

Latrobe Valley Soil Trace Element Analysis

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Executive Summary

The purpose of the Latrobe Valley analysis was to characterise trace element concentrations in surface and subsurface soil in the Morwell area. Of particular focus was the site of a proposed Used Lead Acid Battery (ULAB) facility, from the proponent Pure Environmental Pty Ltd (previously, Chunxing Corporation Ltd).

Surface soil (0 – 2 cm horizon) was collected in triplicate from 90 sites (n = 270 samples) on public open space across the study area. Trace element analysis of the soil samples for aluminium (Al), arsenic (As), chromium (Cr), copper (Cu), iron (Fe), lead (Pb), magnesium (Mg), manganese (Mn), mercury (Hg), nickel (Ni) and zinc (Zn), showed no exceedances of the relevant Health Investigation Levels for public open space (NEPM 2013; HIL-C). Further, no soil samples exceeded the more conservative Health Investigation Level (NEPM 2013; HIL-A) that applies to residential gardens with accessible soil and is more protective of human health.

Given that the measured soil trace element concentrations are below Health Investigation Levels, there are no recommendations for further follow up in relation to the locations sampled.

1. Introduction

Following discussions between EPA and Latrobe City Council, EPA offered to undertake testing to understand current concentrations of trace elements in surface soil, with a focus on lead (Pb), in the Latrobe Valley. Interest in undertaking this work has arisen because of community concerns regarding the possibility of legacy lead contamination from a variety of potential industrial sources such as leaded gasoline emissions, industry (Kristensen et al. 2017) and coal-fired power stations (Schneider et al. 2020). The proposed ULAB facility has raised concerns in the community that it may add contaminants to the soil around the site, such that they could be in exceedance of the NEPM Health Investigation Levels.

Thus, the purpose of the sampling and analysis was to characterise trace element concentrations in the vicinity. This included sampling within 3 km of the proposed ULAB facility, and in residential areas (public open space) of Morwell and Churchill. To undertake this work, EPA Science used portable X-Ray fluorescence spectrometry (pXRF) to measure multi-element concentrations of field collected soil in a laboratory setting. EPA Science has significant in-house expertise in contaminated land assessments using pXRF, both in Australia and internationally (c.f. Fry et al. 2020; 2021; Gillings et al., 2022; Taylor et al. 2021). The outcome of this work is a point in time assessment of the trace element status of soil across the studied area.

2. Aims

- Characterise spatial concentrations of trace elements surrounding the proposed ULAB facility.
- Benchmark soil element concentrations against relevant soil investigation levels.
- Inform Council and community of the status of Pb and other elements of interest across the sampled area.

3. Methods and approach

3.1 Field Sampling

In July 2022, surface soils were sampled from public land at ~ 500 m intervals across the study area (**Figure 1**). Areas within 3 km of the proposed ULAB facility were first selected, with additional opportunistic sampling on public land in the residential areas of Morwell and Churchill to supplement the dataset. Assessment of soil trace element concentrations on private land or at sites beyond the study area was beyond the agreed scope of this study.

At each site (n = 90), surface soils were collected in triplicate using triangular sample configuration, being spaced approximately 1 m equidistant (n = 270 samples, cf. Fry et al. 2020; 2021). Samples were collected using a trowel and stored in sealed polyethylene bags. All sampling equipment was rinsed with Milli-Q water and ethanol between samples. At 10% of locations (n = 9), triplicate sampling was repeated for quality assurance analysis.

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Local background trace element concentrations were assessed at five locations (**Figure 1**). The locations were selected to represent the three predominant local surface geological groups and areas of public interest including Hazelwood North Primary School and Morwell Lake (**Figure 1**). At these sites, soil was collected at the following depth intervals: 0 – 2 cm, 2 – 10 cm, 10 – 30 cm, 30 – 40 cm, to evaluate trace element changes with depth. Soil samples collected at depth from undisturbed sites are considered to be representative of natural soil unaltered by anthropogenic emissions (Wu et al. 2016; Fry et al. 2021). Here we apply trace element concentrations from the 30 – 40 cm depth for background concentration evaluation.

