Background Levels of Agrichemical Residues in Bay Of Plenty Soils

A preliminary technical investigation

Prepared by SEM NZ Limited

March 2005

SEM Reference: NP859.RP1

Environment Bay of Plenty Preface

This report presents the results of the first region wide investigation of the background levels of agrichemical residues in Bay of Plenty soils. While a number of individual sites in the Bay of Plenty have been tested for specific soil contaminants, this is the first study to be undertaken on a comprehensive basis. The study included sampling of sites from six relevant land use classes in the Bay of Plenty plus control sites on unmodified land.

The study was managed by Environment Bay of Plenty as a joint project between Environment Bay of Plenty, Tauranga City Council and the Western Bay of Plenty, Rotorua, Whakatane and Opotiki District Councils. The study was designed to establish the background level of risk to human health and the environment posed by agrichemical residues that are present in the region's soils. The results from the study are being used by both the regional and district councils to develop and implement land use policies to ensure that future changes in land use are both suitable for that new use, safe and environmentally sustainable.

This study would not have been possible without the cooperation of the landowners who participated in the survey to whom Environment Bay of Plenty is very grateful. In total over 130 landowners agreed to participate in the study with 128 sites finally being sampled. This large number of sampled sites provided very useful and statistically reliable data that is relevant to both the regional council and the five participating district councils.

The soil sampling, analysis and writing of the report was undertaken by SEM New Zealand Limited, who recently merged with the larger resource and environmental consultancy group of Kingett Mitchell Limited.

The sampling method adopted was a composite sampling approach[1] which deliberately avoided any known hot spots[2]. While this provided a better estimate of background agrichemical residue levels under different land uses it prevents the results of this study from being used to indicate the actual or maximum level of agrichemical residue either generally or at any one specific location. Further, in order to gain landowner cooperation, the specific results for individual sites were kept confidential to the consultant and the relevant landowner and were not supplied to councils. Studies to establish the actual level of agrichemical residues would therefore, require more comprehensive and expensive site specific surveys.

The one major hurdle to this type of study is the lack of relevant national guidelines that can be used to assess the risks (if any) posed by the identified levels of agrichemicals. The study used trigger level (guideline) values that included both human health and environmental protection values (as did similar studies of soils in the South Auckland and Waikato regions and Tasman district). However, the study strengthens the need to evaluate future land proposed for subdivision to ensure that it at least meets the appropriate human health guideline values. The appropriate guideline values need to reflect the specific circumstances for the particular site.

In addition there are questions relating to the choice and robustness of the applicable guideline values for agrichemical residue studies. Currently there are moves to have some of these guidelines reviewed, especially those relating to copper and DDT. Unfortunately, while work is being undertaken to review these guideline values it is unlikely to be finished within the next two years. In the light of these recent developments some of the initial trigger values used in the study appear to be conservative (low). However a more definitive answer will only be forthcoming after the criteria are fully reviewed by the Ministry for the Environment and the Ministry for Health. Consequently the interpretation of the results from this study will need to take into account the limitation of the study (as outlined in the report).

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[1] The sample analysed from each site was a composite of 10 sub-samples taken on a zigzag pattern from an area of approximately 1 hectare.

[2] Hotspots are areas that are either known to have or likely to have received very high levels of agrichemicals e.g. chemical mixing or storage areas, sheep dip sites etc.

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PRELIMINARY INVESTIGATION REPORT

AGRICHEMICAL RESIDUE CONCENTRATIONS IN THE BAY OF PLENTY

September 2004

Presented to:
Environment Bay of Plenty
5 Quay Street
WHAKATANE

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Acknowledgments

This project was completed with the assistance of a large number of people, and was jointly funded by Environment Bay of Plenty (EBOP) and five district councils, Tauranga City Council (TCC), Western Bay Of Plenty (WBOPDC), Rotorua (RDC), Whakatane (WDC), and Opotiki District Councils (ODC) within the Bay of Plenty region.

Prior to awarding SEM New Zealand Limited (SEM) the investigation and reporting phase of the project, significant consultation was carried out between regional and district council planners. In particular, Edwin Parkes (Senior Project Implementation Officer, EBOP) was involved with a number of district council staff in identifying suitable properties and in obtaining the approval from all of the landowners who participated in the study.

SEM would like to thank Bay of Plenty Polytechnic science students, Aimee Reynolds, Ben Clausen, and Glen Annandale for completing the majority of the field sampling.

In addition, the assistance of the following people is acknowledged: Paula Zinzan, Jake Crockford, Alice Bradley, and Mary Manastyrski (ARC).

We also thank Hill Laboratories for completing all the laboratory analysis work for this project.

SEM would also like to thank Sally Gaw (ADHB) whose depth of experience in this field of research has proved invaluable.

Furthermore, SEM and Environment Bay of Plenty would like to thank all the landowners that cooperated in this investigation. It is acknowledged that this investigation would not have been possible without their participation.

Disclaimer

This report was commissioned by and produced for Environment Bay of Plenty. SEMNZ requests that this information be reproduced in full when it is issued to any third party. The findings and opinions are based on results relevant to the dates of our site work and should not be relied on to represent conditions at later dates.

The opinions included in this report are based on information obtained or provided during this study and on our experience. If additional information becomes available which might affect our conclusions, we request the opportunity to review the information, reassess the potential concerns, and modify our opinions if warranted. This report includes reference to reports prepared by other parties, and it must be recognised that SEMNZ has no responsibility for the accuracy of information contained therein.

Because potential hotspots were deliberately not sampled during this investigation, and because analysed samples were composites of ten sub-samples, the results obtained can not indicate what maximum concentrations may be present on any site. The results can do no more than give a general idea of the average degree of impact of the subject analytes on the soils sampled in the investigation.

Executive Summary

SEM New Zealand Limited (SEMNZ) was engaged by Environment Bay of Plenty (EBOP) (the Regional Council) to carry out an assessment of the levels of agrichemical residues in the Bay of Plenty.

The objective of this investigation was to assess the general risk posed to the environment and to human health by any remnant agrichemical residues in soils associated with a range of horticultural and agricultural land uses.

Methodology

Soil samples were collected from 128 sites in the Bay of Plenty region. These 128 sites comprised seven land use categories; kiwifruit (26 sites), glass houses/market gardens (14), other orchards (16), maize (14), horticulture (10), pasture (23), and control sites[3] (25).

The sampling locations were selected to avoid areas that were likely to contain any potential hotspots such as spray mixing, storage, equipment wash down areas or old sheep dip sites. Such areas have been identified in previous studies (Gaw 2002) to contain concentrations of over 100 times those found on produce growth areas.

A total of ten sub-samples were collected from the representative area at each site, and composited for laboratory testing. The representative area at each site was approximately 1 hectare in size and located within areas where produce was grown (e.g. between rows of fruit trees or vines).

Soil samples were analysed for a selection of contaminants associated with agrichemical application throughout the region. All of the sites were analysed for seven trace metals (Cadmium, Arsenic, Nickel, Copper, Lead, Zinc, and Chromium) and 24 organochlorine pesticides (including DDT and its break down products). Control and maize sites samples were also analysed for 72 Organonitrogen and Organophosphorus compounds (including Simazine and Atrazine). The analyses were carried out by Hill Laboratories, an IANZ accredited laboratory.

The results were compared to both residential and agricultural land use guidelines (trigger levels) as a method of identifying soil contamination levels that may pose either ecological or human health risks. It should be noted that guideline values for human health only are significantly higher than those where ecological protection is considered. Therefore, should the results of this investigation be compared to guidelines for human health only, there would be a considerable reduction in the number of sites exceeding land use values. For the purposes of this report SEMNZ have used the more conservative "50% produce consumption" values from the MfE/MoH, Health and Environmental Guidelines for selected Timber Treatment Chemicals. While SEMNZ is not aware of any studies to determine home grown produce consumption rates in New Zealand, it is likely that the majority of residential occupants consume a much lower percentage of home grown produce.

In addition, the MfE is currently revising human health only guidelines for various contaminants such as copper, arsenic and DDT. These revisions, when completed, will likely result in an increase of guideline values for some contaminants.

Further information on agrichemical toxicity can be found in the references listed in section 7 and by accessing the websites of the Ministry for the Environment at http://www.mfe.govt.nz/ and the United States Environmental Protection Agency at http://www.epa.gov/.

Key Results

Copper, arsenic and total DDT were the analytes that most frequently exceeded the trigger level (exceedances). Copper had the highest exceedance rate, with 13 % of samples. Cadmium, chromium, nickel, dieldrin and total endosulphan did not exceed residential trigger levels for any sample analysed. However, two sites did exceed the cadmium agricultural trigger level (1.4 mg/kg).

Orchards had the highest level of exceedances with 59 % of samples exceeding a trigger level. Samples from glass houses/market gardens exceeded respective trigger levels in 43% of samples, followed by kiwifruit at 38%. Table I summaries the significant results from horticultural and grazing land use sites from the region. Control sites (25) have not been included in this data set due to their effect on median and mean values. These results have been considered separately to determine background concentrations for each contaminant.

[3] Control sites were areas selected to avoid historic pesticide use. They included a number of Department. of Conservation reserves, district council parks and unused road reserves.

Table I: Summary of significant results from all land uses in the Bay of Plenty region (excluding control sites)

Element	No. of Samples	No. of samples exceeding trigger levels [1]	Units are mg/kg dry weight			
			Maximum	Minimum	Mean	Median
Arsenic	103	13	48	BDL	7	5
Cadmium	103	2	2	BDL	0.6	0.5
Chromium	103	0	35	BDL	6	5
Copper	103	16	304	3	40	22
Nickel	103	0	12	BDL	4	4
Lead	103	2	184	1.4	14	8.7
Zinc	103	2	284	16	70.6	62
2,4'-DDD	103	NA	0.18	BDL	BDL	BDL
2,4'-DDT	103	NA	0.62	BDL	0.01	BDL
4,4'-DDD	103	NA	0.51	BDL	0.01	BDL
4,4'-DDE	103	NA	3.46	BDL	0.11	0.01
4,4'-DDT	103	NA	2.40	BDL	0.06	BDL
Total DDT	103	5	6.09	BDL	0.19	0.02
Gamma-BHC (Lindane)	103	0	0.05	BDL	BDL	BDL
Dieldrin	103	0	0.17	BDL	0.01	BDL
Total Endosulphans	103	0	0.39	BDL	0.01	BDL
Endosulphan I	103	0	0.08	BDL	BDL	BDL
Endosulphan II	103	0	0.16	BDL	BDL	BDL
Endosulphan sulphate	103	0	0.32	BDL	BDL	BDL
Hexachlorobenzene	103	0	0.31	BDL	BDL	BDL
Metolachlor	39	0	0.22	0.01	0.02	0.01

Table Note: 1 – individual samples may exceed one or more contaminant trigger values (e.g. sample x exceeds arsenic and Total DDT)
BDL – below laboratory method detection limit
Number of samples is 103 as control data (25 samples) is not included

Conclusions

By comparing the results against conservative land use guidelines (trigger levels), the following conclusions were made:

- Copper, Arsenic and total DDT were the analytes which most frequently exceeded the selected trigger levels;
- Copper had the highest exceedance rate, with13% of the samples exceeding the agricultural trigger level. 11% of the samples also exceeded the residential trigger level for copper;
- Cadmium, chromium, nickel, dieldrin and total endosulphan levels did not exceed residential trigger levels in any sample. Cadmium exceeded the agricultural trigger levels in two samples collected from glass house / market gardens sites in the WBOP district;
- Orchards had the highest level of exceedances with 59% of samples exceeding one or more trigger levels. Samples collected from glass houses/market garden sites exceeded respective trigger levels in 43% of the sites, and 38% of kiwifruit sites;
- When comparing the rate of exceedances between residential and agricultural land uses, residential land use has a lower percentage of exceedances (see Figure 1(a) & Figure 1(b)).

The results of the investigation indicate that a significant number of sites sampled exceed agricultural and residential trigger values for selected residual agri-chemical residues. In addition, due to the limitations of the investigation (see Section 1.4), further investigation of agricultural and horticultural land should be considered prior to development to more sensitive land uses, such as residential.

In conclusion, this preliminary investigation has been useful in determining residual concentrations of selected agrichemicals on various land uses throughout the Bay of Plenty. While the results indicate that some results have exceeded the conservative land use guidelines for human health and ecological protection, the level of investigation at any given site is not sufficient to deem a site as "contaminated", or unsuitable for its' current or intended land use. Such conclusions can only be made following a more detailed site specific investigation.

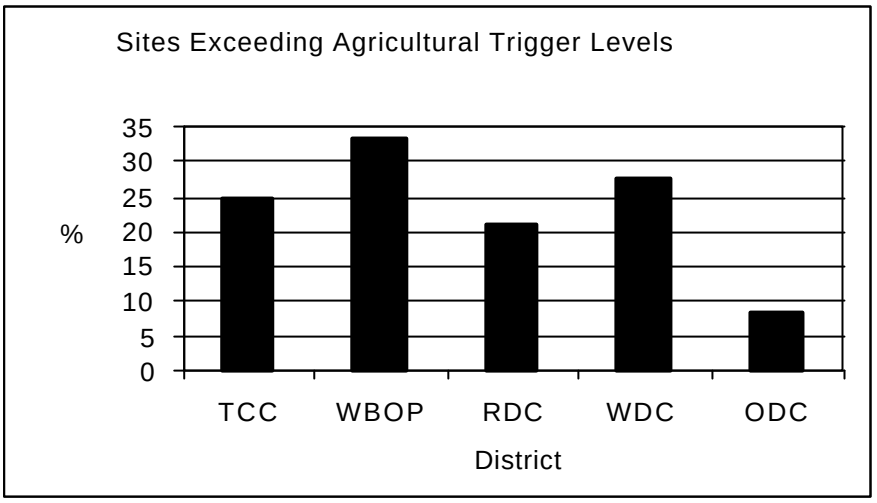

Figure I (a) - % of sites exceeding agricultural trigger levels

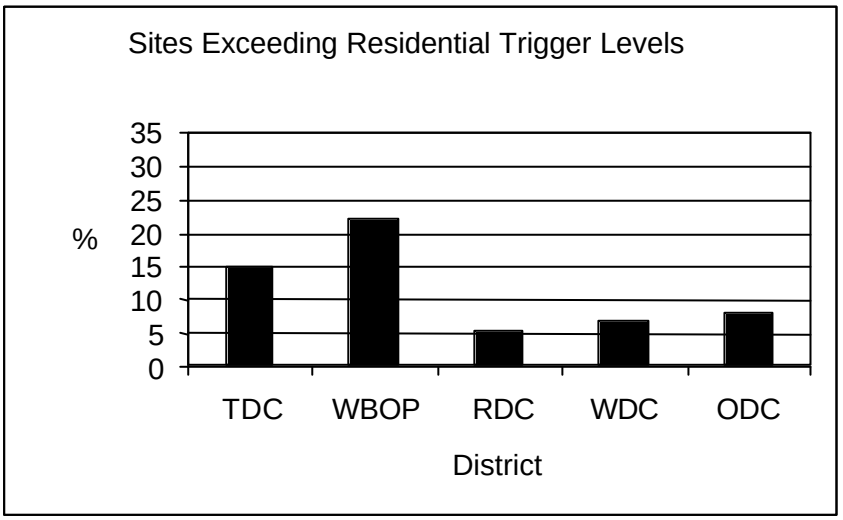

Figure I (b) - % of sites exceeding residential trigger levels

Recommendations

Based on the results of this investigation SEMNZ recommends that territorial local authorities develop policy to ensure that adequate human health and environmental protection is maintained on agricultural and horticultural land developments.

In addition, the results of the investigation identified various land use categories within some districts that may warrant further investigation. Further investigations should provide sufficient data to ensure that the land is suitable for the proposed use, from both a human health and an environmental perspective, and be consistent with Ministry for the Environment contaminated land requirements. In addition, the investigations should address all the issues outlined in the limitations section (Section 1.4) of this report.

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Abbreviations

ANZECC	Australia New Zealand Environment Conservation Council
As	arsenic
CCME	Canadian Council of Ministers for the Environment
Cd	cadmium
Cr	chromium
Cu	copper
DDE	1,1-dichloro-2,2-*bis*(*p*-chlorophenyl) ethylene, degradation product of DDT
DDD	1,1-dichloro-2,2-*bis*(*p*-chlorophenyl)ethane
DDT	1,1,1-trichloro-2,2-*bis*(*p*-chlorophenyl)ethane
SDDT	sum of o,p + p,p-DDT, o,p + p,p-DDE and o,p +p,p-DDD
EBOP	Environment Bay of Plenty
EQG	environmental quality guideline
Fe	iron
GC-ECD	gas chromatography with electron capture detection
GC-MS	gas chromatography mass spectrometry
Hg	mercury
IANZ	International Accreditation New Zealand
MfE	Ministry for the Environment
MoH	Ministry of Health
NEPC	National Environmental Protection Council
Ni	nickel
NSWEPA	New South Wales Environmental Protection Agency
ODC	Opotiki District Council
Pb	lead
QC	quality control
RDC	Rotorua District Council
TCC	Tauranga City Council
USEPA	United States Environmental Protection Agency
WBOPDC	Western Bay of Plenty District Council
WDC	Whakatane District Council
WHO	World Health Organisation
Zn	zinc

Units

%	percent
°C	degrees Celsius
cm	centimetres
g	grams
ha	hectare (10000m^2)
mg/kg	milligram per kilogram
mm	millimetre
mL	millilitre
µg kg^{-1}	microgram per kilogram

1. INTRODUCTION

1.1. Introduction

SEM New Zealand Limited (SEMNZ) was engaged by Environment Bay of Plenty Regional Council (EBOP) to undertake this investigation. The objective of the investigation was to assess the general risk posed to the environment and to human health by remnant agrichemical residues in cropping area soils on a range of horticultural and agricultural properties in the Bay of Plenty region.

