EPA VICTORIA

Environment Report

AIRBORNE PARTICLE MONITORING AT MILDURA, DECEMBER 2004 TO MAY 2005 – INTERIM REPORT

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1. SUMMARY

Land in the north-west of Victoria is often dry. When winds are strong large amounts of fine soil can be lifted, causing dust storms and reduced air quality in the region.

EPA Victoria began monitoring airborne particle pollution levels in Mildura's in December 2004. Measurements were made of the mass of particles in the air smaller than 10 micrometers (0.01 mm), or 'PM_{10}'.

Between December 2004 and May 2005, PM_{10} levels in Mildura were very similar to those in Bendigo and Melbourne, except for some very high levels that occurred during widespread dust storms.

A PM_{10} air quality objective has been set in Victoria to protect human health. Since monitoring began in Mildura, PM_{10} levels were higher than the objective on 14 days. These high readings occurred during a period of very low rainfall and were associated with strong winds.

The consequences of these high PM_{10} levels for human health are uncertain, because most studies that led to the health-based standard for particles looked at urban pollution events (typically haze in autumn and winter). The particles in these urban events come mainly from woodsmoke and vehicle exhausts.

Figure 1: Monitoring station

Research is continuing into the question of how various types of particles affect human health. EPA will continue to monitor particles in rural Victoria, in order to assess air quality and seek improvements to environmental quality for all Victorians.

2. INTRODUCTION

2.1 The Mildura particle study.

Windblown dust is a regular feature of the environment in Mildura, occurring mostly in summer and autumn, and during times of drought. Most measurements to date have been of 'total particles' (including all particle sizes)[1]. This monitoring campaign aims to study the finer particles, which are of more concern to human health.

Most PM_{10} readings in Victoria fall within the Good to Very Good air quality range[2]. On rare occasions, particularly in the city, woodsmoke and motor vehicle emissions accumulate to result in high PM_{10} levels. On other occasions, particularly during drought years, bushfire smoke or windblown dust may cause concern[3].

In recent years EPA has been monitoring PM_{10} in a number of regional towns, in accordance with an overall air quality monitoring plan[4]. Monitoring projects have been undertaken in Ballarat, Bendigo, Shepparton and Mildura.

The key questions to be answered in this study are:

- How high are the PM_{10} concentrations at Mildura?
- Are the patterns of PM_{10} at Mildura different from those measured elsewhere in Victoria?

2.2 Why monitor PM_{10} in Mildura?

Breathing air containing particles smaller than 0.01 mm can result in these particles being absorbed into the lung. Air containing high levels of PM_{10} has been found to be associated with both short-term and long-term health effects.

According to EPA's emissions inventory studies[5], the highest levels of dust likely to be experienced in Victoria will occur in the north-west. Mildura is the most populated area of the north-west and was therefore chosen for monitoring.

2.3 What is the policy objective?

PM_{10} is one of seven air pollutants for which Victoria has set policy objectives and goals.[6] The objective is a maximum pollutant concentration against which air quality can be assessed. The goal is a long-term target for air quality, expressed as an allowable number of high pollution days per year.

The objective for PM_{10} is a maximum of 50 $\mu g/m^3$, measured as a 24-hour average, and the goal is that this level should not be exceeded more than five times per year by 2008.

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[1] Leys, J and McTainsh, G (2004), 'Mallee Dust – The Highs and Lows for the Period 1990–2002', *Proceedings of the Wind-blown Dust Workshop,* CSIRO Atmospheric Research, Aspendale, Victoria, Nov 2004.

[2] Based on EPA's *Air Quality Index*. Details at www.epa.vic.gov.au/Air/Bulletins/abindex.asp.

[3] Walsh, S and Monahan. D (2003). 'Significant Dust and Smoke Events in Victoria in 2002–03', *Proceedings of the National Clean Air Conference*, Newcastle 2003, Clean Air Society of Australia and New Zealand.

[4] Ambient air quality NEPM monitoring plan Victoria *(2001), EPA Publication 763, available from www.epa.vic.gov.au (click on Publications and Legislation).*

[5] Ng, L. (2004). "Estimating Annual Average Windblown Dust Emissions from Agricultural Lands and Unpaved Roads", *Proceedings of the Wind-blown Dust Workshop,* CSIRO Atmospheric Research, Aspendale, Victoria, Nov 2004.

