



Wainuiomata arsenic in air investigation, 2012

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Executive summary

During 2012 the concentration of arsenic in particulate matter (PM₁₀) in outdoor air was measured at Greater Wellington Regional Council's permanent monitoring station in Wainuiomata as part of a research collaboration with GNS Science. The annual average arsenic concentration was 7.1 ng/m³. The national air quality arsenic guideline to protect public health is an annual average of 5.5 ng/m³. Most of the arsenic in air was found during the winter months when PM₁₀ levels peak due to emissions from domestic fires. The primary source of arsenic in air was attributed to the intermittent burning of timber that has been treated with the preservative CCA (copper-chrome-arsenate).

It is recommended that a publicity campaign be undertaken to inform people in Wainuiomata and those in the wider region who use wood for home heating of the potential adverse health effects of burning treated timber. It is also recommended that further investigation into the circumstances surrounding the use of CCA-treated timber for firewood be carried out in partnership with Regional Public Health and Local Territorial Authorities. In addition, further research by appropriate agencies on implications for public health from indoor and outdoor exposure to arsenic is needed.

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1. Introduction and background

1.1 Arsenic in air in New Zealand

Arsenic is classified as a high-potency human carcinogen and therefore the Ministry for the Environment (2002) recommends an annual average guideline for arsenic of 5.5 ng/m³ based on a 1 in 100,000 additional life-time cancer risk. A New Zealand-wide review of ambient arsenic concentrations concluded that national and international guidelines were likely to have been exceeded in many urban areas through out the country, for example, in parts of Auckland, Christchurch, Hastings, Nelson and Timaru (Cavanagh et al. 2012). Most of the arsenic data for the review was obtained from multivariate PM₁₀ source apportionment studies using ion beam analysis (IBA) to determine elemental concentrations rather than from more sensitive methods designed specifically to compare arsenic levels to air quality guidelines. IBA has a high limit of detection (LOD) for arsenic ranging from 20-30 ng/m³ per sample depending on the filter media used. Accordingly, the review recommended further monitoring of arsenic in New Zealand using methods capable of detecting arsenic at low concentrations (ie, <0.1 ng/m³) so that annual averages could be more robustly determined (Cavanagh et al. 2012).

1.2 Air quality in Wainuiomata

Concentrations of particulate matter have been measured at the GWRC air quality monitoring station at the Wainuiomata Bowling Club since late 2000 by three methods (Table 1.1). Although PM₁₀ concentrations peak during the winter months, results to date show that air quality in Wainuiomata complied with the National Environmental Standard for Air Quality (NES-AQ) - as there was no more than one PM₁₀ exceedance (ie, 24-hour average above 50 µg/m³) in any given year.

A source apportionment study of particulate matter in Wainuiomata was carried out by GNS Science using PM_{2.5} and PM_{2.5-10} collected on GENT filters between 2006 and 2008. This study found that biomass burning, primarily due to emissions from solid fuel fires from domestic heating, was the principal contributor to PM₁₀ on high pollution days (Davy et al. 2009). This study also found that arsenic was associated with the biomass burning source and that this was considered to be due to the use of timber that had been treated with copper-chrome-arsenate (CCA) preservative as fuel in domestic fires (Davy et al. 2009, Davy et al. 2012).

1.3 Arsenic monitoring methods inter-comparison study

GNS Science is undertaking a study at the GWRC air quality monitoring site in Wainuiomata to compare arsenic concentrations determined by two different gravimetric particulate sampling instruments and analysis methods as follows:

- a) A reference method used for comparison against the air quality guideline, namely, PM₁₀ filters collected by high volume sampler and subsequent analysis for arsenic using a standard laboratory method with a low limit of detection; and

- b) A research method for multivariate source apportionment that uses PM_{2.5} and PM_{2.5-10} filters collected by GENT sampler and subsequent analysis for arsenic (and other elements) using ion beam analysis (IBA).

The co-location study will run from September 2011 to September 2013. GWRC is providing technical and some financial support for the PM₁₀ monitoring by high volume sampler. Figure 1.1 shows the GWRC and GNS Science monitoring instruments co-located at the GWRC air quality monitoring station at the Wainuiomata Bowling Club.

Table 1.1: Monitoring methods used at Wainuiomata Bowling Club by GWRC and GNS Science between 2001 and 2013. The grey shading indicates timing of instrument deployment.

Method	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	
Hi vol sampler PM ₁₀												*	*****	*
FH62 PM ₁₀														
FH62 PM _{2.5}														
GENT PM _{2.5}						*	*****	*				*	*****	*****
GENT PM _{2.5-10}						*	*****	*				*	*****	*****



Figure 1.1: Photo of GWRC monitoring station showing sample inlets for particulate matter monitoring instruments and the high volume sampler (right foreground)

* Arsenic determined by ICP-MS in PM₁₀ collected by High Volume Sampler

* Arsenic determined by IBA in PM_{2.5} and PM_{2.5-10} collected by GENT sampler

2. Aims and methods

2.1 Aim and monitoring objective

The primary aim was to establish an annual average arsenic concentration in air at the long term GWRC monitoring site in Wainuiomata that could be compared to the national ambient air quality guideline. A secondary aim was to examine the temporal variation in arsenic levels and the relationship between arsenic and PM₁₀ and PM_{2.5} concentrations which were measured concurrently.