3.2 Sample Analysis

Soil samples were oven dried at 40°C at the EPA Centre for Applied Sciences (Macleod, Melbourne), sieved to 2 mm and transferred to X-ray sample cups fitted with mylar film for analysis. Dried samples with large pedes and high clay content were lightly ground in an ethanol rinsed mortar and pestle prior to sieving. Samples were analysed using an Olympus Vanta 50 kV pXRF fitted with a rhodium tube and silicon drift detector. The pXRF was operated in proprietary Geochem mode with three beams (40 kV, 10 kV, 50 kV) operating for 20 s each, reporting in milligrams per kilogram (mg/kg; ppm). Where trace element concentrations were below pXRF limit of detection (LOD, **Appendix 1**) a value of 0.5*LOD was used for statistical assessment. The average of each triplicate was calculated and used as the representative concentration for that site to account for soil heterogeneity.

In terms of risk screening and assessment, soil trace element concentrations were compared to the Health Investigation Level C (HIL-C) for developed open space including parks, playgrounds, playing fields, secondary schools, and footpaths (NEPM, 2013). In addition, data were compared to the more conservative HIL-A for residential areas with gardens with accessible soil, which is more protective of human health. This HIL applies to locations where home grown produce provides < 10% fruit and vegetable intake (no poultry) and in addition to residential gardens includes children's day care centres, preschools, and primary schools.

3.3 Quality Assurance and Data Analysis

Precision and accuracy of pXRF measurements was assessed using Standard Reference Materials (SRM) from the National Institute of Standards and Technology (NIST): NIST2711a, NIST2710a, a silicate blank, and repeat analysis where sites were sampled twice. Recovery of certified values was within acceptable limits (NIST2711a mean 101%; range 90% - 110%; and NIST2710a mean 106%; range 93% - 125%; **Appendix 1**). The majority of blank analyses were below instrument limits of detection (< LOD; **Appendix 1**) for the trace elements assessed. Repeat sample analysis (n = 9) returned a mean percentage recovery of 101% (range 93% to 110%), confirming accuracy in the sampling approach. Given the data was non-normally distributed, a Mann-Whitney U test was used to compare the central tendencies of background soil (subsurface) and surface soil measurements.

A subset of samples (n = 11) was analysed using inductively coupled plasma mass spectrometry (ICP-MS) at the National Measurement Institute (NMI; Sydney, Australia) to compare in-house pXRF total element concentration data to acid digestion analyses. In-house pXRF and NMI ICP-MS data were compared using Pearson's Correlation to examine the linear correlation between analytical methods (**Appendix 2**). Trace elements repeatedly below pXRF LODs (As, Cr, Hg, Mg, Ni) were not included in this statistical analysis. The ICP-MS analysis confirmed that Mg and Hg concentrations were below pXRF LOD (1100 mg/kg Mg; 1 mg/kg Hg), reporting mean concentrations of 206 mg/kg Mg (maximum = 520 mg/kg), and values below ICP-MS laboratory limit of report (0.2 mg/kg) for Hg. Mercury was also tested using cold vapour atomic fluorescence spectroscopy (CV-AFS) to detect low limits (mean = 0.062 mg/kg; **Table 1**). Of the other elements (Al, Cu, Fe, Mn, Pb, Zn) the correlation between pXRF and ICP-MS was found to be statistically significant using a Pearson's Correlation test ($p = 0.016$ to 0.001), returning moderate to very strong correlations between the two analytical methods ($r = 0.703$ to 0.998). For the trace element of interest, Pb, there was a very strong, statistically significant relationship between in-house and external analytical approaches ($p < 0.001$; $R = 0.998$; **Appendix 2**). Quality control measures for ICP-MS and CV-AFS analyses are reported in **Appendix 1**. The quality assurance analysis of the different analytical methods used demonstrates the adequacy of accuracy and precision of the pXRF instrumentation used for the trace element analysis.