[6] State Environment Protection Policy (Ambient Air Quality), Victoria Government Gazette No. S19, 9 Feb 1999 (amended Dec 2001).

2.4 When and where did EPA monitor?

Monitoring began on 10 December 2004. The site is on Fourteenth St, Mildura, adjacent to the Lower Murray Water Office (see Figure 2). Monitoring will continue in Mildura until December 2005.

2.5 How was monitoring conducted?

Particle monitoring was conducted using a Tapered Element Oscillating Microbalance, or 'TEOM'. This instrument provides continuous PM_{10} measurements that are normally averaged over one hour and is the same instrument used to monitor particles in Melbourne. To assist with analysis, wind speed, wind direction and temperature were also recorded.

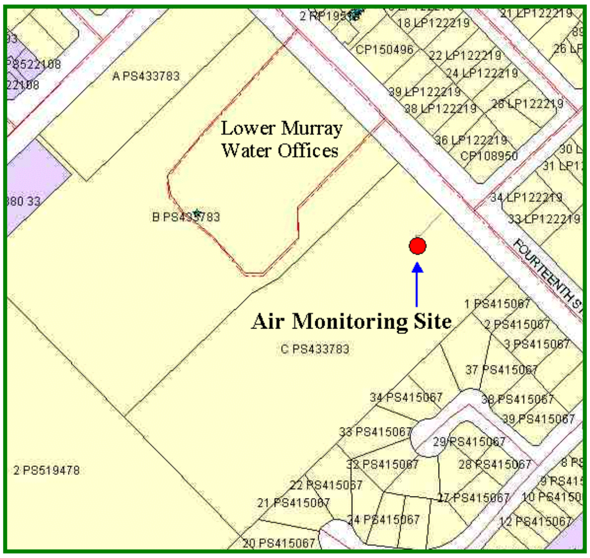

Figure 2: Monitoring location.
(Map published with permission of Mildura Rural City Council)

2.6 Where do the particles come from?

Emission studies have shown that the most likely source of particles in the air in Mildura is windblown dust from agricultural areas and unpaved roads[7]. Other sources of particle pollution in Mildura can be smoke from wood heaters, prescribed burns and wildfires.

The major sources of particles around Mildura are highly seasonal. For example, dust is more likely in summer/autumn, whereas smoke is more likely in autumn/winter. By monitoring for 12 months, it should be possible to observe these seasonal variations.

Note that this study measured the total mass of PM_{10} in the air, but did not measure the separate contributions from each source. Instead, other observational data were used to determine the largest contributing source (see section 3.2).

3. FINDINGS

3.1 The PM_{10} objective and goal were not met at Mildura.

Between 10 December 2004 and 31 May 2005, PM_{10} levels were found to be higher than the objective on 14 occasions. Table 1 shows the levels in Mildura on these days, with Melbourne and Bendigo levels shown for comparison.

The highest PM_{10} levels were recorded on 3 April 2005. The 24-hour average on this day was 476 µg/m^3, almost 10 times the objective level.

[7] Ng, L. (2004).

3.2 High PM_{10} levels were caused by widespread dust storms.

Figure 3 shows 24-hour PM_{10} levels at Mildura[8] compared to Melbourne and Bendigo. It is clear from this graph that Mildura PM_{10} shows strong 'peaks' on certain days.

Comparison with Bureau of Meteorology visibility records showed that, on days of very high PM_{10}, visibility had been reduced in the Mildura region. The Bureau recorded 'dust' as the cause of the reduced visibility on these days.

Monitoring undertaken by the NSW Department of Primary Industries and Natural Resources (DPINR[9]) confirms that the high PM_{10} levels recorded by EPA were widespread in the region around Mildura.

Bushfire smoke was noted by the Bureau of Meteorology on 12–13 January, 30 January and 19 February. The highest 24-hour PM_{10} level associated with smoke was 35.2 $\mu g/m^3$, on 13 January. The effects of windblown dust were much more significant than bushfire smoke over the monitoring period.