1.2. Purpose

The increasing population growth in the Bay of Plenty region (especially in the Western Bay of Plenty) continues to put pressure on resources such as land. With such pressures, the subdivision of orchards or farms into residential lots is a common occurrence. Therefore, it is important to be aware of any potential effects from previous agricultural or horticultural practices on future land uses such as residential use.

The purpose of this study was to:

1. Determine the general level of residual contamination in soils that represent the major horticultural or agricultural land uses, in the Bay of Plenty region.
2. Compare the levels of residual contamination with national and international guidelines for the protection of human health and ecological values.

1.3. Scope of Work

The following outline of work was based on the project brief provided by Environment Bay of Plenty (EBOP), and includes SEM's working knowledge of fieldwork practices and contaminated site management. The number of sample locations selected was based on information provided to SEM by EBOP. Analyte selection for individual land uses was determined by Environment Bay of Plenty staff after reviewing results from similar investigations carried out in New Zealand. This was further refined by Environment Bay of Plenty staff to include regional information on historical and current land and agrichemical use.

In summary, the scope of work conducted to achieve the objective of the investigation comprised:

- Development of a sampling and analysis plan and procedure;
- Field work preparation;
- Project field assistant training;
- Health and Safety Plan development;
- Development of a survey questionnaire
- Site selection and soil sampling;
- Compositing soil samples;
- Data evaluation and analysis;
- Preparation of draft report;
- Completion of final report;
- Reporting the results to the landowners.

1.4. Limitations of Project

This investigation has focused on the determination of the concentrations of various chemical compounds used for disease and pest control on specified land uses at selected sites in the Bay of Plenty.

While the project is useful in determining the risk associated with these land uses, it does not mean that any specific site is suitable for development to a more sensitive land use. Before such conclusions can be drawn, the following limitations of this investigation need to be addressed.

1.4.1. Hotspots

Hotspots are areas on each site that are likely to contain concentrations of residual agrichemicals in excess of the results contained in this report.

Some examples of hotspot areas on agricultural and horticultural properties are:

- Spray storage sheds;
- Spray equipment wash down areas;
- Bulk fuel storage;
- Uncontrolled dumping or land filling of chemical containers and other waste products;
- Sheep dips; and,
- Offal pits.

A previous study (Gaw 2002) measured levels up to 270 mg/kg total DDT, 18.8 mg/kg of mercury, 11800 mg/kg of copper, 2000 mg/kg of lead, and 1050 mg/kg zinc in hotspots on horticultural land.

While these areas are likely to represent small portions of the sites, the management of these areas will require thorough investigation. In all cases where agrichemical concentrations exceed land use trigger levels, remediation or site management should be undertaken to ensure the protection of human health and ecological receptors both during and following site redevelopment. Such investigation works should be consistent with Ministry for the Environment Guidelines for Contaminated Land.

A full list of relevant agricultural and horticultural hotspots is included within the investigation methodology contained in Appendix A.

1.4.2. Composite Sampling

The use of composite samples is beneficial when assessing average concentrations of contaminants over large areas. This method, however, has limitations when comparing laboratory results to land use guidelines due to a potential dilution of the sample analyte concentrations during mixing before laboratory analysis.

Normal procedure for assessing composite sample results against land use criteria or trigger values is to divide the guideline trigger values, or multiply the analyses results, by the number of sub-samples in each composite sample.

1.4.3. Depth Profile Analysis

All samples were collected using purpose-built stainless steel sampling devices and sampled soil from a depth from 0.0-7.5 cm. This study did not collect information on depth profiles of contaminants. The migration of agrichemical residues and breakdown products into deeper soil profiles is dependent on a number of site specific factors. In particular, the use of ploughing equipment is likely to have an effect on the depth of contaminant migration and should be considered in further investigations prior to the development of agricultural and horticultural sites for more sensitive land uses.

1.4.4. Land Use Coverage

It should be noted that not all land use categories were sampled within each district (see Table 2.1). Where land use categories were not sampled in a district or a particular land use was identified as having the highest results, further sampling may be warranted to establish a higher degree of confidence in the level of risk.

1.4.5. Historical Information

Historical information was used to identify site specific cropping area sampling locations. While site history questionnaires were completed during the course of this investigation, the purpose of the questions was to ensure that hotspots were not inadvertently sampled.

SEMNZ recommend that a detailed review of the site history should be undertaken on all sites before investigation and redevelopment. Such site history investigation works should be consistent with Ministry for the Environment Guidelines for Contaminated Land. Where landowners are not able to provide information, other information sources such as aerial photographs should be used to identify potential hotspots.

1.4.6. QA/QC Evaluation

A number of control sites were sampled to determine the level of background soil quality within each district. No duplicate samples were taken. Duplicates are normally collected from every 10th discrete sampling location.

The soil samples were submitted to and analysed by Hill Laboratories, an IANZ accredited laboratory. If further studies of this size are undertaken, it is recommended that a subset of the samples be submitted to another laboratory for analysis.

1.4.7. Development Effects

Development effects have not been considered as part of this project, as these are outside the project scope. Some potential development effects, which should be considered during the consent application stage, include:

- The mobilisation of soil contamination into nearby streams and waterways;
- The inhalation of wind borne particulate by workers during development earthworks;
- The use of groundwater and surface water in close proximity to sites should also be assessed. It should be noted that for some agrichemicals, the soil trigger levels for the protection of groundwater and surface water are orders of magnitude lower than guidelines based on the land use risks associated with soil alone.

1.5. Previous Relevant Studies

A wide range of chemicals have been used on agricultural and horticultural properties in New Zealand to control pests and diseases (Gaw 2002). The types of chemicals used on sites were often related to a particular time-period, pest, disease, or land use. Many of these chemicals are persistent in the environment for considerable time-periods. An evaluation of chemical use regimes in districts may provide further understanding of appropriate analyte lists for assessment of agricultural and horticultural land.

This report does not seek to outline the full history of chemical use on agricultural and horticultural land. Rather, we recognise the work of others, which details this information. In particular the report "Pesticide Residues in Horticultural Soils in the Auckland Region (Gaw 2002)", outlines the history of pesticide use in New Zealand and lists a full range of pesticides which were commonly used on agricultural and horticultural land.

1.5.1. Agrichemical Residue Information - Bay of Plenty Region

During 2002, an investigation was conducted on the level of DDT in over 1200 national composite pastoral soil samples. This investigation was carried out on properties undergoing dairy conversion. The results for the Bay of Plenty (BOP) region indicated that 58% of samples were above the dairy conversion values of 0.2 mg/kg for total DDT. In addition, the EBOP summary states, concerning total DDT that, *"one third of the Bay of Plenty samples were greater than the very conservative Canadian guideline for residential property"*[4].

The results of this study, and those of the Auckland Regional Council Report, "Pesticide Residues in Horticultural Soils in the Auckland Region (February 2002), indicated the need to carry out this investigation.

1.5.2. Agrichemical Residue Studies in New Zealand

Auckland Region

Soil samples were collected from 43 horticultural properties in the Auckland region during 2001. The land uses surveyed included glass houses, market gardens, orchards and vineyards. The contaminants most frequently detected in the highest concentrations in the cropping areas sampled were ΣDDT (sum of DDT and its degradation products DDE and DDD) (<0.03-289 mg/kg), copper (7-490 mg/kg), dieldrin (<0.005-56 mg/kg), arsenic (<2-34 mg/kg) and lead (<3 – 1250 mg/kg).

[4] Extract from internal EBOP memo by Paul Futter dated 15 November 2002, file ref. 7000 04 P01

Approximately 70% of the horticultural properties developed before 1975 exceeded conservative guidelines (NZ where available and international) for the protection of human health and/or ecological receptors for at least one of these contaminants. Acidic herbicides were not detected and generally only low levels of organonitrogen and organochlorine pesticides were detected in cropping areas (Gaw 2002).

Waikato Region

In 2002, 31 horticultural properties (berryfruit, market gardens, orchards, vineyards and glass houses) in the Waikato region were sampled along with seven grazing and seven background sites. Arsenic (4 to 58 mg/kg), copper (22-523 mg/kg), lead (14-251 mg/kg) and ΣDDT (<0.03- 34.5 mg/kg) were the four contaminants most frequently detected at elevated levels in horticultural soils in the Waikato region. Cadmium (0.2-1.5 mg/kg) and tin (<1 -7 mg/kg) were also detected at elevated levels on some properties. DDT and/or its degradation products were detected in 33 out of the 38 samples collected from horticultural and grazing properties. Other organochlorine pesticides with the exception of endosulphan were mainly detected at low levels (generally less than 0.1 mg/kg). Endosulphan is still registered for use in New Zealand.

Samples collected from horticultural properties in the Waikato region exceeded the trigger levels for one or more of ΣDDT, copper, lead, tin, cadmium and arsenic on at least one property. All of the orchard samples exceeded at least one trigger level and one orchard sample exceeded 6 out of 7 trigger levels (Gaw 2003a)

Tasman District

Twenty-five properties (grazing, market gardens, orchards, and former tobacco land and berry fruit) were sampled in the Tasman District in 2002. Arsenic (<2-48 mg/kg), lead (5-243 mg/kg) and ΣDDT (<0.03-7.14 mg/kg) were the three contaminants most frequently detected at elevated levels in cropping soils in the Tasman District. DDT and/or its degradation products were detected in 24 out of the 25 samples collected. Other organochlorine pesticides were detected at low levels (generally less than 0.1 mg/kg) only. Unlike the Auckland and Waikato regions, elevated levels of copper were not found in horticultural soils in the Tasman District.

Samples collected from horticultural properties exceeded the trigger levels for one or more of ΣDDT, copper, lead and arsenic on at least one property. All of the orchards exceeded at least one trigger level. One orchard property exceeded 4 of the trigger levels and 2 orchard samples exceeded 3 of the trigger levels (Gaw 2003b)

2. METHODOLOGY

Soil samples from the cropping areas on 128 sites were collected during the time period April – May 2004 by three field assistants. The field assistants went through a training program conducted by SEMNZ staff members, and had full supervision during the first sampling stage of the project. Copies of the sampling protocol, health and safety plan, and survey questions are included in Appendix A of this report. Table 2.1 summarises the number of sites sampled for each land use within each district.

Table 2.1: Number of land use sites sampled for each district.

Land use	Rotorua	WBOPDC	Opotiki	Whakatane	Tauranga	Total
Control	5	4	5	5	6	25
Kiwifruit	0	10	6	4	4	24
Glass houses & market gardens	0	6	3	2	3	14
Orchards	5	4	4	0	4	17
Maize	0	3	2	8	1	14
Horticulture[5]	4	0	0	6	0	10
Pasture	5	8	4	4	3	24
Total	19	35	24	29	21	128

2.1. Landowner Liaison

Each landowner was approached by EBOP for assistance and access to the site for this investigation. Before field sampling, each landowner or landowner's representative was notified and asked to complete a site questionnaire.

In order to protect the confidentiality of individual landowners, a code system was developed for land uses, and districts. This information is known only to staff members within SEMNZ who were directly involved in the project. Maintenance of site anonymity was a condition of landowner consent.

2.2. Field Sampling

Avoiding potential hotspots, a 1-hectare area representative of the specified land use was identified on each site for sampling. Samples were collected every 20 meters in a 'W' pattern across the area sampled/sampling location, and placed in a plastic bag provided by the laboratory until 10 samples were collected. The samples were then couriered to the laboratory for analyses. Refer to Appendix A for full details on sampling protocols and Appendix C for copies of the sample result laboratory reports.

2.3. Analyte Selection

For the purpose of this investigation, the samples were tested for organochlorine pesticides including DDD, DDT, DDE, lindane, and dieldrin as well as for trace metals (Cadmium, Arsenic, Nickel, Copper, Lead, Zinc, and Chromium). In addition, maize and control sites were tested for organonitrogen and organophosphorus pesticides (specifically for Simazine and Atrazine). A full list of the compounds and laboratory method detection limits is contained in Appendix D.

[5] Refers to asparagus, squash, herb, flower gardens

3. SELECTION OF TRIGGER VALUES

The trigger values for residual agrichemical and trace metals levels in soils were selected from the Ministry for the Environment, Environmental Guideline Value Database in accordance with the Ministry for the Environment publication Contaminated Land Management Guidelines No 2, "Hierarchy and Application in NZ of Environmental Guideline Values". The reference guidelines are "risk based", which is consistent with the preferred approach in New Zealand. It should be noted however, that the values contained in each guideline were developed based on specific receptor/exposure scenarios that may or may not exist at a given site.

The results for this study were compared to both residential and agricultural land use guidelines (trigger levels) as a method of identifying soil contamination levels that may pose either ecological or human health risks. Guideline values for human health only are significantly higher than those where ecological protection is considered. Therefore, should the results of this investigation be compared to guidelines for human health only, there would be a considerable reduction in the number of sites exceeding land use values. For this reason, we refer to the values as trigger levels, which indicate the need for further site specific investigation or consideration.

For the purposes of this report SEMNZ have used the more conservative "50% produce consumption" values from the MfE/MoH, Health and Environmental Guidelines for selected Timber Treatment Chemicals. While SEMNZ is not aware of any studies to determine home grown produce consumption rates in New Zealand, it is likely that the majority of residential occupants consume a much lower percentage of home grown produce.

In addition, the MfE are currently revising human health only guidelines for various contaminants such as arsenic and DDT. These revisions, when completed, will likely result in an increase of guideline values for some contaminants.

Further information on agrichemical toxicity can be found in the references listed in section 7 and by accessing the websites of the Ministry for the Environment at http://www.mfe.govt.nz/ and the United States Environmental Protection Agency at http://www.epa.gov/.

Both the current (agricultural) and proposed (residential) land use trigger levels have been applied. Tables 3.1 and 3.2 list the Agricultural and Residential trigger levels, which have been compared to the results in this report.

Table 3.1 – Agricultural Trigger Levels

Contaminant	Guideline	Trigger Levels (mg/kg)
Cadmium	CCME (a)	1.4
Arsenic	CCME (a)	12
Nickel	CCME (a)	50
Copper	CCME (a)	63
Lead	CCME (a)	70
Zinc	CCME (a)	200
Chromium	CCME (a)	64
DDT Total (total DDT, DDE, DDD)	CCME (a)	0.7

Table note: (a) Canadian Environmental Quality Guidelines (CCME 2002)

3.1. Health & Environmental Guidelines for Selected Timber Treatment Chemicals

The trigger values for, copper, and arsenic were selected from The Health & Environmental Guidelines for Selected Timber Treatment Chemicals (MoE/MoH 1997). These apply only for residential land use using a 50 % produce consumption pathway.

The main considerations for deriving criteria for residential sites are health risk based. The exposure routes considered during the derivation of the guidelines were ingestion, inhalation and produce ingestion.

Table 3.2 – Residential Trigger Levels

Contaminant	Guideline	Trigger Level (mg/kg)
Cadmium	CCME (a)	10
Arsenic	MfE/MoH (b)	30
Nickel	CCME (a)	50
Copper	MfE/MoH (b)	80
Lead	CCME (a)	140
Zinc	CCME (a)	200
Chromium	CCME (a)	64
DDT Total (total DDT, DDE, DDD)	CCME (a)	0.7
Dieldrin	USEPA Region 9 (c)	0.3
Endosulphan	Dutch (d)	4

Table notes: (a) Canadian Environmental Quality Guidelines (CCME 2002)

(b) Health and Environmental Guidelines for Selected Timber Treatment Chemicals (MfE and MoH, 1997), 50% produce consumption pathway

(c) Region 9 Preliminary Remediation Goals (US EPA, 2002b) as cited in MfE Environmental Guideline Value Database, Contaminated Land Management Guidelines No. 2, Hierarchy and Application in New Zealand of Environmental Guideline Values

(d) Ministry of Housing, Spatial Planning and the Environment (2000). Circular on Target Values and Intervention Values for Soil Remediation. Ministry of Housing, Spatial Planning and the Environment. Bilthoven, The Netherlands

3.2. Canadian Environmental Quality Guidelines (CCME 2002)

The total chromium, nickel, lead, zinc, and total DDT trigger levels were taken from the CCME 2002 Environmental Quality Guidelines (EQGs). The EQGs were also adopted for copper and arsenic on agricultural land use results because they consider both human health and ecological receptors. This is preferred to the Health & Environmental Guidelines for Selected Timber Treatment Chemicals (MoE/MoH 1997), which consider human health and phytotoxicity only. It should be noted that the MfE/MoH 1997 agricultural value for copper is 40 mg/kg based on toxicity to sheep, and this should be considered if the intended land use is sheep pasture grazing.

Health & Environmental Guidelines for Selected Timber Treatment Chemicals (MoE/MoH 1997) values for chromium only consider Cr III. The percentages of Cr III and Cr VI within composite samples was not determined and therefore total chromium CCME guidelines have been used as trigger levels.

3.3. Region 9 Preliminary Remediation Goals (US EPA, 2002b)

The trigger level used for comparison of dieldrin on residential land use sites is the USEPA Region 9 preliminary remediation goal. This value has been adjusted for a one in 100,000 cancer risk. The preliminary remediation goals were developed to provide a screening tool to determine sites that require remediation, and as a cleanup level for identified contaminated sites. The derivation of the USEPA Region 9 PRGs only considered human health.

3.4. Australian and New Zealand Guidelines for Fresh and Marine Water Quality

While these guidelines are not considered appropriate for providing an indication of land use suitability, they are beneficial when indicating any potential off-site effects during development works. In particular, the mobilisation of contaminated surface soils during development works into nearby waterways should to be monitored. In such circumstances, these trigger levels would be suitable for monitoring the effects of development works on freshwater habitats surrounding development sites.

The Auckland Regional Council (ARC) has recently completed a study, which is evaluating the effects of development works on former horticultural sites. This study is also investigating methods to minimise impacts during development earthworks.

