Hawke's Bay Region: Background soil concentrations for managing soil quality

Report no. RM 14-03, HBRC plan no. 4611

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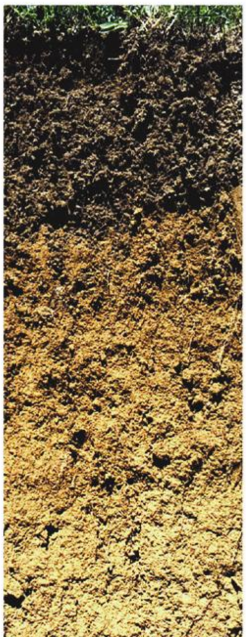

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Contents

Summary

Project and Client

- This report provides an initial assessment of background concentrations of selected trace elements in soil, based on existing data, and provides recommendations for the determination of background concentrations across the Hawke's Bay Region. This project was undertaken for Hawke's Bay Regional Council with funding from Envirolink (Advice Grant 1443-HBRC194).

Objectives

- To develop background soil concentrations for the Hawke's Bay region based on existing data.

Methods

- Statistical analyses of soil quality monitoring data provided by Hawke's Bay Regional Council were undertaken using R version 3.0.2, to determine the 95th and 99th percentile, while a bootstrapping technique was used to determine the 95th percentile upper confidence limit of the 95th percentile. Additional analysis of existing soil monitoring data, including the use of spatial databases (S-Map, LRI and Q-Map) to extract additional information on the current soil monitoring sites.

Results and conclusions

- Soil quality monitoring across the Hawke's Bay Region has been undertaken 2000, 2011 and 2014 on various land-uses including orchards, vineyard, cropping, extensive sheep and beef.
- Various terms used to describe background soil concentrations of naturally occurring trace elements. Baseline concentrations most accurately describe the concentrations determined from soil monitoring undertaken in the Hawke's Bay region to date. Baseline concentrations may be analogous to natural background for chemical substances at sites not influenced by diffuse or other anthropogenic sources.
- In general the trace element concentrations in all samples were relatively low. One orchard site had markedly elevated copper concentrations
- Preliminary estimates of the upper limit for background concentrations were based on the 95th percentile upper confidence limit of the 95th percentile, and are shown below alongside additional information on the concentration of individual trace elements.

Element	N	Max (mg/kg)	Min (mg/kg)	Median (mg/kg)	Estimated upper limit of background concentration (mg/kg)
As	69	10.2	<2	3	9.0
Cd	69	0.79	<0.1	0.27	0.7
Cu	67	53	3	10	32
Cr	69	25	4	13	24
Ni	69	20	2	8	17
Pb	69	36.5	2.6	9.1	27
U	69	3.6	0.4	1.0	2.8
Zn	69	122	24	51.0	105

- Some estimates of background concentrations may over-estimate the naturally occurring background concentrations as all sites are agricultural sites and thus some anthropogenic input for some elements (notably Cu, Cd, Zn and to a lesser extent As and Pb) may have occurred. This is particularly the case for Cd a contaminant in phosphate fertiliser which will have been applied to the majority of sites However, the estimated upper limit of background concentrations for Cd for the Hawke's Bay region was very similar to that determined nationally (0.6 mg/kg) for background soil concentrations.

Recommendations

- Additional sampling is required to develop more robust estimates of background concentrations in the Hawkes Bay region. Specifically additional sampling is required on exotic and indigenous forest, scrub and shrubland sites, primarily located on Podzol, Pumice and Allophanic soils that have typically not been used for agriculture (excluding pumice) and thus included in current sampling regime.
- Additional sampling at locations where anthropogenic input of trace elements is not expected, across the region would also provide additional data to support the development of more robust estimates of background soil concentrations.
- Defining the use of background soil concentration information in a regulatory context would also aid in determining whether the currently proposed upper limits are appropriate or whether alternative upper limits may be appropriate.

1 Introduction

Increasing recognition is being given to the importance of knowing background soil concentrations of various trace elements to assist with managing soil quality (for example, understanding the increase over background of certain trace elements e.g. Cd, to understand the anthropogenic impact and whether this has an impact on soil biota – noting that recent recommendations for the development of Eco-SGVs in New Zealand (MPI 2012) allows for the inclusion of background concentrations in the development of Eco-SGVs for selected substances); management of contaminated land (for example, the recently implemented National Environmental Standards (NES) for contaminants in soil does not apply if it can be demonstrated that any soil contaminants in or on the piece of land of interest are at, or below background concentrations); waste disposal (e.g. cleanfill criteria) and for assessing soil quality.

Understanding the variation in background concentrations of trace elements across the Hawke's Bay region will assist in managing soil quality, contaminated land, including the prevention of unnecessary remediation, and potentially waste disposal, whilst ensuring appropriate protection of the environment.

