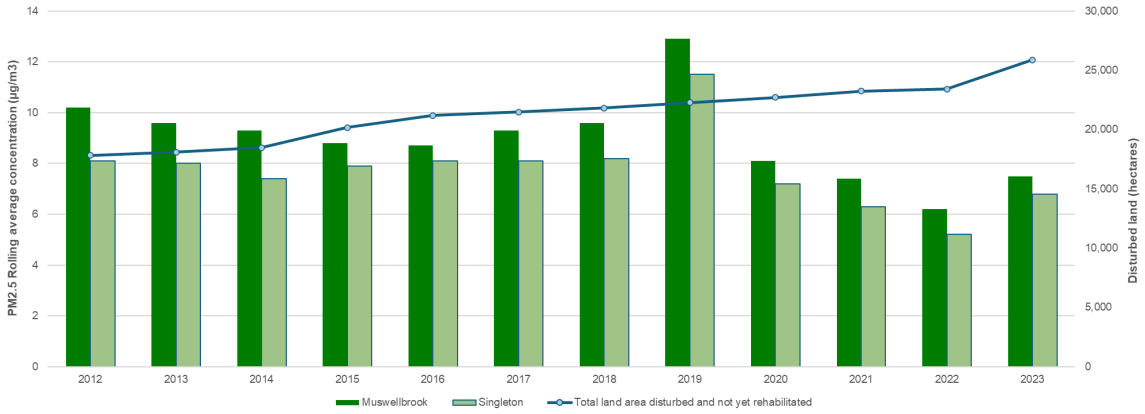

Figure 5: Comparison of PM2.5 annual average concentrations at Singleton and Muswellbrook compared to the total amount of land disturbed and not yet rehabilitated

Overall, these results indicate that there is not a strong correlation between mining land disturbance and the concentrations of PM2.5 in the large population areas. While this can't confidently determine that the speciation of PM2.5 has not changed over this period in time, when considered with the above information it suggests that land disturbance is not a significant driver for an increase in particulate matter concentration in the populated regions.

Comparison of PM2.5 monitoring across other regions of NSW

The Joint Environment Working Group requested a comparison of PM2.5 trends from ANSTO's Aerosol Sampling Program across multiple sites to enable a comparison of the air quality variation with Muswellbrook as the reference. For this comparison, data from Bayside (covering Sydney's Botany and Mascot areas) and Mayfield (Newcastle region) were selected, as both areas feature a mix of industrial and residential environments similar to Muswellbrook.

Figure 6 and Figure 7 below show the average absolute values of PM2.5 species from between 2014 and 2021 for Bayside and Mayfield respectively.

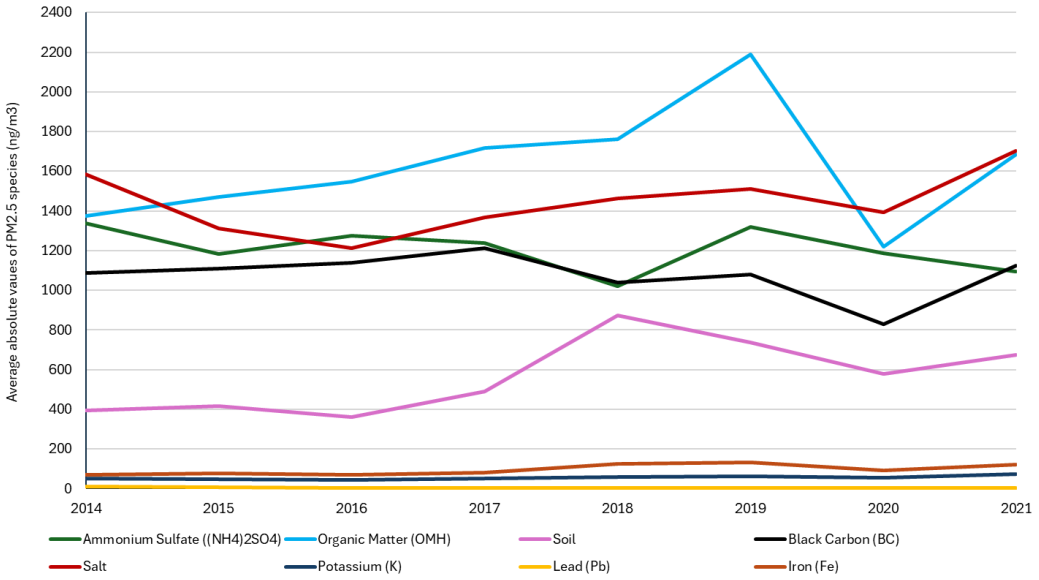

Figure 6: Annual average absolute values of PM2.5 species recorded in Bayside, data sourced from ANSTO Aerosol Sampling Program