4. SOIL SAMPLE RESULTS

The full laboratory analysis reports are included in Appendix C of this report. The results of regional and district data can be evaluated and presented in many ways.

Following discussions with EBOP, it was determined that for graphical outputs of median data would be presented (Appendix B). In order to evaluate median results for each of the land uses, results which fell below laboratory method detection limits (non-detectable) were assigned zero values. In addition, for the benefit of various readers, SEM has developed tables and graphs for comparison of region-wide data, trigger level exceedances, land use results, and district results.

The following results section is summarised as follows:

Section 4.1 – Laboratory QA/QC Results

- Briefly summarises the review of the laboratory QA/QC results.

Section 4.2 - Regional Results

- Summary of the results from control sites Bay of Plenty (BOP) region wide.
- Summary of agrichemical residues presents the high, low, median and mean values for each land use and each contaminant.

Section 4.3 - Trigger Level Exceedances

- Exceedance tables are presented which outline the number of times each contaminant exceeded a trigger value.

Section 4.4 – Land Use Results Evaluation

- Outlines the main findings from the regional results section

Section 4.5 – District Based Results Evaluation

- Outlines the main findings for each district and presents results tables for each land use in each district.

4.1. Laboratory QA/QC Results

The results of the laboratory QA/QC analysis reports are included in Appendix C.

Hill Laboratories is an IANZ accredited laboratory. Quality control measures for the trace metal analyses included procedural blanks, analysis of certified reference materials and the analysis of duplicate samples. Recoveries for the certified reference material were within acceptable limits and laboratory duplicates agreed within 20%.

The samples were submitted for analysis in three batches. The quality control measures for the organochlorine pesticides and the organonitrogen and organophosphorus pesticides included procedural blanks, system monitoring compounds (SMC) and the use of duplicates and matrix spikes. No residues were detected in the procedural blanks.

Organochlorine, organonitrogen and organophosphorus pesticides were not detected in either the primary sample or the laboratory duplicate. The recoveries of the matrix spikes for organonitrogen and organophosphorus pesticides were within acceptable QC limits (46 to 140%) with the exception of acephate (35%), pirimicarb (32%), and quizalofop-p-ethyl (3%) and captan (0%) each on one occasion; none of these compounds were detected in any sample.

The 95% confidence intervals (95% CI) for the recoveries for the SMC (TPP) used for the organonitrogen and organophosphorus pesticides analyses were 91±1%, 97±3% and 92±1%. The matrix spike recoveries for the organochlorine pesticides ranged from 41 to 120%. Two system monitoring compounds were used in the organochlorine analyses; 3BBP and 3-BPP. The 95% CIs for the three batches of samples analysed were 87±2%, 77±5% and 101±6% for PBBP and 102±2%, 114±2% and 107±3% for 3-BBP. In one batch of samples recoveries for one compound (3-BBP) whilst within the acceptable QC limits were generally low (range 58 to 109%; 95% CI 77±5); however recoveries for the second system monitoring compound (PBBP) were acceptable (range 94 to 126%; 95% CI 77±5).

It is recommended that blind duplicates are submitted to the laboratory as part the QC for any future soil sampling surveys.

4.2. Regional Results

4.2.1. Control site results

Control sites around the region were selected to provide an indication of existing background levels of trace metals (Table 4.2.1) and pesticides (Table 4.2.1a). Median values for all trace metals from control sites were lower than the combined land use regional median (Table 4.2.2). None of the maximum trace metal values for the control sites exceeded the residential trigger values.

Table 4.2.1: Summary statistics for trace metals for control sites.

Metal	**No. of Samples**	**Maximum** (mg/kg dry weight)	**Minimum** (mg/kg dry weight)	**Mean** (mg/kg dry weight)	**Median** (mg/kg dry weight)
Arsenic	25	14	BDL	4.92	4
Cadmium	25	0.5	BDL	0.14	0.1
Chromium	25	11	BDL	4.48	3
Copper	25	26	3	10.08	9
Nickel	25	6	BDL	1.64	BDL
Lead	25	37.7	2.9	12.55	10
Zinc	25	99	19	45.04	37

Table Note: BDL – below laboratory method detection limit

Table 4.2.1a: Summary statistics for pesticides for control sites

Agrichemical Compound	**No. of Samples**	**Maximum** (mg/kg dry weight)	**Minimum** (mg/kg dry weight)	**Mean** (mg/kg dry weight)	**Median** (mg/kg dry weight)
DDT (Total)	25	0.14	BDL	0.01	BDL
Endosulphans (Total)	25	BDL	BDL	BDL	BDL
Gamma-BHC (Lindane)	25	BDL	BDL	BDL	BDL
Dieldrin	25	BDL	BDL	BDL	BDL
Hexachlorobenzene	25	0.05	BDL	BDL	BDL
Metolachlor	25	0.05	0.005	0.02	0.025

Table Note: BDL – below laboratory method detection limit

4.2.2. Summary for Agrichemical Residues

Table 4.2.2: Summary of significant results from all land uses in the Bay of Plenty region (excluding control sites)

Element	No. of Samples	No. of samples exceeding trigger levels [1]	Maximum (mg/kg dry weight)	Minimum (mg/kg dry weight)	Mean (mg/kg dry weight)	Median (mg/kg dry weight)
Arsenic	103	13	48	BDL	7	5
Cadmium	103	2	2	BDL	0.6	0.5
Chromium	103	0	35	BDL	6	5
Copper	103	16	304	3	40	22
Nickel	103	0	12	BDL	4	4
Lead	103	2	184	1.4	14	8.7
Zinc	103	2	284	16	70.6	62
2,4'-DDD	103	NA	0.18	BDL	BDL	BDL
2,4'-DDT	103	NA	0.62	BDL	0.01	BDL
4,4'-DDD	103	NA	0.51	BDL	0.01	BDL
4,4'-DDE	103	NA	3.46	BDL	0.11	0.01
4,4'-DDT	103	NA	2.40	BDL	0.06	BDL
Total DDT	103	5	6.09	BDL	0.19	0.02
Gamma-BHC (Lindane)	103	0	0.05	BDL	BDL	BDL
Dieldrin	103	0	0.17	BDL	0.01	BDL
Total Endosulphans	103	0	0.39	BDL	0.01	BDL
Endosulphan I	103	0	0.08	BDL	BDL	BDL
Endosulphan II	103	0	0.16	BDL	BDL	BDL
Endosulphan sulphate	103	0	0.32	BDL	BDL	BDL
Hexachlorobenzene	103	0	0.31	BDL	BDL	BDL
Metolachlor	39	0	0.22	0.01	0.02	0.01

Table Note: 1 – individual samples may exceed one or more contaminant trigger values (e.g. sample x exceeds arsenic and Total DDT)
BDL – below laboratory method detection limit
Number of samples is 103 as control data (25 samples) is not included

4.2.2.1. Arsenic

Arsenic levels above the laboratory Method Detection Limit (detection limit) were measured in 121 of the 128 samples collected. Arsenic levels ranged from <2 mg/kg to 48 mg/kg with a median value of 5 mg/kg. Horticultural land had the highest median arsenic value (10.5 mg/kg) however; the highest arsenic value came from an orchard (48 mg/kg).

Table 4.2.2.1: Summary statistics for arsenic residues in the Bay of Plenty Region

Land use	No. of Samples	Maximum (mg/kg dry weight)	Minimum (mg/kg dry weight)	Mean (mg/kg dry weight)	Median (mg/kg dry weight)
Control	25	14	BDL	4.92	4
Kiwifruit	24	19	3	7.58	7
Glass houses/ market gardens	14	28	3	7.86	6
Orchards	17	48	3	9.71	5
Maize	14	13	2	6.29	5
Horticulture	10	25	BDL	11.10	10.5
Pasture	24	15	BDL	4.50	3.5

Table Note: Arsenic Trigger Level 12 mg/kg for agricultural and 30 mg/kg for residential land use.
BDL – below laboratory method detection limit

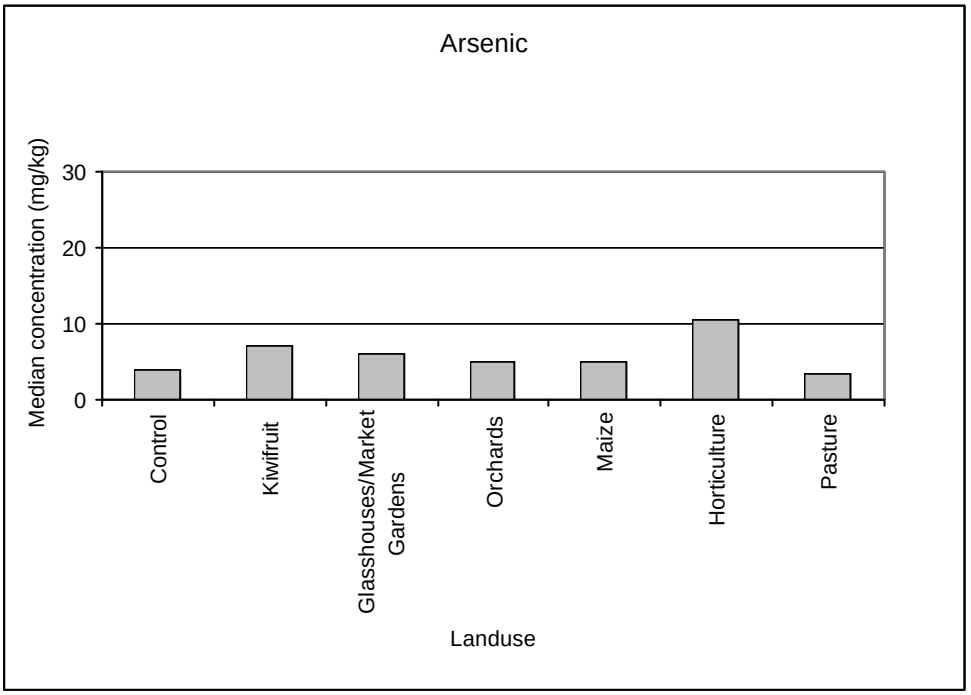

Figure 4.2.2.1 – Regional Median Arsenic Concentrations

4.2.2.2. Cadmium

Cadmium levels above the detection limit were measured in 118 out of the 128 samples collected. The only non-control site registering a level below the detection limit was an orchard. Cadmium levels ranged from < 0.1 mg/kg to 2 mg/kg with a median of 0.5 mg/kg. Kiwifruit had the highest median value (0.7 mg/kg) with maize, and horticulture sharing the lowest median values (0.3 mg/kg).

Table 4.2.2.2: Summary statistics for cadmium residues in the Bay of Plenty Region

Land use	No. of Samples	Maximum (mg/kg dryweight)	Minimum (mg/kg dryweight)	Mean (mg/kg dryweight)	Median (mg/kg dryweight)
Control	25	0.5	BDL	0.14	0.1
Kiwifruit	24	1.2	0.3	0.73	0.7
Glass houses/Market Gardens	14	2	0.1	0.69	0.5
Orchards	17	1.1	BDL	0.59	0.6
Maize	14	0.7	0.1	0.37	0.3
Horticulture	10	0.8	0.1	0.35	0.3
Pasture	24	1.3	0.1	0.56	0.5

Table Note: Cadmium Trigger Level 1.4 mg/kg for agricultural and 10 mg/kg for residential land use.
BDL – below laboratory method detection limit

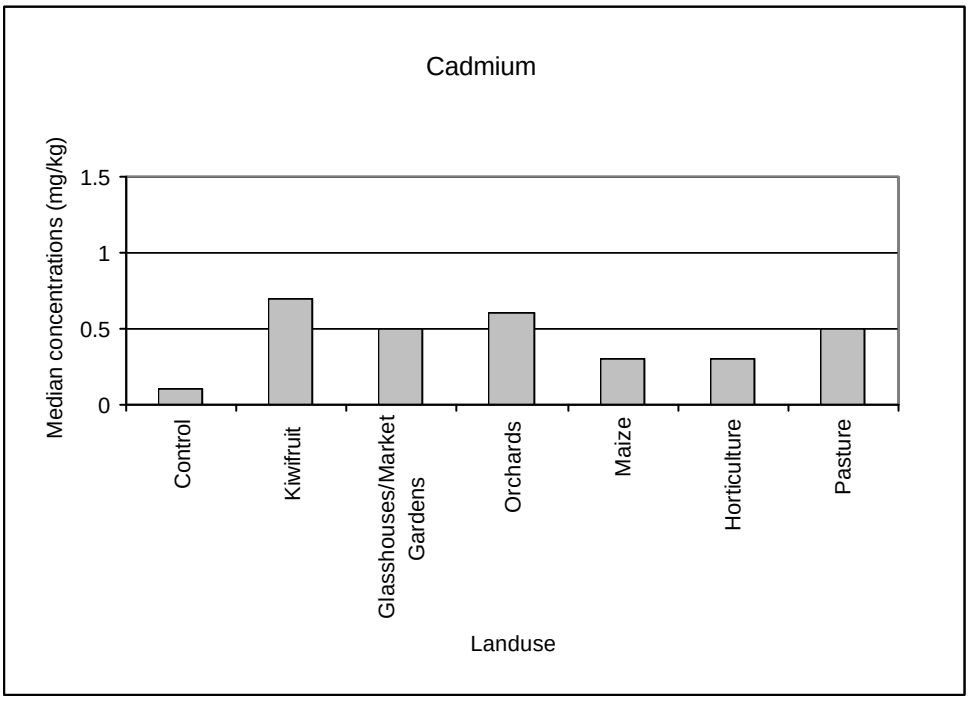

Figure 4.2.2.2 – Regional Median Cadmium Concentrations

4.2.2.3. Chromium

Chromium levels above the detection limit were detected in 122 of the 128 samples. Values ranged from 35 mg/kg to <2 mg/kg. The maximum recorded value was from kiwifruit (35 mg/kg mg). The median chromium values ranged 3 mg/kg for the control sites, to 6 mg/kg for kiwifruit, glass houses/market gardens and orchards. None of the chromium values exceeded the agricultural or residential land use trigger value of 64 mg/kg. The median chromium value for the entire region is 5 mg/kg.

Table 4.2.2.3: Summary statistics for chromium residues in the Bay of Plenty Region

Land use	No. of Samples	Maximum (mg/kg dry weight)	Minimum (mg/kg dry weight)	Mean (mg/kg dry weight)	Median (mg/kg dry weight)
Control	25	11	BDL	5	3
Kiwifruit	24	35	4	8	6
Glass houses/ market gardens	14	13	4	7	6
Orchards	17	19	2	6	6
Maize	14	11	3	6	5
Horticulture	10	6	2	4	4
Pasture	24	11	BDL	5	4

Table Note: Chromium Trigger Level 64 mg/kg for agricultural and 64 mg/kg for residential land use.
BDL – below laboratory method detection limit

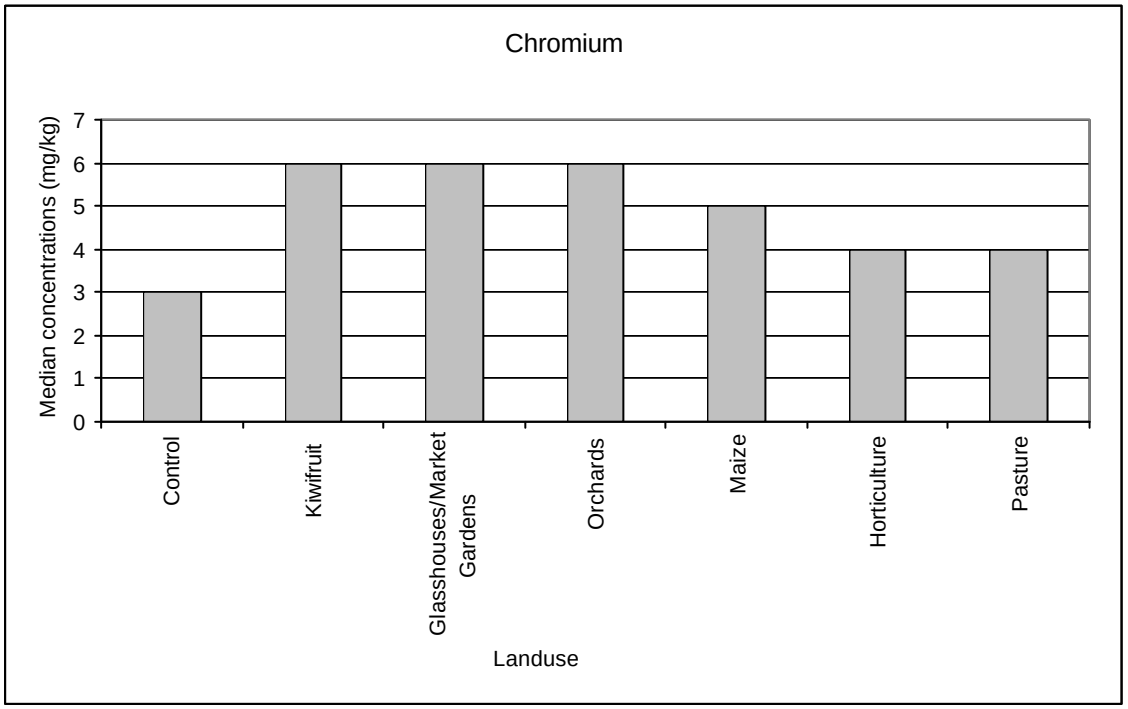

Figure 4.2.2.3 – Regional Median Chromium Concentrations

4.2.2.4. Copper

Copper values ranged from 3 to 304 mg/kg, with a median value of 22 mg/kg. Copper was detected in all of the 128 samples. The copper values found in this survey are comparable with values reported by Gaw (2002). The results of this study measured copper values ranging from 7 to 253 mg/kg and 21 to 490 mg/kg in glass houses and orchards respectively in the Auckland region.