2 Background

There are three different definitions for background concentrations:

Natural background – The concentrations of naturally occurring elements derived/originating from natural processes in the environment as close as possible to natural conditions, exclusive of specific anthropogenic activities or sources. May also be referred to as the geochemical background. Attributable to mineral content derived from parent materials, and influence of soil-forming processes.

Ambient background – The concentrations of chemical substances in the environment that are representative of the area surrounding the site not attributable to a single identifiable source. This can include contaminants from historical activities and widespread diffuse impacts, e.g. fallout from motor vehicles. Referred to as 'normal' concentrations in the UK (DEFRA 2012).

Baseline – The soil concentrations of chemical substances in a specified location at a given point in time. Baseline concentrations are analogous to natural background concentrations where the specified locality is not influenced by diffuse or other anthropogenic sources, or to ambient concentrations when the specified locality is influenced by diffuse anthropogenic sources. In contrast to ambient and natural background concentrations, baseline concentrations also include concentrations in locations known to be influenced by land use (e.g. agricultural land use).

Baseline concentrations most accurately describe the concentrations determined from soil monitoring undertaken in the Hawke's Bay Region. As noted above, baseline concentrations may be analogous to natural background for chemical substances at sites not influenced by diffuse or other anthropogenic sources. For the sites under consideration, this is likely to apply to Cr and Ni, As, Pb (although there is the potential for some historic use of lead arsenate pesticide). There may be some use of products containing Cu (copper-based fungicides), Cd (phosphatic fertilisers), and Zn (facial eczema treatment) on some land-uses that may elevate the concentrations of these trace elements.

3 Objectives

- To determine background soil concentrations for selected trace elements based on existing data and/or identify what is needed (e.g. additional sampling) to adequately determine background concentrations in the Hawke's Bay Region.

4 Methods

Existing soil quality monitoring data was provided by Hawke's Bay Regional Council. Statistical analyses were undertaken using R version 3.0.2, to determine the 95th and 99th percentile, while bootstrapping technique was used to determine the 95th percentile upper confidence limit of the 95th percentile. Additional analysis of the soil monitoring data was undertaken using spatial databases (S-Map (Smap http://smap.landcareresearch.co.nz), LRIS (http://lris.scinfo.org.nz/) and Q-Map – see Cavanagh et al 2013a for more detail) to extract additional information on the current soil monitoring sites. Geographical information systems were used to map the location of sampling sites in relation to soil order, while data from Landcover database 3 (LCDB3) was used to map the location of sample sites in relation to land-cover.

5 Results

5.1 Determination of background concentrations

A summary of the concentrations of arsenic, cadmium, copper, chromium, nickel, lead, uranium and zinc for all soil quality monitoring data are shown in Figure 1, with the detailed data for individual sites in Appendix 1. The majority of concentrations fall within a narrow range, with some outliers observed for As, Cd, Cu, Pb, U. Closer inspection of the data showed that the two highest concentrations of copper were from samples collected from orchard sites. As copper sprays are often used on orchard sites, these sites were excluded from determination of likely background concentrations of copper. The orchard site with the highest copper concentration also had the highest concentration of lead. Elevated lead concentrations on horticultural sites are typically considered to be associated with the historic usage of lead arsenate, however, arsenic concentrations at this site do not appear to be elevated. As such data from all sites were retained in the determination of background concentrations for lead. There were also no obvious reasons to exclude outlying concentrations for As and U from determination of background concentrations, hence all data was retained. All data was retained for the determination of background concentrations for Cd although it is recognised that the application of phosphate fertilisers will result in the addition of Cd to agricultural soils, leading to over-estimation of a natural background concentrations.

Mercury was also analysed at all sites and was typically present at concentrations <0.1 mg/kg (the detection limit for sampling for all years except 2000), with the exception of two sites.