3.3 In between dust storms, PM_{10} levels are similar in different areas of Victoria.

Figure 3 shows that, in between each storm, there is a remarkable similarity between PM_{10} levels in Melbourne, Bendigo and Mildura. The reasons for this effect are still being investigated, but it is possible that similar weather conditions across the state may result in similar fine particle levels in residential areas.

3.4 Dust impacts can follow very soon after a rapid wind change.

Most of the dust events were linked to cold fronts that bring strong winds. Just before a cold front arrives, there can be very strong wind 'gusts' that lift large amounts of dust into the air.

On such days there was a rapid change in wind direction or wind speed just before the dust impact. This can be seen in Figure 4 (1 March 2005) and Figure 5 (3 April 2005). On both these days the highest PM_{10} levels followed very shortly after a sharp rise in wind speed.

For those events that involved a rapid change of wind, the time between the onset of the change and the peak dust impact is shown in Table 1. This time delay varied from 10 to 80 minutes.

3.5 The highest dust levels were linked to south-westerly winds.

According to wind measurements, dust in Mildura can come from any wind direction, but the highest concentrations appear to come from areas south and west of the town. Table 1 shows the wind directions immediately before each PM_{10} event.

Note that high PM_{10} levels do not always involve hot weather – wind speed is a more important factor. Although hot northerly winds may bring dust to Mildura, the gusts associated with cold fronts actually result in the highest wind speeds.

[8] Note that due to an instrument fault, Mildura data are not available for April 11th and April 12th.

[9] DPINR monitors are located at Mildura airport, and at the nearby town of Buronga.

4. ANALYSIS OF PM_{10} EVENTS

4.1 Why are the events so regular?

Figure 3 shows a peak in PM_{10} about once every 12 days. This is because PM_{10} events are strongly linked to weather patterns. In southern Australia, weather systems tend to move from west to east in a fairly regular manner.

4.2 How long do the events last?

Dust events may last from a few hours to almost a whole day. Table 1 shows the number of hours of high[10] particle readings.

Although long storms are not necessarily the most intense, in this study the longest dust event and the highest PM_{10} levels occurred on the same day (3 April 2005). On this day wind speeds were greater than 20 km/h for at least 10 hours, with gusts reaching 67 km/h.

The duration of a dust storm depends on the pattern of winds moving over dry and exposed areas. The strength and duration of a dust storm is difficult to predict, as it can depend on wind strength and land conditions up to hundreds of kilometres away. A number of researchers including CSIRO[11] are currently investigating improved methods for forecasting dust storms in southern Australia.

4.3 Are high dust levels always associated with a cool change?

Not all of the events at Mildura involved a sudden gust of wind. The events on 20 January, 2 March and 25 March 2005 involved several peaks in PM_{10} during the day, with no clear wind changes associated with each peak. Comparison of EPA measurements with DPINR data shows that some peaks on these days were only detected at the EPA station, suggesting that the dust was more localised, whilst other peaks were more widespread.

The events on 2–3 February were associated with fairly consistent wind direction over several days. During times when the wind strength increased, PM_{10} also increased. This is consistent with the fact that wind strength must be higher than a 'threshold' before it can lift dust into the air. The dust transported on these days may have come from a considerable distance away.

The event on 3 April (Figure 5) involved two peaks, one at 3.15 pm (hourly average 4119 $\mu g/m^3$) and another at 1.10 am (hourly average 2361 $\mu g/m^3$, not shown in the figure). This earlier peak was exceptional because it was associated with a drop in wind speed, although wind direction had shifted from northerly to westerly. DPINR data confirm that dust was widespread in the Mildura region at this time. Further analysis is under way to clarify the cause of this peak in PM_{10}.

4.4 Why are the values highest in April?

Over the first four months of 2005, peak dust levels appear to be increasing (Figure 3). This is probably because very little rain fell during these months, so the potential for dust storms would have increased during this time.

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[10] For purposes of this study, dust event duration is defined as the number of hours for which PM_{10} exceeds a nominal value of 100 $\mu g/m^3$.

[11] Wain, A, Hess, D, Lee, S, Mills, G, Cope, M, and Tindale, N (2004). 'Forecasting Raised Dust – model comparisons October 22–24 2002', *Proceedings of the Wind-blown Dust Workshop,* CSIRO Atmospheric Research, Aspendale, Victoria, Nov 2004.