Table 4.2.2.4: Summary statistics for copper residues in the Bay of Plenty Region

Land use	No. of Samples	Maximum (mg/kg dry weight)	Minimum (mg/kg dry weight)	Mean (mg/kg dry weight)	Median (mg/kg dry weight)
Control	25	26	3	10	9
Kiwifruit	24	127	9	44	35
Glass houses/ market gardens	14	215	11	66	48
Orchards	17	304	6	87	50
Maize	14	31	3	13	13
Horticulture	10	33	6	14	11.5
Pasture	24	50	4	14	12

Table Note: Copper Trigger Level 63 mg/kg for agricultural and 80 mg/kg for residential land use.
BDL – below laboratory method detection limit

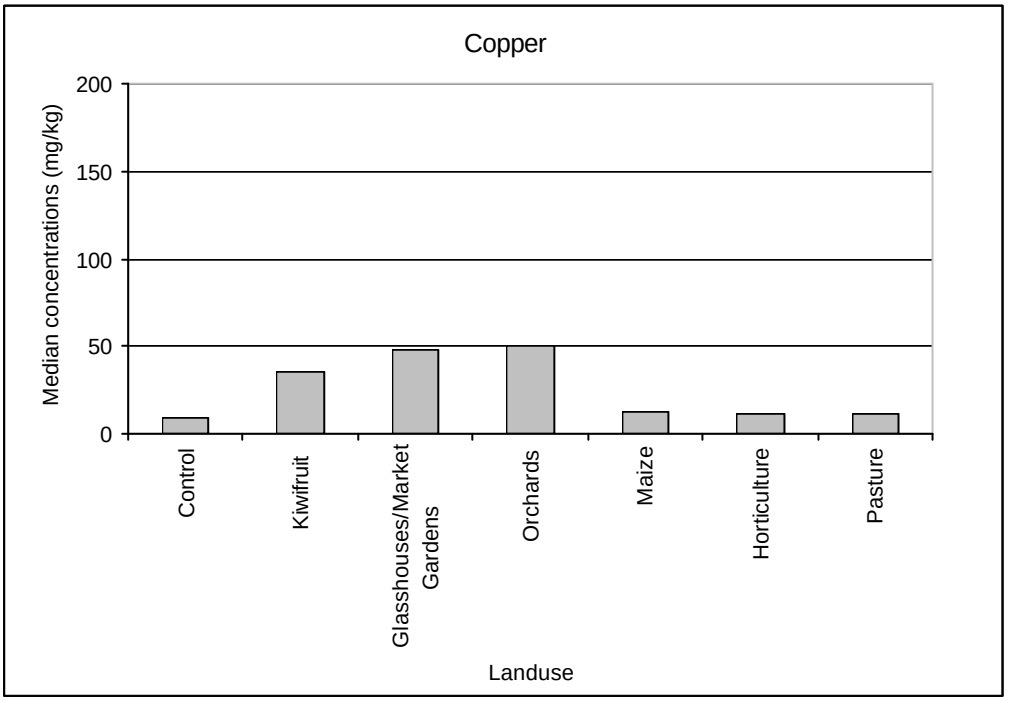

Figure 4.2.2.4 – Regional Median Copper Concentrations

4.2.2.5. Nickel

Nickel levels above detection limits were recorded in 91 of the 128 sites. Nickel levels ranged from 2 mg/kg in kiwifruit to 12 mg/kg in glass houses/market gardens. For all other land use's, minimum levels were below the detection limit. The regional median nickel value was 4 mg/kg. The control values for Nickel ranged form <2 to 6 mg/kg. The results show nickel is slightly elevated in the subject sites when compared to control sites.

Table 4.2.2.5: Summary statistics for nickel residues in the Bay of Plenty Region

Land use	No. of Samples	Maximum (mg/kg dry weight)	Minimum (mg/kg dry weight)	Mean (mg/kg dry weight)	Median (mg/kg dry weight)
Control	25	6	BDL	1.6	BDL
Kiwifruit	24	7	BDL	4.3	4
Glass houses/ market gardens	14	12	BDL	5.0	4
Orchards	17	9	BDL	3.5	3
Maize	14	9	BDL	3.8	3
Horticulture	10	5	BDL	2.6	3
Pasture	24	9	BDL	2.7	2.5

Table Note: Nickel Trigger Level 50 mg/kg for agricultural and 50 mg/kg for residential land use.
BDL – below laboratory method detection limit

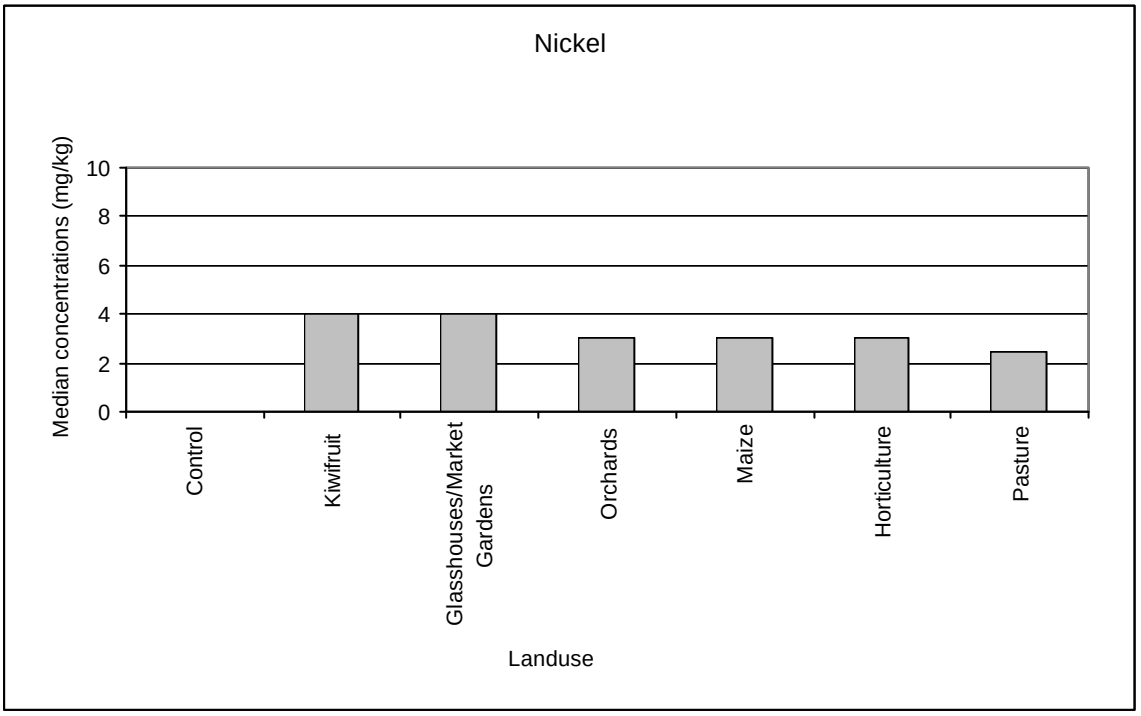

Figure 4.2.2.5 – Regional Median Nickel Concentrations

4.2.2.6. Lead

Lead levels above the detection limit were measured in all 128 samples. Lead values ranged from 1.4 to 184 mg/kg. The highest and lowest values were recorded from an orchard site and pasture site respectively. The highest median value (14.25 mg/kg) was from glass houses and market gardens. The median lead value for all land uses was 8.7 mg/kg. Kiwifruit, maize, horticulture and pasture all had median lead values lower than the control median. The maximum lead values recorded for horticulture (94.7 mg/kg) and orchard (184 mg/kg) land uses both exceed the agricultural trigger level value of 70 mg/kg. The orchard value also exceeds the residential trigger level value of 140 mg/kg (CCME, 2002).

Table 4.2.2.6: Summary statistics for lead residues in the Bay of Plenty Region

Land use	No. of Samples	Maximum (mg/kg dry weight)	Minimum (mg/kg dryweight)	Mean (mg/kg dryweight)	Median (mg/kg dryweight)
Control	25	37.7	2.9	12.6	10
Kiwifruit	24	41.1	3.8	8.9	7.2
Glass houses/Market Gardens	14	63.2	6.2	20	14.3
Orchards	17	184	4.6	22.7	10.7
Maize	14	69.1	2.6	15.8	9.2
Horticulture	10	94.7	1.9	13.7	4.8
Pasture	24	25.2	1.4	8.7	8.9

Table Note: Lead Trigger Level 70 mg/kg for agricultural and 140 mg/kg for residential land use.

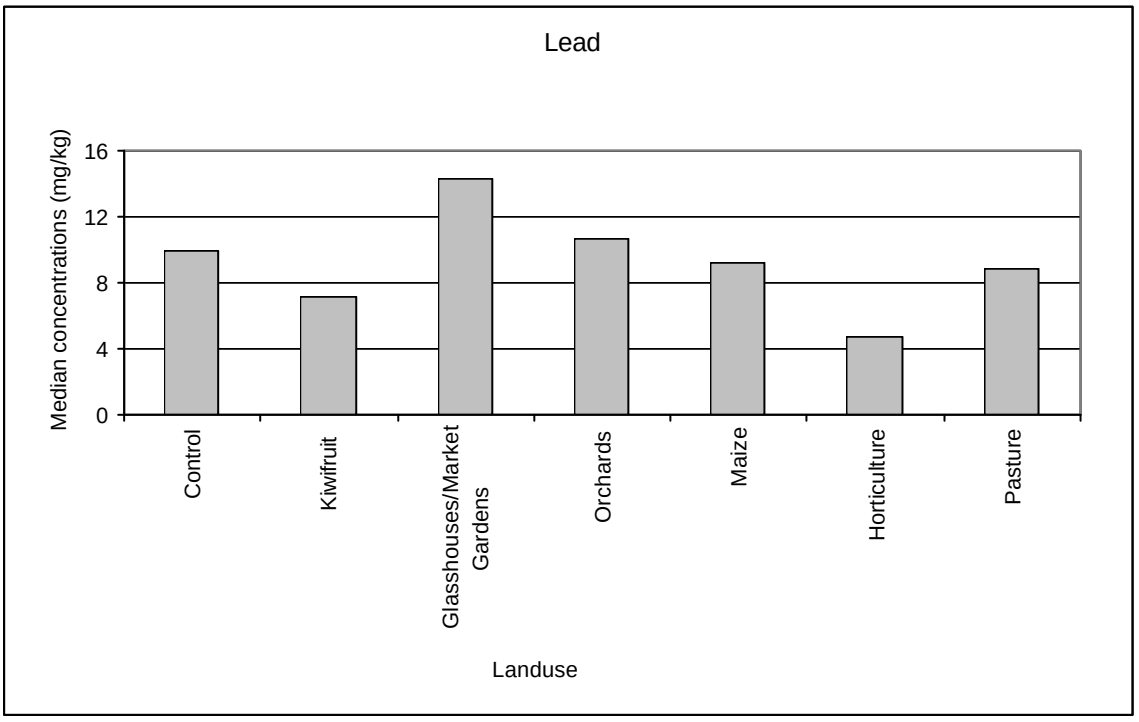

Figure 4.2.2.6 – Regional Median Lead Concentrations

4.2.2.7. Zinc

Zinc values ranged from 19 to 284 mg/kg with a median value of 62 mg/kg. The highest zinc value (284 mg/kg) was measured in a kiwifruit area. Glass houses and market gardens had the highest median value (101.5 mg/kg). This value compares closely to measurements obtained by Gaw (2002), in which glass houses in the Auckland region were shown to have a median value of 102 mg/kg. Horticultural land use had the lowest median zinc value of 31.5 mg/kg followed by the control and pasture land uses, with median values of 37 and 42.5 mg/kg. The maximum recorded values for kiwifruit and orchard sites both exceed the trigger level of 200 mg/kg.

Table 4.2.2.7: Summary statistics for zinc residues in the Bay of Plenty Region

Land use	No. of Samples	Maximum (mg/kg dryweight)	Minimum (mg/kg dryweight)	Mean (mg/kg dryweight)	Median (mg/kg dryweight)
Control	25	99	19	45	37
Kiwifruit	24	284	30	81	68
Glass houses/ market gardens	14	190	40	110	102
Orchards	17	212	21	84	79
Maize	14	100	16	53	60
Horticulture	10	140	20	45	32
Pasture	24	122	21	49	43

Table Note: Zinc Trigger Level 200 mg/kg for agricultural and 200 mg/kg for residential land use.

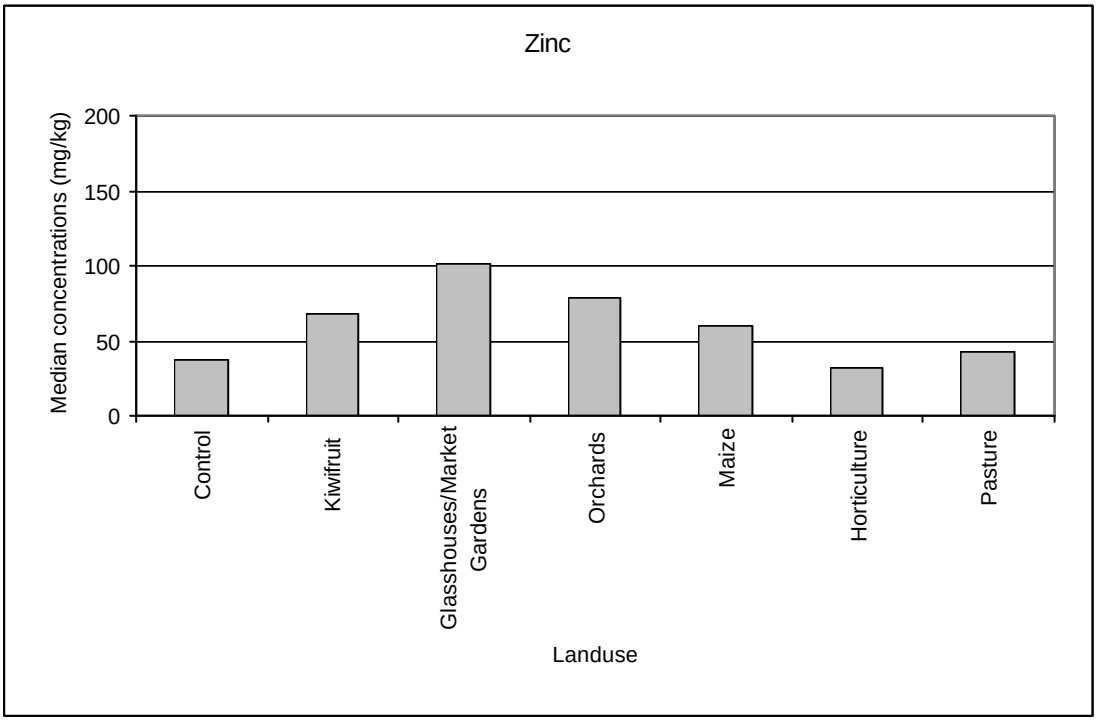

Figure 4.2.2.7 – Regional Median Zinc Concentrations

4.2.2.8. DDT

The values for DDT and its breakdown products (both isomers of DDT, DDE and DDD) have been combined and reported as a single figure of total DDT. DDT and/or its breakdown products were detected in 57 out of 128 soil samples. 4,4'-DDE, and 4,4'-DDT were detected at one of the control sites. The concentrations measured were 0.11 and 0.03 mg/kg respectively.

Table 4.2.2.8: Summary statistics for Total DDT residues in the BOP Region

Land use	No. of samples	No. of positives	Maximum (mg/kg dry weight)	Minimum (mg/kg dry weight)	Mean (mg/kg dry weight)	Median (mg/kg dry weight)
Control	25	2	0.14	BDL	0.01	0
Kiwifruit	24	14	1.11	BDL	0.14	0.04
Glass houses/Market Gardens	14	11	4.37	BDL	0.42	0.095
Orchards	17	9	6.09	BDL	0.40	0.03
Maize	14	3	0.08	BDL	0.01	0
Horticulture	10	7	0.34	BDL	0.12	0.04
Pasture	24	11	1.18	BDL	0.11	0

Table Note: Total DDT Trigger Level 0.7 mg/kg residential land use.
Positives are the number times DDT and its' breakdown compounds were above detection limits.
BDL – below laboratory method detection limit

DDT compounds were detected in 8% of control samples, 58% of kiwifruit samples, 79% of glass house/market garden samples, 53% of orchard samples, and 21%, 70% and 46% of maize, horticulture and pasture samples respectively. Median total DDT residues ranged from <0.01 mg/kg for maize, pasture and control land uses to 0.095 mg/kg for glass houses/market gardens. The maximum value of 6.09 mg/kg total DDT was recorded from an orchard site.

Each sample was assayed for 24 organochlorine pesticides. Overall, 11 of the 24 agrichemical compounds were detected.

Table 4.2.2.8a: Frequency of detection of Organochlorine pesticides

Agrichemical	No. of times detected	Minimum (mg/kg dry weight)	Maximum (mg/kg dry weight)
2,4'-DDD	5	BDL	0.18
2,4'-DDT	9	BDL	0.62
4,4'-DDD	15	BDL	0.51
4,4'-DDE	55*	BDL	3.46
4,4'-DDT	46*	BDL	2.4
Gamma-BHC (Lindane)	1	BDL	0.05
Dieldrin	9	BDL	0.17
Endosulphan I	1	BDL	0.08
Endosulphan II	3	BDL	0.16
Endosulphan sulphate	4	BDL	0.32
Hexachlorobenzene	5*	BDL	0.31

Table Note: The total number of samples is 128.
Detection values marked with an asterisk '*' were detected at individual control sites
BDL – below laboratory method detection limit

The most commonly detected synthetic agrichemical compound was 4,4'-DDE, followed by the active ingredient 4,4'-DDT. The highest detected value (3.46 mg/kg 4,4'-DDE) was obtained from a sample collected from an orchard. Lindane and endosulphan I were both on one occasion at the same glass house/market garden site within the Tauranga City.