2.2 Monitoring site

The Wainuiomata valley is located east of the Hutt Valley and 20 km northeast of central Wellington. The valley is surrounded by hills that are 300 m high to the west, 600 m high to the north and 800 m high to the east. During the winter the valley experiences frosts and temperature inversion conditions. The Wainuiomata ward has a usually resident population of 17,211 (2006 census data).

The monitoring site was located at the Wainuiomata Bowling Club greens on Moohan Street, Wainuiomata at an elevation of 87 m (Figure 2.1.). The Wainuiomata Bowling Club site lies approximately 1 km southeast of the main shopping centre. The predominant land use around the site is residential with some adjacent recreational activities such as a swimming pool complex and rugby fields.

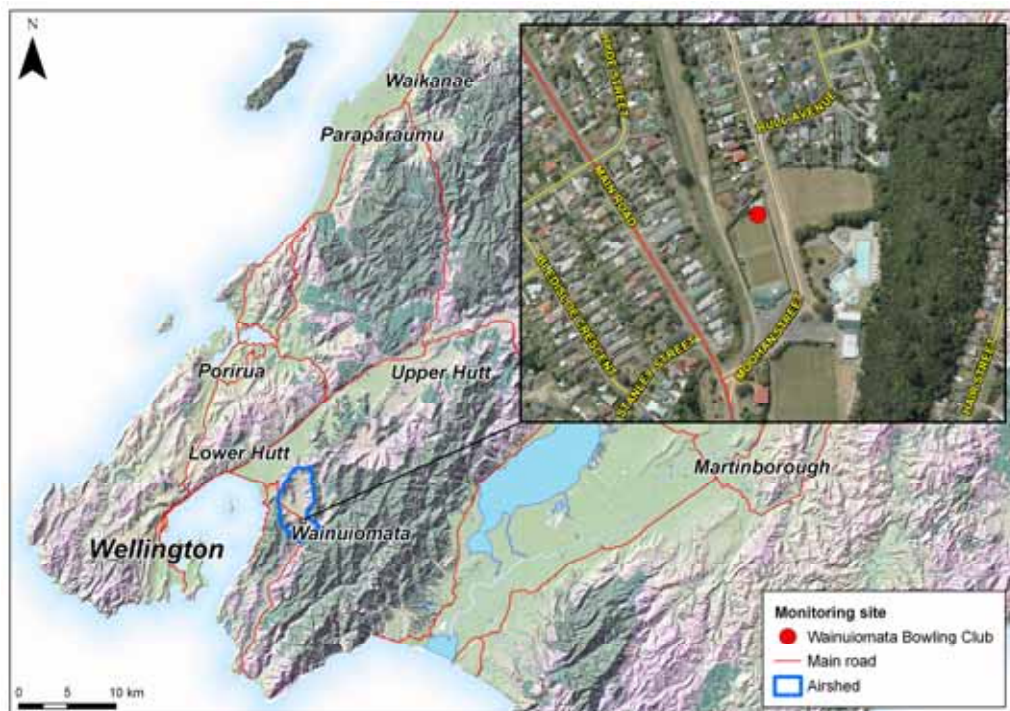


Figure 2.1: Map of the Wainuiomata airshed (outlined in blue). Photo inset shows the location of GWRC's permanent air quality monitoring station at Wainuiomata Bowling Club (NZTM E 1763651 N 5429683)

2.3 Method

2.3.1 PM₁₀ sampling - gravimetric

PM₁₀ was sampled using a high volume sampler (Lear Siegler, serial no. A009) fitted with a PM₁₀ size selective inlet (Graseby Andersen, serial no. 3574 7/97) co-located at the GWRC air quality monitoring site at the Wainuiomata Bowling Club. This instrument was operated in accordance with AS/NZS 35880.9.6:2003 *Method 9.6: Determination of suspended particulate matter – PM₁₀ high volume sampler with size selective method – gravimetric method*¹. The instrument was calibrated monthly using a critical orifice calibrator (Lear Siegler, serial no. 026) to ensure flow rate maintained between the reference method requirement of 65 and 75 m³/hour.

Sequentially numbered 8x10 inch Whatman grade QM-A quartz filters were conditioned and weighed by GNS Science in accordance with AS/NZS 35880.9.6:2003. These filters were exposed for 24-hours (midnight to midnight) on a one-in-three (1:3) day sampling regime which was increased to a one-in-two (1:2) day frequency between May and September (7/5/12 to 16/9/12). The reason for the increased frequency was to provide a greater chance of capturing the winter pollution episodes and to provide more data for analysis. Filters were changed by a Victoria University of Wellington post graduate student. After exposure filters were weighed by GNS Science and stored at -18°C to minimise loss of the volatile fraction of particulate prior to further analysis.

PM₁₀ mass per filter was converted to concentration in air based on flow rates corrected to standard temperature and pressure (ie, 273.15 K and 101.3 hPa) using barometric pressure (2 m) and temperature (2 m) measurements from the GWRC weather station at Wainuiomata Bowling Club.

2.3.2 PM₁₀ and PM_{2.5} sampling – continuous

PM₁₀ concentration was measured with a Thermo Scientific series FH62 C14. This method is an USEPA Automated Equivalent Method for PM₁₀ monitoring (EQPM-1102-150). The sample inlet heater was set to 40°C in accordance with recommended best practice (Ministry for the Environment 2009). PM_{2.5} concentrations were also measured with a FH62 using a PM_{2.5} very sharp cut cyclone after the PM₁₀ head. This method is not USEPA equivalent because the FH62 is an older model that does not have a dynamic heating system. For both instruments the filter tape was set to advance at midnight. All concentrations were corrected to 0°C and standard pressure.