During May rainfall remained very low, but there were no high wind gusts in this month. As a result there were no dust storms recorded in May. Average rainfall in areas around Mildura[12] tends to be lowest in March and April.

Dust monitoring studies[13] by DPINR and Griffith University suggest that the highest dust levels in Mildura are usually experienced in March, with the lowest in July.

4.5 Do strong winds always result in a dust storm?

PM_{10} levels above the policy objective can occur when wind gusts are higher than about 40 km/h. Widespread dust storms are associated with wind gusts of 60 km/h or more.

If winds have blown over areas with good vegetation cover, or where rain has fallen, then even very strong winds may not result in a dust storm. The combination of dry exposed soil and high wind gusts generates high levels of PM_{10}. For example, on 3 February 2005 winds were very strong in Melbourne, but heavy rain kept PM_{10} levels to only 7 µg/m^3.

Note that winds in Mildura are not necessarily stronger than in other places in Victoria. This can be clearly seen in wind gust data from Melbourne Airport (Table 1).

5. COMPARISON WITH OTHER DUST STORM RECORDS

Although the PM_{10} levels recorded in Mildura were very high, comparable levels have been recorded elsewhere in Victoria.

On 19 March 2003, EPA recorded a 24-hour average PM_{10} level of 322 µg/m^3 in Melbourne. This was an exceptional event involving persistent northerly winds transporting very large amounts of dust from central north Victoria, which was experiencing drought conditions.

Bureau of Meteorology records since 1960 indicate that dust storms in southern Australia were once much more frequent than they are today. A severe dust storm was recorded in Melbourne in February 1983, most probably involving higher PM_{10} levels than those of the 2002–03 drought[14].

[12] For climate data in Mildura, see: www.bom.gov.au/climate/averages/tables/cw_076031.shtml

[13] Leys, J. and McTainsh, G. (2004).

[14] Walsh and Monahan (2003).

	Melbourne[15]	Bendigo	**Mildura**							Melbourne Airport
Date	24-hour average PM_{10} [µg/m³]	24-hour average PM_{10} [µg/m³]	**24-hour average PM_{10}** [µg/m³]	Wind direction during dust event	Daily max. temp [°C]	Duration of high[16] PM_{10} levels	Daily max. 1-hour average PM_{10} [µg/m³]	Time from onset of wind change[17] to peak PM_{10}	Daily max. wind gust[18] [km/h]	Daily max. wind gust [km/h]
3 Apr 05	31	40	**476**	WSW	27	17 hours	4119	15 mins	67	81
1 Mar 05	30	33	**258**	SSW	41	6 hours	1714	15 mins	65	54
1 Feb 05	18	29	**178**	SW	39	5 hours	1428	30 mins	70	76
2 Feb 05	6	3	**118**	SW	20	7 hours	914		69	80
20 Jan 05	20	15	**110**	SW	37	10 hours	245		59	44
23 Dec 04	22	23	**102**	WSW	41	2 hours	1416	30 mins	69	46
4 Jan 05	12	12	**101**	W	26	7 hours	440	10 mins	59	61
18 Feb 05	27	20	**82**	SW	37	3 hours	953	35 mins	54	65
10 Apr 05	27	34	**69**	SSW	36	3 hours	525	40 mins	52	76
3 Feb 05	7	6	**68**	WSW	17	7 hours	206		54	102
2 Mar 05	22	16	**58**	S	32	3 hours	167		46	43
15 Mar 05	27	30	**57**	SSW	33	2 hours	271	25 mins	43	41
25 Mar 05	15	15	**54**	S	25	5 hours	182		50	52
19 Dec 04	28	22	**50**	SW	30	1 hour	157	80 mins	46	59

Table 1: Days on which 24-hour average Mildura PM_{10} levels were above 50 µg/m³

[15] Average of all Melbourne stations, excluding Box Hill and Mooroolbark which were affected by local dust sources.
[16] Number of hours for which hourly averaged PM_{10} was greater than a nominal value of 100 µg/m³.
[17] This value is only shown if there was a clear change of wind speed or direction on the day.
[18] Wind Gusts are peak values. Details are available at www.bom.gov.au/climate/dwo/index.shtml.