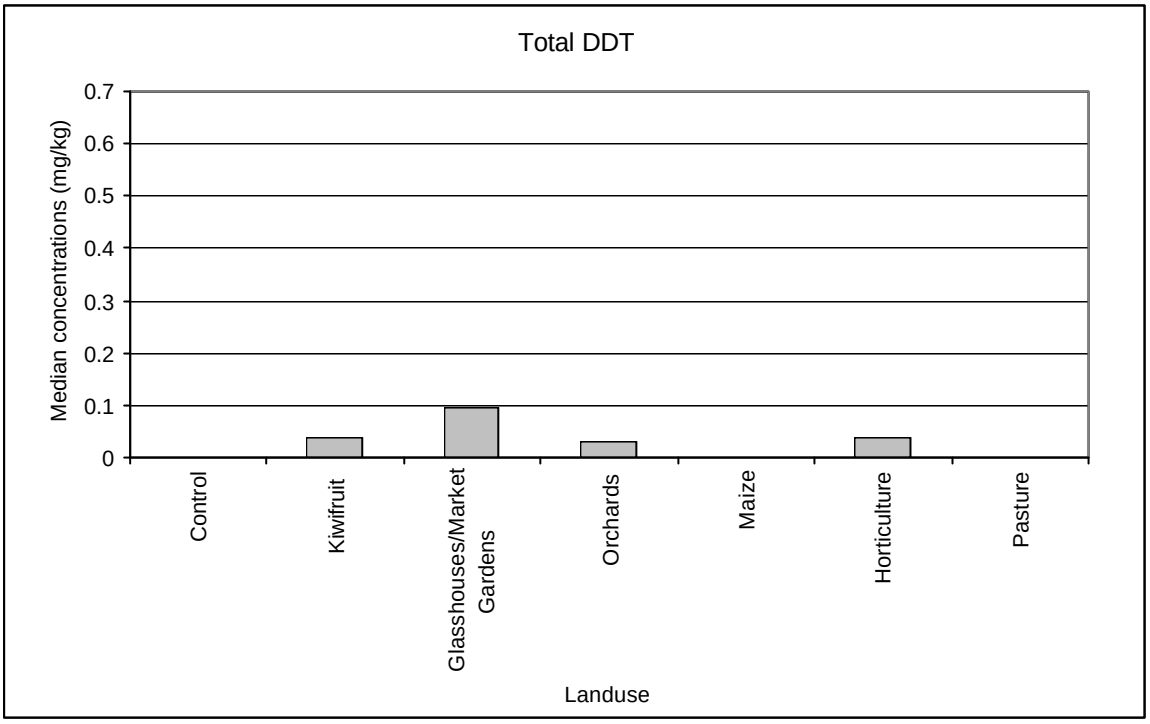

Figure 4.2.2.8 – Regional Median Total DDT Concentrations

4.2.2.9. Dieldrin

Dieldrin was detected in 9 out of 128 soil samples. Dieldrin levels ranged from <0.01 to 0.17 mg/kg. Dieldrin was not detected in any of the control samples. Dieldrin was most frequently detected in samples collected from horticultural sites (3 out of 9).

4.2.2.10. Other organochlorine pesticides

Other organochlorines detected include endosulphan I&II, endosulphan sulphate gamma–BHC (lindane), and Hexachlorobenzene.

Endosulphans were detected in four of the 128 samples. Total endosulphan ranged from <0.01 to 0.39 mg/kg and were only detected in samples from glass house/market garden sites.

Hexachlorobenzene was detected in five of the 128 sites and values ranged from <0.01 to 0.31 mg/kg. Of the five samples in which hexachlorobenzene was detected, two originated from horticultural sites, two from glass house/market garden sites, and one from a control site in the Western Bay of Plenty District.

4.2.2.11. Organonitrogen and organophosphorous pesticides

Samples collected from control sites and maize sites were analysed for organonitrogen and organophosphorous pesticides as well as organochlorines. In total 72 organonitrogen and organophosphorous pesticides were assayed. Of the 72 compounds, only metolachlor was detected (0.22 mg/kg) in one sample collected from a maize site in the Western Bay of Plenty district.

4.3. Trigger value exceedances

Copper, Arsenic and total DDT had the most exceedances of all the analytes. Arsenic, copper, lead, zinc, and total DDT levels exceeded the trigger levels on at least one of the sample sites. None of the median values exceeds the trigger values with exception of copper on glass house and orchard sites in the Western Bay of Plenty District. Copper had the highest exceedance, with 12.5 % of samples exceeding the trigger level. Cadmium, chromium, nickel, dieldrin and total endosulphan did not exceed residential trigger levels for any sample. However, cadmium exceeded the agricultural trigger level (1.4 mg/kg) at two sites. Orchards had the highest level of exceedances with 59 % of samples exceeding a trigger value. Samples from glass houses/market gardens exceeded respective trigger values in 43% of samples, followed by kiwifruit at 38%.

Table 4.3.1: Number of samples exceeding respective agricultural trigger values

Land use		**Control**	**Pasture**	**Kiwifruit**	**Glass houses/market gardens**	**Orchard**	**Maize**	**Horticulture**	**% of sites**
Contaminant	**# of sites**	**25**	**24**	**24**	**14**	**17**	**14**	**10**	
As	15	1	2	4	1	2	1	5	13
Cd	2	0	0	0	2	0	0	0	2
Cr	0	0	0	0	0	0	0	0	0
Cu	16	0	0	6	4	6	0	0	13
Ni	0	0	0	0	0	0	0	0	0
Pb	2	0	0	0	0	1	0	1	2
Zn	2	0	0	1	0	1	0	0	2
Total DDT	**5**	0	1	2	1	1	0	0	4
Dieldrin	**0**	0	0	0	0	0	0	0	0
Total Endosulphan	**0**	0	0	0	0	0	0	0	0

Notes: Results of 128 samples

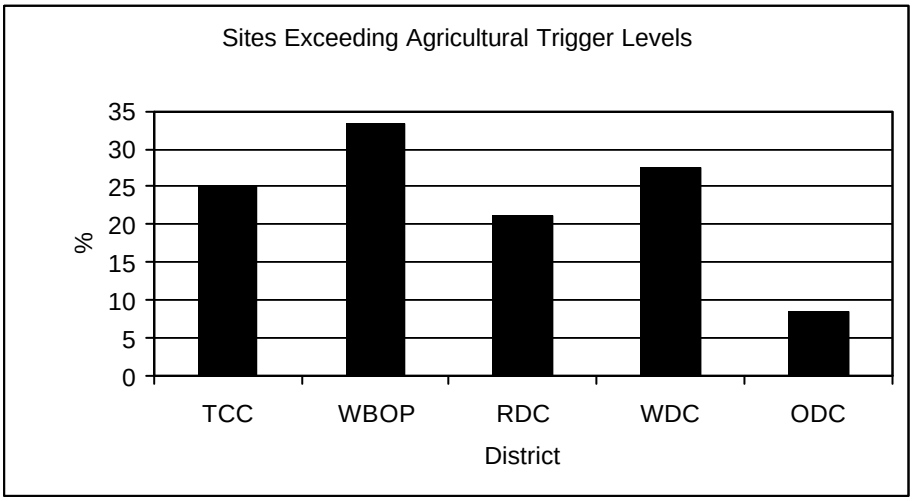

Figure 4.3.1 – Percentage of Sites Exceeding Agricultural Trigger Values

Table 4.3.2: Number of samples exceeding respective residential trigger values

Land use		Control	Pasture	Kiwifruit	Glass houses/Market Gardens	Orchard	Maize	Horticulture	% of sites
Contaminant	**# of sites**	**25**	**24**	**24**	**14**	**17**	**14**	**10**	
As	1	0	0	0	0	1	0	0	1
Cd	0	0	0	0	0	0	0	0	0
Cr	0	0	0	0	0	0	0	0	0
Cu	14	0	0	4	4	6	0	0	11
Ni	0	0	0	0	0	0	0	0	0
Pb	1	0	0	0	0	1	0	0	1
Zn	2	0	0	1	0	1	0	0	2
Total DDT	5	0	1	2	1	1	0	0	4
Dieldrin	0	0	0	0	0	0	0	0	0
Total Endosulphan	0	0	0	0	0	0	0	0	0

Notes: Results of 128 samples

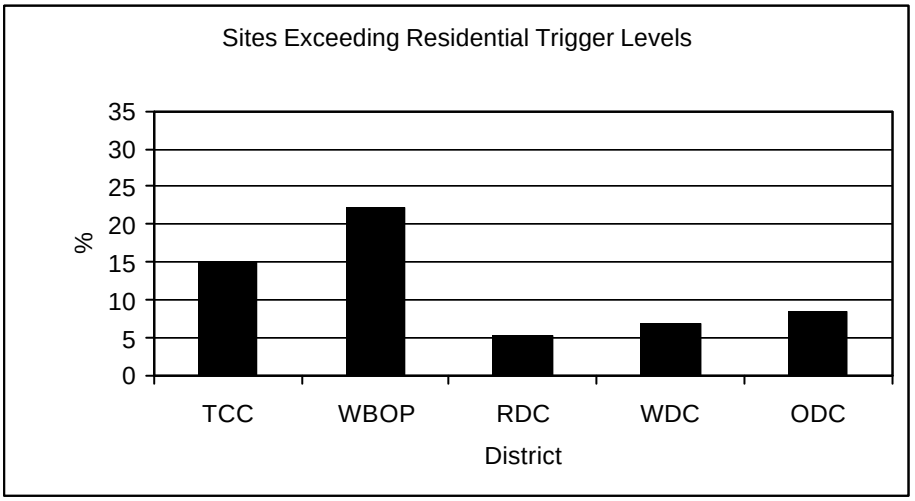

Figure 4.3.2 – Percentage of Sites Exceeding Residential Trigger Values

4.4. Land Use Results Evaluation

In total, 128 composite samples, from six different land use categories were analysed.

Samples collected from glass house/market garden sites recorded the highest median values for chromium (median 6 mg/kg, range 4 to 13 mg/kg), lead (median 14.25 mg/kg, range 6 to 63.2 mg/kg) zinc (median 101.5 mg/kg, range 40 to 190 mg/kg) and total DDT (median 0.095 mg/kg, range <0.01 to 4.37 mg/kg).

The highest median arsenic value measured was in a horticultural site (10.5 mg/kg, range <0.01 to 25 mg/kg). However, the maximum arsenic value measured (48 mg/kg) was recorded from an orchard site, and exceeded both residential and agricultural trigger values.

Orchards had the highest level of exceedances, with 58.8 % of samples exceeding a trigger value. Six of the 17 orchard samples exceeded both the residential and agricultural trigger levels for copper. The highest recorded copper value from an orchard site was 304 mg/kg. Exceedance values from orchard sites were also recorded for lead (184 mg/kg), zinc (212 mg/kg) and total DDT (6.09 mg/kg). These compare with trigger values of 140 and 70 mg/kg (residential and agricultural) for lead, 200 mg/kg (residential and agricultural) for zinc, and 0.7 mg/kg (residential and agricultural) for total DDT. Exceedance results for all land uses are summarised in tables 4.3.1 and 4.3.2.

Six out of 14 glass house/market garden site samples (42.9%) exceeded respective trigger values (see tables in section 4.3). Four of the 6 exceedances were for copper, with 1 sample exceeding the total DDT trigger level value (recorded value 4.37 mg/kg, residential and agricultural trigger value 0.7 mg/kg).

37.5% of samples collected from kiwifruit sites exceeded respective trigger values. Six of the 24 samples exceeded the residential and agricultural trigger values for copper (63 mg/kg) with the highest recorded value being 127 mg/kg. Two of the samples from kiwifruit sites also exceeded the total DDT trigger value of 0.7 mg/kg with a maximum recorded value of 1.11 mg/kg.

One sample collected from a pasture site exceeded the trigger level total DDT value of 0.7 mg/kg , with a DDT value of 1.18 mg/kg.

4.5. District based result evaluation

The following section outlines the results from each district. The tables contained within each section list the high, low, mean, and median results for each land use within each district. Bar graphs are contained in Appendix B for each contaminant, which compare median results against land use and district.

4.5.1. Tauranga City

Summary statistics for Tauranga City are shown in Table 4.5.1. A total of 21 of the 128 samples were collected from this district.

A total of five samples (25%) exceeded trigger values. The trigger value for copper was exceeded in three of the samples. The trigger value for total DDT (agricultural and residential 0.7 mg/kg) was exceeded by two of the samples, with one of the samples exceeded the trigger levels for zinc (agricultural and residential 200 mg/kg). The highest copper exceedance value (171 mg/kg), and the only zinc exceedance value (212 mg/kg) were recorded in samples collected from orchards.

The median copper value for Tauranga orchard sites is 46 mg/kg and the median control value is 18 mg/kg. The Tauranga City area recorded the highest median zinc value (128 mg/kg). Tauranga City results are summarised in Appendix B.

Table 4.5.1: Summary statistics for Tauranga City

Land use	Result	Units are mg/kg dry weight							
		As	**Cd**	**Cr**	**Cu**	**Ni**	**Pb**	**Zn**	**Total DDT**
Pasture	High	3	0.4	4	50	3	14	65	BDL
(n=3)	Low	0	0.1	3	9	0	2.2	21	BDL
	Mean	1	0.3	3.33	26.33	1	8.73	45	BDL
	Median	0	0.4	3	20	0	10	49	BDL
Glass house	High	11	1.1	8	***105***	8	39.7	190	***4.37***
(n=3)	Low	5	0.5	5	26	0	11.5	74	BDL
	Mean	7.67	0.77	6.33	62.67	4	22.07	130.67	***1.49***
	Median	7	0.7	6	57	4	15	128	0.10
Orchard	High	9	0.9	7	***171***	4	29.4	***212***	0.08
(n=4)	Low	3	0.4	2	19	2	11.1	91	BDL
	Mean	5.5	0.63	5	**70.5**	2.75	21.08	127.75	0.02
	Median	5	0.6	5.5	46	2.5	21.9	104	BDL
Kiwifruit	High	**19**	1.1	35	***84***	5	10.6	155	***1.11***
(n=4)	Low	6	0.5	5	33	2	7.9	71	BDL
	Mean	10.75	0.8	14	46.75	3.5	9	109	0.28
	Median	9	0.8	8	35	3.5	8.75	105	BDL
Control	High	**14**	0.5	11	26	2	37.7	99	0.14
(n=6)	Low	2	0	3	9	0	2.9	21	BDL
	Mean	6.83	0.3	5.67	16.67	1	18.3	59.67	0.02
	Median	5.5	0.35	4	15.5	1	18.9	63.5	BDL

Table Note: ***Values highlighted in red bold italics exceed residential and agricultural trigger values***
Values highlighted in blue bold exceed agricultural trigger values
BDL – below laboratory method detection limit

4.5.2. Western Bay of Plenty District

A total of 36 of the 128 samples were collected from the Western Bay of Plenty District. Summary statistics for Western Bay of Plenty district are shown in Table 4.5.2. A total of 11 samples (33%) exceeded respective trigger values. The trigger value for copper (agricultural and residential 63 mg/kg) was exceeded by 10 (35.7%) of the samples. While two cadmium samples exceeded the agricultural trigger value (1.4 mg/kg), none of the samples exceeded the residential value (10 mg/kg). The trigger value for total DDT (agricultural and residential 0.7 mg/kg) was exceeded by two of the samples. The higher value (6.09 mg/kg), collected from an orchard, is an order of magnitude above the trigger value of 0.7 mg/kg.

The Western Bay of Plenty district recorded the highest median arsenic (18 mg/kg), cadmium (0.85 mg/kg) and copper (193.5 mg/kg) concentrations in the region. All these values were recorded for orchard sites. The median copper value for glass houses and orchards exceeded the residential and agricultural trigger values.

Table 4.5.2: Summary statistics for Western Bay of Plenty District

Land use	Result	Units are mg/kg dry weight							
		As	**Cd**	**Cr**	**Cu**	**Ni**	**Pb**	**Zn**	**Total DDT**
Orchard	High	***48***	1.1	8	***304***	7	***184***	120	***6.09***
(n=4)	Low	4	0.7	6	45	4	9.4	63	0.04
	Mean	**22**	0.88	6.75	***184***	5.5	57	91.75	***1.62***
	Median	**18**	0.85	6.5	***193.5***	5.5	17.3	92	0.18
Maize	High	9	0.7	8	31	5	11.9	63	0.02
(n=3)	Low	2	0.2	3	3	0	2.6	16	BDL
	Mean	5.33	0.43	5	13.33	2.33	6.83	36	0.01
	Median	5	0.4	4	6	2	6	29	BDL
Glass house	High	**28**	***2***	13	***215***	12	33.3	169	0.61
(n=6)	Low	3	0.3	4	23	0	7.4	62	BDL
	Mean	9.33	0.9	7	***97.17***	5	17.33	119.83	0.18
	Median	5.5	0.55	5	**74.5**	3	14.3	119.5	0.07
Pasture	High	15	1.3	11	36	9	25.2	122	0.21
(n=8)	Low	3	0.4	4	9	0	3.7	29	BDL
	Mean	6.38	0.84	6	19.25	2.88	11.86	64.63	0.09
	Median	5	0.75	5	20	2.5	12.15	62	0.09
Kiwifruit	High	10	1.2	8	***127***	6	13.7	118	***0.81***
(n=10)	Low	4	0.5	4	17	2	4.6	57	BDL
	Mean	6.6	0.83	5.8	54.1	4.3	8.11	75.4	0.21
	Median	6.5	0.85	6	52	4.5	7.2	67.5	0.15
Control	High	5	0.2	9	14	3	11.8	37	BDL
(n=4)	Low	4	0	3	5	0	8.2	30	BDL
	Mean	4.5	0.08	5	9	0.75	10.13	32.25	BDL
	Median	4.5	0.05	4	8.5	0	10.25	31	BDL

Table Note: ***Values highlighted in red bold italics exceed residential and agricultural trigger values***
Values highlighted in blue bold exceed agricultural trigger values
BDL – below laboratory method detection limit

4.5.3. Rotorua District

A total of 19 of the 128 samples were collected from the Rotorua District. Summary statistics for Rotorua district are shown in Table 4.5.3. A total of four samples (21%) of the samples exceeded a trigger value.