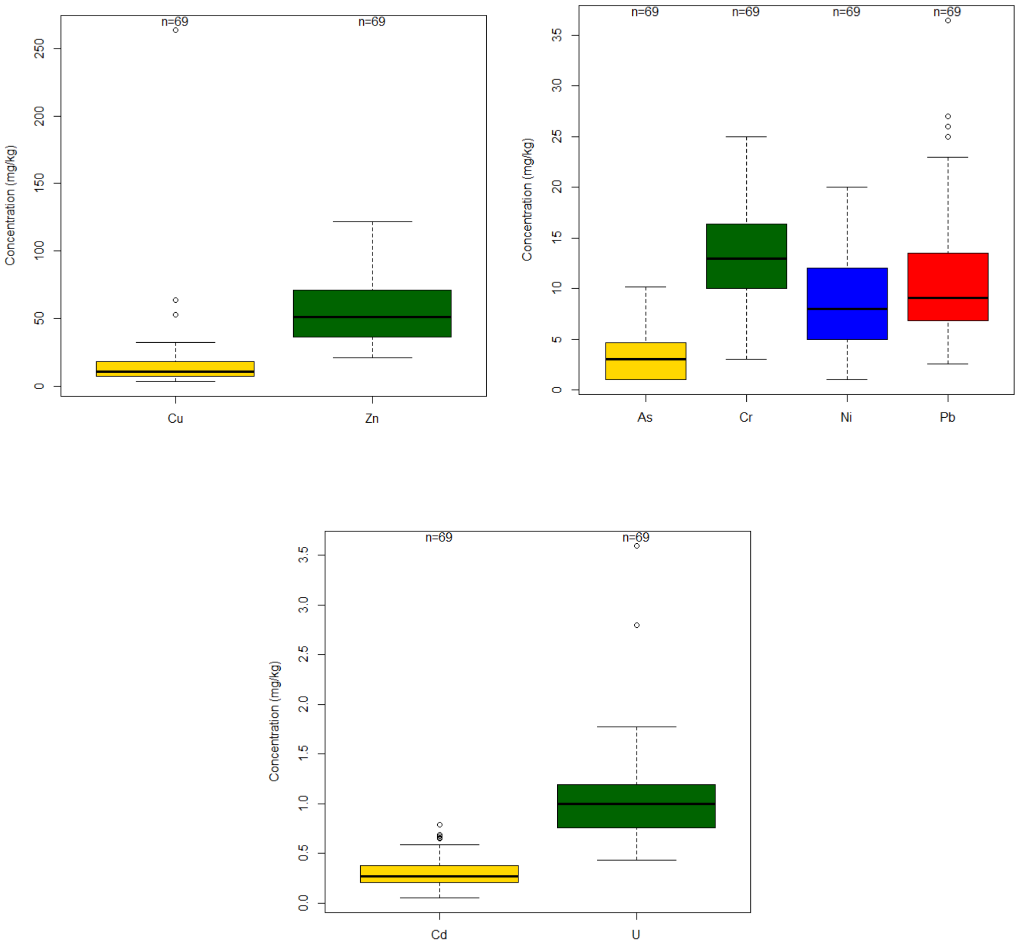

Figure 1 Boxplot showing spread of concentration (mg/kg) for a) Cu and Zn, b) As, Cr, Ni, Pb and c) Cd and U concentrations in all samples.

Different limits have been used to define the upper limits of background concentrations and an aspect raised in Cavanagh (2013a) was that consensus was needed for the appropriate upper limit(s) (e.g. 99th percentile, 95th UCL, median) to be used for different land-management purposes. The 95th percentile of concentrations from locations under different land use has been used in the development of some cleanfill criteria in New Zealand (Cavanagh 2013b). In contrast, the 99th percentile concentration of arsenic in soils collected from around the country and thought not to have been affected by anthropogenic activities was used as the soil contaminant standard (SCS) for the rural residential land-use scenario in the NES, as the derived value for this scenario was below this concentration. Similarly, the 99th percentile concentration of cadmium in soils collected from around the country and thought not to have been affected by anthropogenic activities is used to define the first tier of the Tiered Fertiliser Management System for Cadmium (MAF 2011). Internationally, the upper confidence limit of the 95th percentile is typically used as upper limit for background soil concentrations (see Cavanagh 2013a, although some authors, indicate there is little difference between that and the 99th percentile value (Diamond et al. 2009).

A summary of the concentrations for individual trace elements for the background soil concentrations subset of data, along with calculated 95th percentile, the upper confidence limit of the 95th percentile, and the 99th percentile concentrations are shown in Table 1. As can be seen, the upper confidence limit of the 95th percentile and the 99th percentile concentrations are very similar as observed by Diamond et al. (2009). However, the choice of upper limit may be less significant than the appropriate “grouping” of soils with similar features. Cavanagh (2013a) also recommended that more extensive analysis (including the use of spatial tools such as S-Map) of existing data should be undertaken to identify key factors influencing trace elements. This is discussed in section 5.2.

Table 1 Summary of concentrations (mg/kg) of individual trace elements, and various estimates of upper limits for nominal background concentrations

Element	N	Max	Min	Median	95th percentile	95UCL	99th percentile
As	69	10.2	<2	3	7.0	9.0	10.1
Cd	69	0.79	<0.1	0.27	0.67	0.69	0.72
Cu	67	53	3	10.0	27.7	32	39.1
Cr	69	25.0	4	13.0	22.7	24.8	24.9
Hg	69	0.23	<0.1	<0.1	ND[1]	ND	ND
Ni	69	20.0	2	8	16.9	17.6	18.6
Pb	69	36.5	2.6	9.1	24.2	27	30
U	69	3.6	0.4	1.0	1.6	2.8	3.1
Zn	69	122	24	51.0	99.8	107	112

[1]Not determined – only two samples were present at concentrations >0.1 mg/kg.