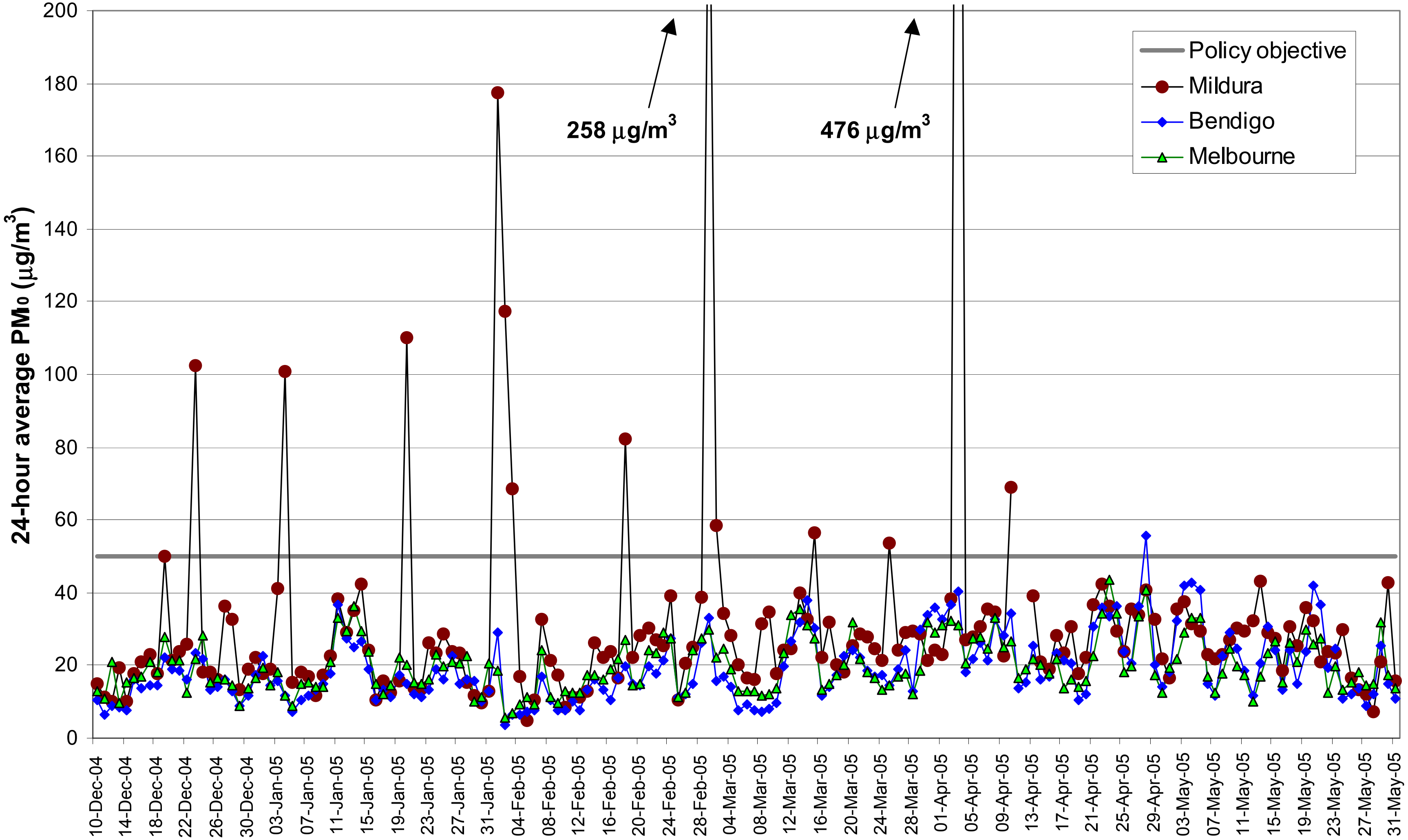

Figure 3: Particle Monitoring at Mildura (compared with Bendigo and Melbourne)

Note: Data for May 2005 have not been subject to final validation.