2.3.3 Determination of arsenic concentrations in PM₁₀

GWRC took a 47 mm diameter punch from each exposed high volume PM₁₀ filter. A total of 149 filter punches (that included five field blanks) for the period 22/10/2011 to 6/11/2012 were couriered to Hill Laboratories (Hamilton) in a chilly bin.

¹ This standard is based on USEPA 40 CFR Part 50, Appendix J – Reference Method for the Determination of Particulate Matter as PM₁₀ in the Atmosphere which is the monitoring method recommended by the ambient air quality guidelines (Ministry for the Environment 2002).

The standard method for determining arsenic concentrations in PM₁₀ is atomic absorption spectrometry (AAS) or an equivalent method. The equivalent method used by Hill Laboratories was ICP-MS (inductively coupled plasma mass spectrometry) which is faster, more precise and sensitive than AAS.

The concentration of arsenic in air was calculated from the concentration determined in the sample, the portion of the filter used, and the volume of air drawn through the high volume sampler over the 24-hour period of filter exposure:

$$\text{Arsenic ng/m}^3 \text{ in PM}_{10} = \frac{\mu\text{g/sample} * 1000}{\text{volume air at STP (m}^3\text{)} * \text{proportion of filter used}}$$

The LOD reported by Hill Laboratories for arsenic obtained by ICP-MS was 0.05 µg per sample. Therefore the LOD for arsenic in ambient air (ng/m³) may differ slightly for each exposed filter depending on the volume of air sampled in that 24-hour period. In this case the LODs for arsenic concentrations ranged from 0.74 to 0.78 ng/m³.

2.3.4 Determination of black carbon

Black carbon is the solid fraction of PM_{2.5} that strongly absorbs light. Black carbon (soot) is formed from the incomplete combustion of fuels. Black carbon measurements were obtained by GNS Science for each PM₁₀ filter using a light reflectance method.

2.4 Statistical analysis of results

2.4.1 Dealing with results below the limit of detection

32% of the filters analysed by Hill Laboratories were found to have arsenic concentrations below the laboratory limit of detection (LOD). In other words, the concentration of arsenic was known only to be somewhere between zero and the ICP-MS detection limit. These measurements are considered too uncertain to report as a single number and so were reported as “<0.05”. There is no regulatory guidance for how to incorporate results below the LOD when calculating an annual average to be compared against national ambient air quality guidelines.

In environmental chemistry a variety of approaches can be used for incorporating values reported at below the LOD into statistical analyses. Typically substitution methods are used, for example, all values reported below LOD can be set to zero, set at half the LOD or at the LOD threshold. Alternatively, the actual non-reported laboratory values (if available) can be used.

An alternative method for calculating summary statistics from data that include values below the LOD is regression on order statistics (ROS). A ‘robust’ approach to ROS developed by Helsel (2005) limits the distributional assumption of log-normality to only those values below the LOD, thus minimising the potential for transformation bias. After fitting a regression equation to observations above the LOD on the probability plot, values for

individual observations below the LOD are predicted from the regression model based on their normal scores. Predicted values from the equation are used and combined with observed values above the LOD to compute summary statistics (Helsel 2005). In this report a sensitivity analysis of using the different methods of incorporating values below the LOD when computing summary statistics was carried out.

Pearson's correlations and simple linear regressions between arsenic and other variables were performed using R version 2.13.0 (R Development Core Team 2011). Data aggregation, time series, scatter plots and the wind rose plot were produced using the R package *Openair* (Carslaw & Ropkins 2012). ROS was calculated using the R package *NADA* (Lee 2010).

2.4.2 Accounting for non-uniform sampling frequency

The sampling frequency for gravimetric monitoring is determined by the requirements of the monitoring objectives. Historically gravimetric sampling for PM₁₀ was based on 1:6 or 1:3 day sampling schedule following USEPA protocols. In this study sampling frequency was intensified from 1:3 to 1:2 day during the winter months as the variability of arsenic concentrations was expected to be higher due to seasonality in source contributions associated with domestic fires found in previous studies (Davy et al. 2011a).

Simply averaging all the measurements would produce a biased estimator of the annual mean as there would be more chance of observing a higher arsenic concentration in winter compared to non-winter period. Therefore the annual average was weighted by the contribution of the proportion of the year representing sampling frequency. The 1:2 day sampling frequency represents 0.36 of the 366² day monitoring period (1/11/2011 to 31/10/2012), ie, 133/366. The 1:3 day sampling frequency represents 0.64 of the 366 day monitoring period (233/366).

² There were 366 days between 1/11/2011 to 31/10/2012 as 2012 was a leap year so there was an additional day in February 2012

3. Results

A statistical summary of the arsenic, PM₁₀ (FH62), PM_{2.5} (FH62), PM₁₀ (high volume sampler) measurements obtained for 138 24-hour periods from 1 November 2011 to 31 October 2012 are presented in Table 3.1. For the purpose of calculating these summary statistics arsenic concentrations reported as below the LOD were assigned to zero concentration. The daily time series of arsenic, PM₁₀ and PM_{2.5} are shown in Figure 3.1 and the full data set of 24-hour averages is presented in Appendix 1. There were periods of missing data for the FH62 instruments due to planned services, calibrations and PM head cleaning. The PM_{2.5} monitoring equipment was not installed until 30 April 2012 as the monitoring station needed to be upgraded from a pillar box to a Portacom to accommodate the PM_{2.5} analyser.