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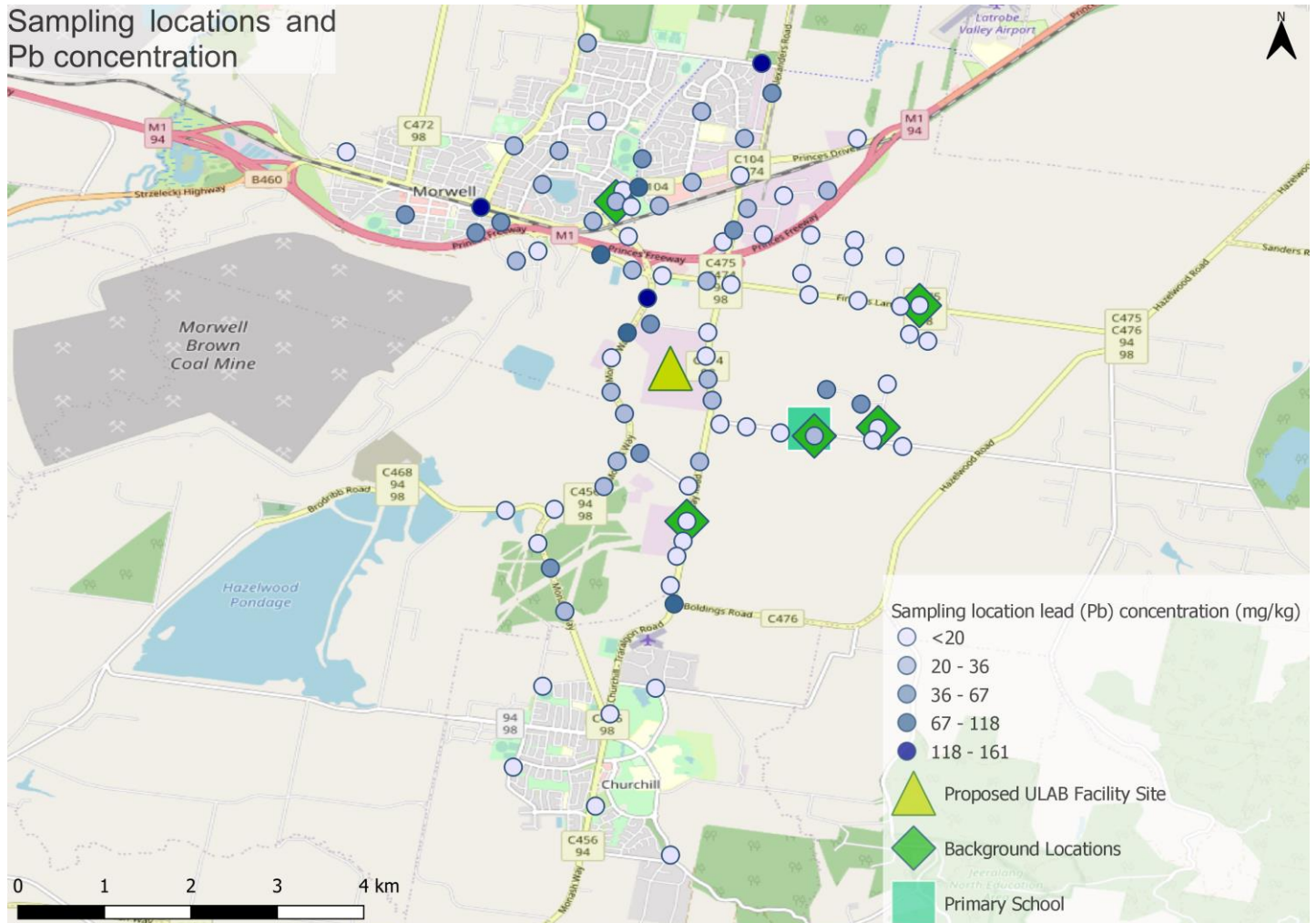


Figure 1. Locations (n = 90) where triplicate surface soil was collected for trace element analysis, and the corresponding concentration of lead (Pb; mg/kg) measured by pXRF at each location. Also identified is the proposed ULAB facility, Hazelwood North Primary School, and five background (subsurface) soil locations.