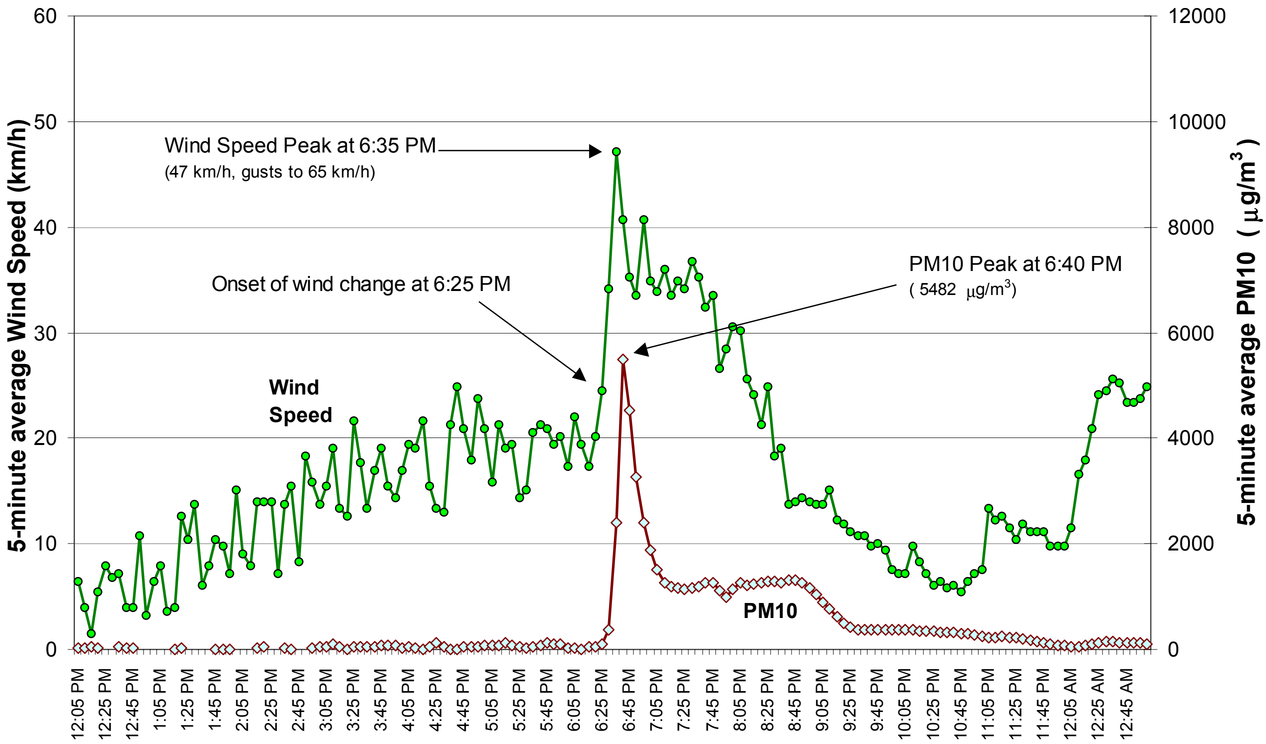

Figure 4: Mildura Dust Storm on 1st March 2005

Note that the graphs show five-minute average PM_{10}. These data cannot be directly compared with the PM_{10} objective, because the objective is based on a 24-hour average.