Table 3.1: Summary statistics for arsenic, PM₁₀, PM_{2.5} and (24-hour averages) between 1 November 2011 and 31 October 2012 (Note: the mean statistics in this table are simple arithmetic means of all samples collected, and should not be confused with weighted annual averages)

	Arsenic (PM ₁₀) LOD = 0	PM ₁₀ (FH62)	PM ₁₀ (Hi Volume Sampler)	PM _{2.5} (FH62)
Units	ng/m ³	µg/m ³	µg/m ³	µg/m ³
Mean	8.3	10.1	11.3	8.6
Median	2.1	9.1	10.3	6.3
SD	14.2	5.4	6.3	6.1
IQR	< 0.74 – 8.10	6.4 – 11.8	7.3 – 12.9	4.3 – 11.5
Max	78.7	28.5	33.8	30.8
Min	< 0.74	1.4	1.0	1.2
Sample size (N)	138	136	138	77

The annual average for PM₁₀ was 10 µg/m³ based on 350 sample days between 1 November 2011 and 31 October 2012 (data capture rate 96%). This compares favourably with the national ambient air quality guideline (annual average) for PM₁₀ of 20 µg/m³. The annual average for PM_{2.5} was 8.6 µg/m³ based on 177 sample days (data capture 48%). The data capture rate for PM_{2.5} is too low to produce a representative annual mean that can be compared to a health-based guideline.

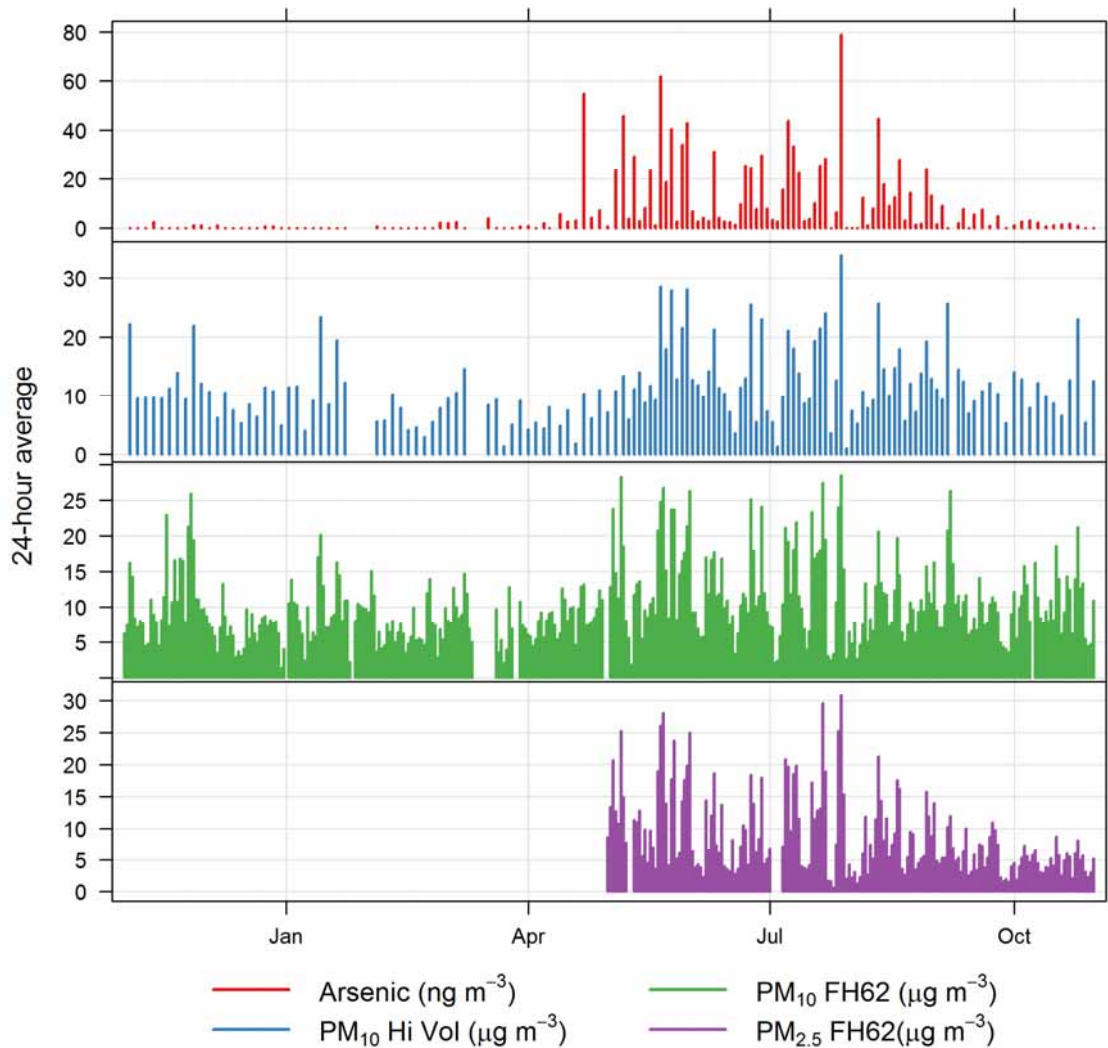


Figure 3.1: Time series of arsenic, PM₁₀ and PM_{2.5} (24-hour average) measured at Wainuiomata Bowling Club between 1 November 2011 and 31 October 2012

3.1 Arsenic annual average weighted by sampling frequency

On 44 of the 138 sampling days (ie, 31.9% of samples), arsenic concentrations were below their LOD. During the winter 1:2 day sampling period, 6 of the 66 days (9.1%) were below their LOD. Of the non-winter 1:3 day sampling period, 38 of 72 days (52.8%) were below the LOD. All five field blanks reported concentrations were below the LOD for arsenic.