5.2 Representativeness of estimates of background concentrations

The location of sites for which soil quality data are available and the distribution of different land-cover classes and soil orders across Hawke’s Bay, and are shown in Figures 2 and 3 respectively. Existing sample information is available only from agricultural sites located across the region. Agricultural land-use is located mainly on Brown, Pallic, Pumice and Recent soils (Table 2) and the most obvious gap in sampling locations is exotic forest, indigenous forest and scrub and shrubland sites which are primarily located on Podzol, Pumice and Allophanic soils.

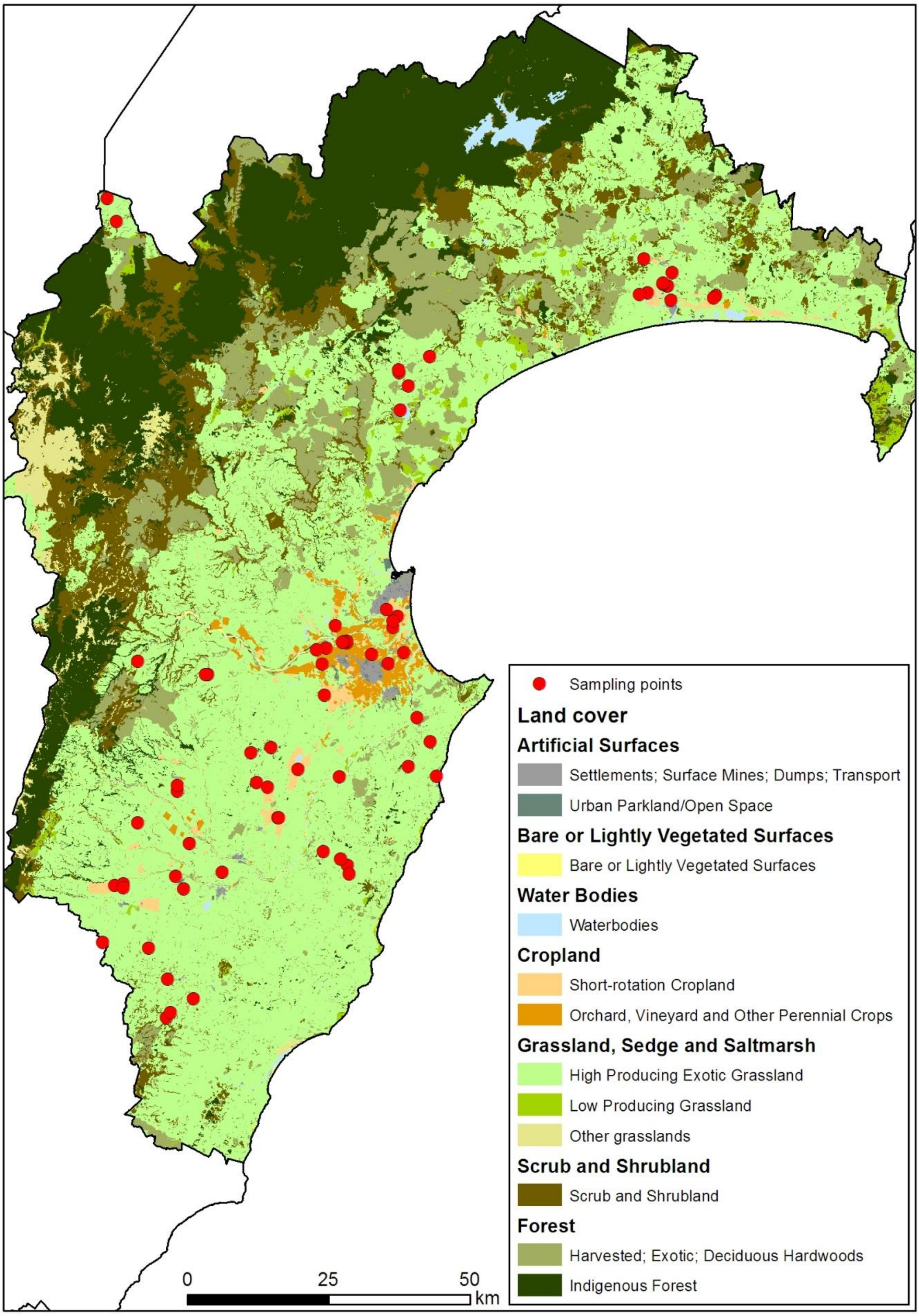

Figure 2 Location of monitoring sites and distribution of different land-cover classes across Hawke's Bay.