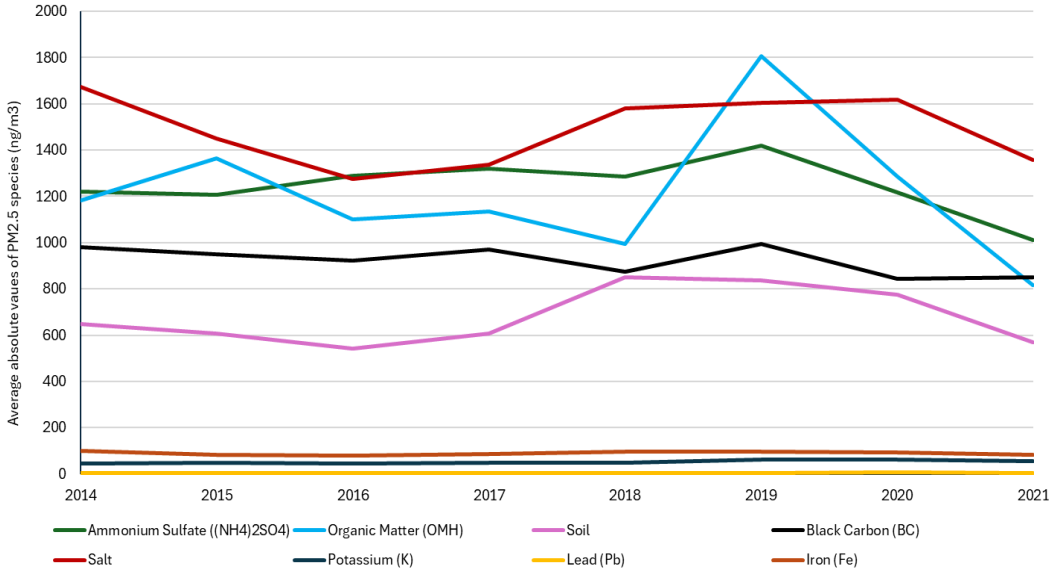

Figure 7: Annual average absolute values of PM2.5 species recorded in Mayfield, data sourced from ANSTO Aerosol Sampling Program

Comparing the above Figures with the Muswellbrook data presented in Figure 3, there are clear differences in the sources of PM2.5. For example, at both Botany and Mayfield, there are significantly higher concentrations of salt which can be attributed to the coastal locations when compared to Muswellbrook. Similarly, the higher levels of Lead and Iron in both Bayside and Mayfield comparatively to Muswellbrook is likely attributed to higher number of vehicles and associated emissions, industrial processes as well as soil disturbance e.g. construction works.

Similar to the trends observed in Muswellbrook, both Bayside and Mayfield show the sensitivity of the PM2.5 concentrations with other events. For example in 2020, when flights were significantly reduced and there were fewer number of vehicle movements due to Covid restrictions, there are notable decreases in organic matter by hydrogen and black carbon concentrations in Bayside.

Additionally, it is worth noting that the total mass of PM2.5 concentrations across the three sites do vary. The average mass of measured PM2.5 species over the period of 2014-2021 at Muswellbrook was 6,692 ng/m^3, Bayside 7,362 ng/m^3 and Mayfield 7,007 ng/m^3. Overall this suggests that while all three locations have varied PM2.5 species contributing to the total amount of particulate matter, Muswellbrook on average experiences a lower concentration of PM2.5.

Conclusion

Based on the information collated above and consistent with the advice provided by the NSW Government on the changes in the region, it appears that there has been no significant changes to the sources of particulate matter in the region since the initial study was undertaken in 2012. While the concentration of PM2.5 has slightly decreased over the period, there is no clear evidence that the proportion of the contributing factors has changed significantly.