Averages for each sample frequency period (1:2 day and 1:3 day) were calculated using LOD substitution methods and robust ROS (Table 3.2). Weighted annual means ranged from 7.0 to 7.1 ng/m³ depending on how values below the LOD were handled.

Table 3.2: Annual average arsenic concentration (between 1 November 2011 and 31 October 2012) using different calculation methods and weighted by sampling frequency

Period	LOD = zero	LOD = LOD/2	LOD = LOD	ROS
Non-winter mean (1:3 day)	2.7	2.9	3.8	2.9
Winter mean (1:2 day)	14.4	14.5	14.5	14.5
Annual weighted mean	7.0	7.1	7.2	7.1

3.2 Meteorology

A wind rose for the monitoring period shows the wind was most frequently from the north (Figure 3.2). Mean monthly temperatures and wind speeds were both lowest during the winter period (Figure 3.3).

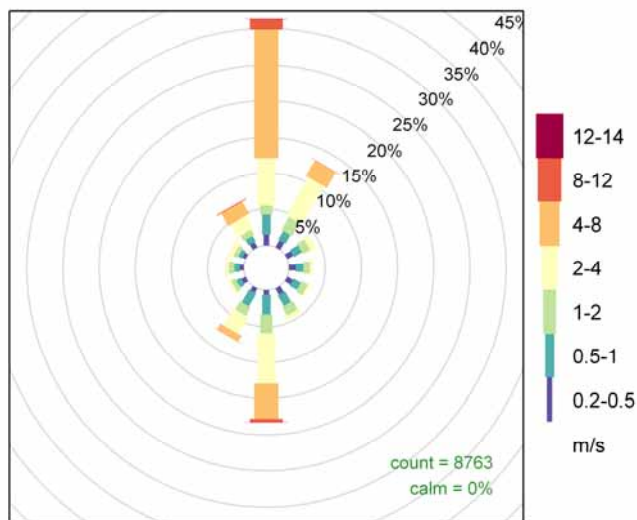


Figure 3.2: Wind rose showing frequency of wind speed and wind direction counts recorded at Wainuiomata Bowling Club at 10m for all dates 1 November 2011 to 31 October 2012

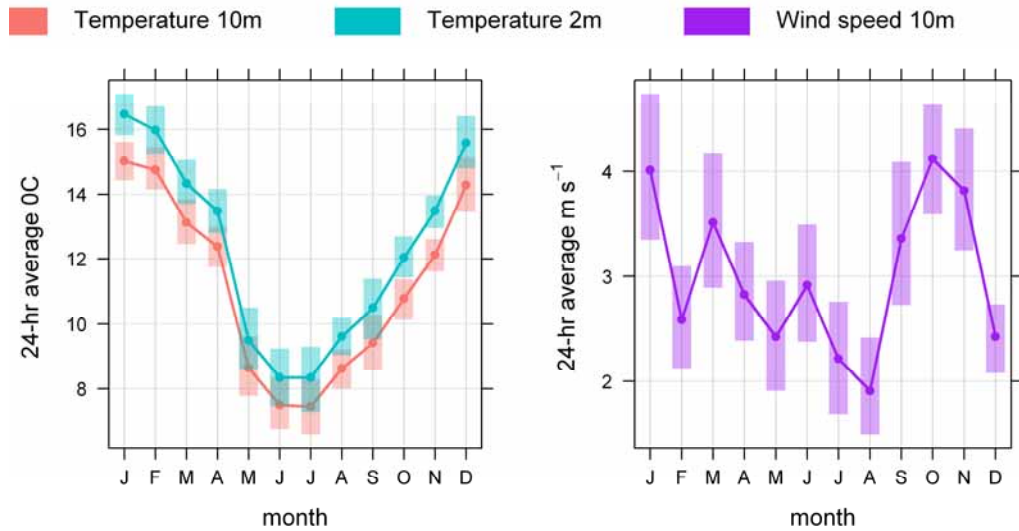


Figure 3.3: Mean monthly temperatures and wind speeds recorded at Wainuiomata Bowling Club at 10m for all dates 1 November 2011 to 31 October 2012. The shaded area shows the 95% confidence interval in the mean

3.3 Relationships between arsenic and other contaminants

During the monitoring period arsenic concentrations were most strongly correlated with PM_{2.5} ($r^2=0.92$, $n=80$), followed by black carbon ($r^2=0.84$, $n=138$) and PM₁₀ FH62 ($r^2=0.70$, $n=136$). Simple linear regression indicates that much of the variability in arsenic concentrations can be explained by PM_{2.5} concentration ($R^2=0.85$) (Figure 3.4). This finding supports the view that arsenic is most likely to be associated with the fine fraction of particulate matter that is emitted from domestic fires (Davy et al. 2012).