4. Results and analysis

Trace element concentrations of Al, As, Cr, Cu, Fe, Hg, Mg, Mn, Ni, Pb and Zn in soil showed there were no exceedances of the respective HIL-C values or the Ecological Investigation Levels (EIL) (NEPM, 2013) for any of the sites assessed in this study (n = 90; **Table 1**), nor for any of the individual triplicate samples (n = 270). Further, no soil sample or site exceeded the more conservative HIL-A value for the trace elements assessed (**Table 1**).

Soil Pb concentrations, the focus of concern for some community members, returned mean and median values of 30 and 10 mg/kg, respectively. No individual sample exceeded the more conservative HIL-A value of 300 mg/kg, with the maximum value measured at 161 mg/kg (**Table 1**).

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Table 1. Summary trace element results from the 90 surface soil sites sampled and the Health Investigation Levels (HIL-C and HIL-A; NEPM 2013) used to compare measured data against.

Surface soil n = 90	Trace element concentration (mg/kg)											
	Al	As	Cr	Cu	Fe	Hg	Hg***	Mg	Mn	Ni	Pb	Zn
Minimum	7480	0.5	4	13	7320	0.5	0.018	550	54	2	6	15
Median	19200	1	4	25	15100	1	0.048	550	255	9	19	61
Mean	21000	1	12	31	18400	1	0.062	899	320	14	30	104
Maximum	62400	9	123	111	52400	3	0.120	6160	1390	57	161	818
Standard Deviation	8010	2	21	18	9740	0	0.037	1030	226	14	30	119
Lower 95% CI^^	19300	1	8	27	16400	0	0.049	687	273	11	24	80
Upper 95% CI^^	22700	2	17	34	20400	1	0.075	1110	366	17	36	129
n sites < LOD	0	60	67	0	0	89	0	77	0	31	0	0
NEPM HIL-C												
(Public open space)	N/A	300	300**	17000	N/A	80*		N/A	19000	1200	600	30000
NEPM HIL-A												
(Residential accessible soil)	N/A	100	100**	6000	N/A	40*		N/A	3800	400	300	7400
n sites > HIL-C or HIL-A^	N/A	0	0	0	N/A	0		N/A	0	0	0	0

^Each surface soil site (n = 90) is the average of three triplicate samples analysed for that site (total samples analysed = 270).

^^The 95% confidence interval (CI) represents the range, in relation to the mean value, in which 95% of samples can be expected to occur.

N/A – No HIL-C or HIL-A value available (NEPM, 2013).

*Hg investigation level for inorganic mercury

**Cr investigation level for hexavalent chromium (CrVI); pXRF reports total Cr.

***Hg measurement via CV-ASF (NMI) for improved data accuracy at low Hg concentrations

Table 2. Background soil trace element concentrations measured from subsurface samples (30 - 40cm depth; n = 5) from predominant surface geological groups and areas of public interest. Additional data of trace element concentration at other depths analysed is provided in Appendix 3.