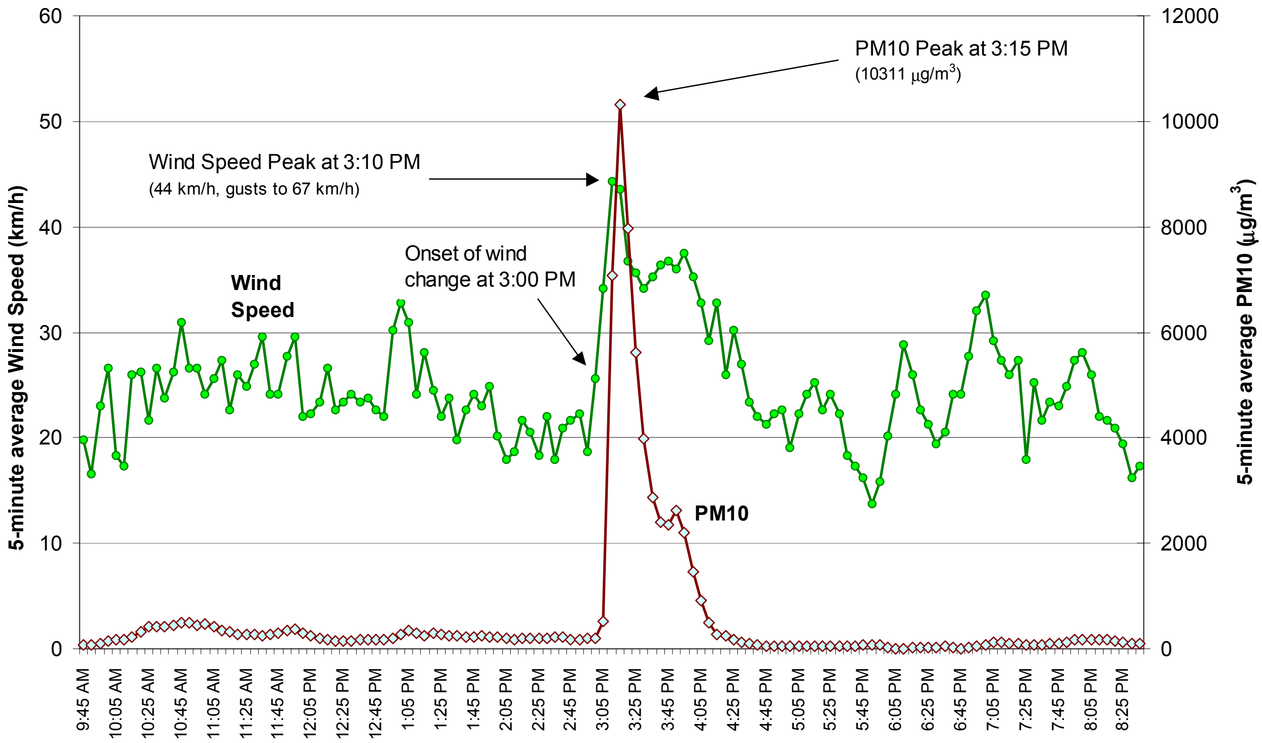

Figure 5: Mildura Dust Storm on 3rd April 2005

6. HOW DOES PM_{10} AFFECT HEALTH?

The PM_{10} objective of 50 µg/m^3 has been set, based on health studies, to provide a level of protection for human health. These health studies have been done mostly in large urban areas in USA and Europe.

Because rural particles are different in chemical and biological composition from urban particles, at this stage it is not possible to estimate the health impacts of the PM_{10} levels that have been recorded at Mildura.

It is possible that health conditions that involve irritation or allergic response in the airways may be affected[19]. Sheltering indoors during dust storms will reduce exposure to harmful levels of particles.

Dust storms are most likely in Mildura from December to April. The Bureau of Meteorology provides a notification service in cases where a dust storm is forecast:

www.bom.gov.au/weather/vic/mildura.

7. INTERIM CONCLUSIONS

Strong winds and dry conditions in the north-west of Victoria can lead to significant dust storms affecting Mildura. Past measurements of 'total' particles show a strong seasonal effect, with most dust impacts occurring in March.

EPA began monitoring for 'fine' particles, of more concern to human health, in December 2004. Very high PM_{10} pollution levels were found in association with windblown dust. Since monitoring began, PM_{10} levels have exceeded the 24-hour objective of 50 µg/m^3 on fourteen occasions.

The health effects of these high levels are unclear, as insufficient research has been conducted on the relationship between rural particles and human health.

Many regional towns in Victoria are affected by semi-natural sources of pollution such as prescribed burns and dust storms. EPA will continue to monitor and assess the impacts of these sources on Mildura and other population centres, making use of the latest available scientific knowledge. A final report on this project will be prepared in 2006.

ACKNOWLEDGEMENTS

EPA Victoria would like to acknowledge Lower Murray Water for allowing the siting of the PM10 monitoring station on the land adjacent to its offices.

We would also like to thank Mildura Rural City Council and the NSW Department of Primary Industries and Natural Resources for their assistance throughout this project.

[19] Rutherford, S, Clark, E, McTainsh, G, Simpson, R & Mitchell, C (1999). 'Characteristics of rural dust events shown to impact on asthma severity in Brisbane, Australia', Int. J. Biometeorol., 1999, **42**:217–225.