Three of the samples exceeded the residential arsenic trigger value. One of the samples exceeded the trigger value for copper (agricultural and residential). The exceedance sample was collected from an orchard (84 mg/kg). The Rotorua district recorded the highest medians for total DDT (0.26 mg/kg), dieldrin (0.1 mg/kg) and hexachlorobenzene (0.04 mg/kg) values.

The median copper value for Rotorua orchard sites is 44 mg/kg, and the median control value is 6 mg/kg. No kiwifruit, glass houses, or maize sites were sampled in the Rotorua district.

Table 4.5.3: Summary Statistics for Rotorua District

Land use	Result	Units are mg/kg dry weight							
		As	**Cd**	**Cr**	**Cu**	**Ni**	**Pb**	**Zn**	**Total DDT**
Pasture	High	**14**	0.6	5	7	5	22.3	38	0.26
(n=5)	Low	0	0.2	0	4	0	1.5	21	BDL
	Mean	5.6	0.44	2.8	5.4	1.6	6.96	29.4	0.07
	Median	3	0.5	3	5	0	4.1	30	BDL
Horticulture	High	**19**	0.5	6	33	4	8.1	54	0.38
(n=4)	Low	5	0.1	3	10	0	5.3	26	BDL
	Mean	11.5	0.25	4	18.5	1.5	7.03	35.25	0.22
	Median	11	0.2	3.5	15.5	1	7.35	30.5	0.26
Orchard	High	10	0.6	19	***84***	4	9.4	87	0.14
(n=5)	Low	4	0	2	6	0	4.7	21	BDL
	Mean	8	0.38	7.4	43.6	2	7.64	52.4	0.05
	Median	9	0.5	6	44	2	7.8	45	0.05
Control	High	8	0.3	3	7	0	9.7	38	BDL
(n=5)	Low	3	0	0	3	0	5.8	19	BDL
	Mean	5.2	0.12	1.2	5.4		7.46	26.6	BDL
	Median	4	0.1	0	6	0	7.1	26	BDL

Table Note: ***Values highlighted in red bold italics exceed residential and agricultural trigger values***
Values highlighted in blue bold exceed agricultural trigger values
BDL – below laboratory method detection limit

4.5.4. Whakatane District

A total of 29 of the 128 samples were collected from the Whakatane District. Summary statistics for Whakatane District are shown in Table 4.5.4. A total of seven (27%) of the samples collected in this district exceeded trigger values.

Four samples exceeded the trigger level for agricultural land use (12 mg/kg). The trigger levels for lead (agricultural 70 mg/kg and residential 140 mg/kg), zinc (agricultural and residential 200 mg/kg), and total DDT (agricultural and residential 0.7 mg/kg) were each exceeded by 1 sample collected from horticultural, kiwifruit and pasture sites respectively. A glass house site in the Whakatane district recorded the highest median total endosulphan value (0.025 mg/kg) within the region.

Table 4.5.4: Summary statistics for Whakatane District

Land use	Result	Units are mg/kg dry weight							
		As	**Cd**	**Cr**	**Cu**	**Ni**	**Pb**	**Zn**	**Total DDT**
Pasture	High	5	0.5	7	9	5	8.6	41	***1.18***
(n=4)	Low	0	0.3	0	4	0	1.4	25	BDL
	Mean	2.5	0.35	3.25	5.75	1.25	4.13	31	0.33
	Median	2.5	0.3	3	5	0	3.25	29	0.06
Kiwifruit	High	**15**	0.6	8	49	5	41.1	***284***	0.06
(n=4)	Low	7	0.4	4	9	3	3.8	30	BDL
	Mean	11.50	0.53	5.75	24.00	4.25	13.68	98	0.03
	Median	12	0.55	5.5	19	4.5	4.9	39	0.02
Horticulture	High	**25**	0.8	6	21	5	**94.7**	140	0.23
(n=6)	Low	0	0.2	2	6	0	1.9	20	BDL
	Mean	10.83	0.42	4.50	11.00	3.33	18.22	52.17	0.06
	Median	9	0.35	4.5	9	3.5	3.1	36	0.02
Glass house	High	8	0.7	8	43	6	10.7	153	0.03
(n=2)	Low	3	0.1	8	14	5	6.2	54	BDL
	Mean	5.5	0.4	8	28.5	5.5	8.45	103.5	0.02
	Median	5.5	0.4	8	28.5	5.5	8.45	103.5	0.02
Maize	High	**13**	0.7	11	23	8	69.1	100	BDL
(n=8)	Low	4	0.1	3	4	2	3.4	19	BDL
	Mean	7.63	0.36	6.25	11.63	4.83	20.70	53.63	BDL
	Median	8	0.3	5	11.5	4	9.5	48	BDL
Control	High	8	0.2	9	10	6	18.7	57	BDL
(n=5)	Low	0	0	0	3	0	6	23	BDL
	Mean	3.2	0.12	5.8	7.2	4.4	12.1	44.8	BDL
	Median	3	0.1	7	7	5	12.5	50	BDL

Table Note: ***Values highlighted in red bold italics exceed residential and agricultural trigger values***
Values highlighted in blue bold exceed agricultural trigger values
BDL – below laboratory method detection limit

4.5.5. Opotiki District

A total of 24 of the 128 regional samples were collected from the Opotiki district. Summary statistics for Opotiki district are shown in Table 4.5.5. Two samples (8.3%) exceeded the trigger value for copper (agricultural 63 mg/kg and residential trigger value 78 mg/kg). The two exceedances were from orchard (81 mg/kg) and kiwifruit (87 mg/kg) land uses.

The Opotiki district also recorded the highest median chromium (11 mg/kg), nickel (8.5 mg/kg) and lead (27.9 mg/kg) values. All these results exceed the regional median control values (Table 4.2.1).

Table 4.5.5: Summary statistics for Opotiki District

Land use	Result	Units are mg/kg dry weight							
		As	**Cd**	**Cr**	**Cu**	**Ni**	**Pb**	**Zn**	**Total DDT**
Glass house (n=3)	High	11	0.4	13	53	10	63.2	112	0.21
	Low	3	0.3	5	11	3	8.1	40	0.10
	Mean	6.8	0.36	8.4	30.8	6	33.06	73.8	0.15
	Median	6.4	0.38	7.2	28.4	5	27.88	69.4	0.15
Kiwifruit (n=6)	High	7	0.9	9	***87***	7	10.5	75	0.05
	Low	3	0.3	5	12	4	4.6	53	0.04
	Mean	4.63	0.64	7.13	40.13	5.13	7.01	61.63	0.05
	Median	4	0.7	7.125	39	5	6.1	59	0.05
Orchard (n=4)	High	4	0.6	12	***81***	9	13.9	100	0.03
	Low	3	0.4	3	40	2	4.6	49	BDL
	Mean	3.75	0.53	6	59.5	4.25	8.78	70.5	0.01
	Median	4	0.55	4.5	58.5	3	8.3	66.5	BDL
Pasture (n=4)	High	5	0.7	11	17	9	11.8	71	0.21
	Low	3	0.3	4	13	3	5.7	54	BDL
	Mean	4	0.575	8.25	14.25	6.25	9.15	62.5	0.05
	Median	4	0.65	9	13.5	6.5	9.55	62.5	BDL
Maize (n=2)	High	4	0.2	11	16	9	14.7	80	0.02
	Low	4	0.2	11	14	8	13.4	62	BDL
	Mean	4	0.2	11	15	8.5	14.05	71	0.01
	Median	4	0.2	11	15	8.5	14.05	71	0.01
Control (n=5)	High	7	0.2	7	16	6	24.3	98	BDL
	Low	3	0	2	4	0	6.1	20	BDL
	Mean	4.4	0.06	4.6	10.6	2	13.22	56.4	BDL
	Median	4	0	5	10	0	10	52	BDL

Table Note: ***Values highlighted in red bold italics exceed residential and agricultural trigger values***
Values highlighted in blue bold exceed agricultural trigger values
BDL – below laboratory method detection limit

5. KEY RESULTS AND CONCLUSIONS

Because potential hotspots were deliberately not sampled during this investigation, and because analysed samples were composited of ten sub-samples, the results obtained can not indicate what maximum concentrations may be present on any site. The results can do no more than give a general idea of the average degree of impact of the subject analytes on agricultural and horticultural soils in the region.

Following a comparison of the results to conservative land use trigger levels the following conclusions can be made:

- Copper, Arsenic and total DDT were the analytes which had the most exceedances;
- Copper had the highest exceedance rate, with13% of the samples exceeding the agricultural trigger level. 11% of the samples also exceeded the residential trigger level for copper;
- Cadmium, chromium, nickel, dieldrin and total endosulphan levels did not exceed residential trigger levels in any sample. Cadmium exceeded the agricultural trigger levels in two samples collected from glass house / market gardens sites in the WBOP district;
- Orchards had the highest level of exceedances with 59% of samples exceeding one or more trigger levels. Samples collected from glass houses/market garden sites exceeded respective trigger levels in 43% of the sites, and 38% of kiwifruit sites;
- When comparing the rate of exceedances between residential and agricultural land uses, residential land use has a lower percentage of exceedances (see Figure 1(a) and 1(b)).

The results of the investigation indicate that a significant number of sites sampled exceed agricultural and residential trigger values for selected residual pesticides and agrichemical residues. In addition, due to the limitations of the investigation (see Section 1.4), further investigation of agricultural and horticultural land should be considered prior to development to more sensitive land uses, such as residential.

In conclusion, this preliminary investigation has been useful in determining residual concentrations of selected agrichemicals on various land uses throughout the Bay of Plenty. While the results indicate that some results have exceeded the conservative land use guidelines for human health and ecological protection, the level of investigation at any given site is not sufficient to deem a site as “contaminated” or unsuitable for its’ current or intended land use. Such conclusions can only be made following a more detailed site specific investigation.

6. RECOMMENDATIONS

Based on the results of this investigation SEMNZ recommends that territorial local authorities develop policy to ensure that adequate human health and environmental protection is maintained on agricultural and horticultural land developments.

In addition, the results of the investigation identified various land use categories within some districts that may warrant further investigation. Further investigations should provide sufficient data to ensure that the land is suitable for the proposed use, from both a human health and an environmental perspective, and be consistent with Ministry for the Environment contaminated land requirements. In addition, the investigations should address all the issues outlined in the limitations section (Section 1.4) of this report.

7. REFERENCES

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APPENDIX A

SOIL SAMPLING PROTOCOL[6]

[6] Adapted from Auckland Regional Council (2002): *Pesticide Residues in Horticultural Soils in the Auckland Region*. Working Report No. 96.

1. Introduction

Specific soil sampling procedures on agricultural and horticultural sites are required for investigating the nature and level of any soil contamination on these sites. This is due to the many and varied activities that were conducted on these sites. Unlike many industrial sites, where activities often took place in defined locations, the chemical parameters of interest on cropping areas of agricultural and horticultural sites were generally applied or used over the entire site. In addition, there is often very little site history available to aid in the design of a sampling plan.

This sampling protocol has been designed to provide the information necessary to assess whether these sites generally pose potential risks to human health and the environment, and whether any remediation for a future proposed land use, such as residential, is required. It does not, however, comment on potential localised contamination, or the environmental quality of individual sites. Appendix 1 provides a checklist for the field assistant to use in the field to ensure that the correct procedures are carried out.

2. Survey Questions

Each field assistant will be provided with a survey questionnaire to be completed when making contact with the landowners and while onsite carrying out the sampling.

Upon initial conversations and meetings with landowners, the field assistant will be sure to introduce themselves, the company they are working for (i.e. SEM who have been contracted by Environment BOP), and explain what they will be doing while on the site. The field assistant will explain that they need answers to a few questions and that the information that the landowner provides will remain confidential as will the results for their individual property. The only people to see results for each individual property will be ESSENTIAL SEM staff and the individual landowner themselves. Confidentiality is assured by the following precautions:

- Unique sample Identification numbers for each property so that results can not be traced back to any individual property;
- Results will be kept on a computer while report is prepared, the results file will be password-protected so that only key SEM personnel have access;
- Once the report is completed, the files will be copied onto a password-protected CD, and all files on the computer will be deleted. The CD will be kept at SEM offices that are locked outside of working hours.

Appendix 2 lists the typical buildings that occur on agricultural and horticultural sites which may also help to identify and therefore avoid potential hotspots.

If you are unable to contact a landowner after trying at least 3 times (allowing at least a day for landowners to get back to you if you have left a message, and trying at least once outside of normal work hours), soil samples may be taken from the property, however a letter, self addressed envelope and survey questions shall be left in the letter box or in a dry secure place where it will be found by a site resident or worker.

3. Sampling

Systematic sampling will be used to collect samples that are representative of the sprayed areas on the property. (These samples will be composited at the laboratory to reduce analysis costs). The 1-hectare area on each property needs to be selected; therefore, initially the field assistants need to identify an area using maps, GPS, address, and owner information when they arrive onsite.

Hotspots (areas of likely contamination) are not to be sampled, therefore, when selecting a sampling area onsite, obvious hotspot areas should be avoided. The following list gives examples of potential hotspots that may be present on agricultural and horticultural sites; other hotspot areas may also exist on specific sites. Site owners may be able to identify the location of possible hotspots.

- storage shed (inside and out)
- underneath/around spray tank
- spray disposal areas
- disposal areas (compost, boiler ash, soil from inside glass houses)
- farm dumps
- glass houses and plant propagation areas

- drainage areas
- sumps
- storage areas for treated timber (fence posts etc.)
- spills or leaks from pressurised spray systems (used prior to tractors)
- sheep dips
- offal pits

3.1 Soil Cores

Each soil core should be of equal volume of soil and collected to a depth of 75mm of soil. Ten (10) soil cores make one representative sample.

An auger that samples to a depth of 75mm will be provided to each field assistant. To get the soil core out of the auger, a plunger or similar device will also be provided to push the core out into the sampling bag. The auger and plunger need to be thoroughly cleaned between each property, but do not require cleaning between collecting soil cores which will form a single sample.

All equipment used shall be decontaminated by:

- Removing all visible soil prior to rinsing using the bottle brush provided;
- A phosphate detergent and water solution will be used to wash all equipment;
- Equipment will then be thoroughly rinsed with distilled water.

3.2 Systematic Sampling of the Area

The aim of the systematic sampling is to collect samples that are representative of the horticultural area on the site. One representative sample is to be collected per hectare. Each representative sample area must be restricted to similar topography. Each representative sample should be made up of 10 soil cores collected on a zigzag pattern as shown in Figure 1. A sample for an area less than 1-hectare should also be composed of 10 soil cores.

The 10 soil cores will be combined to produce a representative sample for that area where: $x \times y \leq 1$ha (see Figure 1).

Samples from the following areas should not be included in representative samples, nor in sample composites.

- areas with significantly different ages of activities or types of crop or spray history. (e.g. different ages of replanting or glass houses of different ages);
- anywhere the site owner has reason to believe may contain higher chemical loads (e.g. spray discharge disposal area);
- at spills and leaks;
- around spray sheds;
- areas where earthworks or filling has occurred;
- areas used for animal husbandry (rabbits and chickens were often raised on horticultural sites);
- around residential dwellings.
- areas with fill materials.

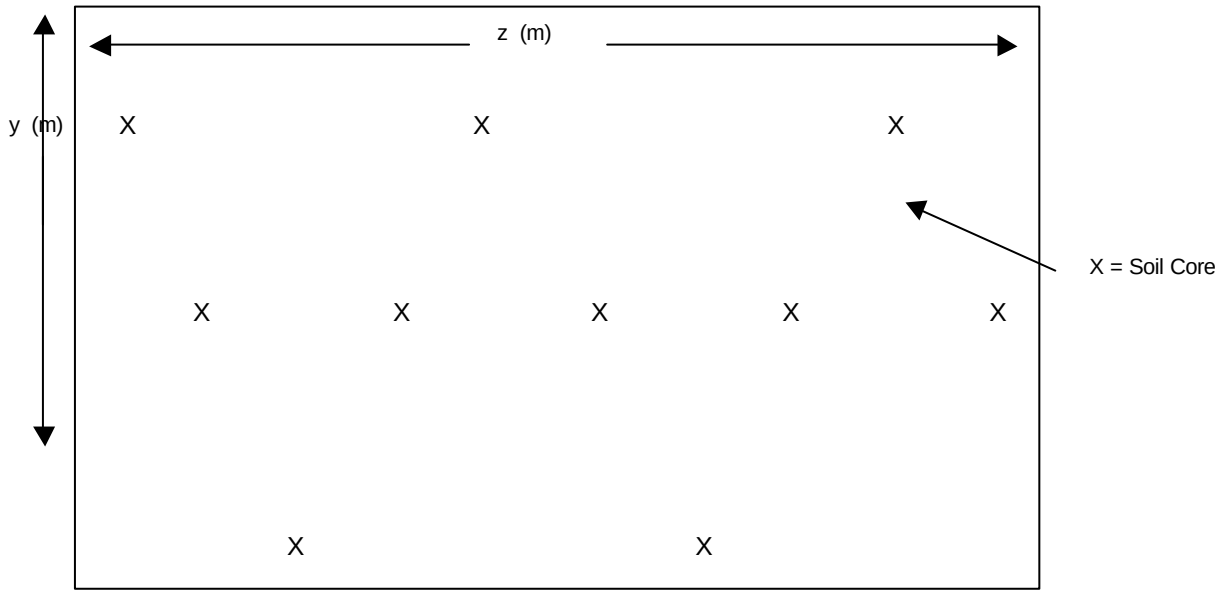


Figure 1: Sampling collection plan for each representation.