Subsurface soil (n = 5)	Trace element concentration (mg/kg)										
	Al	As	Cr	Cu	Fe	Hg	Mg	Mn	Ni	Pb	Zn
Minimum	14300	0.5	4	10	8450	0.5	550	49	2	8	6
Median	21600	0.5	4	19	10100	0.5	550	141	2	11	18
Mean	21600	0.5	22	20	14200	0.5	1220	194	7	16	36
Maximum	28800	0.5	56	29	23000	0.5	3920	426	15	28	101

Comparison of subsurface soil trace element concentrations (n = 5) from the 30 - 40 cm depth to surface soil (n = 90) showed low to no levels of surface alteration from anthropogenic activities (**Table 1**, **Table 2**). With respect to Pb, median surface soil Pb (19 mg/kg; **Table 1**) was greater than measured subsurface soil median Pb (11 mg/kg; **Table 2**), although this difference was not statistically significant (Mann-Whitney U test; $z = 1.35$; $p = 0.177$). Both surface and subsurface values from Latrobe Valley are higher than the median Australian topsoil (0 - 10 cm) geochemical background of 7.22

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mg/kg (Reimann and de Caritat, 2017). However, measured Pb concentrations in this study were considerably less than the median value from 17,256 Australian residential garden soil samples, of 66 mg/kg Pb (Taylor et al. 2021).

Of the other trace elements assessed, most were below Australian residential garden soil median concentrations (Taylor et al. 2021; As, Cr, Cu, Zn). The exceptions to this were for Mn (207 mg/kg versus 255 mg/kg in this study) and Ni (2 mg/kg versus 9 mg/kg in this study), for which the median differences are marginal. The median values for Al (21,600 mg/kg) and Cu (19 mg/kg) found in this study are higher than the Australian geochemical background values of 9600 mg/kg and 11.2 mg/kg for Al and Cu, respectively (Reimann and de Caritat 2017). The concentrations of all other elements (As, Cr, Fe, Mg, Zn, Ni and Zn) analysed from Latrobe Valley samples were below the geochemical median. These findings suggest there has been minimal to no anthropogenic alteration of trace elements in soil across the study area. Latrobe Valley samples show little elevation in trace elements analysed in comparison with Melbourne studies that found elevated levels exceeding investigation levels for community gardens (8%) and residential gardens (21%) due to widespread Pb in many inner cities (Taylor et al. 2021; Laidlaw et al. 2018).

5. Conclusion

Assessment of surface soil in public open space surrounding the proposed ULAB facility and neighbouring residential areas shows no significant impact from previous anthropogenic activities. This finding can be contrasted to the comparatively elevated concentrations of trace elements found in major cities across Australia, including Melbourne. Of particular relevance to the local community is the finding that Pb concentrations in examined Latrobe Valley soil was below the public open space guideline of 600 mg/kg as well as the more conservative residential value of 300 mg/kg Pb. Given the absence of significant anthropogenic contamination, there are no recommended actions based on the samples analysed for this study.

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Appendices

Appendix 1. Quality assurance data including the instrument limits of detection (LOD), percentage recovery for certified reference materials NIST2711a and NIST2710a, recovery of silicate blanks and replicate samples using pXRF, and corresponding quality assurance data from the National Measurement Institute (NMI) for ICP-MS (NT2.49) and CV-AFS (NT2.44; for Hg) analyses.