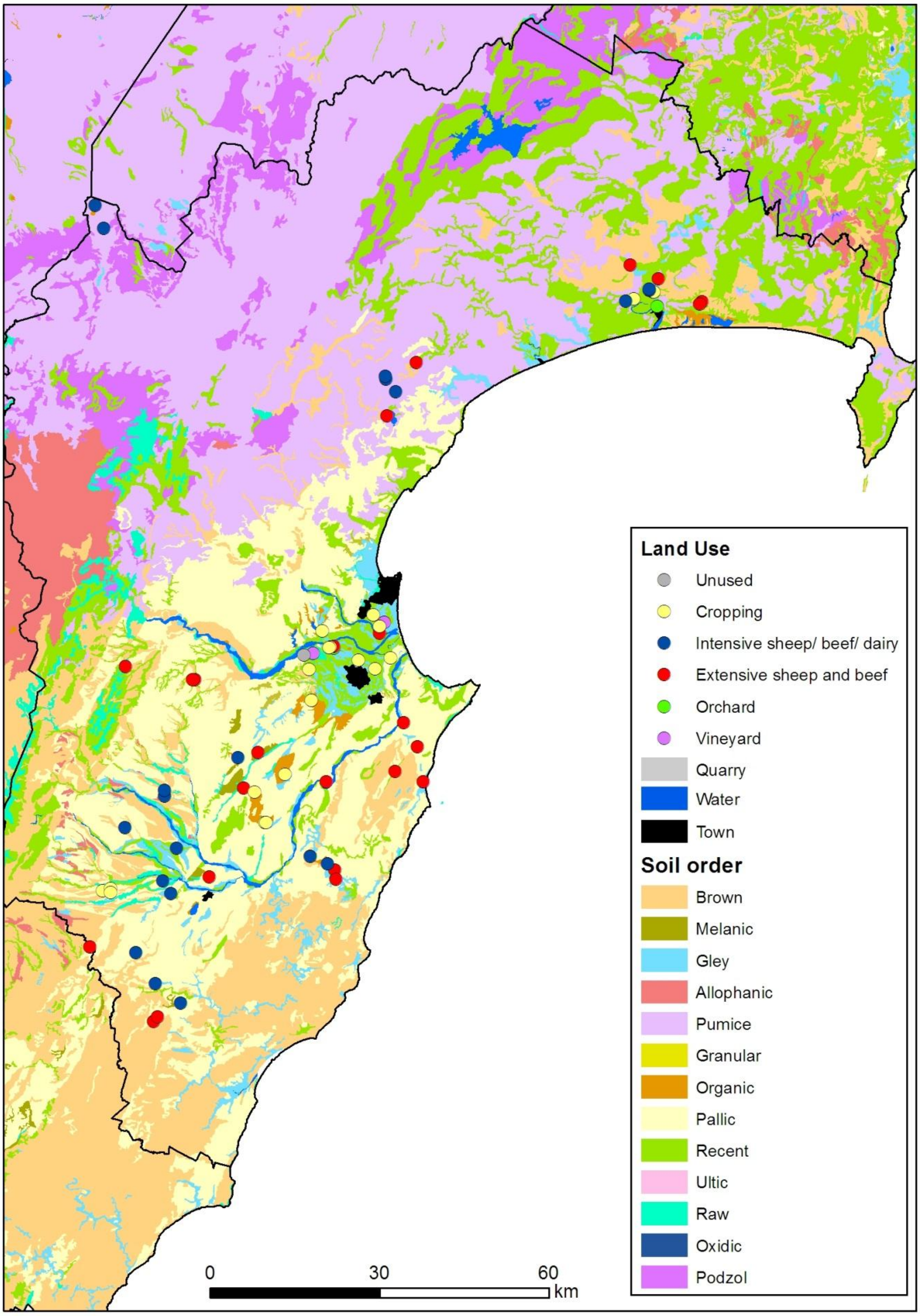

Figure 3 Location of soil monitoring sites with associated land use, and distribution of soils from different Soil Orders across Hawke's Bay.

The key drivers of variation of naturally occurring trace element concentrations in soil in New Zealand have not been identified, although it generally considered that the geological origin of the parent material of the soil will influence concentrations, for example basic rocks with higher concentrations of mafic minerals often have elevated Cr and Ni. Spatial databases such as, S-Map, LRIS and Q-Map (see Cavanagh 2013a for more detailed description of these databases) were used to extract information related to the origin of the soil parent materials at the sampling locations (Table 2). There are constraints in extracting site-specific data from these databases due to the mapping scales used by the respective systems, that is, the information extracted for a given site will be the predominant 'value' for the relevant mapping unit, which may or may not be strictly accurate for that site. However, such information may be useful in identifying general patterns. In this case, there is limited variation in the concentrations of individual trace elements across the sites, suggesting that the variation in trace elements arising from the identified rock-types is also limited. Further sampling across the region, including sites of differing geological origin, will assist in determining whether the initial estimates of background concentrations are applicable across the wider region.