3.3 Site Map

Each field assistant will be provided with a map of the property. In the event that a map is not provided, the assistant shall sketch a map of the sample area. On each map, the sample collection pattern, and approximate location (and GPS reading) of the constituent cores shall be marked on the map.

Sampling Procedure Checklist

General

1. Contact the Landowner at least one day before visiting their property. Inform them of your forthcoming visit. If they are not going to be available on the day, ask questions from the survey over the telephone. Completion of the question forms is likely to take 5 – 10 minutes). Lunch time or between 7pm and about 8.15 PM is a good time to talk with landowners- you get a better reception if you don't ring at dinner time or before the news and weather are finished. Do not ring after 8.20ish as many people go to bed early.

   If a landowner has changed their mind and no longer wishes to be sampled, say thank you and leave.

2. On arrival on the site, check that you are in the correct location, using GPS, maps and address information.

3. Spend a few minutes assessing the property for potential dangers i.e. angry bulls in the paddock to be sampled, dogs, machinery (including sprayers).

Sample Procedure:

1. Complete Survey questions as much as possible
2. Identify area appropriate for sampling (i.e. appropriate land use, topography, avoiding hot spots etc.); do not sample an area if the ground is very wet - the corers do not work very well on very wet soil.
3. Label the plastic bag with the appropriate sticker, if no sticker is provided, mark on the plastic bag the following information with a vivid pen (provided): Site ID, Date of Collection, SEM Tauranga.
4. Ensure coveralls and sturdy footwear are worn, and nitrile gloves;
5. Avoid any dense vegetation;
6. One sample will be taken every 20m in a 'W' pattern, until 10 samples have been collected;
7. Push the soil auger into the soil, using the foot rest;
8. Remove auger from the ground;
9. Place auger into the mouth of the bag, and if necessary, use plunger to push soil core into the bag.
10. Repeat steps 1-9 at each sub-sample location.
11. Take a GPS reading on the 5th sample collected.
12. When each of the 10 samples has been placed into the appropriate bag, seal the bag carefully and place into the chili bin/box provided.
13. Decontaminate the auger and plunger, remove gloves and scrub bottom of footwear, and ensure clothing does not carry soil between sites. To decontaminate equipment, scrub soil off and rinse using decontamination solution and distilled water provided.
14. Sketch the sample pattern on the map;
15. Check that Survey form is completed.

Let the landowner know when you leave their property. Do not take anything (apart from the soil sample) off the property and check with the landowner before moving elsewhere on the property.

The bags of soil samples and the survey forms will be collected from you at regular intervals, or if you are located remotely, these will need to be couriered to SEM NZ.

Horticultural Properties Buildings Lists

Examples of buildings likely to be found on properties

Glass house Sites

- Glass houses typical length 120-150 feet width 30 to 40 feet
- House
- Garage
- Packing shed
- Implement and manure shed (chemicals may have been stored here)
- Boiler rooms and oil storage or coal storage bins (if glass houses were heated)
- Fuel storage tanks are a possibility
- Spray shed (may still have spray mixing tanks)
- Farm dump

Market Gardens/Orchards

- House
- Garage
- Packing shed (sprayer and tractor may have been stored here)
- Implement and manure shed
- Fuel storage tanks are a possibility
- Spray shed (may still have spray mixing tanks)
- Farm dump
- Glass house for plant propagation
- General farm buildings (e.g. poultry sheds, milking shed)

Vineyards

- House
- Garage
- Packing shed/winery (sprayer and tractor may have been stored here)
- Implement and manure shed
- Fuel storage tanks are a possibility
- Spray shed (may still have spray mixing tanks)
- Glass houses for plant propagation
- Farm dump
- General farm buildings (e.g. poultry sheds, milking shed)

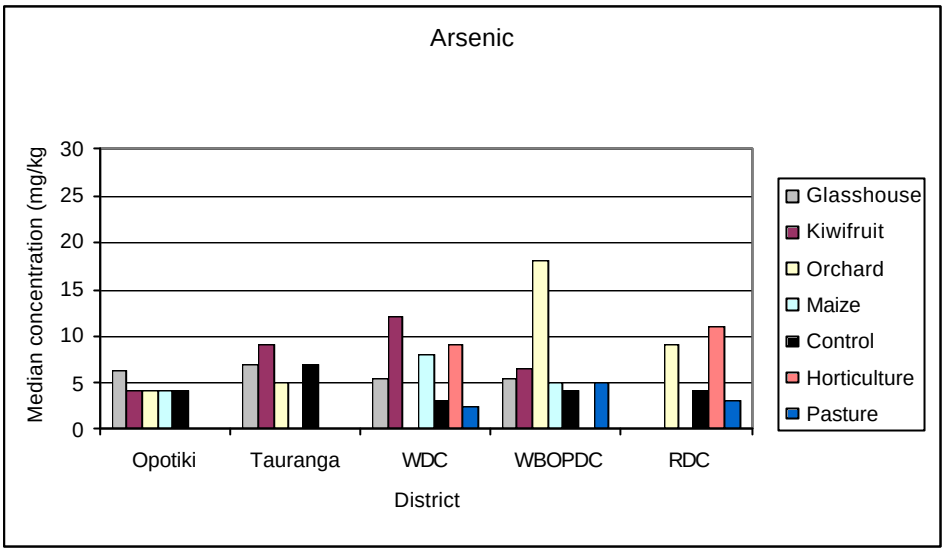
Names for Selected Active Ingredients

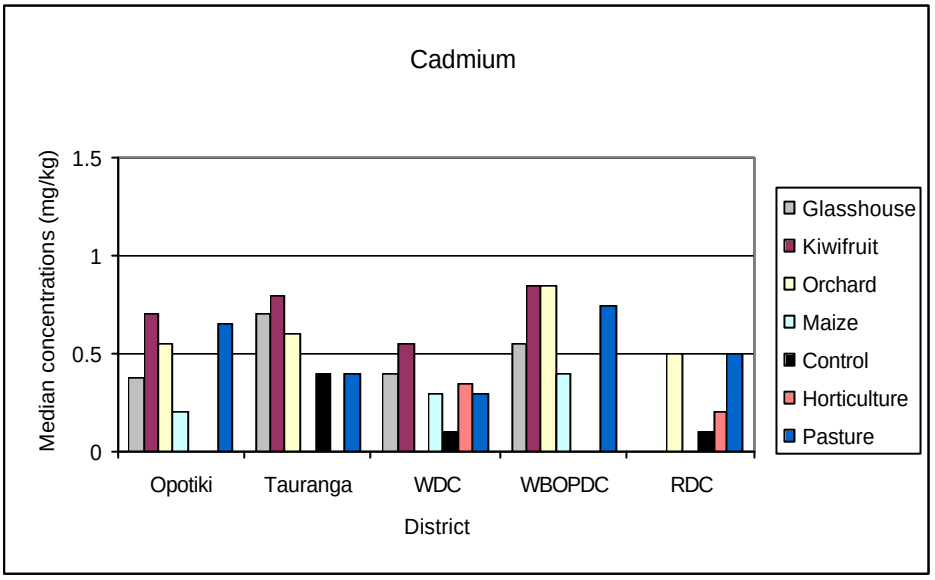
This list is illustrative rather than exhaustive. The following references are recommended for identifying active ingredients in agrichemical formulations; *NZ Agrichemical Manual* (Fussell and Walton 2001), *Manual of Agrichemical Identification and Emergency Management* (Wallace 1997), *Fungous Disease in Fruit Trees* (Cunningham 1925) and *Plant Protection in New Zealand* (Atkinson et al 1956).

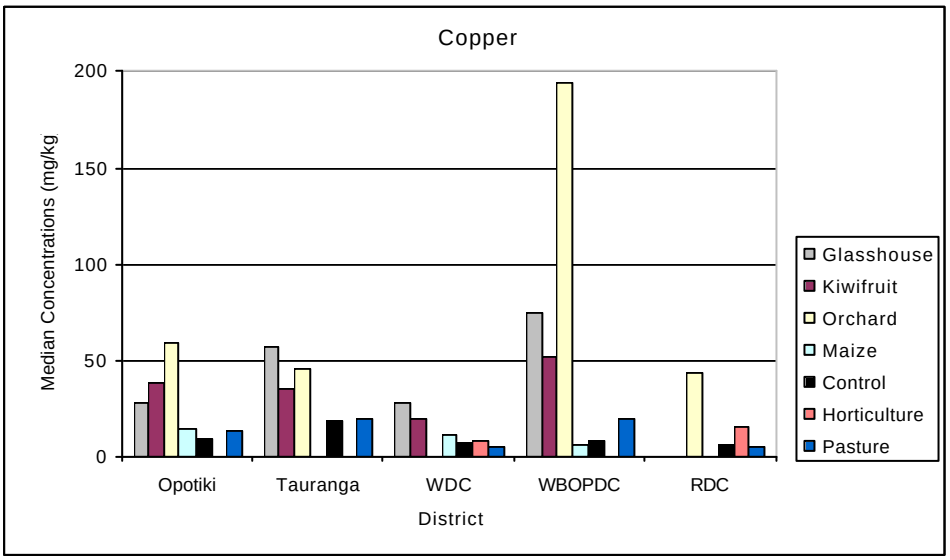
DDT			
Aerocide DDT	Atapest	D-Dust L	D-Dust No 2
D-Spray 50	DD Temul	Decaloid	DeDetane
DDT Prills	DDTol	DDTemul	Emulsol DDT
Fertona 20	Fieldpak DDT	Gardrite DDT	Grubnox
I Spray DDT	Pespruf 2G	Pespruf 20	Pespruf 50
Shell DDT Concentrate	Trimort Wettable DDT	Zerdane	
Dieldrin			
Dieldrix	Compound 497	Octalox	
Arsenic Based Formulations (includes Lead arsenate)			
Blue Bell	Coopers Arsinette	Fertona	Hemway
Orchard Brand	Talbot	Winstones Arsenate of Lead	Weedeath
Weedex	Zeltacal		
Copper based products			
Agpro Cupric	Blitox 50	Blue Shield DF	Blue vitriol
Bluestone	Bordeaux mixture	BP Copper oxychloride	Burgundy mixture
Champ	Champion	Coppesan	Copro 50
Cop-ox	Cop-ox M.M.	Cop-ox 50	Coxysan
Cupravit	Cupromox	Cuprox	Graphic
Fruitfed Copper Oxychloride	Funguran	NuFarm	Hydro-Pro WDG
Ialine	Kocide	Te Papapa	Copper Oxychloride
Perenox	Spin Out	Vitigran	Yellow cuprocide
Iron based formulations			
Ferban	Fermate	Fermspray	Fertran
Weed'N'feed			
Manganese based formulations			
Dithane	Maneb		
Mercury based formulations			
Aerocide P.M 4	Ascospray	Lunevale venturicide	Pruntect Tree Wound Dressing
Tin based formulations			
Cyhexatin	Cytin	Fenbutatin-oxide	
Zinc based formulations			
Dithane Z78	Fuclasin	Milban	Zerospray
Zertate	Zineb	Ziram	

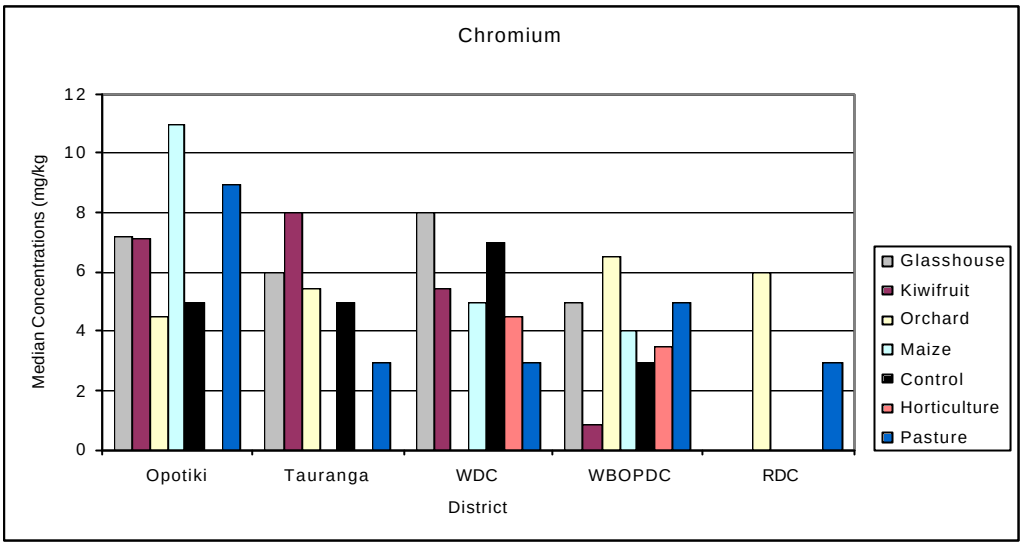
APPENDIX B

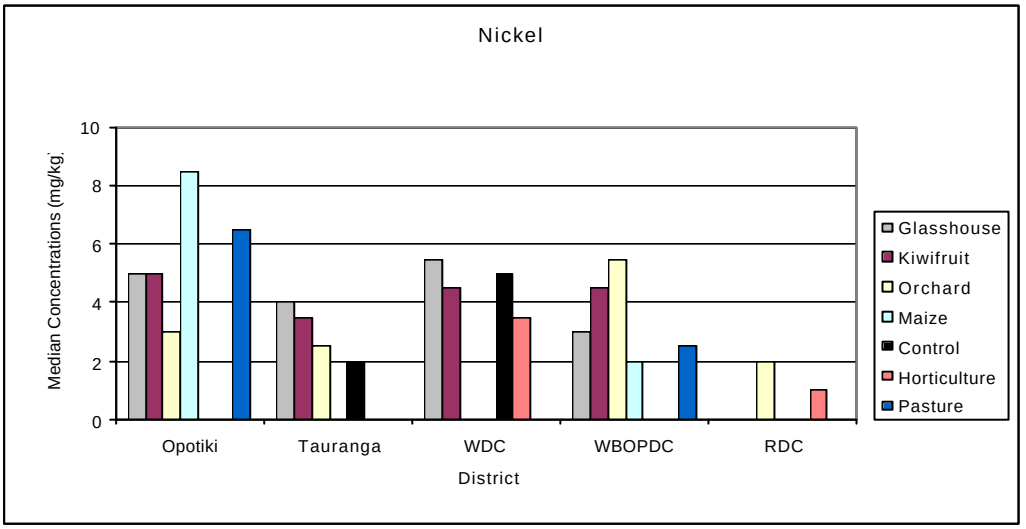
BAR GRAPHS SHOWING DISTRICT/LANDUSE MEDIAN RESULTS

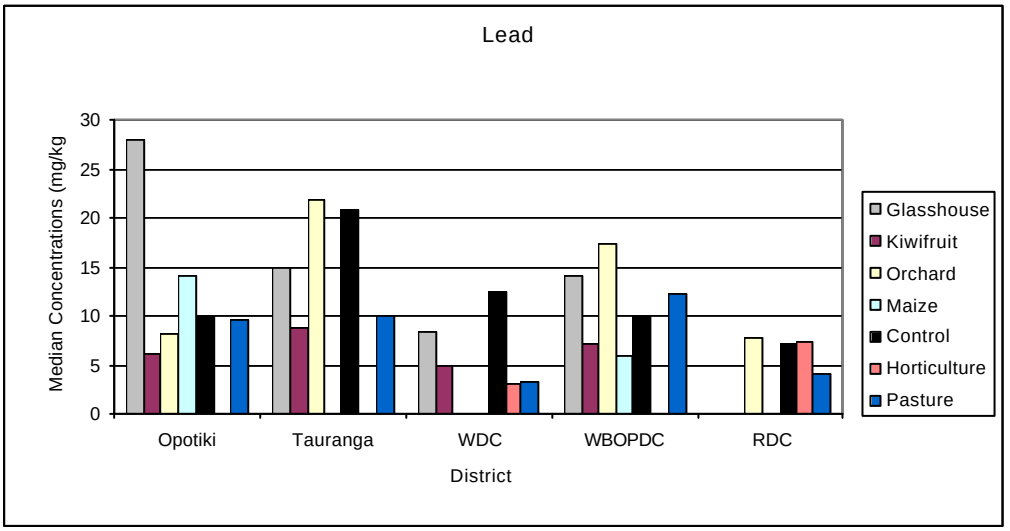

Arsenic
Median concentration (mg/kg
30
25
20
15
10
5
0
Opotiki
Tauranga
WDC
WBOPDC
RDC
District
Glasshouse
Kiwifruit
Orchard
Maize
Control
Horticulture
Pasture