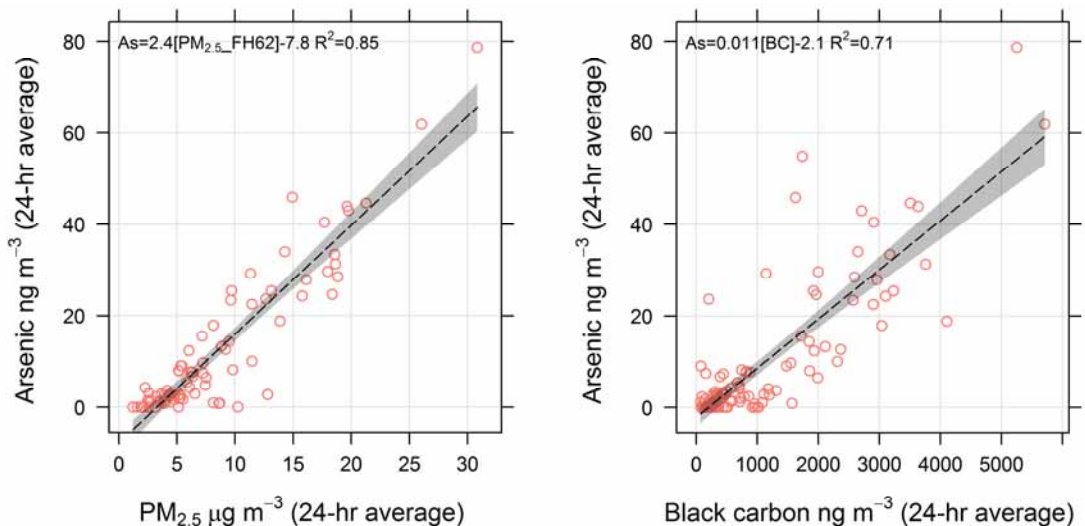


Figure 3.4: Correlation scatter plots and the fitted linear regression line for arsenic, PM_{2.5} and black carbon measurements at Wainuiomata Bowling Club from 1 November 2011 to 31 October 2012. Left: Arsenic (high volume filters) vs PM_{2.5} (FH62) for 80 data points. Right: Arsenic (high volume filters) vs Black Carbon (high volume filters) for 138 data points

4. Discussion and conclusions

The annual average calculated for the period 1 November 2011 to 31 October 2012 was 7.1 ng/m³. The annual mean was not particularly sensitive to the method of incorporating observations below the LOD. The issue of dealing with incorporating values below the LOD is more relevant when the computed average is very close to the guideline value.

The findings support the conclusions of Cavanagh et al. (2012) that attaining the PM₁₀ national environmental standard isn't necessarily sufficient to protect the community from exposure to other hazardous air pollutants, such as arsenic, that are associated with domestic fires.

The national ambient air quality guideline for arsenic is an annual average of 5.5 ng/m³ which is intended to represent an additional lifetime cancer risk of 1 per 100,000 (Ministry for the Environment 2002). Using the approach of Cavanagh et al. (2012) the unit risk estimates derived from WHO (2000) and USEPA (1998) were applied a population of 18,000 (equivalent to Wainuiomata) for an annual average of 7.1 ng/m³. In this situation, the expected additional cancer cases over a lifetime ranged from 0.04 using the WHO (2000) risk estimate to 0.12 using the more conservative USEPA (1998) risk estimate³. This assumes that all Wainuiomata residents are exposed to uniform levels of arsenic in air where as in reality levels may vary with location. It is possible to identify Wainuiomata residents with lung cancer in the Ministry of Health Cancer Registry but it would difficult to link the cases to exposure to arsenic as most would have a history of tobacco use or exposure to second hand smoke³.

The presence of elevated levels of arsenic during the winter months is not unique to Wainuiomata. Elemental analysis of air particulate matter carried out for source apportionment studies in other parts of the region, such as residential areas in Masterton (Ancelet et al. 2012), Raumati South (Davy et al. 2011b) and Upper Hutt (Davy 2007) have all found peak arsenic concentrations during the winter months. Indeed winter arsenic pollution appears to be a potential issue in urban areas throughout New Zealand where fires are used for home heating (Davy et al. 2011a, Cavanagh et al. 2012).

Therefore, if the levels of winter arsenic measured in Wainuiomata are similar both throughout the region and on a national scale, the number of estimated additional cancer cases becomes more significant because more people are exposed. Applying the WHO (2000) and USEPA (1998) risk estimates on a regional basis (population size of 350,000) results in 0.84 to 2.40 additional cancer cases and on a national basis (population size of 1,000,000) results in 2.41 to 6.88 additional cancer cases for a lifetime exposure³.

Furthermore, the highest 24-hour average arsenic concentrations are measured over the few months during the winter period when people are using fires for home heating. The health implications of this potentially elevated level of exposure to arsenic during the winter season are not known. Of most concern may be the potential for acute indoor inhalation exposure to arsenic during fire

³ Personal communication 8/5/2013: Stephen Palmer, Medical Officer of Health, Regional Public Health, Hutt Valley District Health Board.

lighting and re-fuelling activities using CCA-treated timber and the subsequent handling and disposal of ash.

5. Recommendations

1. Publicise the issue of winter outdoor and indoor arsenic air pollution arising from the use of CCA-treated timber for home fires using local media channels during winter 2013.
2. In the longer term, more work needs to be done to understand where and how CCA-treated timber is being sourced for domestic burning and to develop methods that would most effectively discourage its use. This work should be undertaken in partnership with Regional Public Health and Local Territorial Authorities.
3. Continue to provide technical and financial support to GNS Science and Victoria University of Wellington for the collection of arsenic in PM₁₀ by reference method in Wainuiomata during 2013.
4. More research by appropriate agencies on the health impacts of indoor and outdoor inhalation exposure to arsenic is needed so that the actual risks to health can be quantified.