Table 2 Soil Order and rock classification extracted from S-Map, LRI or Q-Map for the Hawke's Bay Regional Council soil monitoring locations shown in Figure 2 and 3. Number of sites from the current dataset that are in the different groups are shown in brackets

Soil Order	Number	'Rock-type-of-fines' – S-Map	Rock – LRIS[1]	Main rock – QMap
Brown	5	Hard sedimentary sandstone (1)	Li+Sm, Gr (2), Lo/Mm, Mm	Gravel (2), sandstone (2), mudstone (2)
Pallic	16	Hard sedimentary sandstone (3)	Me+Mj (1), Me (1), Gr (2), Ac(1), Lo/Li (1), Lo (1), Lo/Li (1),Lo/Gr+Mj (1), Al (1), Lo/Gr (3), Lo/Sm+Li (1), Lo/Li+Sn (1), Mb+ Al (1)	Gravel (9), mudstone (3), claystone (1), debris (1), limestone (1), sandstone (1)
Gley	10	Hard sedimentary sandstone (5)	Al (8), Li+Sm(1), Wb (1)	Gravel (7), mudstone (1), limestone (1),sand (1)
Recent	19	Hard sedimentary sandstone (6), soft sedimentary mudstone (1)	Al (13), Gr/Sm (2), Wb (1), Sm (1), Gr (1), Al/Tp (1)	Gravel (16), sandstone (1), pumice (1), mudstone (1)
Pumice	8	(0)	Mm(3), Mo/Sm (2), Kt/Lp/Vo (1), Tp (1), Sm (1)	Mudstone (2), sandstone (3), ignimbrite (2), gravel (1)
Organic	5	(0)	Al+Pt (2), Al (3)	Peat (3), gravel (2)
Melanic	2	(0)	Lo/Li, Me	Limestone (1), claystone (1)
Raw	3	Hard sedimentary mudstone (2)	Gr (2), Gw (1)	Gravel (2), sandstone (1)

[1] Al-alluvium, Gr- gravels; Lo – loess; Wb-windblown sands; Pt-peat; Mm – massive mudstone; Me-bentonitic mudstone; Mj-jointed Mudstone; Sm-massive sandstone; Li-limestone; Gw – greywacke; Ac-crushed argillite; Kt – Kaharoa &Taupo ashes; Tp – Taupo &Karaoa breccia and pumiceous alluvium; Lp – Pumiceous lapilli ; Vo – Lavas & welded ignimbrites.

6 Conclusions

Preliminary estimates of the upper limit of background concentrations for selected trace elements in the Hawke's Bay region are:

Element	N	Estimated upper limit of background concentration (mg/kg)
As	69	9.0
Cd	69	0.7
Cu	67	32
Cr	69	24
Ni	69	17
Pb	69	27
U	69	2.8
Zn	69	105

These upper limits are based on the 95th upper confidence level of the 95th percentile concentrations for the individual analytes from existing soil quality monitoring sites which were not considered to be significantly impacted by anthropogenic input. However, the estimates for Cd are recognised to over-estimate background concentrations of Cd, as all sites will have had phosphate fertiliser applied, and thus some input of Cd. Nonetheless, Cd concentrations are low and only marginally above national estimates of background soil Cd concentrations (0.6 mg/kg).

Depending on the application of this information on background concentrations, different upper limits may be used, although we noted little difference between 95th upper confidence level of the 95th percentile concentrations (often used internationally) and the 99th percentile concentrations (often used in New Zealand).

7 Recommendations

- Additional sampling is required to develop more robust estimates of background concentrations in the Hawkes Bay region. Specifically additional sampling is required on exotic and indigenous forest, and scrub and shrubland sites that are primarily located on Pumice, Podzol and Allophanic soils. Agricultural landuse typically does not occur on Podzol and Allophanic soils and thus have not been included in current sampling regime.
- Additional sampling at locations across the region where anthropogenic input of trace elements is not expected would also provide additional data to support the development of more robust estimates of background soil concentrations.

- Defining the use of background soil concentration information in a regulatory context would also aid in determining whether the currently proposed upper limits are appropriate or whether alternative upper limits may be appropriate.

8 Acknowledgements

Barry Lynch and Keiko Hashiba (Hawkes Bay Regional Council) are thanked for providing soil quality data. Ian Lynn and Sam Carrick are thanked for providing comment on draft reports.