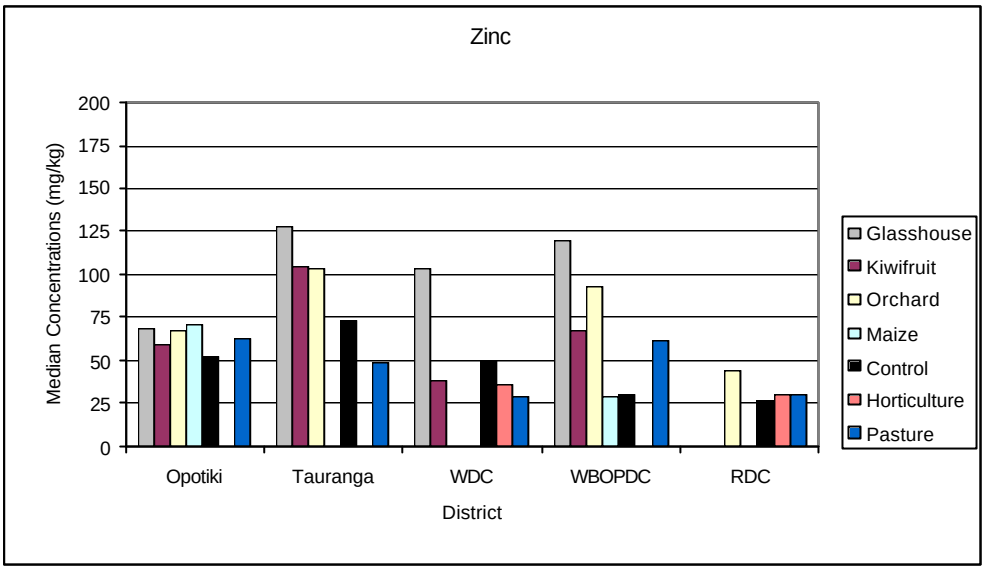

Cadmium
Median concentrations (mg/kg)
1.5
1
0.5
0
Opotiki
Tauranga
WDC
WBOPDC
RDC
District
Glasshouse
Kiwifruit
Orchard
Maize
Control
Horticulture
Pasture

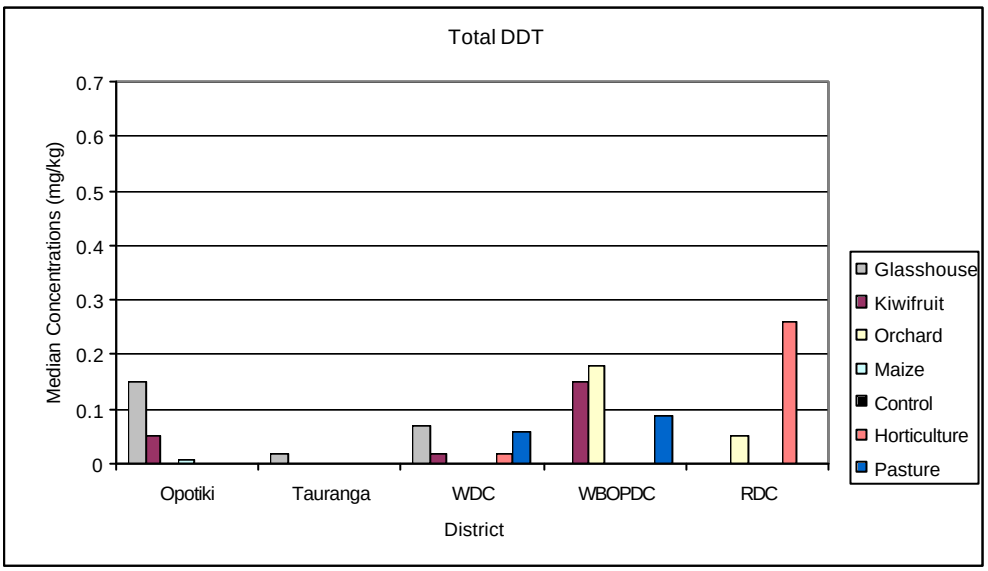

Copper
Median Concentrations (mg/kg
200
150
100
50
0
Opotiki
Tauranga
WDC
WBOPDC
RDC
District
Glasshouse
Kiwifruit
Orchard
Maize
Control
Horticulture
Pasture

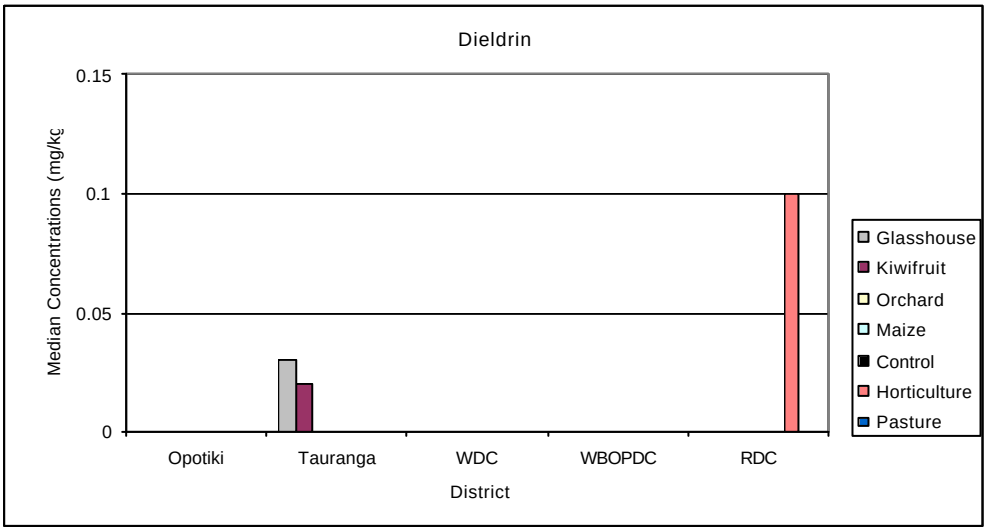

Chromium
Median Concentrations (mg/kg
12
10
8
6
4
2
0
Opotiki
Tauranga
WDC
WBOPDC
RDC
District
Glasshouse
Kiwifruit
Orchard
Maize
Control
Horticulture
Pasture

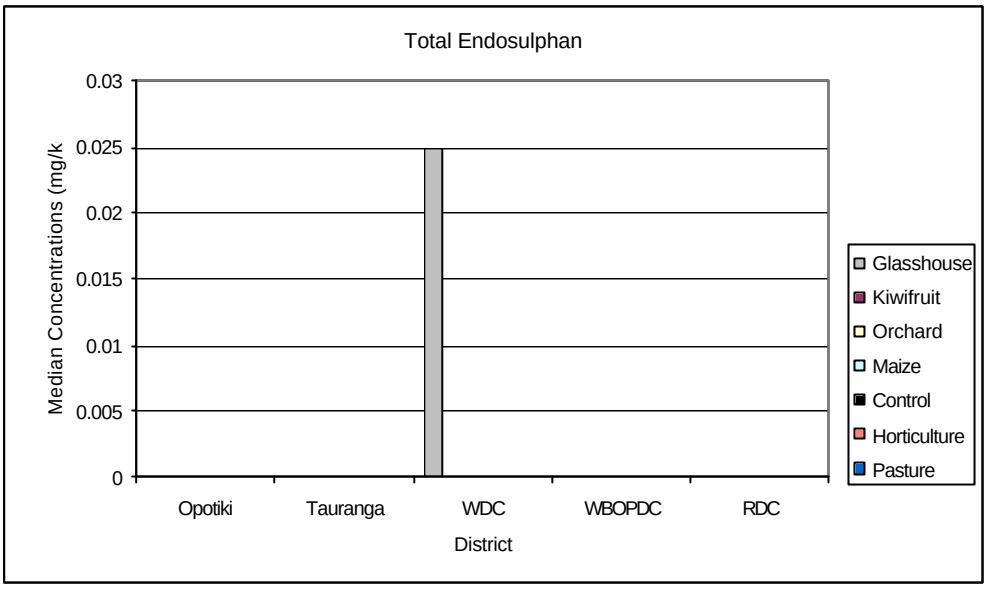

Nickel
Median Concentrations (mg/kg)
10
8
6
4
2
0
Opotiki
Tauranga
WDC
WBOPDC
RDC
District
Glasshouse
Kiwifruit
Orchard
Maize
Control
Horticulture
Pasture

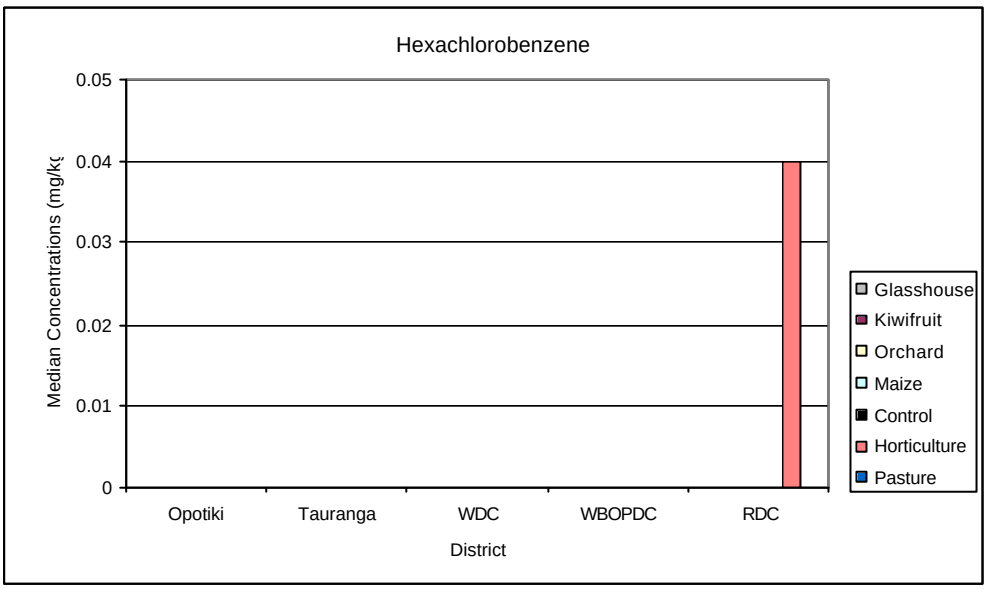

Lead
Median Concentrations (mg/kg
30
25
20
15
10
5
0
Opotiki
Tauranga
WDC
WBOPDC
RDC
District
Glasshouse
Kiwifruit
Orchard
Maize
Control
Horticulture
Pasture


Zinc
Median Concentrations (mg/kg)
200
175
150
125
100
75
50
25
0
Opotiki
Tauranga
WDC
WBOPDC
RDC
District
Glasshouse
Kiwifruit
Orchard
Maize
Control
Horticulture
Pasture


Total DDT
Median Concentrations (mg/kg)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Opotiki
Tauranga
WDC
WBOPDC
RDC
District
Glasshouse
Kiwifruit
Orchard
Maize
Control
Horticulture
Pasture


Dieldrin
Median Concentrations (mg/kg
0.15
0.1
0.05
0
Opotiki
Tauranga
WDC
WBOPDC
RDC
District
Glasshouse
Kiwifruit
Orchard
Maize
Control
Horticulture
Pasture


Total Endosulphan
Median Concentrations (mg/k
0.03
0.025
0.02
0.015
0.01
0.005
0
Opotiki
Tauranga
WDC
WBOPDC
RDC
District
Glasshouse
Kiwifruit
Orchard
Maize
Control
Horticulture
Pasture


Hexachlorobenzene
Median Concentrations (mg/kg
0.05
0.04
0.03
0.02
0.01
0
Opotiki
Tauranga
WDC
WBOPDC
RDC
District
Glasshouse
Kiwifruit
Orchard
Maize
Control
Horticulture
Pasture

APPENDIX C

LABORATORY RESULT & QA/QC CERTIFICATES

APPENDIX D

COMPOUNDS ANALYSED AND DETECTION LIMITS

Summary of Methods Used and Detection Limits

The following tables give a brief description of the methods used to conduct the analyses for this job.
The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilution's be performed during analysis.

Substance Type: Environmental Solids

Parameter	Method Used	Detection Limit
Dry and sieve sample	Air dry (35°C), sieved to pass 2mm	N/A
Total Recoverable Arsenic	Nitric / hydrochloric acid digestion, ICP-MS. US EPA 200.2	2 mg/kg dry wt
Total Recoverable Cadmium	Nitric / hydrochloric acid digestion, ICP-MS. US EPA 200.2	0.1 mg/kg dry wt
Total Recoverable Chromium	Nitric / hydrochloric acid digestion, ICP-MS. US EPA 200.2	2 mg/kg dry wt
Total Recoverable Copper	Nitric / hydrochloric acid digestion, ICP-MS. US EPA 200.2	2 mg/kg dry wt
Total Recoverable Nickel	Nitric / hydrochloric acid digestion, ICP-MS. US EPA 200.2	2 mg/kg dry wt
Total Recoverable Lead	Nitric / hydrochloric acid digestion, ICP-MS. US EPA 200.2	0.4 mg/kg dry wt
Total Recoverable Zinc	Nitric / hydrochloric acid digestion, ICP-MS. US EPA 200.2	4 mg/kg dry wt
Dry Matter	Dried at 103°C, gravimetric (removes 3-5% more water than air drying at 35°C)	0.1 g/100g as rcvd
Organochlorine pesticides, screening	Sonication extraction, GC-ECD	N/A
Organonitrogen & Organophosphorus Pesticides	ONOP screen method, soil: Sonication extraction, GC-MS. In house	N/A

Organochlorine Pesticides (OCP) in Soil.

	Soil **(Note 1)**
	Screen
Code	OCPs
Bottle Code	Gsoil
IANZ accredited	Y
Method	Note 5
Default Testing Level	
Compound List	MDL mg/kg
2,4-DDD	0.005
4,4-DDD	0.005
2,4-DDT	0.005
4,4-DDT	0.005
2,4-DDE	0.005
4,4-DDE	0.005
Aldrin	0.005
alpha-BHC	0.005
beta-BHC	0.005
delta-BHC	0.005
gamma-BHC (Lindane)	0.005
cis-chlordane	0.005
trans-chlordane	0.005
Total chlordane (cis+trans *100/42)	0.02
Dieldrin	0.005
Endosulfan I	0.005
Endosulfan II	0.005
Endosulfan sulphate	0.005
Endrin	0.005
Endrin Aldehyde	0.005
Heptachlor	0.005
Heptachlor Epoxide	0.005
Hexachlorobenzene	0.005
Methoxychlor	0.005

Note 1: These detection limits are based on typical soil and sediment matrices. Samples are dried and ground prior to analysis, and are reported on a “dry weight” basis. Complicated matrices containing high levels of small organic compounds (eg from composted plant and other organic material) can lead to severe matrix interferences which may affect the detection limits achieved.

Note 5: OCP screen method, soil: In house method. Air dry/grind. Sonication extraction, GC-ECD.

Note 6: OCP trace method, soil: In house method. Air dry/grind. Sonication extraction, SPE cleanup, GC-ECD/ECD.

Organonitrogen and Organophosphorus Pesticides (ONOP) in Soil.

	Soil **(Note 1)**
	Screen
Code	ONPs
Bottle Code	Gsoil
IANZ accredited	N
Method	Note 5
Default Testing Level	
Compound List	MDL mg/kg
Acephate	0.4
Acetochlor	0.2
Alachlor	0.2
Atrazine	0.2
Atrazine-desethyl	0.2
Atrazine-desisopropyl	0.6
Azinphos-methyl	0.4
Benalaxyl	0.2
Bitertanol	0.5
Bromacil	0.2
Bromopropylate	0.2
Captan	0.2
Carbaryl	0.4
Carbofuran	0.2
Chlorfluazuron	0.2
Chlorothalonil	
Chlorotoluron	0.2
Chlorpyrifos	0.2
Chlorpyrifos-methyl	0.2
Cyanazine	0.2
Cyfluthrin	0.5
Cyhalothrin	0.2
Cypermethrin	0.5
Deltamethrin	0.2
Diazinon	0.2
Diuron	0.4
Dichlofluanid	0.2
Dicloran	0.2
Dichlorvos	0.5
Difenoconazole	0.5
Diphenylamine	0.4
Fluometuron	0.2

	Soil **(Note 1)**
	Screen
Code	ONPs
Bottle Code	Gsoil
IANZ accredited	N
Method	Note 5
Default Testing Level	
Compound List	MDL mg/kg
Furalaxyl	0.2
Flusilazole	0.4
Fluazifop-p-butyl	0.2
Haloxyfop-r-methyl	0.2
Hexazinone	0.2
Iprodione	1
Kresoxim-methyl	0.2
Linuron	0.5
Malathion	0.2
Metalaxyl	0.2
Metolachlor	0.2
Metribuzin	0.2
Myclobutanil	0.2

Note 1: These detection limits are based on typical soil and sediment matrices and a dry matter of 50%. Samples are analysed "as received", and reported on a dry weight basis. Complicated matrices containing high levels of small organic compounds (e.g. from composted plant and other organic material) can lead to severe matrix interferences which may affect the detection limits achieved.

Note 5: OCP screen method, soil: In house method. Air dry/grind. Sonication extraction, GC-ECD.

Note 6: OCP trace method, soil: In house method. Air dry/grind. Sonication extraction, SPE cleanup, GC-ECD/ECD.

Organonitrogen and Organophosphorus Pesticides (ONOP) in Soil. – continued

	Soil **(Note 1)**
	Screen
Code	ONPs
Compound List	MDL mg/kg
Naled	
Norflurazon	0.2
Oxadiazon	0.2
Oxyfluorfen	0.5
Paclobutrazol	0.2
Parathion-ethyl	0.5
Parathion-methyl	0.5
Pendimethalin	0.5
Permethrin	0.2
Pirimicarb	0.2
Pirimiphos methyl	0.2
Prochloraz	0.5
Procymidone	0.2
Prometryne	0.2
Propachlor	0.4
Propazine	0.2
Propiconazole	0.2
Quizalofop-p-ethyl	0.2
Simazine	0.2
Sulfentrazone	
Terbacil	0.2
Tebuconazole	0.2
Terbumeton	0.2
Terbuthylazine	0.2
Terbuthylazine desethyl	0.2
Tolyfluanid	0.2
Triazophos	0.2
Trifluralin	0.2
Vinclozolin	0.4

Note 1: These detection limits are based on typical soil and sediment matrices and a dry matter of 50%. Samples are analysed "as received", and reported on a dry weight basis. Complicated matrices containing high levels of small organic compounds (e.g. from composted plant and other organic material) can lead to severe matrix interferences which may affect the detection limits achieved.

Note 5: OCP screen method, soil: In house method. Air dry/grind. Sonication extraction, GC-ECD.