Acknowledgments

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Advice from Nick Kim (Massey University) on calculating the weighted annual average and from Stephen Palmer (Regional Public Health) on calculating the health risk assessment is gratefully acknowledged. The site map (Figure 2.1) was produced by Shyam Moar (GWRC). We are grateful to Wainuiomata Bowling Club for allowing us to use their grounds for the monitoring station.

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Appendix 1

Table A1.1: Dataset of arsenic, PM₁₀ and PM_{2.5} (24-hour average). Grey shading denotes arsenic levels below given level of analytical detection

Date	Arsenic ng/m ³	< LOD	PM ₁₀ (high volume) µg/m ³	PM ₁₀ (FH62) µg/m ³	PM _{2.5} (FH62) µg/m ³
3/11/2011	0.78	TRUE	22.20	16.23	NA
6/11/2011	0.77	TRUE	9.52	7.15	NA
9/11/2011	0.77	TRUE	9.65	4.48	NA
12/11/2011	2.45	FALSE	9.59	8.94	NA
15/11/2011	0.77	TRUE	9.50	8.21	NA
18/11/2011	0.77	TRUE	11.28	7.25	NA
21/11/2011	0.78	TRUE	13.96	10.74	NA
24/11/2011	0.77	TRUE	9.39	7.88	NA
27/11/2011	1.22	FALSE	21.9	19.40	NA
30/11/2011	1.19	FALSE	12.12	11.05	NA
3/12/2011	0.77	TRUE	10.71	7.53	NA
6/12/2011	1.08	FALSE	6.19	3.49	NA
9/12/2011	0.76	TRUE	10.54	8.62	NA
12/12/2011	0.77	TRUE	7.51	5.94	NA
15/12/2011	0.78	TRUE	5.27	2.99	NA
18/12/2011	0.76	TRUE	8.55	5.44	NA
21/12/2011	0.75	TRUE	6.37	4.91	NA
24/12/2011	0.76	FALSE	11.4	8.67	NA
27/12/2011	0.77	FALSE	10.77	7.64	NA
30/12/2011	0.77	TRUE	4.92	1.39	NA
2/01/2012	0.77	TRUE	11.43	10.54	NA
5/01/2012	0.77	TRUE	11.65	10.27	NA
8/01/2012	0.77	TRUE	4.03	2.41	NA
11/01/2012	0.78	TRUE	9.11	6.39	NA
14/01/2012	0.78	TRUE	23.4	20.14	NA
17/01/2012	0.75	TRUE	8.48	7.08	NA
20/01/2012	0.78	TRUE	19.43	16.27	NA
23/01/2012	0.76	TRUE	12.28	10.90	NA
4/02/2012	0.77	FALSE	5.57	3.61	NA
7/02/2012	0.76	TRUE	5.78	4.54	NA
10/02/2012	0.77	TRUE	10.28	8.03	NA
13/02/2012	0.76	TRUE	7.87	7.57	NA
16/02/2012	0.76	TRUE	4.08	4.80	NA

Date	Arsenic ng/m ³	< LOD	PM ₁₀ (high volume) µg/m ³	PM ₁₀ (FH62) µg/m ³	PM _{2.5} (FH62) µg/m ³
19/02/2012	0.76	TRUE	4.59	5.23	NA
22/02/2012	0.77	TRUE	2.88	4.61	NA
25/02/2012	0.76	TRUE	5.52	7.68	NA
28/02/2012	2.27	FALSE	7.85	6.83	NA
2/03/2012	1.99	FALSE	9.48	8.04	NA
5/03/2012	2.41	FALSE	10.55	9.96	NA
8/03/2012	0.74	TRUE	14.57	14.69	NA
17/03/2012	4.07	FALSE	8.39	NA	NA
20/03/2012	0.75	TRUE	9.30	9.71	NA
23/03/2012	0.77	TRUE	1.38	2.05	NA
26/03/2012	0.76	TRUE	5.04	6.91	NA
29/03/2012	0.75	FALSE	9.15	10.72	NA
1/04/2012	0.91	FALSE	4.21	6.02	NA
4/04/2012	0.76	TRUE	5.41	5.48	NA
7/04/2012	1.96	FALSE	4.35	5.69	NA
9/04/2012	0.76	TRUE	8.02	9.11	NA
13/04/2012	5.77	FALSE	4.85	6.21	NA
16/04/2012	2.57	FALSE	7.52	8.00	NA
19/04/2012	3.11	FALSE	1.80	4.59	NA
22/04/2012	54.90	FALSE	10.37	13.18	NA
25/04/2012	4.09	FALSE	6.14	7.88	NA
28/04/2012	7.33	FALSE	10.94	12.32	NA
1/05/2012	0.75	FALSE	7.11	NA	8.63
4/05/2012	23.67	FALSE	10.81	14.75	12.66
7/05/2012	45.90	FALSE	13.39	18.50	14.94
9/05/2012	3.65	FALSE	5.92	5.60	NA
11/05/2012	29.23	FALSE	11.19	11.74	11.34
13/05/2012	2.77	FALSE	13.97	13.66	12.81
15/05/2012	8.21	FALSE	8.74	9.53	9.81
17/05/2012	23.41	FALSE	11.74	10.48	9.65
19/05/2012	1.20	FALSE	9.21	8.88	3.51
21/05/2012	61.84	FALSE	28.47	24.74	26.05
23/05/2012	18.83	FALSE	17.92	15.12	13.87
25/05/2012	40.44	FALSE	27.88	23.69	17.69
27/05/2012	2.60	FALSE	12.83	8.18	5.13
29/05/2012	34.02	FALSE	21.54	16.52	14.28
31/05/2012	42.98	FALSE	28.09	21.34	19.78