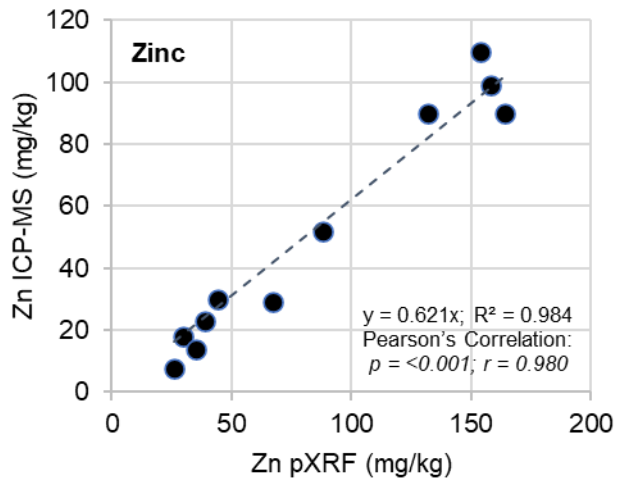
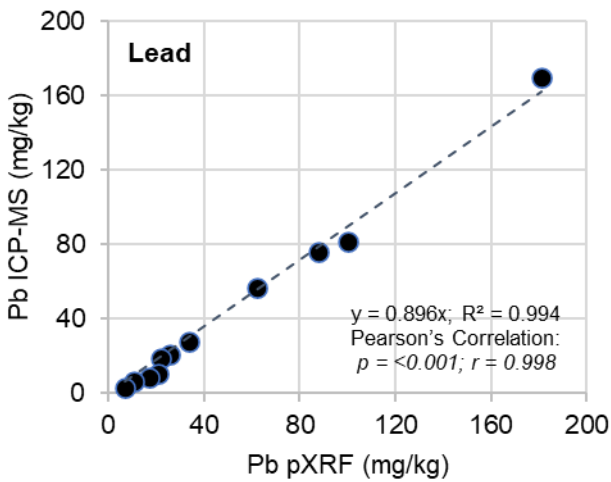
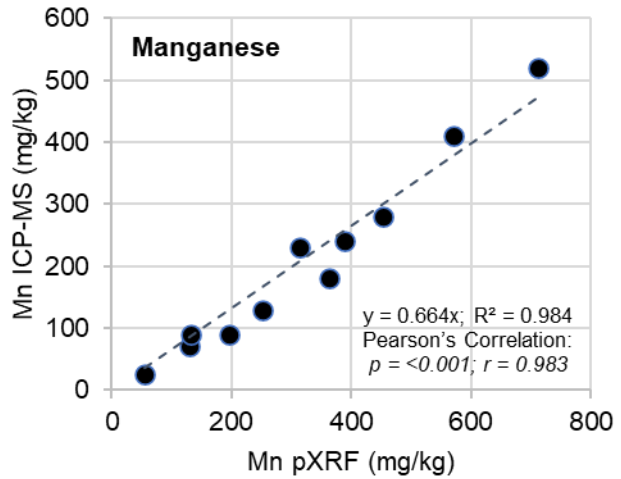
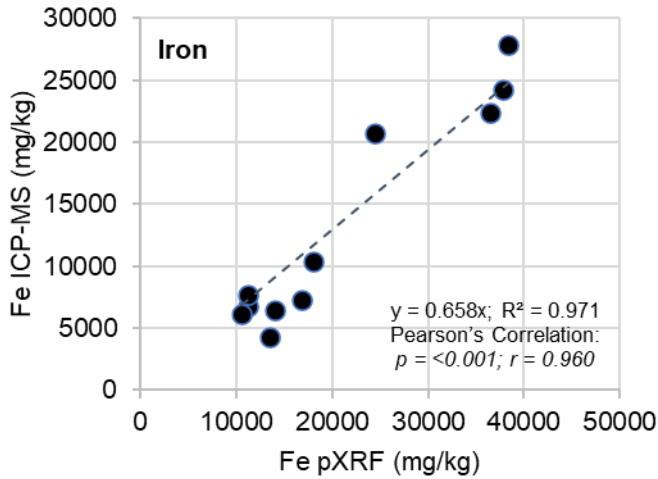
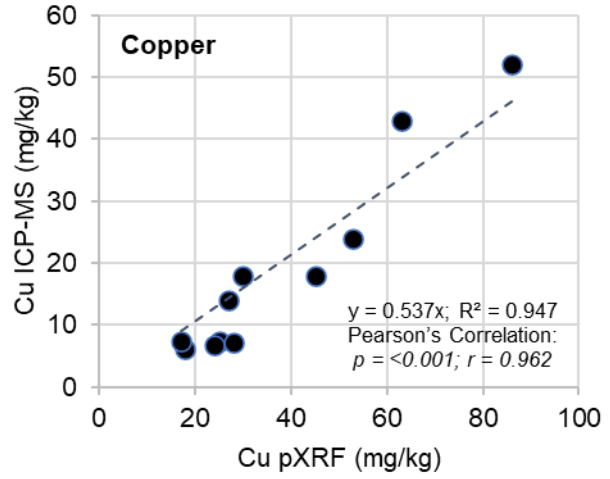
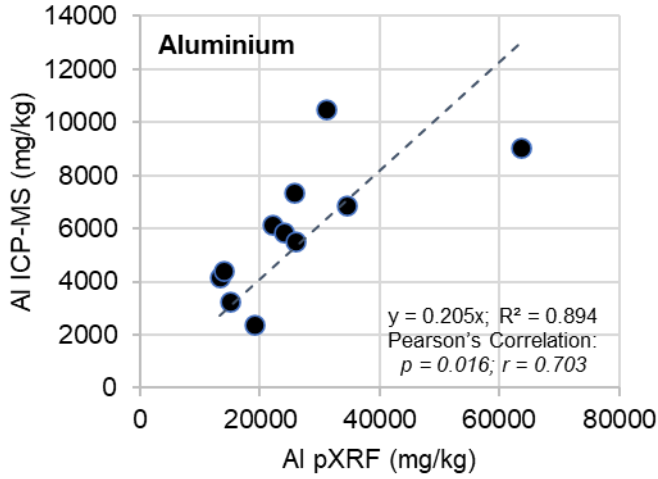
		n	Al	As	Cr	Cu	Fe	Hg	Mg	Mn	Ni	Pb	Zn
pXRF QAQC													
pXRF LOD			95	1	8	2	12	1	1100	5	4	2	1
NIST2711a	Certified value (mg/kg)	11	67200	107	52.3	140	28200	7.42	10700	675	21.7	1400	414
	Recovery (%)	11	98	100.3	90.6	109	98.7	149.5	104	89.5	110.2	98	110.1
NIST2710a	Certified value (mg/kg)	11	59500	1540	23	3420	43200	9.88	7340	2140	8	5520	4180
	Recovery (%)	11	100.4	111.0	<LOD	112.7	100.7	230.0	101.7	92.6	125.0	95.7	111.3
Silicate blank	Mean (mg/kg)	11	<LOD	<LOD	<LOD	6	20	<LOD	<LOD	32	<LOD	<LOD	5
	n > LOD	11	0	0	0	1	1	0	0	1	0	0	5
Replicate Samples	Difference (%)	9	92	40*	105*	99	110	<LOD	<LOD	98	94	101	99
ICP-MS and CV-AFS QAQC													
Blank	Mean (mg/kg)		<1	<0.5	<0.5	<0.5	<1	<0.2/ <0.01 **	<0.5	<0.5	<0.5	<0.5	<0.5
Repeat	Difference (%)		99	100	100	93	100	NA/85 **	111	98	107	189	100
Matrix spike	Recovery (%)		95	102	97	101	102	102/ 102**	101	107	112	109	99
Laboratory control sample	Recovery (%)		104	96	98	98	96	100/ 92**	104	92	103	98	96

*Only one replicate (of 9) reported above pXRF LOD

**Mg is represented as ICP-MS/CV-AFS results for laboratory blanks and samples

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Appendix 2. Comparison of trace element concentrations (Al, Cu, Fe, Mn, Pb, Zn; mg/kg) obtained from pXRF and ICP-MS analyses (n = 11). Due to the recurrence of values below instrument limits of detection comparison of As, Cr, Hg, Mn and Ni are not included.



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Appendix 3. Trace element concentrations at 0 – 2 cm, 2 – 10 cm, 10 – 30 cm and 30 – 40 cm depths measured from five profile pit locations across the study area. Values for As, Cr, Hg, Mg and Ni were below instrument limits of detection at two or more profile pit locations and were not included in the display.