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Appendix 1 – Data from individual sampling sites

Table 3 Summary of trace element concentrations (mg/kg) at individual sampling sites

HBRC land-use category	Detailed land use	Year of sampling	Soil Order	Arsenic (mg/kg)	Cadmium (mg/kg)	Chromium (mg/kg)	Copper (mg/kg)	Lead (mg/kg)	Mercury (mg/kg)	Nickel (mg/kg)	Uranium (mg/kg)	Zinc (mg/kg)	Fluoride (mg/kg)
Orchard	Stonefruit, 20 yrs	2000	Gley	7.4	0.28	24.8	264	36.5	0.23	17.9	1.37	122	
Orchard	Stonefruit, long-term	2000	Recent	3.4	0.19	10.2	63.5	13.6	0.09	6.5	0.825	77.6	
Vineyard	Vineyard	2000	Recent	4.2	0.13	14.7	15.1	8.7	0.04	10.7	0.654	47.4	
Vineyard	Vineyard	2000	Raw	4.6	0.24	16.4	22.0	21.5	0.04	9.5	0.466	107	
Extensive pasture	Horse paddock, rough pasture	2000	Gley	10.2	0.24	21.3	17.7	23.0	0.06	14.9	1.24	84.5	
Extensive pasture	Racing club track	2000	Recent	2.5	0.29	17.5	10.7	16.7	0.06	12.3	1.12	85.2	
Extensive pasture		2000	Gley	2.4	0.32	12.3	6.7	9.1	0.03	8.8	0.728	49.0	
Extensive pasture		2000	Pallic	1.9	0.38	10.9	9.0	8.1	0.04	7	0.986	50.2	
Extensive pasture	Sheep	2000	Recent	5.2	0.18	21.3	18.8	14.5	0.07	16.2	1.20	64.6	
Deer		2000	Pallic	2.2	0.38	11.5	15.3	11.8	0.04	4.8	1.18	36.2	
Unused	Unused (stoney gravels)	2000	Raw	3.2	0.05	13.1	7.1	11.4	0.06	9.3	0.502	51.0	
Cropping	Peas	2000	Gley	5.8	0.20	22.2	23.9	20.1	0.08	16.4	1.30	78.3	
Cropping	Arable	2000	Recent	2.3	0.26	13.2	7.8	9.3	0.05	12.5	0.976	60.4	
Cropping	Peas	2000	Gley	4.7	0.44	16.3	26.9	13.5	0.09	16.7	1.77	73.5	
Cropping	Arable	2000	Recent	6.2	0.17	22.3	24.0	15.8	0.08	17.1	1.25	68.6	
Dairying		2000	Recent	2.6	0.36	12.3	6.4	6.6	0.03	9	1.06	46.7	
Extensive sheep and beef		2011	Pallic	2	0.27	11	11	7.6	<0.10	8	0.96	51	390

HBRC land-use category	Detailed land use	Year of sampling	Soil Order	Arsenic (mg/kg)	Cadmium (mg/kg)	Chromium (mg/kg)	Copper (mg/kg)	Lead (mg/kg)	Mercury (mg/kg)	Nickel (mg/kg)	Uranium (mg/kg)	Zinc (mg/kg)	Fluoride (mg/kg)
Extensive sheep and beef		2011	Pallic	<2	0.11	7	4	7.4	<0.10	4	0.76	34	260
Extensive sheep and beef		2011	Brown	<2	0.1	9	3	6.1	<0.10	4	0.45	41	196
Extensive sheep and beef		2011	Gley	2	0.21	8	4	8.2	<0.10	4	0.57	32	240
Extensive sheep and beef		2011	Pallic	3	0.3	13	20	9.9	<0.10	9	0.76	48	270
Extensive sheep and beef		2011	Pallic	2	0.32	6	7	5.3	<0.10	5	0.63	45	240
Extensive sheep and beef		2011	Brown	2	0.27	10	9	7.5	<0.10	5	0.73	46	260
Extensive sheep and beef		2011	Melanic	2	0.46	12	14	8.9	<0.10	10	0.8	65	300
Extensive sheep and beef		2011	Recent	<2	0.35	11	9	9.1	<0.10	10	1.2	71	300
Extensive sheep and beef		2011	Raw	<2	0.59	12	20	6.8	<0.10	6	1.53	69	500
Extensive sheep and beef		2011	Pumice	<2	0.53	7	5	5.4	<0.10	3	0.94	36	400
Extensive sheep and beef		2011	Recent	<2	0.43	4	5	3.9	<0.10	2	0.66	25	360
Extensive sheep and beef		2011	Recent	<2	0.1	5	3	5.8	<0.10	4	0.43	27	270
Extensive sheep and beef		2011	Brown	2	0.15	15	7	8.8	<0.10	11	1.02	52	340
Extensive sheep		2011	Pumice	<2	0.23	7	4	6	<0.10	5	0.8	36	340