Date	Arsenic ng/m ³	< LOD	PM ₁₀ (high volume) µg/m ³	PM ₁₀ (FH62) µg/m ³	PM _{2.5} (FH62) µg/m ³
2/06/2012	6.75	FALSE	12.69	9.29	6.36
4/06/2012	2.69	FALSE	11.83	6.92	4.29
6/06/2012	4.26	FALSE	9.86	5.76	2.25
8/06/2012	2.90	FALSE	14.22	11.83	6.53
10/06/2012	31.31	FALSE	21.26	17.76	18.65
12/06/2012	4.28	FALSE	11.34	11.79	6.10
14/06/2012	2.69	FALSE	10.35	9.85	3.94
16/06/2012	2.36	FALSE	7.20	7.41	3.20
18/06/2012	1.36	FALSE	3.56	3.32	2.77
20/06/2012	9.72	FALSE	11.42	10.22	7.23
22/06/2012	25.47	FALSE	12.96	11.31	9.72
24/06/2012	24.66	FALSE	25.44	25.12	18.36
26/06/2012	7.76	FALSE	5.45	10.08	6.20
28/06/2012	29.64	FALSE	23.03	24.11	17.98
30/06/2012	7.92	FALSE	7.31	9.32	5.19
2/07/2012	3.39	FALSE	5.50	7.03	NA
4/07/2012	2.72	FALSE	1.22	2.45	NA
6/07/2012	15.57	FALSE	9.85	10.40	7.16
8/07/2012	43.91	FALSE	21.10	19.18	19.64
10/07/2012	33.40	FALSE	18.06	18.03	18.57
12/07/2012	22.50	FALSE	13.81	11.52	11.47
14/07/2012	2.85	FALSE	8.73	6.79	3.68
16/07/2012	3.67	FALSE	9.38	6.51	4.18
18/07/2012	10.06	FALSE	19.31	16.81	11.46
20/07/2012	25.48	FALSE	21.46	17.96	13.13
22/07/2012	28.48	FALSE	24.06	19.47	18.84
24/07/2012	0.76	TRUE	3.57	2.46	1.59
26/07/2012	6.47	FALSE	12.63	10.69	7.51
28/07/2012	78.72	FALSE	33.82	28.49	30.85
30/07/2012	0.77	TRUE	1.00	2.64	1.99
1/08/2012	0.76	TRUE	7.44	4.75	2.18
3/08/2012	0.75	TRUE	5.17	2.61	1.22
5/08/2012	12.37	FALSE	10.67	7.51	6.03
7/08/2012	1.07	FALSE	7.91	5.00	2.59
9/08/2012	8.00	FALSE	9.21	6.62	5.14
11/08/2012	44.67	FALSE	25.63	20.59	21.27
13/08/2012	17.91	FALSE	14.52	12.00	8.15

Date	Arsenic ng/m ³	< LOD	PM ₁₀ (high volume) µg/m ³	PM ₁₀ (FH62) µg/m ³	PM _{2.5} (FH62) µg/m ³
15/08/2012	9.07	FALSE	10.05	7.26	5.42
17/08/2012	12.66	FALSE	14.78	12.32	9.20
19/08/2012	27.89	FALSE	18.00	14.49	16.13
21/08/2012	3.02	FALSE	5.68	5.01	2.59
23/08/2012	14.37	FALSE	12.13	10.59	9.51
25/08/2012	1.35	FALSE	7.20	6.34	3.49
27/08/2012	1.83	FALSE	13.86	11.01	5.16
29/08/2012	24.33	FALSE	19.22	15.74	15.78
31/08/2012	13.29	FALSE	12.92	10.42	8.84
2/09/2012	1.66	FALSE	11.05	9.46	4.81
4/09/2012	9.07	FALSE	9.37	7.07	5.34
6/09/2012	0.76	TRUE	25.68	20.75	10.25
10/09/2012	1.98	FALSE	14.5	11.58	5.30
12/09/2012	7.63	FALSE	12.41	10.67	6.31
14/09/2012	0.75	TRUE	6.97	6.08	2.56
16/09/2012	5.46	FALSE	9.03	8.43	5.87
19/09/2012	7.46	FALSE	10.81	10.61	7.24
22/09/2012	0.88	FALSE	12.17	10.35	8.69
25/09/2012	4.79	FALSE	10.31	9.20	7.44
28/09/2012	0.76	TRUE	5.32	3.99	1.90
1/10/2012	1.08	FALSE	13.99	12.07	4.45
4/10/2012	2.75	FALSE	12.83	11.56	5.29
7/10/2012	3.16	FALSE	7.85	7.97	4.68
10/10/2012	2.29	FALSE	12.17	11.34	4.44
13/10/2012	0.77	FALSE	10.00	9.37	3.92
16/10/2012	1.21	FALSE	8.71	8.13	4.05
19/10/2012	1.51	FALSE	6.61	6.15	2.49
22/10/2012	1.69	FALSE	12.64	12.45	5.51
25/10/2012	0.92	FALSE	23.00	21.24	8.14
28/10/2012	0.77	TRUE	5.42	5.43	3.14
31/10/2012	0.77	TRUE	12.58	10.90	5.13

The Greater Wellington Regional Council promotes **Quality for Life** by ensuring our environment is protected while meeting the economic, social and cultural needs of the community

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