HBRC land-use category	Detailed land use	Year of sampling	Soil Order	Arsenic (mg/kg)	Cadmium (mg/kg)	Chromium (mg/kg)	Copper (mg/kg)	Lead (mg/kg)	Mercury (mg/kg)	Nickel (mg/kg)	Uranium (mg/kg)	Zinc (mg/kg)	Fluoride (mg/kg)
and beef													
Extensive sheep and beef		2011	Recent	<2	0.32	5	4	5.1	<0.10	4	0.73	33	350
Extensive sheep and beef		2011	Recent	2	0.34	14	9	9	<0.10	7	0.97	71	310
Extensive sheep and beef		2011	Recent	3	0.26	14	10	8.2	<0.10	6	0.77	48	240
Extensive sheep and beef		2011	Pallic	4	0.69	17	16	14.4	0.12	6	0.71	63	240
Intensive pasture	Bull beef	2013	Melanic	3	0.66	16	16	11.3	< 0.10	8	1.1	73	280
Intensive pasture	Bull beef	2013	Recent	7	0.25	25	31	25	< 0.10	20	1.05	98	510
Intensive pasture	Bull beef	2013	Pallic	4	0.51	18	14	11.2	< 0.10	11	1.02	61	260
Intensive pasture	Bull beef	2013	Gley	3	0.22	14	15	12.6	< 0.10	11	0.74	65	370
Intensive pasture	Bull Beef	2013	Pallic	3	0.22	10	7	12.1	< 0.10	4	1	28	270
Intensive pasture	Bull Beef	2013	Organic	4	0.43	18	25	12	< 0.10	14	1.62	72	420
Intensive pasture	Dairying	2013	Pumice	< 2	0.79	18	7	2.6	< 0.10	14	1.48	55	600
Intensive pasture	Dairying	2013	Pumice?	< 2	0.34	4	7	3.2	< 0.10	3	0.83	21	460
Intensive pasture	Dairying	2013	Pumice	< 2	0.67	7	10	6	< 0.10	3	1.34	35	510
Intensive pasture	Dairying	2013	?	< 2	0.53	7	15	4.4	< 0.10	3	1.16	33	320
Intensive pasture	Dairying	2013	Pumice	< 2	0.65	5	12	4.6	< 0.10	< 2	1.38	27	400
Intensive pasture	Dairying	2013	Gley	< 2	0.47	11	7	6.1	< 0.10	7	1.09	46	290
Intensive pasture	Dairying	2013	?	< 2	0.22	3	3	4.6	< 0.10	2	0.6	29	330
Cropping	Mixed arable	2014	Gley	10	0.18	23	26	27	< 0.10	16	1.19	98	470
Cropping	Mixed arable	2014	Recent	6	0.21	18	53	26	< 0.10	14	0.85	105	390

HBRC land-use category	Detailed land use	Year of sampling	Soil Order	Arsenic (mg/kg)	Cadmium (mg/kg)	Chromium (mg/kg)	Copper (mg/kg)	Lead (mg/kg)	Mercury (mg/kg)	Nickel (mg/kg)	Uranium (mg/kg)	Zinc (mg/kg)	Fluoride (mg/kg)
Cropping	Mixed arable	2014	Pallic	5	0.26	17	17	18.9	< 0.10	14	1.07	83	360
Cropping	Mixed arable	2014	Recent	7	0.17	24	28	20	< 0.10	17	1.56	83	410
Cropping	Mixed arable	2014	Gley	6	0.16	19	32	16.7	< 0.10	13	1.13	69	390
Cropping	Mixed arable	2014	Recent	5	0.29	16	11	15.3	< 0.10	11	1.03	69	460
Cropping	Mixed arable	2014	Recent	5	0.1	18	9	13.3	< 0.10	12	0.75	60	370
Cropping	Mixed arable	2014	Recent	3	0.24	12	5	9.1	< 0.10	9	0.88	48	300
Cropping	Mixed arable	2014	Gley	5	0.38	15	19	13.6	< 0.10	13	1.64	74	310
Cropping	Mixed arable	2014	Pallic	7	0.37	15	16	11.4	< 0.10	9	2.8	51	270
Cropping	Mixed arable	2014	Organic	5	0.11	7	20	3.1	< 0.10	7	3.6	24	24
Cropping	Mixed arable	2014	Organic	5	0.21	6	17	4.7	< 0.10	3	1.36	24	400
Cropping	Mixed arable	2014	Brown	4	0.28	14	17	11.6	< 0.10	8	1.08	101	270
Cropping	Mixed arable	2014	Pallic	2	0.15	10	6	7.5	< 0.10	5	0.59	40	197
Cropping	Mixed arable	2014	Pallic	3	0.23	13	10	9.7	< 0.10	6	0.89	37	230